Japan International Cooperation Agency

PREPARATORY SURVEY FOR METRO MANILA SEWERAGE AND SANITATION IMPROVEMENT PROJECT- PHASE-2

FINAL REPORT

VOLUME1

JULY 2011

OEC *ORIGINAL ENGINEERING CONSULTANTS CO., LTD.*

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Length			Time		
mm	-	millimeter	s, sec	-	second
cm	-	centimeter	min	-	minute
m	-	meter	hr	-	hour
km	-	kilometer	dy	-	day
			mon	-	month
			yr	-	year

Area			Volume		
sq m	-	square meter	cum	-	cubic meter
sq km	-	square kilometer	l, ltr	-	liter
ha	-	hectare	mcm	-	million cubic meter

Weight			Speed		
g, gr	-	gram	cm/s	-	centimeter per second
kg	-	kilogram	m/s	-	meter per second
t	-	ton	km/h	-	kilometer per hour

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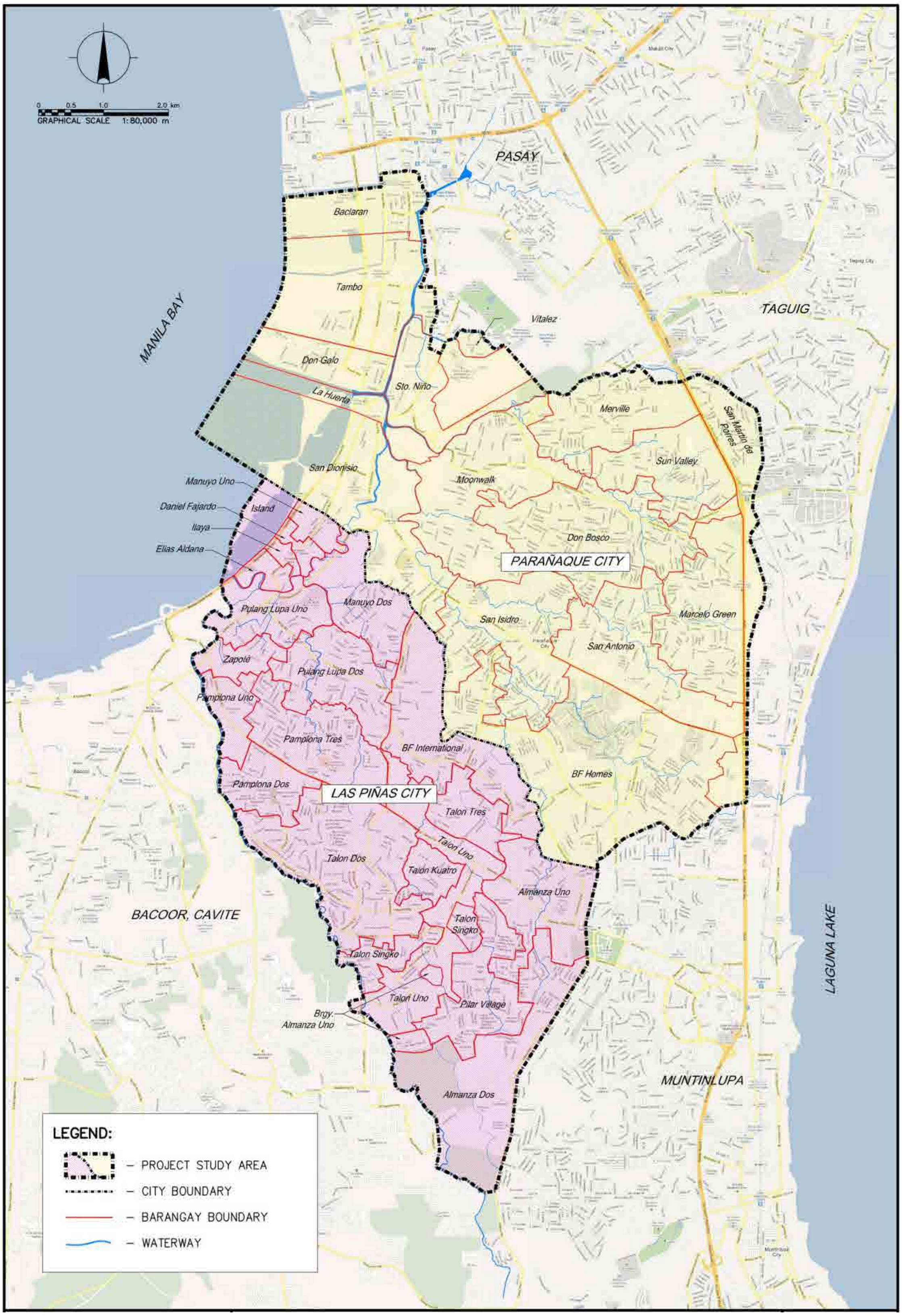
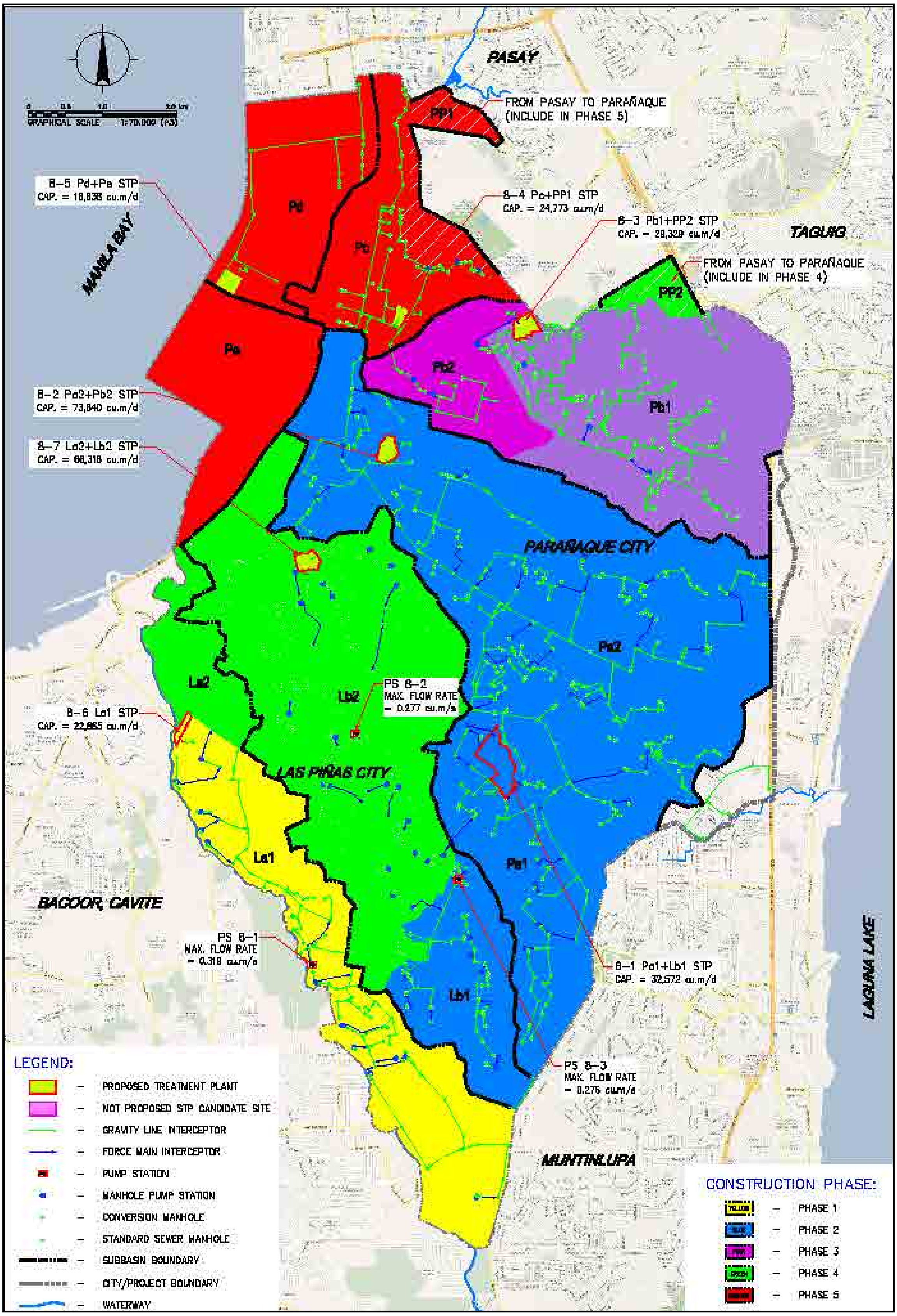
Project Study Area Map (Parañaque & Las Piñas Cities)



Project Study Area Map (Cavite City)

The Recommended Sewerage System for the Project Target Area



Executive Summary

1. Introduction

The Japan International Cooperation Agency (JICA) continues to support the Preparatory Survey for the Metro Manila Sewerage and Sanitation Improvement Project (MMSSIP) under the current Phase 2 component. The MMSSIP-Phase 1 completed in July 2009 aimed to collect information on development plans, project realization plans and support for sewerage system construction and sanitary environmental improvement in Metro Manila, and to offer recommendations geared to realizing projects for sewage treatment and drainage facilities construction, river purification and sanitary environmental system improvement based on the local needs.

Responsive to the result of MMSSIP-Phase 1, the Philippine Government expressed its interest in the implementation of a yen loan project in Metro Manila covering Paranãque City (including parts of Manila and Pasay), Las Piñas City, and five adjoining coastal towns of Cavite Province including Cavite City. Accordingly, a request was made to support the updating of the MWSS sewerage and sanitation master plan, formulation of a feasibility study on construction of a sewerage system targeting the above areas, and determination of an effective method for utilizing sludge generated in Metro Manila. This is the MSSP- Phase 2.

The MMSSIP is one of the investment projects of the MWSS and its concessionaires to expedite the provision of sewerage and sanitation services in Metro Manila, following the 2008 Supreme Court ruling that upheld earlier judicial orders to several government agencies to clean up and rehabilitate Manila Bay, the receiving body of most wastewaters generated in Metro Manila.

2. Project Area Description

The Project areas focused in this survey and feasibility study are the cities of Parañaque, Las Piñas and Cavite. However, except for the sanitation program, no sewerage is planned for Cavite City and other towns in Cavite under the MWSI service area. Sewerage development is focused in Parañaque and Las Piñas areas.

The cities of Parañaque and Las Piñas with areas of 4,657 and 3,299 hectares respectively, are located at the southern part of Metro Manila. This contiguous cities attained peak growth rates in the mid 70s, which were 10.37% and 12.28% respectively for Parañaque and Las Piñas. These growth rates have declined respectively to 2.94% and 1.07% in 2007. Census survey population in 2007 indicated population of 552,660 and 532,330 respectively for Parañaque and Las Piñas.

The west sides of both cities abut Manila Bay, with several thousand hectares of coastal land reclamation for its expanding development. The flood plains adjoining the bay were the seat of early settlements and trading due to the convenient access to the bay. The floodplains are densely populated and prone to flooding from overflows of the two rivers traversing the cities. The inland areas towards the south east have elevations of 5 to 35 meters above mean sea level.

The development of the cities are spurred by improved access provided by the Manila Bay south coastal road or R-1 Expressway, the South Luzon Expressway passing the northeast periphery of the area and major road links to these expressways.

Parañaque and Las Piñas cities are subdivided respectively into 16 and 20 barangays. A barangay represents the smallest unit of local government and is responsible for most of the government public services to the local populace. The barangay plays a significant role in project implementation particularly those concerning environment, sanitation and health. As in many cities and towns in the country, development in Parañaque and Las Piñas cities are guided by its latest Comprehensive Land Use Plans (CLUP). The CLUP provides comprehensive information on the city, its development thrust and programs, land use and zoning, infrastructures and facilities, commerce, institutions, health, security and peace, as well as addressing disasters and emergency situations. In the present study / survey, information in the CLUP was updated by site visits, data gathering and discussions with the local government and concerned agencies.

3. Sanitation Conditions in the Project Area

Parañaque and Las Piñas cities are located in the southern part of the MWSI service area, about 32 km from the Lamesa Treatment Plants, the main source of water supply. Water supply availability have been improved in the recent years with the upgrading of the Pasay Pumping station, set-up of the new Villamor Pumping Station and expansion of transmission pipe mains. Water supply deficiency from the source and delayed installation / expansion of distribution systems constrained the provision of full water supply coverage of the two cities.

Although a government survey of households in 2008 indicated access to safe drinking water as 100% and 86% respectively for Las Piñas and Parañaque cities, the supply by the MWSI estimated respectively a service-covered population of 32% and 66 % of the total population. Private systems using deepwells provide water in many residential subdivisions and commercial and institutional establishments. Private water tankers provide water to a number of households and establishments. Many households still use groundwater hand pumps, particularly those located in the floodplains and near the rivers.

Sanitation services (by septic tank desludging), but no sewerage are provided by MWSI in the two cities. In 2006, the actual coverages of sanitation service are 13% and 3% of the population respectively for Parañaque and Las Piñas, and corresponding to 2,363 and 481 septic tanks desludged. There are a number of prime residential subdivisions with installed sewerage systems, including sewage treatment plants for the recent high-rise residences and several commercial malls.

4. Water Supply Services in the Project Area

1) Service Area and Population Served

The cities of Parainãque and Las Pinãs are service areas of MWSI in south Metro Manila and 6 municipalities/city in Cavite Province including Cavite City. Being at the south-southeast periphery of the MWSI service area and the far distance from the main sources at Lamesa Treatment Plants, the area remains to be fully covered by MWSI's water distribution systems, particularly the Cavite service area.

Excerpts from 2008 MWSI Business Plan indicate information on population and percent water served for 2008, 2010 and 2020 for the 3 cities including the Cavite service area are shown in **Table 4-1** It will be noted that in 2010, water-served population in Parańaque and Cavite City have reached 100%, with Las Piňas at 62%.

Table 4-1 Water-served Population for Las Pińas, Paraňaque, Cavite Area & Cavite City

LAS PINAS CITY	2008	2010	2020	CAVITE (MWSI Service Area)	2008	2010	2020
Total Population	542,978	556,594	611,298	Total Population	1,052,380	1,109,383	1,391,697
Service Covered Population	174,831	240,036	431,963	Service Covered Population	271,183	448,646	1,181,763
Net Population Served	376,589	390,149	444,852	Net Population Served	971,307	1,028,369	1,310,684
Percent Served	46%	62%	97%	Percent Served	28%	44%	90%
Private Served Population	166,445	166,445	166,445	Private Served Population	781,197	660,737	209,934
PARANAQUE CITY	2008	2010	2020	CAVITE CITY	2008	2010	2020
Total Population	565,788	584,194	663,697	Total Population	107,968	111,507	128,211
Service Covered Population	375,016	393,423	472,926	Service Covered Population	102,543	110,302	128,211
Net Population Served	375,016	393,422	472,926	Net Population Served	107,968	111,507	128,211
Percent Served	100%	100%	100%	Percent Served	95%	98%	100%
Private Served Population	190,771	190,771	190,771	Private Served Population	5,425	1,205	0

(1) Service Connections and Metering

Households and establishments connected to the MWSI distribution system are provided with the appropriate water meters. These meters are read at scheduled days during the month and become the basis of billings to customers. As part of the water service connection, MWSI installs calibrated water meters supplied by MWSI. Owner-supplied meters are calibrated by MWSI prior to installation.

(2) Cost of Water and Water Tariff

The water billed to a customer is the volume consumed (based on the water meter reading during the billing period) and the current tariff rate approved by the MWSS Regulatory Office. In addition to the basic water charge, all customers are charged an environmental fee, and if connected to a sewerage system, an additional 20% of the basic charge. For the water tariff effective January 1, 2009, the environmental and sewerage fees are 14% and 20% of the water basic charge.

For residential consumers with 10 cum (cubic meters) or less consumption per month, the water charge is P 110.91 per connection[1]. The basic water charge ranges from P 13.55/cum for next 10 cum beyond the minimum 10 cum to P 45.12 for water consumption of up to 200 cum. Most residential connections consuming 30 to 80 cum per month are charged the average basic water charge of P 28.30/cum.

On its website, MWSI provides a calculation sheet for its customer to estimate their water bill for the billing period. For example, a residential consumer with a consumption of 30 cum is billed P 611.09 and P 697.10(inclusive of discount and tax) respectively for an unsewered and sewered connection.

(3) Proposed Improvement Programs

In 2010, MWSI allotted over P 6.6-billion for capital expenditures. About P 1.7 billion is earmark to the expansion of the water service coverage, P0.7 billion to replace old pipes in the central service area, and P 1.7 billion to modernize the distribution systems, To further reduce its non-revenue water, which is lost to pilferage and leakage, MWSI is ready to spend P1.5 billion for water recovery and reallocation programs, and P0.31 billion for leak repairs alone. The rest of the 2010 budget will be used for sewerage and sanitation, water sources, water production, building and warehouse facilities, natural calamity mitigation and other projects, Maynilad noted.

[1] A 20% discount is provided for less than 10 cum per month consumption.

(4) MWSI Activities for NRW Reduction

The New Maynilad - In January 2008, Maynilad officially created the Central NRW (CNRW) Division dedicated to managing and reducing the water loss in the system. A seasoned leader in NRW management was tapped to lead the new Division.

A part of the plan was to complement this new division with more than 400 employees composed mostly of young and dedicated engineers who will be guided by international and local experts, and who will be trained using new technology. These engineers will be exposed to the latest and tested approach to spearhead and deliver the company's target NRW to 40% in 2012. The reduction from 66% to 40% in just five years is equivalent to an NRW of more than 500 MLD.

From 2008 to 2012, capital investment amounting to almost US$240 million has been allocated to implement a sustainable NRW management programmed. To date, it is considered as one of the world's largest NRW reduction initiatives.

To meet the NRW target for 2012, Maynilad must deliver an average NRW reduction of 100 MLD every year from 2008 to 2012. As only minimal investments were made in the previous years to improve the system, and even much less investment to address the technology gaps, particularly in NRW management, the need to come up with a catch up plan became more evident

The new management of Maynilad realized that this gap needs to be addressed early on. Hence, in 2009, Maynilad engaged the services of Miya, a specialist in water loss management. Maynilad partnered with Miya under a Technical Services Agreement (TSA) to provide experts in the field of NRW management and to be co-responsible in delivering the 2012 NRW targets.

5. Basic Strategy and Study Conception

1) Basic Conception of Sanitation and Sewage Treatment Systems

Metro Manila has already been developed as a megapolis with about 10 million inhabitants, which requires a big investment to cater for improving and protecting environmental conditions. Many areas in Metro Manila are massed populations and many informal settlers are serious obstruction to develop sewerage systems. Many communal sewage treatment plants instead of sanitation services could supplement the sewerage services of the areas where the septage collection and treatment systems are difficult to address the issues, because of access difficulty of the collection vehicles or far distance from the septage treatment plants and not effective or economical because of small population.

The followings are the basic conception to implement the environmental improvement projects by establishing the sanitation and sewerage service facilities.

2) Appropriate Share of the Services by Septage and Sewage Management System

The main factor of the appropriate share of the services depends on how much level of inaccessible situation by the septage collection vehicle, because the effectiveness of septic tanks kept under good maintenance, 40% to 60% reduction of BOD_5 could be expected. Thus, the septic tank effectiveness will be taken as 60% reductive pollution on BOD_5.

Before privatization of sanitation and sewerage service operation, according to the pre-feasibility conducted in 1991 before starting MSSP-2 project, the report summarized the septic tank parameters for Metro Manila as follows.

Number of septic tanks Ng (ea)	600,000
Number of accessible septic tanks Na (ea)	441,000
Average septic tank volume Vs (m3)	6
Septage production rate (l/cap/yr)	32

Desludging activity at that time, before the introduction of the new septage management system with 10-ton vacuum vehicles and septage treatment plant, was done by using an engine-driven sucking pump transported to the houses by a pick-up van..

According to the above data, inaccessible septic tank rate is 26.5% in all targeted tanks. The situation in Metro Manila would not be improved as far as septage collection circumstances, the sanitation services (desludging) should be less than 70% of service population.

3) Parameters for Sanitation and Sewerage Projects

Septage Production Rate - According to the 1991 FS Report, the septage production rate in Metro Manila is 32 l/cap.yr. In actual septage pumped process, 30% of the liquid zone at the lower part of the tank is pumped as well. Therefore total extracted sludge rate shall be 96 l/cap/year.

Similar type of septic tanks is also used in Korea, however, because of the life style difference and 5 to 7 year interval of the extract of sludge by Maynilad, the septage generation rate shall be **100 l/cap.year**

Sewage Water Generation Rate - Taking consideration that major part of land in Las Piñas and Parañaque is residential area, and the increase of water consumption in the future, 180 l/cap.d for wastewater generation rate shall be taken.

Sewage Water Influent Water Quality - Actual wastewater quality analysis was conducted in Parañaque and Las Piñas on January 29,2011 (dry season) by the Consultant Team. The results are shown in **Table 5-1.** Almost all analyzing results of BOD_5 are small and less than 100mg/l, but the value at 8:50 am (time for breakfast and morning work) in residential area is rather higher as 136 mg/l on BOD_5

Table 5-1 Wastewater Quality on Parañaque and Las Piñas

							Sampling Date: January 29, 2011			
Station No.	Category	Sampling Date-Time	Analyzing Items	pH	Temperature (℃)	TSS (mg/L)	BOD5(mg/L) (mg/L)	COD (mg/L) (mg/L)	Oil & Grease mg/L	Total Coliform (MPN100mL)
			DENR Standards	6.5 to 9.0	30	70	50	100	5.0	10,000
Las Piñas										
1 (WW1)	IND1 (Creek)	Jan 29-08:00am		7.60	25.0	12.0	33.0	60.0	1.6	17×10^6
2 (WW2)	RES 4 (Creek)	Jan 29-08:50am		7.90	25.0	136.0	21.5	38.2	2.0	54×10^6
3 (WW3)	Com 2 (Creek)	Jan 29-09:20am		7.90	25.0	1.0	3.0	6.0	< 0.1	23×10^6
Parañarue										
11(WW11)	RES 6 (Creek)	Jan 29-10:05am		7.50	25.0	102.0	100.0	174.0	3.0	35×10^6
12 (WW12)	COM 1 (Creek)	Jan 29-10:40am		7.60	25.0	20.0	152.0	266.0	< 0.1	35×10^6
13 (WW13)	IND 1 (Creek)	Jan 29-12:05pm		7.30	25.0	20.0	92.0	134.0	< 0.1	24×10^6

Note: Red letters show over values than DENR standards

4) Design Conception for the Sanitation and Sewerage System Improvement –Principal constraints against development of sanitation and sewerage projects in the project target areas are identified as follows:

- difficulty to procure land for facility construction,
- many congestion areas scattering in the Metro Manila to obstruct accessing to households,
- difficulty for installation of new sewer lines with political and economical problems,
- lots of garbage trashing in the waterways,
- lots of informal settlements occupying waterways,
- big traffic in the cities which would deny the traffic limitation while construction,
- low perception of the residents for improving their environmental conditions, etc.

In order to address these constrains the following policy will be taken:

- As much as existing creeks, esteros, drainage culverts or canals shall be used as combined sewer collection lines,
- Many communal plants of compact type and underground construction would be planned to address difficult connections in congestion areas, to a central sewage treatment plants
- Renovate or upgrade of existing drainage systems,
- Encourage and urge septage management system by expanding together with newly establishing septage treatment plants and increase of the collection vehicles up to sewerage system put in service.

5) Combined Sewer System Application

Collected sewage water is conveyed into the sewage treatment plant (STP) and treated water in the plant is discharged into the water receiving bodies such as rivers, creeks, etc after dully treated through the treatment process.

Figure 5-1 shows the conception of the sewerage management system with combined interceptors by using the existing wastewater drainage systems. In case that separation sewage collection system is adopted in future, sewage water (grey water) shall be separated from rain water at households, and separated grey water shall be collected by additional sewer lines installed along side of the street drainage and the pipes to be connected to conversion manholes.

Treatment plant in sub-basin should better be located at the lowest level of ground, however, there is no choice to construct the treatment plant but in the vacant and available land area. In the case that the STP is not located in the lowest level of the sub-basin ground area, it would be happened that the gravity flow of the sewage water to STP is difficult, and a manhole-pump system would be required in such sewer flow lines. Inspection and maintenance manhole is basically installed every 60 meters in the straight line or at the curving point. In future, it is preferable to divert this combined sewer system to the separate sewer system. The modification would not require any change of the first stage facilities, and separate sewer collections only shall be installed to connect to the conversion manholes.

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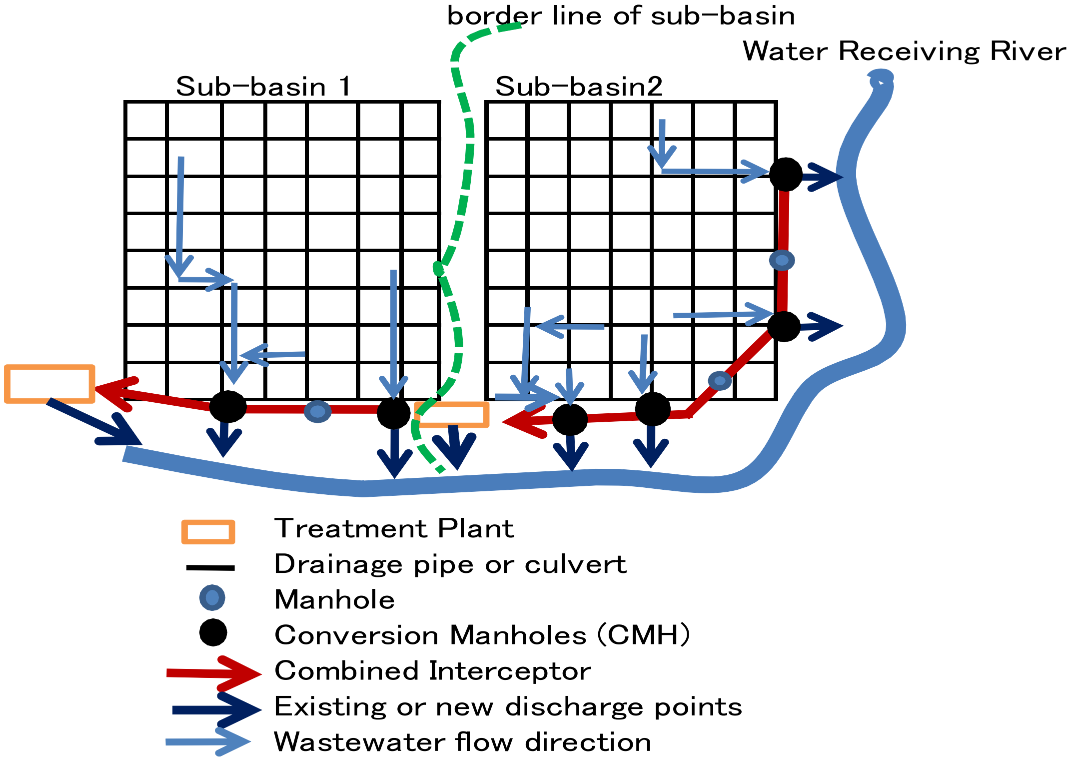


Figure 5-1 Conception of Sewerage Management System with Combined Interceptors

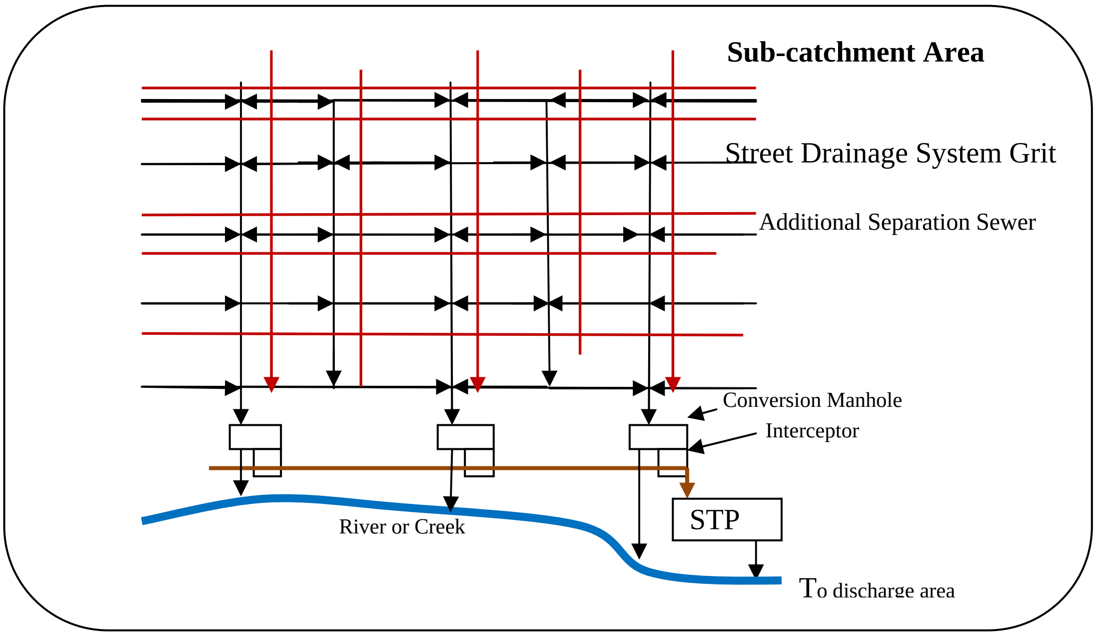


Figure 5-2 Diversion from Combined to Separation Sewerage System

6) Substantial Methodology of the Combined Sewerage System

The sewerage treatment system will consist of sewage conversion manholes, interceptors, manhole pumps or pumping stations and sewage treatment plants (refer **Figure 5-2**). The existing wastewater drainage system would be basically used as sewage collection sewers, and if not available, additional collection sewer lines would be additionally constructed.

Where the creek is used as a collection sewer of sewage water, diversion manhole or box is installed at the cross point of the creek and the road. In most cases, this point is lowest ground level; therefore, the pipe interceptor flow is enforced by boost-up manhole pump. **Figure 5-3**shows Boost up or Lift up Manhole Pump (MHP).

Wastewater conversion to take sewage water is done by installing the diversion weir at the point of collecting sewage water from the wastewater drainage lines. The weir is set in the drainage to divert the water flow into the combined interceptor to convey the sewage water to the sewage treatment plant.

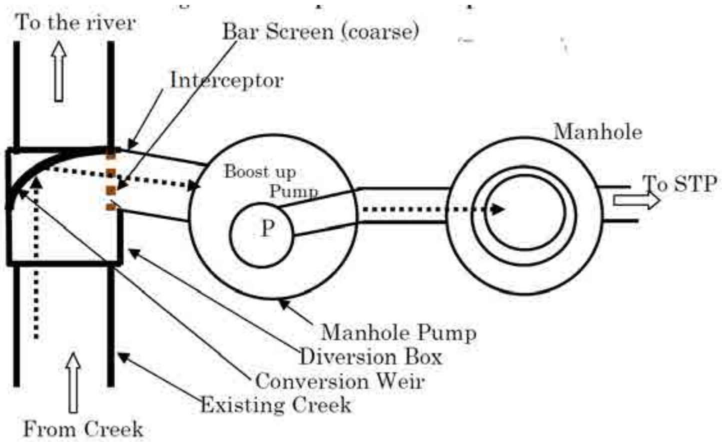


Figure 5-3 Lift up Manhole Pump

7) Manhole Pump and Intermittent Pumping Station

The sewage treatment plant is preferably located at the lowest level of the ground, and sewage water is ideally conveyed through the interceptor by gravity flow, however, it is not always realized because of geographical terrain. In that case, manhole pump station or intermittent pumping station is installed along the way of interceptor to lift up or pressurizing the sewage water. Manhole pump station is used to lift up the sewage water to avoid the deep interceptor excavation and intermittent pump station is used to convey large volume of sewage water to the final STP location.

8) Sewage Treatment and Management System

Sewage water collected in the catchment area shall be conveyed to sewage treatment plant to be treated. Several sewage treatment plants would be constructed at appropriate areas even though a few big size central treatment systems are ideal. Sewage treatment and management system with combined sewer collecting system is the same as separate sewer collecting system.

The effluent water quality from sewage treatment process shall conform to DENR standards; therefore treatment process will be limited in order that the technical functioning may cater for the standard water qualities.

The sewerage system to be established will accept general wastewater, grey water, thus biological process would be adopted. In that case, sewage sludge control generated in the biological process is very important. Sewage sludge is on the other hand to be used for energy resources and provision shall be made to reduce environmental impact to the greenhouse effect in the process of the sludge degradation.

6. Available Sewerage and Sanitation Technology

1) Range of Applicable Sanitation Technologies

The treatment methods that can be applied in the Project are, in terms of communal treatment, ① Sewage systems, ⑥ Community plants and ⑦Communal septic tanks. However, because the design area is so large, the number of treatment plants required in cases ⑥ and ⑦ would be many, and this would be unrealistic in terms of site and maintenance, etc. Moreover, options ②, ③, ④ and ⑤ could not be applied because the pollutant removal effect for treatment plants is too limited; moreover, there is a risk that small bore sewers would become blocked with garbage.

In terms of individual treatment, options ①, ③, ④ and ⑥ are applicable treatment methods. However, since ④ entails contamination of groundwater, its scope of application is limited depending on the groundwater level. Option ② cannot be applied because routine maintenance is left to individuals and this involves too much uncertainty. Option ⑤ is a treatment method for night soil only, however, since miscellaneous wastewater (eating utensil washing, washing wastewater, bath wastewater, etc.) is discharged untreated into the public water body, it is inappropriate as a measure for preventing water pollution. The joint treatment septic tanks in option ⑥ treat both night soil and miscellaneous wastewater, treatment capacity ranges from small-scale (five-person tanks) to large-scale (5,000 people), and this method is the best in terms of prevention of contamination of the public water body. However, because small-scale tanks cost 700,000 yen (350,000 pesos) to install, they are cost prohibitive.

2) Suggested Wastewater Treatment Options

Off-site treatment is the treatment of wastewater that has been conveyed using a sewerage system. Though the system requires installing long sewer lines, it is still easy to maintain the system and to keep the intended treatment level, and in many cases it incurs cheaper cost in total including capital and maintenance cost for big population service areas. However, generally it requires a big initial cost for introduction. There are several system options which would satisfy the budgetary and/or sustainable cost limitations.

(1) Activated Sludge Process - The activated sludge process requires primary settler, aeration tank and secondary settler. The primary and secondary settlers are used for sedimentation of solids contained in the influent and sludge flocs contained in the aerated sewage. The term "Activated Sludge" refers to sludge in the aeration tank of an activated sludge treatment process with aeration. It consists of flocs of bacteria, which consume the biodegradable organic substances in the wastewater. Because of its usefulness in removing organic substances from wastewater, the sludge is kept in the process by separating it from the treated wastewater and recycling it.

Generally this process is divided into three versions as follows which are considered for application for the sewerage project.

a) Conventional Activated Sludge Process

The conventional activated sludge process entails numerous control factors such as MLSS concentration and air flow, etc. and there is a high degree of operating freedom, which makes it possible to respond to fluctuations in influent quality, although sophisticated operating technology is needed. **Figure 6-1** shows the flow of the conventional activated sludge process. Influent into the reaction tank enters the tank with return sludge, the two are mixed and aeration is carried out for a certain length of time. After that, the activated sludge liquid mixture flows into the final sedimentation tank, where solids-liquid separation into supernatant liquor and settled activated sludge takes place. Supernatant in the final sedimentation tank overflows from the tank as treated effluent, while the settled sludge is returned to the reaction tank, where it is once again used in biological treatment.

The aeration term is about 8 hours and bulk aeration blowing is required, but this process is advantageous in terms of the space required for installation.

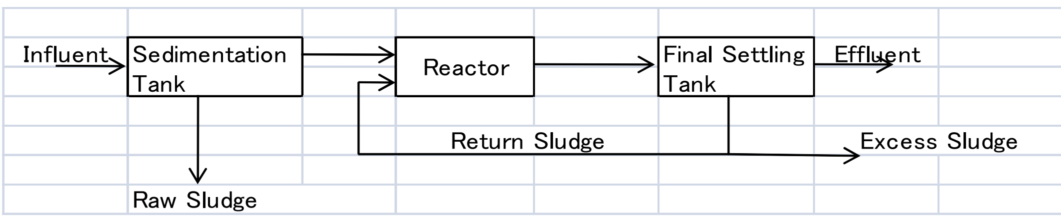


Figure 6-1 Flow of the Conventional Activated Sludge Process

b) Sequencing Batch Reactor Process

The sequencing batch reactor (SBR) process entails flowing sewage into a single reaction tank and repeatedly implementing aeration, sedimentation and supernatant liquor removal. It thus entails combining the conventional functions of the reaction tank and final sedimentation tank into one batch tank. Retention time in the reaction tank is 24 hours. The treatment process flow is illustrated in **Figure 6-2**, **Figure 6-3**.

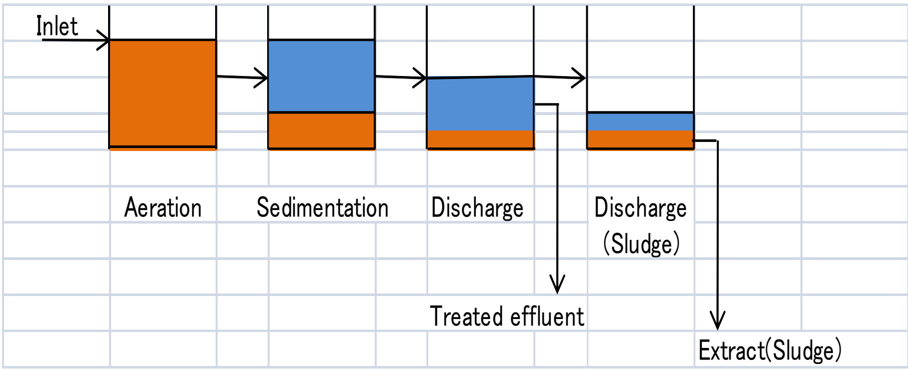


Figure 6-2 Treatment Process Flow of the Sequencing Batch Reactor

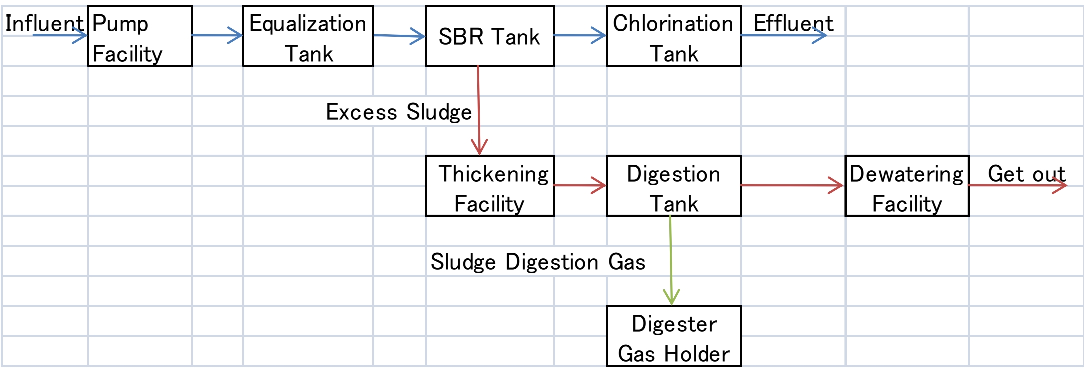


Figure 6-3 Flow sheet of the Sequencing Batch Reactor Process

c) Oxidation Ditch Process

In this method, there is no primary sedimentation tank but a shallow endless channel fitted with a mechanical aeration unit is used as the reaction tank, in which low-load activated sludge treatment is carried out, and solids-liquid separation is then conducted in the final sedimentation tank. Retention time in the reaction tank is 24 hours. The process is illustrated in **Figure 6-4.**

a) Oval type b) Horseshoe type

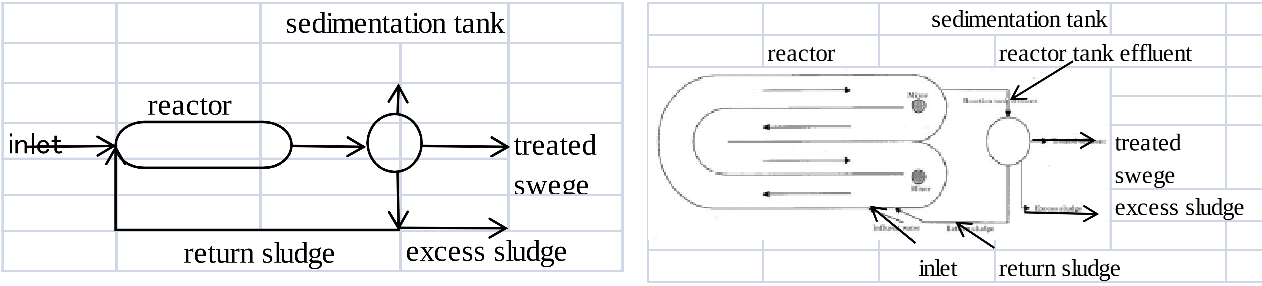


Figure 6-4 Flow of the Oxidation Ditch Method

d) Moving Bed Biofilm Reactor System (MBBR)

The moving bed biofilm system, which requires a small installation area and cheap costs, will be adopted according to the site area. The installation area is 1/3 that of the conventional fixed bed contact aeration process.

In the moving bed biofilm system, through releasing carrier microorganisms into the aeration tank, effective microorganisms are fixed inside the aeration tank in order to enhance the decomposition performance of the organic content.

Moreover, since the fluid carriers with internal fins used in this equipment have a unit surface area of 300 m2/m3, which is at least five times higher than that in the fixed bed, the reaction speed has been dramatically improved.

Moreover, in the case of the moving bed biofilm system, since carriers flow around the aeration tank, the resulting sludge floc is light and small, meaning that sedimentation does not result in adequate separation. As a result, since fine sludge flows out, the carrier filtration process is adopted in order to conduct the final treatment (liquid solids separation) of the sludge and water mix that flows out from the carrier flow tank. The SS performance enabled by filtration is 17 mg/l or less (50 mg/l in the case of a sedimentation tank). Moreover, since backwashing, etc. in the filtration tank is conducted fully automatically based on interlinked operation of a timer, solenoid valve and water level gauge, maintenance is easy.

e) Membrane Process(MBR)

The membrane bioreactor process (MBR), which requires the smallest installation area out of the treatment methods, will be adopted according to the site area.

In the MBR process, a permeable membrane unit is directly immersed in the aeration tank, and suction is carried out in order to separate solids and liquid inside the tank.

Since there is no sedimentation tank, as in the conventional approach, there is no outflow of sludge; moreover, because the perforations of the permeable membrane are microscopically small at 0.4 microns, suspended solids (SS) are reduced to below the measurement threshold and the passage of coli bacteria is prevented. In particular, since the organic flat membrane adopted in this facility is not the hollow fiber used in the conventional membrane separation method, the membrane surface can be hand-washed and maintenance is easy;

3) Suggested Wastewater Collection and Conveyance System

The project target area slopes from southeast to northwest. Zapote River runs along the boundary with Bacoor on the western tip of the district, and numerous other small creeks converge and flow into Manila Bay. Rainwater from the urban area is drained into rivers and creeks through combined sewers, and these rivers and creeks act as sewage main lines. In the case of separate sewer systems like in Japan, around 70% of the total construction cost is spent on building sanitary sewers. If a separate sewer system were adopted in the target area, since this would require massive costs for installing sanitary sewers along roads, it is necessary to select a sewage collection method that is more suited to the local conditions. **Figure 6-1**shows the types of sewage collection systems that are most commonly adopted in Southeast Asia.

Since the target area has low altitude and the downstream area is affected by the ocean, in the case where sanitary sewage is directly taken in from rivers and creeks, it would be necessary to consider the intake points. In other words, the sewage needs to be taken in at positions where the intake creek bottoms are higher than Manila Bay at high tide. If seawater infiltrates sewage, it becomes impossible to conduct proper biological treatment. **Figure 6-2** shows a schematic view of the area affected by tides. The differential between high tide and low tide in Manila Bay is small at 1.80 m at high tide and 1.33 m at low tide. High tide and low tide each occur once per day.

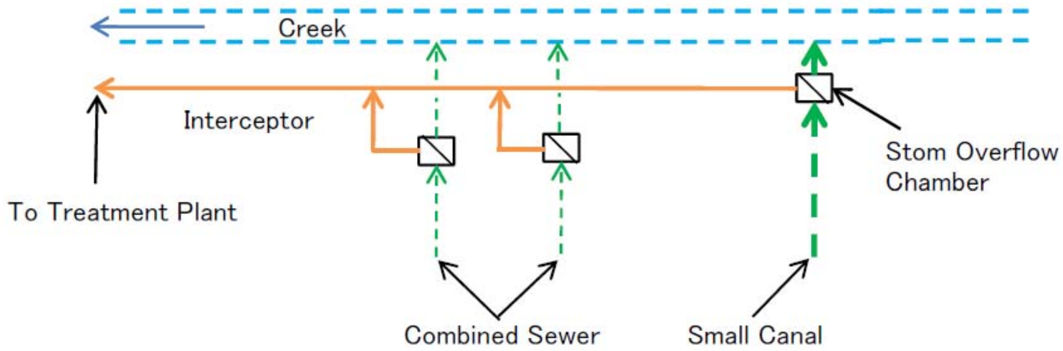


Figure 6-1 Sanitary Sewage Collection System

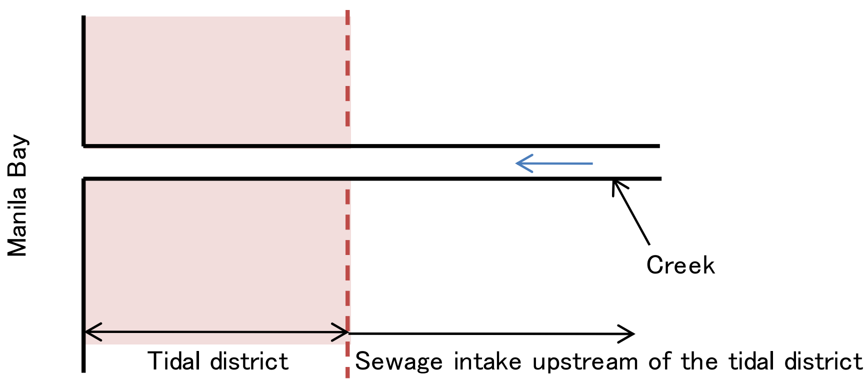


Figure 6-2 Schematic View of the Tidal District (intake method from creek)

4) Proposal of Sewage Collection System Based on Survey Results

In both Parañaque and Las Piñas, storm water and sanitary sewage are drained into creeks via common sewers and side ditches. Since adopting a separate sewer system and installing sanitary sewage sewers along roads would entail huge construction costs, it is proposed that conversion manholes for diverting sanitary sewage be installed in the sewers that lead to creeks and that the separated sanitary sewage be led to sewage treatment facilities via interceptors.

5) Available Sewerage Sludge Management Technology

(1) Sewage Sludge Treatment Process

Construction of sewage systems leads to a steady improvement in living environment and quality of water in public water bodies, etc. In line with this, as the sewage treatment volume grows, the amount of sludge generated in such treatment also increases.

Sludge is an inevitable byproduct of sewage treatment, and treating this in an efficient, stable and sustainable way is a key factor in sewage treatment. Another consideration is that it becomes increasingly difficult to secure final disposal sites as the volume of solid waste discharge grows in line with mass production and mass consumption.

Accordingly, sludge treatment facilities are installed with the objectives of reducing volume (removing water content), reducing the amount of solids, stabilizing quality and finding effective means of use.

The form of sludge generation differs according to the method of sewage treatment. **Figure 6-3** shows the form of sludge generation according to the type of sewage treatment;

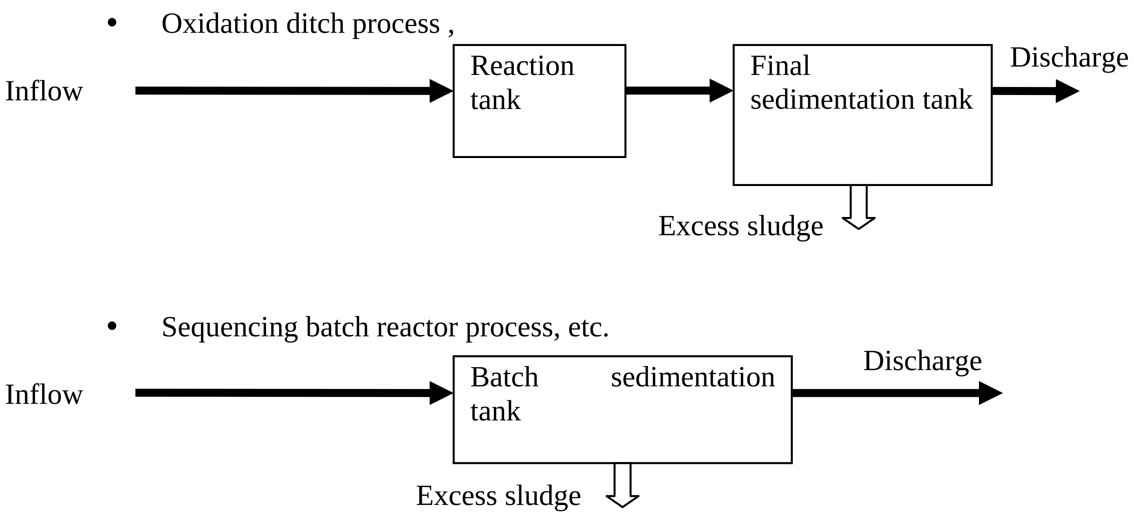


Figure 6-3 Form of Sludge Generation According to Sewage Treatment Method

(2) Form of Sludge Final Disposal

Sludge can be effectively utilized on green spaces and farmland, for energy and as construction materials, etc. On green spaces and farmland, sludge is utilized as dewatered sludge, dried sludge and compost. In the interests of improving stability and safety, it is desirable that dewatered sludge and dried sludge first undergo digestion.

Dried sludge and compost have low water content and are easy to handle. In particular, use as compost is becoming more and more frequent because of improved sanitary safety.

Concerning energy uses, sludge can be converted to a coal substitute energy through fuel conversion, while sludge-digestion gas can be used to heat sludge digestion tanks or as a fuel in power generation. From the viewpoint of building a low-carbon society, it will be necessary to vigorously advance such uses. Moreover, from the viewpoint of promoting resources and energy recycling based around local sewage treatment plants, it will be important to also accept biomass such as raw waste, etc. and combine it with sewage sludge for use as energy, etc.

Concerning uses as construction materials, dewatered sludge can be used as a raw material for cement; incineration ash can be used in cement, soil improving agent, roadbed material, lightweight aggregate, bricks, tiles, water permeable blocks, concrete aggregate and earthenware pipes, etc.; and molten slag can be used in roadbed material, concrete aggregate and water permeable blocks, etc. There are still numerous research and development issues to be overcome in order to further enhance economy and sales channels, etc. in future.

7. Fact Finding and Evaluation of Initial Site Surveys

1) Waterways and Wastewater Discharging

The project areas are located in Parañaque Basin and are divided in 7 sub-basins. Each sub-basin is configured with a principal river or creek, and the wastewater generated in the basin is discharged in to the waterway transporting into Manila Bay. Each basin is ordinarily inclines from Southeast to Northwest**. Figure 7-1** shows the project area sub-basins and incline.

Wastewater Flow - The wastewater flows in the project areas are basically directing from inland to Manila Bay coastal areas. The wastewater carried by the rivers and creeks are finally discharged into Manila Bay through mainly three channel and rivers (refer **Figure 7-2).**

Wastewater Outfall Locations - The rivers and creeks of Parañaque and Las Piñas have a lot of rivers and creeks: there are 195 in Parañaque and 243 in Las Piñas. Many of the outfalls are sewers that combine sanitary sewage and storm water drainage functions, and they flow into creeks.

The wastewater in the project areas are collected, conveyed and discharged into receiving bodies through street drainage lines. The outfalls area located alongside the waterways, such as rivers, creeks, esteros, etc. A total of 294 (173 in Parañaque, 121 in Las Piñas) outfalls were identified by the Consultant Team site surveys.

Tidal Situations - The base height of the rivers or creeks in the project areas are generally low compared with Manila Bay surface seawater level. Therefore the seawater is flowing upstream into the rivers and the tributaries during high tide. Tidal data in 2007 indicated a maximum height of 1.52 m in June 2007, and average was 0.41 to 0.64 m. A tidal elevation of 1.5 m is adopted and equivalent to a 1:100 year storm.

Current Water Quality Conditions – DENR regulations regarding surface waters and discharging waters into the receiving bodies stipulate Water Quality Standards by Administrative Order Nos. 34 and 35. This administrative order classifies water bodies and this classification is very important components of water quality management since the application of effluent standards are dependent on this classification. This administrative order classifies water bodies into five (5) classes, i.e. AA, A, A, C for inland fresh waters and four (4) classes for marine and coastal water, i.e. SA, SB, SC and SD.

According to the standards, class C of fresh surface water would be categorized for Parañaque and Las Piñas, and discharging water quality level in the project areas would be 50mg/l or less on the base of BOD_5.

For the present study, surface water sampling and tests were conducted at 19 stations ns in the Paranaque and Las Pinas river basins as shown in **Figure 7-8**. The results are presented in several tables in Section 7.

Figure 7-1 Project area sub-basins and incline

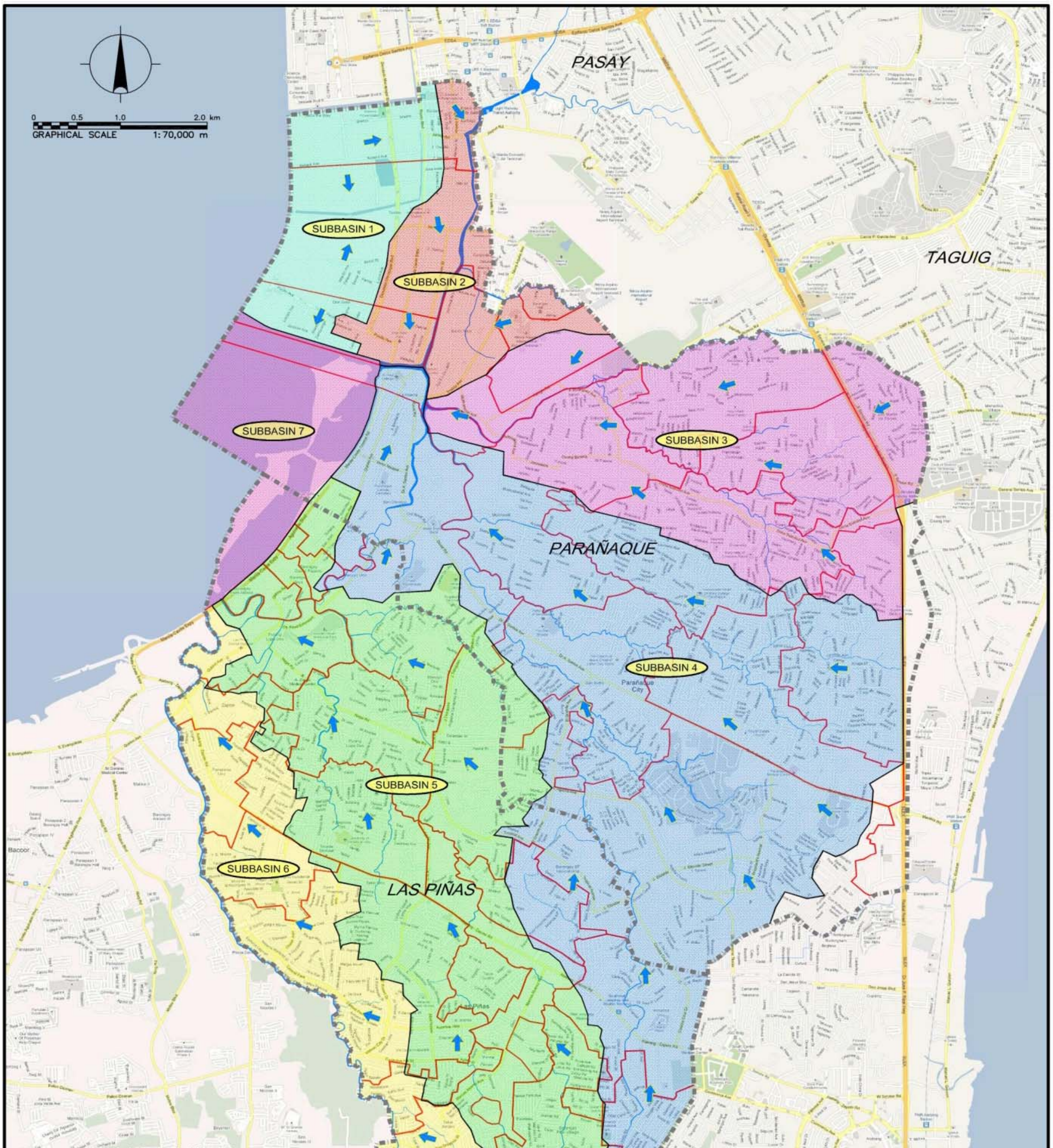


Figure 7-2 Waterways in Parañaque and Las Piñas Cities

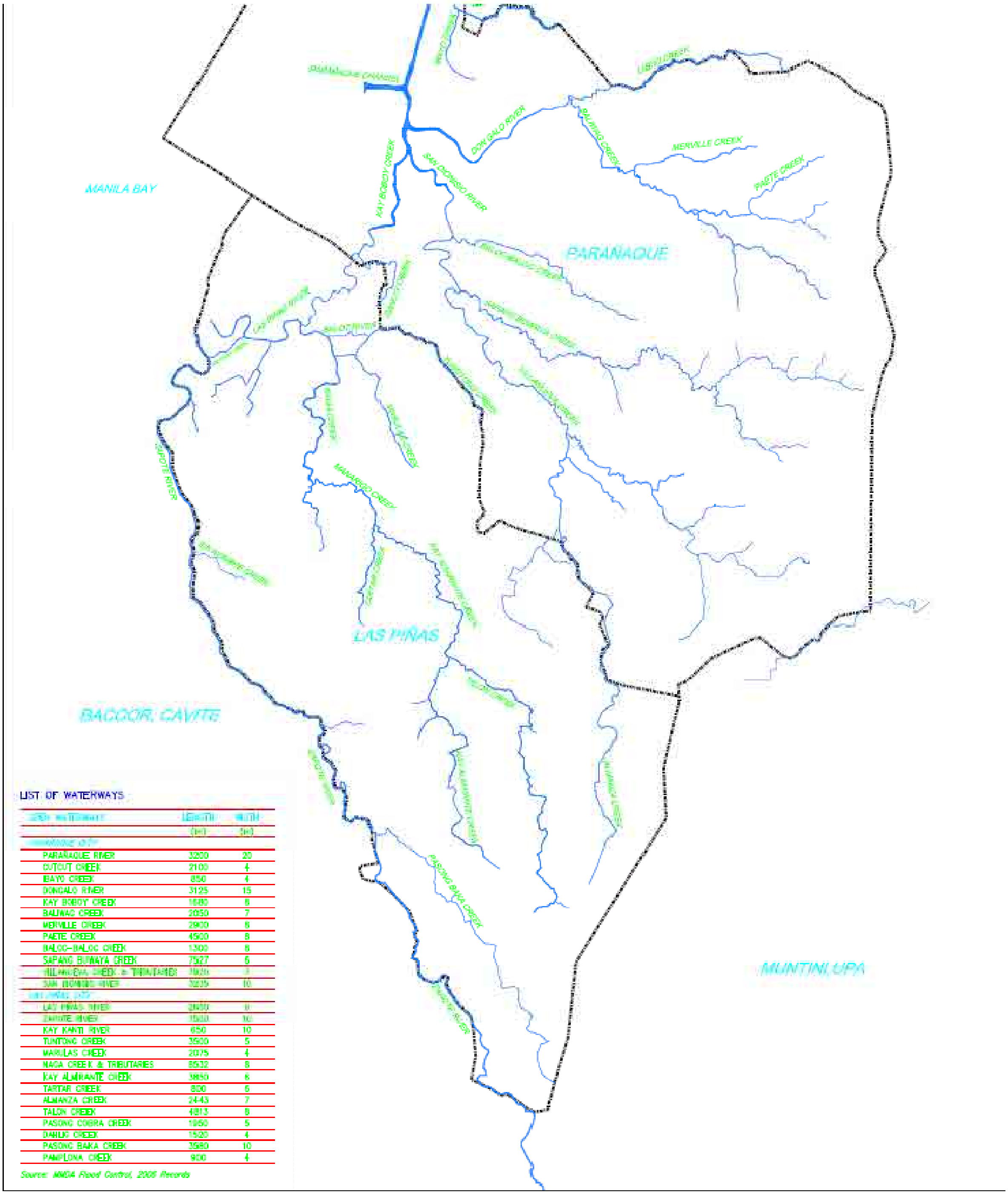
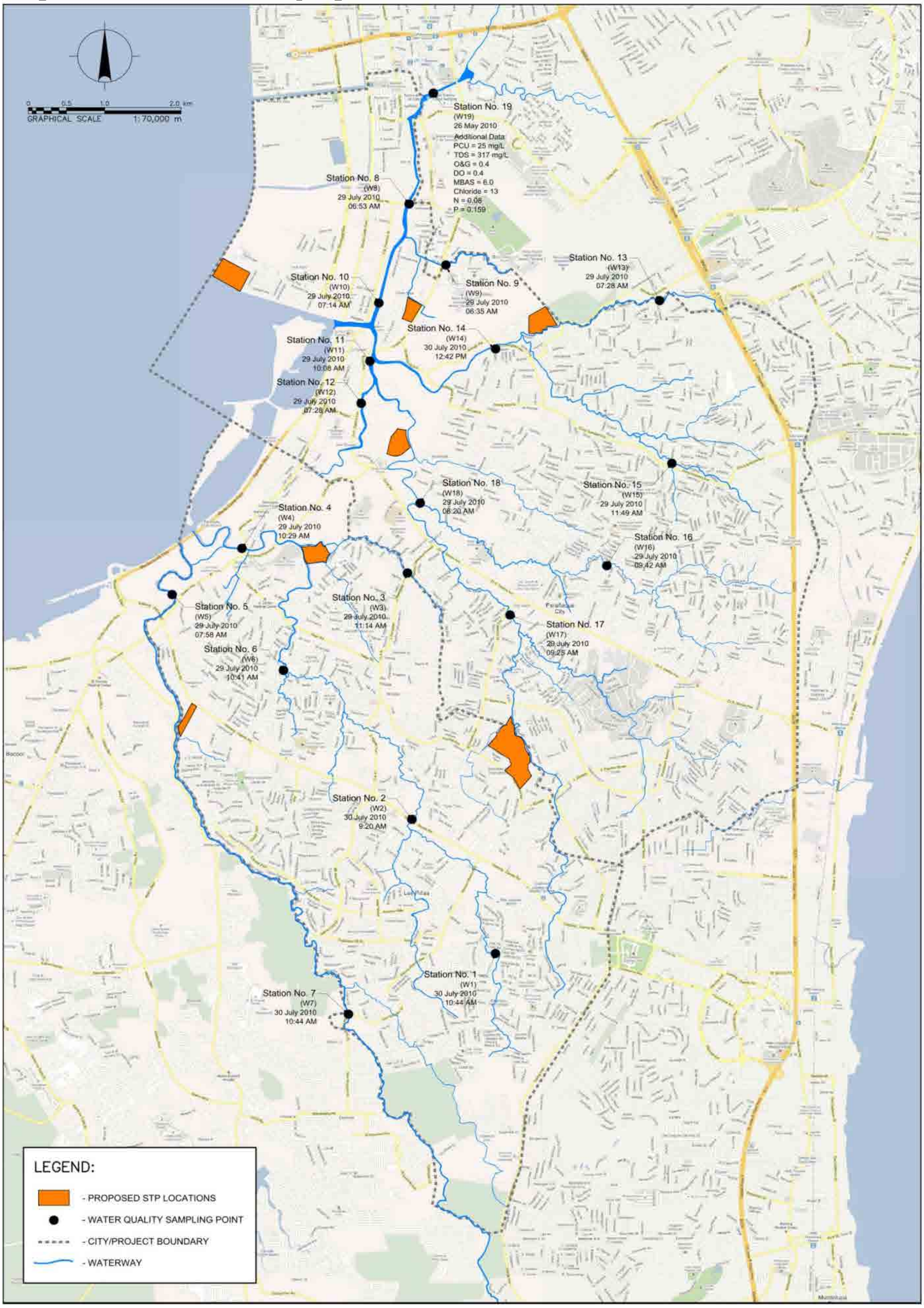


Figure 7-3 Surface water sampling stations



2) Sub-basins and Sewage Flow Rate

Parañaque and Las Piñas are broadly divided into seven sub basins and 57 sub-sub basins. The largest sub-basins are Sub basin 4 (San Dionosio River), followed by Las Piñas Central, and next Sub basin 3 (Don Galo River). The combined population of Parañaque and Las Piñas in 2036 will be 1,393,608, of which approximately 90 percent will reside in Sub basins 3~6. The total sewage flow in both cities will be 250,849 m^3/d.

Sewerage treatment system shall be taken consideration the boundaries of sub or sub-sub basins when the interceptor line plans and selection of STP locations are designed.. The borders of the tub basins and sub-sub basins are shown in **Figure 7-4**.

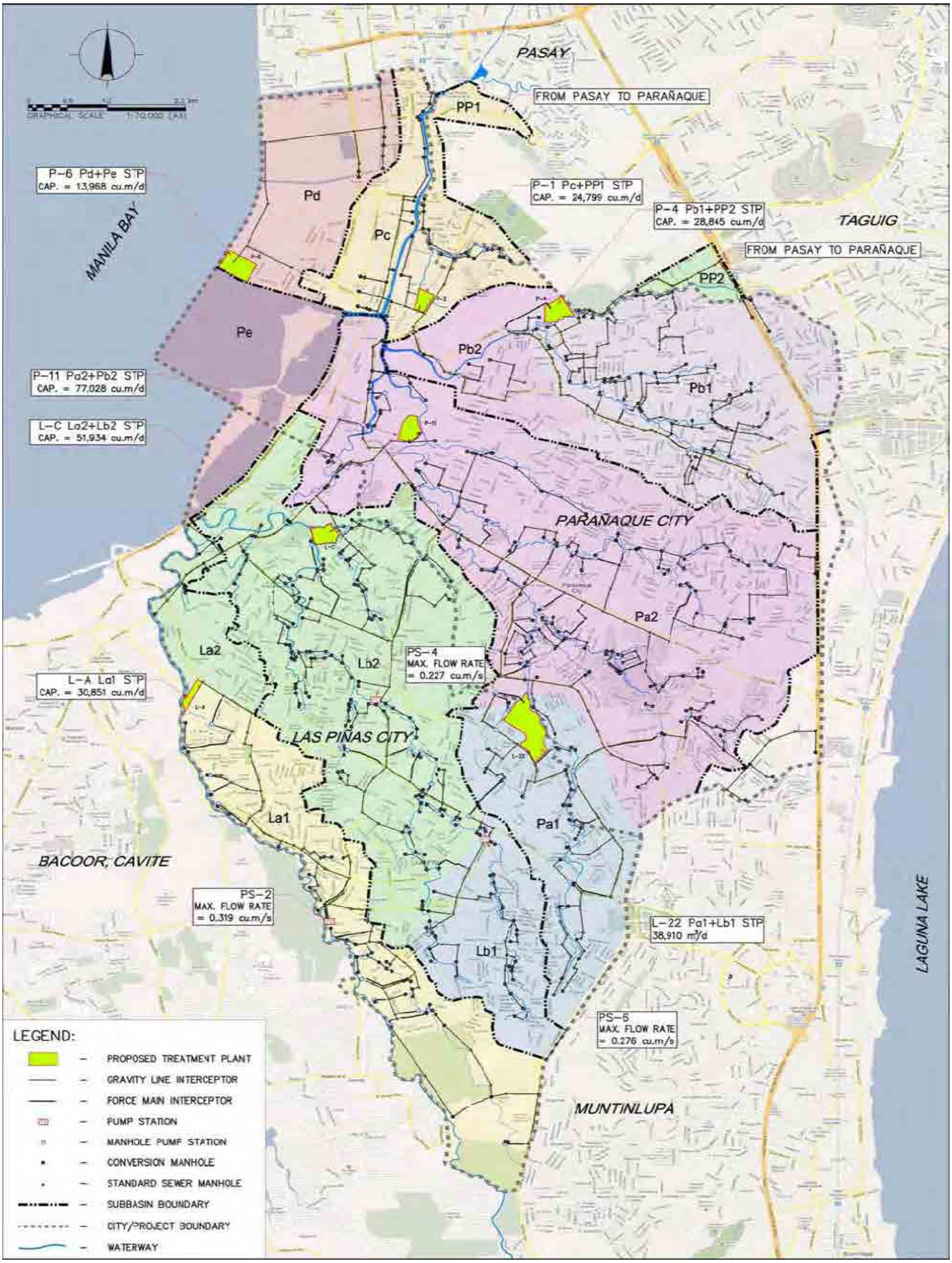
Sub Basins and Sub-sub Basins - Borderlines of the sub basins and the sub-sub basins are not always fallen in line with Barangay border lines. Sewage water collection shall basically be by gravity flow to avoid large cost of sewer installation cost, thus water collection shall be made in each sub-sub basin.

Population in Each Sub Basins - Because of border line difference of Barangay border lines and sub-sub basin borders, the water flow rate of each sub-sub basin shall be calculated from the population of the sub-sub basin. **Table 7-1** shows population on each sub-sub basin. Basically to say, this sub-sub basin unit population shall be used for the interceptor and conversion manhole sizes.

Table 7-1 Parañaque and Las Pinas sub-basins and population in 2036

Basin Area	2036		Note
	Area(ha)	Population	(Sub-Sub-Basin)
SB1	248.71	92,435	SB1-1
SB2	348.51	78,720	SB2-1～SB2-3
SB3	1,195.00	165,836	SB3-1～SB3-8
SB4	2,979.45	487,507	SB4-1～SB4-26
SB5	1,869.16	395,769	SB5-1～SB5-15
SB6	972.92	173,341	SB6-1～SB6-3
SB7	0.00	0	SB7-1
Sub Total	7,734.01	1,393,608	
Pasay	201.78	86,022	PP-1, PP-2
Total	7,935.79	1,479,630	

Figure 8-1 Layout of Case8, the Recommended Sewerage System



3) Recommendation of Implementation Plan of Sewerage System Project Components

(1) Project Description

The Project can broadly be divided into sewer facilities and treatment facilities, and the sewer facilities include conversion manholes, interceptors, manhole pumps and pump stations.

a) Storm Overflow Chambers and Interceptor

The storm overflow chambers, which separate storm water and sanitary sewage from the existing outfall sewers, will be installed near the outfalls from the existing sewers to the creeks. The separated sanitary sewage will be diverted to the downstream treatment facilities by interceptor sewers.

b) Manhole Pump Stations

This district has a grade difference of approximately 2~3 m with the route taken by creeks and interceptor sewers, and since sewers can be buried to a shallow depth and construction cost can be reduced, manhole pumps will be installed as integrated structures with the storm overflow chambers installed near the sanitary sewage outfalls. Manhole pumps, which are simple structures comprising pumps installed in manholes, will be installed in 84 locations.

c) Pump Stations

Since pump stations will be based on gravity flow, meaning that excavation depths will become deep depending on the terrain. pump stations will be installed in appropriate locations. Pump stations will be constructed in three locations.

d) Treatment Plants

The sanitary sewage collected by the interceptors will be treated by the OD process and SBR process, which are cheap and easy to maintain, and the treated sewage will be discharged via creeks and rivers into Manila Bay. The sludge treatment facilities will be consolidated into one place.

The sludge generated in each treatment plant will be thickened in sludge thickening tanks and transported by vacuum truck to the P-11 plant in Parañaque, where it will undergo intensive treatment and will be finally disposed as dry cake. The sludge treatment facilities will be consolidated into one place.

4) Land Acquisition Plan

(1) Proposed Candidate Sites for the Plants

As described above, the project components basically consist of sewage treatment plants with sewage sludge treatment process, pumping stations, and sewer collection system including manhole pumps. The sewer collection facilities will be installed underground of roads or streets running near waterways (creeks, rivers, and esteros), however sewage treatment plants and pumping stations require plant installation sites, thus, necessary land acquisition plan should be made.

(2) Candidate Sites and Land Owners

The candidate lands have been invested in the project sites to comply with technical requirements, that is, sufficient area space to accommodate necessary facilities, locations to be at downstream of waterways or as nearer the positions as possible to apply more gravity collection sewer systems, vacant and possible to be sold.

The candidate sites to be selected are shown in appendix 1.

The land procurement costs are calculated with Candidate site information that was collected by the survey team. **Table 8-5** shows the working process for the team to collect the candidate sites' information. **Table 8-6** shows the information list of candidate sites, showing the land owners, address, tax declaration values, etc.

Table 8-5 Sequence in the Identification & Data/Documents of the Proposed STP Sites

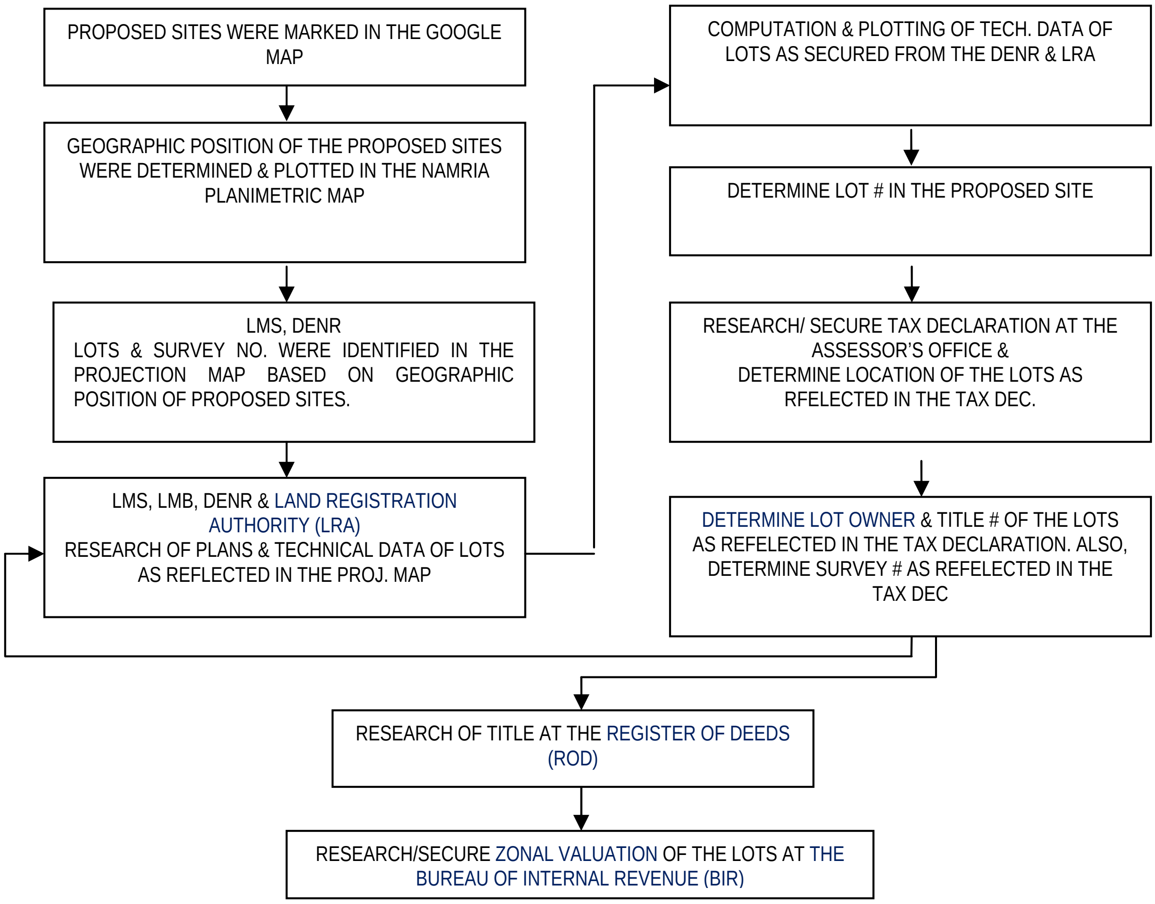


Table 8-6 Candidate Sites' Information (Parañaque and Las Piñas)

SITE	LOCATION	PLAN & SURVEY NUMBER	TAX DECLARATION	TCT NO.	OWNER	MARKET VALUE PER TAX DEC. (IN PESOS/SQ.M.)	ZONAL VALUE	REMARKS
P-1	DONGALO, PARAÑAQUE CITY	Csd-00-1001398, AP-18882, Psd-00-067485, Psu-120184 (Amd.) Psu-162338 (Amd.), Ap-10380, Pcs-351, Psu-165119, Ap-16717 Psu-165119, (LRC) Psd-43815 Ap-9969	E-013-05325 E-013-05326 E-103-05327	175795 175798 175789	LOMBOS, ESTELLA P ET AL	200.00 200.00 200.00	4,500.00 4,500.00 4,500.00	
P-2	Brgy. Ibayo, Parañaque City	Psu-100709 (Lot 3314) Pcs-04-000391 SK-00-000633 Psu-120185 (Lot 3012) Psu-53000 (Lot 3130, 3124, 3123) (LRC) Pcs-1206 (LRC) Psd-115961			Francisca Bautista, et.al.	30,000.00	50,000.00	Tax Dec. for release @ Parañaque Assessor's Office
P-3	LA HUERTA, PARAÑAQUE CITY	Pcs-00-008650, (LRC) Pcs-28052	E-008-18891	155928	GLOBAL EQUITIES INC.	700.00	12,000.00	
P-4	IBAYO, PARAÑAQUE CITY	Psu-123840, Ap-04-000157, Ap-9157, Ap-9137, (LRC) Psd-197642,Pcs-00-008994, Pcs-00-010272, Psd-00-071193 Psu-110176, Pcs-13-000199, Psu-173068-D			NAIA Property (Civil Aeronautics Administration)		4,500.00	Research of Tax Declaration is still on-going
p-6	PARAÑAQUE CITY	Pcs-13-002177, REL-00-000016	E-004-03326 E-004-03766 E-004-03767	173511 177677 177674	LNC (SPV-AMC) CORPORATION, OPAL PORTFOLIO INVESTMENTS (SPV-AMC) INC.,	4,000.00 4,000.00	40,000.00 40,000.00	

			E-004-04143 E-004-03106	181203 168946	MANILA BAY BLUEWATER DEVELOPMENT, CORPORATION LEGACY VENTURES REALTY AND DEVELOPMENT INC.	4,000.00 4,000.00	40,000.00 40,000.00		
P-11	Brgy. La Huerta & San Dionisio, Parañaque City	Psu-142316 Lots 4186, 4306, 4307, 2831 (Case-3) Pcs-13-001647 Pcs-00-008964 Rel-00-000860 Lots 4977, 4976, 4978, 4168 Lots 4076, 4079, 5082, 4167 (LRC) Psd-314787			Francisco Felipe Gonzales	1,000.00	7,500.00	Tax Dec. for release @ Parañaque Assessor's Office
P-12	SAN DIONISIO, PARAÑAQUE CITY	Psu-142101, Ap-20752, Psu-14836, Psu-14236, Psd-00-056398 Cad. Lot 4165, 4166, Parañaque Cad. Case 4	E-008-06688 E-008-14425 E-008-06689	OCT 240 OCT 312	PASCUAL ET AL. LEONARDO VELARDE, MARIANO Z. RODROGUEZ, CARMEN S.	840.00 400.00 840.00	7,000.00 7,000.00 7,000.00	
L-A	PAMPLONA UNO, LAS PIÑAS CITY	A-3-B-4-B, PSD-29031	E-009-05924	T-111103	VAA BUILDERS CORP.	5,000.00	25,400.00	
L-C	MANUYO UNO, LAS PIÑAS CITY	PSU-43709, PSU-13777, BLK. 6	E-004-01759 E-001-02575	T-78061, 233865	ADELFA PROPERTIES, INC., ADELA & MAXIMA FERRER	200.00, 800.00	2,500.00	Two or more Adjoining lots.. Tqx Dec. sampling only.., Number of included lots to be determined later after securing the title & plotting of

								plans
L-6	PULANG LUPA UNO, LAS PIÑAS	PSU-200768	E-005-00571	T-6720	GOLDEN HAVEN MOEMORIAL PARK	1,500.00	3,100.00	
L-22	BF INT'L, LAS PIÑAS CITY	3-B, PSD-007601-025955-D, 1-D-2, PSD-007601-028242-D	E-018-03735 E-012-05250 E-001-08371 E-001-26791 E-001-26790 E-001-26789 E-001-27652 E-001-28205 E-001-28204 E-001-27654	T-39110, T-64050 144512 144511 144513 147545 S-33640 S-33640	HOME INSURANCE & GUARANTY CORP. AGUIRRE, TOMAS B. LAND BANK OF THE PHILIPPINES LUCAS, RUFINO S. & DEBBIE N SPS BF HOMES INC SAULER, AMANDO R.	1,500.00, 1,500.00 1,000.00 700.00 700.00 700.00 1,000.00 1,000.00 1,000.00 4,028.190	2,600.00	Two or more Adjoining lots.. Tqx Dec. sampling only.., Number of included lots to be determined later after securing the title & plotting of plans
PS-1	LA HUERTA, PARAÑAQUE CITY	Pcs-00-007786	E-013-04945 E-013-04946	80041	CORNEJO, LAURA H. HERNANDEZ, CELESTINO, et al	1,000.00 1,000.00	7,500.00 7,500.00	
PS-2	TALON DOS, LAS PIÑAS CITY	LOT 21, BLK. 7, PSD-04-003785, LOT 10, BLK. 43, PCS-14212	E-014-27515 E-017-08755	T-108773, T-108472	NAVARETTE, JUANITO B.	1,500.00, 1,300.00	2,500.00	Two or more Adjoining lots.. Tqx Dec. sampling only.., Number of included lots to be determined later after securing the title & plotting of

								plans
PS-3	TALON CINCO, LAS PIÑAS CITY	LOT 7 & 12, BLK. 4, PCS-1664	E-017-07306, E-017-12269	T-11507, 101213	MANUELA CORPORATION	800.00, 800.00	2,100.00	
PS-6	TALON CINCO, LAS PIÑAS CITY	1-B-2-A-1, PSD-00-074670	E-017-19841	T-110087	DIVERSIFIED HOLDINS, INC.	2,000.00	2,400.00	
PS-4	PULANG LUPA DOS, LAS PIÑAS, CITY	1-B, PSD-287465	E-008-05039	T-37921	PASCUAL, ALFREDO, ET AL	1,500.00	2,600.00	

(3) Recommended Candidate Site Information

Sewerage system alternative case 8 is recommended through the selection process described in former sections. The lands information of sewerage treatment system plants and pumping stations is reviewed hereunder (**Table 8-7**).

Table 8-7 Candidate Site Information

Plant	Area 1,000M^3	Owner	Tax Dec. Value Peso/M^3	Condition
P-2	42	Francisca Bautista, et.al.	30,000	Vacant
P-4	88	NAIA Property (Civil Aeronautics Administration)	4,500	Do
P-6	132	LNC (SPV-AMC) Corporation,	4,000	Do
P-11	76.2	Francisco Felipe Gonzales	1,000	Do
L-A	32.5	VAA BUILDERS Corp.	5,000	Do
L-C	70	ADELFA PROPERTIES, INC., ADELA & MAXIMA FERRER	200 800	Do
L-22	190	HOME INSURANCE & GUARANTY CORP. AGUIRRE, TOMAS B. LAND BANK OF THE PHILIPPINES LUCAS, RUFINO S. & DEBBIE N SPS BF HOMES INC, SAULER, AMANDO R.	700～4,000	Do
PS-2	0.544	NAVARETTE, JUANITO B.	1300/1500	Do
PS-4	2.040	PASCUAL, ALFREDO, ET AL	1,500	Do
PS-6	1.988	DIVERSIFIED HOLDINS, INC.	2,000	Do

(4) Land Acquisition Plan

All candidate lands are kept by private or corporation ownership. There are not any residents, houses, facilities, buildings, nor materials stored in the lands. Most of all site candidate lands are perfectly reclaimed vacant lands and well managed/protected from outsiders. The owners are just keeping the land without any future use plan at this moment and maintaining for selling (refer appendix 1, site pictures).

Thus the land acquisition could be made through ordinal business transaction to transfer officially the land owner record and registration from those owners to MWSI when they reach agreement to the price, that is, any involuntary resettlement won't be raised.

Confirmation items for land procurement are made subject to OP 4.12, the World Bank, December, 2011.

5) Breakdown of Project Cost Estimates

Table 8-8 shows construction cost in each of the seven treatment districts.

Table 8-8 Construction Cost in Each Treatment District (unit:10^{3}Pesos)

	Pa1+Lb1	Pa2+Pb2	Pb1	Pc	Pd+Pe	La1	La2+Lb2	Total
ID No	L-22	P-11	P-4	P-2	P-6	L-A	L-C	
1.STP	2,129,470	4,981,733	1,575,816	1,357,214	766,475	1,996,345	2,853,187	15,660,240
2.Pump Stations	22,006					14,647	22,006	58,659
3.Manhole Pump	33,700	57,600	5,700	5,500		29,400	40,600	172,500
4.Force Main Pipe	37,906	93,061	5,026	2,457		83,475	55,204	277,129
5.Interceptor(Gravity)	481,210	996,216	511,072	284,464	159,484	457,998	740,412	3,630,856
6.Conversion Manhole	21,350	43,708	15,520	10,457	1,183	15,442	44,979	152,639
Sub Total	**2,725,642**	**6,172,318**	**2,113,134**	**1,660,092**	**927,142**	**2,597,307**	**3,756,388**	**19,952,023**
7.Land Procurement(STP)	190,000	76,200	396,000	1,260,000	528,000	162,500	35,000	2,647,700
8.Land Procurement(PS)	398					756	3,060	4,214
Sub Total	**190,398**	**76,200**	**396,000**	**1,260,000**	**528,000**	**163,256**	**38,060**	**2,651,914**
Total	**2,916,040**	**6,248,518**	**2,509,134**	**2,920,092**	**1,455,142**	**2,760,563**	**3,794,448**	**22,603,937**

6) Project Scope

(1) Project Scope

① Design treatment area Parañaque: 4,544.01 ha, Las Piñas: 3,190.0 ha

② Design treatment population Parañaque: 740,871, Las Piñas: 652,737

③ Total treatment capacity of treatment facilities: 266,333 m^3/day

- Oxidation Ditch Process: 5 locations
- Sequential Batch Reactor: 2 locations

④Manhole Pump Station: 73 locations

⑤Pump Station: 3 locations

⑥Interceptor: 180,658 m

⑦Conversion Manhole: 545 locations

⑧Construction period ~2028

⑨Construction cost 22,604 MP (including land acquisition cost 2,652 MP)

⑩Effect Effluent discharge into Manila Bay with quality no greater than 50 mg/ℓ standard

⑪Sludge Treatment Process including sludge digesting process. Only installed in STP "P-11"

(2) Description of Project Scope

The combined population of Parañaque and Las Piñas in 2008 accounted for 12 percent of the entire population under MWSI jurisdiction. As was stated in Section 4.1.6, the combined pollutant load from both cities in 2036 will be 62.7 t/day, and this load will flow into Manila Bay if the sewerage system is not constructed. Through constructing the sewerage system, it will be possible to greatly reduce the pollutant load entering Manila Bay to 5.6 t/day, thereby enabling a major water quality preservation effect.

The benefiting population in 2036 will be 1,479,630 (including part of the population of Pasay), and **Table 8-9** shows the design scale of the seven treatment districts. It is planned to treat the sewage from this area at seven sewage treatment plants. Each plant will install sewage treatment processes and sludge thickening tanks, however, the sludge treatment system will only be constructed at the P-11 plant so that this can conduct intensive treatment of the sludge gathered from the other facilities. Moreover, digestion tanks will be incorporated into the sludge treatment system so that methane gas can be captured, global warming can be addressed and the quantity of treated sludge can be reduced.

Due to the large scale of the construction, the work will be executed over phases as described in the next section. It is planned to divide the construction works into four phases by 2036.

Table 8-9 Project Scale

ID No		L-22	P-11	P-4	P-2	P-6	L-A	L-C
1.STP	Treatment Volume (m^3/d)	38,910	77,028	28,845	24,799	13,968	30,851	51,934
	Treatment System	OD	SBR	OD	OD	OD	SBR	OD
	Quantity	1	1	1	1	1	1	1
2. Pump Station	ID No	PS-6					PS-2	PS-4
	Pump Dischage (m^3/min)	16.6					19.1	16.6
	Quantity	1					1	1
3. Manhole Pump	Power(kw)	3.7～22	1.5～22	3.7～22	3.7～15	5.5	1.5～11	1.5～11
	Quantity	15	24	2	2	0	12	18
4. Force Main Pipe	Diameter(mm)	75～400	100～500	150～500	150～400	150	75～400	75～400
	Length (m)	3,490	8	280	110	0	4,720	5,110
5. Interceptor(Gravity	Diameter(mm)	150～1350	150～1350	150～900	150～900	150～700	150～700	150～1350
	Length (m)	21,780	48,810	24,460	12,940	5,170	21,600	32,180
6. Conversion	Size(700mm)	51	106	40	28	2	37	107
	Size(1000mm)	25	50	16	10	2	18	53

7) Project Implementation plan

(1) Construction Schedule

Due to the large size of the plan, construction will be divided into four phases. Regarding the order of construction, **Table 8-10** show the phasing plan that has been determined with a view to realizing an early project effect in relation to the investment and building treatment facilities first in upstream areas so that water quality in upstream creeks can be improved through a dilution effect, thereby providing a model effect for other districts. Incidentally, the plan of treatment facilities includes both sewage water treatment and sludge treatment facilities.

Table 8-10 Construction Phasing Plan

Construction Phase	Loan Agreement	Detail Design	Tender	Construction & Procurement	Service Commence
Phase 1	2012 Mar.	Jan. -Dec. 2013	Jan.-Jun. 2014	Jul. '14 - Dec '16	Jan. 2017
Phase 2	2016 Mar.	Jan. -Dec. 2017	Jan.-Jun. 2018	Jul. '18 - Dec '20	Jan. 2021
Phase 3	2020 Mar.	Jan. -Dec. 2021	Jan.-Jun. 2022	Jul. '22 - Dec '24	Jan. 2025
Phase 4	2024 Mar.	Jan. -Dec. 2025	Jan.-Jun. 2026	Jul. '26 - Dec '28	Jan. 2029

Engagement of Consulting service contract:	Phase 1: Dec. 2012	Phase 2: Dec. 2016
	Phase 3: Dec. 2020	Phase 4: Dec. 2024

Table 8-11 Phased Construction Plan

			2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	'29, '30
1	Pledge and L/A		★✤	Phase 1		★✤		Phase 2		★✤		Phase 3		★✤		Phase 4				
2	Selection of Consultant																			
Phase 1	P-11 (SB: Pa2, Pb2)																			
	Detail Design																			
	Bid Process/Purchase an order																			
	Construction																			
		Plants																		
		Sewer Lines																		
Phase 2	L-22, L-A (SB: Pa1, Lb1, La1)																			
	Detail Design																			
	Bid Process/Purchase an order																			
	Construction																			
		Plants																		
		Sewer Lines																		
Phase 3	L-C, P-2 (SB: La2, Lb2, Pc)																			
	Detail Design																			
	Bid Process/Purchase an order																			
	Construction																			
		Plants																		
		Sewer Lines																		
Phase 4	P-4, P6 (SB: Pb1, Pd)																			
	Detail Design																			
	Bid Process/Purchase an order																			
	Construction																			
		Plants																		
		Sewer Lines																		

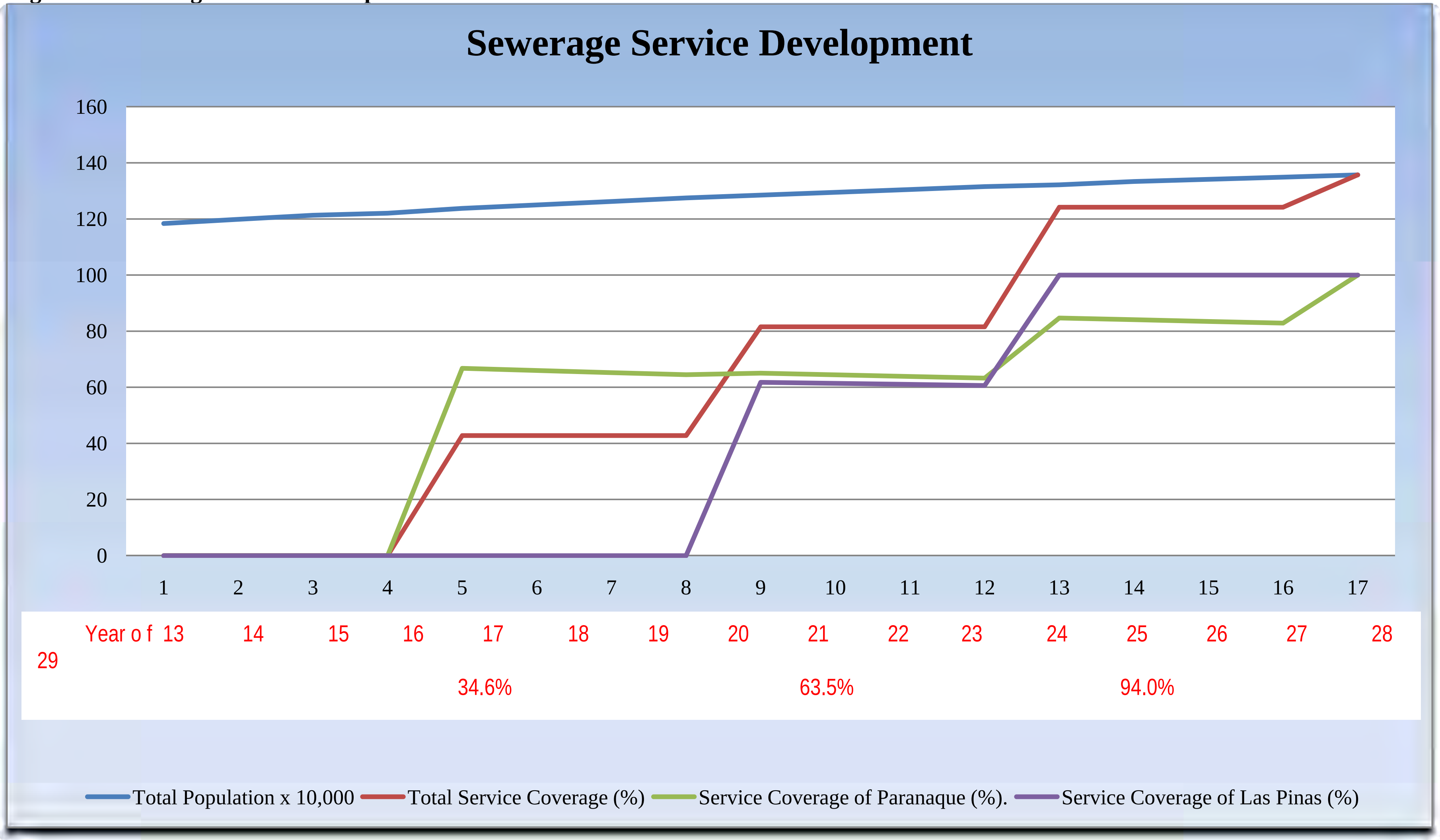
Notes: 1) ★ means Pledge in December, and ✤ Loan Agreement (L/A) in February.
2) Pledge will be made in December of last year before L/A is done.
3) Sewer lines Including construction of PSs, CMHs, MHPs, Interceptors
4) Red lines mean critical passes.
4) SB means Sub-basin.
5) ⟷ Field operation for verification

Table 8-12 Project Cost and Scope

Construction		STP		Number of Sewer Collection Facilities				Construction	Land Acquisition				Project
Phase	Completion Year	Location	Capacity m^3/d	PS set	MHP pc	CMH pc	Interceptor km	Cost	STP		PS		Total Cost
									ha	Cost	ha	Cost	
1	2016	P-11	77,028	0	24	156	48.8	6,172,318	7.620	76,200	-	-	6,248,518
2	2020	L-22	38,910	1	15	76	25.3	2,725,642	19.000	190,000	1.988	3,976	2,919,618
		L-A	30,851	1	12	55	26.3	2,597,307	3.200	162,500	0.054	756	2,760,563
3	2024	L-C	51,934	1	18	160	37.3	3,756,388	7.000	35,000	0.204	3,060	3,794,448
		P-2	24,799	0	2	38	13.1	1,660,092	4.200	1,260,000	-	-	2,920,092
4	2028	P-4	28,845	0	2	56	24.7	2,113,134	8.800	396,000	-	-	2,509,134
		P-6	13,968	0	0	4	5.2	927,142	13.200	528,000	-	-	1,455,142
Total			266,335	3	73	545	181	19,952,023	63	2,647,700	2.246	7,792	22,607,515

STP : Sewerage Treatment Plant Including Sewage Sludge Treatment Process)
PS : Pumping Station
MHP : Manhole Pump
CMH : Conversion Manhole

Figure 8-2 Sewerage Service Development



(2) **Stakeholders and Sewerage Service Charges**

The stakeholders of this project are relative personnel or agencies to the project goals, objectives and outputs that are described in **Table 8-13** "Project Framework". However, main stakeholders of this project are the prospective residents covered by sewerage service in Parañaque and Las Piñas Cities. **Figure 8-3 and 8-4** show development number of sewerage service beneficiaries.

Table 8-14 shows how much additional charge is necessary to water tariff in order to recover the project capital cost and sustain the operation cost. According to the table, at the project final stage 0.036 pesos /l.month should be added to the current water tariff. **Table 8-15** shows indicative water tariff calculations based on the current Maynilad water tariff policy. The result shows that after completion of the project, about 1.9 times the current water tariff would be required to the service residents.

Table 8-13 (1/2) Project Framework

Design Summary	Performance Indicators/Targets	Monitoring Mechanisms	Assumptions and Risks
1. Goals			
To improve of life and health status urban residents in Paranaque and Las Pinãs Cities.	Improved environmental conditions and reduced incidence of waterborne diseases.	Baseline survey on health, pollution, and coverage of sewerage and sanitation services.	
To promote regional economic development and reduce migration from the cities to the other districts	Increased investment and per-capita income and reduce net migration from the districts.	Local government statistics on investment and income in the project cities. Government statistics on population migration to/ from the project districts.	
2. Objective			
To improve sewerage and sanitation conditions in Paranaque and Las Pinãs	Increased coverage and efficiency of urban sewerage and sanitation services. Reduces pollution of surface water. Rehabilitated and upgraded drainage, wastewater, sanitation, and sludge infrastructure in the target areas.	Baseline survey on pollution of surface water before and after Project. Project progress reports, loan review missions, completion reports and post-project evaluations.	Central and local governments adopt and implement the institutional and policy reforms necessary to facilitate sustainable management of urban services, including solid waste management and river/creek silt controls.
	Promote poverty families' domestic water supply and wastewater drainage facilities.		Sewerage and sanitation management fees increased to ensure that MWSI has enough resources for proper operation and maintenance of sewerage collection and treatment systems.
3. Output			
(a) Establish sewerage treatment and management systems for the cities	100% of completion of sewerage treatment plants and sewage collection sewer lines at each project phase completion year, as;	Physical inspections, project progress reports, loan review missions and post Project evaluations.	Land acquisition plan timely implemented. Available and timely release of loan fund. Timely recruitment of competent consultants.
	Phase 1: One STP, and 48.8 km sewer collection lines by year 2016	Ward recorded of services. MWSI customer and operation records.	MWSS/MWSI appoint qualified and experienced staff to the project implementation unit.
	Phase 2: Two STPs, and 51.6 km sewer collection lines by year 2020		
	Phase 3: Two STPs, and 50.4 km sewer collection lines by year 2024		Coordination and effective arrangement of the other sewerage and sanitation implementation programs under parallel construction running.
	Phase 4: Two STPs, and 29.9 km sewer collection lines by year 2028		

8-13 (2/2) Project Framework

Design Summary	Performance Indicators/Targets	Monitoring Mechanisms	Assumptions and Risks
(b) Capacity building for improved autonomy. managerial, and technical capacity of MWSI	O & M plans, manuals and being used correctly and proper budgets allocated for O & M. Increased managerial and technical capacity of staff in MWSI. MWSS capabilities to coordinate and monitor MWSI operations. Water surcharge for sewerage service implemented to recover O & M costs of sewage and sewage sludge systems by 2036. Environmental charge on water supply by 2036 to recover capital cost investments in the sewerage and sanitation established.	MWSS/MWSI organizational chart and staff records. Job description and training plans. Training reports and tests of staff. Project progress reports, loan review missions and post-evaluations. Financial and management information reports, O & M documents and inspections. Annual budget. Customer complaint records. Tariff schedule increases and income collected. Billing statistics.	Project implementation cost-recovery tariff and budget allocations necessary for financial sustainability. Appropriate staff made available for training. Sufficient coordination among departments within MWSI and with other concerned agencies.
4. Inputs			
(a) Sewerage and sewage sludge treatment construction with sewer collection systems	Phase 1: 6,577 MP by 2016 Phase 2: 6,009 MP by 2020 Phase 3: 7,040 MP by 2024 Phase 4: 4,293 MP by 2028 Total 23,920 MP		
(b) Capacity buildings			Overseas Training as attached program: MWSS: 390 MP for 18 M/M MWSI: 1,160 M/M for 54 M/M

Figure 8-3 Sewerage Implementation in Parañaque and Las Piñas

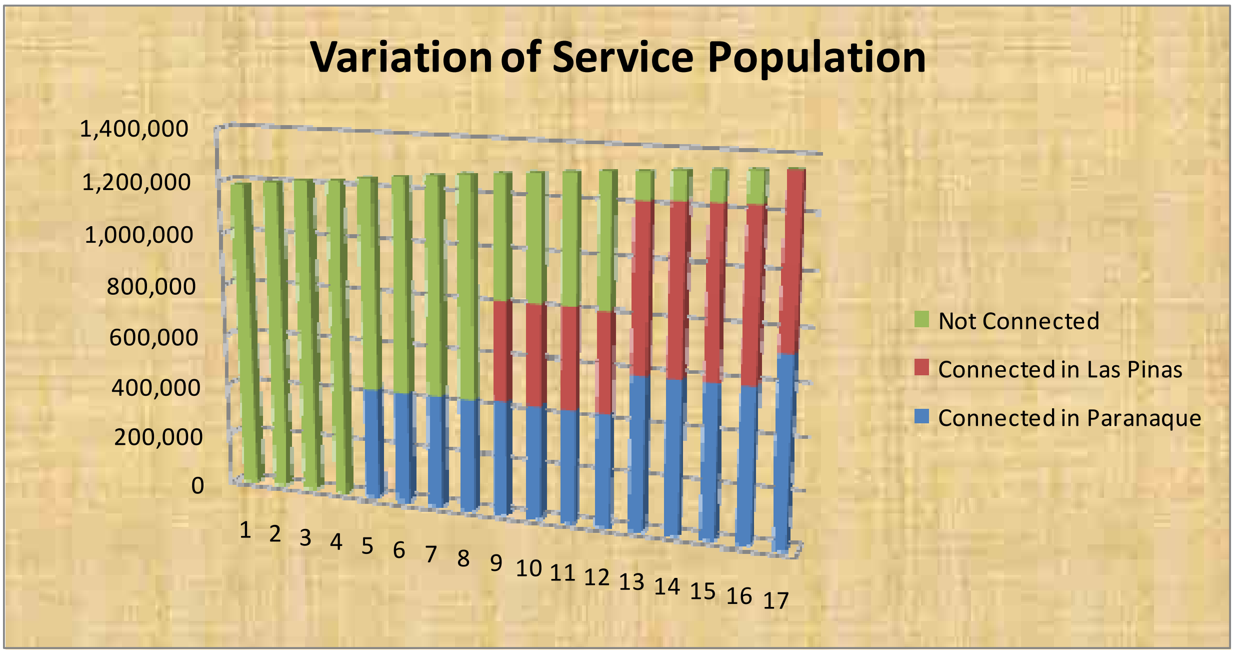


Table 8-14 Additional Sewerage Charge

Construction Phase	Year of Service Commencement	Service Population Total Population	Water Demand Projection L/pcp	(c)ML/month	(a) Operation (O & M) Cost/Yr Cumulative MP	(b) Construction Cost Cumulative MP	Additional Monthly Cost (a+b/40)/12/c Php/L.month	Environmental Charge of 20% P/L.month	Total Charge Additional for Sewerage P/L.month
Phase 1	2017	427,932	180	2,311	697	6,249	0.031	0.006	0.037
		1,237,607		6,683			0.011	0.002	0.013
Phase 2	2021	815,489	186	4,538	1,295	11,926	0.029	0.006	0.035
		1,284,930		7,151			0.019	0.004	0.022
Phase 3	2025	1,215,239	186	6,763	1,839	18,640	0.028	0.006	0.034
		1,321,618		7,355			0.026	0.005	0.031
Phase 4	2029	1,356,866*1	186	7,551	2,138	22,604	0.030	0.006	0.036
		1,356,866		7,551			0.030	0.006	0.036

*1: Population defined only in Palañaque and Las Piñas.

Table 8-15 Assumption of Sewerage Charge added to Water Tariff

Standard Family Water Expenses-1 (30m³/M)			New Charge		Standard Family Water Expenses-2 (10m³/M)			New Charge	
Charge per m³	19.07		19.07		Charge per m³	12.93		12.93	
Basic Charge	572.11		572.11		Basic Charge	129.31		129.31	
FCDA	0.54		0.54		FCDA	0.12		0.01	
Environmetal Charge	91.45	16%	91.45	16%	Environmetal Charge	20.67	16%	20.67	16%
Sewer Charge	114.31	20%	900.00	157%	Sewer Charge	25.84	20%	203.42	157%
MSC	1.50		1.50		MSC	1.50		0.34	
VAT	93.46	16%	93.46	16%	VAT	21.26	16%	21.12	16%
Total	873.37		1,678.13	1.92 times	Total	198.70		387.81	1.95 times

Figure 8-4 Service Population at Each Phase

Year	Copmmencement of sewerage Service				Max. Service Population		Paranaque			Las Pinas			Both Cities		
					Additional	Total	Total Pop	Service Pop	Coverage (%)	Total Pop	Service Pop	Coverage (%)	Total Pop	Service Pop	Coverage (%)
2013							609,285	0	0.0	574,468	0	0.0	1,183,753	0	0.0
2014							617,886	0	0.0	580,552	0	0.0	1,198,438	0	0.0
2015	P-11						626,609	0	0.0	586,701	0	0.0	1,213,309	0	0.0
2016	77,028						633,857	0	0.0	586,701	0	0.0	1,220,557	0	0.0
2017					427,932	427,932	641,189	427,932	66.7	596,419	0	0.0	1,237,607	427,932	34.6
2018							648,605	427,932	66.0	601,338	0	0.0	1,249,943	427,932	34.2
2019		L-22 + L-A					656,108	427,932	65.2	606,297	0	0.0	1,262,405	427,932	33.9
2020		69,761					663,697	427,932	64.5	611,298	0	0.0	1,274,995	427,932	33.6
2021					387,557	815,489	669,860	435,561	65.0	615,070	379,928	61.8	1,284,930	815,489	63.5
2022							676,081	435,561	64.4	618,866	379,928	61.4	1,294,946	815,489	63.0
2023			L-C+ P-2				682,359	435,561	63.8	622,685	379,928	61.0	1,305,044	815,489	62.5
2024			76,733				688,696	435,561	63.2	626,527	379,928	60.6	1,315,223	815,489	62.0
2025					426,291	1,241,780	695,091	588,712	84.7	626,527	626,527	100.0	1,321,618	1,215,239	92.0
2026							700,130	588,712	84.1	633,127	633,127	100.0	1,333,257	1,221,839	91.6
2027				P4 + P-6			705,205	588,712	83.5	635,873	635,873	100.0	1,341,078	1,224,585	91.3
2028				42,813			710,317	588,712	82.9	638,630	638,630	100.0	1,348,947	1,227,342	91.0
2029					237,850	1,479,630	715,466	715,466	100.0	641,399	641,399	100.0	1,356,866	1,356,866	100.0
2030							720,653	720,653	100.0	644,181	644,181	100.0	1,364,833	1,364,833	100.0
2031							724,263	724,263	100.0	645,662	645,662	100.0	1,369,924	1,369,924	100.0
2032							727,891	727,891	100.0	647,146	647,146	100.0	1,375,037	1,375,037	100.0
2033							731,537	731,537	100.0	648,634	648,634	100.0	1,380,171	1,380,171	100.0
2034							735,202	735,202	100.0	650,125	650,125	100.0	1,385,327	1,385,327	100.0
2035					Total Capacity		738,885	738,885	100.0	651,620	651,620	100.0	1,390,504	1,390,504	100.0
2036	77,028	69,761	76,733	42,813	266,355m^3/d		740,871	740,871	100.0	652,737	652,737	100.0	1,393,608	*1) 1,479,630	100.0

Note: *1) Include 86,022 from Pasay City.

8) Contract Package

Contract packages are divided into two categories, one for international bids and another for domestic bids. The contracts for sewage treatment facilities shall be made for each phase. Interceptors, manhole pumps and pumping stations shall be ordered to local bidders and contract packages shall basically be divided into each phasing schedule. However, pump stations works and interceptor with manhole pumps shall be divided into independent contract bid.

The Contract Package Plan will be divided into three parts, namely 1) treatment facilities, 2) manhole pumps and interceptors, and 3) pump stations. Since the Philippine side has little experience of treatment plants, the construction of treatment facilities will be open to international tender. Meanwhile, sewer construction and pumping stations shall be open to domestic tender because the Philippine side has ample experience in this area. The design and build method cannot be recommended because consistency in terms of technical, quality and lead-time cannot be guaranteed between different contractors. Since the manhole pumps, interceptors and pump stations can be divided into small works sections, they will be open to local tender. The sewers, pump facilities and treatment facilities are important facilities, and it will be necessary to conduct design work and works management in order to fully realize their capability.

Works procurement entails the seven sewage treatment plants (Pa2+Pb2, Pa1+Lb1, La1, Pc, La2+Lb2, Pb1, Pd,) and the interceptors for conveying sewage to the plants. The interceptors also include manhole pumps and pump stations.

Since the Philippine side has little experience treatment plants, these facilities shall be opened to international tender. Meanwhile, sewer construction shall be open to domestic tender because the Philippine side has ample experience in this area. **Table8-16** shows the project work procurement plan.

Table8-16 Work procurement plan

1	2	3	4	5	6	7	8	9
Phase	Contract (Component)	Estimated Cost M Pesos	Procurement Method	P-Q	Preference (yes/no)	Review by JICA (Prior/Post)	Expected Bid Opening Data	Contruct Rod
Phase1	STP （P-11）	4,982	ICB	No	No	Prior	Jul. 2014	1
	Collection System	1,191	LCB	No	No	Post	Jul. 2014	1
Phase2	STP (L-22）	2,129	ICB	No	No	Prior	Jul. 2018	1
	Collection System	597	LCB	No	No	Post	Jul. 2018	1
	STP (L-A）	1,996	ICB	No	No	Prior	Jul. 2018	1
	Collection System	601	LCB	No	No	Post	Jul. 2018	1
Phase3	STP (P-2）	1,357	ICB	No	No	Prior	Jul. 2022	1
	Collection System	303	LCB	No	No	Post	Jul. 2022	1
	STP (L-c）	2,853	ICB	No	No	Prior	Jul. 2022	1
	Collection System	903	LCB	No	No	Post	Jul. 2022	1
Phase4	STP (P-4）	1,576	ICB	No	No	Prior	Jul. 2026	1
	Collection System	537	LCB	No	No	Post	Jul. 2026	1
	STP (P-6）	766	ICB	No	No	Prior	Jul. 2026	1
	Collection System	161	LCB	No	No	Post	Jul. 2026	1

9) Organization of Project Implementation

(1) Associated Agencies for Implementation of the Project

Mainland Water Service, Inc. (MWSI), the implementing agency, shall carry out project procurement activities through its Project Implementation Unit (PIU). Department of Program Management is responsible for the project implementation and department of sewerage and sanitation is responsible for the sewerage system operation, thus the PIU should compose of appropriate staffs from both departments. Project manager of PIU shall be chosen from these departments.

The sewerage treatment projects relate to various government agencies. The Department of Health (DOH) is the principal government organization responsible for planning, implementation and coordination of the policies and programs for public health protection and sanitation. The DENR is the primary government agency responsible for the promulgation of rules and regulations for the control of water, air, and land pollution in the Philippines. EMB is a line bureau of DENR and is mandated to formulate policies on environment and implement environmental laws.

The Department of Public Works and Highways (DPWH) is the government agency that is in-charge of infrastructure construction. Under the Clean Water Act (CWA), the DPWH is given the lead role with regards to the preparation of the national program on sewerage and septage management.

MWSS, attached agency to the DPWH, is responsible for domestic sewage collection, disposal, and treatment in Metro Manila and the surrounding municipalities, and the operations of the facilities of MWSS were turned over to MWSI and MWCI.

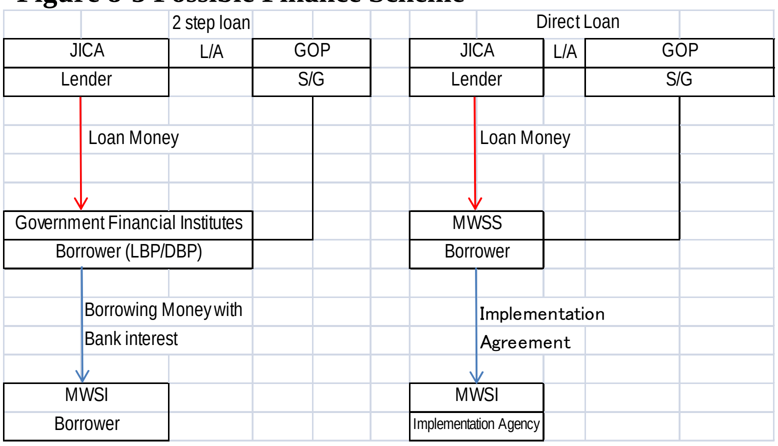
MMDA is responsible for management of solid waste and maintenance of rivers or creeks. LGUs are responsible for the provision of basic services, such as water supply systems, sewerage, and sanitation, either directly or through contracts with the private sector. They are also empowered to collect taxes and fees necessary for providing these services.

Under this proposed project, it is necessary for the departments to coordinate closely in order to maximize the impacts of the sewerage treatment development programs.

(2) Project Implementation Structure

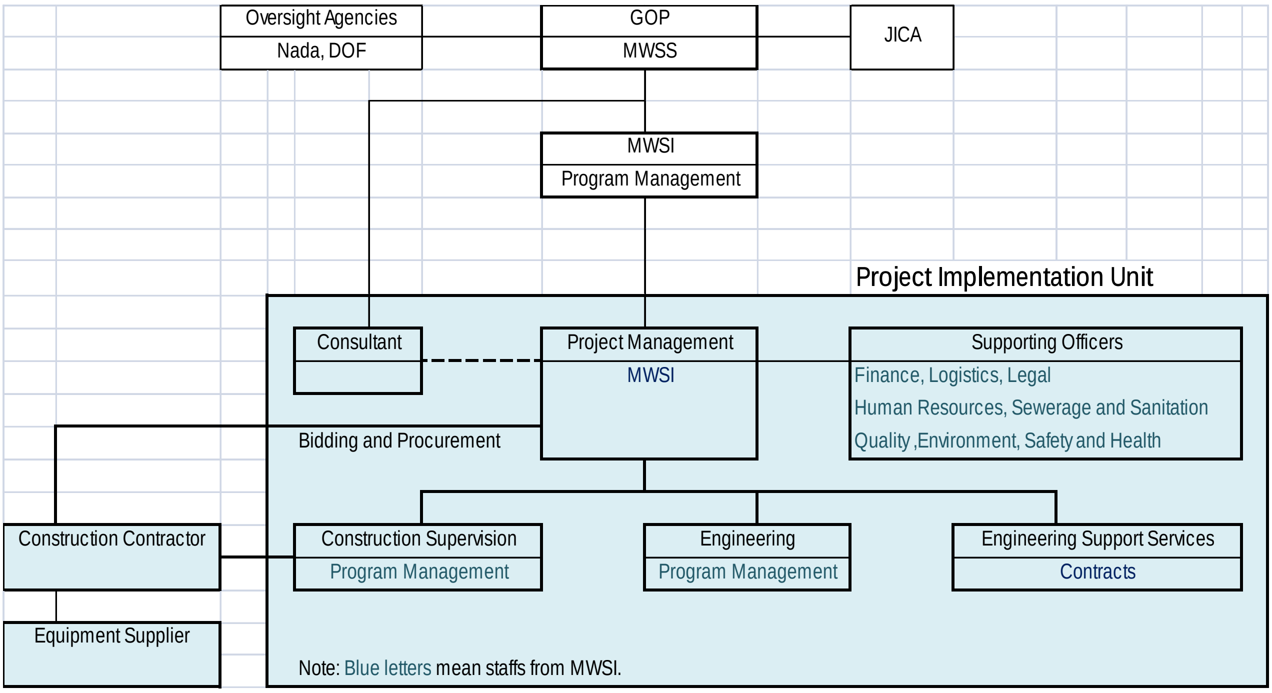
PIU organization will not be differed by project loaning structure. There would be two way to fund for the project (loan money), one is direct loan from JICA; another is two step loan from JICA through Government Financial Institutes (GFIs). The flow of the loan money is shown in **Figure 8-5**.

Figure 8-5 Possible Finance Scheme



In any case, the project implementation unit organization should be the same. **Figure 8-6** shows project implementation structure. Difference between the case of MWSS and GFIs as borrower just is in repayment responsibility to JICA (donor).

Figure 8-6 Project Implementation Structure



Relative agencies roles are shown hereunder.

Roles of Relative Agencies	
LGUs	Assist in selection of site for treatment facilities, and information dissemination of information of the project area
	Review Project, Its alignment and project implementation schedule with other government project
	Ensure proper implementation of Project through resolution with correction in the Project area
	Ensure proper maintenance of drainage
DPWH	Ensure proper implementation of Project through resolution sold with correction in the PJ areas
	Ensure proper maintenance of drainage
	Review Project, Its alignment and project implementation schedule with other government project
DENR	Ensure that no untreated industrial waste enter drainage
	Assist speedy issuance environmental permits of the project
	Review Project, Its alignment and project implementation schedule with other government project
MMDA	Ensure proper implementation of Project through resolution with correction in the PJ areas
	Ensure proper maintenance of drainage
DOH	Monitoring implementation of Project based on sanitation code
	Assist issuance for all sanitation permits of the project

Roles of Project Implementation Agencies	
GOP	Approve Project, provide sovereign guarantee, and secure loan from JICA
MWSS	Monitors Project implementation of MWSI, and submit report to JICA
	Review project proposal of MWSI and recommends to GOP for Government borrowing to JICA
MWSI	Preparing and submit Project proposal to MWSS,
	Implementing Project
	Submit reports of implementation to MWSS
	Provides funds for the loan payment

(3) Recruiting Consultants to assist PIU

Since MWSI has not enough experience of the large scale sewage treatment plants like this project, and also has insufficient experience of design and construction of the plants together with the conversion manholes, interceptors incorporated into combined sewer collection systems. Therefore competent international consultant firm(s) should be recruited to join the PIU. Consultant services should cover both of project detail designs and construction supervises. Total numbers of consultant inputs for this work is estimated that international expert: 164 person-months, local engineer: 210 person-months and total cost is 4,995,000 us dollars. The consultant input schedule, cost and TORs are shown in Annex 7.

10) Indicators of Project Operation Effect

The operation indicators used for evaluating the Project are geared to grasping the state of facilities utilization, realization of functions and operation and maintenance, and such indicators shall be set to ensure that the implementing agency specifies the regular implementation of monitoring and appropriately conducts operation and maintenance. **Table 8-17(1),(2)** shows the operation indicators.

Effect indicators are set in order to clarify planned effects and measure degree of achievement of the Project purpose through quantitatively setting and grasping the attainment of effect items. **Table 8-18 (1),(2)**shows the effect indicators.

Table 8-3-13(1) Operation Indicator

Regarding project target area						
Category	Name	Policy and method of establishing the indicator※2	Base Line	Target	Purpose	Remarks
Basic	Population Treated(Persons)	Population treated=(population connected to sewage network) Yearly data	ph1(2011):0	ph1(2019):427,932	To assess if the sewage water operation is properly conducted	Values should be constantly improving when the project is effective. When the population connected to sewage network is unknown, adopt similar indicators(population served with water supply, population in the area sewage system is installed, etc.)
			ph2(2011):0	ph2(2023):387,567		
			ph3(2011):0	ph3(2027):399,740		
			ph4(2011):0	ph4(2031):141,627		
Basic	Amount of Wastewater Treated (m^3/Day)	As shown by the name of the indicator Yearly data	ph1(2011):0	ph1(2019):77,028m^3/d	To assess if the sewage water operation is properly conducted	Values should be constantly improving when the project is effective. (Indicator covers the treatment of industrial waste water as well)
			ph2(2011):0	ph2(2023):69,761m^3/d		
			ph3(2011):0	ph3(2027):76,731m^3/d		
			ph4(2011):0	ph4(2031):42,813m^3/d		
	Rate of Facility Utilization(%)	Rate of Utilization=(daily average amount of treated wastewater)/(capacity of the facility) Yearly data	ph1(2011):0	ph1(2019):100	To assess if the network improvement is properly conducted	This corresponds to rate of facility operation. It is desirable to indicate 40% or over three years after stating operation.
			ph2(2011):0	ph2(2023):100		
			ph3(2011):0	ph3(2027):100		
			ph4(2011):0	ph4(2031):100		
Basic	BOD Concentration-influent, effluent, reduction rate (mg/ℓ; assessed monthly)	As shown by the name of the indicator Monthly data (monthly average of data obtained regularly)	ph1(2011):0	ph1(2019):50mg/ℓ	To assess if the treatment plant is properly operated	When the treated wastewater is discharged into closed waters (lakes, inland sea, etc.), substitute the indicator by COD ※3. Reduction rate: 70ー85％
			ph2(2011):0	ph2(2023):50mg/ℓ		
			ph3(2011):0	ph3(2027):50mg/ℓ		
			ph4(2011):0	ph4(2031):50mg/ℓ		
Auxiliary	Covered Ratio of Sewer Main(%)	Covered ratio=(length of sewage pipes covered)/(planned total length) Yearly data	ph1(2011):0	ph1(2019):100	To assess if the network improvement is properly conducted	Sewer main is referred to as sewage pipe that is directly connected to a treatment plant or pumping station.
			ph2(2011):0	ph2(2023):100		
			ph3(2011):0	ph3(2027):100		
			ph4(2011):0	ph4(2031):100		
Auxiliary	Suspended Solid(TSS) Concentration※3 influent, effluent reduction rate(mg/ℓ; assessed monthly)	As shown by the name of the indicator Monthly data (monthly average of data obtained regularly)	ph1(2011):0	ph1(2019):70mg/ℓ	To assess if the treatment plant is properly operated	
			ph2(2011):0	ph2(2023):70mg/ℓ		
			ph3(2011):0	ph3(2027):70mg/ℓ		
			ph4(2011):0	ph4(2031):70mg/ℓ		
Auxiliary	Form of Sludge Disposal (each form DS※3-T/Year)	Amount of sludge disposal by form of disposal※4 Yearly data	ph1(2011):0	ph1(2019):2,482t	To assess effect of environment burden reduction and resource recovery.	promotion of recycling should be strongly demanded as far as possible.
			ph2(2011):0	ph2(2023):2,227t		
			ph3(2011):0	ph3(2027):2,446t		
			ph4(2011):0	ph4(2031):1,387t		
Auxiliary	Rate of Service Charge Recovery(%)	Rate of service charge recovery=(recovered service charge)/(service charge claimed) Yearly data (annual average worked out from monthly data)	ph1(2011):0	ph1(2019):100	To assess if guidance and dissemination to local residents are properly carried out.	Management indicator; it is desirable to improve the rate closer to 100%
			ph2(2011):0	ph2(2023):100		
			ph3(2011):0	ph3(2027):100		
			ph3(2011):0	ph4(2031):100		

Note) Ph1:Phase1

Table 8-3-13(2) Operation Indicator

Regarding project target area						
Category	Name	Policy and method of establishing the indicator※2	Base Line	Target	Purpose	Remarks
Auxiliary	Sludge generation rate Generated amount of sludge (m3/d) Sludge concentration (%)	As indicated in the name of the indicator Monthly indicator (monthly average of periodically acquired data) Sludge generation rate = Generated amount of sludge Ds -t/d/SS amount of reduction Ds-t/d	ph1(2011):0 ph2(2011):0 ph3(2011):0 ph4(2011):0	ph1(2019):1,073m3/d ph2(2023):971m3/d ph3(2027):1,069m3/d ph4(2031):596m3/d	Assess whether the sludge treatment facilities are appropriately managed or not.	Operation that ensures around 75% of the daily average SS reduction amount is desirable.
Auxiliary	Thickened sludge quantity (m^3/d) Sludge concentration (%) Organic content (%)	As indicated in the name of the indicator Monthly data (monthly average of periodically acquired data)	ph1(2011):0 ph2(2011):0 ph3(2011):0 ph4(2011):0	ph1(2019):425m3/d ph2(2023):385m3/d ph3(2027):424m3/d ph4(2031):236m3/d	Assess whether the sludge thickening equipment is appropriately managed or not.	In the case of gravity thickening, sludge concentration is around 1~3%.
	Rate of Facility Utilization(%)	Rate of Utilization=(daily average amount of treated wastewater)/(capacity of the facility) Yearly data	ph1(2011):0 ph2(2011):0 ph3(2011):0 ph4(2011):0	ph1(2019):100 ph2(2023):100 ph3(2027):100 ph4(2031):100	To assess if the network improvement is properly conducted	This corresponds to rate of facility operation. It is desirable to indicate 40% or over three years after stating operation.
Auxiliary	Sludge digestion rate (digested sludge amount m3/d, sludge concentration %)	As indicated in the name of the indicator Digestion rate = Digested sludge Ds/Thickened sludge Ds	ph1(2011):0 ph2(2011):0 ph3(2011):0 ph4(2011):0	ph1(2019):425m3/d ph2(2023):385m3/d ph3(2027):424m3/d ph4(2031):236m3/d	Assess whether the anaerobic digestion equipment is appropriately managed or not.	As far as possible, it is desirable to achieve a digestion rate of no more than 60%.
Auxiliary	Digestion gas generation rate Generated amount of digestion gas m^3/d	As indicated in the name of the indicator Generation rate = Generated amount of digestion gas m3/d//organize content of thickened sludge kg/d	ph1(2011):0 ph2(2011):0 ph3(2011):0 ph4(2011):0	ph1(2019):9,681m3/d ph2(2023):8,770m3/d ph3(2027):9,043m3/d ph4(2031):3,205m3/d	Assess whether the anaerobic digestion equipment is appropriately managed or not.	As far as possible, it is desirable to achieve a generation rate of 0.6 m3 per kilogram of organic matter put into the digestion tank
Auxiliary	Form of effective use of digestion gas (methane gas) (10^3m3/year)	Stated usage by form of use Monthly data	ph1(2011):0 ph2(2011):0 ph3(2011):0 ph4(2011):0	ph1(2019):3,534m3/y ph2(2023):3,201m3/y ph3(2027):3,301m3/y ph4(2031):1,170m3/y	Assess the greenhouse gas reduction effect.	This should be recycled as much as possible.

Table 8-3-14 (1) Effect Indicator

Effect Indicator						
Regarding Project target area						
Category	Name	Policy and method of establishing the indicator※2	Base Line	Target	Purpose	Remarks
Basic	Percentage of population Served(%)	Percentage of Population Served= (Population that is actually served with treatment)/(target population of treatment service) Yearly data	ph1(2011):0	ph1(2019):100	To assess if the sewage water operation is properly conducted.	Indicator for the whole project Plan.
			ph2(2011):0	ph2(2023):100		
			ph3(2011):0	ph3(2027):100		
			ph4(2011):0	ph4(2031):100		
Basic	Improvement of water Quality (BOD/COD)	As shown by the name of the indicator Monthly data(monthly average of data obtained regularly)	ph1(2011):0	ph1(2019):7(10)	To assess if sewage project is effective.	When the treated wastewater is discharged into closed waters (lakes, inland sea, etc.), substitute the indicator by COD※3.
			ph2(2011):0	ph2(2023):7(10)		
			ph3(2011):0	ph3(2027):7(10)		
			ph4(2011):0	ph4(2031):7(10)		
Basic	BOD Concentration (when discharged) (mg/ℓ)	As shown by the name of the indicator Monthly data(monthly average of data obtained regularly)	ph1(2011):0	ph1(2019):50	To assess if sewage project is effective.	
			ph2(2011):0	ph2(2023):50		
			ph3(2011):0	ph3(2027):50		
			ph4(2011):0	ph4(2031):50		
Auxiliary	Percentage of population Connected(%)	Percentage of population Connected=(population connected to sewage network)/(target population of treatment service) Yearly data	ph1(2011):0	ph1(2019):100	To assess if the network improvement is properly conducted.	Indicator for the whole project Plan.
			ph2(2011):0	ph2(2023):100		
			ph3(2011):0	ph3(2027):100		
			ph4(2011):0	ph4(2031):100		
Auxiliary	Ratio of Cost Recovery(%)※5	Ratio of cost recovery=(Amount of service charge collected)/(cost of treatment service) Yearly data (annual average worked out from monthly data)	ph1(2011):0	ph1(2019):100	To assess if sewage project is properly managed	Management indicator: it should cover at least maintenance and operation costs.
			ph2(2011):0	ph2(2023):100		
			ph3(2011):0	ph3(2027):100		
			ph4(2011):0	ph4(2031):100		
Auxiliary	Reducing Ratio of Sludge Disposal(%)※6	(Volume recycled)/ (volume of sludge) Yearly data (annual average worked out from monthly data)	ph1(2011):0	ph1(2019):100	To assess if sewage project is properly managed	
			ph2(2011):0	ph2(2023):100		
			ph3(2011):0	ph3(2027):100		
			ph4(2011):0	ph4(2031):100		
Regarding whole administrative district						
Auxiliary	Percentage of population Served(%)※7	Percentage of Population Served= (Population that is actually served with treatment)/(population in the administrative district) Yearly data	ph1(2011):0	ph1(2019):100	To confirm the degree of contribution of the project to the whole administrative district (residents)	Not reaching the target dose not always lead to low evaluation.
			ph2(2011):0	ph2(2023):100		
			ph3(2011):0	ph3(2027):100		
			ph4(2011):0	ph4(2031):100		

Table 8-3-14 (2) Effect Indicator

Table 8-3-14 (2) Effect Indicator

Auxiliary	Percentage of wastewater Treatment (%)	Percentage of wastewater Treatment=(volume of wastewater treatment)/(total volume of wastewater)	ph1(2011):0 ph2(2011):0 ph3(2011):0 ph4(2011):0	ph1(2019):100 ph2(2023):100 ph3(2027):100 ph4(2031):100	To confirm the degree of contribution of the project to the whole administrative district (residents and industry)	Not reaching the target dose not always lead to low evaluation.

	Benefit at two years after completion of each phase (1,000Php)	2019	2023	2027	2031	Total Benefits
Auxiliary	Avoided Cost on Medical Expence due to Water-Related Disease	5,135	4,651	4,797	1,700	16,283
	Savings due to Reduction in Morbidity	2,640,804	2,391,709	2,466,829	873,992	8,373,334
	Savings due to Reduction in Morbtality	316,897	287,005	296,019	104,879	1,004,800
	Total Benefits	2,962,836	2,683,365	2,767,645	980,571	9,394,417

	Improvement in water quality as a result of conducting sewage treatment	The Phase 1 sewage treatment will lead to improvement of water quality in San Dionisio River (a tributary of Parañaque River) and Kay Boboy Creek. In numerical terms, treatment will lead to improvement in river water quality from 17mg/ℓ to 4mg/ℓ, thereby achieving the DNR standard of 7mg/ℓ. In Phase 2, water quality will be improved in Villanueva Creek, also a tributary of Parañaque River, and the improvement effect will be the same as in Phase 1. Moreover, in Zapote River, treatment will lead to improvement in river water quality from 20mg/ℓ to 5mg/ℓ, thereby achieving the DNR standard. In Phase 3, water quality will be improved in Balot River, a tributary of Las Piñs River, with river water quality improving from 13mg/ℓ to 3mg/ℓ. Moreover, in Ibayo Creek, also a tributary of Parañaque River, treatment will improve the river water quality from 19mg/ℓ to 5mg/ℓ, thereby achieving the DNR standard. In Phase 4, water quality will be improved in Don Galo Creek, another tributary of Parañaque River, with river water quality improving from 19mg/ℓ to 5mg/ℓ. Therefore, the sewage treatment that will be implemented in Phases 1~4 will make a major contribution to water quality not only in rivers but also Manila Bay.

Notes:

※1 Basic concept of operation indicators: indicate how well the operation of a sewage project is carried out in order to have the above mentioned effects
Basic concept of effect indicators: indicate how comfortable the daily life of community people has become(percentage of population served) and how well the water environment is conserved (water quality improvement)

※2 "Yearly data" is referred to as the end of the financial year, and "monthly data" as the values at the end of the month, and "data obtained regularly" as values obtained several times/week or daily.

※3 Densities of Biochemical Oxygen Demand(BOD), Chemical Oxygen Demand(COD), and Suspended Solids(SS) indicate the degree of organic contamination. Dried Sludge(DS) indicates the
In closed waters such as bays or lakes, the value of BOD is lower than the actual sludge volume. Accordingly it is desirable to indicate it by COD.
In a case in which the treated wastewater is discharged into a general sea area, it is desirable to indicate the degree of water quality improvement by the number of coli-aerogenes group or COD measured at the adjacent seashore.

※4 Forms of final disposal after sludge treatment at a treatment Plant include landfill, recycled as construction material, recycled as compost, etc.

※5 Basic cost includes operation and management cost of the treatment plants and sewage network. It should be decided through discussion with the executing agency if undistributed profits are to be included in preparation for the future. Even if self-support accounting is not attained, at least maintenance and operation cost should be paid by the service charge recovered.

※6 Generally, sludge is disposed in landfill at a cost. Promoting recycling of sludge in green or farm land will reduce the cost.

※7 As the most popular indicator in and out of Japan is percentage of population served at the autonomous community level, this indicator is established.

11) Conceptual Design

(1) Technical Specifications

Table 8-19 shows the works items and works quantities for the seven planned treatment districts.

1) Conversion Manholes (CM)

Two types of conversion manholes, i.e. the type with inlet sewer diameter of ϕ 700 mm or less and the type with inlet diameter of ϕ 1,000 mm or more, will be installed at 545 locations around the outfalls of sewers that drain sanitary sewage into creeks.

2) Manhole Pump (MP)

Manhole pumps, which are simple structures comprising pumps installed in manholes with the aim of conveying the sanitary sewage separated in the conversion manholes to interceptors, are planned in 73 locations with pumping capacity ranging between 1.5~22 kw.

3) Force Main Pipe

Force main pipes, which are intended to convey sanitary sewage pumped by manhole pumps and pump stations to interceptors, are planned over 21,270 m with diameter ranging between ϕ 75 mm~600 mm.

4) Interceptor (gravity)

The sanitary sewage that is separated by the conversion manholes will be collected in the interceptors comprising 166,940 m of sewers with diameter of ϕ 150 mm~ ϕ 1000 mm for conveying the sewage to the treatment facilities at the end of the lines.

5) Pump Station (PS)

Since the buried depth of sewers along the interceptors becomes deep in places, pump stations will be constructed in order to reduce this depth. Pump stations with pumping capacity of 4.8 m^3/min~5.6 m^3/min will be constructed in three locations.

6) Sewage Treatment Plant (7STPs)

Sewage treatment plants are planned in seven locations, five of which will adopt the oxidation ditch process and two the sequencing batch reactor process.

Table 8-19 Works Items in the Seven Treatment Districts

Name		Pa1+Lb1	Pa2+Pb2	Pb1	Pc	Pd+Pe	La1	La2+Lb2
ID No		L-22	P-11	P-4	P-2	P-6	L-A	L-C
STP	Influent Wastewater（m^3/d)	38,910	77,028	28,845	24,799	13,968	30,851	51,934
	Treatment Process	OD	SBR	OD	OD	OD	SBR	OD
	Infulent BOD (mg/ℓ)	200	200	200	200	200	200	200
	Infulent SS (mg/ℓ)	200	200	200	200	200	200	200
	Outflow BOD (mg/ℓ)	20	20	20	20	20	20	20
	Outflow SS (mg/ℓ)	20	20	20	20	20	20	20
PS	ID No	PS-6					PS-2	PS-4
	φ200×5.5m^3/m×15kw×4Unit(Place)	1						
	φ200×4.8m^3/m×15kw×5Unit(Place)						1	
	φ200×5.6m^3/m×15kw×4Unit(Place)							1
MP	1.5kw×2Unit (Place)	2					1	1
	2.2kw×2Unit (Place)						1	2
	3.7kw×2Unit (Place)	6	6				2	6
	5.5kw×2Unit (Place)	4	10		1		2	5
	7.5kw×2Unit (Place)	1	4	1			4	2
	11kw×2Unit (Place)	2	2				1	2
	15kw×2Unit (Place)		2	1	1			
	22kw×2Unit (Place)						1	
Force Main Pipe	75mm (m)	1,320					810	910
	100mm (m)		440				840	150
	150mm (m)	630	2,820				300	1,700
	200mm (m)	500	1,700				250	900
	250mm (m)		1,180	210			450	100
	300mm (m)	150	210		50		190	1,350
	350mm (m)	590	990					
	400mm (m)	150	220	70	60		430	
	450mm (m)							
	500mm (m)	150						
	600mm (m)						800	
Interceptor(Gravity Main)	150mm (m)	3,280	9,480	5,860	2,120	1,010	6,590	7,030
	200mm (m)	3,890	9,600	3,070	1,790	250	1,210	2,850
	250mm (m)	1,560	4,570	3,870	1,470	380	3,010	4,840
	300mm (m)	3,180	7,010	1,850	930		1,070	2,750
	350mm (m)	1,020	2,420	910	300			1,450
	400mm (m)	580	2,570	310	1,300		1,500	2,050
	450mm (m)	2,160	1,330		1,200		1,390	1,800
	500mm (m)	740	2,730	3,950	870	100	100	2,160
	600mm (m)	1,140	2,760	1,400	1,540		3,030	1,610
	700mm (m)	2,820	3,160	1,520	1,420	3,430	3,700	1,610
	800mm (m)	1,410		1,720				1,350
	900mm (m)		1,420					680
	1000mm (m)		1,340					1,250
	1100mm (m)							750
	1350mm (m)							
CM	700mm (Place)	51	106	40	28	2	37	107
	1000mm (Place)	25	50	16	10	2	18	53

注）1. STP:Treatment Plant、PS: Pump Station 、MP: Manhole Pump 、CM: Conversion Manhole

12) Project Design Drawings

Conceptual drawings of the facilities planned in the project are indicated according to the sewage flow in the order of: Conversion manhole (**Figure 3-3-1(1) and 3-3-1(2)** attached as appendix) , Manhole pump (**Figure 3-3-2** attached as appendix), Pump station (**Figure 3-3-3** attached as appendix), and Treatment plant (**Figure 3-4-1(1)** through **3-4-1(7)** attached as appendix).

13) Least Cost Study of Project Facility Construction

The following policies will be adopted in order to reduce the construction cost of sewerage facilities in the project.

● Installation height of treatment facilities

Treatment facilities will be installed between 1.5 m higher in order to reduce the costs of civil engineering works and earth retaining works. Since the planned locations of treatment facilities are in areas that were inundated in the past (according to the interview survey of flood level), it will be necessary to elevate facilities above this level.

● Prevention of groundwater infiltration

Groundwater infiltration of 20 ℓ/day/cap is expected during fine weather, however, infiltration will be prevented through improving the used sewer joints and installation methods.

● Primarily the OD process will be adopted in order to reduce construction and operating costs, and the SBR method will be adopted in places where the OD process cannot be applied.

●In order to reduce the construction cost and maintenance cost for sludge facilities, they will be consolidated into one location.

●Monitoring and control will be conducted by monitors in order to reduce the size of the monitoring building.

9. Sub Pilot Project Enhancing the Main Project Activities

In the implementation of the sewerage projects in Parañaque and Las Piñas Cities, several supporting programs related to the sewerage systems considered useful to promote and enhance the sewerage and sanitation development are discussed. The program is focused supporting program for hygienic improvement of poor families and on river cleaning and the promotion of sewerage system development to be implemented parallel with the proposed main project activities.

Supporting Program for Hygienic Improvement of Poor Families

Families considered under poverty conditions are likely to have unhygienic conditions of households without or insufficient sanitary facilities and could not be improved by the sewerage system due to the difficulty to charge the sewerage tariff as there is no water supply connection.

The measures addressing such poor families would be prepared as follows:

1) Establishing Revolving Fund for Promoting Water supply and Sanitary Facility Installation - Revolving fund should better be established to encourage the households to install water supply and sanitary facilities.

The predicted cost for the promotion would be as follows (per one family);

Water supply facility (Water pipe and tap)	-	P 4,000
Water Closet (supply and install)	-	P 6,800
φ150 PVC with Earth Work (10m)	-	P 13,000
Total	-	P 23,800

If the revolving fund is PhP 250 million, about 100,000 people (10,000 families, assuming 10 persons per one family) could got the benefit the first 5 years, that means 8% of service population, and in case that bridge finance is made to sustain initial fund value, about 100,000 people (10,000 families), 36% of service population, would additionally be possible to use the fund, which would realize 16% of service population to be able to improve their domestic hygienic conditions in the first 10 years. The fund sources would preferably be studied such as Japanese Grant.

River Cleaning Plan

The presence of a sewerage system is considered the most effective way to clean up the polluted rivers However, the residents' behavior throwing garbage in to the rivers, creeks or in public spaces hampers environmental improvement activities. Pictures in the report confirm this situation.

The solid wastes in the waterways are also one of the problems affecting the efficient performances of the sewerage treatment systems. The environmental improvement of waterways requires reducing the garbage dumping into the rivers and public spaces in parallel with sewerage treatment system development. The garbage left on the roads eventually are transported by rain water into the street drainages and discharged into rivers.

The rivers transporting bio-solids also accumulate silts on the riverbed. The silts should be dredged up periodically to keep smooth water stream and clean water. These problems would be expected to be improved through improved solid waste management, river dredging, educational programs and on-site treatment. Solid waste management program and river dredging are to be in coordination respectively with the LGU and MMDA.

10. Mitigation Measures of Climate Change Integrated in the Project

Treatment process of sewage water is basically classified broadly by physical-chemical process and biological process. Because of difficulty of treatment of dissolved solid by physical process, biological wastewater treatment process is prevailingly used. Biological treatment system is also divided into two processes, anaerobic and aerobic process. For the sewage treatment system, aerobic treatment process is generally applied. Sewage sludge generated in the treatment process are basically thickened, dewatered or digested before dewatering, and finally incinerated or land-filled. Other uses of sludge are: (a) materials for the production of compost fertilizer, (b) as construction materials from the processed sludge.

The sludge generated from existing treatment plants of MWSI is currently at low level (less than 15% in 2020). Because the generated sewage sludge will increase with the operation of more treatment plants, sludge treatment system shall be essential to incorporate into the sewage treatment plants otherwise, could be constructed solely outside of the plants. These sludge treatment systems shall be established together with digesting systems, and at the early sewerage system developing stage, inflaming the methane gas or using it as bio-energy for on-site power generation system are viable, in aspect of the measures of economical and realistic sludge reduction systems, and devoting to mitigation of climate change.

Sewage sludge contains comparatively much organic materials, and it is well known that fermentation heat is emitted under biological aerobic degradation. And methane gas is possible to use as energy source, and dry cake of sewage sludge itself could be combustion material. That is, internal energy stored in the sludge as organic material can be converted to outside energy source. Sludge digestion gas includes 60% and more methane gas, and methane gas decomposition into CO_2 and H_2O is effective 21 times for reduction of greenhouse gas effect than reduction of GHG emission, (that is, $GWP_{CH4}=21GWP_{CO2}$). Therefore, as one of sewage sludge management process, sludge digestion and utilization of sludge gas are recommended. These utilizations eventually reduce methane gas emission from sewage sludge degrading process, that is, the sewage sludge utilization itself is one of the climate change mitigation countermeasures.

If the methane gas generated by sludge digesting process is burned or used for gas power generation system, this is effective for greenhouse gas reduction. From population projections in the MWSS service area, the potential generated sewage and sludge are estimated.

Sewage Sludge Generation Rate – Assuming that influent wastewater quality is 200mg/l.BOD_5, and effluent water quality standard is 50mg/l or less in the project areas, the solid sludge rate, Qs and the liquid sludge rate scrubbed, Ql per 1 m^3/d of wastewater are calculated as follows,

$$\mathbf{Qs = 1 \times 200 \times (1-50/200) \times 1 \times 10^{-6} = 150 \times 10^{-6} t/d}$$
$$\mathbf{Ql = 150 \times 1/ (0.025\ to\ 0.015) \times 10^{-6}= 0.6\ to\ 1.0 \times 10^{-2} m^3/d}$$

Therefore sewage sludge generation rate is expected 0.6% to 1.0% of influent flow rate. This rate depends on influent water quality and effluent water quality standard.

Sludge Digestion Gas Generation Rate - The digesting gas volume produced from activated sludge is estimated by the following expression;

Gd = Gm x Ql

where

Gd: digestion gas volume (m^3/d)

Gm: multiplier

With a Gm value around 7, the digestion gas production volume per $1m^3/d$ influent flow is:

$$\mathbf{Gd = 7 \times Ql = 7 \times 0.6 \text{ to } 1.0 \times 10^{-2} m^3/d = (4.2 \text{ to } 7.0) \times 10^{-2} m^3/d}$$

Therefore digestion gas production rate is expected 4.2 to 7.0 % of influent flow rate. Measurements in Japan treatment plants confirmed the above values of Ql, Gd and Gm.

Sludge Digestion Gas Power Generation - The sludge that is generated during sewage treatment is also regarded as a biomass resource, and by effectively utilizing the digestion gas that is obtained by anaerobically digesting sewage sludge to generate electricity, not only can fossil fuels be saved, but also a contribution can be made to cutting down on green house gas emission

Digested gas includes methane gas in percentage of 60 to 65%. Therefore decomposition of the gas by incineration or energy for power generator operation is much effective to reduce greenhouse effect by methane gas generated in the process of natural degradation.

Prediction of Optimistic Digestion Gas Volume Generated in MWSS Jurisdiction Areas

Population & Sewage Sludge Projection – Population projections are available from the 2005 MWSS Master Plan. Assuming a sewage water per capita of 180 l/d and a sludge generation rate of 1%, the potential sewage sludge generated in service areas of MWSS and MWSI are shown in **Table 10-1** and **Table 10-2** respectively.

Table 10-1 Potential Sewage Sludge Production in MWSS Territory in 2020

Area	Population	Potential Sludge Generation (m^3/d)
NCR	12,077,301	21,739
Cavite	1,179,874	2,124
Total	13,257,175	23,863
Rizal	4,672,308	8,411
Grand Total	17,929,483	32,273

Table 10-2 Potential Sewage Sludge Production in Maynilad Territory in 2021

Area	Population	Potential Sludge Generation (m^3/d)
NCR	8,302,484	14,944
Cavite	1,214,651	2,186
Total	9,517,135	17,131
Pranãque	479,089	862
Las Piñas	437,575	788
Subtotal	916,664	1,650

Calculations used for **Table 10-1** and **10-2** are done assuming that swage water per capita is 180l/d, and sludge generation rate is 1% of Influents flow rate.

Sludge Gas Production and Electric Power Generation - Gas production and power generation are estimated using the following conservative rates such as;

Daily Digesting Gas Production 0.06 x sewage influent rate (m^3/d)
Daily Gas Power Generation Rate 1.6 x digesting gas volume (kWh)

In MWSS territory, using the following assumption, the estimated sludge gas production and power generation in 2020 is shown n **Table 10-3**:

Water Supply Coverage 90%
Wastewater Effluent 80%
Sewerage Service Coverage
NCR 60%
Cavite 30%
Rizal 20%

Table 10-3 Sludge Gas Production and Electric Power Generation in MWSS in 2020

Area	Gas Production (m^3/d)	Power Generation (MWh/d)
NCR	78,260	125
Cavite	3,823	6
Total	82,083	131
Rizal	10,093	16
Grand Total	92,176	147

Similarly for the MWSI service area, using the following assumption, the estimated sludge gas production and power generation in 2020 is shown n **Table 10-4**:

Water Supply Coverage 91%
Wastewater Effluent 80%
Sewerage Service Coverage
NCR 60%
Cavite 30%
Parañaque 60%
Las Piñas 60%

Table 10-4 Sludge Gas Production and Electric Power Generation in Maynilad

Area	Gas Production (m^3/d)	Power Generation (MWh/d)
NCR	53,798	86.10
Cavite	3,935	6.30
Total	57,733	92.40
Prañaque	3,103	5.00
Las Piñas	2,837	4.54
Subtotal	5,940	9.54

Effectiveness as Mitigation Measure against Climate Change by Sludge Digestion

The methane gas produces in the process of sewage sludge digestion should be inflamed and/or used for the digestion gas power generation system, and consequently the methane gas is decomposed into CO_2 and H_2O. Since GWP_{CH4} is 21times GWP_{CO2}, this decomposition is effective for reduction of greenhouse gas effect by methane gas emitted during the course of CH_4 degradation.

The baseline emission of greenhouse gas is predicted by the following expression;

$$\mathbf{BE_y=(MB_y - MD_{reg.y}) \cdot GWP_{CH4} + BE_{EN.y}}$$

where:

BE_y: Baseline emission in year of y (ton CO_2 equivalent: tCO_2e)
MB_y. Generated methane gas volume in year of y（tCH_4）
$MD_{reg.y}$: Natural decomposition volume of methane gas in year of y (tCH_4)
GWP_{CH4}: Climate change Potential（$tCO_2e/tCH_4 = 21$）
$BE_{EN.y}$.: Electric power Substituted by methane gas power generation system in year of y（tCO_2e: 0.36tCO2/MWH by Federation of Electric Power Companies-FEPC in1999）

If 50% of the total methane gas production predicted in the sewage treatment plants in MWSS territory is decomposed by sewage sludge gas usage as bio-energy, the greenhouse gas reduction would be expected as follow.

Table 10-5 Reduction of Greenhouse Gas Effect (in MWSS: 2020)

Area	Methane gas generation (1,000t/yr)	Methane gas consumption				Total reduction of greenhouse gas (baseline emission) ($1{,}000tCO_2e/yr$)	
		CH4 consumed (1,000t/yr)	CO2 equivalent (1,000t/yr)	Gas Power Generation (Mwh/yr)	CO2 equivalent (1,000t/yr)	Inflamed	Plus gas power Generation
NCR	12.24	6.12	128.54	22,813	8.21	128.54	265.30
Cavite	0.60	0.30	6.28	1,095	0.39	6.28	12.95
Total	12.84	6.42	134.82	23.908	8.61	134.82	278.25
Rizal	1.58	0.79	16.58	2,920	1.05	16.58	34.21
Grand Total	14.42	7.21	151.40	26,828	9.66	151.40	312.46

Note: 1. Methane gas concentration is assumed 60%.
2. Because of daily treatment system of sewage sludge, $MD_{reg.y}$ should be neglected.

Table 10-6 Reduction of Greenhouse Gas Effect (in Maynilad: 2021)

Area	Methane gas generation (1,000t/yr)	Methane gas consumption				Total reduction of greenhouse gas (baseline emission) ($1{,}000tCO_2e/yr$)	
		CH4 consumed (1,000t/yr)	CO2 equivalent (1,000t/yr)	Gas Power Generation (Mwh/yr)	CO2 equivalent (1,000t/yr)	Inflamed	Plus gas power Generation
Pranãque	0.49	0.24	5.10	913	0.33	5.10	10.52
Las Piñas	0.44	0.22	4.66	829	0.30	4.66	9.62
Subtotal	0.93	7.50	157.00	16,863	6.10	9.76	320
NCR	8.42	4.21	88.36	15,713	5.66	88.36	182.38
Cavite	0.62	0.31	6.46	1,150	0.41	6.46	13.34
Total	9.96	12.02	251.83	33,726	12.17	104.58	215.86

Note: 1. Methane gas concentration is assumed 60%.
2. Because of daily treatment system of sewage sludge, $MD_{reg.y}$ should be neglected.

If MWSS is developing sewerage treatment system to cover 50% of residents in their territory and sewage sludge digesting system in the plants is integrated in the systems, reduction of greenhouse effect would reach at 312.46×10^3 tCO_2e /year in year of 2020, and Maynilad would devotes 215.86×10^3 $tCO_2.e$/year in 2021 to the reduction effect.

The role of digesting gas power generation system seems to be small in aspect of greenhouse gas effect reduction, but distribution to power consumption of sewerage system operation would be effective. The effect of the power reduction from the commercial power supply to the plant would reach at one third of total electric demand of the plant.

Possibility of CDM Application

Sewerage Treatment System contains principally of sewage treatment process, sewage sludge treatment process, sewage collection sewers, and sewage treatment system is essential to integrate into sewage treatment system. The sewage sludge digesting process is conventional and prevailingly adopted to much sewerage treatment systems in many countries. The main purpose of the process is to reduce total excess sludge volume, realize immunological security against virus or pathogenic bacteria, and digested sludge itself is very stable matters under appropriate conditions like dewatered or as acid soil, and shows sluggish turnover at least several decades. The digesting process is in anaerobic condition, thus in the process, sludge digestion gas is generated. The sewage sludge digesting gas containing around 60 to 65% methane gas, and methane gas is toxic, so the gas is stored in the gasholder after desulferizing process and then flared or used as gas power generator fuel. This treatment system eventually decomposes methane gas into innoxious CO_2 and H_2O. GOW of methane gas is 21 times CO_2, therefore this digestion process also dedicates as countermeasure against climate change.

The expected methane gas reduction generated in Parañaque and Las Piñas sewerage treatment systems could be $20KtCO_2e$/year. The possibility of CDM application of the sewage sludge digesting process was studied considering the Kyoto Protocol and the Clean Development Mechanism (CDM).

11.Capacity Building

The institutional study of MWSS and MWSI/MWSCI proposed an organizational improvement plan taking into consideration the current conditions of MWSI/MWCI, future sewage system plans, organization of the operation management departments, staffing arrangements and items such as: (a) operation and maintenance system, and (b) suggested enhancement of the corporate organization of MWSS, MWSI and MWCIL Such enhancement stresses asset management and a planning and overall managing office for the present MWSS organization, and the creation of a construction supervision group in the organization of MWSI and MWCI.

A training plan for MWSS is formulated as shown in **Table 11-1**, as well as for MWSI/MWCI shown in **Table 11-2**.

Table 11-1 Training Plan of MWSS

Necessary job description	Training contents	Training staff (persons)	Overseas training	Domestic training	Training period (month)	Training cost (peso)
Planning and Overall Managing Office	Learning of project adjustment methods, creating and reconsiders of master plan	2	○		3	1, 300, 000
Asset Management's Office	Learning of asset management methods for the entire sewage system	2	○		3	1, 300, 000
Tariff Study	Enhance the skills in calculating rates and analyzing financial information; gain knowledge on advance techniques in cost service, determination of Appropriate Discount Rate (ADR) asset usefulness and demand profiling	2	○		3	1, 300, 000
Total		6				3, 900, 000

Table 11-2 Training Plan of MWSI/MWCI

<table>
<tr><th colspan="3">Necessary job description</th><th>Training contents</th><th>Training staff (persons)</th><th>Overseas training</th><th>Domestic training</th><th>Training period (month)</th><th>Training cost (peso)</th></tr>
<tr><td rowspan="3">Fixed assets</td><td colspan="2">Sewerage Ledger Section</td><td rowspan="3">Preparation and amendment of sewerage ledger, learning of asset management methods for the entire sewage system</td><td rowspan="3">2</td><td rowspan="3">○</td><td rowspan="3"></td><td rowspan="3">3</td><td rowspan="3">1, 300, 000</td></tr>
<tr><td colspan="2">Ledger Management Section</td></tr>
<tr><td colspan="2">Asset Management Section</td></tr>
<tr><td rowspan="5">Design</td><td colspan="2">Planning Section</td><td rowspan="2">Learning of project adjustment methods, creating and reconsiders of master plan</td><td rowspan="2">2</td><td rowspan="2">○</td><td rowspan="2"></td><td rowspan="2">3</td><td rowspan="2">1, 300, 000</td></tr>
<tr><td colspan="2">Utility Coordination Section</td></tr>
<tr><td rowspan="3">Design Section</td><td>Civil Engineering Desk:</td><td>Design of civil engineering works, learning of works management techniques</td><td>2</td><td>○</td><td></td><td>3</td><td>1, 190, 000</td></tr>
<tr><td>Machine Equipment Desk</td><td>Design of machine equipment works, learning of works management techniques</td><td>2</td><td>○</td><td></td><td>3</td><td>1, 230, 000</td></tr>
<tr><td>Electrical Equipment Desk</td><td>Design of electrical works, learning of works management techniques</td><td>2</td><td>○</td><td></td><td>3</td><td>1, 290, 000</td></tr>
<tr><td rowspan="5">Treatment plants</td><td rowspan="2">Operation Management Section</td><td>Water Treatment Operation Management Desk</td><td>Learning of operation management techniques (including operation management of pump stations) for each treatment process</td><td rowspan="2">2</td><td rowspan="2">○</td><td rowspan="2"></td><td rowspan="2">3</td><td rowspan="2">1, 300, 000</td></tr>
<tr><td>Sludge Treatment Operation Management Section</td><td>Learning of operation management techniques for each sludge treatment process</td></tr>
<tr><td rowspan="2">Maintenance Inspection Section</td><td>Water Treatment Maintenance Desk</td><td>Learning of maintenance inspection work techniques (including maintenance inspection of pump stations)</td><td rowspan="2">2</td><td rowspan="2">○</td><td rowspan="2"></td><td rowspan="2">3</td><td rowspan="2">1, 290, 000</td></tr>
<tr><td>Sludge Treatment Maintenance Desk</td><td>Learning of maintenance inspection work techniques</td></tr>
<tr><td>Water Quality Management Section</td><td>Water Quality Test Desk</td><td>Learning of water quality test techniques necessary for operation management and techniques for giving advice to operation managers</td><td>2</td><td>○</td><td></td><td>3</td><td>1, 190, 000</td></tr>
<tr><td>Sewer Department</td><td>Maintenance Inspection Section</td><td>Sewer Maintenance Desk</td><td>Learning of design and maintenance inspection work techniques</td><td>2</td><td>○</td><td></td><td>3</td><td>1, 510, 000</td></tr>
<tr><td colspan="3">Total</td><td></td><td>18</td><td></td><td></td><td></td><td>11, 600, 000</td></tr>
</table>

12. Updating the Latest Master Plans of MWSS

The Metro Manila sewerage and sanitation master plan of 2005 is being updating and will take into consideration the latest MWSI & MWCI business plans, the MWSI's feasibility studies for areas like Imus, Cavite and the cities of Muntinlupa, Pasay, and Valenzuela and as well as. the results of the MMSSIP surveys and studies,.

The impact areas of MMSSIP is focused on Parañaque and Las Piñas cities. A comparison of the sewerage and sanitation targets of the updated 2008 Master Plan and the JICA development plan is shown **Table 12-1** below that shows substantial increase in the served population for sewerage and sanitation.

Table 12-1 Summary of JICA Sewerage and Sanitation Development Plan

Citys	Plans	Items	Year of							
			2006	2007	2011	2016	2021	2025	2031	2036
Parañaque	Master Plan	Population	542,411	557,857	592,440	633,857	669,860			
	(year 2008)	Sewerage Coverage	0%	0%	8%	16%	30%			
		Sanitation Coverage	28%	48%	45%	50%	70%			
	JICA Plan	Population	542411	552,660	592,440	633,857	669,860	700,130	724,267	740,871
	(updated)	Sewerage coverage	0.0%	0.0%	0.0%	59.2%	62.9%	64.1%	102.3%	100.0%
		Sanitation coverage	28%	48%	45%	40.8%	37.1%	35.9%	0.0%	0.0%
Las Piñas	Master Plan	Population	526,620	535,280	562,490	591,540	615,070			
	(year 2008)	Sewerage Coverage	0%	0%	9%	17%	37%			
		Sanitation Coverage	31%	48%	41%	44%	63%			
	JICA Plan	Population	526,620	532,330	562,490	591,540	615,070	633,127	645,662	652,737
	(updated)	Sewerage coverage	0.0%	0.0%	0.0%	0.9%	64.1%	103.5%	101.5%	100.0%
		Sanitation coverage	31%	48%	41%	44%	35.9%	0.0%	0.0%	0.0%

13. Financial and Economic Analysis

The financial and economic analyses established the financial and economic viability of the proposed Project aimed to provide full sewerage coverage for Las Piñas and Parañaque by 2036. The analyses aimed to establish the financial and economic viability of the recommended Project option.

The Philippine Government does not provide significant grants for sewerage systems. It cannot afford to pay for the major cost of such projects because of the huge capital investment. Annual investment in sewerage on a national level is a very small percentage of the total investment in water supply. Since 1970, for every PhP97 spent on water, only PhP3 has been spent on sanitation and sewerage (Data Source: 2005-2025 Sewerage and Sanitation Master Plan for Metro Manila).

Financial Conditions - Based on its financial statements, MWSI depicts a positive financial performance from 2007-2009 and it has continued to perform well during the first three quarter periods of 2010. The company has posted positive comprehensive incomes for the last three years with an average increase of 23 percentage points from its year-to-year financial performance. In 2009, the posted income was PhP 2.825 billion.

The MWSI proposed sewerage and sanitation project will impact on its financial situation in terms of increase in cost in capital or equity payments and related charges as interest and guarantee payments/ performance bond during the development or construction phase. MWSI, as the Company, can compensate for the 'shortage' from other financial sources (i.e. short term investments, current and non-current assets, sinking fund, etc)

Financing Schemes - Two schemes were considered for evaluation: 1) channeling the funds from JICA-OEC through the existing banks (i.e. Land Bank of the Philippines (LBP), Development Bank of the Philippines (DBP); or 2) through the MWSS. At present, the MWSI has a project with the World Bank of which the funds is being channeled through the LBP. The advantages and disadvantages of each scheme are still to be further evaluated.

Table 13-3 shows the advantages and disadvantages of the 2 financing options given the financial assumptions for each financing strategy. In Option 1, the MWSI has an ongoing Project with the World Bank (WB) with LBP as intermediary financing institution. Performance of MWSI should be assessed relative to achievement of targets and implementation of financing arrangement with the LBP, and LBP with the WB.

JICA-OEC Loan - Investments for proposed sewerage project will come from a loan from the Japan International Cooperation Agency–Overseas Economic Cooperation (JICA-OEC) with equity from the MWSI. Eight (8) technical design options of different investment estimates, technical soundness and service coverage were originally considered but only **Option 8** which is the recommended/technical design option was subjected to financial and economic evaluation. The profile of the recommended Option 8 is shown in **Table 13-1**)

Table 13-1 Profile of the Recommended Technical Design Option

Project Option	Design Population	Proposed Investment Cost in Php'000	Description
Option 8	Phase 1 – 427,932 Phase 2 – 387,557 Phase 3 – 426.291 Phase 4 – 237,850 Total – 1,479,630	Phase 1 – Php 6,249.00 Phase 2 – 5,677.00 Phase 3 – 6,714.00 Phase 4 – 3,964.00 Total - Php 22,604.00	The treatment districts are more finely divided into seven districts (5 treatment plants in Paranaque and 2 in Las Pinas). The plants are located in the locations designated by MWSI.

Financial Viability – With the assumptions shown in **Table 13-2**, the financial viability analysis for the recommended Technical Design Option 8 and Financing Option 1, indicated a non-viable project as the computed FIRR of 4.88% and WACC of 6.08% are below the APR of MWSI and the WACC of the Land Bank financing options.

Investing on sanitation and sewerage projects is not generally financially-attractive. But the fact that it is a basic service, it will significantly impact on the socio-economic conditions of the target populace in terms of health (i.e. reduction in morbidity and mortality cases), access to safe water and on some economic activities like tourism.

Economic Viability – The assumptions shown in **Table 13-3**, the economic viability analysis of the recommended technical and financing option indicated an economically viable project with an EIRR of 30% and economic BCR of 1.62. It remains economically feasible at a combination of 30% increase in project cost and 25% decrease in project benefits.

Table 13-2 Financial Assumptions Used in the Viability Computation

Financial Assumptions	Details
Period of Analysis	Period of analysis is 35 years for Financing Option 1 and 39 years for Financing Option 2 to accommodate the period of payments in Financing Option 2 which entails 10 years grace period and 10 years payment for the principal loan amount
Prices	Prices used is at 2010 current prices
Financing Mix and Financing Plan	Financing Mix used is 75% Loan and 25% Equity from MWSI Financing Option 1: 5% interest payment, 1% guarantee fund and 0.85% commitment fee of which start payment is at investment year. Grace period is 5 years while payment of principal loan will be for 10 years. Financing Option 2: 5% interest payment, 1% guarantee fund and 0.85% commitment fee of which start payment is at investment year. Grace period 10 years while payment for principal loan will cover 20 years. These assumptions, however, are still subject for validation.
Discount Rates	Separate computations based on the discount rate derived from the computation of the Weighted Average Cost of Capital (WACC) per financing option. Computed WACC for Financing Option1 is at 6.9 percent while Option 2 is at 4.21 percent. Another computation for financial viability used the 9.3 appropriate discount rate (APR) used by the MWSI in discounting it s equity for the project. The said APR was approved by the MWSS- Regulatory Office during its latest rebasing.
Construction Schedules and Development Phases	Phase 1 will be implemented in 2011-2018; Phase 2 will cover 2019-2024; Phase 3 will be constructed in 2025-2030 and Phase 4 in 2031-2036
Operating Cost (OPEX) Estimates	For purposes of computation, the total estimated OPEX is about 25 percent of the investment cost. Yearly OPEX is about 2.5 percent of the total estimated OPEX. This, however, is subject to revision upon the availability of recommended OPEX for the project.
Projected Water Revenues due to additional sanitation and sewerage service	Will be based on the design population and investment cost. On the average, additional cost to the water tariff is about Php 33.4 for the first 30 cubic meter consumption which can be translated to an additional Php25-Php28 to the monthly water bill. This is about 0.07 of the total amount of water tariff.

Table 13- 3 Assumptions in the Economic Viability Computations

Financial Assumptions	Details
Period of Analysis	Period of analysis is 35 years for Financing Option 1 and 39 years for Financing Option 2 to accommodate the period of payments in Financing Option 2 which entails 10 years grace period and 10 years payment for the principal loan amount
Prices	Financial prices were converted to economic prices using appropriate methodologies and conversion factors. Shadow exchange rate (SER) factor of 1.2 for traded components, and a shadow wage rate (SWR) factor of 1.6 for unskilled labor were used, consistent with the NEDA Investment Coordinator Board (ICC) standards. The above assumptions were applied specifically to the investment and operation and maintenance cost (or OPEX).
Economic Benefits Used in the Viability Computations	Benefits used in the viability computations were the following: • Avoided Cost on Medical Expense due to Water-borne related diseases • Savings due to reduction in Morbidity cases • Savings due to reduction in Mortality cases

14. Environmental Assessment

The MMSSIP-Phase 2 is an environmental enhancement and mitigation project which will primarily improve the quality of the receiving bodies of water bordering the catchment areas of Parañaque and Las Piñas towards Manila Bay. However, the project alone cannot impact significant improvement to Manila Bay unless wastewater collection and treatment systems in the adjacent sub-catchment areas discharging to the bay are to be improved as well.

During the construction period, there will be minimal and localized disturbance such as traffic, dust emission and noise in the surrounding areas primarily brought about by excavation and pipe laying works. Appropriate mitigating measures can be easily implemented to minimize any nuisance to the community. During operation, particularly in the treatment plant, problems on noise and odor may arise but may be mitigated by proper operation and maintenance procedures.

The significant environmental baseline information in the Project area are described for geology, land use, air quality, hydrology, water quality, flora and fauna, cultural heritage, indigeneous people and informal settlers. This will be the base data to compare changes in the environment resulting from project implementation and operation.

Related environmental tasks during project implementations are identified. For the pre-construction phases these are: (a) Secure the necessary government clearances and permits (i.e. ECC, building permit, discharge permit, etc.); (b) Conduct public information campaigns and consultation with the host communities and local government units; and (c) Purchase of the identified land lots and compensation for affected properties.

During the construction phase, the more important environmental mitigation measures are: (a) provision at the construction workers' camp site with adequate sanitation facilities and practice of good solid waste management; (b) iImplement worker and public safety programs by providing adequate precautionary lights/signages, safety devices, first aid kits, personal protective equipment (PPE); (c) install containment/security barriers along the perimeter of the construction site to minimize noise and dust propagation, as well as unauthorized access; (d) provide soil erosion and run-off controls; (e) establish worker and public safety programs; and (f) reduce/eliminate possible pollution sources.

At post construction, proper disposal of the construction debris, solid and liquid wastes, and any hazardous items need to be done. At the operation phase, the environmental concerns that need to be addressed include sewage conveyance and treatment, and the disposal of treated sewage and sludge.

The matrix of environmental aspects and corresponding impacts are presented in **Table 14-1** below.

The prediction of impacts covered the positive and negative impacts, socio-economic beneftes and risk assessment. The matrix of environmental aspect, impacts and corresponding mitigation and enhancement measures are presented in **Table 14-2**. The environmental monitoring plan is presented in **Table 14-3**.

Table 14-1 Matrix of Environmental Aspects and Corresponding Impacts

Activity	Environmental Aspects	Potential Environmental Impacts	Parameter Most Likely to be Affected	Significance of Impact			
				+/- (positive/ negative)	D/In (direct/ indirect)	L/S (long-/ short-term)	R/I (reversible/ irreversible
A. Construction Phase							
A1. Construction of Sewage Treatment Plant & Pump Stations	Earth-movement and civil/ structural works	Disturbance and/or displacement of flora and fauna	Flora and fauna	-	D	L	I
		Increased erosion	Land	-	D	S	R
		Generation of construction spoils and debris	Land	-	D	S	R
		Restriction or alteration of drainage flow	Water	-	D	S	R
		Siltation and increased turbidity on the affected water body	Water	-	D	S	R
		Generation of dust	Air	-	D	S	R
	Influx of construction equipment	Ground vibration	Land	-	D	S	R
		Generation of air emissions	Air	-	D	S	R
	Influx of construction personnel	Generation of solid wastes	Land/Water	-	D	S	R
		Generation of domestic wastewater	Water	-	D	S	R
		Increased occupational safety & health risks	People	-	D	S	R
		Disturbance on peace and order	People	-	In	S	R
A2. Pipe Laying Activities / Laying of Primary & Trunk Sewers	Road and drainage excavation	Increase in traffic	People	-	In	S	R
		Generation of dust, noise, and ground vibration	People, Air, Land	-	D	S	R
		Siltation and increased turbidity on the affected water body	Water	-	D	S	R
B. Post-construction/Operations Phase							
B1. Operation and maintenance of STP and Pump Stations	Treatment of raw sewage	Generation of hazardous wastes (i.e. chemical containers)	Land, Water	-	D	L	R
		Increase in air emission and noise levels	Air	-	D	S	R
		Increased risks to occupational safety	People	-	D	S	R

Activity	Environmental Aspects	Potential Environmental Impacts	Parameter Most Likely to be Affected	Significance of Impact			
				+/- (positive/ negative)	D/In (direct/ indirect)	L/S (long-/ short-term)	R/I (reversible/ irreversible
		Possible contamination of nearby water bodies and groundwater	Water	-	D	S	R
		Generation of sludges and biosolids	Land	-	D	L	R

Table 14-2 Matrix of Environmental Aspects, Impacts, and Corresponding Mitigation and Enhancement Measures

Activity	Environmental Aspects	Potential Environmental Impacts	Mitigation and Enhancement Measures	Responsibility	Cost	Guarantees
A. Construction Phase						
A1. Construction of Sewage Treatment Plant and Pump Stations	Earth-movement and civil/ structural works	Disturbance and/or displacement of flora and fauna	• Perform earth-balling for applicable tree species • Avoidance of unnecessary vegetation clearing	Contractor	Part of construction costs	MOA / EMP
		Increased erosion	• Avoid long exposure of open soil to wind and flowing water	Contractor	Part of construction costs	MOA / EMP
		Generation of construction spoils and debris	• Use of excavated soil as backfill material • Segregation of solid wastes according to re-usable, recyclable, and disposal items	Contractor	Part of construction costs	MOA / EMP
		Restriction or alteration of drainage flow	• Provide a temporary diversionary channel to allow continuous water flow of drainage channels	Contractor	Part of construction costs	MOA / EMP
		Siltation and increased turbidity on the affected water body	• Avoidance of disposing excavated items, washing of concrete-mixing equipment in drainage	Contractor	Part of construction costs	MOA / EMP
		Generation of dust	• Minimize/prevent unnecessary earth-movement • Regular watering of construction areas that have high dust generation potential • Establish construction containment barriers/buffer zones	Contractor	Part of construction costs	MOA / EMP
A1. Construction of Sewage Treatment Plant and Pump Stations *(cont'd.)*	Influx of construction equipment	Ground vibration	• Apply non-vibrating methods (i.e. bored piling) for areas that are near concrete structures • Monitor possible ground instability within the vicinity of the proposed Project	Contractor	Part of construction costs	MOA / EMP
		Generation of air	• Proper and regular maintenance of heavy	Contractor	Part of	MOA / EMP

Activity	Environmental Aspects	Potential Environmental Impacts	Mitigation and Enhancement Measures	Responsibility	Cost	Guarantees
		emissions	equipment		construction costs	
	Influx of construction workers	Generation of solid wastes	• Segregation of solid wastes according to re-usable, recyclable, and disposal items • Hauling of waste residuals by licensed waste service provider • Proper housekeeping at construction areas	Contractor	Part of construction costs	MOA / EMP
		Generation of domestic wastewater	• Establish a designated work area with sanitation facilities (i.e. portable toilets)	Contractor	Part of construction costs	MOA / EMP
		Increased occupational safety and health risks	• Provide construction personnel with adequate personal protective equipment • Supervision of civil and structural works • Provision of first-aid stations, safety equipment, and warning signages on working areas • Implementation of Emergency Response Plan	Contractor	Part of construction costs	MOA / EMP
		Disturbance on peace and order	• Establish a drug-free, anti-alcohol drinking, gambling, etc. system for construction personnel • Coordination with local police and peace and order councils	Contractor	Part of construction costs	MOA / EMP
A2. Pipe Laying Activities / Laying of Primary & Trunk Sewers	Road and drainage excavation	Increase in traffic	• Coordinate traffic procedures with the local barangay and city ordinances • All vehicles shall stay at the designated parking areas within the construction premises • Security personnel/traffic marshals will assist in directing traffic near the construction areas	Contractor	Part of construction costs	MOA / EMP
		Increase in noise and dust emission	• Excavate by segment and rehabilitate areas as soon as possible			

Activity	Environmental Aspects	Potential Environmental Impacts	Mitigation and Enhancement Measures	Responsibility	Cost	Guarantees
			•			
		Siltation of drainage	• Collection and proper disposal of spoils • Store excavated materials properly			
B. Post-construction/Operations Phase						
B1. Operation and maintenance of STP and Pump Stations	Treatment of raw sewage	Generation of hazardous wastes (i.e. containers)	• Segregation of hazardous wastes from regular wastes • Storage of hazardous items on sealed, sturdy, and properly-marked containers	MWSI	Part of operations costs	MOA / EMP
		Increase in air emission and noise levels	• Establishment of air pollution controls fro genet • Proper maintenance of equipment to minimize noise and vibration • Capture of methane gas	MWSI	Part of operations costs	MOA / EMP
		Increased risks to occupational safety	• Provide personnel with PPE (i.e. goggles and masks) • Extensive training for selected personnel in handling and operating chemicals	MWSI	Part of operations costs	MOA / EMP
B1. Operation and maintenance of STP and Pump Stations *(cont'd.)*	Treatment of raw sewage *(cont'd.)*	Possible contamination of nearby water bodies and groundwater	• Proper operation of the STP to ensure discharge shall meet standards • Provision of containment barriers and spill response procedures in case of chemical spills	MWSI	Part of operations costs	MOA / EMP
		Generation excess sludges and biosolids	• Stabilize sludge prior to disposal through certified sludge treaters • Provide good sludge drying procedure	MWSI	Part of operations costs	MOA / EMP

Table 14-3 Matrix Summary of the Environmental Monitoring Plan

Concern	Parameter to be Monitored	Sampling Measurement Plan			Responsibility	Estimated Cost
		Method	Frequency	Location		
A. Pre-construction Phase						
A1. Area of land to be developed	Hectares	Land survey	Twice (preliminary and final survey)	Identified STP and pumping station sites	Design contractor	Part of design costs/ feasibility study
A2. No. of properties to be affected	Hectares of land, no. of built structures	Land survey	Twice (preliminary and final survey)	Identified STP and pumping station sites	Design contractor	Part of design costs/ feasibility study
A3. Public perception and acceptability	No. of valid concerns or complaints	Public consultation/ survey	Variable (depending on the	Affected local communities	MWSI	Part of design costs/ feasibility study
B. Construction Phase						
B1. Siltation of nearby water bodies	Water turbidity, sediments	Visual observation/ water quality sampling	Daily (for visual observation), monthly (for water quality testing)	Nearby affected water body	MWSI contractor	Minimal (for visual observation), PhP 5,000 to PhP 10,000 per water sampling activity
B2. Air quality	Dust and noise *Odor**	Digital sound level meter; **Subjective odor assessment*	Daily	Immediate vicinity of the construction sites	MWSI contractor	Minimal (for visual observation), PhP 5,000 air and noise sampling activity
B3. Occupational and public safety	No. of injuries, no. of safety man-hours	Log-book recording/ database registration	Daily	Within the construction zones	MWSI contractor	Part of construction costs
C. Post-construction and Operational Phase						
C1. Sewage intake and discharge	Volume (m^3) of raw and treated sewage	Meter reading	Daily	Within the STP and PS sites	MWSI	Part of operations costs
	BOD, COD, TSS, pH, heavy metals, oil and grease, surfactants, total coliforms	Laboratory analysis	Daily	Intake and outlet ports of the STP	MWSI	Part of operations costs
C2. Sludge generation	Volume (m^3) of sludge generated	Log-book recording/ weighing	Daily	Within the STP	MWSI	Part of operations costs
	Moisture content, heavy metals, total coliforms	Laboratory analysis	Weekly	Within the STP	MWSI	Part of operations costs

15. Social – Institutional Assessment

The social and institutional assessments seek to provide a social impact assessment on the proposed sewerage project for Parañaque and Las Piñas in order to determine the social safeguards that need to be addressed, particularly involuntary resettlement and compensation, before the project initiates any development activity concerning civil works, construction and other operation works.

In most infrastructures development project, the adverse social impacts result in involuntary settlement, land and right-of-way acquisition and damage to or loss of assets. For the MMSSIP, these compliance to the various categories of these impacts are addressed during the pre-construction stage. There are existing policies and laws (e.g. 1985 Executive Order 1035, Supreme Court Ruling 1987, RAs 6389, 7279 & 8974) that set the guidelines and procedures of addressing the adverse social impact.

The social impact assessment (SIA) is a validation of the "likely impacts" of the Project. An initial SIA checklist of 12 items to determine if the project has adverse social impacts that require social safeguards compliance indicated most of the items required no resettlement action plan and not applicable. An initial social impact assessment of the various project components identified the potential impact and social safeguard compliance as shown in Table 15-4. A social development plan is presented in Table 15-5 that identified the responsible community member / beneficiary and government agency responsible in addressing the social concern.

A perception survey was conducted amongst barangay officials at the STP sites as well as officials of randomly selected barangays. The survey results indicated a relatively low awareness of the project but perceived the significant benefits of the Project.

The social impacts (positive and negative) of the proposed Project were determined during the construction and operation phases of the Project facilities. Recommendations of future activities to address these impacts were listed that includes sustained consultations with the affected populace.

16. Regulatory and Legal Review

The important rules and regulations governing sewerage and sanitation undertakings in the Philippines were reviewed, namely: Philippine Code of Sanitation, the Clean Water Act (CWA), the Philippine Environmental Impact Statement (EIS) System and other regulatory and permitting requirements.

The Sanitation Code of 1975 is the basis of rules and regulations on health and sanitation. In 2008, the DOH issued the Operations Manual for Chapter XVII prescribing the approved methods of handling, transport and treatment of domestic sludges and septage from sewage treatment plants (STPs) and septic tanks. The CWA primarily addresses the abatement and control of pollution from land-based sources and covers all water bodies such as fresh, brackish, and saline waters, and includes aquifers, groundwater, springs, creeks, streams, rivers, ponds, lagoons, water reservoirs, lakes, bays, estuarine, coastal and marine waters. The EIS System requires Proponents of projects with potential impacts on the environment to obtain an Environmental Compliance Certificate (ECC) as a prerequisite for implementation. A sewerage project, although considered as environmental enhancement initiatives is still covered by the EIS system.

The CWA specifies mandatory connection of residential and commercial establishments' sewage outfalls to existing sewerage systems. However, there remains a resistance to connect and as an incentive the MWSS/MWSI, in 2008, reduced the sewerage fee to 20% of the water bill from the previous 50%.

On the basis of the CWA, the Supreme Court, on the case of MMDA and other government agencies versus concerned residents around Manila Bay, issued a *mandamus* for the immediate cleanup of the bay. In response, a Water Quality Management Area (WQMA) was formed covering the Parañaque and Las Piñas river basins. The WQMA enables the integration of water quality management framework through coordination of functions of various agencies. The sewerage project for Parañaque and Las Piñas will be an integral component of the WQMA action plan and will be a milestone commitment of MWSI being part of the Technical Secretariat.

The MWSS Concession Agreement (CA) with MWSI, which in April 2010 was extended up to 2037 accelerated sanitation and sewerage coverage targets to comply with the *mandamus* of the Supreme Court for Manila Bay Sewerage coverage will be 100% by 2036 with 66% coverage by 2021. These targets are regional and may already supersede the specific sewerage coverage target for Parañaque and Las Piñas (i.e., only partial sewerage coverage were committed by MWSI in its 2008 Business Plan to these 2 LGUs).

The detailed flowchart for EIA application, review and ECC issuances specified in the DENR procedural manual is presented (Figure 16-2). The flowchart shows the submission requirements and logical process for approval and denial. The checklist for Initial Environmental Examination (IEE) is presented.

17. Conclusions and Recommendations

This preparatory survey report concludes and recommends the viable proposals for sewerage and sanitation system development projects to be established in Parañaque and Las Piñas Cities which would likely be accepted by the stakeholders, such as relative agencies like LGUs, DOH, DENR, NEDA, DPWH, etc., MWSS or MWSI as the proponent and also entrepreneur, local residents, and so on. However, there would be also hurdles, obstacles, hampers or obstructions to be overcome.

1) Financial and Budgetary Matters

The project alternatives proposed are aiming cost effective, operationally efficient, and functionally sufficient sewerage system establishment, which finally would cover 100 percent households in the cities. However, the following matters should be considered:

i) MWSS and MWSI are now rushing up to develop sewerage and sanitation services in their jurisdiction areas within rather short period. These urgent implementation programs should be reflected by financial and budgetary consideration. MWSS envisages 100% service coverage with separate sewer collection systems by finishing concessionaires' agreements, year 2036, and this conversion from combined sewer collection systems will require additional huge expenses.

ii) Most sewerage treatment system plans adopt combined sewer collection system, because of low capital investment cost and fast completion of construction, that is, fast commencement of the services. In this system connection of house holds' drain pipe to the sewer lines is not required. The service charge shall be levied on the all residents in the area, but the service charge payment exception could not be applied to any individual household; therefore it is difficult to charge the sewerage tariff to the households without water supply connection or to the residents who cannot afford to pay or are not willing to pay.

2) Operation of Sewerage Treatment Service Works

The rapid development of the sewerage treatment systems also requires sufficient areas for the sewage treatment plants. More operation and maintenance technicians will be necessary to cater for keeping good performances of the services. Thus the following consideration shall be made.

ⅰ) The land procurement for sewage treatment plants will need the business negotiations with land owners. In case that the negotiation fails, the project implementation plans shall be modified or partially re-planned.

ⅱ) The sewage sludge treatment process will be constructed together with sewage treatment process. Maynilad plans to implement septage treatment plants for sanitation services as a transition measure before the sewerage services are completed or to cover the areas not in the plan by sanitation services. MWSI need to harmonize the septage treatment plant implementation with progress of the sewage treatment plants construction program, because septage treatment system would require some modifications to accept sewage sludge.

ⅲ) The fast-paced development of the sewerage treatment services will necessitate augmentation of technical staffs together with administrative staffs. And the new management and operation technologies especially sewage sludge treatment systems with methane gas utilization shall be trained on the staffs.

ⅳ) Central Supervisory and Data Acquisition Systems by using Web recommended in the MWSI Master Plan (year 2008) should better be introduced as earlier as possible. The system would comprehensively support effective and efficient operations of current and future sewage treatment plants with the ancillary facilities.

3) Technical Matters

The project alternatives proposed here were done without detail design based investigations in the field, due to constraints for the preparatory surveys, like short time study and difficult permission to enter in specific areas. Thus the following items should be reviewed at the design stage when the project implementation programs are approved and the substantial project components are come out.

ⅰ) In Metro Manila, outside personnel are not allowed to enter in the STP candidate sites until completion of contract for the land procurement transaction, thus topographical and geographical investigations of the site are impossible. Therefore measurements and soil analysis of STP sites shall be done when MWSI has procured them. The cost estimate of civil works are tentatively made with figures prevailingly in Metro Manila

ⅱ) The interceptors are planned to be installed near the river or creek sides, however there are many congested areas in the identified project sites, such that the original plan should be studied at the design stage.

ⅲ) The STP alternatives are proposed with emergency power generator set. The capacity of the set is planned to cater for the least emergency power loads

ⅳ) Tidal stream may affect conversion manholes installed at respective outfalls, in case that the outfalls gone underwater at the high tide, the diversion manhole pumps shall be installed instead

4) Conclusions and Recommendations

Need for sanitation and sewerage improvement - The pollutant load is projected in Year 2036 at 62.7 t/d, which is 1.28 times higher than the value in 2007. With the implementation and operation of sewerage, the pollution load is projected to decrease to 5.6 t/d by 2036.

Surveys and Alternative Planning and Design - Based on maps and extensive field inspections, the drainage sub-basins of the Project area were delineated and the alternative sites of treatment facilities were identified and evaluated. The analysis of a range of applicable sewage treatment technologies resulted in the selection of Sequencing Batch Reactor (SBR) and Oxidation Ditch (OD) as the technology most suitable for the Project considering the space constraint, costs and manageability.

The extensive site analysis for the Project target area delineated 6 major sub-basins with areas area ranging from 249 to 2,979 ha. There are 36 sub-sub-basins in the largest sub-basin with area ranging from 15 to 416 ha. These sub-basins were further subdivided into smaller basins. The wastewater flow rates calculated from these sub-basins range from 14,170 to 250,852 m^3/d. On the basis of flow rate, available space and costs, the appropriate treatment process was designed for each site.

Some eight (8) alternative options or cases were developed for the sewerage system of the Project area. These cases were subjected to a selection criteria matrix and Case 8 was considered the most viable option.

The recommended project is planned for a four-phase implementation (detailed design, procurement, construction and operation) in the period 2013 to 2036. Construction duration of the various facilities are presented.

5) Financial and Economic Analysis

Investing on sanitation and sewerage projects is not generally financially-attractive. But the fact that it is a basic service, it will significantly impact on the socio-economic conditions of the target populace in terms of health (i.e. reduction in morbidity and mortality cases), access to safe water and on some economic activities like tourism.

The recommended Option (8) has a FIRR of 4.88% which is not viable when based on the MWSS APR of 9.3 percent and computed weighted average costs of capital or WACC of 6.08 percent. Recovery of investment can be sourced by MWSI from its other financial activities like revenues for short term investments. As long as the high collection efficiency rate of 97 percent is maintained by the MWSI, possibility of cost recovery for the project will be achieved.

In terms of economic viability, the said Option is economically feasible. Based on the sensitivity/risk analysis conducted, it can remain economically feasible up to a combination of 30 percent increase in project costs and 25 percent decrease in project benefits.

On one hand, an updated WTP should be conducted in the target cities to determine the degree of willingness and the affordability to pay of the residents and commercial establishments in said areas.

6) Environmental Assessment

All proposed project options will impact the environment positively, most notably the water bodies surrounding Parañaque and Las Piñas. The main purpose of the Project, regardless where its components are built and operated, will reduce the amount of pollutants that degrade the water quality of the creeks, rivers, and portions of Manila Bay. The Project, once fully-established, shall improve the poor state of the waterways of Parañaque and Las Piñas. This in turn could result reduction of environmental and public health costs, thus improving the local economies of the community. The proposed Project's positive impacts on the environment outweigh the negative impacts.

7) Social and Institutional Assessment

The social and institutional assessment established the social safeguards that need to be addressed, particularly involuntary resettlement and compensation, before the project initiates any development activity concerning civil works, construction and other operation works. The assessment also addressed the land acquisition and resettlement on the affected areas of the Project, particularly, the informal settlers.

8) Regulatory Review

The important rules and regulations governing sewerage and sanitation undertakings in the Philippines which may be applicable to the proposed sewerage project were reviewed. There are pertinent provisions of recently passed laws and administrative orders that may have impacts on the development and implementation of existing and future sanitation and sewerage projects of MWSI.

Reviews on the Clean Water Act and the *mandamus* issued by the Supreme Court of the Philippines on the Manila Bay cleanup have impacts on the on-going and future undertakings of MWSI.

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MEASUREMENT UNITS

Length			Time		
mm	-	millimeter	s, sec	-	second
cm	-	centimeter	min	-	minute
m	-	meter	hr	-	hour
km	-	kilometer	dy	-	day
			mon	-	month
			yr	-	year
Area			**Volume**		
sq m	-	square meter	cum	-	cubic meter
sq km	-	square kilometer	l, ltr	-	liter
ha	-	hectare	mcm	-	million cubic meter
Weight			**Speed**		
g, gr	-	gram	cm/s	-	centimeter per second
kg	-	kilogram	m/s	-	meter per second
t	-	ton	km/h	-	kilometer per hour

1 INTRODUCTION

This Section presents the project background, objectives of the Surveys and Feasibility Study, scope of the Preparatory service, the Project area coverage and its current conditions, and the priority of work implementation.

1.1 Project Background

The sewerage situation in the Philippines as of 2000 stands at approximately 4 percent nationwide and 10 percent in Metro Manila, and the large majority of the households uses onsite facilities such as septic tanks for sewage treatment. Since most household wastewater is directly discharged into drainage channels, the pollution of channels and rivers advances significantly. Moreover, due to inadequate maintenance of septic tanks, treatment capability deteriorates and there is concern over the impact on the pollution of groundwater.

Considering that more than 10 percent of the national population (88.57 million in August 2007 census) resides in Metro Manila, the population density here is extremely high, and as it is expected to continue increasing dramatically in future, there is urgent need to construct and install sanitation facilities. Development of the sewerage sector has been slow in the past; however, it is most important to conduct sewage and wastewater treatment in urban development. The MWSS, which is the official regulatory and supervisory agency for sanitation and sewerage in Metro Manila, needs to promote appropriate project implementation based on its master plan with 2025 as the target year.

Regarding the sewerage utility in Metro Manila, although the MWSS sewerage and sanitation master plan exists, this is not kept up to date. Among the factors contributing to the slow development of the utility are that the public and private investment in the sanitary sector is insufficient to cover the massive costs of the sewerage utility, and operators are unable to secure sufficient funds based on collection of sewage treatment tariffs. In order for the sewage treatment utility to cover the entire Metro Manila jurisdiction of MWSS, treatment capacity of 2,400,000 m^3/day is required, however, as of 2003 the existing facilities of MWCI and MWSI only have the capacity to treat approximately 60,000~80,000 m^3/day.

Regarding support provided by JICA to the sewerage sector in the Philippines, it has so far conducted the Metro Manila Water Supply and Sewerage Master Plan Study, constructed sewerage and sanitation management facilities in mostly provincial cities via grant aid and yen loans, and conducted support for water quality improvement and water quality management via technical cooperation. Also, from April to August in 2009, JICA implemented the Preparatory Survey for Metro Manila Sewerage and Sanitation Improvement (MMSSIP) Phase I, which aimed to collect information on development plans, project realization plans and support for sewerage system construction and sanitary environmental improvement in Metro Manila and to offer recommendations geared to realizing projects for sewage treatment and drainage facilities, river purification and sanitary environmental system improvement based on the local needs.

As a result of the MMSSIP-Phase I, the Philippine Government expressed its interest in the implementation of a yen loan project in Metro Manila, covering Parañaque City (including parts of Manila and Pasay), Las Piñas City and Cavite City. Accordingly, a request was made for support concerning the updating of the MWSS master plan, formulation of a feasibility study on construction of a sewerage system targeting the above areas, and determination of an effective method for utilizing sludge generated in Metro Manila.

1.2 Project Objectives

The goals of the JICA Technical Assistance are aimed to provide a safe environmental setting for the long-term growth of Metro Manila, to assist economic and industrial growth in Metro Manila, and improvement of public health and hygienic situation in the urban areas.

Within this framework, the specific objectives of the Project are to:

a) Enhance wastewater, municipal solid waste management, human waste and storm water management,
b) Reduce pollution, facilitating pollution control,
c) Expand wastewater treatment and water quality monitoring,
d) Improve municipal wastewater utility financial management, and
e) Support training, feasibility studies and future investment for the sewerage and sanitation improvement projects in the project area.

Thus, the direct objectives of this survey and study work are;

a) Supplemental assistance to MWSS to update the current master plan,
b) Conduct feasibility study for sewerage and sanitation improvement projects in Parañaque and Las Piñas cities,
c) Collection of environmental information and basic data of sewerage and sanitation in the target project areas;
d) Prepare alternatives of sewerage and sanitation system project components in Parañaque and Las Piñas catchment areas with conceptual designs and cost estimates as investment project packages, and
e) Prepare the project implementation and operation/maintenance plans in the project areas for consideration by Japan ODA fund.

1.3 Scope of Preparatory services

The JICA mission visited the Philippines in January 18-20, 2010 and had discussion on the draft Implementation Program of JICA Preparatory Survey for Metro Manila Sewerage and Sanitation Improvement Project with officials of Metropolitan Waterworks and Sewerage System, and the two concessionaires, namely: Maynilad Water Service Inc. and Manila Water Company Inc. Based on these discussions, both the JICA and the Philippine Government agreed on the Implementation Program of the Survey for preparation of the Metro Manila Sewerage and Sanitation Improvement Project.

Accordingly, JICA selected Original Engineering Consultants Co., Ltd. (OEC) as the surveyor firm and dispatched a team to carry out the survey works. The team included the following expatriates.

- Team Leader (Sewerage and sanitation planning expert)
- Sewerage System Planning (Construction planning expert)
- Sewerage Management (Operation and maintenance expert)
- Financial Analysis (Cost and benefit analysis expert)
- Legal analysis (Contract analysis expert)
- Environmental Consideration (Environmental specialist)
- Social Consideration (Social specialist)

The technical assistance through the Consultant services aims to execute tasks and duties defined by JICA, as their cooperative activities to MWSS, in order:

a) to assist MWSS and MWSI in preparing the implementation plan including project scope, cost estimates, implementation program and draft Environmental Impact Statement (EIS) of the Project in Paraňaque and Las Piňas river basins,

b) to assist MWSS and MWSI in collecting basic information/data on the Project in Cavite City for the future formulation of the project,
c) to recommend MWSSS, MWSI, MWCI, the appropriate implementation arrangements by identifying the agency responsible for project management both during construction and after completion of the investment project,
d) to assist MWSS in incorporating the current business plan of MWSI and MWCI into its Master Plan,
e) to recommend MWSS the capacity building plan in order to strengthen its competence for the planning/monitoring/implementation of the sewerage and sanitation development in Metro Manila,
f) to assist MWSS, MWSI and MWCI in formulating the appropriate tools and mechanisms for “Bio Solid Management” to be implemented under the Project, and
g) to recommend to MWSS, MWSI, MWCI and other concerned agencies such as Metro Manila Development Authority (MMDA), the relevant subprojects such as Solid Waste Management and River Cleaning with the appropriate information and education campaign (IEC) to be implemented as a pilot sub project under the MMSSIP in order to get synergistic effect.

1.4 Basic Policy of Work Implementation

The basic policy of work implementation is to propose a specific, effective and efficient sewerage and sanitation management system through implementing the project objective of a general study of sewage, sanitation improvement and solid waste management in Las Piňas City and Paraňaque City. To this end, it is essential that the proposed project components are realistic and sustainable. Accordingly, when advancing the study work, consideration must be given to past projects, future plans and current conditions in Metro Manila.

1.4.1 The Project Coverage Area

The Project covers the whole areas of Parañaque and Las Piñas Cities, which are included in Maynilad business jurisdiction. This area is within the Parañaque and Las Piňas River basins. The total area is 7,734 ha with 4,544 ha in Parañaque City and 3,190 ha in Las Piñas City. **Figure 2-1** shows the Project area boundary. The potential population of sewerage coverage in 2010 is around 1,170,000, consisting of 600,000 in Parañaque and 570,000 in Las Piñas. At the end of the concession period in 2036, the projected population is estimated at 1,390,000 distributed as 740,000 and 650,000 respectively in Parañaque and Las Piñas.

The effluent of wastewater generated in the two cities under the jurisdiction of Maynilad is highly polluting the river water, consequently Parañaque River, one of main rivers, has been identified as one of the major pollution source of Manila Bay.

At this moment, effective sanitation systems or facilities are non-existent except individual septic tanks, but not all of the households, thus Maynilad is undertaking septage collection service in this area.

The waterways in the project area consist mainly of the rivers, creeks shown in **Table 2-1** and indicated in **Figure 2-2**. Wastewater generated in the reclaimed land area in Paranaque, Barangays Baclaran, Tambo and Don Galo, and part of La Huerta in Parañaque City is discharged into Redemptorist Channel and Baclraran Channel, and in the other areas is discharged into rivers, creeks or esteros and finally discharged into Manila Bay through

Paranaque Channel. Wastewater in Las Piñas is finally discharged into Manila Bay through three rivers, Las Pinas, Balot and Zapote River.

Table 1-1 Main Rivers and Tributaries in Parañaque and Las Piñas

	Final Effluent to Manila Bay	Main Rivers (Creeks)	Tributaries
Parañaque	Redemptorist Cannel		
	Baclaran Channel		
	Parañaque Channel	Parañaque River	Cutcut Creek Ibayo Creek Maricaban Creek (Pasay) Tripa de Gallina (Pasay)
		San Dionisio River	Villanueva Creek Sapang Buwaya Creek Baloc Baloc Creek Almanza Creek (Las Piñas)
		Kay Boboy Creek	Dahlig Creek
		Don Galo River	Liboh Creek Baliway Creek Merville Creek Paete Creek
Las Piñas	Las Piñas River	Las Piñas River	Kay Kanti Creek Naga Creek Manarigo Creek Tartar Creek Kay Almirante Creek Talon Creek
	Balot River		Tung Tong Creek Maruras Creek
	Zapote River	Zapote River	Sin Nombre Creek Pasong Baka Creek

Maynilad has prioritized the project implementation program in most polluted river basins including Parañaque River and Las Piñas River to improve the water quality of Manila Bay coastal areas.

Feasibility study of Parañaque and Las Piñas Cities sewerage and sanitation improvement project has been initiated by JICA Project “Preparatory Survey of Metro Manila Sewerage and Sanitation Improvement Project (MMSSIP) conducted in 2009, and designated as MMSSIP Phase 2. Regarding Parañaque and Las Piñas cities, sewerage treatment service plan was not made in the MWSI business plan in 2007 and in the revised business plan in 2008. The plan aims sewerage service coverage in whole business area at 43% to 66% by 2021. As small population of 24,000 people in total out of whole residents in Parañaque and Las Piñas are only planned to be involved in the revised sewerage service business plan.

This Project is a feasibility study to develop the sewerage treatment service coverage in the project areas as much as possible reaching to whole project areas; taking into consideration MWSI plan for sewerage coverage to almost 100% of population by 2036.

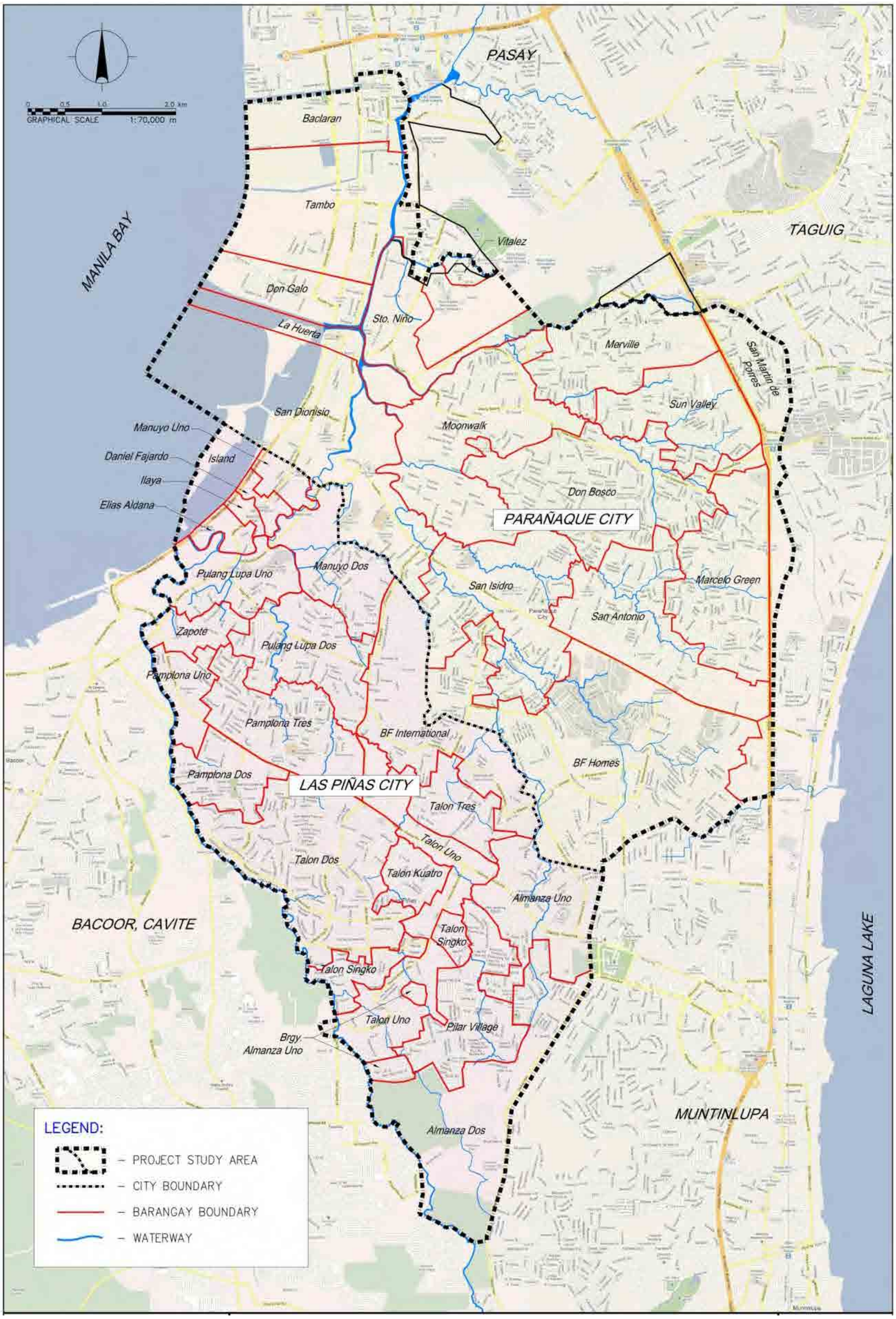
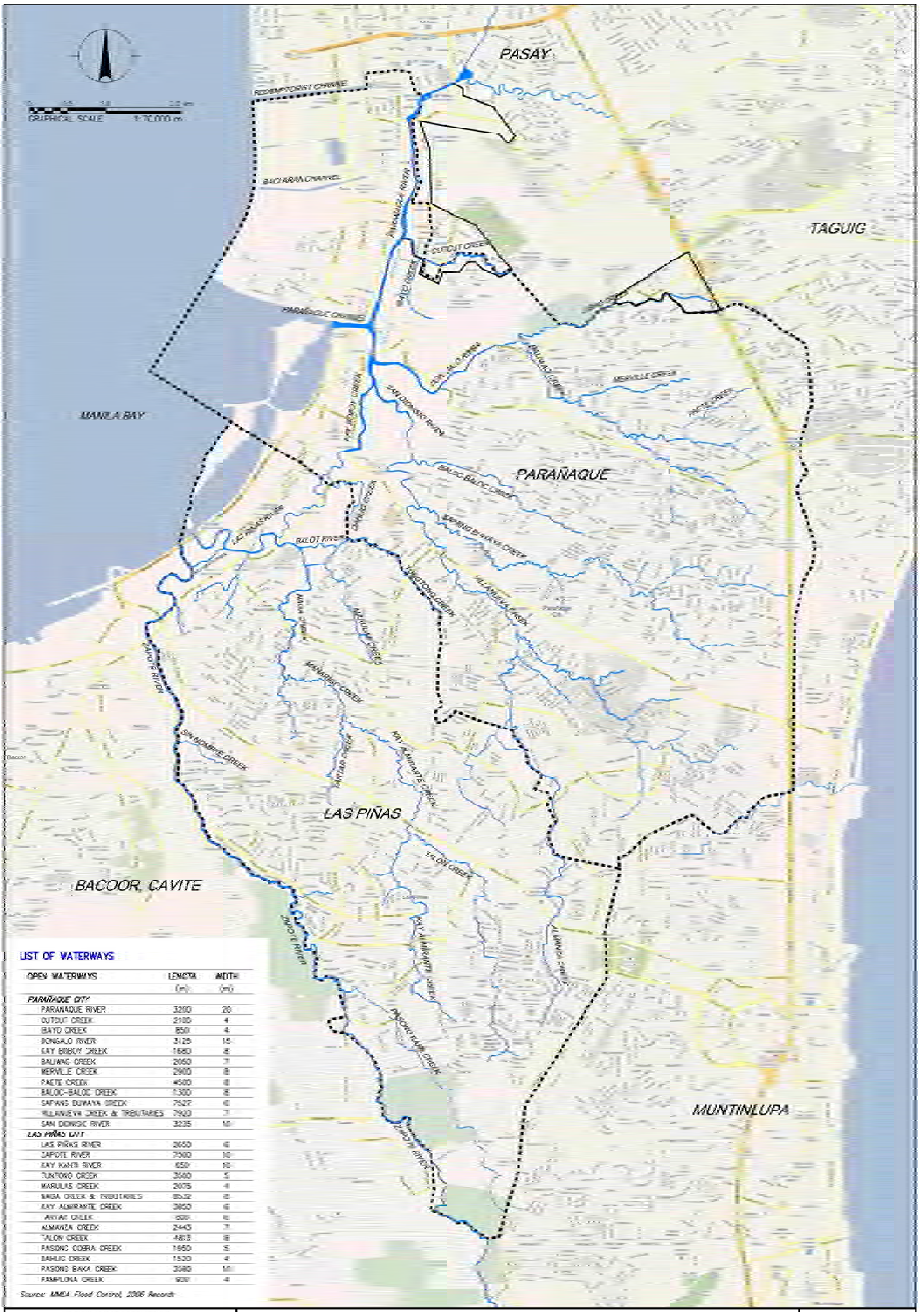


Figure 1-1 The Project Coverage Area



OPEN WATERWAYS	LENGTH (m)	WIDTH (m)
PARAÑAQUE CITY		
PARAÑAQUE RIVER	3200	20
CUTCUT CREEK	2100	4
IBAYO CREEK	850	4
DONGALO RIVER	3125	15
KAY BIBOY CREEK	1680	8
BALIWAG CREEK	2050	7
MERVILLE CREEK	2900	8
PAETE CREEK	4500	8
BALOC-BALOC CREEK	1300	8
SAPANG BUWAYA CREEK	7527	6
VILLANUEVA CREEK & TRIBUTARIES	7920	7
SAN DIONISIO RIVER	3235	10
LAS PIÑAS CITY		
LAS PIÑAS RIVER	2650	6
ZAPOTE RIVER	7500	10
KAY KANTI RIVER	650	10
TUNTONG CREEK	3500	5
MARULAS CREEK	2075	4
NAGA CREEK & TRIBUTARIES	8532	6
KAY ALMIRANTE CREEK	3850	6
TARTAR CREEK	800	6
ALMANZA CREEK	2443	7
TALON CREEK	4813	8
PASONG COBRA CREEK	1950	5
BAHUG CREEK	1520	4
PASONG BAKA CREEK	3580	10
PAMPLONA CREEK	900	4

Figure 1-2 Rivers and Tributaries in the Project Area

1.4.2 Current Conditions in the Project Area

The current environmental conditions available to the Consultant Team at the beginning of the project assignment are described below. Validation work for this background information was made as the first step of the Consultant tasks.

1) Understanding the Current Conditions in Metro Manila

Metro Manila has a population of approximately 12 million, and most of the generated household sewage is discharged without undergoing treatment. The major receiving bodies of sewage in Metro Manila are Manila Bay, Pasig River and Laguna Lake. In the project target area, the main sources of pollution discharging untreated sewage into Manila Bay are Parañaque River, Las Piñas River, and creeks and esteros in Cavite project area. These streams impart serious water pollution that impacts to residents including water-borne diseases and vector-borne diseases such as diarrhea, dysentery, cholera and typhoid, etc. and malaria carried by mosquitoes attracted to the sewage. Such impacts are causing immeasurable damage to the health of residents and to the economic activities.

Manila Bay is composed of the Metro Manila western coastline and the shallow ocean area used for marine transportation. It is the water body into which wastewater flows from 26 districts, and it is the final receiving body for household and industrial wastewater, agricultural overflow water and oil leaks. Roughly 21% of the organic pollutant load flowing into Manila Bay originates from the Pasig River basin, while approximately 82 percent of sanitary sewage in Manila is discharged into Manila Bay via the Tondo Pump Station.

Laguna Lake in the south of Metro Manila is an important water source for the southern districts; however, 60% of household wastewater and garbage in the catchment area is discharged directly into the Lake or its tributary rivers. Pollution from residential areas arises because approximately 70% of the organic load is directly discharged into the Lake. Pasig River is the sole outlet from Laguna Lake, however, depending on the tide level in Manila Bay, pollutants move back and forth between the two water bodies.

Land south of Pasig River in Metro Manila (the present concession area of MWSI and the main project area) is low-lying and wastewater sometimes flows back up drainage channels when Manila Bay is at high tide. The water level also rises in rivers, causing backflows to occur in the drainage channels that feed them. In the eastern portion under the jurisdiction of MWCI, wastewater collects in lowland parts (Marikina City, etc.) and such areas suffer from perennial flooding at times of heavy rainfall.

Storm water drainage channels in Metro Manila are insufficient and have small drainage capacity due to poor maintenance and garbage dumped by residents. Consequently, channels become inundated at times of typhoons and heavy rains irrespective of the height of the terrain. Furthermore, rivers on the Manila Bay side are constrained in their drainage capability when the bay is at high tide.

Around 23 million people live in the three main catchment areas including the Manila Bay coastal area. The bay area is a source of food, means of livelihood, provider of employment and place of recreation. Moreover, the Manila Bay watershed accounts for 55% of the national GDP and one-third of national production in the agriculture, forestry and fisheries sectors. It can thus be appreciated how important the sewerage and sanitation project is in three out of the five major sources of pollution in Manila Bay.

2) Situation of Sewage and Sanitation Projects in Metro Manila

The MWSS Metro Manila Sewerage Master Plan was prepared in 1979 in order to reinforce the MWSS Master Plan of 1960. In line with this, the sewerage projects: Metros-1 to Metros-5 was implemented from 1982. The Central Manila Sewerage System was established that consisted of sewer collection networks, seven lift stations, Tondo Pump Station and an outfall to Manila Bay. After that, in the government housing Projects 7 and 8, four communal septic tanks and one Imhoff tank (all separate systems) were constructed. No subsequent sewerage and sanitation systems were established due to financial constraints and other factors in the MWSS.

In 1994, the Manila Second Sewerage Project (MSSP) was implemented that included the full-scale review of the previous master plan, construction of Dagat-dagatan lagoon treatment system, review and renovation of Ayala sewage treatment plant, investigation of storm water street drainage and compilation of the existing rehabilitation program. Instead of constructing sewage treatment plants, it was proposed as more realistic to construct four facilities for treating septage from septic tanks and to purchase vacuum trucks for septic tank desludging and transport the collected septage to the septage treatment plants. The first septage treatment plant was constructed as a pilot plant (200 m^3/d) at Dagat-dagatan, and three more facilities have since been added at Pasig, San Mateo and Taguig.

A reorganization plan was also presented and privatization eventually led to the division of management and operation into MWSI, MWCI and MWSS, and projects were implemented according to the MSSP. In MSSP, the Tondo ocean outfall was repaired, 138 km of sewer repairs / clean-up were implemented, a system for preventing inflow of seawater due to backflows from overflow pipes at each pump station caused by high tide in Manila Bay was installed, and design revisions and improvements were implemented in order to resolve problems such as the inflow of garbage and sediment, etc. As a result, the sewerage systems were revitalized.

Currently, based on the MWSI Master Plan 2008, rapid filter works geared to improving water quality are being implemented with the aim of achieving standard BOD discharge of 100 mg/d into Manila Bay by the time of completion. MWSI is also implementing a sewerage project in the catchment areas of the San Juan River in San Juan City, which is one of the biggest sources of pollution to the Pasig River. Tenders are currently being conducted for five (5) treatment plants; preparations are underway for tenders geared to the reconstruction of four (4) treatment plants based on new technology, and another eleven (11) treatment plants are undergoing examination. The study here also represents the feasibility study for sewerage and sanitation projects in three districts of the MWSI service area.

The MSSP was funded by the World Bank; however, all components except the Ayala Treatment Plant are within the MWSI jurisdiction. In 2005 under the Manila Third Sewerage Project (MTSP) funded by World Bank and GEF, MWCI expanded its sewerage coverage in its jurisdiction area by the construction of a large number of small-scale treatment plants serving existing and new areas. These small treatment plants also treat sludge from septic tanks, thereby reducing the number of vacuum trucks for transporting sludge and boosting the local sludge treatment–related sectors and employment.

The Imhoff tank treatment plant under MWSI was also renovated into a sludge treatment facility under World Bank funding. These projects constitute components of a wide area project to prevent pollution in the South China Sea including neighboring countries, and they are based on consensus by surrounding countries, MWSS (thru MWSI and MWCI) and other parties. Joint operation by MWSI and MWCI, with DENR acting as the responsible agency, is also being considered for sludge treatment. It will be necessary to bear this in mind in this study too.

MWCI has constructed 10 treatment plants between 2006 and 2010 utilizing the MTSP budget of US$60 million. These are being constructed on the design and build format, however, not all plants performed according to plan. A surveyor was employed in 2008 to review from design through to supervision of all the plants including the ones already completed.

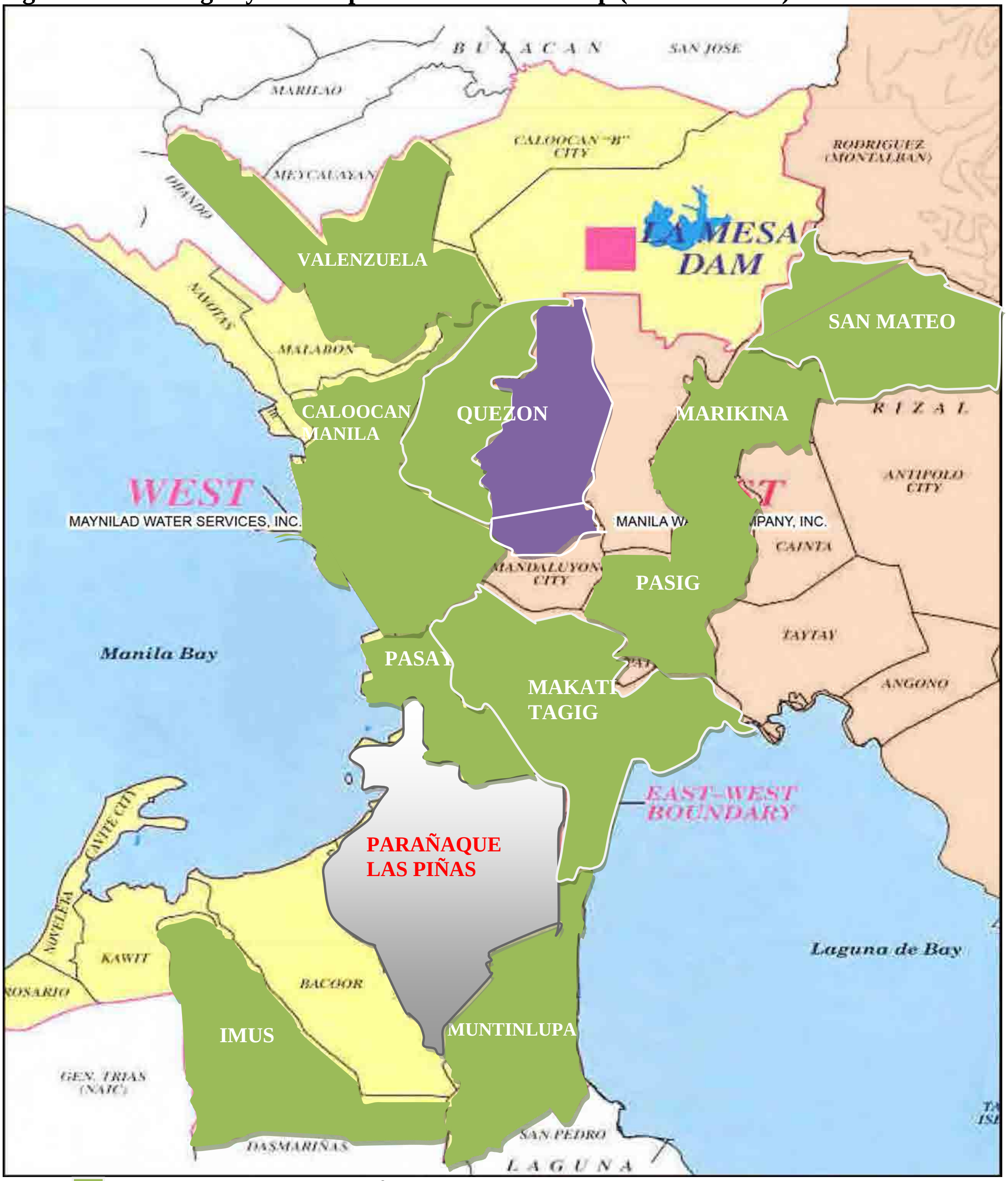
Currently tenders are being conducted for Marikina treatment plant (100,000 m^3/d) and Taguig treatment plant (40,000 m^3/d). However, these are not the small-scale facilities designated by the World Bank and neither will they be able to treat sludge from septic tanks.

During the updating of the MWSS master plan of 1996 and 2005, it has reviewed and implemented feasibility studies for the MSSP and MTSP. In reality, even following privatization, each corporation is finding difficulty in executing projects according to the master plan for various reasons and they are implementing more feasible versions of projects upon taking current conditions into account. Actually, MWCI has offered a large-scale treatment plant for tender, while Marikina treatment plant is currently undergoing design review and renewed tender after being flooded under more than 5 m of water during Typhoon Ondoy.

Other projects currently being prepared by MWCI include Marikina North, expansion of Taguig, WC-West and Rodriguez. Considering that priorities and conditions differ according to each district in Metro Manila, realistic considerations have led to revisions in the master plans on numerous occasions. Other factors have been the organizations and roles described in the following paragraphs.

Figure 1-3 shows current sewerage implementation program and past main projects with donors.

Figure 1-3 Sewerage System Implementation Area Map (Metro Manila)



Legends:

(green) **World Bank**: (principal facilities)
Under FS: Imus, Pasay, Muntenlupa, Manila Caloocan, Valenzuela,
Under construction or completed: Caloocan City (Dagat-tagatan STP & STPT)
Manila City (: MCSS STP), Makati City (Ayala STP, Makati STP)
Marikina City (Mrikina STP), Tagig City (Tagig STPT & STP)
Pasig City (Kapitorio STP, Pasig N/S STP, Pasig SPTP)
QuezonCity (San Juan STPs), San Mateo City (San Mateo SPTP)

(purple) **Asian Development Ban**k: Under FS: Quezon & San Juan Cities

(gray) **JICA:** Under preparatory survey: Parañaque, Las Piñas Cities

3) Scope of Responsibility of Government Agencies

General improvement of the water environment in Metro Manila must be implemented by considering Laguna Lake, Pasig River, its tributaries and the catchment areas around Manila Bay as an interlinked system. While no single area can be resolved independently, numerous government agencies hold authority and operating responsibility and each one has specified competence. Specifically, these agencies refer to Metropolitan Waterworks and Sewerage System (MWSS), Department of Public Works and Highway (DPWH), Pasig River Rehabilitation Commission (PRRC), Laguna Lake Development Authority (LLDA), Metro Manila Development Authority (MMDA), Department of Environment and Natural Resources (DENR), and the local government units (LGUs) and administrative agencies in the covered cities.

Out of these, DENR and the LGUs and administrative agencies take precedence when it comes to compiling strategy, action plans, surveyor supervision and sustainable development and environmental management. A fundamentally major problem exists when it comes to compiling specific policies of water environment improvement and continuity of projects based on consensus between these agencies. Although efforts have been made to formalize organizational and operational cohesion, it is extremely difficult to reach compromise plans that include policies, regulations, investment plans, environmental criteria and coordination of interests with private corporations.

In order to speed up the promotion of MWSS sewerage and sanitation management services according to the Clean Water Act of 2004, it is necessary to build projects over limited scopes of local drainage basins and to gradually expand the coverage of services while securing consensus with each concerned agency.

4) Solid Waste Treatment and Management

In the past, the solid waste generated in Metro Manila was dumped in Tondo district around the estuary of Manila Bay. This led to the contamination of soil, groundwater and Manila Bay. Because the heat generated by the pressure of the waste mountain caused smoke, this district was dubbed “Smoky Mountain”. The dump supported the lifestyles of people who scavenged for recyclable objects. Smoky Mountain was closed down some 10 years ago for environmental protection reasons and is now being redeveloped as a residential district.

In addition, the temporary garbage depot that existed in Las Piňas was closed down and waste holding functions were transferred to each municipality, however, the issue of solid waste final disposal still remained. The idea of building incineration facilities was examined for a while; however, landfill disposal sites were eventually constructed at San Mateo and Quezon City as a disposal site of industrial waste, and other areas.

Another problematic area concerns the low level of waste management awareness among residents, discharge of solid wastes into rivers and creeks, and the accumulation of street litter into storm water drainage channels. These are causing adverse impacts on the sewage and wastewater environment.

Even granting that MWSS is responsible for screening waste at sewage treatment plants, the treatment before and after plants is the responsibility of local governments. Taking the case of MWCI which has implemented a combined sewerage system, issues concerning the sewage treatment system and solid waste are handled based on agreements reached with related local agencies in each system.

1.4.3 Priority of Work Implementation

In pursuing the MMSSIP survey and study, emphasis was placed on the following points while considering the conditions described in Section 1.4.2 with the aim of immediately implementing realistic and effective sewerage and sanitation systems mainly in the cities of Parańaque, Las Pińas and Cavite.

- Conduct surveys with emphasis placed on the short-term infrastructure development plans of administrative agencies in the target districts, the wishes of residents regarding the water environment, problems in the local living sanitation situation and the local environment;
- In particular, investigate current conditions regarding storm water drainage channels, pollution of catchment areas, solid waste management, district activity groups, committees and their activities, and especially focus on countermeasures and NGO activities pertaining to illegal settlers;
- Conduct topographical investigations in order to confirm wastewater flow regimes, determine sub-catchment areas and establish borderlines;
- Confirm site utilization plans and survey the positions, areas and owners of feasible and useable sites;
- Considering the above surveys, prepare draft plans and alternative plans regarding methods and routes of wastewater collection, treatment methods, plant locations, plant scale, service population, development schedule and budget size, etc.; and,
- In order to examine the feasibility of the above measures, provide explanations and obtain opinions from related agencies and residents and ultimately arrive at a realistic proposal for a feasible sewerage and sanitation management project in Paranãque City and Las Pińas City. However, concerning Cavite City, also collect basic information (population, land use, main industries, economic conditions, social conditions, environmental pollution, conditions of sewerage-related facilities, storm water drainage and inundation situation, sub-catchments), but no sewerage plans will be developed in this present Project.

2 DESCRIPTION OF THE PROJECT TARGET AREAS

The description of existing conditions of the survey target areas is presented. Survey areas are the cities of Parańaque and Las Piňas in Metro Manila, and Cavite City in Cavite Province. Presented are the city's brief history and the summary descriptions or profiles of the various sectors such as physical and environment, demography, social, infrastructure, land use and economy.

2.1 Parańaque City

2.1.1 Brief History

Parañaque (Palanyag) is among the oldest city of Luzon. It was founded in 1572 and was accepted as a municipal town on May 11, 1580 through the endeavor of Augustinian Missionary Superior, Fr. Diego de Espinar. Its geographic location made it socio-economical and politically strategic, especially during the time of the Lima Hong, Spanish-British conflict, the American-Japanese occupation, the Philippine revolution based in Kawit, Cavite and until today. It received its cityhood on February 15, 1998 as the 11th city of Metro Manila by Pres. Fidel V. Ramos during its 426th founding anniversary. Currently, Parañaque is considered as one of the fastest growing urban community in terms of commercial, industrial and housing development investment.

2.1.2 Physical and Environmental Profile

Geographical Location – Parańaque lies at the southern portion of Metro Manila (refer to inset map at right), about 9.5 km south of Manila; its center is geographically located at latitude 14° 30" North and longitude 121° 01" East. The City is bounded on the north by Pasay City, Taguig City on the northeast and Muntinlupa on the east & southeast, Las Pińas on the southwest and Manila Bay on the west.

Land Area and Political Boundaries – The City has a total land area of about 4,657 ha making it the third largest city in Metro Manila. It is politically subdivided into two congressional/legislative districts which are further subdivided into 16 barangays. Legislative District I is comprised of 8 barangays in the western half of the city, while District II contains the other 8 barangays in the eastern portion. Barangays for each district is shown in **Table 2-1.** The barangay map is shown in the front page figure.

Table 2-1 Parananque City Barangays Land Area & Distribution

Barangay	Land Area (ha)	Percent of Total (%)	Barangay	Land Area (ha)	Percent of Total (%)
District 1	**1,781.30**	**37.9%**	**District 2**	**2,762.71**	**58.8%**
1. Baclaran	63.72	1.4%	1. San Antonio	287.19	6.1%
2. Tambo	662.56	14.1%	2. BF	769.50	16.4%
3. Don Galo	23.22	0.5%	3. Sun Valley	177.75	3.8%
4. La Huerta	53.72	1.1%	4. Marcelo Green	306.19	6.5%
5. Sto. Niño	245.97	5.2%	5. Don Bosco	384.75	8.2%
6. Vitalez	57.20	1.2%	6. Merville	304.40	6.5%
7. San Dionisio	309.69	6.6%	7. San Martin De Porres	155.65	3.3%
8. San Isidro	365.22	7.8%	8. Moonwalk	377.28	8.0%
Undeclared	152.99	**3.3%**			
Total				**4,697.00**	**100.0%**

Climate –Parańaque experiences similar climate and weather conditions with that of Metro Manila having two distinct seasons: wet season from July to September and dry season during the rest of the year. Annual rainfall in the city area is 1,822 mm and average temperature is 34.4^0 C, average relative humidity of 76% and a prevailing southeast winds at 5 km/hr.

Soil – The soil type of Parańaque is classified under Guadalupe soil, a volcanic eject that produces a loam to clay loam texture that can hold more water. The soil contains more clay than silt, with a low permeability and high swelling capacity.

Topography – The City is relatively flat at the 6 coastline barangays (Baclaran, Tambo, Don Galo, La Huerta, San Dionisio) including Sto. Niňo (refer to front page map). The inner or inland barangays have land elevations ranging from 10 to 35 m amsl.

2.1.3 Demographic Profile

Population – The 2007 census data indicates a city population of 552,660.with an annual growth rate of 2.94% from the 2000 census. Historical (census) population data shown in **Table 2-2** indicates a decreasing growth trend from a high of 10.37% in 1975 to 2.94% in 2007. Projected growth trends[1] to 2025 (**Table 2-2**) indicates further decline of growth rates.

The City's fast population growth was due to rapid urbanization influenced by the construction of major infrastructure such as the South Expressway in the late 1960s. The population continued to grow especially in the 1970s when a lot of migrants from the provinces came to Las Piñas to seek greener pastures in what is now known as Metro Manila.

However, a decline in growth rate was experienced beginning in the mid 70ss due to the increased land prices in Las Piñas. As a result, people moved out of the city and into nearby municipalities where land and rent were more affordable.

Barangay population size and density are shown in **Table 2-3**. Barangay BF has the highest population representing 14.5% of the city population but its population density 104.4 pers/ha, which is lower than the City average of 117.7 pers/ha. The most densely populated barangay is Baclaran (447.8 pers/ha) but represents only 4.7% of the total population.

Table 2-2 Parańaque City: Historical and Projected Population & Growth Rate

Census Date	Census Population*	Annual Growth Rate	Year	Projected Population**	Projected Growth Rate**
May 1, 1960	62,479	-	2010	556,594	-
May 6, 1970	97,214	4.52%	2015	586,701	1.06%
May 1, 1975	158,974	10.37%	2020	611,298	0.82%
May 1, 1980	208,552	5.58%	2025	630,393	0.62%
May 1, 1990	308,236	3.98%			
Sep 1, 1995	391,296	4.57%			
May1, 2000	449,811	3.03%			
Aug 1, 2007	552,660	2.94%			

'* National Census Office data '** MWSI Business Plan 2008

[1] Sewerage and Sanitation Master Plan for Metro Manila, 2005

Table 2-3 Parańaque City Barangay Population Size and Density

Barangay	Year 2007			Projected 2010*	
	Population	Density (pers/ha)	Distribution (%)	Population	Density (pers/ha)
1. Baclaran	26,159	410.53	4.73%	28,535	447.8
2. Tambo	25,371	38.29	4.59%	27,675	41.8
3. Don Galo	9,106	392.16	1.65%	9,933	427.8
4. La Huerta	7,298	135.85	1.32%	7,960	148.2
5. Sto. Niño	28,019	113.91	5.07%	30,564	124.3
6. Vitalez	3,886	67.94	0.70%	4,238	74.1
7. San Dionisio	60,175	194.31	10.89%	66,642	215.2
8. San Isidro	60,405	165.39	10.93%	65,893	180.4
9. San Antonio	55,719	194.01	10.08%	60,781	211.6
10. BF	80,316	104.37	14.53%	87,612	113.9
11. Sun Valley	35,448	199.43	6.41%	38,668	217.5
12. Marcelo Green	28,103	91.78	5.09%	30,656	100.1
13. Don Bosco	42,338	110.04	7.66%	46,184	120.0
14. Merville	17,118	56.24	3.10%	18,672	61.3
15. San Martin De Porres	23,519	151.10	4.26%	25,656	164.8
16. Moonwalk	49,680	131.68	8.99%	54,193	143.6
Undeclared					
TOTAL	**552,660**	117.7	**100.0%**	**603,862**	128.6
	*2010 projected population using the 2000 population distribution (CPDO)				

2.1.4 Social Sector Profile

Health – The city health situation in the last 2 years is considered outstanding being the recipient of Healthy City by the Alliance of Healthy Cities of Western Pacific Region. A healthy city is the process of improving the health of city dwellers through improved living condition and better health services with various urban development activities through the partnership of public, private and voluntary sectors. The trend of vital health indices for the period 2001 to 2007 is shown in **Table 2.4**.

The crude birth rate (CBR) is a measure of the increase in population through statistics of births and registered in the Office of the Civil Registrar. In 2007, the City recorded 7,382 live births by a crude birth rate of 12.80 per 1,000 population but increased to 18.59 in 2008.

There were 2,289 deaths from all causes in 2007 with a crude death rate of 3.91 per 1,000 population. Causes of death are coronary artery disease (24%), hypertension (13%) and pneumonia (105). Majority of the leading causes of morbidity were still communicable; the leading causes were upper respiratory infection, bronchitis, wound, diarrhea, hypertension, parasitism and others.

Table 2-4 Trends of Vital Health Indices (number per 1000 population)

Health Indices	2001	2002	2004	2005	2006	2007	2008
Crude Birth Rate (CBR)	14.47	21.27	16.3	12.31	14.02	12.80	18.59
Crude Death Rate (CDR)	5.47	5.36	3.63	3.48	4.48	3.91	5.60
Maternal Mortality Rate (MMR)	0.32	1.92	0.22	0.29	0.13	1.24	0.40
Infant Mortality Rate (IMR)	28.60	25.80	12.70	19.90	19.10	18.56	25.36

Source: City Health Office, Parañaque City

The City Health Office delivers its health services through promotion, protection, preservation and restoration of health of its populace in 16 health centers and 4 barangay health stations. The curative aspect is taken cared by 7 private and 1 government hospitals.

Education –Parañaque City has a diverse educational system with specializations in various academic and technical fields and is home to many schools and colleges. Because of this, the city registered a literacy rate of 96.3%. The city currently houses 108 Day Care Centers in 16 barangays of Parañaque with 133 Day Care Workers. The City government supports 84 Day Care Teachers; and 43 Day Care Workers are funded by the barangays.

Formal education in elementary and secondary levels is served by both public and private schools. There are 21 elementary schools and 9 high schools in various barangays of Parañaque. Tertiary education is being served by 14 private schools and 1 public college, the Parañaque City College of Science and Technology.

Housing – There are about 227 Urban Mission Areas (UMA) in the City. Four of the UMA areas are considered areas for priority development (APD) and 14 are undergoing community mortgage program (CMP).

Brgy Sto Nino has the most number of informal settler community with 35, San Antonio – 25, San Dionisio – 22, and Sun Valley with 20 clustered settlements. Household population in each settlement ranges from 50 to 1,700 families. Non-government organizations (NGOs) like Gawad Kalinga and Habitat for Humanity are assisting housing projects respectively in 9 and 4 sites in barangays of the City.

The City is home to about 25,073 informal settler families, covering an estimated land area of 45,131 ha. These settlers made up 21% of the total household in the city. Majority of the informal settler dwellings are made of light materials; with a few of concrete and semi-permanent materials.

2.1.5 Infrastructure Sector

Roads – The City is served by major road system in Metro Manila area like the South Luzon Expressway (SLEX) and the Manila Bay Coastal Road (R1 Expressway) routed respectively at the south and west periphery of the City.

To ease traffic congestion, many residential subdivisions have opened up their main roads as friendship routes. Private vehicles bearing the friendship sticker can pass through the subdivision to reach other areas.

Drainage and Flood Control – Flooding in some parts of the City occur in the low-lying areas due to poor drainage system, aggravated by improper garbage disposal by some undisciplined population. Flood prone areas are the coastal barangays particularly those traversed by the Parańaque River at the floodplains in the western part of the city.

Observations in the past indicated the flood prone areas enumerated in Table 2-5 for several barangays.

Table 2-5 Flood Prone Areas in Paranãque City

Barangay	Location	Barangay	Location
Baclaran	Portion of FB Harrison cor Aguarra St (clogged drainage) Bagong Lipunan Site (creek overflow) Redemptorist Road-Quirino Ave (clogged drainage)	San Antonio	Equity Homes-Meliton Fourth Estate (low-lying area) Monte Carlo – Fatima St (low-lying area) San Antonio Valley 3 Maria Susafe SAV (creek overflow)
Marcelo Green	Marcelo Green (overflow) Landscape Ilang-ilang (low lying area) Sampaguita	San Dionisio	Evacom Vicinity of Paranãque National High School Sitio Kuliglig Villanueva Village
Don Bosco	France St and Guatemala St (creek overflow)	San Isidro	San Antonio Valley 6 (low-lying area) Lopez Bridge Sitio Nazareth Papa Pio San Felipe
Don Galo	Coastal area (low-lying)	Merville	Sitio Wella
La Huerte	Perpetual	Moonwalk	Daang Hari (low-lying area) Cecila Village
BF	Clinic Site		

Water Services –Maynilad Water Services, Inc. (MWSI) is the main provider of potable water supply in the City. The insufficient supply had opened up opportunities for MWSI to deliver this basic service to most of the residential areas. Subdivisions not served by MWSI are provided by its developers through centralized deepwell and distribution network to individual houses. Where supply is inadequate, mobile water providers or water tankers deliver to houses or establishments. At present, portions of 14 barangays are served by MWSI.

Energy – Meralco, the franchised power distributor Metro Manila, supplies the electricity to the City. Power service is provided to all types of consumers: residential, commercial and industry. Most large commercial establishments have stand-by power generators due to the occasional brown outs.

Communications – The situation of communications in Metro Manila applies to the City. Landline telecommunication services are provided dominantly by PLDT and partly by other companies like Globe Telecom and Bayan Telecom. The use of mobile cellular phones has emerged rapidly due to its market popularity, convenience and efficiency. Mobile telecommunications providers include Smart Communications, Sun Cellular, Touch Mobile and as well as the landline providers.

The telecom providers have also become internet broadband solutions media providers. Because of the broadband technology and wireless platform, personal and business emails could be sent and received simultaneously by addresses anywhere in the world. This has partially replaced postal use and fax technology to transmit documents through the internet media.

The Parańaque Central Post Office and an annex in the City Hall continue to serve the postal system, including private courier services with branches in the City. The volume of Post Office mails has been decreasing since the mid 00’s due to the advent of internet mails. Postal communications will remain as commonly used channels for mails and packages despite technology advances.

Transportation - Parañaque is served by the Light Railway Transit (LRT) via Baclaran terminal located in Pasay City. There is plan to extend the LRT further south to Bacoor, Cavite and rail would pass through the coastal barangays of the City. The Philippine National Railway (PNR) route to south Luzon passes the eastern edge of the City and access to the PNR line is via the Bicutan and Sucat stations.

The City is also served by public buses that ply the main roads to various centers of Metro Manila and nearby Cavite towns.

Solid Waste Management - The management of solid waste in the City practices waste segregation at the source, collection of the waste, establishment of a Materials Recovery Facility (MRF), proper haulage of the waste to the City Dumpsite or Sanitary Landfill.

Wastes are segregated into types such as biodegradable, recyclable, hazardous and residual. Each household or establishments shall adequately provide separate container for each type; each container properly marked as “compostable”, “recyclable”, or “special waste”.

As far as practicable, the solid wastes shall be collected on a door-to-door basis. In case of inaccessibility by the waste truck, an eco-aide/handler collects the wastes and brings to designated pick-up points. Regular collection schedule is set for each area or zone or barangay. Waste haulers and eco-aide are required to obtain appropriate accreditation at the City Hall.

An MRF shall be established in every barangay or cluster of barangays, where biodegradable wastes for composting, and mixed non-biodegradable wastes for final segregation, re-use and recycling are conducted. Such facility is set up in a barangay-owned or leased land or any suitable space.

The disposal of solid wastes is as follows:

- Compost generated by individual households and neighborhood associations may either be used, sold and/or transported to the Barangay MRF, at their option;
- Compost generated and/or stored at the MRF shall be disposed / sold to existing markets through the assistance of City Hall Office;
- Non-hazardous residual wastes which can neither be composed nor recycled are to be hauled to disposal facility or sanitary landfill.

For 2009, the estimated solid wastes generated by the 585,644 population of the City are as follows:

- Residential – 351.4 tons (using 0.6 kg/person/day)
- Commercial / Industrial – 57.4 tons
- Waste reduction due to segregation – 40.6 tons
- Collected / disposed – 368.1 tons

The designated dumpsite of the waste is at Barangay San Dionisio, with a haul distance ranging from 0.4 to 10.7 km (or average of 5km) from the various barangay dispatch points.

2.1.6 Land Use

As of 2008, the land uses of the City are shown in **Table 2-6**, which indicate residential use at 48.0% (2,237 ha), commercial at 13.2% (613 ha), industrial at 11,6% (537 ha), institutional at 1.2% (58 ha), open space & others at 7.5% (351 ha) and reclamation / rivers at 18.5% (861 ha).The propose land use and zoning is shown in **Figure 2-1**.

The Sangguniang Panlungsod passed Ordinance No. 07-027 of 2007, more commonly known as the Comprehensive Land Use Plan and Zoning of Parańaque, the legal tool in implementing the land use goals and objectives in the all-out support to develop the City. The Ordinance will guide, control, regulate the future growth and development of the City while protecting public health, safety, peace, comfort and convenience of the city's constituents.

Under the Ordinance, all land development and building construction / alterations of residential, commercial, and industrial structures are required to secure the necessary zoning/locational clearance prior to the implementation.

Table 2-6 Parañaque City Land Use as of 2008

Land Use	Area (ha)	Percent	Land Use	Area (ha)	Percent
Residential	2,237.348	48.04%	Industrial	536.813	11.53%
Residential I	16.965	0.36%	Industrial I	166.728	3.58%
Residential II	2,072.680	44.51%	Industrial II	370.085	7.95%
Residential III	112.086	2.41%	Institutional	57.810	1.24%
Residential IV	35.617	0.76%	Parks & Playground	122.746	2.64%
Commercial	613.434	13.17%	Cemetery	124.615	2.68%
Commercial I	102.994	2.21%	Utilities	103.154	2.22%
Commercial II	118.260	2.54%	Creeks & Rivers	34.080	0.73%
Commercial III	392.180	8.42%	Reclamationa Area	827.000	17.76%
Subtotal	2,850.782	61.21%		1,806.218	38.79%
Total				4,657.000	100.00%

Source: CPDO Socio-economic profile

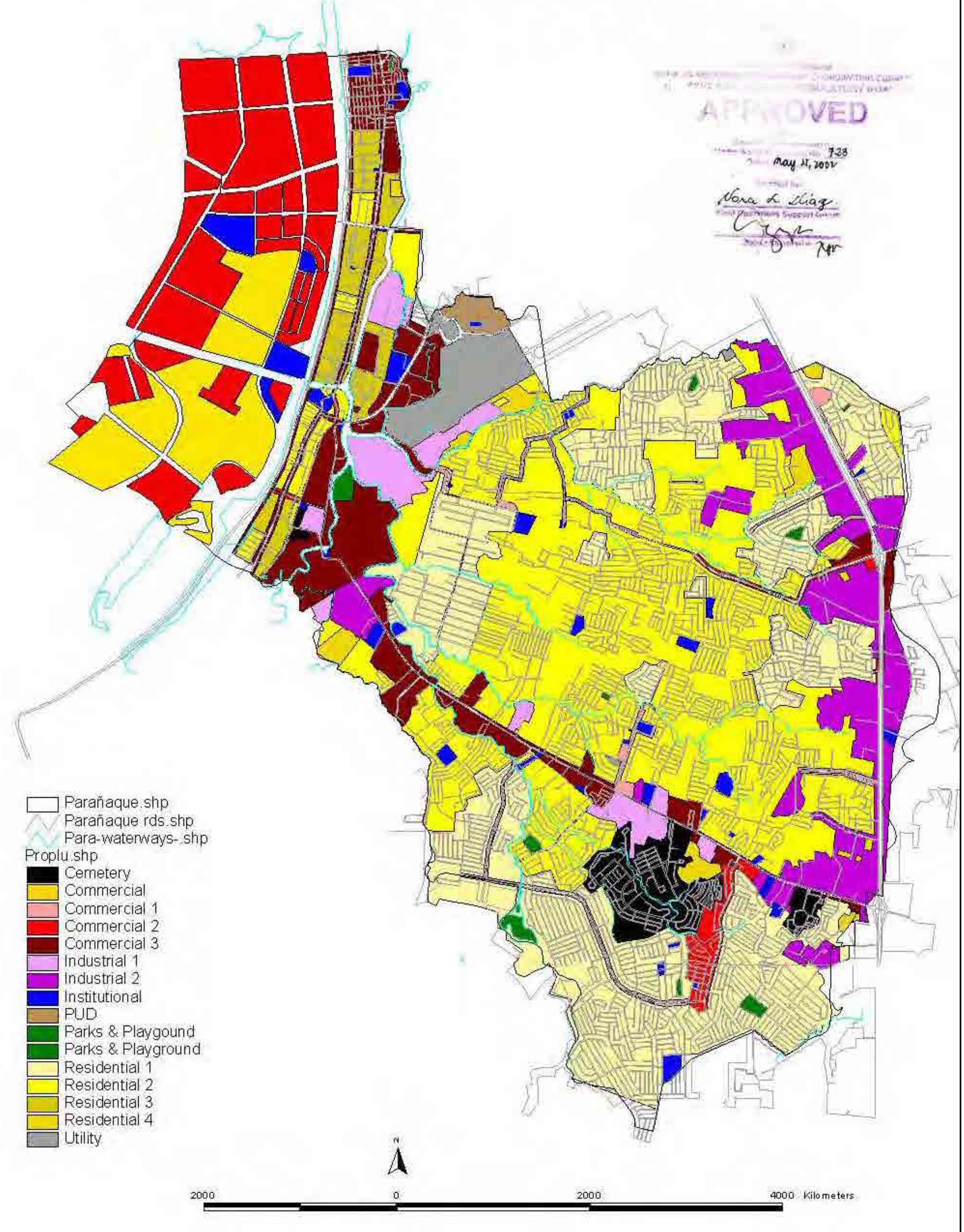
2.1.7 Economic Profile

Labor Force – The total labor force in Parańaque in 2007 was 348,741 persons, approximately 61% of the population. Employment rate among the economically active persons was estimated at 89.3% or 219,860 employed persons and the unemployment rate was 10.7% or 26,345 unemployed persons. The labor force is composed of 52.7% male and 47.3% female.

Revenue Sources – As in other cities and municipalities, the City derives its revenues from sources like:

- Real property tax on land, buildings, machinery and other improvements;
- License tax upon persons in any occupation or business or exercising privileges and other taxes;
- Profits and receipts from occupations of public utilities and from other business enterprises, including public markets as well as fees charged for services rendered and for regulating certain activities;
- BIR allotment in varying amounts from national aid and loans.

EXISTING LAND USE & ZONING PLAN OF PARAÑAQUE CITY
(Ordinance No. 97-08 series of 1997)



2.2 Las Piňas City

Most of the information on the City presented below were mostly obtained from the city's Comprehensive Land Use Plan (CLUP) 2009-2024[2]. Other sources include the city website and relevant reports.

2.2.1 Brief History

Las Piñas City (Las Peñas) used to be a barrio of Parañaque City during the early 1700s. It was known as the center of salt production and fishing because of its Spanish port. It was also popular as a commercial trading site for pineapple from Batangas and Cavite, where historians believe it derived its name. It was incorporated to Rizal Province on 1901 pursuant to the Philippine Commission Act No. 137, which apparently merged with Parañaque two years after. On February 12, 1997, President Fidel V. Ramos signed the bill declaring Las Piñas a new city. A plebiscite held a month after found the residents in approval of cityhood and Las Piñas became the 10th city of Metro Manila on March 26, 1997.

2.2.2 Physical and Environmental Profile

Geographical Location – Las Piñas is geographically located at latitude 14° 25' 5" North and longitude 121° 0' 41" East. The City lies in the southern portion of Metro Manila. It is bounded on the north by Manila Bay, northeast by Parańaque City, west by Bacoor, Cavite, southeast by Muntinlupa City and on the south by Imus, Cavite.

Land Area – The City has a total land area of approximately 3,298.6 ha, making it the sixth largest city in Metro Manila. It has two congressional districts covering twenty (20) barangays including the island located within the reclamation area. District 1 covers about the north half portion of the City abutting Manila Bay while District 2 are the southern barangays. The barangays for each district is shown in Table 3.3 and the barangay locations are shown in the front page map. The land area of each barangays is shown in **Table 2-7.** Barangay areas range from 13.3 ha (Ilay) to 507 ha (Almanza Dos), representing 0.4% to 15.4% of the total city area.

Topography and Slope – The City is located at the mouth of the Zapote and Las Pińas Rivers and is generally characterized by flat lands with elevations ranging from 0 to 10 m above mean sea level (amsl). Alluvial plains extend inland to a distance of about 2 km. Rivers and marine ponds can be found within. Surface and groundwater are characterized as saline.

Land slopes gently behind this alluvial plain and reached predominant elevation of 20 to 40 m amsl. A gently undulating hill can be found at its southern portion in Barangay Almanza Dos at the boundary to Bacoor and Muntinlupa City, which has an elevation of about 80 m amsl.

[2] Las Pińas City Comprehensive Land Use Plan (CLUP, 2009-2024, City Planning Development Office, August 2008

Table 2-7 Las Pińas City Barangays Land Area & Distribution

Barangay	Land Area (ha)	Percent of Total (%)	Barangay	Land Area (ha)	Percent of Total (%)
District 1:	**1,273.43**	**38.61%**	**District 2:**	**2,025.17**	**61.39%**
B.F International - CAA	216.65	6.57%	Almanza Uno	247.44	7.50%
Daniel Fajardo	30.77	0.93%	Almanza Dos	507.01	15.37%
Elias Aldana	33.36	1.01%	Pamplona Dos	112.16	3.40%
Ilaya	13.32	0.40%	Pilar Village	204.09	6.19%
Manuyo Uno	74.85	2.27%	Talon Uno	209.62	6.35%
Manuyo Dos	187.89	5.70%	Talon Dos	391.61	11.87%
Pamplona Uno	72.64	2.20%	Talon Tres	115.22	3.49%
Pamplona Tres	235.31	7.13%	Talon Kuatro	70.77	2.15%
Pulang Lupa Uno	143.56	4.35%	Talon Singko	137.25	4.16%
Pulang Lupa Dos	195.40	5.92%	Island	30.00	0.91%
Zapote	69.68	2.11%	**Total Land Area**	**3,298.60**	**100.00%**

Soil – The alluvial plain in the City is composed of sand and clay with shell fragments. The alluvium is observed to extend to depths of about 10 to 20 m. The hilly portion is composed of sandstone, conglomerate, mudstone and stuff, and reaches a thickness of 2,000 m. No fault line is found to cross the area. The nearest fault is the creeping fault segment of the Valley Faultline in the Muntinlupa-San Pedro-Binan area.

Climate – The climate in Las Pińas is Type I according to the modified Corona Classification use by the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). There are two pronounced seasons: dry during the months from November to April and wet in May to October.

2.2.3 Demographic Profile

Population and Distribution – The city population was 16,093 in 1960 and had increased about 35 times in the last five decades as shown in **Table 2-8**. The annual growth peaked at 12.28% in 1970 to 1975. Thereon, annual rates declined to 1.70% from 2000 to 2007. Population in 2007 is 531,330 and projected to 576,749 in 2010.

The city has a population density of 161.5 pers/ha in 2007. The most densely populated barangay is Ilaya with 465.2 pers/ha, but its population represent only 1.2% of the city population. The most sparely populated barangay is Almanza Dos with a density of 69.7 pers;ha and its population is 6.6% of the total. Barangay BF-International CAA with a population of 68,912 has the largest representing 12.9% of the total, but its population density is 318.1 pers/ha or about twice the city average population density.

Table 2-8 Las Pińas City Census Population and Annual Growth Rates

Year	Census Population*	Annual Growth Rate	Year	Projected Population**	Projected Growth Rate
1960	16,093	-	2010	652,906	-
1970	45,372	11.01%	2015	754,286	2.93%
1975	81,610	12.28%	2020	860,899	2.68%
1980	136,514	10.84%	2025	970,158	2.42%
1990	296,896	8.08%			
1995	413,086	6.39%			
2000	472,780	2.39%			
2007	532,330	1.70%			

‘* National Census Office data ‘** MWSS Master Plan (2005) Report

Households - From the NSO census data in Yr 2000, the city has 97,962 households and household size of 5.43 persons.

2.2.4 Social Sector Profile

Health – The registered live births of 8,118 had been highest in 2007, indicating an annual average growth of 3% in births. The same year also posted the highest number of deaths and indicated an increase of 2%.

population for 2007 is shown in **Table 2-9.**

The top leading cause of morbidity as recorded from 2005 to 2007 had been acute upper respiratory tract infection (URTI). The prevalence rate of acute URTI had been 198 for every 1000 population. Bronchitis ranked second, with a prevalence rate of 24 cases followed by diarrhea with 18 cases per 1,000 population.

Table 2-9 Las Pińas City Barangay Population and Density

Barangay	Year 2007			Projected 2010	
	Population	Density (pers/ha)	Distribution (%)	Population	Density (pers/ha)
1. Almanza Uno	30,074	121.5	5.6%	32,583	131.7
2. Daniel Fajardo	14,690	477.4	2.8%	15,916	517.3
3. Elias Aldana	10,342	310.0	1.9%	11,205	335.9
4. Ilaya	6,196	465.2	1.2%	6,713	504.0
5. Manuyo Uno	12,057	161.1	2.3%	13,063	174.5
6. Pamplona Uno	15,272	210.2	2.9%	16,546	227.8
7. Pulang Lupa Uno	33,838	235.7	6.4%	36,662	255.4
8. Talon Uno	28,109	134.1	5.3%	30,454	145.3
9. Zapote	17,944	257.5	3.4%	19,441	279.0
10. Almanza Dos	35,337	69.7	6.6%	38,286	75.5
11. B.F International - CAA	68,912	318.1	12.9%	74,662	344.6
12. Manuyo Dos	26,094	138.9	4.9%	28,271	150.5
13. Pamplona Dos	8,408	75.0	1.6%	9,110	81.2
14. Pamplona Tres	31,215	132.7	5.9%	33,820	143.7
15. Pilar	31,583	154.8	5.9%	34,218	167.7
16. Pulang Lupa Dos	31,922	163.4	6.0%	34,586	177.0
17. Talon Dos	47,479	121.2	8.9%	51,441	131.4
18. Talon Tres	25,083	217.7	4.7%	27,176	235.9
19. Talon Kuatro	21,547	304.5	4.0%	23,345	329.9
20. Talon Singko	36,228	267.9	6.8%	39,251	290.2
21. Island		0.0	0.0%	0.0%	0.0
TOTAL	**532,330**	161.5	**100.0%**	**576,749**	175.0

The top 4 leading causes of mortality in all ages had been coronary artery disease, pneumonia, cancer and hypertension since 2005. In 2007, the prevalence of coronary artery disease had been 67 per 1,000 population. Coronary artery disease and pneumonia had been increasing while cancer had been slightly decreasing. The number of deaths caused by hypertension had largely decreased.

Comparative public health personnel complement from 2005 to 2007 indicated sufficiency ratio of 1:17,000 physicians, much better than the standard of 1:20,000. The most number of health workers needed has been for midwives with a backlog of 40, followed by dentist at 29, sanitary inspectors and nutritionist at 17 each.

There are 11 private hospitals and clinics serving barangays and neighboring cities. Las Pińas Doctors Hospital, a private tertiary hospital has a 100 bed capacity and has been supporting the City in its Green Card Hospitalization Program for bona fide city residents. Bed capacity ratio in the city is 1:1,137, which is better than the standard ratio of 1:2,000.

Education – Las Piñas city prides with its 99% literacy rate across age group and sex. It is highest among residents between 35 and 39 years old (99.38%) and lowest among those who are 70 and over (95.21%). Males are slightly more literate than females. Females, however, are more functionally literate than males.

Participation rate, or the proportion of enrolment in the school-age range to the total population of the age range, in elementary and high school levels had been 85% and 64% respectively in 2007-2008. Completion rate or the percentage of first year entrants to those who complete the level in the required number of years was 70% (i.e. 7 out of 10 did completed the level) and 88% respectively for elementary and high school.

In 2007-2008 school year, there were 6 elementary schools with moderate shortage of teachers. There has been classroom shortage with classroom-student ratio of 1:61 and 1:71 respectively in elementary and high school.

Socialized Housing – In 2007, there are 40,628 informal household structures occupying about 80 ha area in the City. About 66% of these informal settlers are located in socialized housing sites, 66% on private properties, 4% on waterways and 1% in others (e.g. roads & bridges, public utilities, public buildings, dams). These settlers have become members to 287 community-based organizations.

Barangay CAA-BF International ranked as the top barangay with 11,638 informal settlers households or 29% of total, followed by Barangay Manuyo Dos at 11%. Barangay E. Aldana has the least number with 247 informal settlers household or 0.6%.

The City government through its Urban Poor Affairs Office has adopted humane approached in addressing the informal settler families. This includes:

- In-city development to upgrade conditions of informal dwellers and minimize relocation;
- Acquisition of lands through different modes, making it possible for informal settlers to own lots they presently occupy or the lots where they will be relocated;
- Off-site and on-site development programs extended to around 22,132 socialized housing beneficiaries in 2008;
- The Estate Management Development Office has been tasked in the demolition of illegal structures, land titling collection of monthly land amortizations, etc. The CAA Compound is an example of on-going housing program since the 1980s.

Social Welfare –The City's social welfare scheme is a concerted effort between the national and local government to extend services and assistance to children, youth, differently able persons, senior citizens, socially disadvantaged women and families. It is essential that timely response be extended to victims of calamities, individuals and communities in critical situations.

There has been an alarming increase in the number of report cases of child abuse from 2005 to 2006. Within a year, the number of cases served by the Department of Social Welfare and Development (DSWD) quadrupled reaching 756 cases, which about half were cases of neglected children, about one-fourth were physically exploited and maltreated and about one-tenth sexually abused.

Services in the past years conducted by the City Government in cooperation with DSWD included the following:

- Massive reach-out to 120 street children in 2005;

- Provision of 67 barangay day-care centers for more than 6,000 children as of 2006;
- Assistance to rising number of children in conflict with law from 161 in 2005 to 239 in 2006;
- Educational assistance to 225 and 750 children respectively in 2005 and 2006;
- 75 job placements in 2006;
- 392 children underwent psychological tests and evaluation; 108 referred to institutions;
- 6,329 children assisted through the DSWD initiated Food-for-School-Program.

2.2.5 Infrastructure Sector

Roads and Bridges – The road lengths of the city is about 80,396 km. City roads comprise 92% of the total road length and the remaining 8% are national roads. About 60% of roads are concrete paved, and about 75 km of city roads are still earth-type and need improvement. The main road is the Alabang-Zapote road that traverses the midsection of the City from southeast (at Alabang, Muntinlupa City) to northwest at Baranagay Zapote and connecting to the R-1 Expressway at the coast of Manila Bay. Other major roads include the CAA Road, Marcos Alvarez Road, Tramo Road and Naga Road.

More than 30 subdivision roads had been opened up to be included as friendship routes to alleviate the traffic situation. Private vehicles bearing the City's friendship sticker can pass through these subdivisions to reach other areas.

Drainage and Flood Control – Flooding in some parts of the City is attributed to low-lying areas or caused by poor drainage, aggravated by improper garbage disposal by some undisciplined residents. The identified flood prone areas include the Zapote Junction at Barangay Zapote, portion of Moonwalk Village and Equitable Village in Barangay Talon Quatro, Gloria Diaz street portion at BF Resort Village at Barangay Talon Dos, San Antonio Village portion in Barangay Talon Uno, CV Starr Ave nearby Philam Village and others.

Water Service – Maynilad Water Services, Inc. (MWSI) is the main provider of potable water supply in the City. The insufficient supply had opened up opportunities for MWSI to deliver this basic service to most of the residential areas. At present, portions of 14 barangays are served by MWSI. Subdivisions not served by MWSI are provided by its developers through centralized deepwell and distribution network to individual houses. Where supply is inadequate, mobile water providers or water tankers deliver to house.

Energy –The provision of power or electricity supply to the City is similar to that described for Parańaque City. Meralco, the power service provider has franchise covering Metro Manila.

Communications – The situation of communications in the City is similar to that described for Parańaque city. The telecom service providers have franchise in Metro Manila and nearby provinces. The bigger firms covers nationwide and linked to international network.

Solid Waste Management – The practice of solid waste management for the City is similar to that discussed for Paranãque City in Section 2.1.5.

2.2.6 Land Use

The development of Las Pińas City is described in urban planning as the linear or ribbon type development. The Alabang-Zapote Road is the major or primary spine cutting through the eastern and western divides that are dominantly residential in character. A secondary spine is the old Quirino Road (now P. Diego Cera Avenue) that traverses the old town area, a congested strip development but a site of historical buildings and Spanish cultural heritages, the subject of physical restoration by the City Historical Corridor Project.

The City is predominantly residential in the land use distribution of 2005 and the proposed land use of 2009 – 2024 as shown in **Table 2-10**. Residential development will increase from the present 49% to 58% or an additional 300 ha developed for residential use. Commercial land use slightly increase from 183 ha to 334 ha or 10% by 2024. Planned unit development (PUD) will increase from 2% in 2005 to 10%, equivalent to 283 ha by 2024. The present vacant land of 700 ha will be essentially occupied by 2024. Other land uses (institutional, utility, parks, open space, rivers, etc) will remain unchanged or slightly increased. The city's land use plan is shown in **Figure 2-3**.

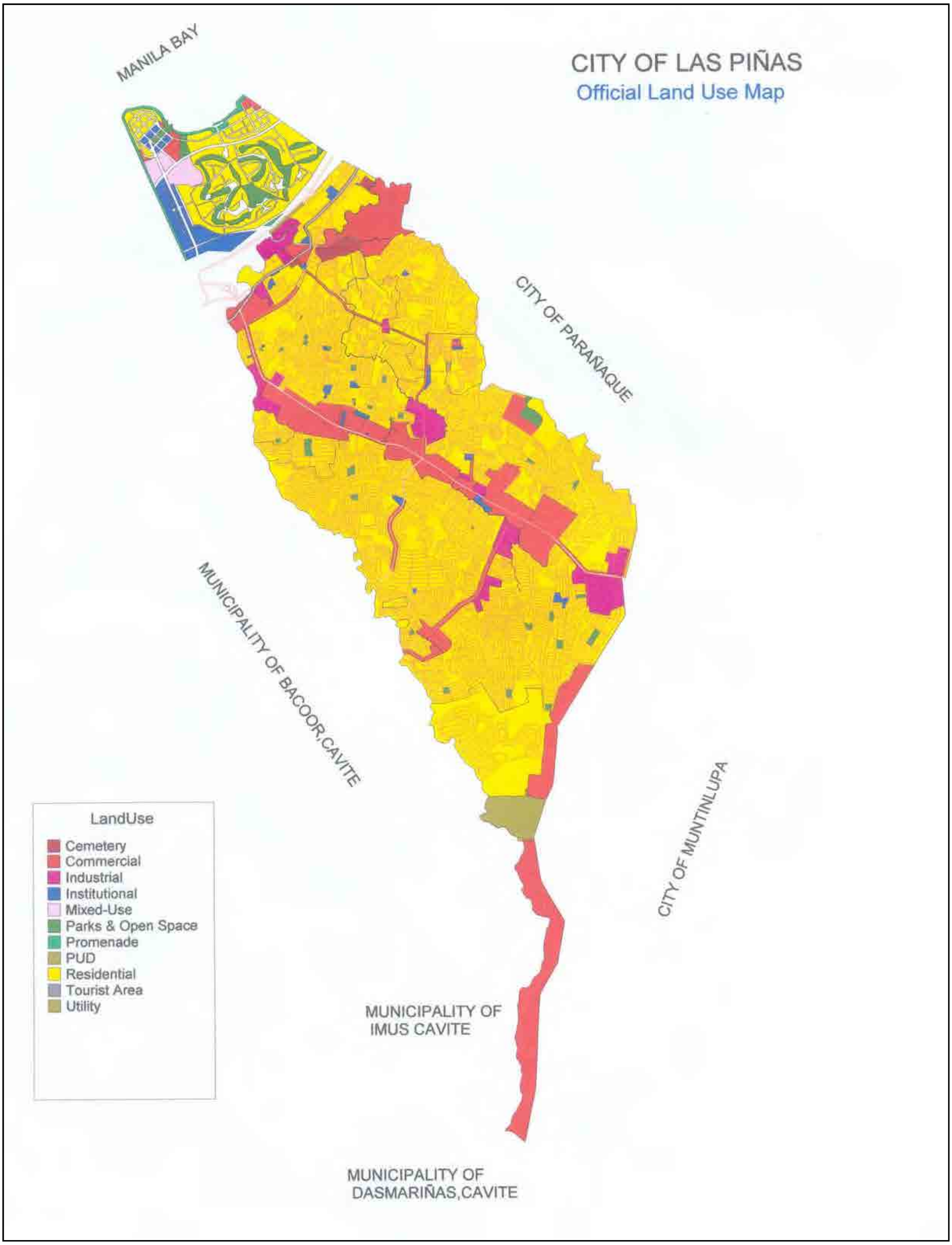
Table 2-10 Las Pińas City Land Use: Existing and Proposed

Land Use	Existing Land Use: 2005		Proposed Land Use: 2009-2024	
	Area (ha)	Distribution (%)	Area (ha)	Distribution (%)
Residential	1,625.75	49.3%	1,925.84	58.4%
Commercial	183.31	5.6%	334.02	10.1%
Industrial	96.03	2.9%	62.91	1.9%
Institutional	62.31	1.9%	61.08	1.9%
Parks & Recreation	13.86	0.4%	9.22	0.3%
Cemetery	20.56	0.6%	20.56	0.6%
Utility	15.25	0.5%	5.45	0.2%
Saltbed / Fishpond	4.40	0.1%	2.00	0.1%
Open Space**	111.05	3.4%	121.05	3.7%
Vacant Land	700.67	21.2%	0.00	0.0%
PUD	56.45	1.7%	338.07	10.2%
Tourist Area	10.06	0.3%	10.06	0.3%
River Systems	36.04	1.1%	36.04	1.1%
Road	362.87	11.0%	372.32	11.3%
Total	**3,298.61**	**100.0%**	**3,298.61**	**100.0%**
PUD - Planned Unit Development				

2.2.7 Economic Profile

Employment - Data from the Public Employment Service Office indicated that the working –age population of the City had increased by an average of 2% yearly from 2004 to 2006. Employment rate has increased from 88% in 2004 to 92% in 2006. Unemployment rate was highest in 2004 at 12% and decreased to 8% in 2006. The number of underemployed or employed persons who want additional hours of work had been increasing and is highest at 24% in 2006.

Tourisms - The RA 8003 of 1995 named as tourist destinations the Las Pińas Church and Bamboo Organ, P. Diego Cera Bridge, and the old District Hospital, located in the City's Historical Corridor that included such landmarks as the Manpower Building, Irasan (salt making) Center, Gabaldon School, Plaza Quezon, as well as the old fire station and municipal hall.


CITY OF LAS PIÑAS
Official Land Use Map
MANILA BAY
CITY OF PARAÑAQUE
MUNICIPALITY OF BACOOR,CAVITE
CITY OF MUNTINLUPA
MUNICIPALITY OF IMUS CAVITE
MUNICIPALITY OF DASMARIÑAS,CAVITE
LandUse
Cemetery
Commercial
Industrial
Institutional
Mixed-Use
Parks & Open Space
Promenade
PUD
Residential
Tourist Area
Utility

Business Registrations - Almost 8,000 establishments filed for registrations at the City Business Permit and Licensing Office in 2007. Since the 90's, most of the businesses operating in the City are in wholesale, retail and services. Dominating are small and medium enterprises, with a few metropolitan-scale commercial establishments. The highest number of business permit applications of 10,500 occurred in 2000.

The 7,728 firms that registered in 2007 represent a 2% increase from the previous year. Closing business was experienced by 178 firms in 2007, which was lower compared to the 410 in 2006.

2.3 Cavite City

Most of the information on the City presented below were obtained from the city's Socio-Economic Profile[3] Other sources include the city website and relevant reports.

2.3.1 Brief History

Linked to a narrow strip of land, the name Cavite came from the Tagalog work "Kabit" which means joined or connected. Another story claims that Cavite came from the word "Kalawit" or "hook" because it is shaped like a hook. The City is believed to have been a part of the municipality of Kawit. The place that is now called Cavite City used to be the trading center for the natives and Chinese merchants as early as 932 A.D. due to its strategic position and extensive coastline. Cavite City was called "Puerto de Cavite" (Port of Cavite) during the early part of the Spanish rule, being a port of entry and departure for Spanish and foreign ships. The most significant event in the City's history was the execution of three Filipino priests – Mariano Gomez, Jose Burgos and Jacinto Zamora after having been falsely implicated in the Cavite Mutiny of January 20, 1872.

The area was used in 1898 as a naval base by the US Naval Forces, while the region was governed by Filipino "Presidente Municipals". The Philippine Commission united the three pueblos of Cavite Puerto, San Roque and Caridad in 1903, to create the Municipality of Cavite. It became the capital of the province by an Act of the First Philippine Assembly. The area was further enlarged to include the district of San Antonio and the island of Corregidor. The municipality of Cavite was converted into a chartered city by virtue of Commonwealth Act No. 547 of 1909. The Philippine Congress subsequently passed, in 1945, Republic Act No. 981 transferring the provincial capital to Trece Martires City.

2.3.2 Physical and Environmental Profile

Geographical Location – Cavite City is a peninsula lying at the northern tip of the Province of Cavite with coordinates 14^{o} 29.04' latitude and 122^{o} 54.02' longitude. The peninsula encloses Bacoor Bay to the southeast and Canacao Bay to the north east. The Sangley

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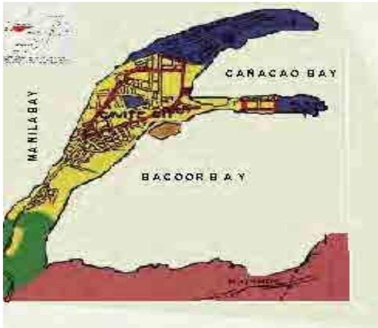
[3] Socio-Economic Profile, Cavite City 2010, prepared by the City Planning and Development Office

Point Naval Base is part of the City and occupies the northern most portion of the peninsula. The city borders the Municipality of Noveleta at the south.

The City is 8 nautical miles southwest of Manila and is accessible by ferry boat plying the Manila Cultural Center – Canacao Bay City Port route and 34 km by land via the Manila-Cavite coastal road.

Land Area and Political Boundaries – The City has a total land area of 1,239 ha distributed as: City Proper– 27%, Sangley Point– 11%, Fort San Felipe– 8%, Corregidor& 6 Adjacent Islands - 49% and road network – 5%.



The City is subdivided into five districts, namely: San Antonio on the north, including the Sangley Point Reservation, Caridad at the center, San Roque at the east including the Philippine Naval Reservation of Fort San Felipe, Sta Cruz at the south west and Dalahican on the south towards the Municipality of Noveleta.

The City is comprised of 84 barangays in 8 barangay zones, namely: Zone 1– 8 barangays (Bgys 1-8), Zone 2- 12 (Bgys 9-18), Zone 3- 11 (Bgys 9-28), Zone 4- 10 (Bgys 29-36-A), Zone 5- 7 (Bgys 37-41), Zone 6- 12 (Bgys 42-47-B), Zone 7- 10 (Brys 48-53-B), and Zone 8- Bgys 54-62-B).

Climate –Cavite City experiences similar climate and weather conditions with that of Metro Manila having two distinct seasons: wet season from July to November and dry season during the rest of the year. Annual rainfall in the city area is about 1,800 mm and average temperature is 34.4^0 C, average relative humidity of 76% and a prevailing southeast winds at 5 km/hr.

Soil – The soil type of Cavite City is classified as hydrosol, obando sand and obando very fine sand.

Topography – Considering that the City lies at a peninsula, the entire City is essentially flat with slopes ranging from 0 to 3%. There are no rugged features and rural sections. Three bodies of water surround the City: Bacoor Bay on the east, Canacao Bay on the northeast and Manila Bay on the west.

2.3.3 Demographic Profile

Population – The 2007 census data indicates a city population of 104,581with an annual growth rate of 0.73% from the 2000 census population of 99,367. Historical (census) population data shown in **Table 2-11** indicates a decrease of about half from the 1995-2000 growth rate of 1.51% to 0,73% for the years 2000-2007. The projected growth rates used in the 2008 MWSI Business Plan, though also declining are much larger than the historical growth rates.

Zone areas, population, and population density are shown in **Table 2-12**. The zones are subdivisions of the City Proper. A zone covers 5 or more contiguous barangays.

Population Density - The Gross density of the City is 84.43 persons per hectare on the basis of 1,238.63 hectares of usable area including Corregidor and its adjacent island over the total population of 104,581 as of 2007 census year. However, its Gross Urban Density, based on the total urban population over total build-up/urban area is 166.2 persons per hectare.

Number of Households - The household population of the City as of Census year 2000 is 98,961 in 21,342 households or an average of 4.64 persons per household.

Urban-Rural Population – With its population density of 8,443 persons per sq km in 2007, the City is classified as an urban area. This is in accordance with the Bureau of Census and Statistics criteria of a municipality or city with a population density of 1,000 per sq km and above is considered an urban area. . However, its Gross Urban Density, based on the total urban population/build-up area over total build-up/urban area is 16,620 persons per sq km. As such, the city of Cavite is categorized as a medium density city.

Table 2-11 Cavite CityHistorical and Projected Population & Growth Rate

Census Date	Census Population*	Annual Growth Rate	Year	Projected Population**	Projected Growth Rate**
May 1, 1990			2010	111,507	-
Sep 1, 1995	92,641		2015	119,422	1.38%
May1, 2000	99,367	1.51%	2020	126,851	1.21%
Aug 1, 2007	104,581	0.73%	2025	133,799	1.07%
			2030	139,795	0.88%
			2035	144,807	0,71%
			2040	148,740	0.54%

'* National Census Office data '** MWSI Business Plan 2008 with Year 2000 population as base

Table 2-12 Cavite City Proper Zones, Population and Density

Zone	Area (hectare)	Census Population 2000	Census Population 2007	Projected Population 2009*	Population Density (2009) pers/ha
Zone 1 (Brgys 1-8)	44.79	10,438	11,895	12,015	268.2
Zone 2 (Brgys 9-20)	46.68	11,595	12,585	12,776	273.7
Zone 3 (Brgys 21-31)	33.10	11,665	10,743	10,907	329.5
Zone 4 (Brgys 32-36A)	23.89	9,828	9,872	10,023	419.5
Zone 5 (Brgys 37-41)	27.47	6,769	7,008	7,115	259.0
Zone 6 (Brgys 42-47B)	37.77	15,941	17,240	17,503	463.4
Zone 7 (Brgys 48-53)	48.76	15,076	16,184	16,430	336.9
Zone 8 (Brgys 54-62B)	75.58	18,055	19,054	19,344	256.0
Total	**338.04**	**99,367**	**104,581**	**106,113**	313.9

2.3.4 Social Sector Profile

Health – Health conditions of the populace in the City is taken cared by sufficient number of health facilities that includes: 3 private hospitals with primary / secondary / tertiary health care facilities with a total 170 bed capacity, a district hospital under the supervision of the Provincial Government, a city hospital managed by the city government, the 94-bed Naval Hospital and the 15-bed hospital of the Philippine Air Force 15^{h} Strike Wing. There are also 5 health center / clinics specializing in family planning, nutrition and maternal child hygiene.

The crude birth rate (CBR) is a measure of the increase in population through statistics of births and registered in the Office of the Civil Registrar. In 2009, the City recorded 1,749 live births, 509 deaths and 15 infant deaths.

The top 3 leading causes of mortality in 2009 are pneumonia, heart disease and cerebro vascular accident with 73, 63 and 52 deaths in 2009, a total of 188 and represent to 56 % of the total deaths. Of the 15 infant deaths in 2009, the top 2 causes are pneumonia and prematurity with 7 and 3 deaths respectively. The top 3 causes of morbidity are acute respiratory infection, skin dematoses and urinary tract infection with 10,789, 2320, and 1994 deaths respectively or a total of 15,103 and represent 82% of the total mortality in 2009.

There are 5 family planning clinics in the City adequately manned by doctors, nurses, sanitary inspectors, midwives, medical technicians and barangay health workers.

Education –Formal education in elementary and secondary levels is served by both public and private schools located are various barangays of the City. There are 23 elementary schools (12 public and 11 private) with a total enrolment in school year 2009-2010 of about 27,000 pupils. The eleven high schools, 2 public and 9 private, has respective enrolments in 2009-2010 of about 7,700 and 1,100 pupils.

There exist one state university, three private tertiary educational institutions, one private vocational school and one public technical school in the city – the Cavite City Institute of Technology. These institutions offer varied courses from Graduate Study to Business Administration, Education, Engineering, Health Science, Bachelor of Arts, Computer Science, Industrial Technology, Hotel and Restaurant Management, Seaman Course and Computer Technician.

Specialized vocational courses are also being offered in selected Public Schools. It is known as the Non-Formal Education (NFE). Courses offered include dressmaking, Hi-speed sewing, tailoring, hair science, culinary arts, handicraft, reflexology, ballroom dancing, typing, and others. There are also technical and vocational courses like automotive electronics, electricity and welding in the pilot center.

Considering the life of those less fortunate students who have not been blessed to acquire higher education, the City Government of Cavite, established and managed the former Cavite City Institute of Technology (CCIT) in 1998, now Cavite City Technical and Vocational School. CCTVS is envisioned that in the next few years, this institute will grow fast to become a city college, offering not only technical/vocational training but also formal tertiary education

2.3.5 Infrastructure Sector

Roads – There are a total of 270 city roads with an aggregate length of 77,150 km and 6 national roads with a total length of 10,749 km of national roads or a grand total length of 87,899 km. Most of the roads are concrete paved and less than 10% are either asphalt paved or unpaved. There is only one bridged in the city.

Transportation – Land transportation plying the Cavite-Manila-Olongapo-Baguio routes is provided by two large bus companies. Jeepneys, tricycles and pedicabs are the main public utility-vehicles in the City. Transportation to nearby towns is by means of mini-buses and jeepneys.

Sea transport is also provided by the Metro Star Ferry, a twin-hulled catamaran fiberglass boat that started operation in July 2007 with routes covering the Cavite City – Mall of Asia (Paranaque City) at eight daily trips by two vessels. Travel time is 45 minutes. Each vessel can accommodate 240 passengers and a crew of 12.

The Phillippine Air Force Base at Sangley Point has an airstrip for military and emergency use. Also located at Sangley Point is the pier/wharf of the Philippine Navy with dry-docking facilities at both Sangley Point and Fort San Felipe bases.

Drainage and Flood Control – As the city is bordered by water bodies, rainfall run-offs are drained via the roadside drainage system or naturally through the sloping land surface to these water bodies. Portions of the City Proper coastline are provided with sea walls for flood control purposes. Low-lying areas are prone to flooding specially during high tide.

Water Services –Maynilad Water Services, Inc. (MWSI) thru its Cavite-Las Pińas Business Center, is the main provider of potable water supply in the City. Water is supplied to the City from the MWSI's Noveleta reservoir and Booster Station and from 7 local deepwells of the City.

There are about 10,000 registered customers of which about 89% is residential, 7% semi-business and the rest are commercial and industrial. There are about 47 active and 10 inactive public faucets within the city serving its depressed areas. As of June 2009, the service area coverage of the MWSI to the city's population is at about 74%, hopefully 100% by 2011 upon improvement / expansion of MWSI water supply system to the Cavite area.

There is no sewerage service provided by MWSI except septage management by septic tank desludging.

Energy – The Manila Electric Company (Meralco) is the franchise holder for power utility service in the City. There are two substations that are sources of the city's power requirement. A total of 1,440 streetlights surrounds the City. Almost all dwelling units in the city utilized power from Meralco

The air force and naval bases have standby power generators, including some of the large commercial and industrial establishments.

Communications – The situation of communications in Metro Manila applies to the City. Landline telecommunication services are provided dominantly by PLDT and Digitel. Wireless telecommunications are facilitated by the installation of seven cell sites providing nationwide and global link-up by service providers like Globe, Smart, Sun and Digitel.

The telecom providers have also become internet broadband solutions media providers. Because of the broadband technology and wireless platform, personal and business emails could be sent and received simultaneously by addresses anywhere in the world. This has partially replaced postal use and fax technology to transmit documents through the internet media.

Telegraph services is also provided by the Bureau of Telecommunications of the Dept. of Transportation and Communications with a volume of service of about 3,000 transactions per month. A private firm, Radio Communications of the Philippines, Inc (RCPI) also provides telegraph services.

Postal services are provided by Philpost, a government owned corporation at its local office. Presently the postal office has 7 letter carriers and handling about 22,500 mails per month.

The City has **one (1) FM Radio Station, 91.9 the Bomb FM**, operating since 2002. The station caters to Caviteños' taste for quality music and primarily attracts young audiences as well as those who are still young at heart. It is affiliated with Manila Broadcasting Company carrying the tag names Cavite Beat FM, The station is under the CALABARZON Radio Network and airs from 6:00 a.m. to 2:00 a.m. beamed through a 100W transmitter with Cavite Province as primary coverage and Las Piñas and Parañaque Cities as secondary coverage.

Solid Waste Management – As in other urban communities, solid waste management in the City practices waste segregation at the source, collection of the waste, establishment of a Materials Recovery Facility (MRF), proper haulage of the waste to it controlled dumpsite facility.

Complying with the provisions of RA 9003 – Ecological Solid Waste Management Act of 2000, the City Government closed its old dumpsite located behind the public cemetery and with massive earthworks, converted the vicinity area into a controlled dumpsite facility. In July 2008, its MRF was also established in the area as part of the solid waste management program.

In recent years, garbage collections around the barangays were intensified and now covering almost 90% of the city. The MRF continued to operate about 8 hours per day receiving approximately 45 tons daily for processing. The commitment is to make the City environment friendly with both the LGUt and residents working together.

2.3.6 Land Use

As of 2008, the land uses of the City are shown in **Table 2-13**, which indicate the various land uses such as residential, commercial, industrial agricultural, institutional, playground/parks/ and others. Land uses are concentrated at the city proper with an area of 338 ha. Land use classified as "others" refer to the islands composing about 50% of the total land jurisdiction of the City.

Table 2-13 Cavite City Land Use as of 2008

Land Use	Area (ha)	Percent
Residential	236.09	19.06%
Commercial	26.60	2.15%
Industrial	26.35	2.13%
Agricultural	5.45	0.44%
Institutional	101.14	8.17%
Parks/Playgrounds	19.50	1.57%
Infrastructures	183.58	14.82%
Others (islands,etc)	639.92	51.66%
Total	1,238.63	100.00%

The present land use and zoning is shown in **Figure 2-4. T**he proposed land use plan is shown in **Figure 2-5** that indicates a large land reclamation north of the City and other small reclamations. The land reclamation will increase significantly the city land area

2.3.7 Economic Profile

Marine Fisheries –The City is a peninsula bounded by 3 bodies of water, namely Bacoor Bay, Cañacao Bay and Manila Bay. The fishery and, to a small extent, the livestock sectors are the only agricultural sectors represented in the city. There are 2,696 municipal fishermen, 150 mussel farm operators and 26 oyster farm operators in the 35 out of a total of 84 barangays who are dependent upon the productivity of these waters for their means of livelihood.

There are motorized and non-motorized fishing bancas being used by registered fishermen in the City using the traditional fishing gears such as hook and line, gill net, lift, net, trawl, beach seine and multiple hook and line. Species caught are goby, mullet, asohos, kanduli samaral, kitang, lapu-lapu, albacore, Spanish mackerel, hasa-hasa, busugo, malabansi, salay-salay, oerles, malakapas, mamali, talakitok, sapsap, alimasag, hipon, alimango and posit.

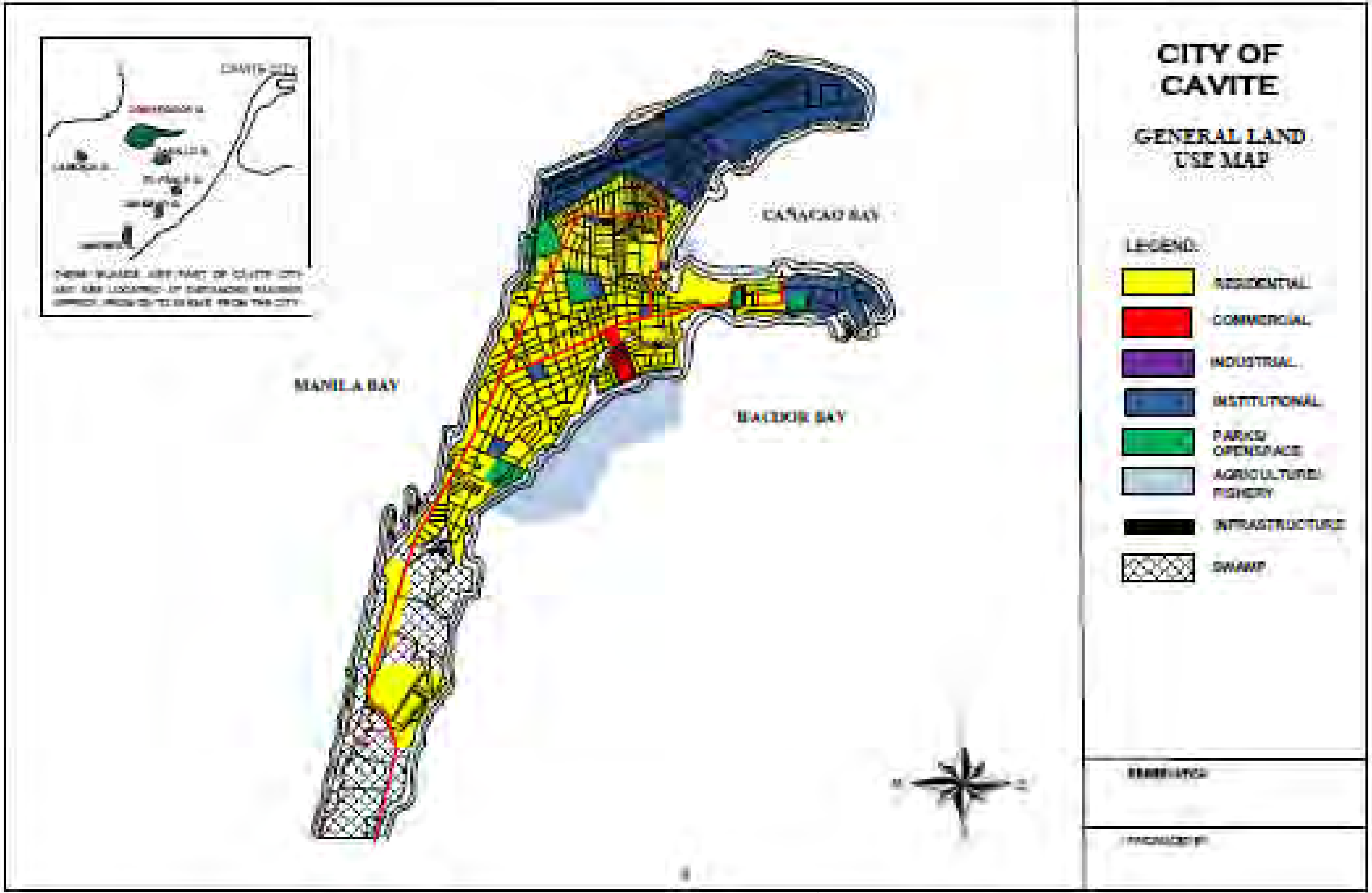


Figure 2-3 Existing Land Use Map of Cavite City

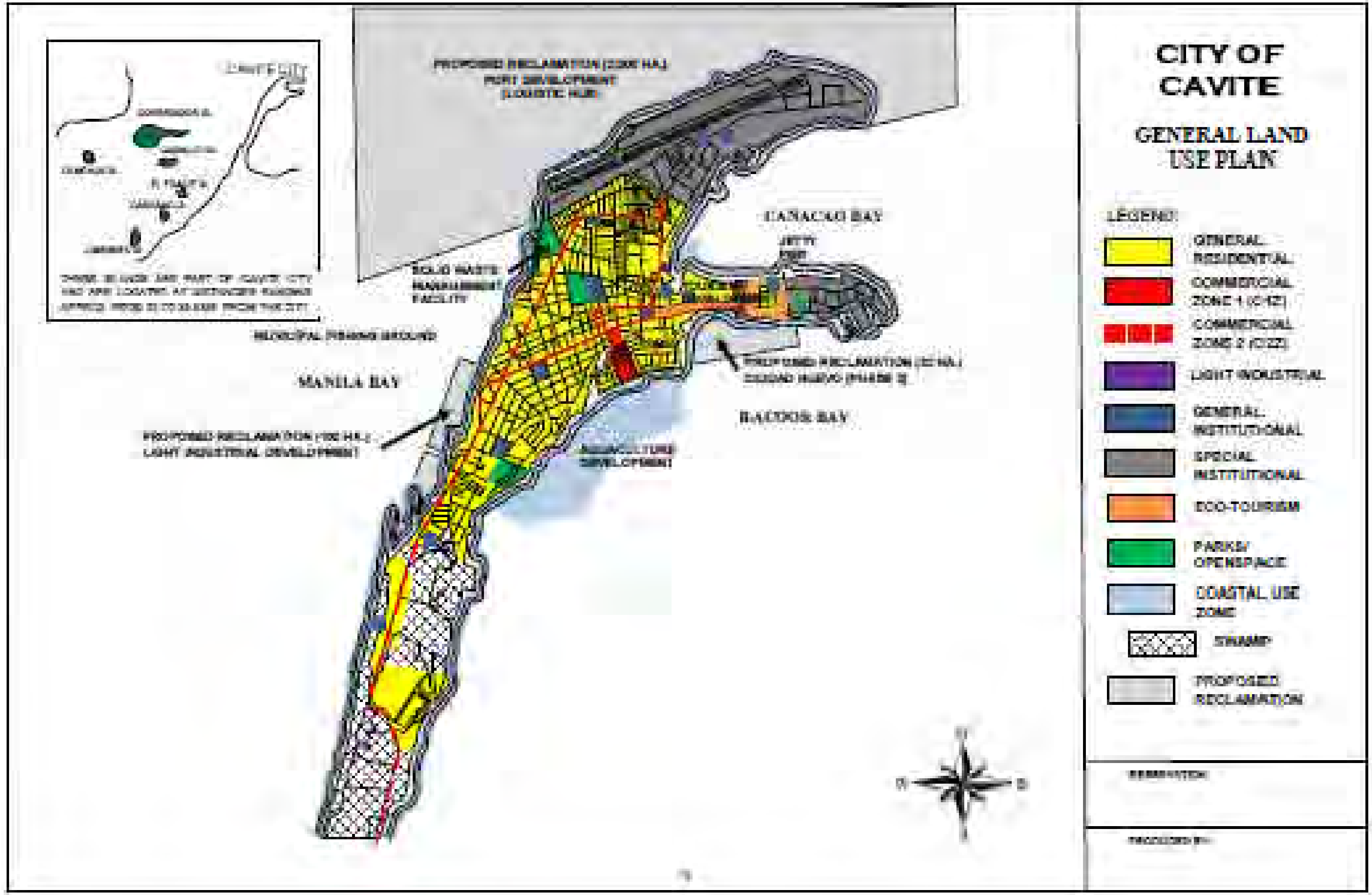


Figure 2-4 General Land Use Plan of Cavite City

Fishes caught by local fishermen are for local consumption delivered to local fishing markets in the city as well as surrounding municipalities. There are 3 local fish landing facilities in the city.

The fishery resources of the city are subjected to a myriad of problems. These are the pollution from dense population centers and industries in Metro Manila, open access or uncontrolled fishing (anyone with a fishing equipment can go fishing) and increasing siltation of the shore areas.

Industries – The presence of the Philippine Naval Base and the Sangley Point Naval Station in the city area makes shipbuilding and repair is a major industry. There are three establishments that repair ships and other similar vessels.

Minor industries consist of furniture retailing/repair that caters mostly to middle and high income groups for made-to-order furniture. There are also about 21 tailor shops that cater to customers who prefer personalized made-to-order clothes rather than the ready to wear types.

Several cottage industries operates in the City. These include bamboo crafts, shoe and slipper making, embroidery and others. These activities cater to a small group and are confined mostly to made-to-order services.

Tourism – Considering the long history of the City, there are old shrines and historical site. Among there are: a) Fort San Felipe built in the 16th century where the Cavite mutiny occurred in 1872 when Filipino workers were implicated in the armed uprising against the Spanish government; (b) Caňacao Bay was port to the Spanish galleons and the Pan Am Clipper seaplanses. The skyline of Manila is visible at the mouth of the bay. (c) Old Spanish Slipway- Built in 1874 in the same area where the galleons are built, the old steam boiler and other equipment are still operational; (d) San Roque Church – Built in the 18th century, gutted by fire in 1901, it has been enlarged and remodeled several times. The 17th century icon of the Blessed Virgin of Soletude of Porta Vaga is enshrined here; (e) Corregidor – The island at the mouth of Manila Bay has always been associated with the bravery, gallantry and heroism. There is a museum at the Pacific War Memorial Complex and an inspiring Eternal Flame of Freedom Sculpture, and many others.

Financial Resources – The City Government has an annual income of about P 276.21 million in 2009, an increase of 13% from the previous year. Expenditure in 2009 amounted to P 211.77 million or about 77% of the income. The trend of revenues and expenditures in the last 5 years is shown in **Figure 2-6.** The trend indicates an increasing revenues and expenditures.

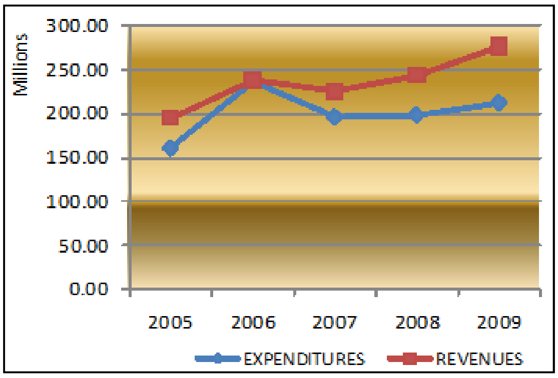


Figure 2-5 Cavite City Revenue & Expenditures Trend (2005-2009)

The City's revenue is derived mostly from property taxes, municipal license and operation of market, slaughterhouse and cemeteries. Others are from allotment of the National Government

It is expected that the City's income would gradually increase due to the revised assessment valuation of real property and the operation of the New Public Market.

Local Financial Institutions – Most Metro Manila based banks like Land Bank, Metrobank, Allied Bank, Banco de Oro, Philippine National Bank, etc have branches in the City. These provide short term collateral loans for commercial purposes. Traditional banking services like drafts, letters of credit, credit lines, deposit and other are also provided.

There are a number of local insurance agencies and branches as well as specialized financing groups like pawnshops, home appliances dealers, etc., offering financing schemes to residents and businesses.

2.4 City Plans Related to the MMSSIP

Development in each city is guided by its City Landuse Plan and Zoning Ordinance. City investments in infrastructure development may be limited to public services like schools, hospitals, public markets, transport terminals, housing, city roads expansion / improvement, etc. Private sector projects in the cities consist of commercial complexes, new residential subdivision, high-density housing or residential high-rises. With the MMSSIP, there will be increased awareness on proper sewage disposal and sanitation and such projects will consider utilization of the sewerage facilities.

The city governments has jurisdiction (construction and maintenance) on local streets and drainage systems. The MMSSIP implementation will require close coordination with the local government as these drainage systems are a major component of the proposed new sewerage systems.

The construction and maintenance of national roads, including its drainage systems are under the jurisdiction of the DPWH. However, the flood control and drainage in major waterways are under the MMDA. The MMSSIP implementation will be coordinated with the DPWH and MMDA.

Current conditions and plans by the Cities on sanitation and solid waste management in the Project area are described in Section 3.

3 SANITATION CONDITIONS IN THE PROJECT AREAS

This Section presents a description of the existing sewerage and sanitation conditions in the Project Area: cities of Parañaque, Las Piňas and Cavite based on secondary information. The types of household sanitation systems and their evaluation are presented as well as the situation of sludge disposal and solid wastes management. The environmental conditions at the Parañaque and Las Piňas River basins are described.

3.1 Sewerage and Sanitation Facilities

The sewerage and sanitation facilities operated by MWSI are shown in **Table 3-1**. It will be noted that there are no sewerage facilities in the Las Pinãs-Parañaque-Cavite service areas operated by the MWSI. The sanitation facility at Dagat-Dagatan, located in Tondo, Manila is the lone facility serving the whole of the MWSI service area. These facilities are well described in the MMSSIP Phase 1 Report[1] for Metro Manila

Table 3-1 Existing Sewerage and Sanitation Facilities of MWSI

Facility	System Components	Location	Capacity (cum/day)	Rehabilitated / Constructed Under
Sewerage Facility				
1. Manila Central Sewerage System	300 km of sewers, 3.5 km outfall to Manila Bay, 7 lift stations	Manila	432,000 (ave. loading – 130,000)	Manila Second Sewerage Project (MSSP)
2. Dagat-Dagatan Sewerage System	Aerated Lagoon System 67 km of sewers, I pumping station	Boundary area of Malabon, Navotas and Caloocan	13,000 (ave loading – 4,000)	MSSP
3. Quezon City Communal System	4 communal septic tanks, 1 Imhoff tank 18 km sewer	Project 7 & 8, Quezon City		
Sanitation Facility				
1. Dagat-Dagatan Septage Treatment Plant (SpTP)	Screw press system; Filtrate conveyed to the lagoon system. Septage collected by 7 mobile dewatering units and 25 vacuum trucks	Tondo, Manila	450 (12-hour shift)	MSSP

There are no sewerage systems installed / operated by the MWSI in Paranaque, Las Pinas and Cavite cities. However, private developers have sewerage facilities at prime residential subdivisions and sewage treatment plants at high-rise condominiums and large

[1] JICA-MWSS Preparatory Survey for Metro Manila Sewerage and Sanitation Improvement, Final Report by CTI Engineering International Co., Ltd., July 2009

commercial centers or malls that were constructed in the last few years in compliance with recent environmental laws and regulations.

3.2 Household Sanitation Facilities and Excreta Disposal Methods

In Metro Manila, the sanitation systems are a mix of individual toilet / septic tanks, public toilets, communal septic tanks, sewer lines, treatment facilities (wastewater and seepage), desludging, and re-use / recycling sludge / effluent.

3.2.1 Household SanitaryToilets

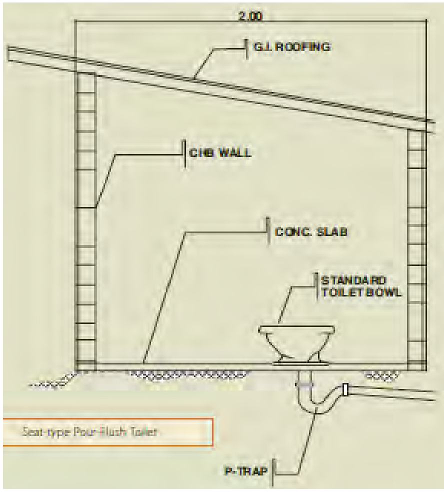
Information from the 2008 Department of Health (DOH) water and sanitation survey indicated that 91.5% of the households in Metro Manila (National Capital Region) have access to safe water supply and 90.0% of these households have sanitary toilets[2]. Per 2000 NSO survey, household access to sanitary toilets was 84% for the NCR.

For the cities of Las Pinãs, Parnaque and Cavite, access by households to sanitary toilets in 2008 is 95.5%, 75.3% and 86.9% respectively.

To maintain the treatment capacity of septic tanks, periodic desludging or removal of the septage content of the tank by a vacuum trucks and transport of the septage to a septage treatment plant is an on-going program of MWSI in its service area.

3.2.2 Types of Household Sanitation

Types household sanitation technology[3] in the Philippines include pour-flush toilets, ventilated pit latrine, and aqua privy. These toilet types provide the sanitary disposal of human wastes and widely used in informal settlements where space is very limited and common in rural communities.



Pour-Flush Toilet - This type of toilet (a sketch shown at right), has a bowl with a water-sealed trap. The bowl could be either squat or seat type. The excreta is flushed with a pail or scoop of water poured into the bowl. The bowl could be set in place at the concrete slab cover of the pit or septic tank or offset and pipe connected to a septic tank. The toilet can be within the house or in a separate structure outside the house. This type of toilet is commonly used in urban areas with limited space or in rural areas. It is inexpensive, readily available bowls, hygienic, easy to clean, and reliable

Ventilated Pit Latrine – A pit latrine shown in the sketch below consist of a pit on the ground with either a squatting plate or slab provided with riser and seat. A housing or toilet room is built over the pit. The pit latrine operates without water. The VIP is a

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[2] Sanitary toilet consists of the toilet bowl as receptacle of excreta to be flushed with water through the sewer pipe to a septic tank

[3] World Bank – Water and Sanitation Program, Philippines Sanitation Sourcebook and Decision Aid, Chapter 4 Sanitation Technology Sheets, 2004

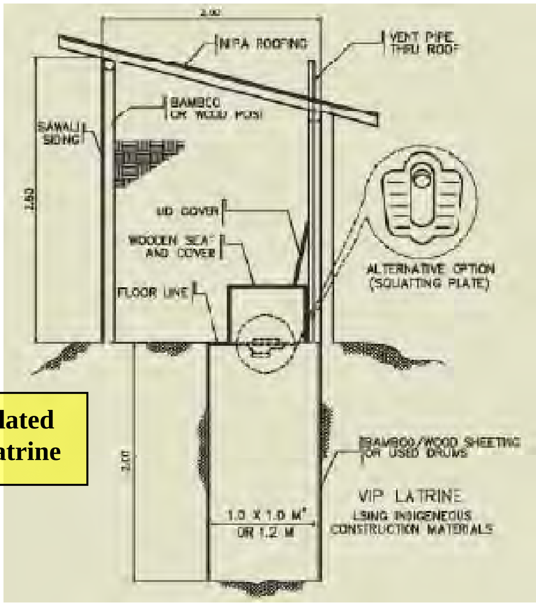
pit latrine win a screened vent installed directly over the pit. The vent provides odor control and a screen on top of the vent prevents entry of insects. Filled pits are covered with soil for composting. The VIP is easy to construct and inexpensive using local materials.

Aqua Privy - The conventional aqua privy is essentially a small septic tank located directly below a squatting plate which has a drop pipe extending below the liquid level in the tank to form a simple water seal. To prevent odor, fly or mosquito nuisance in the toilet, the water seal has to be maintained by adding sufficient water per toilet use. Advantages include low odor and insect problem, no danger of clogging by bulky anal cleansing material, minimal risk to health. A sketch is shown below.

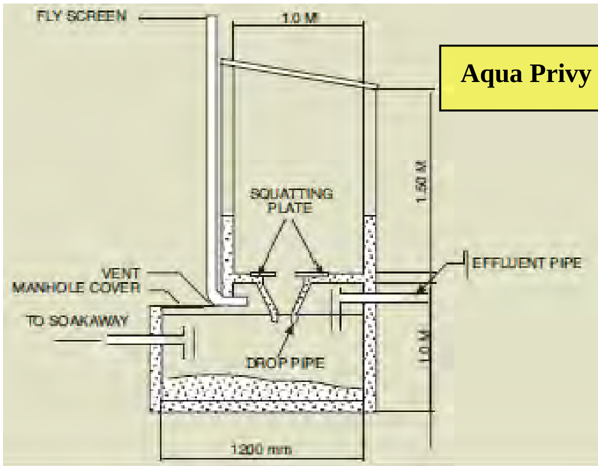
3.2.3 Public Toilets

Public or community toilets could be designed to serve urban poor communities, as well as parks and public places where large number of people congregates. Public toilets are numerous in Manila serving densely populated barangays. The report by the Manila City Hall in 2005 indicated 43barangay public toilets in its 6 districts, a number of which are closed, some in poor conditions, but more than half are in satisfactory operation. Public toilets installed in the recent past years, mostly by the local government as part of beautification program, particularly those located in parks, are well maintained, as a token fee is paid by the user to ensure a clean toilet closet.

The actual survey of public toilets in Las Piňasand Parañaque remains to be done, including those in the Cavite towns of the Project area.

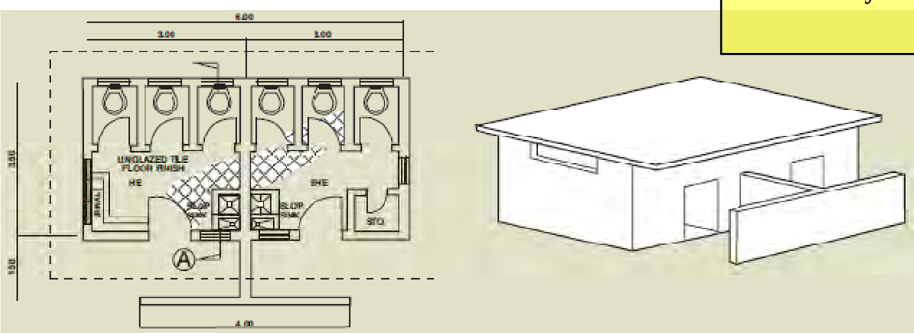


Ventilated Pit Latrine



Aqua Privy

Community Toilet



3.3 Biosolids Management

From the septic tank desludging operation, a huge amount of bio-solids are generated by the septage treatment plants. Sludge are produced from the physical and biological treatment of wastewater and septage. The MWCI produced about 11,000 cum of biosolids in 2007. Instead of treating bio-solids as waste, MWCI disposes the bio-solids through the application in lahar areas for purposes of soil reconditioning. Soil quality is enhanced and the studies have shown that the practice is effective in increasing yields at sugarcane fields.

With the expected increased volume of biosolids production, MWSI is adopting the biosolids operation of MWCI including getting a license as solid conditioner manufacturer and distributor from the government's Fertilizer and Pesticides Authority, on the basis of its pilot studies conducted in Floridablanca, Pampanga, with a research institution.

3.4 Recycled Wastewater

The production of wastewater from MWSI's sewage treatment plants is nil as its large Manila Central Sewerage System disposes sewage via a long outfall that disperses the wastewater to Manila Bay. The Dagat-Dagatan Septage Treatment Plant is a lagoon treatment system with an outfall to a nearby river.

However, with the planned sewage treatment plants for several combined sewerage systems scattered in its service area, wastewater recycling, similar to MWCI's Effluent Reuse Program may be adopted. The scattered small treatment plants has the locational advantage for the effluent reuse for watering the main roads islands green and park landscapes.

3.5 Sanitation Coverage

As shown in the 2008 MWSI Business Plan, the actual sanitation coverage (primarily septic tank desludging) for 2006 and projections are shown in Table 3-2, including the corresponding number of septic tank to be desludged at the MWSI's service area and the MMSSIP study areas.

For the Las Piňasand Paraňaque cities, sanitation coverages in 2010 are 57% and 46% respectively and increased to 100% coverage by about 10 years from today. Corresponding number of septic tanks desludged is about 2,200 units for 2010 in the 2 cities of the Project Area. Projections for the 5 years beyond 2012 and 2017 are shown in the Table 3-2

3.5.1 Desludging Services

Desludging of household septic tanks at frequency of once in every 3 to 5 years are undertaken by MWSI and MWCI with their fleet of vacuum trucks and Mobile Dewatering Units. Disposal of the collected septage / sludge are at the various septage treatment facilities.

Private septic tank desludgers have been operating in Metro Manila prior to the MWSS privatization, but their exact numbers could not be determined as ownership and official registrations to government agencies or their respective local governments in their area of operation are not traceable. Further, approved proper disposal sites or facilities of these private desludgers are often non-existent.

Table 3-2 MWSI Business Plan's Sanitation Coverage and Septic Tank Desludging

City/Municipality	Sanitation Service Coverage*				
	Actual	Projected			
	2006	2008	2010	2016	2021
NCR (MWSI Service Area)	22%	18%	37%	51%	54%
MMSSIP-Ph2 Study Area					
Las Pinas	3%	41%	57%	61%	100%
Paranaque	13%	30%	46%	66%	100%
Cavite (MWSI)	0.2%	48%	68%	54%	100%
Cavite City	7.0%	50%	84%	96%	100%
	Number of Septic Tanks to be Desludged				
	Actual	Projected			
	2006	2008	2010	2012-2016	2017-2021
NCR (MWSI Service Area)	32,185	33,029	47,890	287,529	315,017
MMSSIP-Ph2 Study Area					
Las Pinas	481	2,607	2,234	30,297	24,818
Paranaque	2,363	4,955	2,153	18,769	30,907
Cavite (MWSI)	238	2,214	61,612	42,900	92,985
Cavite City	120	394	1,372	7,317	8,203

* Sanitation service coverage expressed as % of population

Source; 2008 MWSI Business Plan

3.5.2 Sewerage and Sanitation Programs

With the revived focus in the implementation of sanitation and sewerage programs by the government as mandated by the Clean Water Act of 2004, the Department of Health issued the operation manual for septage management in 2008 and a recent administrative order on sustainable sanitation. In early 2010, the Department of Public Works and Highways (DPWH) also issued the national sewerage and sanitation program (NSSMP) for implementation by local government units of urbanizing cities outside Metro Manila. The NSSMP primary focus is on sewerage and sanitation management infrastructures and the promotions of supporting environment programs to make them successful. Targets have been set in the the next 5 to 10 years, in terms of the number of LGUs / Water Districts /Public-Private Partnerships installing / operating sewerage and septage management facilities.

3.5.3 Sewerage and Sanitation Projects

The MWSI Master Plan in 2009 through short-term investment (2008-2012) intends to improve the current 9% sewerage coverage to 13% in 2011, with an ultimate 39% in 2021. The estimated investment for the treatment plants and facilities in the 5-year business plan period is P 5.01 billion.

The majority of the Projects will be located at the north and central portion of the service area. Serving the south portion of the service area is the proposed South Septage Treatment Plant (SpTP) with 250 cum/day capacity to be located in Parañaque City and scheduled for implementation in 2011-2012. Procurement of additional vacuum tankers will complement the operation of the South SpTP.

Long-term projects identified for the southern part of the concession area are shown in the in **Table 3-3.** It will be noted that no sewerage is planned for Las Piňas and Cavite areas in the long-term, except for Paraňaque in 2020. The Business Plan indicates no sewer connections for these areas in the long term. However, the MMSSIP will advance the sewerage services.

Table 3-3 Proposed MWSI Sewerage and Sanitation Projects (2009 Master Plan)

Project /Location	Capacity (cum/d)	Project Cost (P million	Target Completion
Paraňaque:			
Jokaso	780	81	2018
STP	1,560	78	2020
South SpTP	50	235	2016
Las Pinãs			
Jokaso	1.300	150	2016
Muntinlupa			
STP	30,000	1,509	2015
	6000	302	2016
Kawit:			
SpTP	350	235	2016, 2021
Cavite City:			
Jokaso	1,950	150	2016, 2021

3.6 Drainage and Flood Control Facilities

The DPWH is the government agency that has jurisdiction over drainage and flood control facilities located in national roads and rivers or large waterways. The local government is responsible for the drainage at its local roads / catchments, and flood control in its creeks or small waterways. However, for Metro Manila, the Metro Manila Development Authority (MMDA) has assumed the DPWH jurisdiction.

3.6.1 Main Rivers and Creeks in the Areas

The project study area are within the 92-sq km catchment of Paraňaque Basin formed by the Las PiňasRiver and Paraňaque River.

In its CLUP, the Las PiňasCity CPDO has made an inventory of its rivers and creeks as shown in Table 3-3. There are 2 rivers with lengths of 3 to 18 km and 4 creeks with lengths of 1.5 to 2.5 km. The barangays traversed by these waterways are shown in **Table 3-4**.

Similar inventory by the Paraňaque City Planning Office remains to be made. However, as part of the MSSIP-Phase 2Volume II Report, the drainage patterns for the various creeks and waterways for the identified STP sites were investigated and described in the Report.

Table 3-4 List of Rivers and Creeks in Las PiňasCity, 2008

Name	Length (km)	Barangay Covered
Las PiňasRiver	2.9	Bernabe, Real Street, Tramo, Pulanglupa Uno Daang Kariton, Korva St., Plaza Quezon, Aldana, Balite St., Aldana Balite St, Ilaya-Sagip Ilog Wharf Gatchalian, Manuyo Dos Versaville Townhomes 2, Pulang lupa Dos, Riverside Dona Julita Subdivision, Dona Paz, Pulanglupa dos
Zapote River	18.3	Sta Cruz Compound along coastal, Sitio Makipot, Mateo and Velasquez Compound, Pulanglupa Uno Basa I Compound, Zapote Long Beach Homes, San Isidro Subdivision, Pamplona Uno Margie Moran Dulo, Cesiro St., Carbaggio St., Upper Riverside, P. Sabido St., BFRV, Talon Dos Moonwalk, Talon Singko Soldiers Hills II, Almanza Uno
Dalic Creel	1.4	Tramo, Pulanglupa Elementary School, Toda, Chua's Compound, Casimiro Townhomes, Perpetual Village, Pulanglupa Uno
Balihatar Creek	1.8	Tubuhan, Manuyo Uno; Daniel Fajardo
Tungtong Creek	2.5	Gatchalian, Manuyo Dos BF Homes Martinville portion, Pulanglupa Dos CAA
Marulas Creek	2.1	Airmen's Village, Martinville, Pulanglupa Dos CAA

Source: Las Piňas City, Comprehensive Land Use Plan, 2009-2024, August 2008

There is no main river in Cavite City as it is a narrow peninsula.

3.6.2 Flood Prone Areas

The flood prone areas for each of the two cities are described in Sections 2.1 and 2.2.

3.6.3 Flood Control Facilities

Major flood control facilities in Metro Manila are the responsibility of the Metro Manila Development Authority (MMDA). Such facilities include diversion culverts, flood gates and pumping stations at the rivers and tributaries, mostly located in the floodplains of Manila Bay.

Local flood protection facilities such as flood dikes, retaining walls, creek bank riprap and other small structures are the responsibility of the local government.

4 WATER SUPPLY SERVICES

This Section presents the conditions of water supply services, the organization providing the service, service area and population served, service connections, system facilities and proposed improvement programs, including an evaluation of the water distribution system. The activities of Maynilad on NRW management aimed at an NRW target of 40% in 2012 is described.

4.1 Service Area and Population Served

The cities of Paranãque and Las Pinãs are service areas of MWSI in south Metro Manila and 6 municipalities/city in Cavite Province including Cavite City. Profiles of the three cities are presented in Sections 2.1, 2, and 2.3.

Being at the south-southeast periphery of the MWSI service area and the far distance from the main sources at Lamesa Treatment Plants, the area remains to be fully covered by MWSI's water distribution systems, particularly the Cavite service area.

Excerpts from 2008 MWSI Business Plan indicate information on population and percent water served for 2008, 2010 and 2020 for the 3 cities including the Cavite service area are shown in **Table 4-1** It will be noted that in 2010, water-served population in Parańaque and Cavite City have reached 100%, with Las Piňas at 62%.

Table 4-1 Water-served Population for Las Pińas, Paraňaque, Cavite Area & Cavite City

LAS PINAS CITY	2008	2010	2020	CAVITE (MWSI Service Area)	2008	2010	2020
Total Population	542,978	556,594	611,298	Total Population	1,052,380	1,109,383	1,391,697
Service Covered Population	174,831	240,036	431,963	Service Covered Population	271,183	448,646	1,181,763
Net Population Served	376,589	390,149	444,852	Net Population Served	971,307	1,028,369	1,310,684
Percent Served	46%	62%	97%	Percent Served	28%	44%	90%
Private Served Population	166,445	166,445	166,445	Private Served Population	781,197	660,737	209,934
PARANAQUE CITY	2008	2010	2020	CAVITE CITY	2008	2010	2020
Total Population	565,788	584,194	663,697	Total Population	107,968	111,507	128,211
Service Covered Population	375,016	393,423	472,926	Service Covered Population	102,543	110,302	128,211
Net Population Served	375,016	393,422	472,926	Net Population Served	107,968	111,507	128,211
Percent Served	100%	100%	100%	Percent Served	95%	98%	100%
Private Served Population	190,771	190,771	190,771	Private Served Population	5,425	1,205	0

4.2 Water Sources for those Not Connected to the System

The NSO survey of households in 2008 indicated access to safe drinking water is 100% and 86% respectively for Las Pinãs and Parainãque cities.

Information gathered indicated the following water sources in the project area: (i) independent water supply systems (deepwell) (s) and distribution network) for residential subdivisions developed by the private sector as well as government units; (ii) shallow wells with manual or electric pumps; and (i) hauled water by house owner or private water tankers.

4.3 Description of Physical Facilities

At present, water supply to the western portions of Las Piňas and Parańaque are provided by the Pasay Booster Pump Stations through a 2400 pipemain along the coastal area and its 1200 mm dia extension serves Cavite coastal towns. The Villamor Booster Pumping Station with a 1200 mm dia pipemain along the South Luzon Expressway, supplies the eastern part of the two cities. A 2800 mm dia pipemain from the Bagbag Reservoir, branching into 2400 mm dia and 2200 mm dia connect respectively to the Pasay and Villamor booster pumping stations. A sketch of the water supply system is shown in **Figure 4-1.**

Due to inadequate supply from the supply pipe mains to the Pasay and Villamor Pump stations, water service availability at the service connections in some of the distribution systems, particularly at the eastern part of Parainãque, is not continuous during the day. Based on MWSI 2008 2nd Qtr Report, water availability in this area is less than 12 hours a day. Some high areas (also at the eastern part of Parainãque) suffer low pressure (less than 7 psi) to no water during peak hour periods. Distribution valves are controlled to for purposes of rationing the insufficient supply and maintaining adequate pressure at the service taps.

Water supply to Cavite service areas in Bacoor, Imus, Kawit, Noveleta and Cavite City is covered by the MWSI's Cavite-Las Piňas Business Center. Water originating from the Lamesa Treatment Plants is presently booster pumped with a dedicated pipeline from the Pasay Pumping Station to service areas in Bacoor, Imus and Kawit. Rosario, Noveleta and Cavite City is supplied by the Noveleta Deepwell and Reservoir system. With the completion of the Pagcor Reservoir & Pumping Station in Parańaque, water from Lamesa will augment supply to the Noveleta system, thus significantly increasing supply to Cavite service areas. A schematic layout of the pipemains is shown in **Figure 4-2.**

4.4 Service Connections and Metering

Households and establishments connected to the MWSI distribution system are provided with the appropriate water meters. These meters are read at scheduled days during the month and become the basis of billings to customers. As part of the water service connection, MWSI installs calibrated water meters supplied by MWSI. Owner-supplied meters are calibrated by MWSI prior to installation.

4.5 Cost of Water and Water Tariff

The water billed to a customer is the volume consumed (based on the water meter reading during the billing period) and the current tariff rate approved by the MWSS Regulatory Office. In addition to the basic water charge, all customers are charged an environmental fee, and if connected to a sewerage system, an additional 20% of the basic charge. For the water tariff effective January 1, 2009, the environmental and sewerage fees are 14% and 20% of the water basic charge.

For residential consumers with 10 cum (cubic meters) or less consumption per month, the water charge is P 110.91 per connection[1]. The basic water charge ranges from P 13.55/cum for next 10 cum beyond the minimum 10 cum to P 45.12 for water consumption of up to 200 cum. Most residential connections consuming 30 to 80 cum per month are charged the average basic water charge of P 28.30/cum.

On its website, MWSI provides a calculation sheet for its customer to estimate their water bill for the billing period. For example, a residential consumer with a consumption of 30 cum is billed P 611.09 and P 697.10(inclusive of discount and tax) respectively for an unsewered and sewered connection.

[1] A 20% discount is provided for less than 10 cum per month consumption.

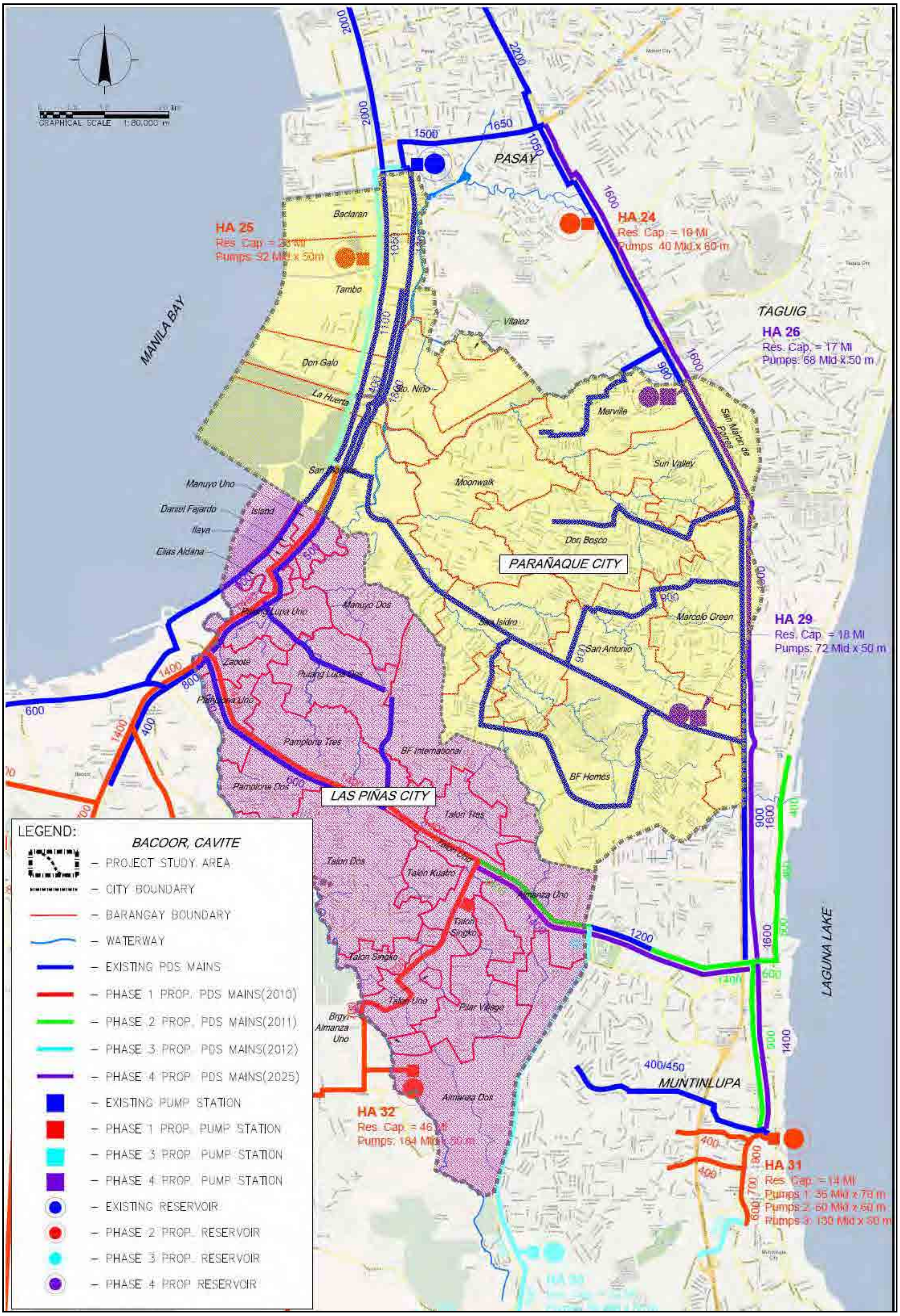


Figure 4-1 Layout of Water Supply Mains for Parañaque and Las Piñas Cities

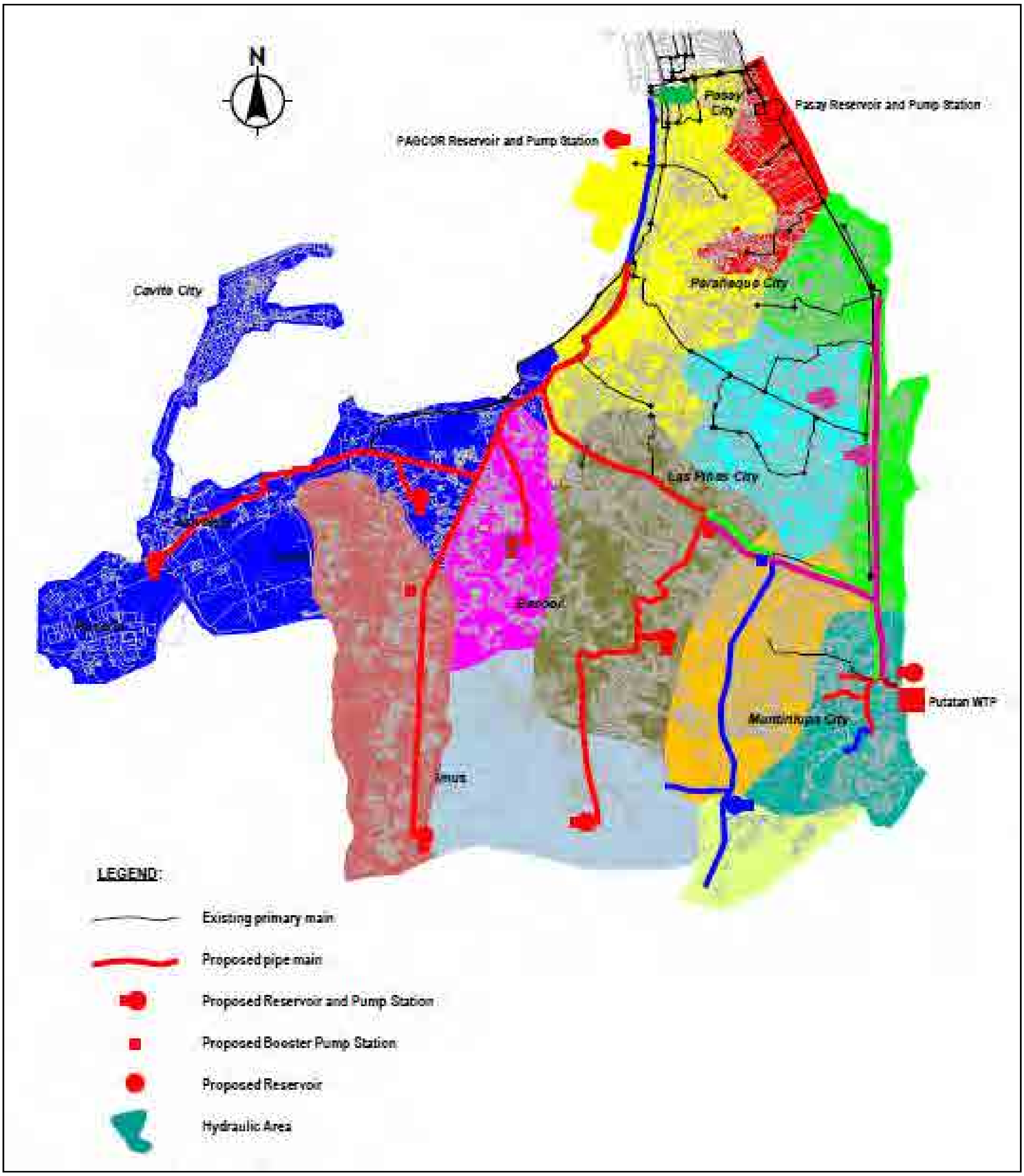


Figure 4-2 .Layout of Water Supply Mains for Cavite Area (from Pasay Area)

4.6 Water Accountability

MWSI service area of 540.43 sq km is divided into 12 business areas; each business area is subdivided into zones, sub-zones and district monitoring area. A Business Area (BA) manages the water system operation in its area of jurisdiction, i.e. it is responsible in the efficient utilization of the water supply inflow from the transmission mains into the distribution systems in its jurisdiction. Such inflow is monitored and is the basis for the Non-Revenue-Water (NRW) calculation. A low NRW means low water losses in the the business area.

Parainãque City is under the jurisdiction of the Parainãque BA, while Las Pinãs is within the coverage of the Cavite- Las Pinãs BA.

4.7 Proposed Improvement Programs

In 2010, MWSI allotted over P 6.6-billion for capital expenditures. About P 1.7 billion is earmark to the expansion of the water service coverage, P0.7 billion to replace old pipes in the central service area, and P 1.7 billion to modernize the distribution systems, To further reduce its non-revenue water, which is lost to pilferage and leakage, MWSI is ready to spend P1.5 billion for water recovery and reallocation programs, and P0.31 billion for leak repairs alone. The rest of the 2010 budget will be used for sewerage and sanitation, water sources, water production, building and warehouse facilities, natural calamity mitigation and other projects, Maynilad noted.

Non-revenue water (NRW) is the water lost to pilferage and leakage, From the 66% NRW in 2007, MWSI has brought down its water loss to 59% in 2009. To reduce the NRW and improve water use efficiency, MWSI engaged the services of a consultant firm to train Maynilad engineers in the use of Sahara, a state-of-the-art technology that detects leaks, pockets of trapped gas, and structural defects in main water lines. The new technology enables the inspection of pipes without interrupting water service and will help the MWSI to intensify its leak detection efforts without affecting water delivery services to its customers.

4.8 MWSI Activities for NRW Reduction

The New Maynilad - In January 2008, Maynilad officially created the Central NRW (CNRW) Division dedicated to managing and reducing the water loss in the system. A seasoned leader in NRW management was tapped to lead the new Division.

Preparing the NRW program and carrying out the plans to effectively reduce NRW required exhaustive effort and the full support of Maynilad’s new management and employees , backed-up by significant capital investment.

A part of the plan was to complement this new division with more than 400 employees composed mostly of young and dedicated engineers who will be guided by international and local experts, and who will be trained using new technology. These engineers will be exposed to the latest and tested approach to spearhead and deliver the company’s target NRW to 40% in 2012. The reduction from 66% to 40% in just five years is equivalent to an NRW of more than 500 MLD.

From 2008 to 2012, capital investment amounting to almost US$240 million has been allocated to implement a sustainable NRW management programmed. To date, it is considered as one of the world’s largest NRW reduction initiatives.

Realizing the need for a competent technical partner – To meet the NRW target for 2012, Maynilad must deliver an average NRW reduction of 100 MLD every year from 2008 to 2012. As only minimal investments were made in the previous years to improve the system, and even much less investment to address the technology gaps, particularly in NRW management, the need to come up with a catch up plan became more evident

The new management of Maynilad realized that this gap needs to be addressed early on. Hence, in 2009, Maynilad engaged the services of Miya, a specialist in water loss management. Maynilad partnered with Miya under a Technical Services Agreement (TSA) to provide experts in the field of NRW management and to be co-responsible in delivering the 2012 NRW targets.

The NRW in 2010 is now 50%. Historical and projected NRW levels are shown the **Figure 4-3**.

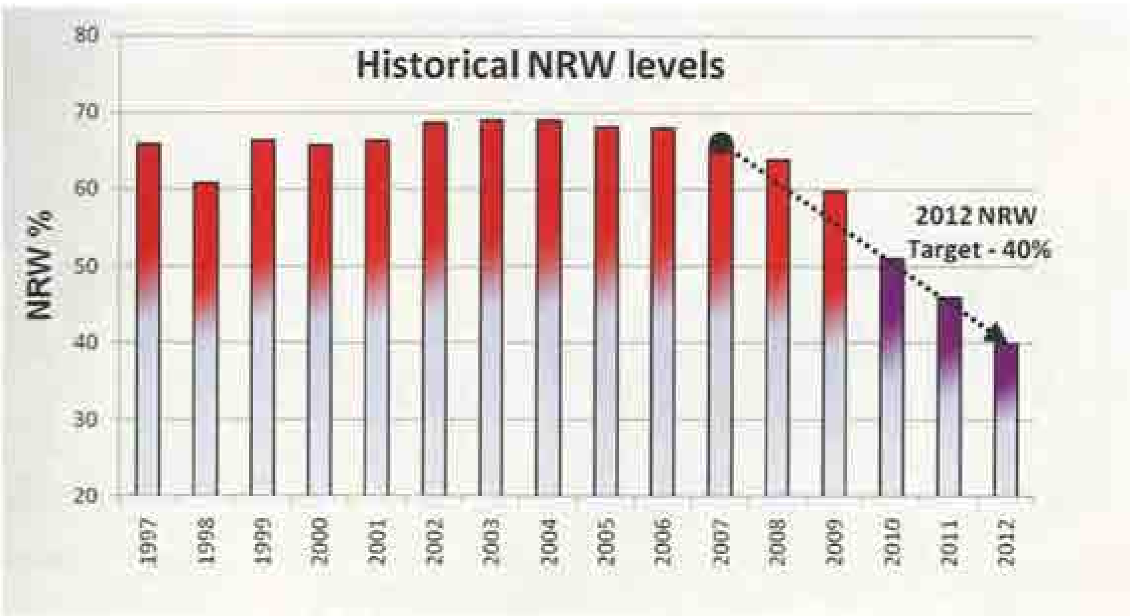


Figure 4-3 Historical NRW Levels and Projections to 2012

5. BASIC STRATEGY AND STUDY CONCEPT

The Section provides a review of past sewerage and sanitation master plans, beginning with the 1968 master plan to its update in 2005, as well as the Business Plans of both MWCI and MWSI 2008. Master plan updates are on-going considering the business plans and the on-going surveys and feasibility studies under the MMSSIP. The design concepts of the sanitation and sewerage systems improvement are presented taking into consideration recent data of wastewater quality and volumes rates. Components of a combined sewerage system are described and presented with sketches. Given the extensive site inspections, the strategy is considered applicable and suitable.

5.1 Past Master Plans and Latest Survey Reports for MWSS Sewerage System

Recommendations, comments, evaluations or descriptions regarding the project areas of Parañaque and Las Piñas Cities made in past Master Plans or Survey Reports are reviewed herein under.

(1) Sewage and Sanitation Master Plan for Metro Manila (WB in 1968)

Collection of sewer is collected to the three disposal points in Manila Bay. Basically combined system was envisaged and major interceptors were proposed Major interceptor sewers were proposed adjacent to drainage paths to transport sewage to the disposal points. A significant feature of the plan was construction of a major sewer which would run along the bed of the Pasig River and intercept dry weather flows from the storm water system. Parañaque and Las Piñas were planned to implement as the second stage in the three staging development plan.

(2) Sewage and Sanitation Master Plan for Metro Manila (WB in 1969)

This plan discarded the previous plan on the basis of cost and from many options recommended a plan based on:

A sewerage expansion program involving rehabilitation of existing facilities and a monitoring system called METROSS. (Metro Manila Sewerage and Sanitation)

- Improve the quality of sanitation services
- Combined sewers;
- Secondary treatment of sewage with four outfalls into Manila Bay
- A sanitation programme comprising minor drainage projects for the depressed areas

(PROGRESS) are a septic tank desludging programme

(STAMP) are Part of PROGRESS and STAMP were implemented as a component of METROSS – 1

Only METROSS – 1 was implemented, although rehabilitation of the Central Sewerage System remained uncompleted.

(3) Manila Second Sewerage Project (WB in 1994)

The Manila Second Sewerage Project (MSSP) was envisaged to begin addressing the increasing water pollution in Metro Manila. MWSS proceeded with the implementation of the MSSP in 1994 with World Bank assistance. Although based on the 1991 Second Manila Sewerage Feasibility Study, changes in the proposed project components were made due to the high cost of implementation.

MSSP sought to provide specific measures for the following objectives:

- Improve the quality of sanitation services
- Reduce environmental pollution
- Minimize the health hazards from wastewater

In order to achieve these goals, the project was divided into four components. These were as follows (i) Septage Management Plan, (ii) Ayala Sewage Treatment and Sewerage System Rehabilitation, (iii) Manila Central Sewerage System Rehabilitation and (iv) Supply of Laboratory Equipment, Vacuum Trucks and Other Vehicles.

Parañaque and Las Piñas were considered as the areas served mainly by sanitation services.

(4) Study on Water Supply and Sewerage Master Plan of Metro Manila (JICA in 1996)

This 1996 Study on Water Supply and Sewerage Master Plan of Metro Manila addressed the pressing issues on both water supply and wastewater generated.

The options between separate and combined sewer systems were evaluated. Other concerns were the drainage system improvement and expansion, septage management, maintenance of overflow chambers and household service connections.

Proposals for systems comprising smaller service areas were introduced to enable more immediate implementation of the sewerage plans. The proposed smaller-scale treatment plants were to be eventually integrated thereby forming a centralized system. Assessment was made on Ayala System, North Manila System, Central Manila System, South Manila System, and West Mangahan. Paranaque and Las Pinãs were touched as the remaining catchment areas, and the use of aerated lagoons for sewage treatment of the East Mangahan, Muntinlupa and Parañaque catchments was assessed to be favourable in reducing operation and maintenance costs. This was deemed for the required land areas in these catchments were available.

(5) 2000 West Zone Sewerage Master Plan

A draft sewerage master plan (SMP) for MWSI was prepared by PhilAqua Consultants Inc in 2000. Due to a misunderstanding between the concessionaire and the consulting firm, the draft proposal was not recognized by MWSI as an official document.

The draft recommended the use of centralized sewerage systems in the West Zone until 2011. After then a decision should be made on whether centralized or decentralized systems would be more advantageous. A comparison between sewerage and sanitation (septic tanks) was also presented as a short special topic.

(6) 2005 East Concession Area Master Plan Update

The 2005 East Concession Master Plan Update was based on a study undertaken by JICA in 2000. The updated master plan has integrated some of the packages proposed in the Manila Third Sewerage Project to form an overall strategy in the implementation of the sewerage and sanitation programs for the service area of MWCI. Thus Parañaque and Las Piñas are not covered in this study.

(7) MWSS Master Plan 2005 (WB in 2005)

This plan was studied to develop an integrated strategy for sewerage and sanitation services across the entire MWSS service area that will take into account the targets, plans and programs of the concessionaires, including MTSP. The strategy was to address the environmental degradation of the water bodies in Metro Manila by providing affordable solutions to the disposal and treatment of domestic wastewater within and beyond the concession period. The report therefore examined existing sewerage and sanitation facilities and the targets, plans and programs of the concessionaires in the context of recommending least cost technical solutions for sanitation, wastewater collection and treatment. Issues that have constrained the development of sewerage and sanitation facilities in Metro Manila in the past were examined in order to guide the strategy such that these constraints could be addressed. Taking into account the targets of the concessionaires, short, medium and long-term strategies for sewerage and sanitation were developed. Phased development programs covering the Master Plan planning periods were prepared, based on affordability and willingness-to-pay criteria.

In the plan, Parañaque and Las Piñas are included in the combined catchment of South Manila and there is a centralized STP planned to establish in the reclaim land of Pasay to collect all sewers from the catchment area. Proposal is made for 2 sewage treatment plants in Parañaque and Las Piñas respectively in 2025 to be established in the limited residential areas where the families can afford the sewerage service payment.

(8) Master Plan for Sewerage and Sanitation Improvement Project (MWSI in 2008)

Master plan was made in order to realize Maynilad Business Plan 2007. This plan covers all Maynilad business territories and proposes substantial STPs and interceptor specifications to realize their final target of sewerage service coverage of 66%. In the plan, Sewerage service population in Parañaque and Las Piñas are only 24,000 (about 5% coverage) in 2021.Sewerage system mainly consists of combined sewer system with biological treatment process.

(9) Preparatory Survey for Metro Manila Sewerage and Sanitation Improvement (JICA 2009)

As preparatory survey works to implement the sewerage and sanitation projects in Metro Manila, review works on the existing sewerage and sanitation systems, current implementation plans, for environmental improvement projects, relative acts and regulations, government agencies, study reports and the other relative activities to the sewerage and sanitation implementation programs have been made, and commented with the evaluations. It recommended the combined sewer systems and pointed that the existing sewerage systems should better be continued rather than changing the system to a new technology. The new ideas like Shimanto-gawa system deemed difficult to apply to the Metro Manila areas. It also presented the current issues in or among relative agencies to be addressed. Regarding MWSS master plan, it recommends consolidating or modifying with concessionaires' business plans and new development strategies of sewerage and sanitation implementation plans, taking consideration 15 year extension of concession period of the both concessionaires, and MWSS master plan 2005 should be based on the modifications, instead of a new master plan preparation.

5.2 Basic Strategy of Development of the Business Plan for Sewerage Services

As the Maynilad business plan for sanitation and sewerage service development in 2008, the principal sanitation and sewerage system shall be of sewerage treatment systems covering 66% in average of Maynilad whole jurisdictional areas and out of the sewerage treatment service would be complemented by the septage treatment and management service by year 2021. Therefore the basic strategy of sanitation service development plan is as follows.

(1) Basic Sanitation Management Plan

Basically the houses/buildings shall facilitate their own septic tank systems. In the sense, the septic tank systems (conventional septic tanks) for the sewage treatment would be taken consideration in the territory.

Desludging of septic tanks shall be done by Maynilad septage collection system by using vacuum vehicles (septage collection vehicles), and septage collected would be sent to the central septage treatment plant for the final treatment. At this moment, only Dagat-dagatan treatment plant is under operation as a test pilot plant.

In order to cover all septage generated in Maynilad service area, another septage treatment plants should be constructed to accept total septage predicted through the business plan.

Manila Water Corporation established three septage treatment plants for their service treatment of the septage generated in their territory, however, it might be studied that septage treatment plants would independently be managed to accept all septage generated in Metro Manila. At that time, the collection vehicles and septage treatment plants could be managed in monogenetic management by a new independent company

(2) Existing Separate Sewerage Systems

Central Manila, a part of Tondo in Dagat-dagatan area, the north part of Quezon City, four communal plants, and a part of Ayala area are applying separate sewerage systems. In the Central Manila, sea outfall system through Tondo Terminal Pumping Station with seven lift-up stations is used. This system would contribute to Manila bay area water contamination, therefore improvement of effluent water quality at Tondo Pumping Station shall be planned, which also expand the collecting capacity to accept the wastewater generated in the outer areas.

Dagat-dagatan sewerage system is applying aeration pond system, and the sewage plant could expand its treatment capacity by replacing the existing system to more effective process.

The four communal plants in Quezon City are under rehabilitation program to recover the functioning and renovated by superseding them by advanced process to cater for sufficient effluent water qualities of the recent regulations.

(3) Sewerage Treatment System Development

Maynilad is now encouraging sewerage system development mainly in San Juan River Basin, and combined sewer collection system is adopted.

(4) Developing Sewerage System Application

MWCI and MWSI envisage expanding application of sewerage services as large as possible, finally up to reaching 100% sewerage system coverage in the business area. Therefore, their basic coverage plan of septage management service would be reduced less than Maynilad business plan.

(5) Basic Plan of Sewer Collection System Expansion

Even though septage desludging service would be complementarily used in the area where sewerage service is not available or by the time of sewerage systems put in service, there are many places where septage collection by the collection vehicles is difficult. Those areas shall basically introduce separate or combined sewerage system to connect to centralized or communal sewage treatment plants. Especially the coastal areas and Parañaque river sides of the project sites are highly congested and with insufficient width of the access road for septage collection vehicles, collection sewer line service would be required. Not only congestion areas with narrow roads, but the areas where rainwater drainage system is poor or insufficient, drainage outfalls are at lower levels than river water levels, or seawater reverse stream is ordinal like Paranaque River side areas in, separate sewerage system might be considered.

(6) Difficulty of Land Procurement for Sewage Treatment Plant

Metro Manila has been developing for long time. These kinds of metropolitan areas have enough developed long time before sewerage system be introduced; therefore land procurement for septage treatment plant construction would be crucial problem. Because the land had been occupied by houses and the other utilities essential to life keepings, and consequently only few land space is available, but insufficient area and/or with expensive land prices. Furthermore, many areas are congested with houses because of the just same reasons.

In the case of Parañaque and Las Piñas City, availability of land for sewage treatment plant is limited. There are still wide vacant land found in Las Piñas, but those are low and wet lands, former salt farms, otherwise reclaimed land with big landfill investment to sell them with high price to get good benefit, consequently those lands in well developed urban areas like the project areas would be sold for housings or commercial entities.

The sewage system is preferable to establish with reasonable cost, that is plant sustainable cost, but environmental standards for treated water qualities are severe, thus treatment process to be able to clear the standards should be more expensive and limited comparing with conventional cheap system like aeration pond, septic tank, sewage trickling system, upstream anaerobic sludge bed, wet land, etc., and also these system occupy bigger land space.

One of the most feasible systems of the sewer collection system is combined system with interceptors and conversion weirs, and also there are many creeks, drainage sewer or canals and esteros installed in Metro Manila, that could be as combined sewer lines for collecting wastewater.

The land requirement to construct sewerage treatment plants would be limited, so compact modular type or sequential batch reactor process would be applied and mechanical process with membrane instead of bio reactor would be selected in case of the most limited space for the plant.

5.3 Basic Concept of Sanitation and Sewage Treatment Systems

Metro Manila has already been developed as a metropolice with about 10 million inhabitants, which requires a big investment to cater for improving and protecting environmental circumstances. Many areas in Metro Manila are densely populated and many informal settlers obstruct development of sewerage systems. As mentioned in Section 3.1, many communal sewage treatment plants instead of sanitation services could supplement the sewerage services of the areas where the septage collection and treatment systems are difficult to address the issues, because of access difficulty of the collection vehicles or far distance from the septage treatment plants and not effective or economical because of small population.

The followings are the basic concept to implement the environmental improvement projects by establishing the sanitation and sewerage service facilities.

5.3.1 Appropriate Share of the Services by Septage and Sewage Management System

The main factor of the appropriate share of the services depends on how much level of inaccessible situation by the septage collection vehicle, because the effectiveness of septic tanks kept under good maintenance, 40% to 60% reduction of BOD_5 could be expected. Thus, the septic tank functioning shall be taken the value of 60% reductive pollution on $BOD_{5.}$

Before privatization of sanitation and sewerage service operation, according to the pre-feasibility conducted in 1991 before starting MSSP-2 project, the F.3 report summarized the septic tank parameters for Metro Manila as follows.

Number of septic tanks Ng (ea)	600,000
Number of accessible septic tanks Na (ea)	441,000
Average septic tank volume Vs (m)	6
Septage production rate (l/cap.yr)	32

Desludging activity at that time, before introduction the new septage management system with 10t vacuum vehicles and septage treatment plant, was done by using an engine-driven sucking pump transported to the houses by a pick-up van. This is the case.

According to the above data, inaccessible septic tank rate is 26.5% in all targeted tanks. The situation in Metro Manila would not be improved as far as septage collection circumstances, the sanitation services (desludging) should be less than 70% of service population.

According to Maynilad business plan in 2007 by combination of sewerage and sanitation services, the service sharing by the sanitation and sewerage management systems will be around 58% of overall service population by sanitation against 38% by sewerage service at the year of 2021. Taking consideration Metro Manila residential area situations, expanding the sanitation service deems more efficient. However, when the septic tank is installed in congestion areas and/or a vehicle access to households is hampered by narrow roads, or when the tank is installed some distance from a road where a work vehicle can be parked, a small work vehicle can be used as a relay to a large vehicle to increase sludge collection efficiency. However, it may require a small pick-up van with an engine driven pump unit to pump up the sludge. With this system, at least 4 workers are required for each group, thus it is inefficient.

By the field test report in 1979, 20 septic tanks were tried to desludge by JET-VAC system and VAC-ALL system, but it did not work well. Because the technology required maintaining the machine is complex and the equipment is too large. Therefore the development project plan should not be undifferentiated in the service coverage to each district.

5.3.2 Parameters for Sanitation and Sewerage Projects

1) Septage Production Rate

According to the 1991 F.3 Report, the septage production rate in Metro Manila is 32 l/cap.yr. **Table 5-1** shows per capita generation rate in the other countries, including Japan.

Table 5-1 Per Capita Septage Generation Rate in Foreign Countries

Country	USA ①	Norway ②	Sweden ③	Japan ④	Korea
Per cap.year (l)	273	250	225	438	140

Notes:

① To ③: Quoted from “Handbook of Septage Treatment and Disposal, ERA (USA)

④: In Japan, by law the sludge must be removed from combined-type septage tanks at least once a year. Also as its structure is the separated cell type, the amount removed is large. Septic tanks which treat toilet flushing only reach at 0.75 l/cap.day (274 l/cap.year).

In actual septage pumped process, 30% of the liquid zone at the lower part of the tank is pumped as well. Therefore total extracted sludge rate shall be 96 l/cap.year.

Similar type of septic tanks is also used in Korea, however, because of the life style difference and 5 to 7 year interval of the extract of sludge by Maynilad, the septage generation rate shall be **100 l/cap.year.**

2) Sewage Water Generation Rate

(1) Assumption from Water Supply Rate

According to MWSI business plan reviewed in 2007, water demand at 2036 in Parañaque and Las Piñas Cities is assumed to reach at **186 l/cap.d** in average. The influent water volume into sewage treatment process is assumed to include 15% ground water infiltration in the system. If 80% of water supply is discharged into the sewer lines, the wastewater generation rate should be **149 l/cap.d**. As described in another chapter hereafter, new established treatment system shall use a combined sewer lines, thus actual influent into the treatment process would be expected less than 15/% and more reduced because of shallower street drainage pipe installation than the separated sewer pipes, less underground water infiltration could be anticipated. Therefore actual design parameter for the wastewater generation rate to be treated could be **149 l/cap.d**. Actually to say, saving water activity in the citizen life will be encouraged more in future, so the design value for wastewater generation rate might assume 140 l/cap.d in average**.** Conversion rate shall be taken day average (1.2 times 149 per cap.d) without underground water, that is, **178 l per cap.d.**

According to the Local Water Utilities Administration (LWUA), the ratio of daily maximum water supply to the daily average water supply is prescribed as follows based on the supply population:

Supply population	Less than 30,000	1.30
Supply population	30,000~199,999	1.25
Supply population	200,000 or more	1.20

Assuming that the daily average water supply planned of 186 l/cap.d at year 2036, the daily maximum water supply, using the LWUA fluctuation rate, is calculated as follows. The rate of discharge from water supply to sewage is assumed to be 80 percent without ground water infiltration is assumed. The hourly maximum sewage flow will be 1.5 times the daily maximum sewage (1.2 times daily average) flow.

Daily average sewage flow	186 x 0.8 ＝ 148.8≒149 ℓ/cap.d
Daily maximum sewage flow	149 x 1.2 ＝ 178.8≒180 ℓ/cap.d
Hourly maximum sewage flow (>200,000p)	(149 x 1.2) x 1.8≒322 ℓ /cap.d

In conclusion, the wastewater generation could be **180l per cap.d** as this project parameter.

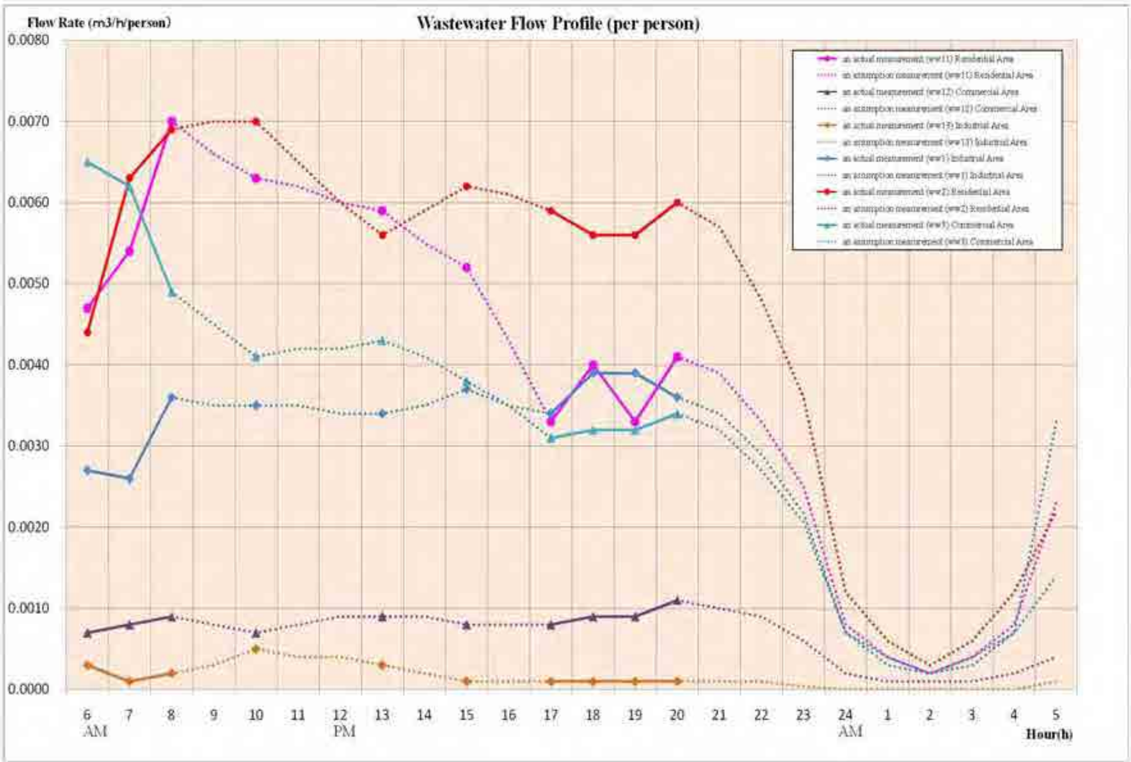
(1)Assumption from Field Record

According to the field data of Makati Pabahay Sewage Treatment Plant from January 2002 to July 2003, average wastewater influent volume is 430.81m^3/d in average. Since the service population is 2,880, the average sewage water generation rate per person is **150 l/cap.d** (refer Table. 5-4).

Actual wastewater rate was checked in Parañaque and Las Piñas when the wastewater flow profile was studied with data sampling conducted on 29 July 2011 (dry season) by OEC refer **Annex 2-1**). The sampling from three categorized zones as residential, commercial and industrial areas were made, and **Figure 5-1** shows the resident water consumption profile at the sampling stations in Parañaque and Las Piñas Cities.

According to this profile, the day max flow shows 7 l/hr.person, so the average flow rate per capital day is **94 l/cap.d** (7 x 24/1.8). According to the profile, wastewater flow rate would be assumed as **99 l/cap.d**, thus the hourly max flow rate multiplier is 1.7 against ordinal criteria of 1.8, which is not so different. Thus, at this moment wastewater rate could be **100 l/cap.d** or less.

Figure 5-1 Wastewater Profile in Parañaque and Las Piñas



(2) Parameter of Wastewater Flow adopted to the Project

Taking consideration that major part of land in Las Piñas and Parañaque is residential area (refer comparison of wastewater among residential, commercial and industrial areas in **Annex 2-1**), and water consumption increase in future, 180 l/cap.d for wastewater generation rate shall be taken.

3) Sewage Water Influent Water Quality

(1) Assumption from Existing Sewerage Treatment Systems

Taking consideration that food customs and materials in Metro Manila is similar to Korea or Japan, wastewater quality level in the countries would be applicable. Japanese standard sewage water quality is assumed that one human biological excretion is about 50g/d, and water use / per cap.d is 200 to 250 litters, thus wastewater quality would be 200 to 250 mg/l, and taking consideration 20 % scrubbed in the transportation and diluted by groundwater, influent wastewater quality level at the sewage treatment plant would be **200mg/l** or less in average as standard. **Table 5-2** shows actual field analysis of the sewage water quality that was done October and November at four pumping stations in Central Manila Sewerage System CMSS) in 2007. Water qualities on BOD_5 base varies from 40 to 72 mg/l except one sample of Paco lift station in October, which was reported of $BOD_{5,}$ as 140 mg/l. Because of few data procured, if taking the value of 75% Non-Exceeding Probability, it is as small as 75mg/l. The sampling months of November and October are still in rainy season and sewer collection system is still not in perfect, the water quality might show lower contamination than actual values, that is; the sewer lines are assumed to accept lots of ground and rainwater interfusion before rehabilitation program.

Table 5-2 Sewage Water Quality Analysis in CMSS (Year of 2007)

	Paco L.S		Malate L.S		Legarda L.S		Tondo P.S	
	10/26/07	11/26/07	10/26/07	11/26/07	10/26/07	11/26/07	10/26/07	11/26/07
Dissolved Oxygen	0	0	0	0	0	0	0	0
Total Suspended Solids	1,010	240	30	72	270	95	38	58
BOD5	140	40	62	40	72	61	59	61
COD	3,523	156	330	312	222	257	157	162
Oil & grease	509	84	5.8	18	55	16	7.1	16

Table 5-3 shows the wastewater quality of influent flow into the wastewater treatment plant in Project 7 (separate system). The analysis of the water qualities was done on 16 to 18 December 2010. According to the table, BOD_5 in average is less than 150mg/L

Table 5-3 Influent Water Quality of Communal Plant in Project 7

		Sampling Station & Date: Project 7 STP Influent, December 16, 17, 18, 2010					
Station No.	Sampling Date-Time	Analyzing Items	MLSS (mg/L)	BOD5(mg/L) (mg/L)	COD (mg/L) (mg/L)	Oil & Grease mg/L	Total Coliform (MPN100mL)
		DENR Standards	70	50	100	5.0	10,000
1 (WW1)	Dec16-06:50am		61.6	140.0	20.4	10.4	35×10^6
2 (WW2)	Dec 16-08:38am		17.0	56.0	72.8	6.0	24×10^6
3 (WW3)	Dec 16-09:07am		7.3	50.0	81.6	5.2	45×10^5
4 (WW4)	Dec 16-09:27am		6.4	61.0	95.2	0.8	79×10^5
5 (WW5)	Dec 16-10:39am		3.1	30.0	56.0	1.2	2×10^5
6 (WW6)	Dec 16-11:41am		2.6	30.0	56.0	1.2	18×10^4
7 (WW7)	Dec 16-04:26pm		31.6	56.0	74.0	3.0	2×10^5
8 (WW8)	Dec 16-07:00am		14.4	57.0	66.0	<0.1	23×10^5
9(WW9)	Dec 16-06:30pm		5.6	9.0	27.0	4.0	18×10^4
10 (WW10)	Dec 17-07:00am		49.7	95.0	176.0	8.2	35×10^6
11 (WW11)	Dec 17-08:17am		5.4	34.0	56.0	6.2	18×10^4
12 (WW12)	Dec17-09:90am		4.8	38.0	59.0	0.4	18×10^{64}
13 (WW13)	Dec 17-09:30am		7.0	36.0	60.0	<0.1	24×10^6
14 (WW14)	Dec 17-10:30am		7.3	50.0	81.6	5.2	18×10^4
15 (WW15)	Dec 17-11:00am		79.0	84.0	138.0	11.4	92×10^6
16 (WW16)	Dec 17-01:20pm		44.5	82.0	126.0	6.2	24×10^6
17 (WW17)	Dec 17-03:45pm		6.0	41.0	66.0	4.0	54×10^6
18 (WW18)	Dec 18-06:35pm		35.4	301.0	532.0	20.8	16×10^7
19 (WW19)	Dec 18-07:30am		1.3	134.0	170.0	13.2	79×10^5

Note: Red letters show the figures over DENR Standards.

Ayala sewage treatment plant assumes influent water quality as 250 to 300mg/l, and the design value of Baguio is 200mg/l. **Table 5-4** shows the field data sampled from January 2002 to July 2003 at Pabahay Sewage Treatment Plant in Makati. The sewer is collected near elementary school and condominiums adjacent to the STP, thus few collecting piped scrubbing and ground water interfusion is predicted (the plant capacity is 600 m^3/d for about service covering population of 2,880). The field data is shown in **Figure 5-2** and **5-3** together with K sewage treatment works in Singapore. Judging from these figures, influent water quality is predicted **150 to 300mg/l** on BOD_5 base**,** and it is understandable that influent water quality has no-relation to influent water flow rate. K sewage treatment plant in Singapore receives high BOD wastewater from Chinese restaurant area and the resident food style is generally of oily. The wastewater quality in Pabahay is assumed higher BOD than the combined sewerage system in Parañaque and Las Piñas project areas, because very short transportation sewer collection pipes. In case of combined sewer system applied, which has been used in mega towns in Tokyo, Osaka in Japan, Seoul in Korea, any counter measures for oil or grease mixture in sewage water would not be needed. Oil or grease discharge into sewer lines should be prohibited by applicable laws. In the case of separate sewer line system applied in amusement area with lot of restaurants, oil removal process would be installed. The analysis for the oil or grease mixture in the influent of the lift stations in CMSS shows rather high level of oil or grease as much as 509 mg/l at Paco Lift Station, locating in one of Manila amusement areas with lot of restaurants, CMSS separate sewer line system might need oil removal process, even though Paco has any specific situation for that.

(Reference Note) Suspended Solid Scrubbed in Sewer Pipes (interceptors)

Some rates of Suspended solids in the sewage water settle down to the bottom of the sewers during the travelling from infilling to the sewers to the entrance of the STPs. Light solids once down to the bottom would soar up by the sewage water stream and eventually reach at STPs, but heavy solids would be accumulated in the pipes. Therefore the BOD level at the sewage water infill into the pipes should be less than original level at STP influent positions.

The limit wastewater velocity in the pipe to soaring up is expressed by Darcy/Weisbach expression shown hereunder.

$$\sqrt{Vc = \frac{8\beta}{1{,}000\ f}\ g(S-1)D}$$

Where:

Vc *Limit velocity (m/s)*

β : *Constant (0.6)*

f : *Friction factor (0.01)*

g: *G-forces (9.8m/s²)*

S: *Gravity of solid*

D: *Diameter of solid (mm)*

Because Vc will be one m/s in the interceptor, D is;

$$D = \frac{2.12}{(S-1)} + 1$$

Where S is2.65, D is 1.28mm, and where S is 1.20, D is 1.1mm.

Settlement velocities of solids are as follows.

Table R5-1 Sedimentation Velocity of Solids (mm/s)

Diameter (mm) / Gravity	.00	.90	.8	.7	.6	.5	.4	.3	.2	.15	.10	.09	.08	.07	.06	.05
2.05	00	2	3	2	3	3	2	2	1	5	.4	.6	.8	.7	.5	.7
1.20	2.0	0.5	.5	.4	.7	.2	.9	.8	.2	.5	.8	.75	.58	.45	.35	.26

(Japan Sewerage Association)

Relation between sewage water velocity and effective water depth is as follows.

$$L = \frac{HV}{\nu}$$

Where:

L *Flow distance till reaching at bottom of pipe (m)*

H *Effective water depth (m)*

ν *Sedimentation velocity of solid (m)*

V *Flow velocity (m/s)*

The interceptor diameter is 0.3m in average, thus H is less than 0.15m, because pipe diameter is selected to fill half of the pipe at the maximum flow rate. V is 1m/s and ν is more than 0.012mm/s. Thus L is less than 12.5m. Interceptor length is about 26km; therefore solids traveling distance to STPs would be 13km in average. This length is enough long comparing with L (12.5m), that is, almost all suspended solids with the diameter of more than 1mm to 20mm are scrubbed during the interceptor travelling time. The solids with diameter of more than 20mm are caught by the coarse screen in the conversion manhole.

Wastewater Quality Analysis

Actual wastewater quality analysis was conducted in Parañaque and Las Piñas when the wastewater flow profile was studied with data sampling conducted on 29 July 2011 (dry season) by OEC refer **Annex 2-1**).

The results are shown in **Table 5-5.** The water sampling was done on January 29 2011 in dry season. Almost all analyzing results of BOD_5 are as small as less than 100mg/l, but the value at 8:50am (time for breakfast and morning work) in residential area is rather higher as 136mg/l on BOD_5

(2) Process design Parameters adopted to the Project

According to the field data, pollutants found in the field wastewater are mainly detected as BOD5 and number of total coliform. That is, the sewerage treatment system should be planned to target on reduce these two factors down less than DENR standards, 50mg/l for BOD5 and 10,000 or less for total coliform.

Process Design Parameters

Sewage Water generation rate	*180L/cap.d (day max)*
Influent Water Quality	*200mg/L, BOD5, 400mg/L COD*
Effluent Water Quality	*50mg/L, Total Coliform 10,000 or less*
The other discharge water quality	*Subject to DENR standard.*

Table 5-4 Influent Water Quality Laboratory Record (Pabahay STP in Makati)

DATE			pH		SS (mg/l)		BOD (mg/l)		COD (mg/l)		Flow	Remarks
			Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	m3/d	
24	Jan	2002		7.78 /25.8℃		18.00		17.00		87.72		
8	Feb	2002	7.84 /20.9℃	7.98 /21.6℃	18.00	10.00	74.42	8.00	340.00	55.81		
22	Feb	2002	7.85 /14.3℃	8.03 /17.8℃	50.00	20.00	90.00	20.70	183.35	55.10		
8	Mar	2002	7.71 /22.2℃	7.90 /22.7℃	43.00	11.00	120.00	48.57	108.08	50.80		
13	Mar	2002	7.83 /21.5℃	7.10 /21.5℃	23.00	5.00	90.00	49.02	199.01	57.80		
22	Mar	2002	7.50 /21.6℃	7.84 /20.0℃	30.00	4.00	106.70	39.84	228.58	47.82	559.5	
28	Mar	2002	7.64 /28.7℃	7.89 /27.1℃	30.00	4.00	196.82	50.00	453.35	56.22	441.7	
3	Apr	2002	7.54 /25.3℃	7.74 /25.1℃	18.00	12.00	168.19	37.38	520.80	58.70	353.4	
5	Apr	2002	7.68 /11.9℃	7.95 /13.2℃	25.00	8.00	540.00	53.10	650.00	60.71	441.7	
10	Apr	2002	7.64 /18.7℃	7.87 /19.1℃	20.00	11.00	90.00	57.82	181.84	63.64	441.7	
17	Apr	2002	7.40 /22.0℃	7.68 /21.9℃	12.00	10.00	254.90	29.10	300.00	45.60	441.7	
23	Apr	2002									677.4	
24	Apr	2002	7.50 /25.0℃	7.57 /22.3℃	50.00	14.00	128.00	60.00	274.52	107.64		
29	Apr	2002		7.07 /25.5℃			nons	83.33	nons	116.67	235.6	
2	May	2002	7.40 /23.3℃	7.84 /23.2℃	75.00	15.00	150.00	40.00	203.72	69.45	441.7	
7	May	2002										
8	May	2002	7.42 /22.1℃	7.58 /23.4℃	22.00	14.00	150.00	50.00	256.93	73.41	29.4	
10	May	2002	nons	7.82 /28.0℃	nons	19.00	nons	50.00	nons	77.20	353.4	
24	May	2002	7.52 /24.1℃	7.34 /25.1℃	73.00	24.00	150.00	40.00	292.39	80.18	88.3	
29	May	2002	5.17 /18.2℃	5.89 /19.7℃	96.00	4.00	210.00	18.30	301.82	28.30	88.3	
5	Jun	2002	7.44 /21.0℃	7.28 /20.2℃	64.00	9.00	200.00	35.99	259.28	46.30	58.8	
11	Jun	2002	7.45 /21.0℃	7.88 /21.0℃	68.00	7.00	373.56	48.22	480.00	58.39	323.9	
19	Jun	2002	7.41 /21.0℃	7.53 /21.0℃	40.00	15.00	520.00	39.70	617.39	47.82		
25	Jun	2002									235.6	
28	Jun	2002	7.48 /21.0℃	6.94 /19.4℃	60.00	21.00	506.00	47.84	564.70	97.84	88.3	
3	Jul	2002	7.51 /20.0℃	7.62 /19.4℃	58.00	28.00	289.10	54.88	309.12	82.11	559.5	
10	Jul	2002	7.45 /19.0℃	7.09 /20.0℃	88.00	23.00	181.6	90.6	280.32	135.49	441.7	
18	Jul	2002	nons	7.84 /24.2℃	nons	84.00	nons	28.8	nons	35.39	323.9	
24	Jul	2002	7.54 /21.9℃	7.88 /24.3℃	38.00	13.00	180	30.7	198.00	49.02	441.7	
31	Jul	2002	7.40 /24.1℃	6.91 /20.4℃	42.00	10.00	330	16	485.98	58.25	530.1	
7	Aug	2002	7.25 /21.2℃	8.41 /18.7℃	40.00	17.00	60.00	49.00	55.70	69.10	294.5	
16	Aug	2002	7.28 /25.5℃	7.41 /28.6℃	102.00	32.00	158.60	33.40	321.41	80.38	235.8	
21	Aug	2002	7.40 /24.1℃	6.91 /20.4℃	30.00	18.00	215.60	45.08	293.58	82.57	235.5	
28	Aug	2002	7.25 /10.7℃	7.47 /22.0℃	84.00	19.00	640.00	25.00	763.80	40.20	235.6	
11	Sep	2002	7.30 /22.5℃	7.88 /21.9℃	38.00	20.00	104.00	43.50	158.10	58.54	441.7	
13	Sep	2002	-	7.52 /27.1℃	nons	53.00	-	19.70	-	22.05	382.9	
18	Sep	2002	7.40 /24.3℃	7.53 /24.7℃	102.00	23.00	152.50	49.70	384.54	75.45	559.6	
25	Sep	2002	7.44 /23.3℃	7.54 /21.6℃	70.00	25.00	325.00	49.70	584.78	75.45	559.6	
2	Oct	2002	7.33 /20.7℃	7.82 /21.8℃	92.00	35.00	315.00	18.60	656.72	159.74	677.4	
9	Oct	2002	7.66 /22.5℃	7.55 /23.9℃	64.00	8.00	189.00	30.70	199.89	36.36	324	
16	Oct	2002	7.88 /22.5℃	7.55 /23.9℃	92.00	4.00	110.00	21.00	144.13	27.02	441.8	
17	Oct	2002	-	7.65 /29.1℃	-	19.00	-	28.00	-	53.80	441.8	
23	Oct	2002	7.42 /28.4℃	7.80 /25.8℃	330.00	24.00	265.00	29.70	313.05	95.58	441.7	
30	Oct	2002	7.40 /24.6℃	7.88 /24.4℃	52.00	18.00	211.20	9.50	296.32	46.30		
8	Nov	2002	7.42 /22.4℃	7.52 /24.2℃	170.00	31.00	278.40	10.56	293.63	55.06		
13	Nov	2002	7.01 /21.8℃	7.77 /21.0℃	38.00	18.00	120.00	30.72	183.66	36.37		
20	Nov	2002	7.55 /23.7℃	7.78 /24.4℃	148.00	82.00	185.00	28.80	218.19	38.03		
21	Nov	2002	-	7.70 /29.1℃	-	47.00	-	37.44	-	72.06		
27	Nov	2002	7.05 /21.4℃	7.75 /22.6℃	334.00	47.00	244.80	23.00	300.83	53.09	559.5	
4	Dec	2002	7.40 /22.0℃	7.58 /22.3℃	112.00	47.00	288.80	32.58	327.58	43.10	441.8	
11	Dec	2002	7.30 /24.0℃	7.47 /25.8℃	82.00	27.00	284.00	11.52	273.54	17.10	441.8	
12	Dec	2002	-	7.70 /29.1℃	-	32.00	-	11.52	-	17.10	877.4	
18	Dec	2002	7.40 /22.0℃	7.58 /22.3℃	84.00	18.00	264.00	23.04	278.66	40.98	441.8	
20	Dec	2002	7.38 /24.0℃	7.47 /25.8℃	62.00	27.00	264.00	11.52	273.54	17.10		
27	Dec	2002	7.40 /22.0℃	7.58 /22.3℃	108.00	80.00	338.00	23.04	390.14	32.51	877.4	
5	Jan	2003	7.33 /24.3℃	7.65 /24.4℃	94.00	61.00	320.00	34.50	335.30	37.38	677.4	
15	Jan	2003	7.34 /21.0℃	7.70 /20.7℃	174.00	30.00	345.00	24.00	361.91	20.57	323.6	
22	Jan	2003	7.43 /22.3℃	7.74 /21.8℃	106.00	83.00	240.00	21.00	309.18	36.37	677.4	
29	Jan	2003	7.35 /21.3℃	7.71 /19.1℃	372.00	32.00	375.00	32.00	434.40	43.44	671.4	
30	Jan	2003	-	7.73 /26.1℃	-	7.00	-	38.00	-	52.10	553.8	
5	Feb	2003	7.64 /23.5℃	7.42 /23.1℃	76	34	340.00	45.00	365.00	95.66	441.7	
12	Feb	2003	7.40 /21.3℃	7.40 /21.8℃	204	28	335.00	21.00	417.40	43.48	577.4	
13	Feb	2003	-	7.75 /25.5℃	-	26.00	-	24.00	-	122.48		
16	Feb	2003	7.50 /23.6℃	7.53 /22.4℃	88.00	46.00	272.00	35.06	346.94	96.15	553.5	
25	Feb	2003	7.42 /19.7℃	7.64 /19.1℃	132.00	71.00	250.00	32.00	249.25	96.16	533.5	
5	Mar	2003	7.35 /27.7℃	7.67 /28.1℃	102.00	81.00	300.00	40.00	345.41	86.54	441.7	
17	Mar	2003	7.58 /22.6℃	7.63 /24.1℃	58.00	32.00	150.00	50.00	392.45	93.44	441.7	
20	Mar	2003	-	7.80 /22.0℃	-	46.00	-	50.00	-	91.00		
26	Mar	2003	7.46 /	7.88 /	106.00	47.00	295.00	33.00	427.00	126.00		
3	Apr	2003	7.30 /	7.60 /	86.00	50.00	275.00	46.00	310.00	107.00		
16	Apr	2003	7.20 /	7.60 /	76.00	86.00	265.00	18.00	373.00	74.00		
23	Apr	2003	7.10 /	7.60 /	182.00	220.00	430.00	200.00	543.00	324.00		
30	Apr	2003	7.20 /	7.60 /	76.00	26.00	310.00	47.00	455.00	53.00		
7	May	2003	7.20 /	7.80 /	130.00	51.00	318.00	68.00	353.00	133.00		
14	May	2003	7.20 /	7.50 /	102.00	40.00	450.00	101.00	481.00	186.00		
11	Jun	2003		7.30 /		80.00		127.00		245.00		
2	Jul	2003	7.45 /25.6℃	7.50 /25.0℃	90.00	71.00	300.00	271.00	418.00	671.00		
5	Jul	2003	7.40 /24.0℃	7.60 /27.0℃	370.00	135.00	375.00	154.00	405.00	242.00		
High			7.88	8.41	372.00	220.00	640.00	271.00	763.80	671.00	877.40	
Low			5.17	5.89	12.00	4.00	60.00	8.00	55.70	17.10	29.40	
Average			7.40	7.60	93.67	34.69	254.88	44.70	344.81	82.99	430.81	

Figure 5-2 Influent Water Quality Analysis Record (Pabahay STP in Makati)

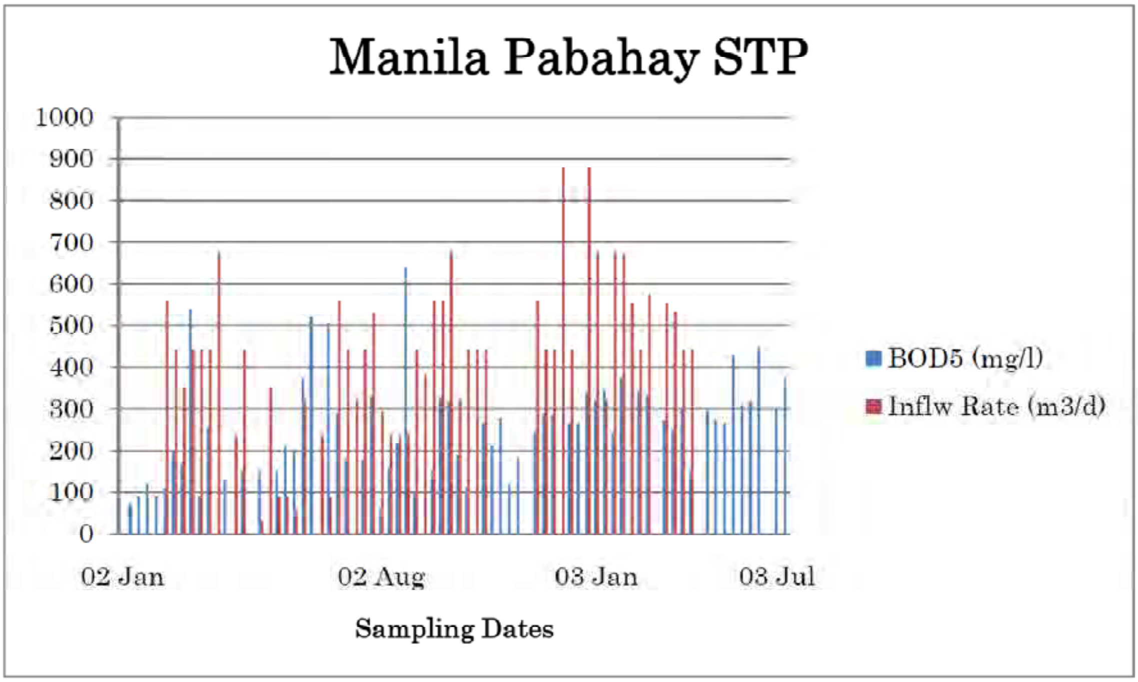
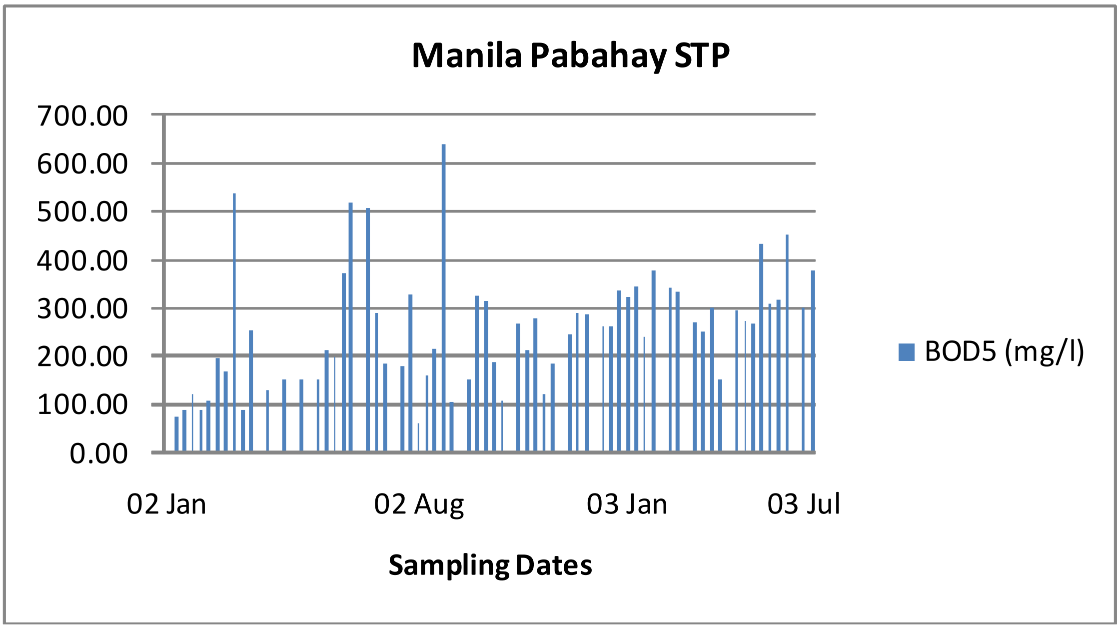


Figure 5-3 Influent Water Quality Analysis Record (K STP in Singapore)



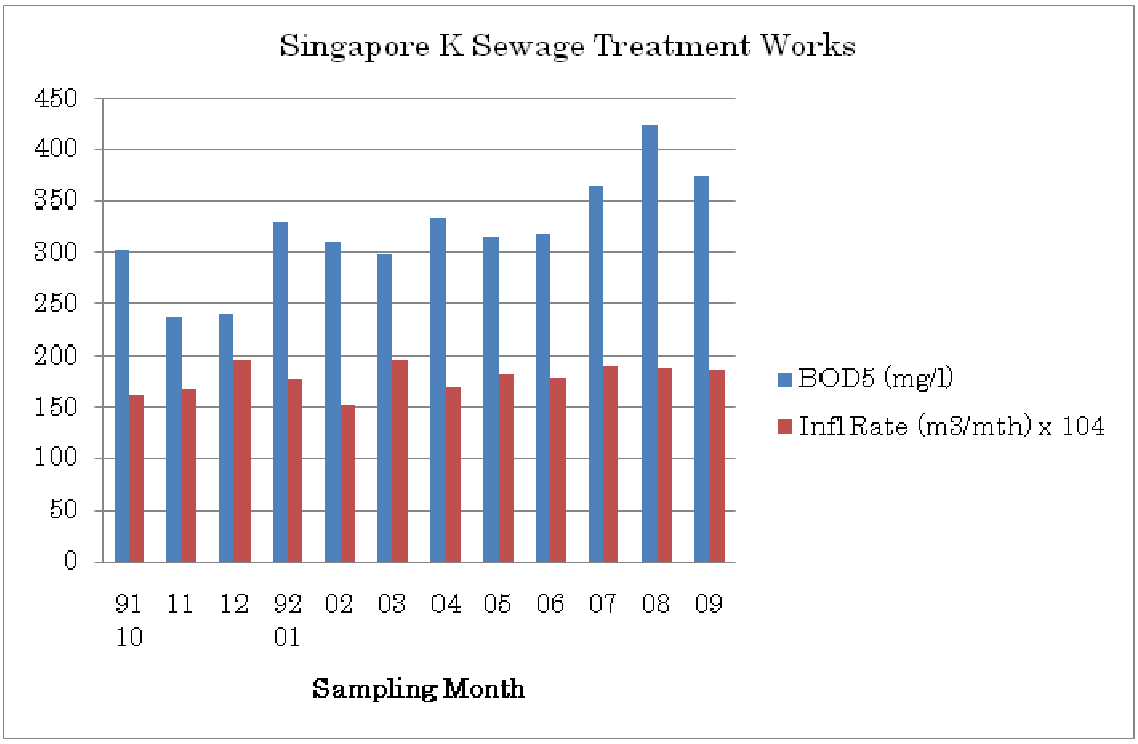


Table 5-5 Wastewater Quality on Parañaque and Las Piñas

							Sampling Date: January 29, 2011			
Station No.	Category	Sampling Date-Time	Analyzing Items	pH	Temperature (℃)	TSS (mg/L)	BOD5(mg/L) (mg/L)	COD (mg/L) (mg/L)	Oil & Grease mg/L	Total Coliform (MPN100mL)
			DENR Standards	6.5 to 9.0	30	70	50	100	5.0	10,000
Las Piñas										
1 (WW1)	IND1 (Creek)	Jan 29-08:00am		7.60	25.0	12.0	33.0	60.0	1.6	17×10^6
2 (WW2)	RES 4 (Creek)	Jan 29-08:50am		7.90	25.0	136.0	215.0	382.0	2.0	54×10^6
3 (WW3)	Com 2 (Creek)	Jan 29-09:20am		7.90	25.0	1.0	3.0	6.0	< 0.1	23×10^6
Parañarue										
11(WW11)	RES 6 (Creek)	Jan 29-10:05am		7.50	25.0	102.0	100.0	174.0	3.0	35×10^6
12 (WW12)	COM 1 (Creek)	Jan 29-10:40am		7.60	25.0	20.0	152.0	266.0	< 0.1	35×10^6
13 (WW13)	IND 1 (Creek)	Jan 29-12:05pm		7.30	25.0	20.0	92.0	134.0	< 0.1	24×10^6

Note: Red letters mean the figures over DENR standards.

5.3.3 Design Concept for the Sanitation and Sewerage System Improvement

Because of lots of hampering conditions when implementing sanitation and sewerage projects in Maynilad concession area, several counter measures to mitigate those situations shall be taken.

Principal constraints against development of sanitation and sewerage projects in the project target areas are as follows;

(a) difficulty to procure land for facility construction, many congestion areas scattering in the Metro Manila to obstruct accessing to households,
(b) difficulty for installation of new sewer lines with political and economical problems,
(c) lots of garbage trashing in the waterways,
(d) lots of informal settlements occupying waterways,

(e) big traffic in the cities which would deny the traffic limitation while construction,
(f) low perception of the residents for improving their environmental conditions,etc.

In order to address these constraints against sanitation and sewerage project implementation, following policy shall be taken;

(a) as much as existing creeks, esteros, drainage culverts or canals shall be used as combined sewer collection lines,
(b) many communal plants of compact type and underground construction would be planned to address difficult connections in congestion areas, to a central sewage treatment plants
(c) Renovate or upgrade of existing drainage systems,
(d) Encourage and urge septage management system by expanding together with newly establishing septage treatment plants and increase of the collection vehicles up to sewerage system put in service.

5.4 Combined Sewer System Application

There are many creeks, drainage culverts or troughs and esteros installed in Metro Manila. These could be as used as combined sewer lines for collecting and treating wastewater.

Pictures 5-1 to 5-7 show the typical drainage situation in the cities.

Picture. 5-1 shows downstream of a drainage PASSING through the balangay and Picture. 3-2 shows crossing point at the street. **Picture. 5-3** shows the downstream flow discharging to the main river. **Picture. 5-4** shows the discharging point of the creek, and **Picture. 3-5** shows the detail of the discharging mouth of creek (out falling) to the river (Creek).

Picture. 5-6 shows another bigger and deeper creek outfall into the river. Ordinarily the creek discharge point is located lowest ground level, so garbage casted out in the street are flowing on the road and gathered into the open culvert (creek). **Picture. 5-7** shows the garbage accumulation at the creek discharge point.

In order to get rid of the garbage, it is possible to install a screen in the creek, however, garbage clogging in the screen also blocks the water flow, and it would become the reason subsequently to make over flood in the upstream area. Therefore, any screens should not be installed in the creek except the case with special reason.

Picture. 5-1 Downstream of a Creek Passing Through a Barangay (Las Piñas)

Picture. 5-2 Crossing Point under the Road beside the River (Las Piñas)

Picture. 5-3 Discharge Point of the Creek to the River (Parañaque)

Picture. 5-4 Discharging into the River (Las Piñas)

Picture. 5-5 Detail of the Creek Discharging Mouth (Parañaque)

Picture. 5-6 Another Creek (bigger) Meeting Point to the River (Las Piñas)

Picture. 5-7   Garbage Accumulated at the Creek Discharging Culvert

Collected sewage water is conveyed into the sewage treatment plant (STP) and treated water in the plant is discharged into the water receiving bodies such as rivers, creeks, etc after dully treated through the treatment process.

Figure 5-4 shows the concept of the sewerage management system with combined interceptors by using the existing wastewater drainage systems. In case that separation sewage collection system is adopted in future, sewage water (grey water) shall be separated from rain water at households, and separated grey water shall be collected by additional sewer lines installed along side of the street drainage and the pipes to be connected to conversion manholes.

Treatment plant in sub-basin should better be located at the lowest level of ground, however, there is no choice to construct the treatment plant but in the vacant and available land area. In the case that the STP is not located in the lowest level of the sub-basin ground area, it would be happened that the gravity flow of the sewage water to STP is difficult, and a manhole-pump system would be required in such sewer flow lines. Inspection and maintenance manhole is basically installed every 60 meters in the straight line or at the curving point. In future, it is preferable to divert this combined sewer system to the separate sewer system. The modification would not require any change of the first stage facilities, and separate sewer collections only shall be installed to connect to the conversion manholes. **Figure 5-5** shows the system diversion from the first stage combined system to the separation system.

Figure 5-4 Concept of Sewerage Management System with Combined Interceptors

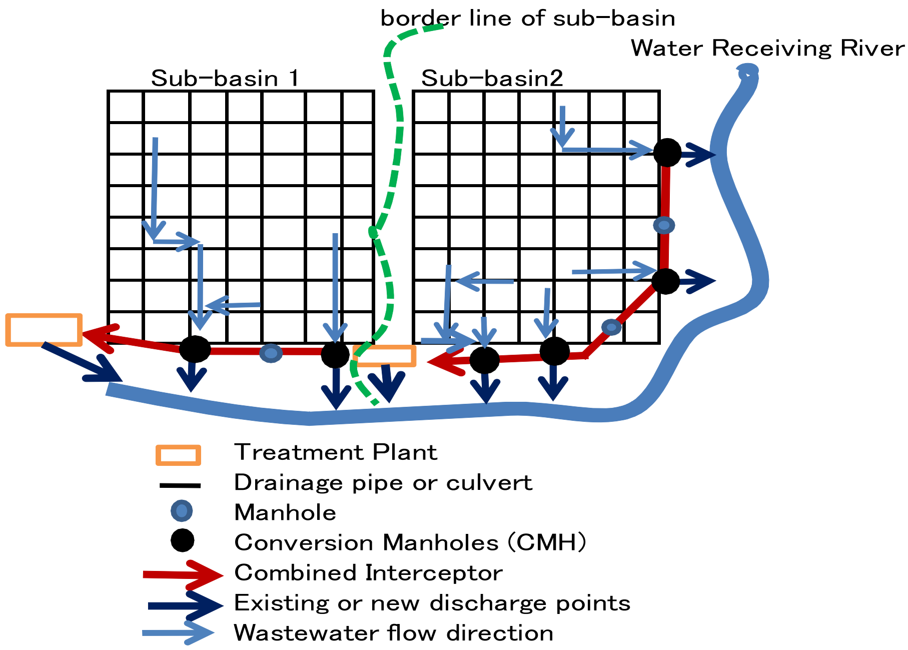
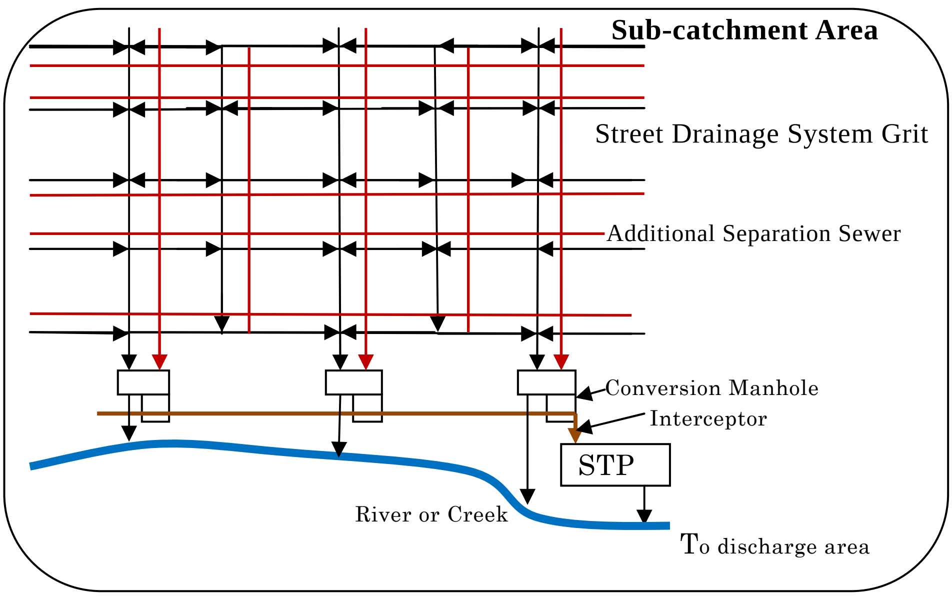


Figure 5-5 Diversion from Combined to Separation Sewerage System



5.5 Substantial Methodology of the Combined Sewerage System

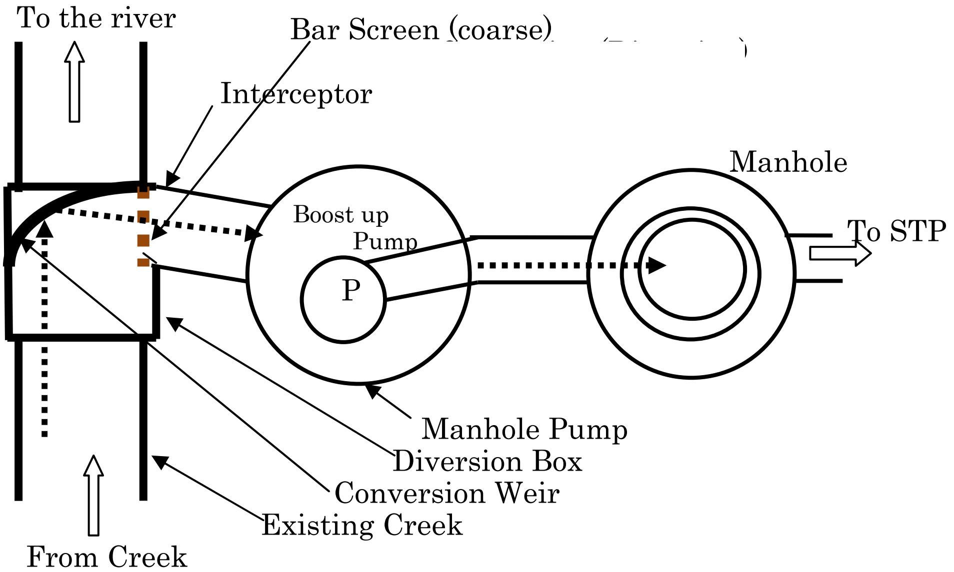
The sewerage treatment system will consist of sewage conversion manholes, interceptors, manhole pumps or pumping stations and sewage treatment plants (refer **Figure 5-4**).

The existing wastewater drainage system would be basically used as sewage collection sewers, and if not available, additional collection sewer lines would be additionally constructed.

Where the creek is used as a collection sewer of sewage water, diversion manhole or box is installed at the cross point of the creek and the road (refer **Picture. 5-2**). In most cases, this point is lowest ground level; therefore, the pipe interceptor flow is enforced by boost-up manhole pump. **Figure 5-6** shows Boost up or Lift up Manhole Pump (MHP).

Wastewater conversion to take sewage water is done by installing the diversion weir at the point of collecting sewage water from the wastewater drainage lines. The weir is set in the drainage to divert the water flow into the combined interceptor to convey the sewage water to the sewage treatment plant.

Figure 5-6 Lift up Manhole Pump



The height of the conversion weir is decided to catch the maximum water flow rate of 1.2 to 1.5 times of day average of sewage water generated value in the water basin. If the flow rate is over the value, the excess flow shall be discharged into the catchment area trough the existing drainage water ways carried over the weir.

Because of the land terrain on Parañaque Basin and area congestion, the basin will be separated into 5 to 7 sub-basins, and whole sewage water generated in the basins ideally be treated at one centralized STP, however, in case that it is not feasible, at least wastewater generated in each basin would preferably be treated at the sub-basin STP respectively. Sub-basin border lines shall be decided in order that the water flow in each basin might be directed to the lowest position in the area by gravity, that is, the border lines should be at the highest line in the sub-basin.

Sewage Treatment Plant in each sub-basin should better be located at the lowest level of ground, however, there is no choice to construct the treatment plant but in the vacant and available land area. In the case that the STP is not located in the lowest level of the sub-basin ground area, it would be happened that the gravity flow of the sewage water to STP is difficult, and a manhole-pump system would be required in such sewer flow lines, otherwise intermittent pumping stations would be required. In the case that there is a small area in the sub-basin or independent island area, and it seems costly or difficult to find the short line to transport the area wastewater to the main interceptor, small size STP like modular type STP would be constructed in the small island area, if any proper vacant space for the STP is available there. Inspection and maintenance manhole is basically installed every 60 meters in the straight line or at the curving point.

5.5.1 Conversion Manhole

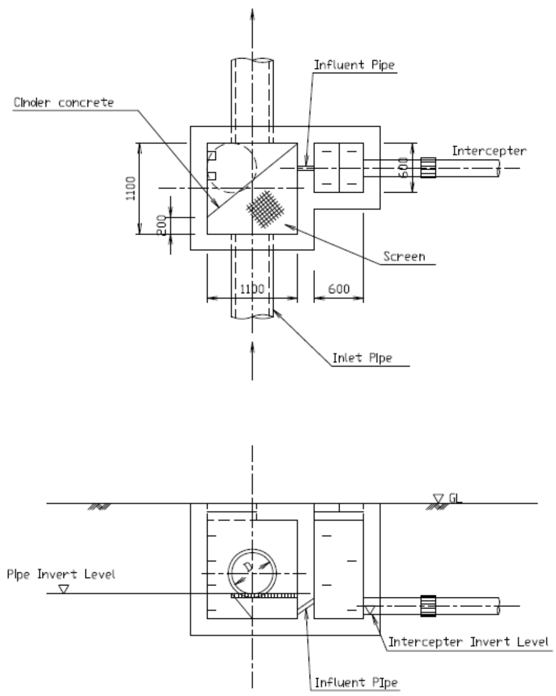
Wastewater conversion to take sewage water is ordinarily done by installing the diversion weir at the point of collecting sewage water from the wastewater drainage lines. The weir is set in the drainage to divert the water flow into the combined interceptor to convey the sewage water to the sewage treatment plant.

Because of garbage trashed in the waterways, the conversion weir is easily clogged by garbage stoppage at the weir wall in the waterway. In order to get rid of the garbage, it is possible to install a screen in the creek, however, garbage clogging in the screen also blocks the water flow, and it would become the reason subsequently to make over flood in the upstream area. Therefore, any screens should not be installed in the creek except the case with special reason.

Because of garbage clogging problems by the conversion weir, the weirless conversion manhole is preferable.

There are shown variations of conversion manholes are shown in **Figures 5-7 to 5-10**

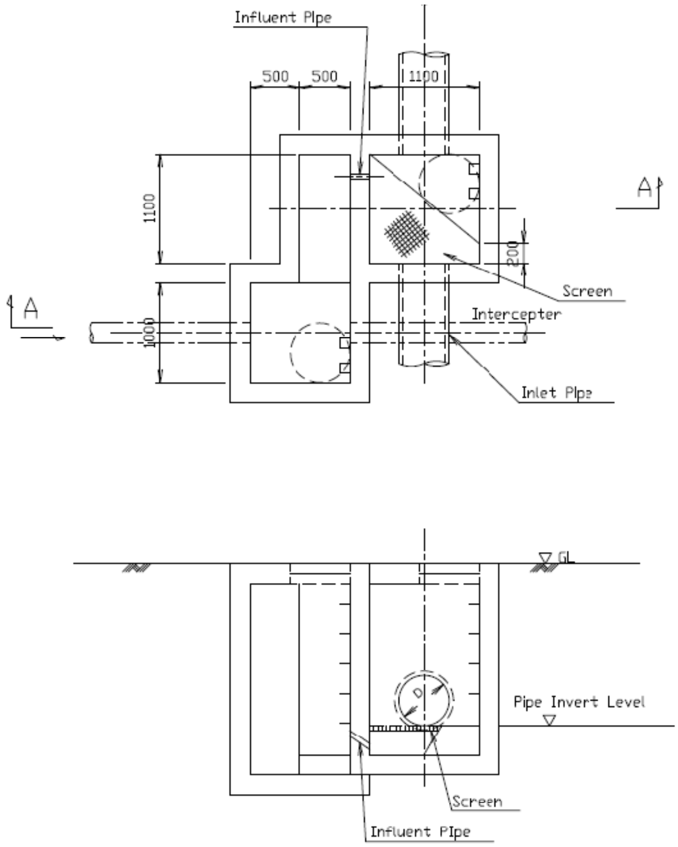
Figure 5-7 Standard Structure of Conversion Manhole (Type 1)



the outfalls.

Drainage pipe is intercepted by the interceptor pipe and conveyed to the sewer chamber connected to the interceptor to STP. Garbage is screened on the creek base level.

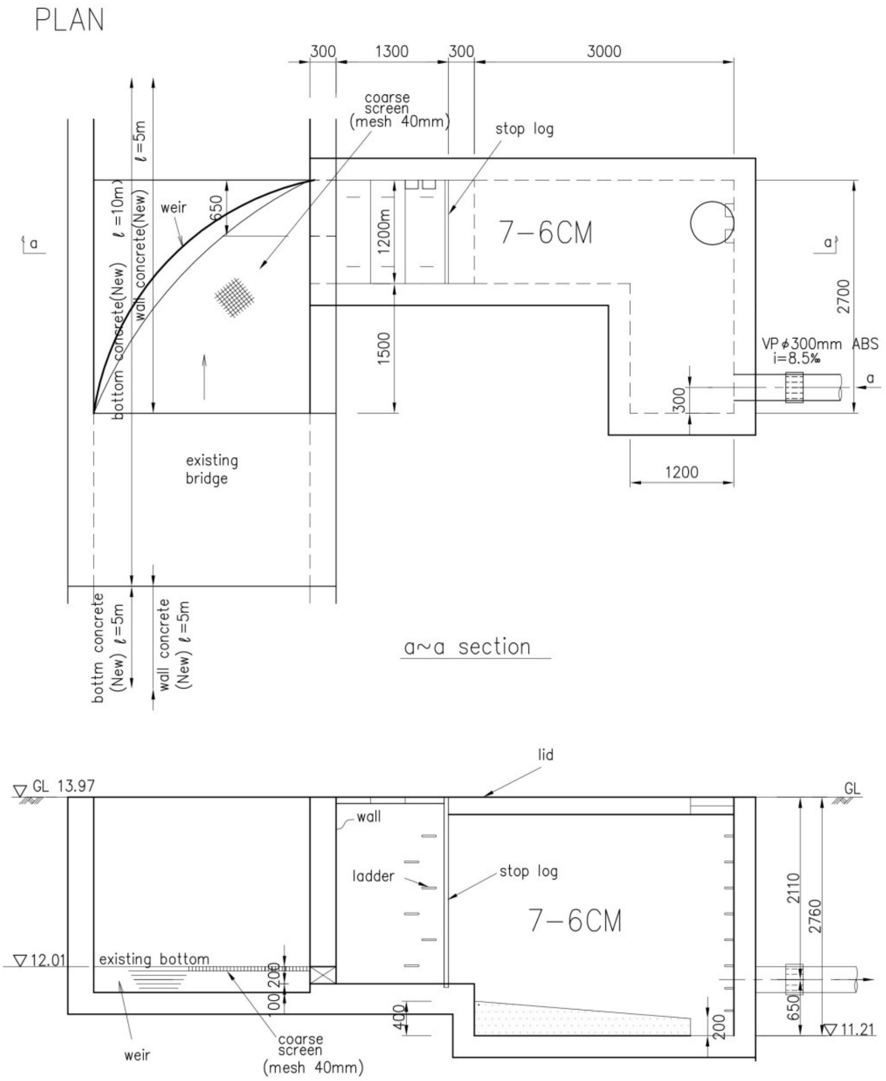
Figure 5-8 Standard Structure of Conversion Manhole (Type 2)



This type is used for the several outfall positions are included in the same catchment area, and each conversion manhole shall be connected to convey separated sewer to the STP. Drainage pipe is intercepted by the interception pipe and conveyed to the sewer chamber connected to the interceptor to STP. Garbage is screened on the creek base level.

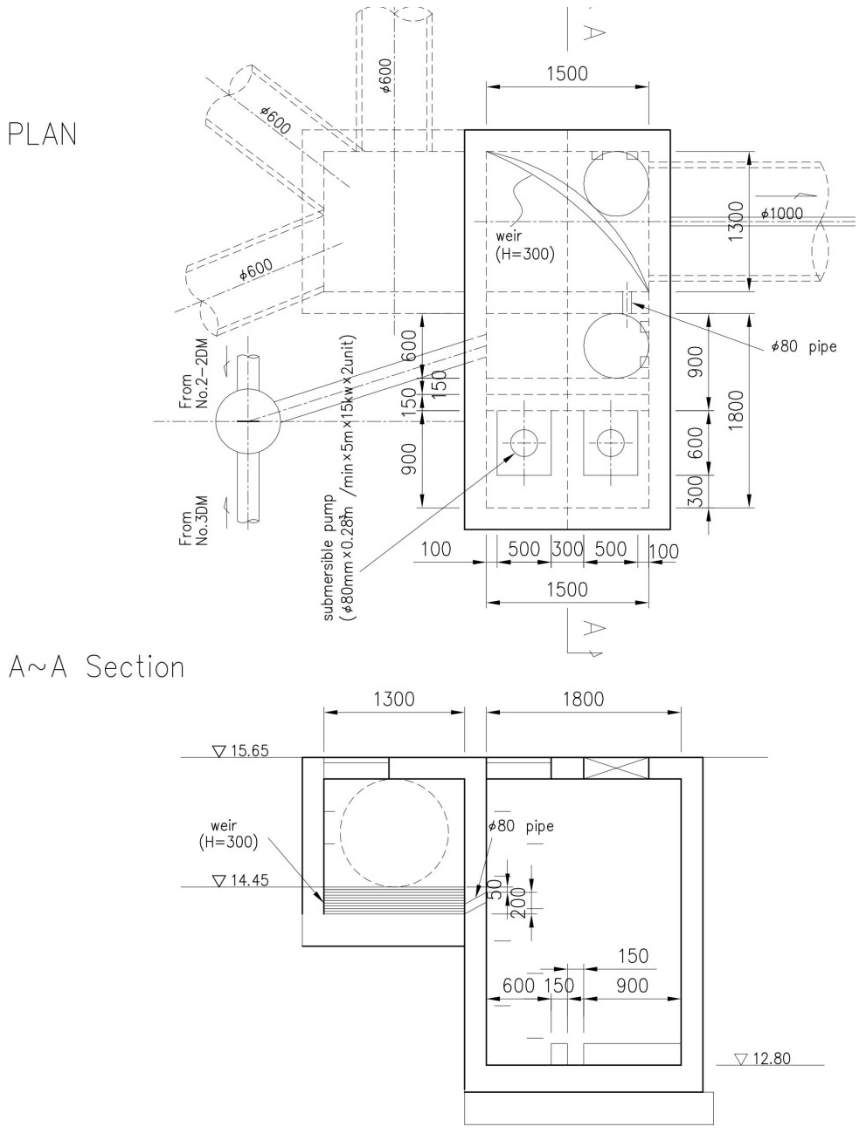
Figure 5-9 Conversion Configuration when installed in Creek Bed

This is the case that conversion manhole is not installed because of open culvert drainages or creeks.



This type is used for multi-connection of street drainage because of the location is at the point of small drainage pipes connected to the main drainage pipe.

Figure 5-10 Multi-connection Type of Street Drainage



This type is used for multi-connection of street drainage because of the location is at the point of small drainage pipes connected to the main drainage pipe.

5.5.2 Manhole Pump and Intermittent Pumping Station

The sewage treatment plant is preferably located at the lowest level of the ground, and sewage water is ideally conveyed through the interceptor by gravity flow, however, it is not always realized because of geographical terrain. In that case, manhole pump station or intermittent pumping station is installed along the way of interceptor to lift up or pressurizing the sewage water. Manhole pump station is used to lift up the sewage water to avoid the deep interceptor excavation and intermittent pump station is used to convey large volume of sewage water to the final STP location.

Figure 5-11 and **Figure 5-12** show manhole pump station and intermittent pump station respectively.

Figure 5-11 Manhole Pump Station

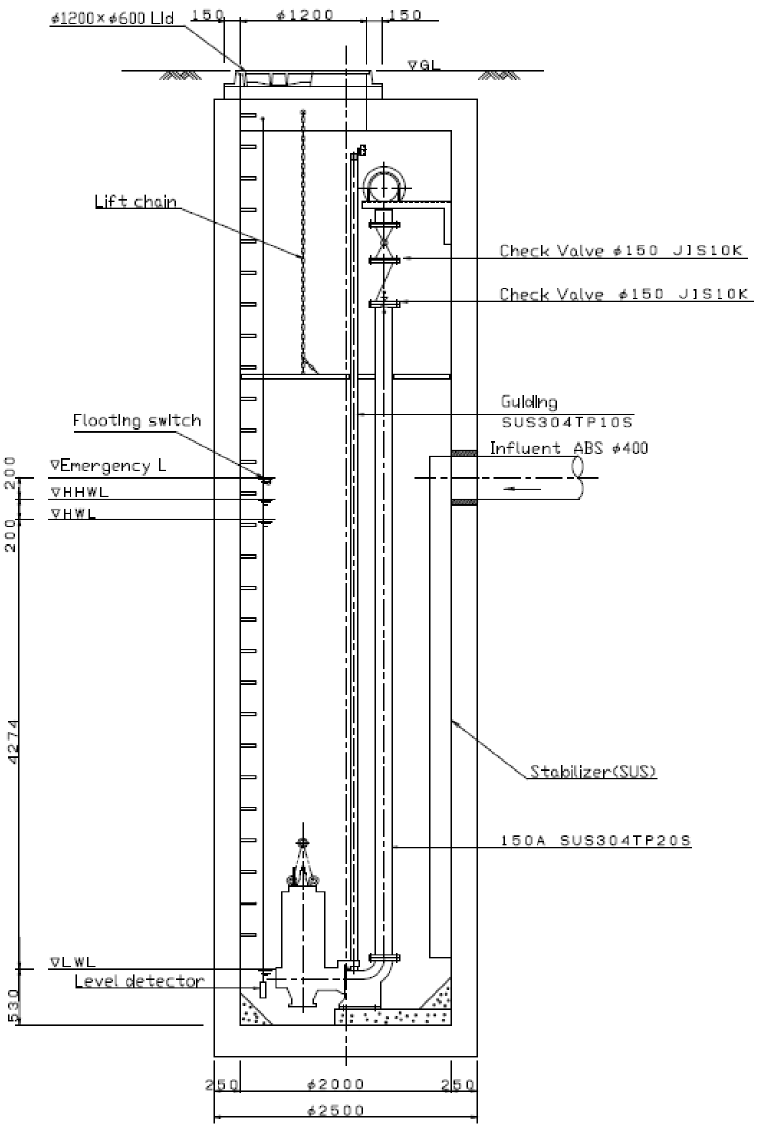
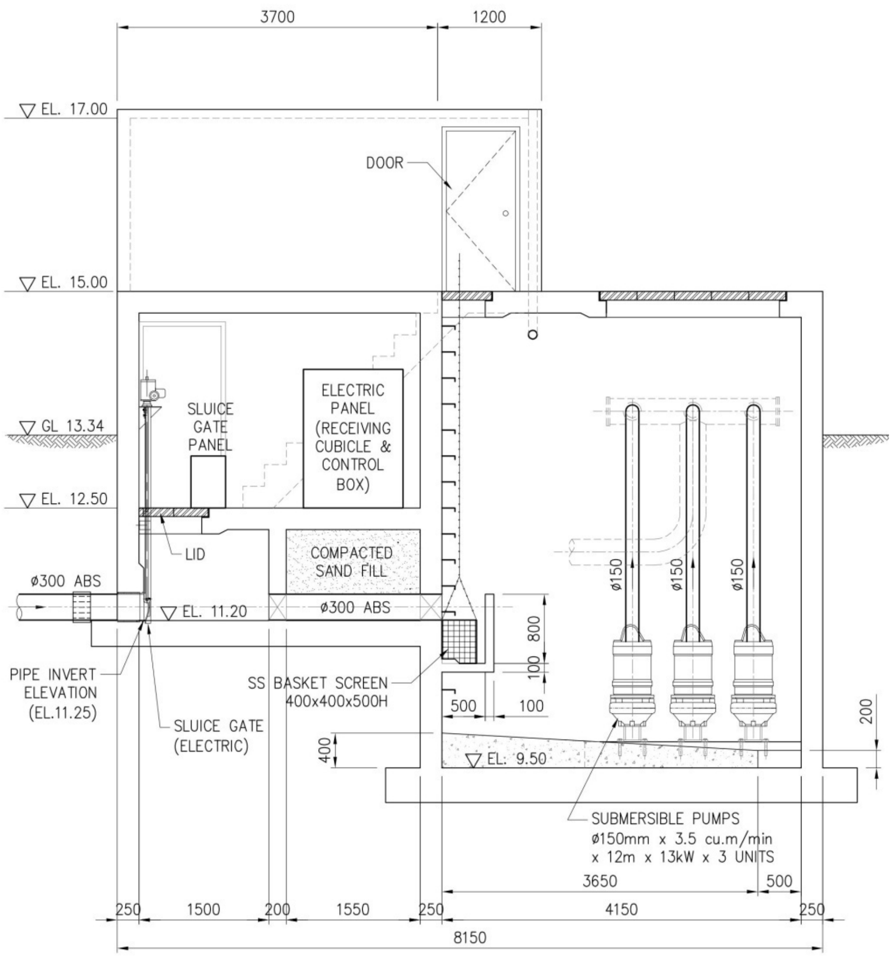


Figure 5-12 Intermittent Pump Station



5.5.3 Sewage Treatment and Management System

Sewage water collected in the catchment area shall be conveyed to sewage treatment plant to be treated. Several sewage treatment plants would be constructed at appropriate areas even though a few big size central treatment systems are ideal. Sewage treatment and management system with combined sewer collecting system is the same as separate sewer collecting system.

The effluent water quality from sewage treatment process shall conform to DENR standards; therefore treatment process will be limited in order that the technical functioning may cater for the standard water qualities.

The sewerage system to be established will accept general wastewater, grey water, thus biological process would be adopted. In that case, sewage sludge control generated in the biological process is very important. Sewage sludge is on the other hand to be used for energy resources and provision shall be made to reduce environmental impact to the greenhouse effect in the process of the sludge degradation.

5.6 Installation Interceptors and Conversion Manholes

Interceptors and conversion manholes will be installed in the town roads or streets. Interceptors will be under the roads that are managed operated by DPWH or LGUs. Conversion manholes will also be installed in the roads and connected to the street drainages managed by LGUs. Conversion manholes incorporate mesh screens inside and in dry seasons, garbage trapped by the screens shall be cleaned up periodically. Therefore agreement to install the interceptors and conversion manholes should be made among relative agencies as LGUs, MMDA and DPWH.

Installation process of the sewage collection system, that is, installation of interceptor pipes and conversion manholes, is as follows.

i) installation of Conversion Manholes.

Install the manhole on the outfall of drainage in the street near the discharge point. Thus, first the drainage pipe is once cut off and connects to the drainage pipe then the drainage pipe is fixed again to secure rain water discharge rout to the receiving body (river or creek).

This work should be done by MWSS under the LGU's approval and supervisor.

ii) Installation of Interceptor

Interceptor will be installed under street by MWSI. MWSI should get necessary approval from associated agencies. And the pipe will be connected to the conversion manhole by MWSI under the LGU's supervisor.

Maintenance work of the conversion manholes should be done by MWSS as follows.

i) cleaning garbage trapped in the screen and sludge in the silt trap in the Manhole should be done by MWSI every end of rainy season.

ii) collected sludge will be transported to the septage treatment plant under the responsibility for MWSI. Garbage collected by MWSI will be transferred to solid waste deposit site by LGUs and final dumping of it will be done by MMDA.

6. AVAILABLE SEWERAG AND SANITATION TECHNOLOGY

This Section describes the available sewerage management technology, sewerage sludge management, sewage treatment plant operation and maintenance systems, and the effective utilization of sewage sludge. Listed and described are options for on-site excreta disposal, options for wastewater collection and conveyance. and various options for wastewater treatment and disposal. Sewage sludge treatment systems and forms of sludge final disposal are discussed. The effective utilization of sewage sludge by composting for fertilizer, sludge melting for construction materials and sludge-gas generation are also presented.

6.1. Available Sewerage and Management Technology

6.1.1 Basic Technological Strategy

Treatment methods for domestic sewage are broadly divided into communal treatment and individual treatment methods.

1) Communal treatment

① Sewage systems
② Collection via sewers and basic treatment comprising sedimentation + disinfecting, etc.
③ Basic treatment or ocean outfall
④ Condominial sewers
⑤ Small bore sewers
⑥ Community plants
⑦ Communal septic tanks

2) Individual treatment

① Ventilated improved pit latrine)
② Composting toilets
③ Pour-flush toilets
④ Septic tanks
⑤ Independent treatment septic tanks
⑥ Joint treatment septic tanks

6.1.2. Range of Applications for Sanitation Technology

The treatment methods that can be applied in the Project are, in terms of communal treatment, ① Sewage systems, ⑥ Community plants and ⑦Communal septic tanks. However, because the design area is so large, the number of treatment plants required in cases ⑥ and ⑦ would be many, and this would be unrealistic in terms of site and maintenance, etc. Moreover, options ②, ③, ④ and ⑤ could not be applied because the pollutant removal effect for treatment plants is too limited; moreover, there is a risk that small bore sewers would become blocked with garbage.

In terms of individual treatment, options ①, ③, ④ and ⑥ are applicable treatment methods. However, since ④ entails contamination of groundwater, its scope of application is limited depending on the groundwater level. Option ② cannot be applied because routine

maintenance is left to individuals and this involves too much uncertainty. Option ⑤ is a treatment method for night soil only; however, since miscellaneous wastewater (eating utensil washing, washing wastewater, bath wastewater, etc.) is discharged untreated into the public water body, it is inappropriate as a measure for preventing water pollution. The joint treatment septic tanks in option ⑥ treat both night soil and miscellaneous wastewater, treatment capacity ranges from small-scale (five-person tanks) to large-scale (5,000 people), and this method is the best in terms of prevention of contamination of the public water body. However, because small-scale tanks cost 700,000 yen (350,000 pesos) to install, they are cost prohibitive.
Table 6-1-1 shows a comparison of communal treatment and individual treatment.

Table 6-1-1 comparison of communal treatment and individual treatment.

Name	Applicable at Density Levels	Flushing Water Needs	Influence by Ground water Table	Land Requirements	Initial Capital Investments	Operating Cost Levels	Potential Adverse(Negative) Impact	Wastewater Treatment Accomplished
Communal Treatment								
①Sewage systems	All levels	M	None	M	H	M	None	90%
②Basic treatment comprising sedimentation + disinfecting,etc.	All levels	M	None	L	M	M	H	35%
③Basic treatment or ocean outfall	All levels	M	None	L	L	M	H	L
④Condminial sewers	Dense existing development	M	None	Needs agreement	M	L	None	Needs treatment facility
⑤Small bore sewers	Dense existing development	M	None	L	M	M	None	Needs treatment facility
⑥Community plants	All levels	M	None	M	M	M	None	90%
⑦Communal septic tanks	All levels	M	None	L	L	M	None	30～50%
Individual Treatment								
①Ventilated improved pit latrine	L,M	None	From surface 1.5m or deeper	L	VL	L	Leachate could contaminate groundwater.	None
②Composting toilets	L,M	None	None	L	L	L	Routine maintenance &mixing with organic waste/ash needed.	None
③Pour-flush toilets	L,M	L	1.5m or deeper	L	L	L	Leachate contamination of groundwater.	None
④Septic tanks	L,M	H	1.5m or deeper	M	M	L	Leachate contamination of groundwater.	30～50%
⑤Independent treatment septic tanks(Night soil treatment--Johkasou)	L,M	L	None	L	L	L	H	65%
⑥Joint treatment septic tanks (Johkasou System)	M	M	None	L	M	L	None	90%

Notes:
L= Low VH= Very High
M= Medium N/A= Not Applicable
H= High

6.1.3 Options for On-site Excreta Disposal

1) Review of Optional Technology

Where any appropriate sanitation system is considered for establishment in the community, the use of natural purification systems and the role of microorganisms are always taken into consideration. And in any case, major issues of settlement planning, community participation and hygiene program, and financing and cost recovery need to be integrated. When the sanitation system is planned for establishment in the communities, capital, running and maintenance costs are among the biggest elements in considering the sanitary system options.

In the case of using facilities with the wastewater treatment process, two types of micro-organisms functions are adopted in the aerobic and anaerobic oxidation atmosphere.

In the aerobic oxidation atmosphere, organic matter in wastewater is degraded by bacteria into new cells as well as CO_2, NH_3 and H_2O. And in anaerobic atmosphere, the organic matter is degraded by bacteria into new cells and intermediate products, which eventually are degraded again by bacteria into new cells, and CH_4, H_2S, CO_2, NH_3 and H_2O. CH_4 generated in the anaerobic process usually has more than 60% concentration in the generation gas, therefore if the gas is reused, this shall be one of the factors for process selection.

(1) On-site Wastewater Treatment Systems

Where central or bulk type wastewater treatment systems are not applicable to regions with low population density or for other reasons, such as there is no space for construction, budgetary deficit (due to capital cost), technical difficulties in the region, inappropriate terrain for the system and temporary requirements, etc., the on-site wastewater treatment system should be used. Basically this type is installed in individual households, buildings or small groups of communities. Technically, many cases rely on decomposition of the organic wastes in human excreta by bacteria. This can take place in a simple pit in the ground or in specially designed tanks to promote the bacteria decomposition of the wastes. The overflow from the pit or tank is allowed to soak into ground. Further decomposition and purification processes take place in the soil. Potential for groundwater pollution still exists with on-site treatment and disposal systems; however, well developed processes are recently available and adapted to individual or small sized on-site treatment facilities and effluent from those can clear the treatment level required for public sewerage treatment systems.

● Ventilated Improved Pit Latrine

This is the simplest and most primitive sanitation facility. Ordinarily a pit latrine collects excreta in a pit dug in the ground beneath the toilet structure. The toilet facility has a vent pipe with fly screen for exhausting gas generated in the pit and preventing odor from the toilet. During storage in the pit, the organic matter decomposes in the anaerobic condition. Seepage through the surrounding soil walls takes place reducing the BOD of the water, and storage period also causes die-off of bacteria and viruses. In the case of usage of pit tank, separate collection system and off-site bulk treatment system or pond are necessitated, but the system is free from problems of insect, odor emissions and residual nutrients, etc.

● Composting Toilet

Where the pit latrine is settled above ground, aerobic decomposition is promoted. Composting is done in the compost toilet with air introduced through an opening to pass through the sludge and exit through the vent, while excess liquid is allowed to drain for collection or evaporation. With two adjoining composting chambers or vaults used alternately, the process of composting in an already full chamber can be allowed to proceed until chamber is to be used again. Materials such as newspaper or sawdust can be added to balance the carbon to nitrogen ratio for optimal composting. Mature compost takes several months, so the chamber should be large enough to hold a supply of six months. Preventing insect growth and odor control are complications while and alternate chamber are problematic.

● Pour-Flush Toilets

The pour flush toilet is a variation on the ordinal pit latrine. Because it has a water seal, the problems associated with odor and insects are avoided. Flushing the excreta requires 2~3 liters of water. More water percolates though the soil surrounding the pit, and potential for groundwater pollution is higher than in the ordinal pit latrine, so it is advisable to avoid this facility when the groundwater table is shallow. Sludge has to be regularly emptied from the pit, therefore provision needs to be made for sludge removal, otherwise an alternate chamber for maintenance is necessary.

● Septic Tank

A septic tank is a watertight tank usually just below ground that receives both black and grey water. It can be used with pour flush toilets or cistern flush toilets. It functions as a storage tank for settled solids and floating materials. The storage time of the wastewater in the tank is usually between two to four days, and about 50% removal of BOD and suspended solids is usually achieved in a properly operated septic tank. It seems to be an economical facility for installing, but good maintenance to keep the proper functioning is hard to realize and off-site desludging system is required in some cases. The overflow from septic tanks should be directed to a leach pit or trench, however, because of insufficient effluent water quality, some provision like seepage trench or evaporation bed may be required.

a) Improved On-site Treatment Unit

There are several systems for treating human excreta without any emission from the systems, and there are more developed systems than septic tank that can realize high level treatment equal to or better than conventional sewage treatment plants. These systems are dedicated to protecting the environment from human wastes.

● Bio-Toilet

This is a toilet for treating human excreta together with ancillary organic materials like toilet paper without any emission from the system. It uses drum type bio-porous storing treatment bacteria that degrade and eliminate the excreta. The treatment capacity is normally 90 times for 24 hours. In case of using chaff or cedar chips instead of bio-porous material, the treatment capability is about 50 times a day, and if combined with burning or soil treatment, the treatment capacity can be improved to 150 times a day. The chaff of cedar chips should be replaced every three years.

● Combustion Toilet

This type is ordinarily used with flush toilets. The flushing water is reused after the combustion process. The flush toilet integrates an oil combustion process. The multi-flush toilet type uses sewerage transfer pumps to the combustion process, while the single toilet type incorporates a direct rotary drum combustion furnace. The emission material is burned ashes of several hundred grams from 1,000 times treatment. The ashes are innocuous, so can be discharged with the other wastes. The treatment capacity is 50 times an hour.

● Advanced Septic Tank (Jyokaso-Sewerage Package Treatment)

Jyokaso is a package type sewage treatment facility that contains combination treatment processes inside an anaerobic processing chamber and contact aeration or membrane separation processing chamber. Treatment capacity of the package is generally for 5~50 persons (roughly 1~10 households). Level of final effluent from the package is 5~20 mg/ℓ of BOD and SS. Denitrification and dephosphorization are also conducted in the system. Replacement cycle of the membrane is more than 10 years.

2) Unit Costs of Various Technologies

The construction costs of commonly used on-site treatment facilities are as follows:

● Ventilated Improved Pit Latrine	15,000Pesos
●Composting Toilets	15,000
● Pour-Flush Toilets	17,000
● Septic Tank	24,800

3) Squatter Areas

Squatter areas are densely populated areas characterized by narrow roads and site and economic problems that make it impossible to adopt separate treatment systems. Communal septic tanks could be applied to the squatter areas, however, the problem would be how to raise the maintenance cost for periodically removing sludge and so on.

4) Low Income Areas

In terms of individual treatment methods, it is possible to introduce ventilated improved pit latrines, pour-flush toilets and septic tanks with infiltration pits. However, septic tanks with infiltration pits could only be installed when there is no risk of contamination of groundwater in the area. It would also be necessary to periodically remove sludge.

5) Middle and Higher Income Housing and New Developments

It is possible to introduce ventilated improved pit latrines, pour-flush toilets and septic tanks with infiltration pits in these areas. In terms of the water quality preservation effect, joint septic tanks are suitable for adoption in high income households and landfill districts on the west side of Rhxas Boulevard.

6) Commercial Areas and Institutions

Since these areas have a lot of usage by visitors, joint septic tanks would be appropriate in terms of separate treatment. Moreover, since it is forecast that reclaimed areas in Manila Bay will be used for large-scale commercial facilities and wealthy residential districts, it would be appropriate to adopt joint septic tanks here too.

6.1.4 Options for Wastewater Collection and Conveyance

1) Review of Optional Technologies

Sewage removal systems include separate sewer systems, in which household sewage and rainwater are collected in separate pipelines, and combined sewer systems, in which household sewage and rainwater are collected in unified pipelines.

(Separate sewer system)

In the separate sewer system, since only sanitary sewage is conveyed to treatment plants, there is no discharge of sewage to the public water body during rainfall and this is advantageous in terms of preventing water pollution. In areas that already possess rainwater drainage facilities, because these facilities can be effectively utilized, it is possible to spread the sewage system in an economical manner. However, the separate sewer system also has potential drawbacks, for example, contaminated surface wastewater flows into water bodies via storm sewers during rainfall, it is difficult to newly install both sanitary sewage and storm sewers in built-up areas, and traffic interruptions are likely to be caused in such cases. Because sanitary sewers in separate sewer systems are small bore, they tend to be buried at deeper depths and with steeper gradients compared to combined sewer systems. Since the target area has flat terrain and a high groundwater level, the cost of burying sanitary sewers would be expensive.

(Combined sewer system)

Combined sewer systems, in which sanitary sewage and rainwater are drained in the same sewers, have been constructed mainly in large cities with the goal of preventing flooding caused by rainwater in low-lying areas. System installation is easier than in the case of separate sewer systems. However, when rain falls, sediments inside sewers are washed out and contaminate water bodies. **Table 6-1-2** shows a comparison of drainage systems.

Table 6-1-2 Comparison of Drainage Systems

Item		Combined System	Separate System
Construction works	Ease of execution	There is just 1 pipeline, less clashes with other underground structures. Compared with sanitary sewage pipes, the pipe diameter is larger.	Since there are 2 pipelines, installation is difficult on narrow roads. Sanitary sewage pipes are buried deep.
	Cost	Costs are lower because there is only 1 pipeline.	Cost is higher when constructing separate sanitary sewage pipes and rainwater pipes.
Maintenance	Sewer sediments	Sediments accumulate during fine weather but are washed out by rain.	Sediments are relatively few in sanitary sewage pipes. Conditions are the same as in the combined system in rainwater pipes.
	Sediment inflow	There is a lot of inflow from road surfaces. This causes abrasion of mechanical.	Inflow is relatively small in sanitary sewage pipes. Conditions are the same as in the combined system in rainwater pipes.
	Inspection and cleaning	Large Pipe diameters enable easy maintenance. Garbage tends to build up.	There is risk of blockage in small bore sanitary sewage pipes, however, cleaning is easy. Garbage is apt to accumulate.
	Wrong connections of drainage	None	Guidance is needed. Infiltration problems occur during rainfall.
Water quality conservation	Overflow at times of rain	Pollutants flow out and contaminate the public water body.	None
	Non-point soured sewage load	The initial pollution load can be collected and treated. Any excess load is discharged into the public water body without undergoing treatment.	Rainwater is discharged into the public water body without undergoing treatment.

2) Unit Costs of Various Collection Technologies

Concerning the types of pipe (sewer) for collecting sanitary sewage, various kinds of materials are used. In small bore sewers, hard PVC pipes, which are light and easy to install, are used, while in medium bore sewers, reinforced plastic pipes and reinforced concrete pipes are frequently adopted. Since the Study target area has flat terrain, hard PVC pipes and reinforced plastic pipes, which have a small roughness coefficient and enable gentle gradients, are advantageous. Since temperature and sewage temperature are high in this district, hydrogen sulfide is apt to be generated and sulfuric acid leads to the rapid corrosion of pipes. However, hard PVC pipes and reinforced plastic pipes are resistant to hydrogen sulfide. **Table 6-1-3** shows the sewer construction costs.

Table 6-1-3 Sewer Construction Costs (Pesos/m)

Diameter(mm)	Force Main Pipe	Gravity Main Pipe	Notes
75	2,400		
100	4,300		
150	8,100	6,800	
200	11,900	9,700	
250	15,700	11,200	
300	19,500	16,800	
350	21,000	20,300	
400	21,300	23,300	
450	24,700	28,200	
500	34,500	35,900	
600	37,700	39,100	
700	40,100	41,500	
800		47,500	
900		51,000	
1000		63,400	
1200		73,400	
1350		87,600	
1500		102,500	
1650		106,900	
1800		117,200	

3) Suggested Wastewater Collection and Conveyance Technology

The target area slopes from southeast to northwest. Zapote River runs along the boundary with Bacoor on the western tip of the district, and numerous other small creeks converge and flow into Manila Bay. Rainwater from the urban area is drained into rivers and creeks through combined sewers, and these rivers and creeks act as sewage main lines. In the case of separate sewer systems like in Japan, around 70% of the total construction cost is spent on building sanitary sewers. If a separate sewer system were adopted in the target area, since this would require massive costs for installing sanitary sewers along roads, it is necessary to select a sewage collection method that is more suited to the local conditions. **Figure 6-1-1** shows the types of sewage collection systems that are most commonly adopted in Southeast Asia.

Since the target area has low altitude and the downstream area is affected by the ocean, in the case where sanitary sewage is directly taken in from rivers and creeks, it would be necessary to consider the intake points. In other words, the sewage needs to be taken in at positions where the intake creek bottoms are higher than Manila Bay at high tide. If seawater infiltrates sewage, it becomes impossible to conduct proper biological treatment. **Figure 6-1-2** shows a schematic view of the area affected by tides. The differential between high tide and low tide in Manila Bay is small at 1.80 m at high tide and 1.33 m at low tide. High tide and low tide each occur once per day.

Figure 6-1-1 Sanitary Sewage Collection System

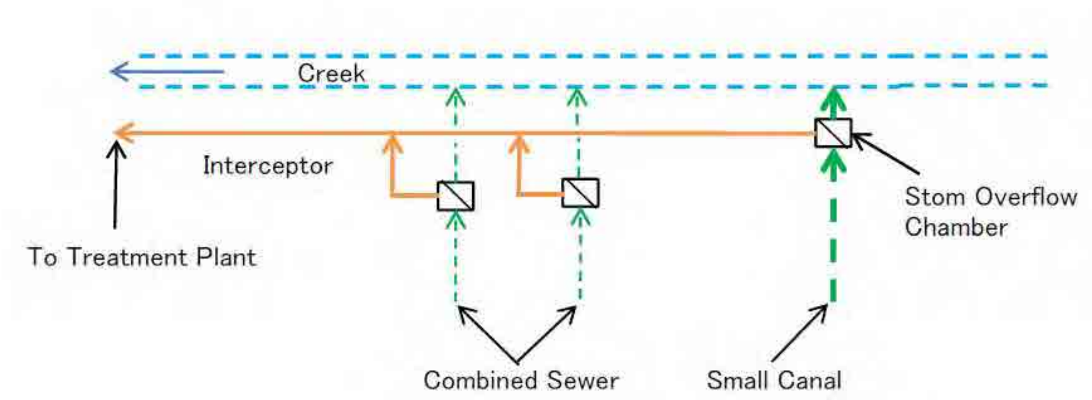
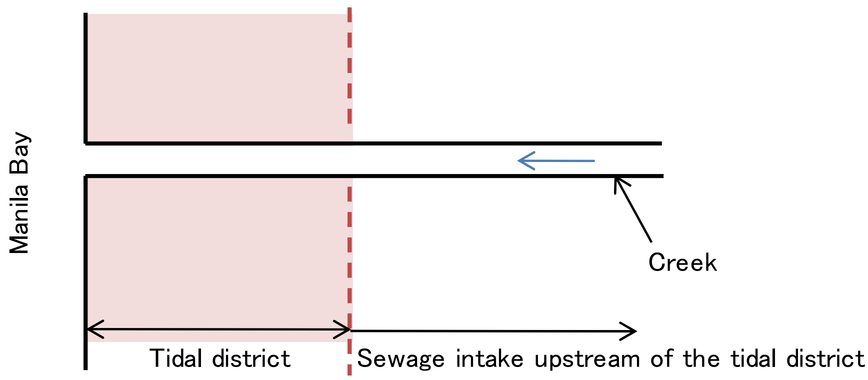


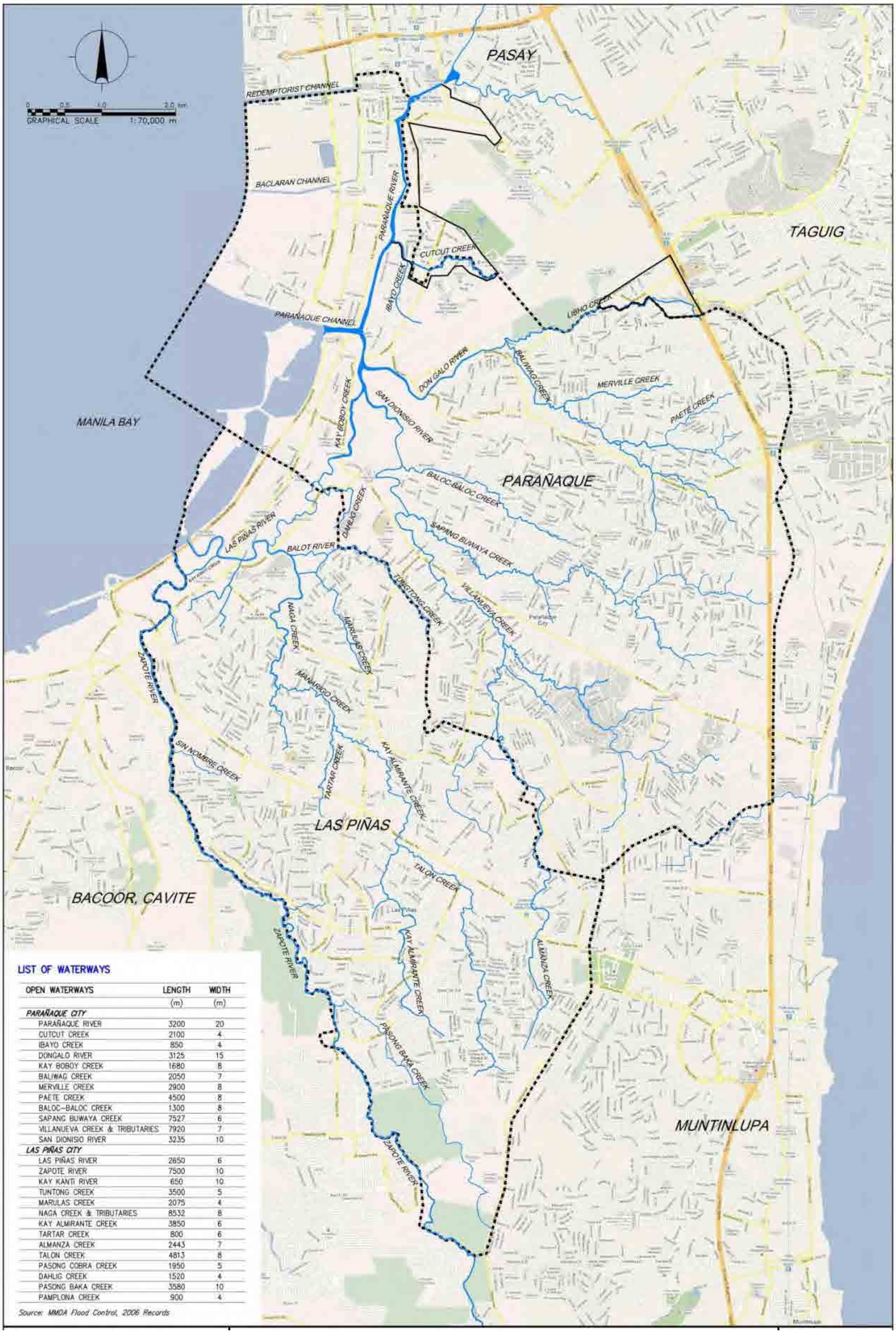
Figure 6-1-2 Schematic View of the Tidal District (intake method from creek)



4) Proposal of Sewage Collection System Based on Survey Results

In both Parañaque and Las Piñas, storm water and sanitary sewage are drained into creeks via common sewers and side ditches. Since adopting a separate sewer system and installing sanitary sewage sewers along roads would entail huge construction costs, it is proposed that conversion manholes for diverting sanitary sewage be installed in the sewers that lead to creeks and that the separated sanitary sewage be led to sewage treatment facilities via interceptors (see Section 5-4 **Figure 5-5**). **Figure 6-1-3** shows a Waterways in Paranãque and Las Pinãs.

Figure 6-1-3 Waterways in Paranãque and Las Pinãs



LIST OF WATERWAYS

OPEN WATERWAYS	LENGTH (m)	WIDTH (m)
PARAÑAQUE CITY		
PARAÑAQUE RIVER	3200	20
CUTCUT CREEK	2100	4
IBAYO CREEK	850	4
DONGALO RIVER	3125	15
KAY BOBOY CREEK	1680	8
BALIWAG CREEK	2050	7
MERVILLE CREEK	2900	8
PAETE CREEK	4500	8
BALOC-BALOC CREEK	1300	8
SAPANG BUWAYA CREEK	7527	6
VILLANUEVA CREEK & TRIBUTARIES	7920	7
SAN DIONISIO RIVER	3235	10
LAS PIÑAS CITY		
LAS PIÑAS RIVER	2650	6
ZAPOTE RIVER	7500	10
KAY KANTI RIVER	650	10
TUNTONG CREEK	3500	5
MARULAS CREEK	2075	4
NAGA CREEK & TRIBUTARIES	8532	8
KAY ALMIRANTE CREEK	3850	6
TARTAR CREEK	800	6
ALMANZA CREEK	2443	7
TALON CREEK	4813	8
PASONG COBRA CREEK	1950	5
DAHLIG CREEK	1520	4
PASONG BAKA CREEK	3580	10
PAMPLONA CREEK	900	4

Source: MMDA Flood Control, 2006 Records

6.1.5 Options for Wastewater Treatment and Disposal

The basic roles of the sewage system are threefold as indicated below:

- Securing of public health and living environment

Through rapidly draining and treating sanitary sewage discharged in household and business activities, this greatly contributes to improvement of the living environment including inside homes.

- Prevention of flooding

Flood countermeasures are taken in the shape of internal drainage of rainwater in the urban area via the sewage system and river works such widening of river courses, etc.

- Conservation of water quality in the public water body

There are numerous rivers and creeks that flow into Manila Bay. Through removing and treating pollutants that flow into Manila Bay, it is possible to conserve water quality in the creeks, rivers and bay.

1) Review of Optional Technologies

The natural world contains numerous microorganisms that break down organic matter. When sanitary sewage that includes organic matter is discharged into natural water bodies such as rivers, etc., microbes attached to stones and suspended solids in the water decompose organic matter in an oxygen environment. Biological treatment of sewage is mainly intended to remove organic matter in sewage through utilizing aerobic microbes that exist in the natural environment. As is shown in **Figure 6-1-4**, the biological treatment methods commonly used in sewage treatment in Japan are broadly divided into the activated sludge method, whereby microorganisms are treated while suspended in the water, and the biofilm method, whereby microorganisms are treated while attached to filter media. Furthermore, there is the method whereby microorganism carriers are put into an activated sludge process reaction tank and treated (treatment method utilizing fixed carriers). **Table 6-1-4** shows the number of treatment plants according to each method in Japan.

As is shown in **Table 6-1-4** the sewage treatment method differs according to local characteristics (available site and water quality criteria) and scale of treatment, however, the conventional activated sludge method is adopted at a lot of medium-scale and large-scale treatment facilities with a treatment flow of 10,000 m3/day or more. Small treatment plants with a treatment flow of less than 10,000 m3/day adopt various kinds of treatment methods.

When considering the sewage treatment method for the target district, it is important to realize cheap construction and maintenance costs and easy maintenance work. Treatment methods selected in tropical and subtropical zones typically include stabilization pond, aerated lagoon, sequencing batch reactor process, oxidation ditch process and extended aeration process. **Table 6-1-5** shows a comparison of the different methods.

Figure 6-1-4 Classification of Biological Treatment Methods

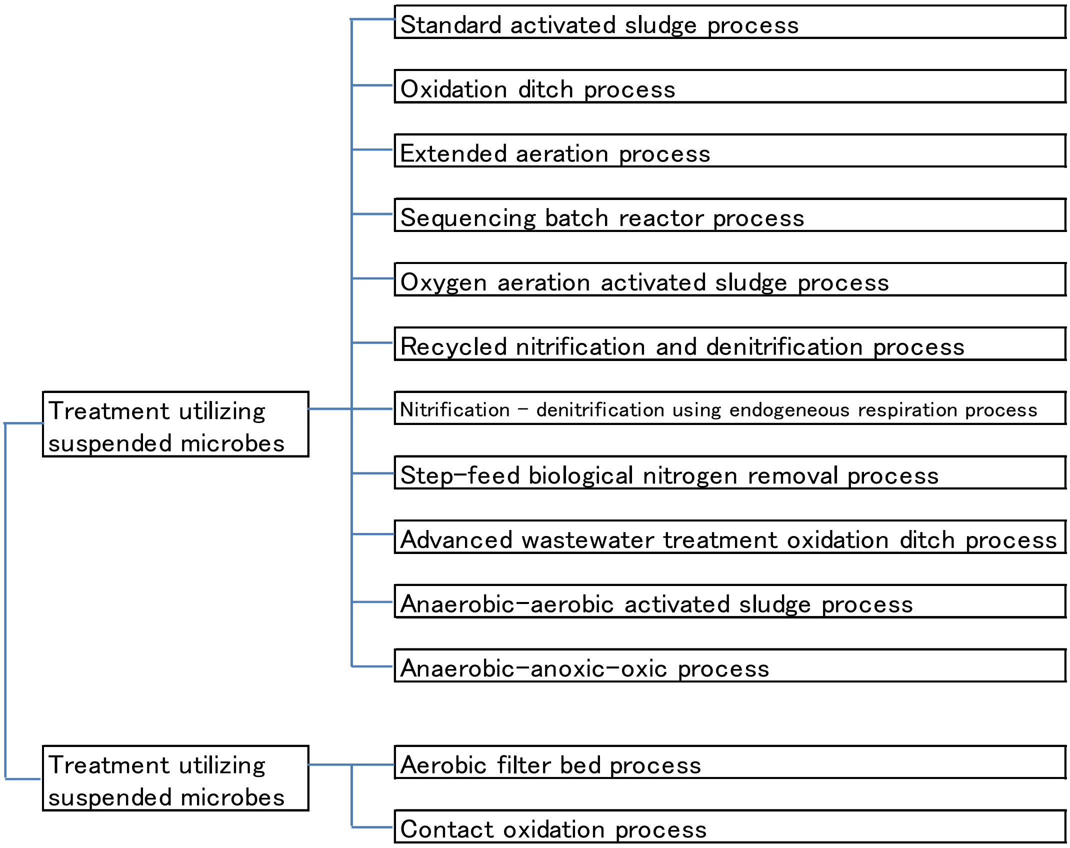


Table 6-1-4 Number of Treatment Plants by Treatment Method

Treatment Process \ Quantity(1000m³／d)		5under	5～10	10～50	50～100	100～500	500more than	Total
Primary	Sedimentation method	1	0	1	0	0	0	2
Secondary Treatment	Anaerobic anoxic toxic process	0	2	11	9	27	3	52
	Recycled nitrification and denitrification process	9	3	12	4	5	1	34
	Nitrification － denitrification using endogeneous respiration process	1	1	1	0	2	0	5
	Step-feed biological nitrogen removal process	0	2	7	7	9	0	25
	Anaerobic aerobic activated sludge process	14	0	12	8	18	2	54
	Standard activated sludge process	48	57	316	114	113	8	656
	Extended aeration process	32	7	3	0	0	0	42
	Oxygen aeration activated sludge process	2	1	6	1	0	0	10
	Modified aeration process	0	0	0	0	0	0	0
	Step aeration process	1	0	1	1	1	0	4
	Sequencing batch reactor process	66	6	2	0	0	0	74
	Aerobic filter bed process	22	6	0	0	0	0	28
	Anaerobic aerobic filter bed process	36	1	0	0	0	0	37
	Standard trickling filter process	0	0	0	0	0	0	0
	High rate trickling filter process	0	1	2	0	0	0	3
	Contact oxidation process	14	0	1	0	0	0	15
	Rotating biological contactor process	12	4	5	1	0	0	22
	Soil covered conglomerate contact process	23	0	1	0	1	0	25
	Advanced wastewater treatment oxidation ditch process	24	3	2	0	0	0	29
	Oxidation ditch process	780	89	35	0	0	0	904
	others	12	2	2	0	2	0	18
Total		1,097	185	420	145	178	14	2,039

Source: Sewage Systems in Japan(2005)

Table 6-1-5 Comparison of Treatment Methods

Assessment item		Standard activated sludge process	Sequencing batch reactor process	Extended aeration process	Oxidation ditch process	Stabilization pond process	Aerated lagoon	Rotating biological contactor process
Flexibility	Stability regarding shock load	Possible with installation of an equalization tank	Possible with installation of an equalization tank	Feasible	Feasible	Good	Good	Good
	Stability regarding load fluctuations	Possible with installation of an equalization tank	Possible with installation of an equalization tank	Feasible	Feasible	Good	Good	Good
	Stability regarding harmful substances	Possible with installation of an equalization tank	Possible with installation of an equalization tank	Feasible	Feasible	Good	Good	Feasible
Workability	Ease of maintenance	Easy	Fairly easy	Fairly easy	Very easy	Very easy	Very easy	Fairly easy
	Level of establishment of management system	Well established	Well established	Well established	Established	Established	Established	Slightly inadequate
	Quantity of inspection points	Many	Few	Few	Very few	Very few	Very few	Few
	Need for advanced technology	Necessary to an extent	Not very necessary	Necessary to an extent	Not very necessary	Not necessary	Not necessary	Not necessary
General characteristics	Amount of generated sludge (sludge generation rate)	Lot (95%)	Little (75%)	Little (75%)	Little (75%)	Less than in the OD process	Less than in the OD process	Lot (85%)
	Stability regarding water temperature changes	Slightly unstable	Slightly unstable	Slightly unstable	Stable	Slightly unstable	Slightly unstable	Slightly unstable
	Record of use	Quite a lot	Recently used a lot in the Philippines	Quite a lot	Quite a lot	Quite a lot	Quite a lot	A few cases
	Impact on local environment (noise, vibration)	No problem if countermeasures are taken	No problem if countermeasures are taken	No problem if countermeasures are taken	No problem if countermeasures are taken	No problem	No problem	No problem if countermeasures are taken
Treatment level (removal rate)	BOD	90	90	90	90	70	70	90
	SS	85	85	85	85	70	70	85

Note) 1. Sludge generation rate: Per unit amount of SS removed in the reaction tank.

2) Suggested Wastewater Treatment Technologies

Off-site treatment is the treatment of wastewater that has been conveyed using a sewerage system. Though the system requires installing long sewer lines, it is still easy to maintain the system and to keep the intended treatment level, and in many cases it incurs cheaper cost in total including capital and maintenance cost for big population service areas. However, generally it requires a big initial cost for introduction. There are several system options which would satisfy the budgetary and/or sustainable cost limitations.

(1) Activated Sludge Process

The activated sludge process requires primary settler, aeration tank and secondary settler. The primary and secondary settlers are used for sedimentation of solids contained in the influent and sludge flocs contained in the aerated sewage. The term “Activated Sludge” refers to sludge in the aeration tank of an activated sludge treatment process with aeration. It consists of flocs of bacteria, which consume the biodegradable organic substances in the wastewater. Because of its usefulness in removing organic substances from wastewater, the sludge is kept in the process by separating it from the treated wastewater and recycling it.

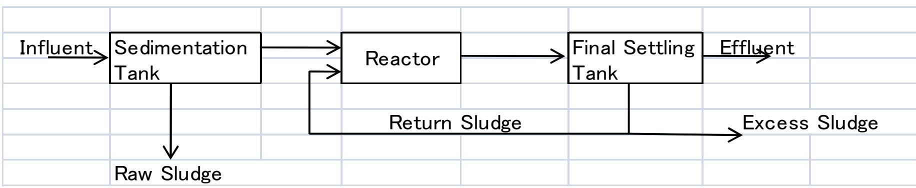
Generally this process is divided into three versions as follows;

a) Conventional Activated Sludge Process

The conventional activated sludge process entails numerous control factors such as MLSS concentration and air flow, etc. and there is a high degree of operating freedom, which makes it possible to respond to fluctuations in influent quality, although sophisticated operating technology is needed. **Figure 6-1-5** shows the flow of the conventional activated sludge process. Influent into the reaction tank enters the tank with return sludge, the two are mixed and aeration is carried out for a certain length of time. After that, the activated sludge liquid mixture flows into the final sedimentation tank, where solids-liquid separation into supernatant liquor and settled activated sludge takes place. Supernatant in the final sedimentation tank overflows from the tank as treated effluent, while the settled sludge is returned to the reaction tank, where it is once again used in biological treatment.

The aeration term is about 8 hours and bulk aeration blowing is required, but this process is advantageous in terms of the space required for installation.

Figure 6-1-5 Flow of the Conventional Activated Sludge Process



b) Sequencing Batch Reactor Process

The sequencing batch reactor process entails flowing sewage into a single reaction tank and repeatedly implementing aeration, sedimentation and supernatant liquor removal. It thus entails combining the conventional functions of the reaction tank and final sedimentation tank into one batch tank. Retention time in the reaction tank is 24 hours. The features of the sequencing batch reactor process are as follows:

① Aeration time and sedimentation time, etc. can be set relatively freely according to the quantity and quality of influent. Since sedimentation takes places in the still state, the stability of solids-liquid separation is higher than in the case of continuous flow final sedimentation tanks.

② Concerning the response to future strengthening of water quality regulations (nitrogen and

phosphorous removal), since it is possible to freely set the anaerobic-anoxic-aerobic conditions during a single cycle in the same reaction tank (batch tank), it is possible to conduct digestion and denitrification and remove biological phosphorous according to the load conditions.
③ Even if designing with the same retention time, this process requires smaller site area because tanks can be made deeper than in the oxidation ditch method.
④ The sequencing batch reactor process can curtail the generation of filate bulking according to the operation process.
⑤ Since reaction tank and final sedimentation tank functions are concentrated into a single tank, the sequencing batch reactor process entails no sludge return operation and management is easy and requires little manpower. Under low load conditions, since the designated water quality can be maintained through controlling the sludge-liquid interface and aeration flow, automatic operation is possible.
⑥ Since operation in a single tank is possible and the number of cycles (one cycle comprising aeration, sedimentation and removal) can be reduced when the water flow rate is low, it is possible to widely respond to changes in load conditions.
⑦ In the sequencing batch reactor process, since the batch tank switches to the sedimentation and removal processes after the blowers are stopped, more foam and scum tend to remain inside the tank compared to the conventional continuous final sedimentation tank process. **Figure 6-1-6**, **Figure 6-1-7**, shows the treatment process flow.

Figure 6-1-6 Treatment Process Flow of the Sequencing Batch Reactor

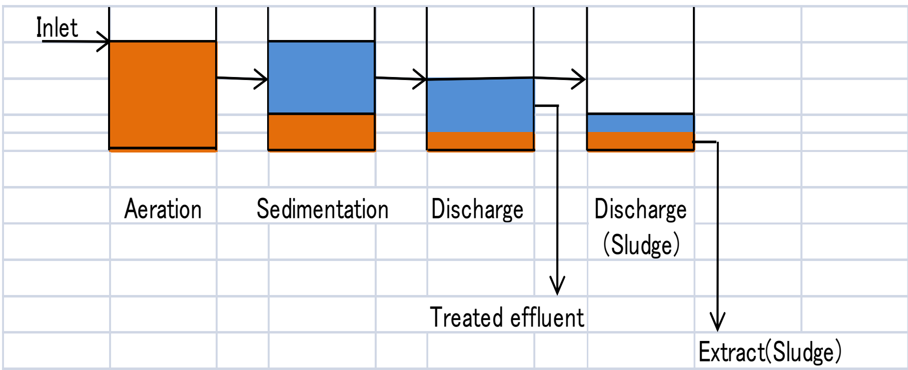
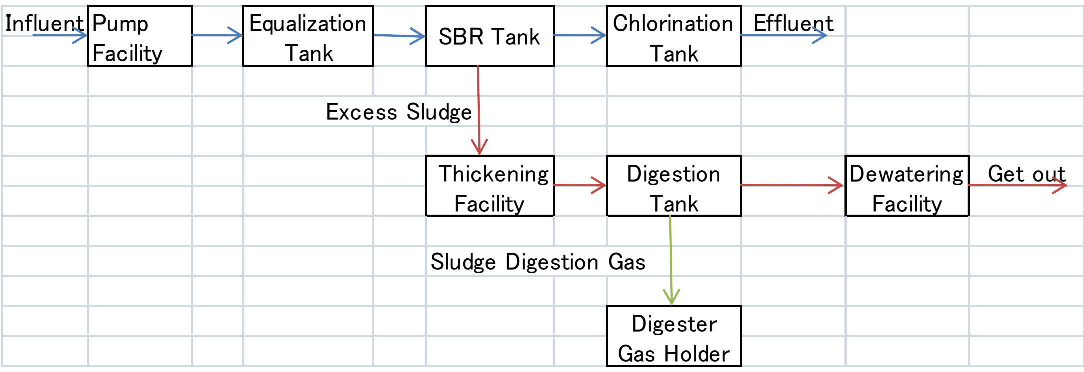


Figure 6-1-7 Flow sheet of the Sequencing Batch Reactor Process



① Pump facility

Because the scheduled site of the treatment plant is in a low-lying district at risk of flooding, it will be necessary to raise structures by 1.5~2.0 m and deeply install the inflow pipe in order to counter this. Accordingly, pump facilities will be installed in order to lift the incoming sanitary sewage to the plant.

② Equalization Tank

The equalization tank will be installed in order to respond to fluctuations in incoming sewage flow and to obtain good quality effluent. **Table 6-1-6** shows the merits and demerits of the equalization tank.

Table 6-1-6 Merits and Demerits of the Equalization Tank

Merits	Demerits
①The system can negate quantity and quality fluctuations and can operate at almost uniform load.	①New water tanks are needed, thereby increasing the tank capacity over the entire treatment plant.
②As the treatment flow is stabilized, quality and appearance can be improved.	②Accessory equipment is needed, thereby making it necessary to have more instruments.
③Since load fluctuations are reduced, excessive aeration or aeration deficiency are less likely to occur.	
④Water quality management in the reactor tank is improved.	
⑤Since the scope of operation control in the reactor is reduced, only simple control instruments are required.	
⑥During initial operation, it is possible to conduct single tank operation based on intermittent inflow.	
⑦The system can respond well to abnormal inflow.	

③ Sequencing Batch Reactor (SBR Tank)

The sequencing batch reactor process combines reaction tank and final sedimentation tank functions in a single batch tank. As is shown in **Figure 6-1-6**, the process treats sewage through repeatedly implementing activated sludge reaction, sedimentation of activated sludge and liquid mixture, supernatant removal, and removal of excess sludge. An intermittent flow process utilizing two tanks in a single series is usually adopted.

④ Chlorination Tank

The chlorination tank is installed in order to reduce the level of coliform bacteria in treated effluent to the required standard (3,000 mpn/100 ml or less). Disinfecting is usually performed using liquid chlorine, sodium hypochlorite, calcium hypochlorite, ozone and UV rays. The chlorine contact rate is set at 15 minutes or more.

⑤ Thickening facility

Since the amount of sludge is largely affected by the water content, the capacity of facilities in subsequent processes can be reduced through thickening and reducing the quantity of sludge. Sludge thickening methods include gravity sludge thickening tank, flotation sludge thickening tank and centrifugal thickening equipment, and the most suitable method should be selected upon taking the quantity and properties of sludge into consideration.

⑥ Digestion Tank

Sludge digestion processes are divided into anaerobic sludge digestion and aerobic sludge digestion. Normally, the anaerobic sludge digestion process is adopted at large treatment facilities that handle large quantities of sludge. Anaerobic sludge digestion entails biologically decomposing the organic matter in sludge in an anoxic environment. When sludge is left in a sludge digestion tank for around 20 days, the organic matter in the sludge is gasified and the sludge is reduced in quantity to around 40~60%. Following digestion, the sludge undergoes sedimentation and is separated into supernatant (separated liquid) that includes soluble organic matter, digestion gas and stable digested sludge.

⑦ Dewatering Facility

Sludge dewatering is carried out with the objective of removing the water content from sludge, thereby reducing its volume and making it more amenable to treatment and disposal. Sludge dewatering can be performed either by sun drying, utilizing natural solar and wind energy, or by mechanical dewatering. Sun drying is economical, however, it is unfeasible because the installation area is large and restrictions are imposed by the local environment. Mechanical dewatering methods include the centrifugal dewatering machine, belt press filter, multi-disc dewatering machine and so on, and it is necessary to select the most suitable type upon considering the quantity and properties of sludge.

c) Oxidation Ditch Process

In this method, there is no Primary sedimentation tank but a shallow endless channel fitted with a mechanical aeration unit is used as the reaction tank, in which low-load activated sludge treatment is carried out, and solids-liquid separation is then conducted in the final sedimentation tank. Retention time in the reaction tank is 24 hours. Features of this process are as follows.

① Since the system is operated at low load, nitrification and denitrification proceed smoothly and stable treatment can be secured even when there are fluctuations in influent quantity and quality and water temperature falls.

② Mixing inside the reaction tank slopes towards the direction of flow, however, MLSS concentration and alkalinity, etc. are almost uniform inside the reaction tank.

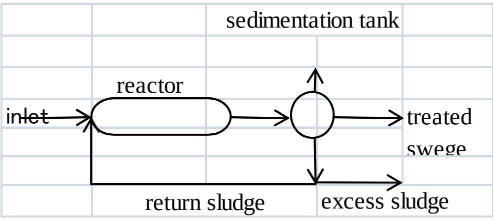
③ Excess sludge undergoes more advanced aerobic decomposition and is more stable than in the conventional activated sludge process.

④ Since the facility retention time is long and water depth is shallow, this process requires a large site area.

Figure 6-1-8 shows the flow in the oxidation ditch method according to the type of reaction tank. **Table 6-1-7** shows the main aeration units that are adopted in the oxidation ditch method.

Figure 6-1-8 Flow of the Oxidation Ditch Method

a) Oval type



b) Horseshoe type

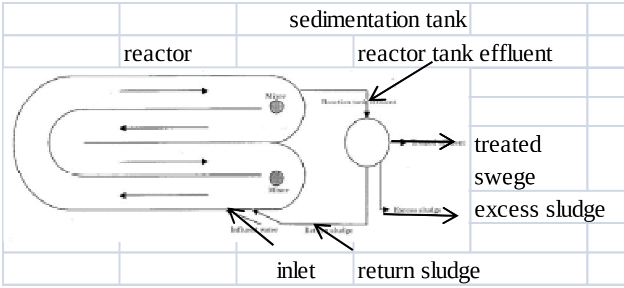
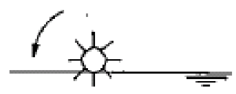
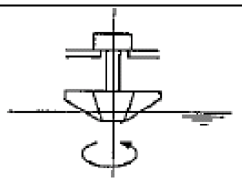
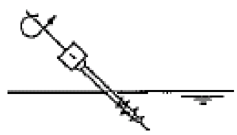
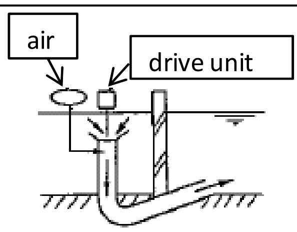
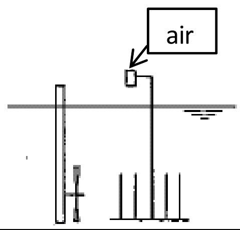


Table 6-1-7 Main Aeration Units and Their Features in the OD Method

Type	Outline		Features
Horizontal axis type		This is a surface aeration method in which a rotor comprising blades attached to a horizontal rotating axis stirs the water surface.	If controlling the oxygen supply, it is necessary to do so by controlling the number of rotations or switching On and Off. In that case, the flow velocity (stirring) cannot be controlled.
Vertical axis type		This is a surface aeration method in which the rotating force of the drive section is conveyed to an impeller immersed in the reaction tank water.	Ditto
Screw type		This is submersible aeration method in which the negative pressure generated by turning the screw is used to supply air and diffuse it in the water as micro bubbles.	Oxygen supply and flow velocity(stirring) can be controlled separately.
Axial flow pump		In this method, which combines string by a vertical axis impeller and air suction from an aeration pipe, a mixture of air and liquid is blown by the axial flow pump from the bottom of the tank on the downstream side.	Ditto
Propeller type		In this method, stirring and mixing are conducted by a submersed propeller and oxygen is fed by means of an aeration plate.	Ditto

(2) Membrane Process

The membrane bioreactor process (MBR), which requires the smallest installation area out of the treatment methods, will be adopted according to the site area.

In the MBR process, a permeable membrane unit is directly immersed in the aeration tank, and suction is carried out in order to separate solids and liquid inside the tank.

Since there is no sedimentation tank, as in the conventional approach, there is no outflow of sludge; moreover, because the perforations of the permeable membrane are microscopically small at 0.4 microns, suspended solids (SS) are reduced to below the measurement threshold and the passage of coli bacteria is prevented. In particular, since the organic flat membrane adopted in this facility is not the hollow fiber used in the conventional membrane separation method, the membrane surface can be hand-washed and maintenance is easy;

(3) Moving Bed Biofilm Reactor System (MBBR)

The moving bed biofilm system, which requires a small installation area and cheap costs, will be adopted according to the site area. The installation area is 1/3 that of the conventional fixed bed contact aeration process. In the moving bed biofilm system, through releasing carrier microorganisms into the aeration tank, effective microorganisms are fixed inside the aeration tank in order to enhance the decomposition performance of the organic content.

Moreover, since the fluid carriers with internal fins used in this equipment have a unit surface area of 300 m2/m3, which is at least five times higher than that in the fixed bed, the reaction speed has been dramatically improved.

Moreover, in the case of the moving bed biofilm system, since carriers flow around the aeration tank, the resulting sludge floc is light and small, meaning that sedimentation does not result in adequate separation. As a result, since fine sludge flows out, the carrier filtration process is adopted in order to conduct the final treatment (liquid solids separation) of the sludge and water mix that flows out from the carrier flow tank. The SS performance enabled by filtration is 17 mg/l or less (50 mg/l in the case of a sedimentation tank). Moreover, since backwashing, etc. in the filtration tank is conducted fully automatically based on interlinked operation of a timer, solenoid valve and water level gauge, maintenance is easy.

(4) Trickling Filtration

A trickling filter is a bed of solid media for bacteria to attach on its surfaces. Wastewater is irrigated on the solid media. It is also called a biological filter to emphasize that the filtration process is not mechanical straining of solids, but removal of organic substances by use of bacterial action. The solid media can be stones, waste coal gravel, shell exoskeleton or specially manufactured plastic media. The solid media are placed in a tank on a support with openings to allow air to move up by natural convection and treated wastewater to be collected in the under-drain. Wastewater has to undergo primary treatment and the final sedimentation tank is required to separate sludge from treated water. Because of non-use of forced aeration, operation energy is less than activated sludge process.

(5) Stabilization Pond

This process uses a large site area, however, it doesn’t require any complicated maintenance and it secures relatively stable final effluent quality. The stabilization pond is a system combining three pond types with differing properties, namely anaerobic ponds, facultative ponds and maturation ponds. Various combinations are possible and the system can be freely designed according to the objective, for example, facultative pond only, facultative pond + maturation pond, anaerobic pond + facultative pond, or all three types together. The basic flow is anaerobic pond → facultative pond → maturation pond, and the facultative pond is never omitted.

The facultative pond is intended to settle and remove suspended solids, remove larval roundworms and parasites and reduce the quantity of sludge. The pond has an ordinary depth of 2.5~5 m and the retention period ranges from 20 to 50 days.

Because the facultative pond is shallower and has larger surface area than the anaerobic pond, aeration based on algae photosynthesis is accelerated, and the oxygen generated by photosynthesis is used as facultative bacteria stabilize the organic matter (aerobic process). The tank depth is generally between 1.2~2.5 m and the retention time is around 5~30 days.

The maturation pond, also known as a polishing pond, is the final stage in the sewage treatment. The primary objective of this process is to remove bacteria.

The stabilization pond requires no mechanical equipment and is thus highly advantageous in terms of maintenance, however, problems are that it requires a large site area and the discharged effluent from the tank contains a lot of algae and SS. Assuming the influent flow to be 10,000 m3/day (around 70,000 people), the required site area would be 22 ha, which means that this process would not be feasible for adoption.

(6) Aerated Lagoon

This process entails installing an air diffuser and mechanical aerator to the stabilization pond, which utilizes photosynthesis of algae to supply oxygen, in order to reduce space and enhance the quality of treated effluent. The aerated lagoon is generally deeper than the stabilization pond at 2~6 m and it has a retention time of roughly 3~10 days. Assuming the influent flow to be 10,000 m3/day, the required site area would be 8 ha, which means that this process would not be feasible for adoption.

(7) Land Based Treatment

Land based treatment of wastewater relies on the action of soil bacteria to degrade the organic wastes in the wastewater, and it works well in arid or semi-arid regions, where the soil is generally not saturated with water over much of the year. Basically, there are two systems for applying land based treatment, namely the rapid-rate land application system and the slow-rate land application system.

Rapid rate land application system or soil aquifer treatment is applied when soil permeability is high, 1 meter per day or less, and the highest groundwater table is at least 2 meters below the bottom of the basin. During flooding, wastewater percolates through the soil beneath the basin to the underground water aquifer, organic substances are consumed by soil bacteria and suspended solids are trapped at the bottom of the basin. During drying, the layer of solids accumulating at the bottom of the basin is degraded by bacteria and also dried. The percolating capacity for wastewater is therefore rejuvenated.

The slow-rate land application system is an application of the wastewater to land through channels in the upper part of the gradient and treated wastewater through the slope pass is collected in channels in the lower part of the gradient of the slightly inclined ground. The organic substances in the wastewater are biodegraded by soil bacteria at the surface of the soil and during percolation through the soil. When the soil is saturated with water, overland flow or grass filtration mode of operation is used. In this case, wastewater flows over the soil surface and the organic substances are removed by bacteria attached to the vegetation and soil surface.

(8) Constructed Wetlands

Constructed wetlands are in-between lagoons and land based treatment systems. A constructed wetland consists of a gravel bed in which wetland species, such as reeds, are planted. Wastewater, usually after settling of solids, passes through the gravel bed, and organic substances are degraded by bacteria attached to the surfaces of the bed and plant roots. Constructed wetlands need to be designed to mitigate problems with insects such as mosquitoes and midges.

(9) Anaerobic Treatment of Wastewater

Anaerobic treatment is more suited to wastewater high in BOD, however, this system variation has been applied recently also to the ordinal wastewater system, thanks to the economical and efficient operation realized.

A simple anaerobic treatment system is a simple digesting tank with floating cover to store the grey and black wastewater in the tank. During digestion, biogas is generated and the gas can be used in cooking by combusting the methane gas content.

In the up-flow anaerobic sludge blanket (UASB) process, settled wastewater is passed up through a sludge blanket. The sludge blanket consists of anaerobic bacteria, which have developed into granules. Because of the high setting velocity of the granules, the granules are not carried over in the up-flowing wastewater. A high concentration of bacteria is therefore retained in the tank. The tank itself has no internal moving parts. If wastewater is distributed evenly at the base of the tank, mixing between the wastewater and the granules of bacteria is promoted by the carbon dioxide and methane gases produced by the anaerobic treatment process and the upward moving flow of the wastewater. Methane gas is produced which needs special handling procedures to prevent leakage and explosion. Wastewater treated anaerobically requires further aerobic treatment to reduce its BOD and odor, otherwise the effluent as treated for the prior treatment in the industrial park, is sent to the public sewer lines. The mixture of methane gas and carbon dioxide (bio-gas) is combusted, used for heating the content of the anaerobic reactor, or generating electricity.

3) Wastewater Treatment options

In order to realize the environmental conditions for the people to spend their lives in healthy circumstances, hygienic improvement in their general life is very important. When the government and community implement sanitation improvement programs, they soon encounter many barriers to establish the project policy, such as budgetary deficit, sustainability, technical levels for maintenance and operation, tariff policy, residents' awareness, and other infrastructural priorities more preferable to the regions, etc. In this situation options to be introduced should be realistic and viable. Important items to study before selecting any sanitation option are as follows.

● Which is important, in terms of environmental or conditional improvement?
Target indicator should better be coliform bacillus than BOD in some cases.
● Timing factor to confirm effective service to be provided after completion of the program. Long term identification of the service effectiveness should not be avoided,
● Some for all rather than more for some. However wastewater collection should follow gravity flow; therefore it is very difficult to realize "Some for All". Accordingly, several options including temporary facilities should be planned at the beginning of the implementation planning,
● Programs geared to reaching the final target of the plan should be compiled from the aspect of budgetary planning including tariff study, not from the aspect of technical program.
● Promote residential participation and perception in tandem in order to sustain the sanitation facilities introduced.
● Conduct institutional strengthening with tariff study.
● Consider all possible aid from outside agencies or foreign entities.

We are discussing possible sanitation options hereunder by concentrating on sanitation facilities and systems. Water supply and potable water systems to support hygienic lifestyles are not referred to at this time.

(1) Low Cost Treatment Systems

Characteristics of the off-site wastewater treatment systems vary depending on influent quality, regional climate, operating conditions, etc., however, characteristics of the low-cost treatment system compare as follows (**Table6-1-8**).

Table 6-1-8 Comparison of Low-cost Treatment Systems (off-site systems)

Type of Process	Removal efficiency BOD(%)	Installation space & power demand		Cost of Construction (%)	HRT (day)
		Land(m2/psn)	Power(w/psn)		
Facultative pond	75 to 85	2.00 to 5.00	0	100	15 to 30
Anaerobic plus Facultative pond	75 to 90	1.50 to 3.50	0	100	12 to 24
Partial mixed aerated lagoon	75 to 90	0.25 to 0.50	1.0 to 1.7	100	3 to 9
Trickling filtration	83 to 85	0.50 to 0.70	0.2 to 0.6	460	
Fast trickling filtration	80 to 90	0.30 to 0.45	0.5 to 1.0	370	
UASB	60 to 80	0.05 to 0.10	0	200	0.3 to 0.5
Septic tank plus anaerobic filter bed	70 to 90	0.20 to 0.40	0	370	1.0 to 2.0

The final effluent criteria for the Project area prescribe a BOD5 level of 50 mg/l. Since the quality of influent flowing into the treatment plant is 200~300 mg/l, the final effluent standard cannot be satisfied by the low-cost treatment methods shown in **Table 6-1-8**. Moreover, almost all these treatment systems require a large treatment plant area. Accordingly, adoption of a low-cost treatment system in this Project is not a viable option.

(2) Asset and Maintenance Management and Loan Management Systems

In order to enlarge the coverage of the sanitation services, installation of private flush toilets with connections to e trunk sewer lines and/or private pit latrines are essential. However, in many cases, the cost for installation would be levied on those households requesting to get the public services. Therefore, some funding program like revolving fund might be settled in parallel with the sanitation service implementation program. The local governments or responsible agencies would need appropriate private loan management which includes repayment records together with tariff payment records, households' economical categorization, individual lending limit, arrears or default of repayment or tariff, dunning schedule and so on.

Maintenance and operation system of public sanitation service facilities are ordinarily conducted with other relative information of system inventories, maintenance records, specification of utilities, cost records, rehabilitation or implementation records of facilities, staff rotations, and so on.

These asset and maintenance management and loan management systems should be computerized in the sanitation service program.

Since existing drainage facilities will be utilized in a combined sewer system for collecting sanitary sewage in this Project, the above records, etc. will not be needed. However, they will need to be considered when switching to a separate collection system in future.

6.1.6. Determination of Needs for Sanitation and Sewerage

1) Needs for Sanitation Improvements

(1) Determination of the Sanitation Deficit

Household sewage is composed of miscellaneous wastewater (water from dishwashing, laundry and face washing, etc.) and night soil. Concerning the BOD pollutant load of household wastewater, the WHO prescribes 45 g/person/day as an appropriate level, and the breakdown of this is 25 g/person/day from miscellaneous wastewater and 20 g/person/day from night soil.

The most commonly used individual treatment facilities for night soil in the Philippines are soak-away septic tanks. These septic tanks enable a BOD removal rate of 35~40% providing that proper maintenance is carried out, however, because sludge accumulated under the septic tank is not managed well, the designated BOD removal rate is not obtained. The treated sewage is percolated underground after passing through the septic tank. Since the treated effluent from the septic tank contains organic matter and pathogenic bacteria, it contaminates groundwater. Meanwhile miscellaneous wastewater is discharged into creeks via side ditches, etc. without undergoing any treatment. In the creeks, many children come into contact with this contaminated wastewater and the situation is highly unhygienic.

Accordingly, if only individual sanitary treatment facilities are adopted, problems still remain in terms of the sanitary environment for residents and pollution of water in creeks and Manila Bay.

6.2 Available Sewerage Sludge Management Technology

6.2.1 Sewage Sludge Treatment System

1) Sewage Sludge Treatment Process

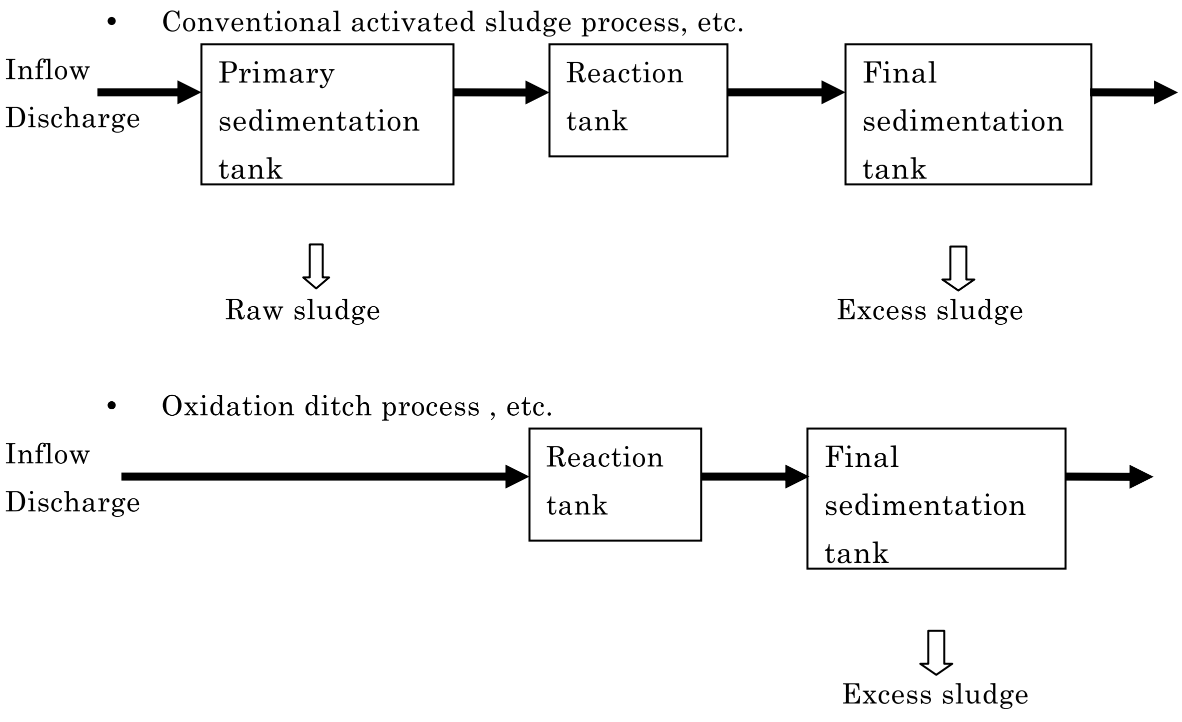
Construction of sewage systems leads to a steady improvement in living environment and quality of water in public water bodies, etc. In line with this, as the sewage treatment volume grows, the amount of sludge generated in such treatment also increases.

Sludge is an inevitable byproduct of sewage treatment, and treating this in an efficient, stable and sustainable way is a key factor in sewage treatment. Another consideration is that it becomes increasingly difficult to secure final disposal sites as the volume of solid waste discharge grows in line with mass production and mass consumption.

Accordingly, sludge treatment facilities are installed with the objectives of reducing volume (removing water content), reducing the amount of solids, stabilizing quality and finding effective means of use.

The form of sludge generation differs according to the method of sewage treatment. **Figure 6-2-1** shows the form of sludge generation according to the type of sewage treatment; **Table 6-2-1** shows the sludge generation rate; and **Table 6-2-2** shows the properties of generated sludge.

Figure 6-2-1 Form of Sludge Generation According to Sewage Treatment Method



- Sequencing batch reactor process, etc.

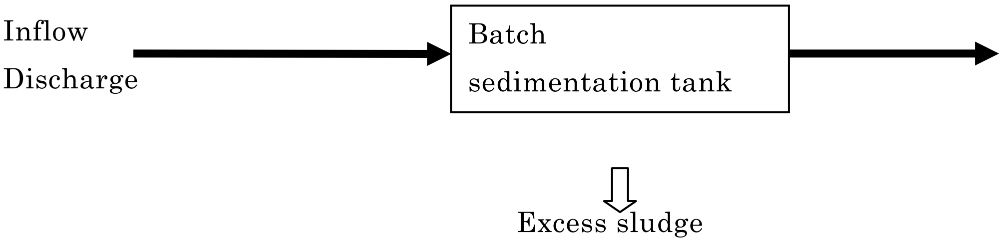


Table 6-2-1 Sludge Generation Rate per Unit Value of Removed SS According to Treatment Method

Generation rate / Treatment method	Sludge Generation Rate per Unit Value of Removed SS	Remarks
Conventional activated sludge process	100%	
Oxidation ditch process	75%	
Extended aeration process	75%	
Sequencing batch reactor process (low load)	75%	
Aerobic filter bed	100%	
Contact oxidation	93%	

Table 6-2-2 Sludge Concentration by Treatment Method

Generation rate / Treatment method	Sludge Concentration (%)		
	Initial settled sludge	Excess sludge	Mixed sludge
Conventional activated sludge process	2~4	0.5~1.0	1
Oxidation ditch process	-	0.5~1.0	-
Extended aeration process	-	0.5~1.0	-
Sequencing batch reactor process (low load)	-	0.5~1.0	-
Aerobic filter bed	-	-	1
Contact oxidation	2	0.8	1

Sedimentation tanks are facilities for settling and removing suspended solids (SS), and they comprise primary process sedimentation tanks and final sedimentation tanks. The primary sedimentation tank serves to conduct primary treatment and preliminary treatment for biological treatment, while the final sedimentation tank serves to separate treated liquids from the sludge arising from biological treatment and to smoothly thicken the precipitating sludge.

Accordingly, in the primary sedimentation tank, SS of relatively large specific gravity comprising mainly organic matter in sewage is precipitated and separated and the resulting sludge is raw sludge. In the final sedimentation tank, SS of relatively small specific gravity comprising largely microbial floc produced in the reaction tank is precipitated and separated, and the sludge removed after subtracting some for return to the biological reaction process is called excess sludge.

Moreover, in the OD process, a primary sedimentation tank is usually not installed. Similarly, in the Sequencing batch reactor process, no primary sedimentation tank is used but the reaction tank is given reaction tank (batch sedimentation tank) and final sedimentation tank functions and the following processes are repeated, i.e. activated sludge reaction, liquid mixture precipitation, supernatant removal, and sludge removal. The settled sludge here is also called excess sludge.

2) Unit Processes according to Purpose

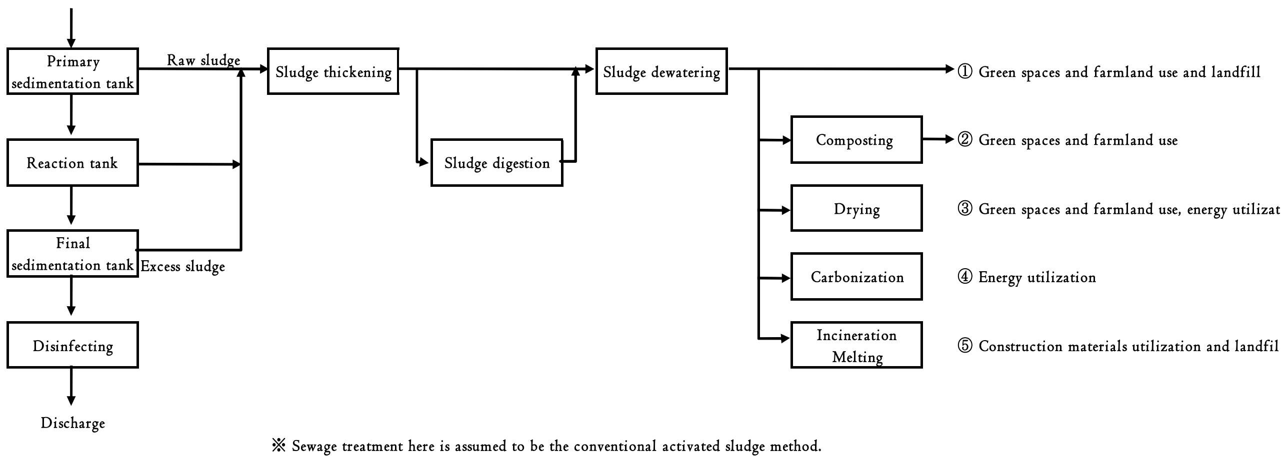
Unit processes corresponding to the purpose of sludge treatment are generally as follows, and these processes are combined. **Figure 6-2-2** shows a typical sludge process.

Volume reduction: Thickening, dewatering, drying

Reduction of solids: Digestion, incineration, melting

Qualitative stabilization: Anaerobic digestion, composting, incineration. Melting, carbonization, fuel conversion

Figure 6-2-2 Typical Sludge Treatment Process



The sludge treatment method combines the thickening, digestion, dewatering, drying, incineration and melting, etc. processes and this combination is suited to the effective utilization and final disposal of sludge. The selection of processes is dependent on the amount and properties of treated sludge, the types of utilization and disposal, trends in treatment technology, environmental conditions, local geographical conditions, future potential and stability, etc. Each process is outlined below.

(1) Sludge thickening

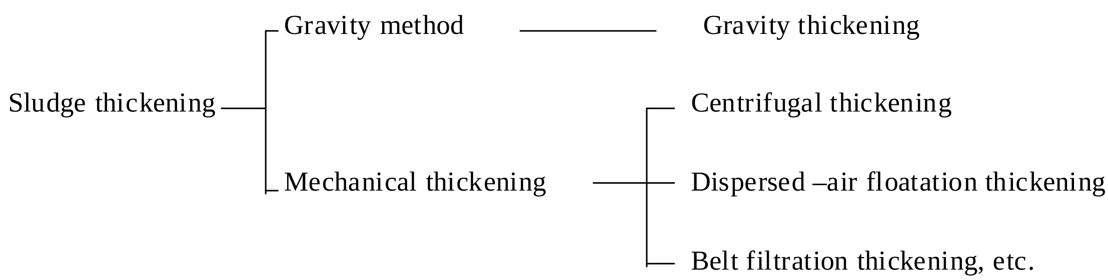
The role of sludge thickening is to thicken and reduce the volume of low-concentration sludge generated in sewage treatment facilities, and to ensure effective sludge digestion and dewatering in later stages. The low-concentration sludge generated in sewage treatment facilities sometimes suffers from reduced thickening performance due to changes in the sludge properties. Particularly during the summer, when water temperatures increase, sludge tends to putrefy and become less suitable for thickening. Sludge thickening methods are broadly divided into gravity thickening and mechanical thickening. As for methods for thickening excess sludge, which is less conducive to thickening, mechanical methods such as centrifugal thickening, Dispersed –air floatation thickening and belt filtration thickening, etc. are adopted.

If the sludge thickening is inadequate, this will lead to reduced treatment efficiency in later processes and return of separated liquids containing a high volume of suspended solids to the sewage treatment plant, which can cause deterioration in the quality of treated effluent.

Accordingly, excess sludge, which is difficult to thicken by the gravity method, is being thickened by mechanical methods more and more. In particular, in cases where the thickened sludge has water content of 98% or higher, it is necessary to consider separated thickening of the raw sludge and excess sludge.

Moreover, when conducting the concentrated treatment of sludge, since this entails treating sludge of differing properties, it is essential to have forced thickening processes as typified by mechanical thickening equipment.

Figure 6-2-3 Outline of Sludge Thickening Equipment



In the case of the general activated sludge process, thickened sludge comprises primary sedimentation tank sludge (raw sludge) and excess sludge from the final sedimentation tank.

Sludge thickening methods are broadly divided into gravity thickening and mechanical thickening as indicated in **Figure 6-2-3**, and mechanical methods are further divided into centrifugal thickening, atmospheric pressure flotation thickening and belt filtration thickening, etc.

The water content of sludge is determined according to the following formula:

$$W_w(\%) = \frac{W}{S+W} \times 100 \qquad \text{————————————————4-2-1}$$

Where,

S: Weight of dry solids in sludge

W: Weight of water in sludge

W_w: Water content of sludge

a) Gravity thickening

(a) Thickening mechanism

Gravity thickening entails holding sludge inside a tank and utilizing the natural force of gravity to conduct thickening. The thickened sludge that accumulates on the bottom of the tank is collected around the removal outlet by a sludge scraper. The system comprises the following components (see **Figure 6-2-4** ,**6-2-5** and the following):

- Tank (usually a reinforced concrete structure fitted with effluent weir and scum removal pipe
- Sludge scraper (drive unit, sludge scraping plate, scum scraping plate and picket fence)
- Sludge insertion pipe and removal pipe

Figure 6-2-4 Example of a Gravity Tank

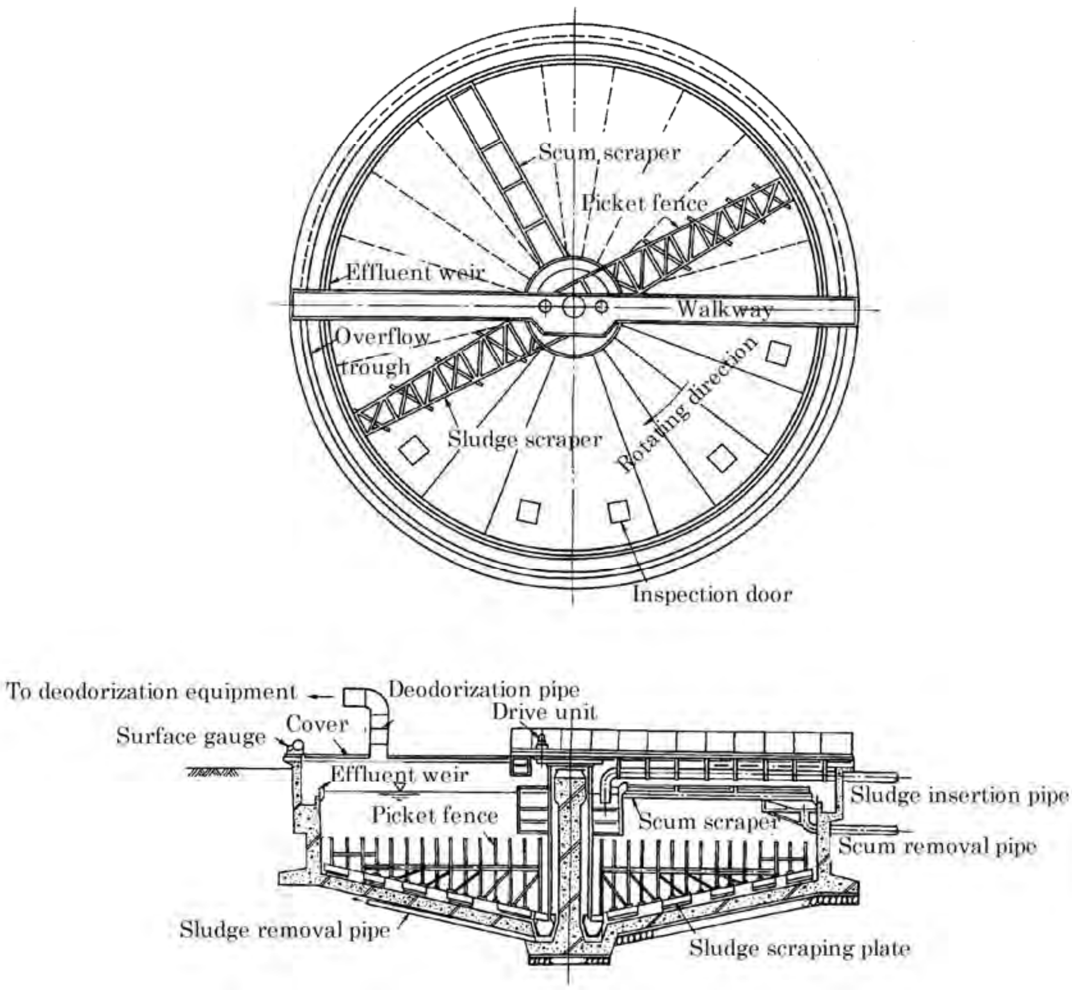
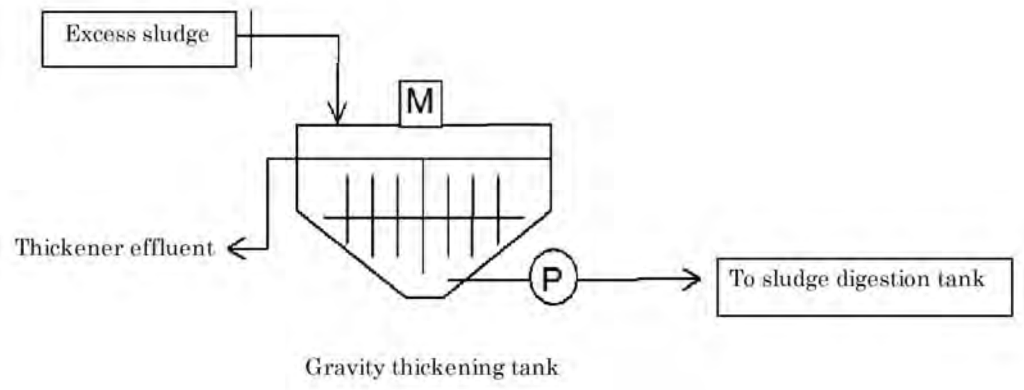


Figure 6-2-5 Gravity Thickening Flow



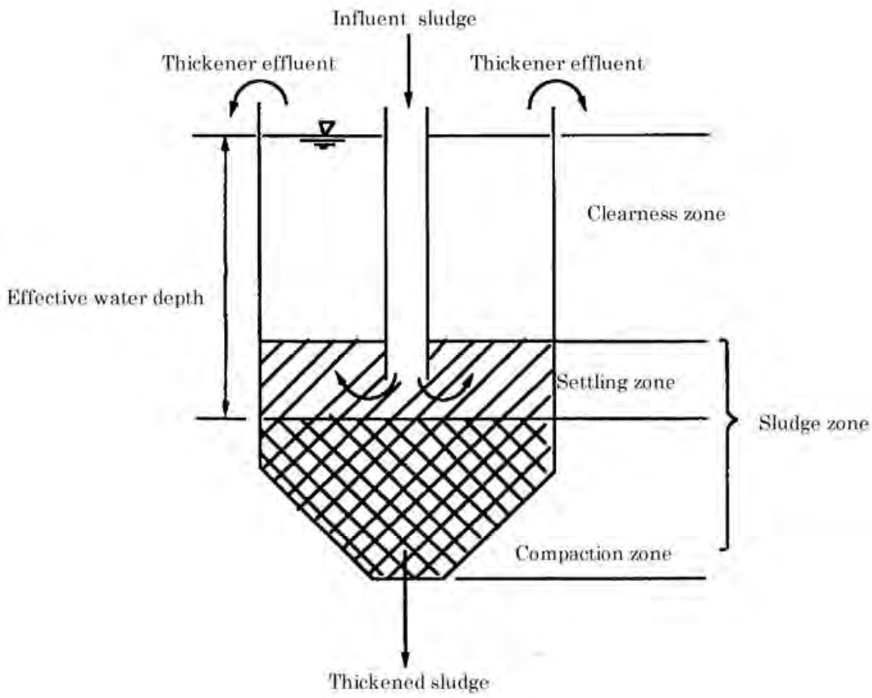
(b) Capacity of thickening tank

Tank capacity is often determined upon taking the solids load and effective water depth, etc. into consideration based on experience. The required tank capacity can be sought from two conditions, i.e. in the clearness zone shown in **Figure 6-2-6**, SS are not lifted by upward currents inside the tank and do not overflow (clarity condition), and the sludge layer inside the tank is at a uniform depth from the water surface, i.e. the tank has sufficient surface area to enable solids to pass through the settling zone in the unit time (thickening condition).

In cases where the inserted sludge has low concentration, the impact of water surface load is large, however, as the concentration of inserted sludge increases, the impact of the solids load becomes larger. In the case of routine inserted sludge concentration, the impact of water surface load is small but the solids load is important.

Depending on the state of the sludge before it is put into the tank, it is sometimes diluted before insertion in order to improve the thickening characteristics. In such cases, the sludge is diluted by stirring with secondary treated effluent; however, it is easier to adjust concentration through increasing the amount of sludge removed from the sedimentation tank. Incidentally, thickened sludge generally has water content of 96~98%.

Figure 6-2-6 Sludge Thickening Phenomena



b) Centrifugal Thickening

(a) Thickening mechanism

In the case of centrifugal thickening, sludge is thickened by conducting solids-liquid separation in a centrifuge. The system is composed of a centrifugal thickener, sludge supply tank and sludge supply pump, etc.

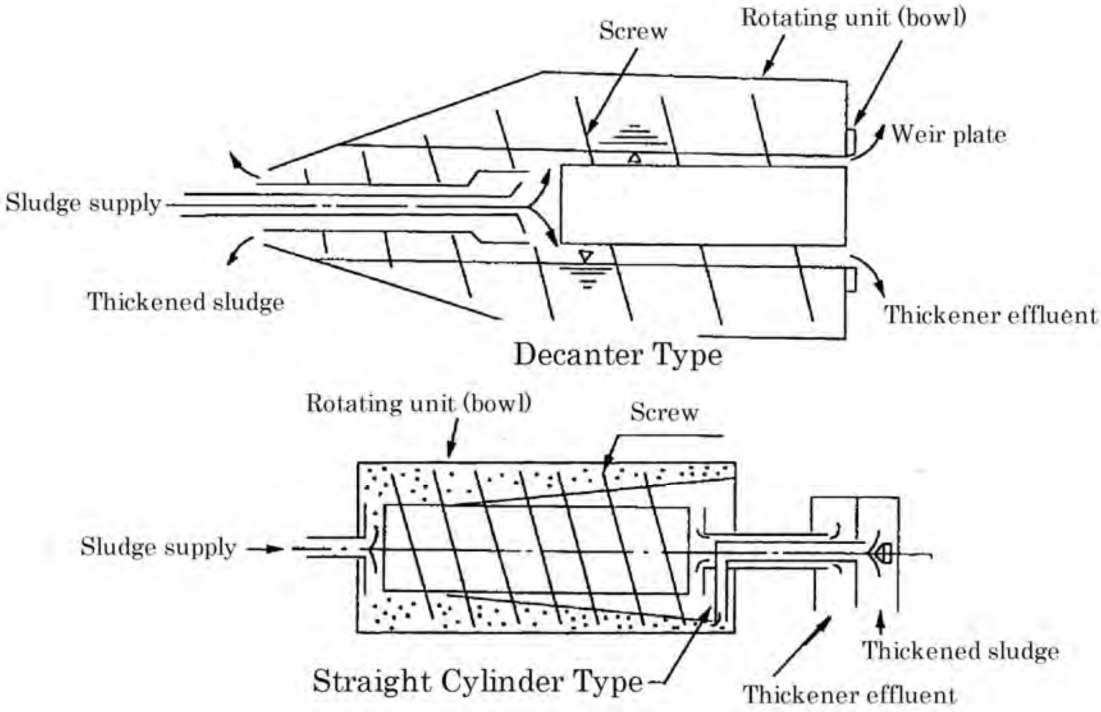
There are two types of centrifugal thickener – the continuous horizontal type and the batch standing type, but currently the horizontal type is almost always used. In both cases, sludge that is difficult to precipitate and thicken by gravity alone is efficiently and effectively thickened by using centrifugal force.

Through conducting solids-liquid separation of sludge in a high centrifugal force field, the centrifugal thickener can thicken excess sludge that is not conducive to gravity thickening to a concentration of around 4% in a short time. When installing the thickened sludge conveyance pipe sideways, consideration is given to gradient due to high viscosity. The installed area too is smaller than in the case of gravity thickening. Electric power consumption is the highest of any thickening process, however, chemical injection equipment is not always necessary and, considering the cost of purchasing high polymer coagulant, there is not a great difference with other methods in terms of the life cycle cost.

The horizontal type centrifugal thickener main unit consists of a rotating bowl and screw. The inserted sludge receives centrifugal force inside the rotating bowl so that thickened sludge is separated out towards the edges and is conveyed to the discharge side by the screw, which turns at a slightly different rate to the bowl.

The discharge side of the horizontal centrifugal thickener is shaped like a cone. There are two types: one is the decanter type, in which the screw scrapes thickened sludge along the sloping part and continuously discharges it, and the other is the straight cylindrical type, in which the rotating bowl is cylindrical and thickened sludge is continuously discharged from the discharge nozzle (see **Figure 6-2-7**).

Figure 6-2-7 Horizontal Centrifugal Thickeners



(b) Capacity of centrifugal thickening equipment

Capacity of the centrifugal thickener is sought upon considering the following items.

(b)-1 Capacity and number of units shall be according to the centrifugal thickener described later. At least two units are installed as a rule.

The centrifugal thickener must undergo an autonomous inspection once per year. Moreover, in consideration of repairs and so on, if there are no alternative facilities, it is necessary to install at least two units including a spare. Moreover, centrifugal thickeners should be installed with the ability to respond to cases where the supply sludge concentration falls and the supply volume increases, cases where the sludge volume changes seasonally, cases where the sludge volume increases at times of rainfall in a combined system, and cases where there are differences between the separated sludge washing interval and washing time.

(b)-2 Assume thickened sludge has water content of around 96% and that the solids recovery rate is 95% (85~95%).

Assuming the standard water content of thickened sludge to be around 96% and the solids recovery rate to be 85~95%, determine the centrifugal effect of the thickener according to each model. The standard centrifugal effect of a horizontal thickener is between 700~2,000 G. Because the concentration of thickened sludge varies according to the properties of sludge, take care to give later process facilities such as dewatering machines, etc. adequate spare capacity.

(b)-3 Estimation of equipment capacity

- Necessary treatment capacity per unit

$$q = \frac{Q}{N \times t}$$

Where,

N: Number of units

Q: Amount of supplied sludge (m^3/d)

t: Daily operating time (h/d)

Assume 24 hour operation. (Set the operating rate at 0.85 in consideration of equipment inspections and maintenance).

(c) Features

(c)-1 Merit

- It has a strong track record.
- Automatic operation is easy.
- Large-capacity treatment is possible.
- There is no blockage.
- Washing isn’t needed.
- Structure is closed.
- The SS recovery rate is high.

(c)-2 Demerits

- Motor capacity is large.
- Screw repairs are needed.
- The equipment is noisy.

c) Dispersed –Air Floatation Thickening

(a) Thickening mechanism

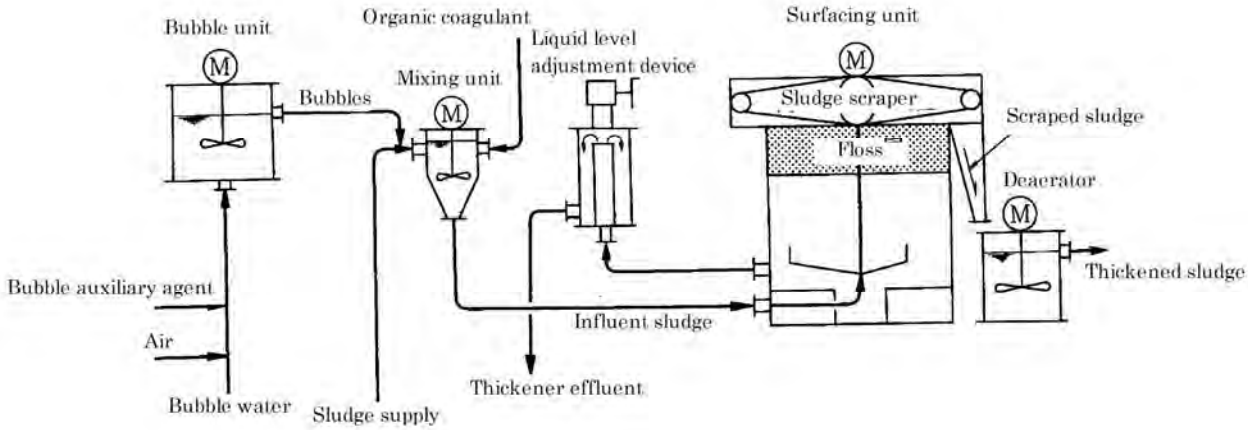
This approach entails adding coagulant and causing the sediment to adsorb, float to the surface and thicken.

The dispersed –air floatation thickening mechanism is composed of primary instruments such as a flotation unit, foaming unit, stirring unit and water level adjustment unit, and auxiliary equipment such as a sludge pump and floating sludge deaeration unit, etc. **Figure 6-2-8** shows the treatment flow.

In the foaming unit, water mixed with foaming agent and air is mechanically mixed to generate foam under normal atmospheric pressure; then this foam and solids in sludge are absorbed by adding high polymer coagulant in the stirring unit, and solid floc and foam possessing string bonding strength is formed.

The floc and foam solids are sent to the flotation unit and after the sludge solids are separated by flotation and scraped away, the minute air bubbles in the sludge are eliminated (deaerated) by mechanical agitation. Separated liquid is removed from the bottom of the flotation unit and flows over the water level adjustment unit.

Figure 6-2-8 Flow of Dispersed –Air Floatation Thickening System



(b) Capacity of the atmospheric flotation thickening equipment

Capacity of the flotation tank is sought upon considering the following items.

(b)-1 The solids load is assumed to be 25kg- DS/(m^2/hour) and the solids recovery rate is assumed to be 95% or higher as standard.

The solids load is expressed as the amount of treated solids per unit surface area of the flotation unit and is usually around 25kg- DS/(m^2/hour).

The gas-solid ratio is expressed as the air flow per unit amount of sludge solids, and this is influenced by the thickened sludge concentration, the collected amount of solids and the stability of operation. When the air flow is small, the quality of the separated liquid deteriorates, but when the air flow is excessive, the scraping sludge threshold becomes unstable and the thickened sludge concentration goes down. Generally speaking, the standard gas-solid ratio is 0.05~0.1 kg air/(kg-DS).

Concerning the performance of sludge thickening equipment, the thickened sludge concentration is usually between 4~5% and the solids recovery rate is 95~96% as standard.

(b)-2 Effective water depth inside the tank is assumed to be 4 m.

In the flotation thickening process, sludge to which bubbles have adsorbed floats to the surface, and it is necessary for the sludge flotation to form a floss (floating sludge) layer thick enough to possess sufficient consolidation. Since separated liquid is discharged through the discharge outlet at the bottom of the tank, it is necessary to have sufficient space for the floating sludge and liquid to adequately separate. An effective water depth of around 4 m is required in order to secure sufficient space and ensure that sludge doesn't flow into the separated liquid side.

(b)-3 The standard shape is circular.

The flotation tank is assumed to be circular as standard. The largest size tank in practice has an inner diameter of 5.5 m. The smallest known tank has an inner diameter of 1.7 m due to constraints imparted by the flotation unit including floss scraper and sludge supply pump.

(b)-4 At least two units are installed as a rule.
In consideration of repairs and so on, if there are no alternative facilities, it is necessary to install at least two flotation tanks including a spare.

(b)-5 Estimation of equipment capacity
- Necessary area per tank

$$A = \frac{Q}{V \times N \times t}$$

Where,
V: Solids load 25kg- DS/(m^2/hour)
N: Number of units
Q: Amount of supplied sludge (t-DS/d)
t: Daily operating time (h/d)
Assume 24 hour operation. (Set the operating rate at 0.85 in consideration of equipment inspections and maintenance).

(c) Features
(c)-1 Merits
- Since chemicals are dosed, stable thickening performance is obtained.
- There is hardly any noise or vibration.

(c)-2 Demerits
- There are numerous instruments and maintenance is complicated.
- Construction costs are rather expensive.
- Maintenance costs are rather expensive.

d) Belt Filtration Thickening

(a) Thickening mechanism

The belt filtration thickener filters and thickens coagulated sludge on a moving conveyor belt. **Figure 6-2-9** shows the conceptual view while **Figure 6-2-10** shows the flow.

After being coagulated with high polymer coagulant, the sludge is put onto the moving belt where it is filtered and becomes high concentration thickened sludge by the time it reaches the discharge section. The belt is washed on the return side to that stable thickening can be continued. This machine has the following advantages compared to other thickeners.

- Structure is extremely simple and entails only rotating a stainless belt.
- Since the belt has low torque and rotates at a low speed, the belt life is long.
- The two ends of the belt are driven via a chain. There is no need for an elastic corrective device such as a filter cloth belt.
- Thanks to installation of a low speed rotating and odor prevention cover, there are hardly any problems concerning vibration, noise and odor.

Figure 6-2-9 Concept of Belt Filtration Thickening

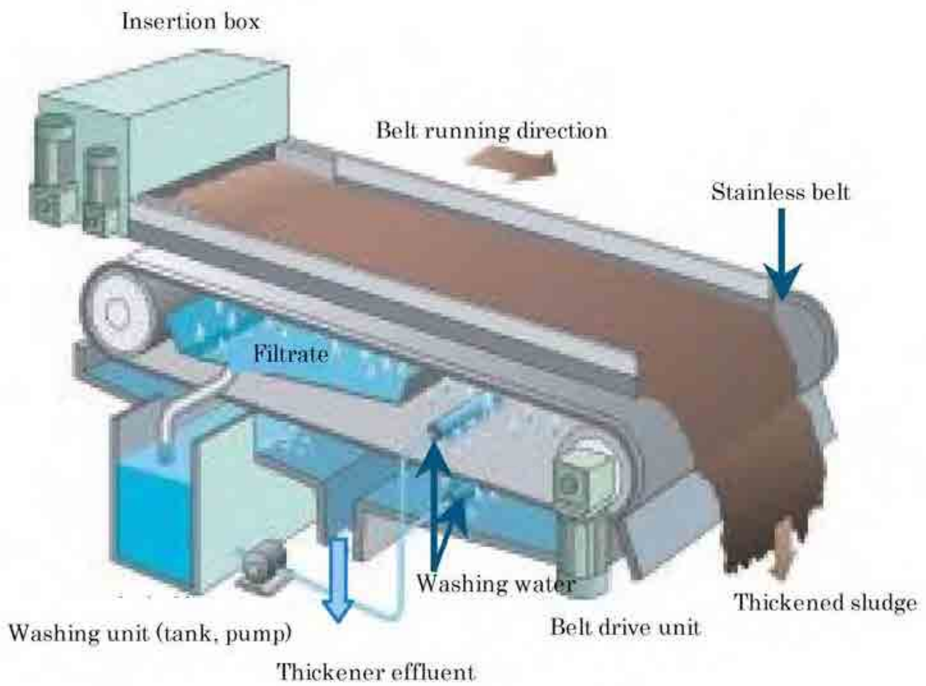
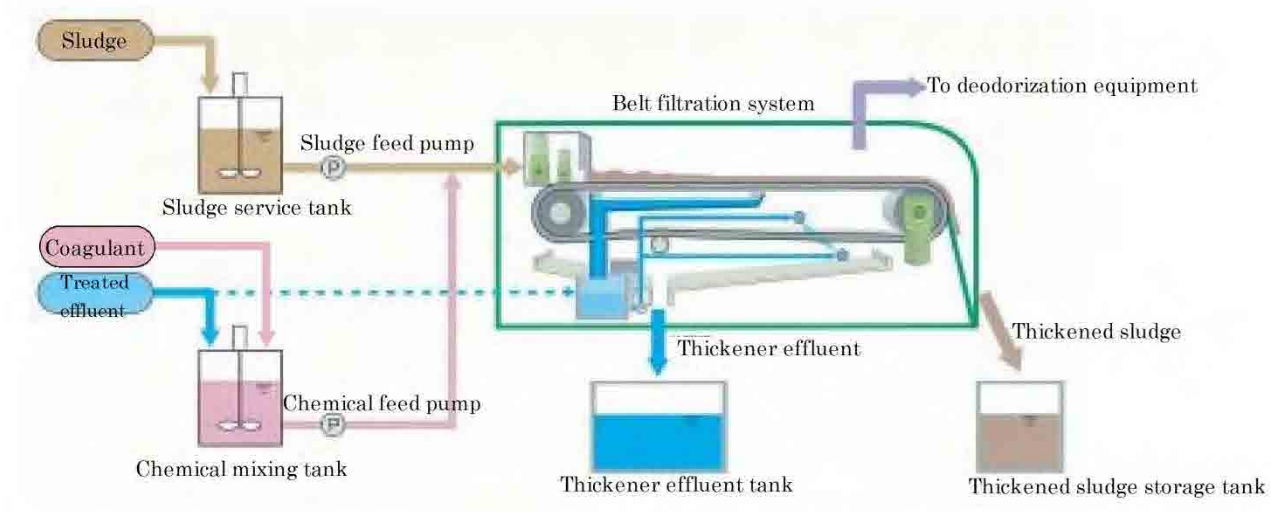


Figure 6-2-10 Flow of Belt Filtration Thickening



(b) Capacity of belt thickening equipment

Capacity of the belt thickener is determined upon taking the following items into consideration.

(b)-1 Capacity is assumed to be 20 m^3/hour (inserted amount of sludge).

- Necessary treatment capacity per unit

$$q = \frac{Q}{N \times t}$$

Where,
N: Number of units
Q: Amount of supplied sludge (m^3/d)
q: Capacity per unit (m^3/h)
t: Daily operating time (h/d)

$$B = \frac{q}{V}$$

Where,
B: Necessary effective belt width (m)
V: Inserted amount of sludge (20 m^3/m- h)

(b)-2 The water content of thickened sludge is assumed to be around 96% while the solids recovery rate is 95%.

Assuming a chemical dosing rate of 0.3%, sludge insertion rate of 20 m^3/m- Hr and filtering time of 20~30 seconds, thickening concentration of 4% or more and a recovery rate of 95% or more can be anticipated.

(c) Features

(c)-1 Merits

- Since chemicals are dosed, stable thickening performance is obtained.
- Construction costs are rather inexpensive.
- Maintenance costs are rather inexpensive.
- There are few instruments and maintenance is easy.
- There is hardly any noise or vibration.

(c)-2 Demerits

- There is no record of actual application.

e) Comparison of Sludge Thickening Systems.

Table 6-2-3 shows the Comparison of Sludge Thickening Systems.

Table 6-2-3 Comparison of Sludge Thickening Systems

Item	Centrifugal thickening	Atmospheric pressure flotation thickening	Belt filtration thickening	Gravity thickening
General comparison	2	3	1	3
Record of use	2	2	3	1
Construction cost	3	3	2	1
Maintenance cost	3	2	2	1
General evaluation	3	3	2	1

Note: The numbers in the last column means superiority orders (smaller number is better than larger.)

(2) Digestion

Sludge digestion equipment is installed with the objectives of reducing volume in later process facilities, stabilizing sludge so that it is ready for final disposal and making effective use of energy.

There are two approaches to digestion – aerobic digestion and anaerobic digestion, and both approaches are primarily designed to decompose and stabilize the organic matter in sludge.

a) Aerobic digestion system

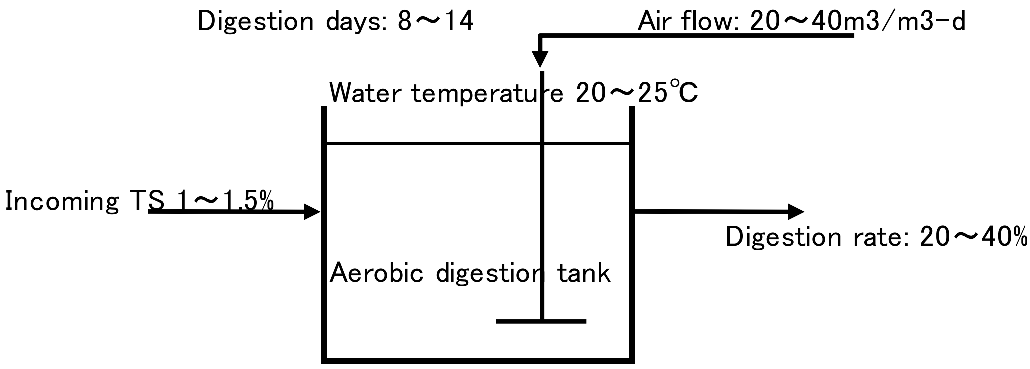
The aerobic digestion system entails aerating sludge for an extended period in order to reduce the volume of and stabilize sludge through the action of aerobic microorganisms. The system is composed of a sludge digestion tank and a sludge thickening tank for conducting the solids-liquid separation of digested sludge.

Since aerobic digestion entails easier maintenance and less odor than anaerobic digestion, it is adopted in some small-scale facilities. Moreover, in cases where there is spare room in the facilities capacity at the start of service, as an initial measure, part of the aeration tanks is used to conduct aerobic digestion treatment.

Aerobic sludge digestion tanks usually receive mixed sludge or excess sludge with a solids concentration of 1~1.5%. The air diffuser is a vertical axis rotating type or uses a diffuser plate and disc diffuser, etc., and the air flow is 20~40m^3/m^3-d per the tank capacity.

Digestion takes between 8~14 days and the sludge 20～40m3/m3- d rate is 20~40%. **Figure 6-2-11** shows the aerobic digestion model.

Figure 6-2-11 Aerobic digestion model



This system is more suited to small-scale treatment plants. Since the project targets large-scale plants and not enough sludge-digestion gas can be expected to enable effective utilization for energy, it will be difficult to adopt aerobic digestion in the project.

b) Anaerobic Digestion Tank

Anaerobic digestion entails utilizing the action of anaerobic microbes to reduce the molecular weight, liquefy and gasify organic substances inside a sludge digestion tank that is maintained in an anaerobic state. The organic substances in sludge become decomposed after passing through the stages of acidic fermentation (phase 1), acidic reduction (phase 2) and alkaline fermentation (phase 3).

In the first two phases, facultative anaerobic bacteria known as acidic generative bacteria act so as to hydrolyze high polymer organic materials such as carbohydrates, proteins and fats, etc. containing cellulose in the sludge into volatile organic acids such as acetic acid, proprionic acid and butyric acid, etc. and low-level alcohol. In phase 1, the pH value drops to 5~6, and in phase 2 it rises to approximately 6.8.

In the third phase, intermediate products such as organic acid, etc. are broken down into final products such as methane, carbon dioxide and ammonia, etc. through the action of methane-generated bacteria, which are absolute anaerobic bacteria. In phase 3, the pH value becomes around 7.0~7.4.

In actual operating facilities, since sludge is continually inserted into tanks during the alkaline fermentation stage, digestion processes from phase 1 through to phase 3 simultaneously exist.

When sludge is left in the digestion tank for the appropriate number of days according to the digestion temperature, organic substances in the inserted sludge are reduced by between 40~60% as a result of liquefaction and gasification.

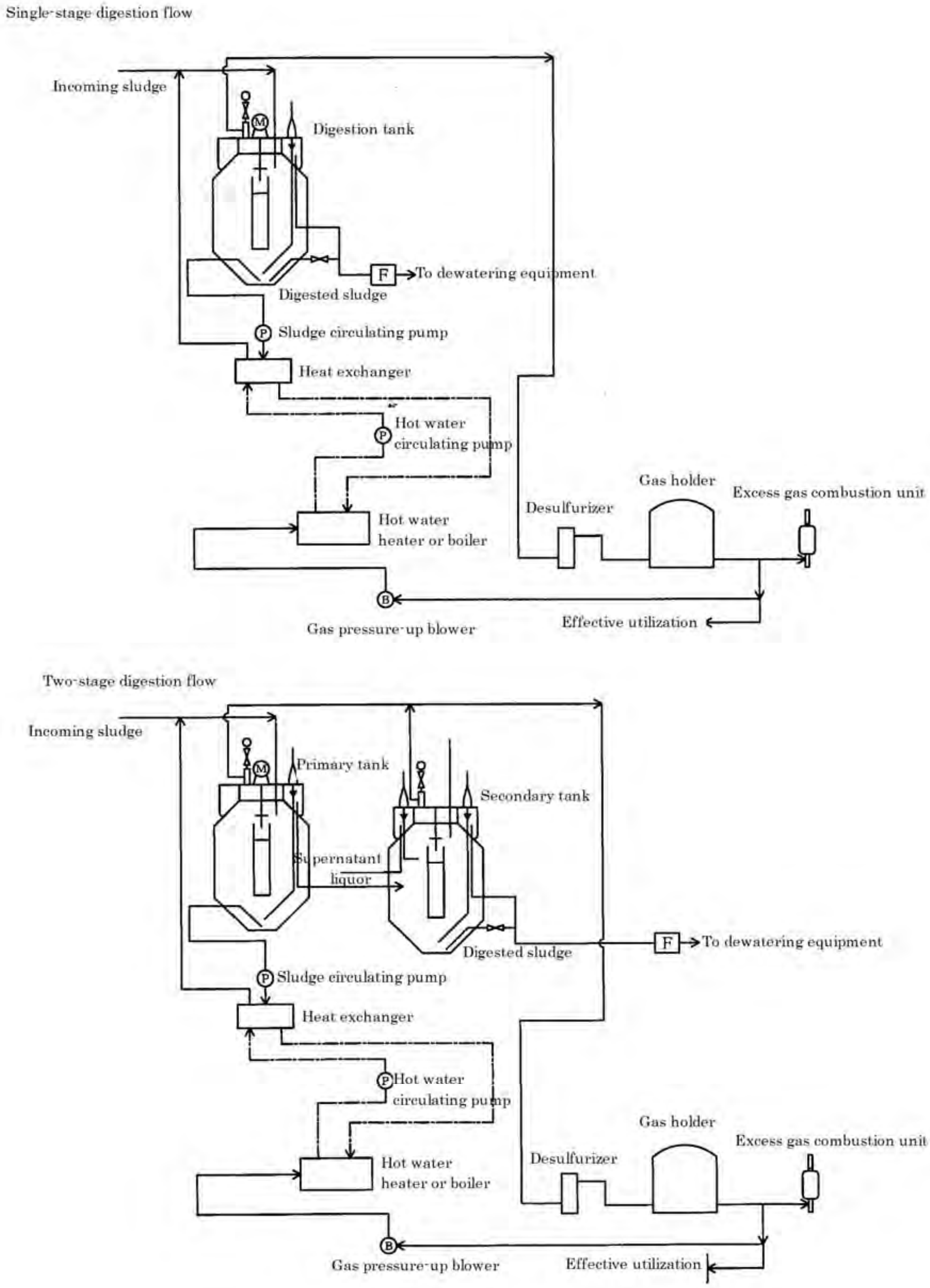
As a result, the volume of sludge is reduced, its quality is stabilized and sanitary safety is enhanced. The resulting digested sludge can be finally disposed in cake form. Moreover, because the volume of sludge is reduced, it is possible to downsize the capacity of facilities in subsequent dewatering and incineration processes, etc.

After the organic content has been decomposed, the digested sludge is sent to the sludge dewatering plant. In cases where supernatant liquid is generated in two-stage digestion processes, this is usually sent to the sewage treatment plant for treatment. Meanwhile, sludge-digestion gases, which primarily consist of methane generated as a byproduct of anaerobic digestion, are desulfurized and then used as auxiliary fuel in the incineration furnace or for heating the sludge digestion tanks; alternatively they may be used for power generation, etc. Thus anaerobic digestion has numerous advantages and has long been utilized in sewage sludge treatment.

High concentration digestion methods, which entail mechanically thickening sludge before inserting it into the digestion tank, enable the effective capacity of tanks to be reduced and heating energy to be saved on. Moreover, there is no need to extract supernatant liquor, while the digestion gas generation rate per unit quantity of inserted sludge is higher. Accordingly, it is possible to increase the amount of excess sludge-digestion gas and expand the scope for energy utilization, and thereby construct a more energy self-sufficient sludge treatment system. **Figure 6-2-12** shows an example of the anaerobic sludge digestion flow.

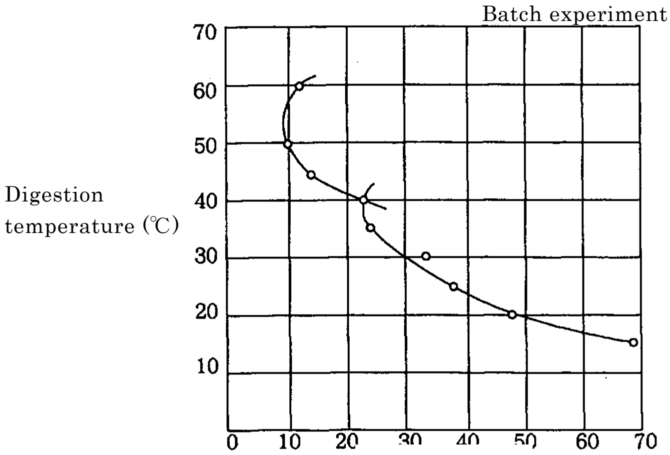
The main function of the sludge digestion tank is to break down complex organic materials into simple substances through the action of anaerobic bacteria. Following digestion, sludge is turned into digestion gases and stable digested sludge. Digestion methods can either be the single-stage type or the two-stage type as shown in **Figure 6-2-12**.

Figure 6-2-12 Sample Flow of Anaerobic Sludge Digestion



The number of days required until 90% of digestion gas is generated in sludge digestion differs according to the digestion temperature as shown in **Figure 6-2-13**. In other words, digestion temperature of less than 20℃ is called the low-temperature digestion zone, temperature of 20~39℃ is the intermediate-temperature digestion zone, and temperature of up to 40~65℃ is called the high-temperature digestion zone, and these distinctions are said to exist due to differences in the types of anaerobic bacteria that are useful for digestion.

Figure 6-2-13 Relationship between Digestion Time and Digestion Temperature



The most efficient temperatures in each digestion zone are 15~20℃ for low-temperature bacteria, 30~37℃ for medium-temperature bacteria and 50~55℃ for high-temperature bacteria and, although an irregular belt has been confirmed between the medium-temperature and high-temperature zones, this is said to disappear when bacteria become accustomed to the environment.

Generally speaking, the gas generation speed increases in line with temperature increase.

(b)-1 High-temperature digestion (requires heating)

High-temperature digestion has a number of advantages compared to medium-temperature digestion, for example, capacity of the sludge digestion tank can be reduced due to the higher load and shorter digestion period. However, because of poor heating economy arising from the need to heat the tank, it has not been adopted widely. Having said that, there have recently been cases of high-temperature digestion where waste heat from engine exhaust gases and cooling water is used and digestion gas it utilized for power generation.

There are also cases where combination with high-concentration digestion methods generates so much digestion gas that there is no need for heating with auxiliary fuel (heavy oil, etc.), and there are situations where it is more advantageous to adopt high-temperature digestion rather than medium-temperature digestion.

Retention time in the high-temperature digestion zone is around 10~15 days.

(b)-2 Medium-temperature digestion (requires heating)

The digestion temperature is almost always set at around 35℃ in the medium-temperature zone where the digestion tank heating fuel requirement can be almost totally satisfied by sludge-digestion gas.

The number of retention days needed in order to ensure the anaerobic decomposition of organic matter in sludge and generation of ample digestion gas in the medium-temperature zone is around 20~30 days. In the case of two-stage digestion, since the secondary tank is mainly intended to conduct solids-liquid separation, it is desirable to secure the required n number of days for sludge digestion in the primary tank.

Concerning retention time in the secondary tank, around 10 days are deemed sufficient based on experience. In actually operating facilities, the combined digestion time in primary tanks and secondary tanks is usually between 20~30 days.
Moreover, depending on the properties of sludge inserted into the digestion tanks, the digestion temperature, digestion rate and sludge treatment and disposal methods after digestion, it is desirable to conduct separate examination and to determine the most efficient retention period in the planning stage.

(b)-3 Low-temperature digestion (no heating)

Digestion without heating corresponds to low-temperature digestion, so of necessity the digestion period becomes longer and capacity of the sludge digestion tank becomes larger. Moreover, the digestion temperature is affected by the atmospheric temperature. However, since there is no need for heating equipment, thereby enabling energy conservation and making maintenance work easier. Accordingly, the unheated approach is adopted in cases of small-scale facilities where the inserted amount of sludge is small and as a provisional measure when commissioning sludge digestion tanks for the first time, etc.

The digestion period is set at around 60~90 days upon taking the winter temperature of sludge and air temperature into account.

(b)-4 Digestion time (retention period)

The following design values are adopted regarding the digestion period.

- Concerning digestion temperature, medium-temperature digestion is assumed.
  Since the Philippines has no prior experience of anaerobic sludge digestion systems in operation, there is doubt over whether enough generated gas can be recovered to conduct high-temperature heating. There is thus risk involved in adopting digestion in the high-temperature zone. On the other hand, as for low-temperature digestion, digestion gas cannot be effectively utilized and only a small amount of digestion gas can be generated. In contrast, medium-temperature digestion has been already adopted extensively and entails using digestion gas to generate power and using engine exhaust gas and heat from cooling water to conduct heating. Accordingly, medium-temperature digestion shall be adopted here.
- Digestion time of 25 days in the primary tank is assumed.
  According to **Figure 6-2-13**, the necessary retention time when the digestion temperature is 35℃ is 25 days.

(c) Shape and number of units

The shape and number of tanks shall be determined upon taking the following points into consideration.

(c)-1 The shape of tanks is cylindrical, oval or hexagonal, and the inner diameter and effective water depth of tanks are decided in view of the stirring effect.

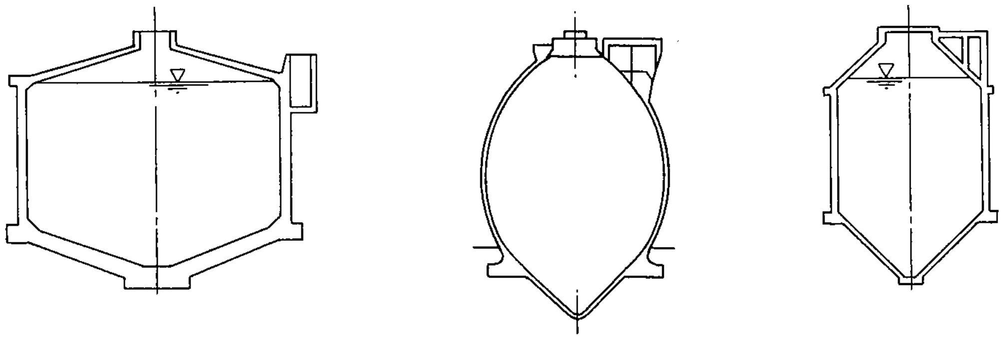
The shape of sludge digestion tanks is determined with a view to equalizing the sludge stirring and temperature inside the tank and enhancing the economy and stability of heating, insulation and structure. Generally speaking, cylindrical tanks have traditionally been adopted because they are easy to install and economical. In recent times, oval shaped tanks are becoming more popular because they enable a better stirring effect. Moreover, hexagonal tanks combine the economic merits of cylindrical tanks and favorable stirring characteristics of oval tanks. The cylindrical tank has an inner diameter of 10~30 m and the ratio of inner diameter to side depth (effective water depth) is roughly 2: 1. Also, if the water depth is too shallow, since the gas stirring effect will diminish, a minimum depth of 4 m should be secured.

The egg-shaped tank has spherical shell-shaped sides and a straight roof and base, while the walls are continuous and smooth. Moreover, since there is no localized concentration of stress in such a structure, it is possible to adopt large tanks and the surface area per unit capacity is small. As a result, heat loss is minor and tank capacity can be always secured because it is difficult for sand and sediment in the sludge to accumulate.

In the hexagonal tank, the ratio of inner diameter to side depth (effective water depth) is roughly 1: 1.

Figure 6-2-14 shows some examples of different shaped sludge digestion tanks.

Figure 6-2-14 Different Shapes of Sludge Digestion Tanks



Cylindrical   Egg-shaped   Hexagonal shape

(c)-2 Bottom gradient

Since the accumulation of sediment on the bottom of the tank reduces the effective capacity and also hinders the removal of sludge, it is desirable to adopt a steep gradient on the bottom of the tank to prevent this from happening. Accordingly, a Cylindrical tank with a 30/100 gradient should be adopted.

(c)-3 Number of sludge digestion tanks

Around two lines of sludge digestion tanks should be adopted in consideration of operation stoppages for the repair, inspection and cleaning, etc. of tanks.

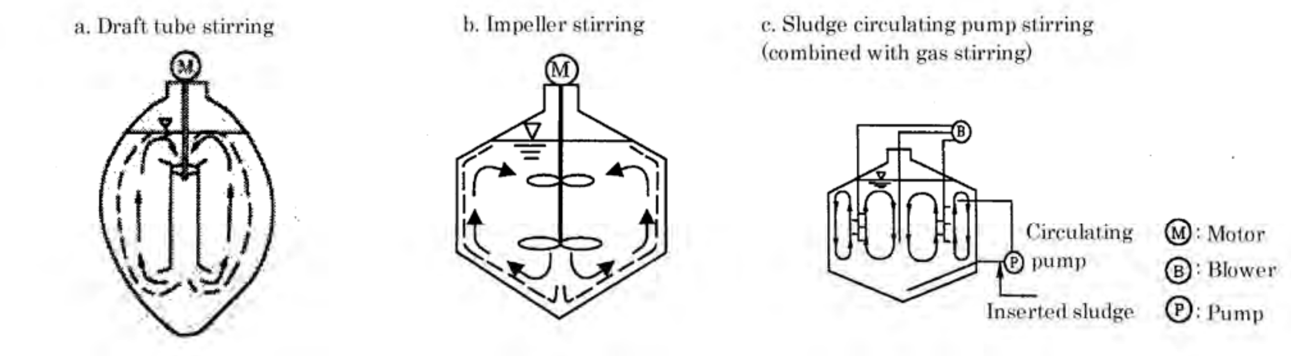
(d) Stirring method

Stirring is implemented with the objectives of mixing inserted sludge with digested sludge, equalizing temperature inside the tank, enhancing digestion efficiency through separating gases attached to particles, and preventing reduction in effective capacity due to generation of scum. Moreover, in two-stage digestion, surface stirring is frequently adopted in the secondary tank too in order to break up scum.

As is shown in **Figure 6-2-15**, approaches to mechanical stirring include the draft tube stirrer or impeller stirrer that have power full stirring force or the method that utilizes a sludge circulating pump outside of the tank in order to conduct stirring.

In the case of draft tube stirrer or impeller stirrer, because the drive axis penetrates the tank from the surrounding atmosphere, care is required regarding gas leaks. Stirring by sludge circulating pump is usually adopted as a supplementary option in combination with gas stirring.

Figure 6-2-15 Mechanical Stirring Methods



In the gas stirring system, digestion gas generated in the tank is directly sucked from the gas dome through the conveyance pipe, pressurized by a gas compressor, and then passed through a pipe into to mix with sludge by gas-lift effect in the tank.

Gas stirring has the following merits and is utilized a lot.

- Even if fluctuations occur in the tank liquid level, the stirring force is kept constant.
- Breakdowns are rare because there are no moving parts inside the tank.

However, it is difficult to gauge the appropriate gas flow for stirring.

In the case of high-concentration digestion systems, in which mechanically thickened sludge, etc. is put into sludge digestion tanks, because the sludge becomes very viscous, gas stirring does not impart a sufficient stirring effect and it is thus necessary to adopt mechanical stirring. Moreover, sludge-digestion gas cannot be utilized as energy in the case of gas stirring.

(e) Heating system

Anaerobic digestion systems are broadly divided into heated systems and unheated systems. In heated systems, a boiler or hot water heater that use digestion gas as fuel as generally installed. In cases where there are digestion gas power generation facilities, etc., waste heat can be converted to use in heating the tank.

The heating method can either be direct heating or indirect heating.

(e)-1 Direct heating method (steam suction type)

In direct heating, steam is directly blown into sludge inside the tank and, so long as the stirring is good, there is little decline in microbial action due to the steam; moreover, since the equipment is simple and operations are easy, this approach is widely adopted.

This method requires enough boiler makeup water to correspond to the blown steam flow.

(e)-2 Indirect heating method (using heat exchanger)

In indirect heating, a heat exchanger is fitted outside the tank, and sludge circulating between the tank and heat exchanger is heated by hot water that circulates between the heat source and heat exchanger.

Compared to the steam blowing method, the indirect heating method uses a lot of auxiliary equipment such as circulating pump and heat exchanger, etc., however, since it involves circulating he digested sludge, it assists the stirring of sludge.

The heat transfer area of the heat exchanger is sought by the following equation:

$$A = \frac{Q_{max}}{K \times T} \times 1.2$$

Where,

A: Heat exchanger heat transfer area (m^2)

Q_{max}: Maximum calorific value of sludge digestion tank heating (l kcal/h)

K: Overall heat transfer coefficient {W/(m^3- K)}{Kcal/(h- m^2- ℃)}

T: Log-mean temperature difference

$$\left[\frac{T_1 - T_2}{2.3 \log (T_1 / T_2)} \right] \quad (K)\{℃\}$$

T1: Difference between hot water temperature T_w at heat exchanger inlet and sludge temperature T_s' at outlet (K){℃}

T2: Difference between hot water temperature T_w' at heat exchanger inlet and sludge temperature T_s at outlet (K) {℃}

The value 1.2 in the equation is the value that takes fluctuations in the overall heat transfer coefficient into account.

Assuming the sludge circulation flow to be Q_s(m^3/h) and the hot water circulation flow to be Qw(m^3/h), T_s' and T_w' are obtained by the following equation:

$$T_s' = T_s + \frac{Q_{max}}{Q_s \times 1{,}000}$$

$$T_w' = T_w + \frac{Q_{max}}{Q_s \times 1{,}000}$$

(T_w is between 60~90℃ and T_w - T_w' is roughly 10~15℃).

c) Gas holder

If digestion proceeds smoothly, between 500~600 Nℓ of sludge-digestion gas is generated for every kilogram of organic matter.

The constituents of sludge-digestion gas differ according to the digested state of sludge, however, they are generally as indicated in **Table 6-2-4**, and there is danger of explosion occurring if air equivalent to 3~15 times the gas flow is mixed in. Incidentally, the lower heating value of gas is between 21,000~23,000 kJ/N m^3 (5,000～5,500kcaL/N m^3).

The capacity for gas capture and storage equipment is assumed to be 600 Nℓ per kilogram of sludge organic matter taking into account fluctuations in the generated sludge-digestion gas flow.

Table 6-2-4 sludge-Digestion Gas Constituents (v/v%)

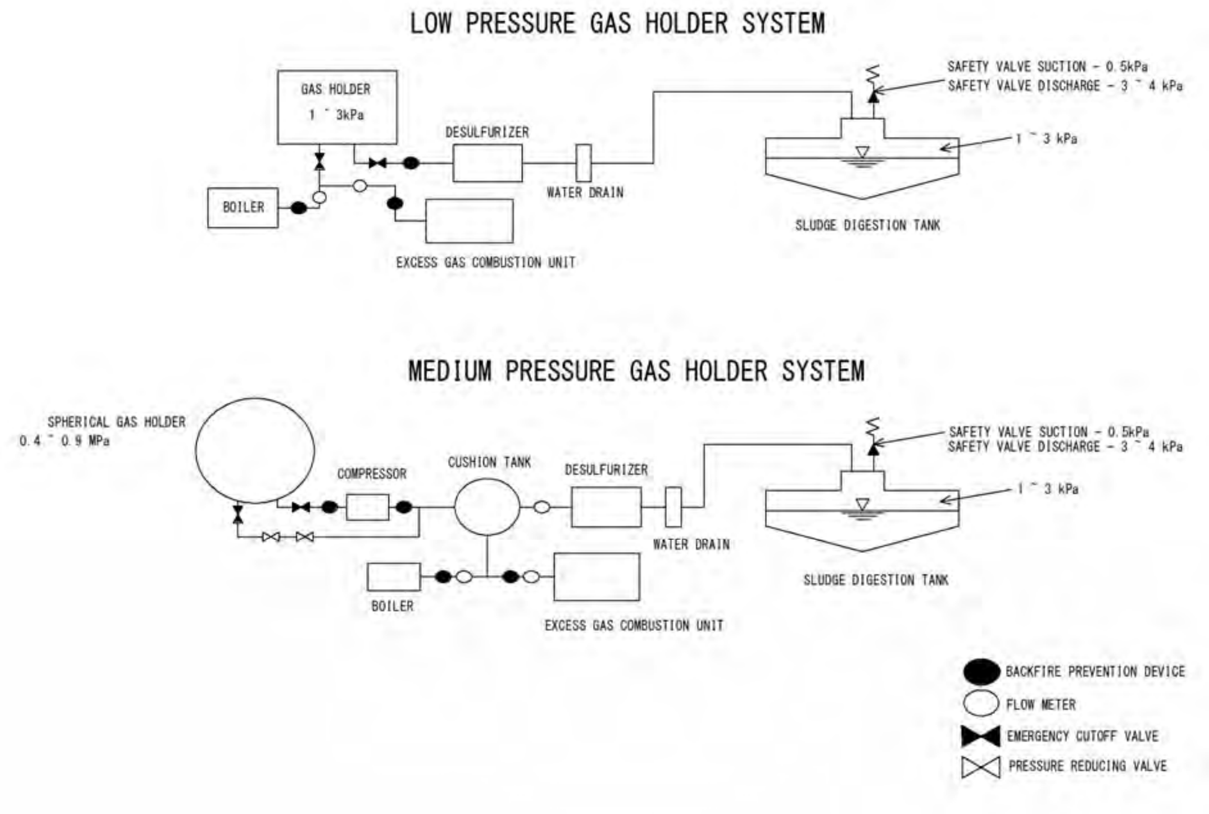
Methane	Carbon Dioxide	Hydrogen	Nitrogen	Hydrogen sulfide
60～65	33～35	0～2	0～3	0.02～0.08

The gas capture and storage equipment is determined upon taking the following points into consideration.

(a) Gas repair equipment

The generated sludge-digestion gas flow and gas pressure inside the sludge digestion tank fluctuates greatly depending on the state of digestion, raw sludge insertion, removal of digested sludge and extraction of supernatant liquor (in the case of two-stage digestion). When a negative pressure state arises in the tank and air flows in, there is a risk of gas explosion occurring. Accordingly, it should be possible to maintain gas pressure inside the sludge digestion tank at a constant level of 1~3 kPa (100~300 mm Aq) or more. **Figure 6-2-16** shows the flow of the sludge-digestion gas capture and storage equipment.

Figure 6-2-16 sludge-Digestion Gas Capture and Storage Equipment Flow



The diameter of pipes between sludge-digestion gas holders is assumed to be between 100~300 mm as standard in consideration of condensation, misting, fluctuations in gas flow and pressure settings of safety valves, etc. Moreover, in cases where the liquid level falls by an abnormal degree during removal of digested sludge, it is necessary to set the diameter of pipes between tanks and gas holders in consideration of pressure loss to ensure that gas pressure inside tanks doesn't become negative and air is not frequently sucked in from safety valves. The diameter of gas pipes on the outlet side of the gas holders should be sought assuming a gas flow rate of 3~5 m/second to be on the safe side. Since there is a risk that saturated steam in the generated sludge-digestion gas will condense inside the gas capture pipe and hinder the flow of sludge-digestion gas, a gradient of around 1/200 should be imparted in the direction of pipe flow while water drains should be installed in low areas and before rises, etc.

(b) Equipment safety devices on the gas domes and gas holders.

In order to gather sludge-digestion gas from the sludge digestion tank, a gas dome is formed in the center of the tank and gas is captured and measured through a gas capture pipe leading from here. Since gas pressure inside the dome is constantly changing, in order to prevent abnormally high pressure or negative pressure from occurring, a gas safety valve or hydraulic backpressure valve should be attached.

Moreover, manual valves shall be attached in order to allow the safety valves to be inspected. In cases where the gas holder is spherical (medium pressure) and cushion tank capacity is small, since there is a possibility that removal of digested sludge could create a negative pressure environment inside the sludge digestion tank, a connecting pipe fitted with a tank negative pressure prevention valve should be installed between the tank and gas holder. The gas holder should be fitted with a safety valve and emergency shutoff valve for closing the holder in the event of earthquake, etc. At least two such valves should be fitted on the gas holder and desulfurizer.

(c) Gas tank capacity

The generated gas flow fluctuates according to the amount of sludge insertion and removal, and the gas holder is installed in order to maintain the balance between these events.

In cases where there are many sludge digestion tanks, the fluctuation in the total generated sludge-digestion gas flow will be small. Accordingly, the storage capacity of gas holders in the project shall be a minimum of 12 hours of the daily mean generated sludge-digestion gas flow.

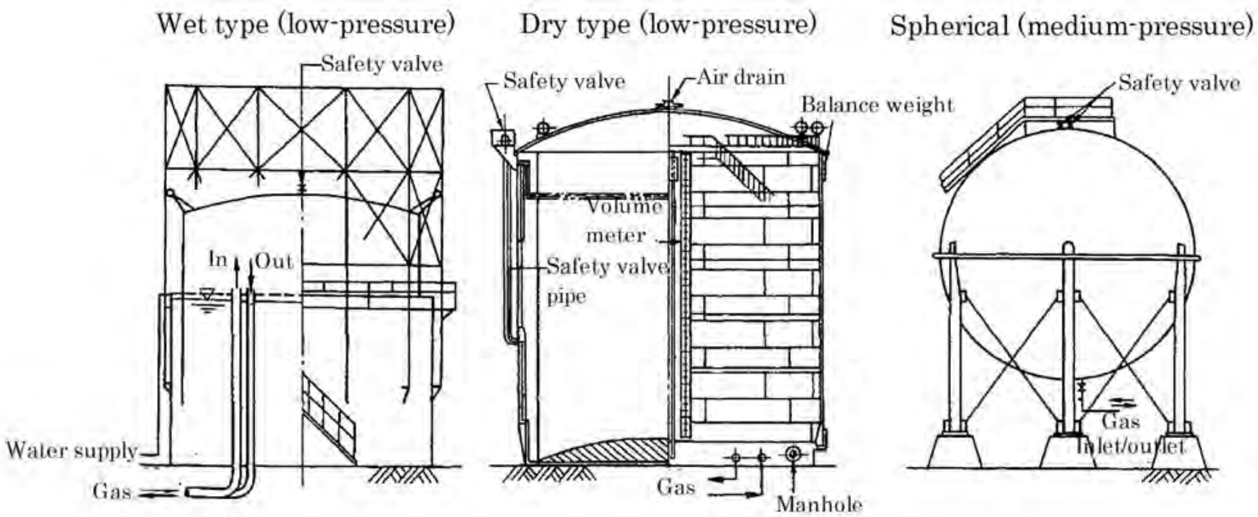
(d) Gas holder structure

Gas holders are available as low pressure and medium pressure types; moreover, low-pressure gas tanks are divided into wet types, in which digestion gas is sealed by water trap, and dry types, in which the gas is sealed by rubber bellows, etc.

Internal pressure ranges between 1~3kPa(100~300mmAq) in low-pressure gas tanks and between 0.4~0.9MPa (4~9kgf/cm2) in medium-pressure (spherical) gas tanks.
Usually low-pressure gas tanks are used, however, medium-pressure tanks are used in large-scale facilities.

The number of gas tanks should be two or more. **Figure 6-2-17** shows the types of gas holders.

Figure 6-2-17 Types of Gas Holders



(e) Install excess gas combustion equipment.

Since the generated amount of sludge-digestion gas is subject to fluctuation, even if the gas is utilized for energy purposes, there will still be some gas that goes unused. Such unused gas should always be combusted in the interests of safety and prevention of global warming. For this purpose, excess gas combustion equipment shall be installed.

The combustion equipment should be installed in a safe location and should be fitted with an automatic shutoff valve and backfire prevention device, etc. Excess gas combustion equipment is divided into in-furnace combustion and out-of-furnace combustion types, however, since the latter type sometimes has in-duct combustion not visible from the outside, it is hard to make a distinction. In terms of mechanism, equipment is distinguished according to whether or not gas pressure to the burner and air pressure to the furnace are pressurized. In cases where sludge-digestion gas needs to be directly drawn from the sludge digestion tank and combusted even during repair of the gas holder, it is desirable to adopt a model that doesn’t entail pressurizing the sludge-digestion gas, however, because the equipment becomes large in such cases, gas pressurizing types are often adopted in large-scale facilities.

Capacity of the excess gas combustion equipment shall be set as the generated sludge-digestion gas flow in consideration of fluctuations in the generated gas flow and usage of gas, etc.

d) Desulfurizer

The hydrogen sulfide of sludge-digestion gas is generally between 200~800 ppm, however, in mixing with night soil, this sometimes reaches up to 1,000~2,000 ppm. Hydrogen sulfide is a colorless gas with a very strong putrid odor; it has specific gravity of 1.2 (compared to air) and is extremely toxic. Particularly in the moist state, corrosion of metals occurs quickly when there is 600 ppm of hydrogen sulfide.

Furthermore, since combustion of hydrogen sulfide leads to the generation of highly corrosive sulfurous acid gas, desulfurization treatment is usually conducted on sludge-digestion gas.

The sulfur content of sludge-digestion gas should be desulfurized to no more than 50 ppm in consideration of the corrosive nature of hydrogen sulfide and generation of sulfur oxides. Generally, the sulfur oxide content of sludge-digestion gas is reduced to 10 ppm or less through conducting alkaline washing or passing though desulfurizing agent.

Moreover, since hydrogen sulfide is more corrosive in the wet state than in the dry state, it is necessary to remove droplets from digestion gas in a sediment trap (water drainage unit) and immediately remove condensation from inside gas pipes, etc.

Two or more desulfurizers should be installed in consideration of desulfurizing agent replacement and tower maintenance work, etc.

(a) Dry desulfurizer

Brown iron oxide desulfurizers have a mixture of brown iron oxide and sawdust packed into the tower. This comes into contact with the sludge-digestion gas so the saturated desulfurizing agent is sprinkled and exposed to the air for later recycling.

In preformed desulfurizing agent types, iron powder and clay pellets, etc. are packed into the tower and brought into contact with the sludge-digestion gas. The used desulfurizing agent is then appropriately disposed of as an industrial waste product.

The preformed desulfurizing agent system is frequently adopted because it offers easier handling. The reaction equations are as follows:

$$Fe_2O_3\text{-}3H_2O+3H_2S \rightarrow Fe_2S_3+6H_2O$$

$$Fe_2O_3\text{-}3H_2O+3H_2S \rightarrow FeS+S+6H_2O$$

(b) Wet desulfurizer

The washing system uses secondary treated effluent, etc. to clean digestion gas. Although this requires relatively low construction cost, the system generates a lot of wastewater and the hydrogen sulfide removal rate is relatively low.

In the alkaline washing system, a 2~3% sodium carbonate or sodium hydrate solution is brought into countercurrent contact with digestion gas. The chemical solution is circulated but it is also partially renewed.

It is necessary to manage the concentration of chemicals, however, the hydrogen sulfide removal rate is high.

The chemical solution regeneration desulfurizer combines an absorption tower with a regeneration tower. Following alkaline washing, the chemical solution is regenerated in the regeneration tower where a catalyst is used to isolate the sulfur content. The chemical solution regeneration type incurs a high construction cost, however, in cases where the hydrogen sulfide content is high and a lot of sludge-digestion gas is generated, maintenance costs are cheaper.

The reaction equations are as follows:

Case of sodium carbonate

$$Na_2CO_3+H_2S \rightarrow NaHS+NaHCO3$$

Case of sodium hydrate

$$NaOH+H_2S \rightarrow NaHS+H_2O$$

The dry type desulfurizer (preformed desulfurization agent), which allows easy handling and has a proven track record, shall be adopted.

(3) Sludge dewatering

The sewage sludge dewatering process reduces the volume of sludge through removing water content and, because this has a major impact on the cost and efficiency of final disposal, incineration or recycling, etc., it is one of the most important processes in sludge treatment.

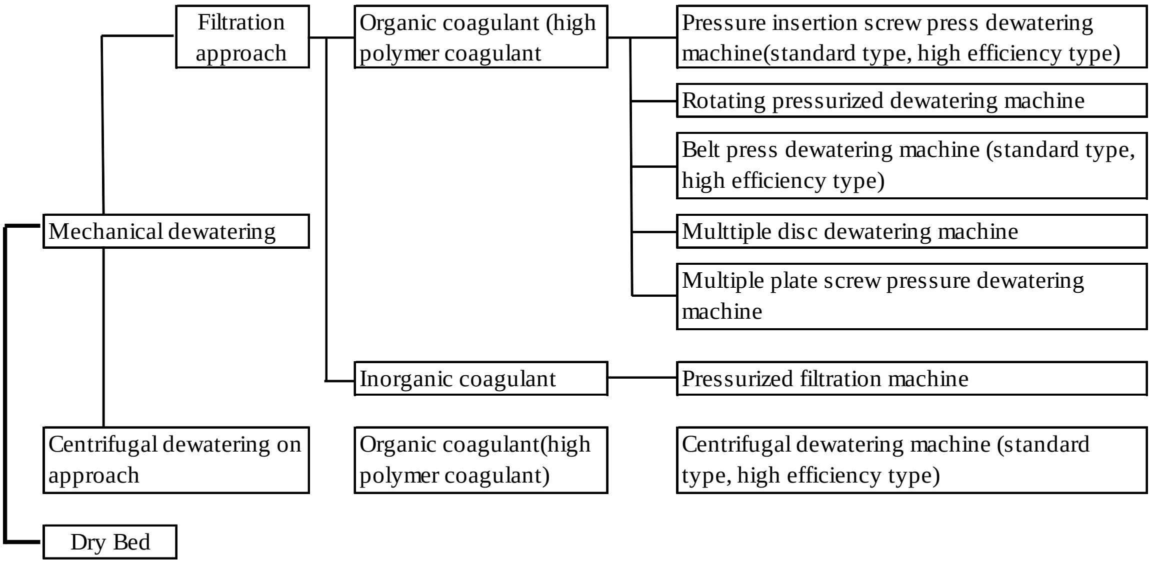
Moreover, since the derived amount of dewatered cake and maintenance costs comprising chemicals expenses and power costs, etc. are influenced by the type of sludge dewatering machine and method of sludge quality adjustment, an important issue from the viewpoint of economic operation of the sewage utility is to select the dewatering method that is appropriate to the state of treated sludge.

Generally speaking, the water content of thickened or digested sludge is somewhere between 96~98%. When sludge in this state is dewatered to a water content of around 80%, liquid sludge turns to sludge cake consisting of between 1/5~1/10 the volume and making handling much easier.

As is indicated in **Figure 6-2-18**, sludge dewatering methods are divided into the filtration approach and the centrifugal approach. In the filtration approach, depending on the filtration pressure and filtration method, equipment comprises the pressure insertion screw press dewatering machine, the rotating pressurized dewatering machine, the belt press dewatering machine and the pressurized filtration machine, etc.

In recent times, the pressure insertion screw press dewatering machine and the rotating pressurized dewatering machine are being adopted more and more.

Figure 6-2-18 Types of Mechanical Dewatering Machines



Sewage sludge in recent years is becoming lower in concentration and higher in organic content, making it increasingly difficult to dewater. Meanwhile, thanks to advances in high polymer technology, dewatering methods that utilize high polymer coagulants are increasingly capable of dealing with such unsuitable sludge. Accordingly, a large-scale treatment plant like this project, would be considered to introduce the following types of dewatering equipment: pressure insertion screw press dewatering machine , rotating pressurized dewatering machine, belt press dewatering machine, centrifugal dewatering machine (high-efficiency type),and dry bed.

a) Pressure Insertion Screw Press Dewatering Machine

(a) Dewatering mechanism

As is shown in **Figure 6-2-19**, the pressure insertion screw press dewatering machine is composed of a cylindrical screen and screw blades, and the gap between these two parts decreases moving towards the dewatered sludge outlet. Coagulated sludge is fed between the screw and screen and dewatered continuously through rotating the screw. Gravity filtration is conducted in the first part of the dewatering machine while dewatering is performed from the middle stage by means of pressure applied by action of the screw blades and shearing force from rotation. The separated filtrate passes through the cylindrical screen and is discharged from the machine.

During filtration, while the screw is continuously rotated, coagulated sludge that has been adjusted by means of organic coagulant is fed to the filtration chamber and the water contained in gaps between floc is filtered in the external cylindrical screen. Furthermore, sludge that has been transferred by rotation of the screw is pressed under the compaction force of the presser and screw. The dewatered sludge is discharged from the gap between the external screen and presser. In recent times a more efficient pressure insertion screw press dewatering machine, in which the external cylindrical screw is divided and a rotating function is given to the coagulated sludge supply side, has also been developed.

Figure 6-2-20 and **figure 6-2-21** shows an example flow of the pressure insertion screw press dewatering machine.

Figure 6-2-19 Outline Drawing of the Pressure Insertion Screw Press Dewatering Machine

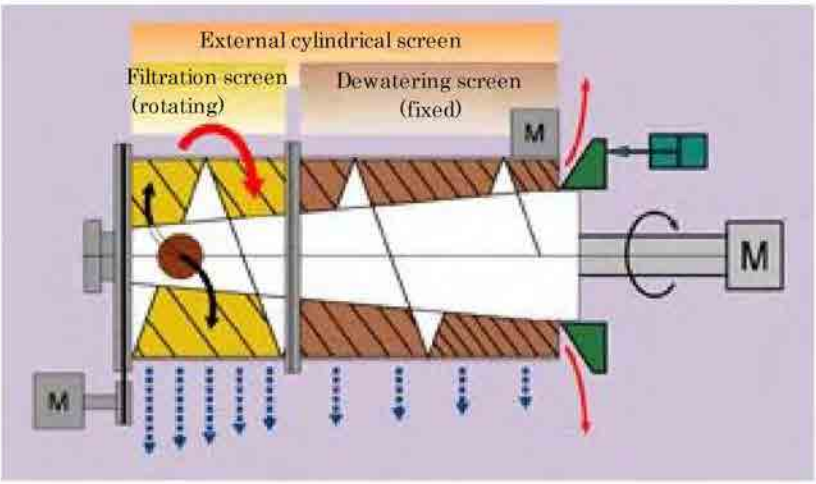


Figure 6-2-20 Example Flow of Pressure Insertion Screw Press Dewatering Equipment

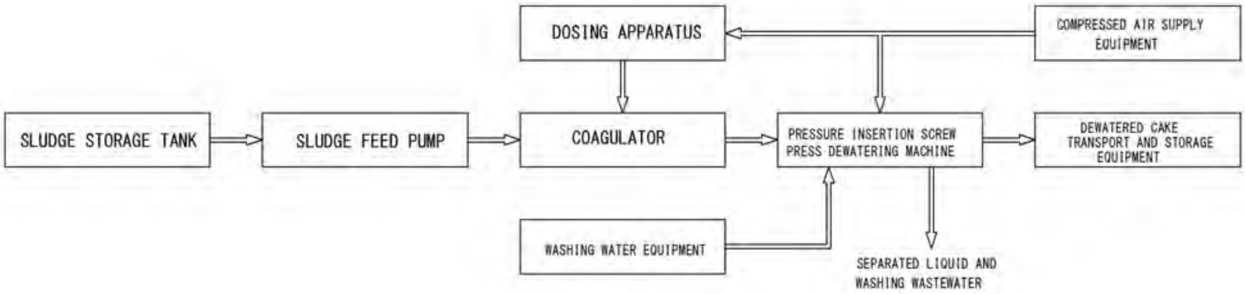
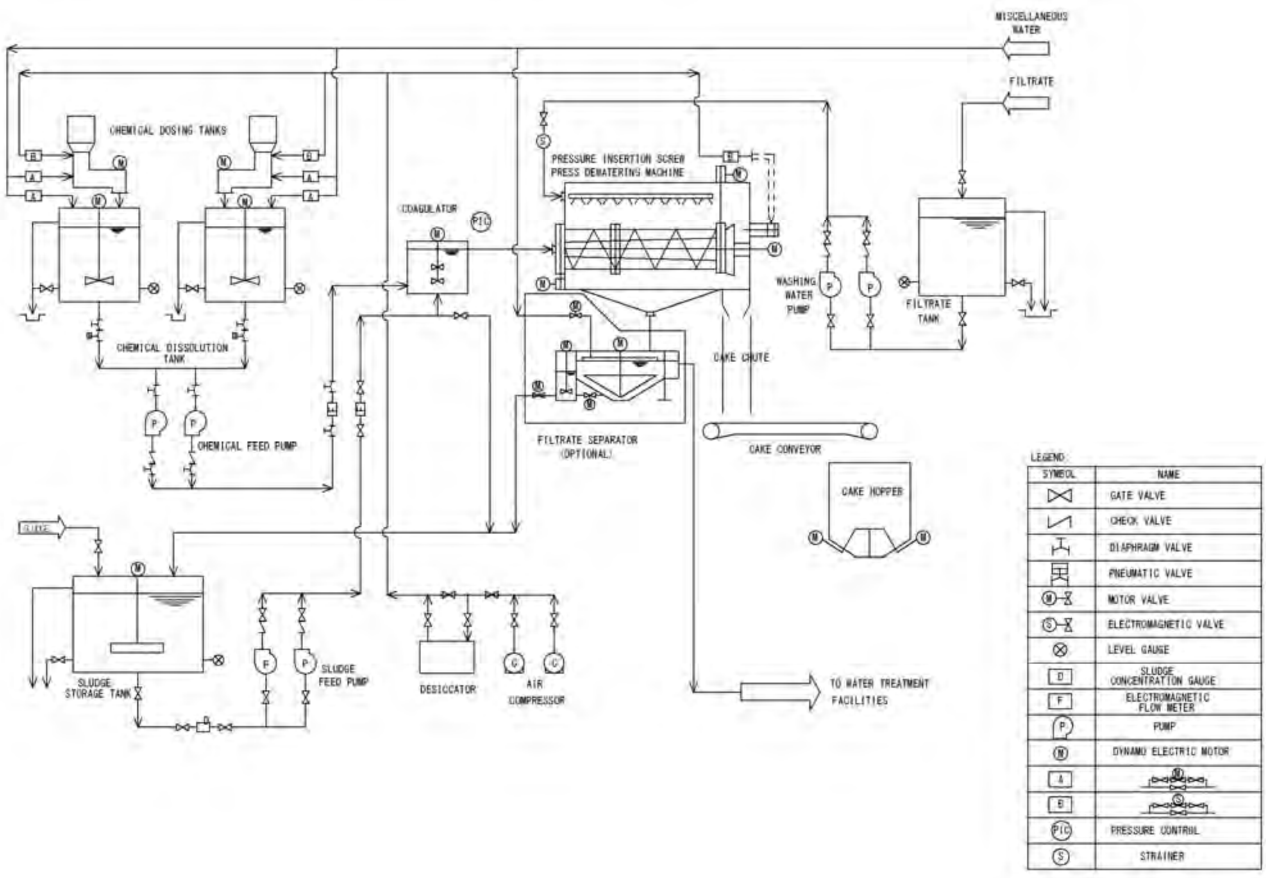


Figure 6-2-21 Example Flow Sheet of Pressure Insertion Screw Press Dewatering Equipment



(Note) The * mark indicates instruments that can be omitted depending on design conditions (small scale, etc.).

(b) Capacity of the pressure insertion screw press dewatering machine

Capacity of the pressure insertion screw press dewatering machine is sought upon considering the following items.

$Qo = So \times 1 /(t \times N)$

Where,

Qo: Required solids treatment capacity per dewatering machine (kg/ DS/h/ machine)

So: Treated sludge quantity (kg- DS/d)

t: Dewatering machine daily operating time (h/d)

N: Number of operating dewatering machines

Screen diameter is sought through the following equations:

$A = (Q_o/Q_{300})^{1/2.2} \times 300$

Where,

A: Screen diameter (mm)

Qo: Required solids treatment capacity per dewatering machine (kg/ DS/h/ machine)

Q_{300}: High efficiency type, reference treatment amount in a φ300mm screen (kg- DS/h)

See **Table 6-2-5** (filtration speed)

However, the calculated value sought in A is rounded up to units of 100 mm to a maximum of 1,200 mm.

The required solids treatment capacity per dewatering machine is sought according to the amount of treated sludge, the installed number of dewatering machines and the machine operating conditions.

In the case where the dewatering machines are operated for 24 hours, since screen washing is conducted once every 6~8 hours, this washing process time is considered when calculating the daily operating time of dewatering machines.

As a rule at least two dewatering machines including a spare unit are installed in readiness for maintenance, inspections and breakdowns. Also, the selection of screen diameter is carried out according to the following procedure.

- Determine the targeted dewatered cake water content.
- Based on the standard dewatering performance indicated in **Table 6-2-5**, obtain the dewatered cake dewatering performance corresponding to the type and properties of the treated sludge.
- Select a screen diameter that offers greater dewatering performance than the hourly solids treatment capacity calculated above.

Table 6-2-5 Standard Dewatering Performance (Screw Diameter ϕ 300mm)

Sludge type		Gravity thickening Mixed raw sludge	Mechanical thickening Mixed raw sludge	Gravity thickening Anaerobic digested sludge
Sludge properties	TS	1.5~2.5%	Approx. 3.5%	1.5~2.5%
	VTS	75~83%	77~83%	57~64%
Chemical dosing rate		1.0~1.3% vis a vis TS	Approx. 1.0% vis a vis TS	1.2~1.4% vis a vis TS
Filtration speed		41.4 kg-ds/h-φ300	Approx. 41.4 kg-ds/h-φ300	25.7 kg-ds/h-φ100
Dewatered sludge water content		76~79%	78~79%	79~81%
SS collection rate		95% or higher	95% or higher	95% or higher

According to maker materials

(c) Features

(c)-1 Merits

- Energy saving
- There is little noise
- There is little washing water Not much washing water is needed.
- There is hardly any noise or vibration.

(c)-2 Demerits

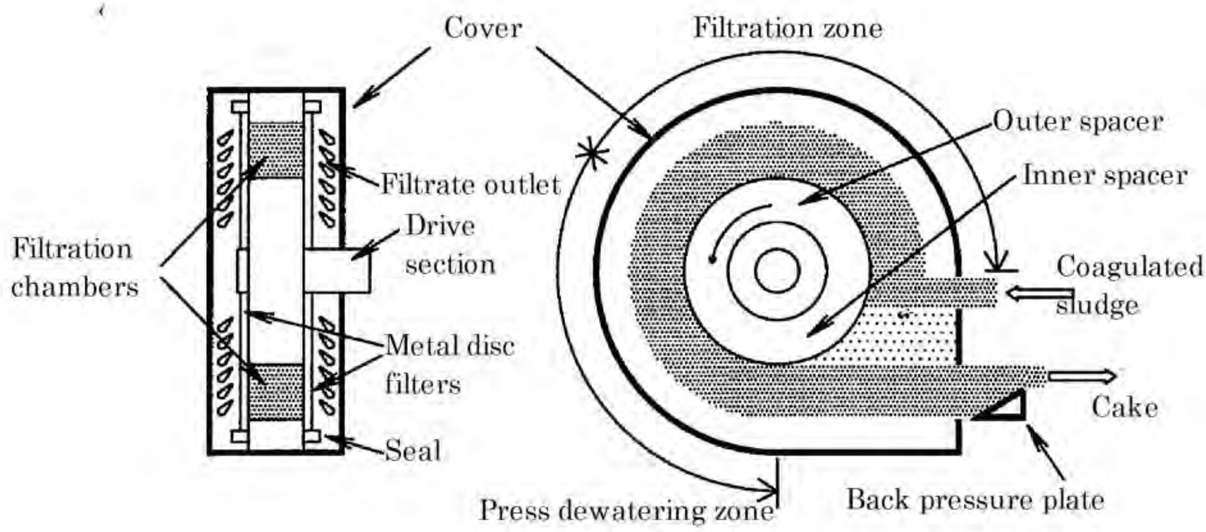
- Track record is limited.
- SS recovery rate is low.
- Outer cylinder washing is necessary. Problems exist in the treatment of anaerobic digested sludge.

b) Rotating Pressurized Dewatering Machine (a)Dewatering mechanism

The rotating pressurized dewatering machine comprises two metal disc filters and filtration chambers fitted between an inner and an outer spacer. The filtration chamber is formed on the inside of the channels (dewatering structure), and the channels are operated either singly or in combination.

Figure 6-2-22 shows Dewatering Principle of the Rotating Pressurized Dewatering Machine.

Figure 6-2-22 Dewatering Principle of the Rotating Pressurized Dewatering Machine



The dewatering principle is described as follows. When coagulated sediment that has been adjusted with high polymer coagulant is fed into the filtration chamber while the metal disc filters are slowly rotated at 0.2~2.0 min-1, initial filtration is conducted so that the water trapped between flocs is removed. Next, the sludge is moved to the filtration zone by rotation of the metal disc filters and it forms a cake on the filter surface, thereby enhancing the solids capture effect. Next, in the press dewatering zone, pressure is applied on the sludge by the back pressure plate, shearing force generated by disparity in rotating speed accelerates the dewatering effect, and the dewatered sludge is extruded between the inner and outer spacers. Rotating pressurized dewatering machines are available as standard types with filter diameter of 600 mm or 1200 mm or high-speed filtration types with filter diameter of 900 mm. **Figure 6-2-23** and **Figure 6-2-24** show example flows of the rotating pressurized dewatering machine.

Figure 6-2-23 Example Flow of the Rotating Pressurized Dewatering Machine

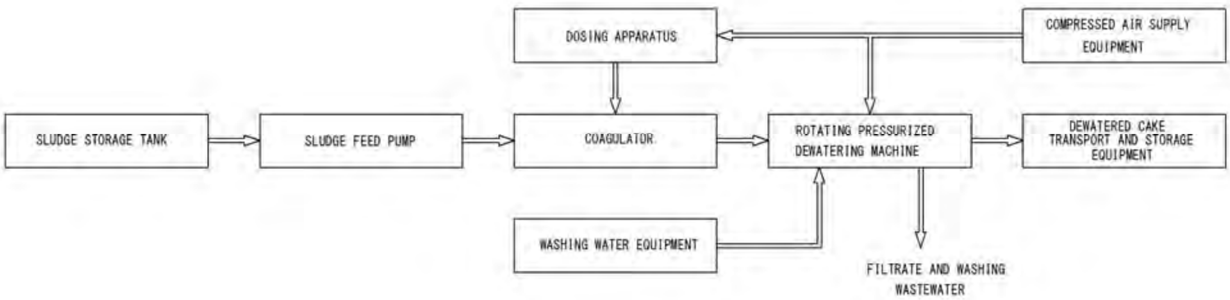
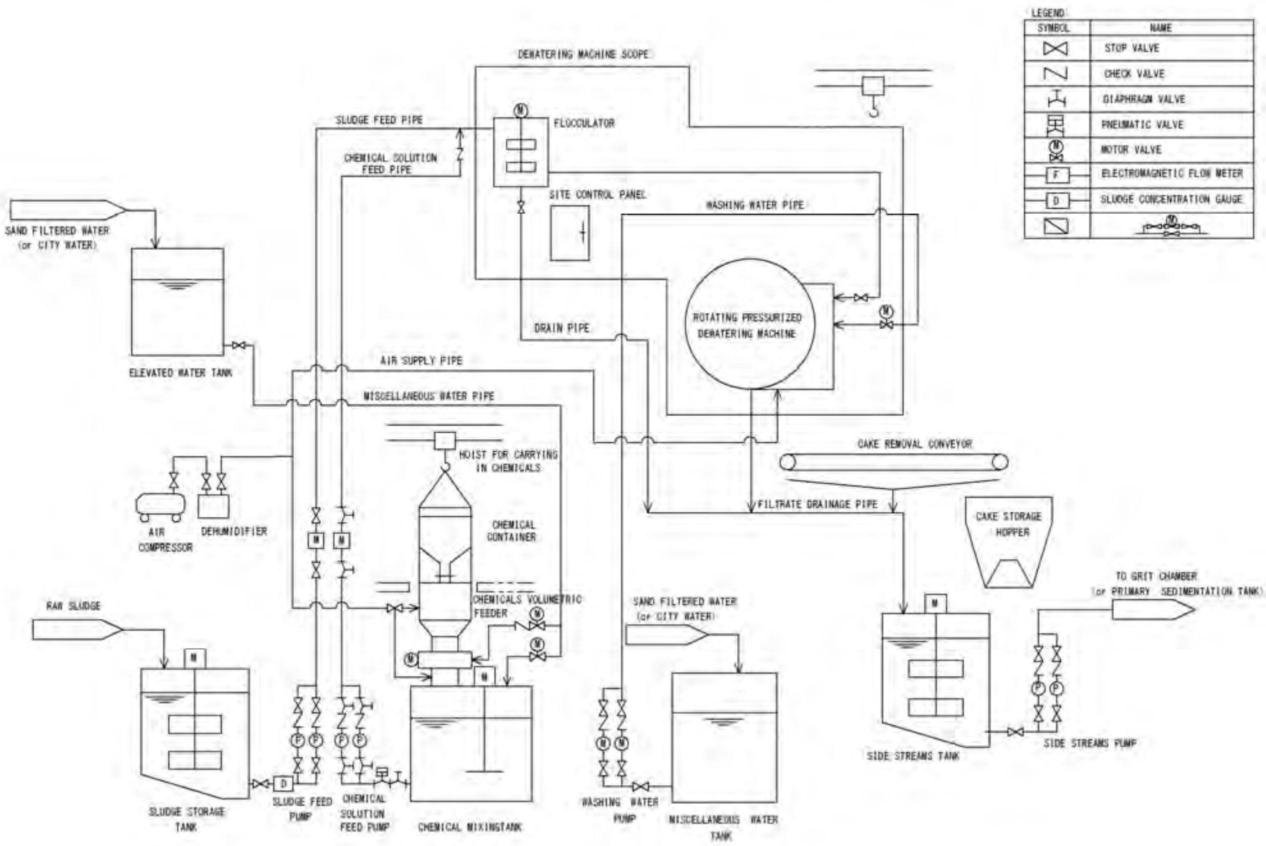


Figure 6-2-24 Example Flow Sheet of the Rotating Pressurized Dewatering Machine



(b) Capacity of the rotating pressurized dewatering machine

Capacity (filtration area) of the rotating pressurized dewatering machine is sought upon considering the following items.

$$A = \frac{Q}{V \cdot t}$$

Where,
A: Necessary filtration area (m^2)
Q: Sludge treatment quantity (kg/d)
V: Filtration speed (kg- DS/m^2- h)

t: Daily operating time (h/d)

$$N = \frac{A}{a}$$

Where,
N: Number of units
a: Filtration area per unit (m^2)

As the method for determining dewatering conditions and performance such as the filtration chamber width, rotating speed, optimum chemical dosing rate and dewatered cake water content, etc. in the rotating pressurized dewatering machine, it is desirable to conduct preliminary experiments in a test unit and set the treatment capacity. Treatment capacity of the rotating pressurized dewatering machine can be increased by increasing the number of channels (increasing the filtration area).

As a rule at least two dewatering machines including a spare unit are installed in readiness for maintenance, inspections and breakdowns.

The solids treatment capacity per dewatering machine is calculated from the standard dewatering performance shown in **Table 6-2-6** and the filtration area corresponding to the surface filter diameter shown in **Table 6-2-7**.

Table 6-2-6 Standard Dewatering Performance

Sludge type		Gravity thickening Mixed raw sludge	Mechanical thickening Mixed raw sludge	
Sludge properties	TS	1.5~2.5%	Approx. 3.5%	
	VTS	75~83%	75~83%	
Chemical dosing rate		L0~1.3%, single liquid method	1.0%, single liquid method	
Filtration speed		50~150 kg-ds/m^2-h	100~180 kg-ds/m^2-h	
Dewatered sludge water content		76~81%	76~81%	
SS collection rate		95% or higher	95% or higher	

Table 6-2-7 Filter Diameter and Filtration Area

Filter Diameter (mm)	600				1200					
Channels	1	2	3	4	1	2	3	4	5	6
Filtration area (m2)	0.3	0.6	0.9	1.2	1.5	3	4.5	6	7.5	9

(c) Features

(c)-1 Merits

- Installation space is small.
- Not much washing water is needed.
- Not much power is needed.
- There is hardly any noise or vibration.

(c)-2 Demerits

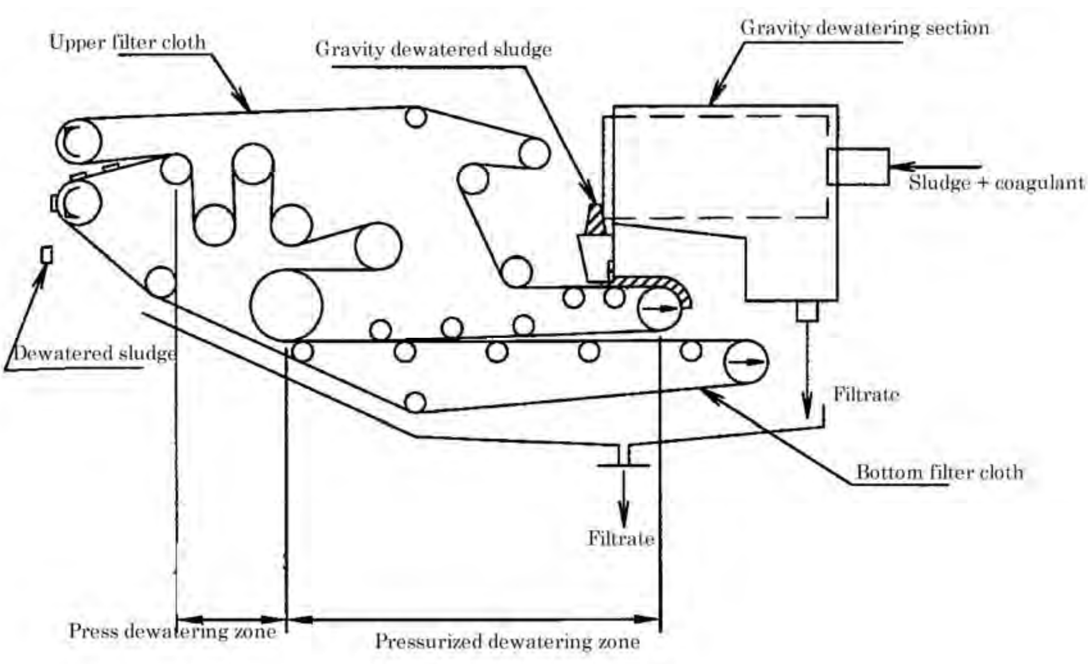
- Practical application experience is limited.
- The dewatering is prone to the influence of sludge adjustment.
- Metal disc filter replacements are necessary.
- Dewatering performance declines dramatically with respect to sludge not conducive to dewatering (anaerobic digested sludge, etc.).

c) Belt Press Dewatering Machine

(a) Dewatering mechanism

The belt press dewatering machine consists of numerous rollers connected by filter cloth as shown in **Figure 6-2-25**.

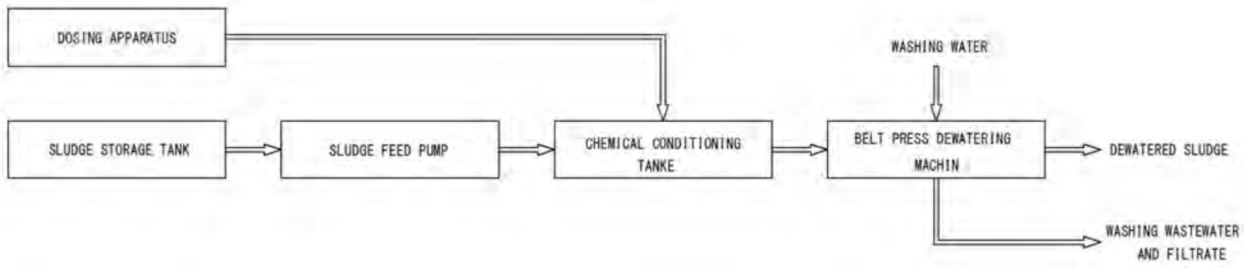
Figure 6-2-25 Example of a Belt Pres Dewatering Machine



During filtration, the filter cloth is kept constantly on the move, while coagulated sludge dosed with organic coagulant is supplied onto the upper filter cloth and water in the gaps between flocs is squeezed out by gravity. Furthermore, the water in gaps and attached to the floc particles is removed from the moving sludge through squeezing of the filter cloth. Finally, the sludge undulates through the rollers, which apply shearing force and pressing force. The dewatered sludge is peeled off the filter cloth by a scraper. The cloth undergoes continuous washing by pressurized water in order to prevent blockage and is returned to the gravity filtration section. These filtration processes are implemented consecutively.

Figure 6-2-26 show examples of the flow in belt press dewatering equipment.

Figure 6-2-26 Example Flow of the Belt Press Dewatering Machine



(b) Capacity of the belt press dewatering machine

The capacity and number of units of the belt press dewatering machine are sought upon considering the following items.

$$B = \frac{Q}{V \cdot t}$$

Where,
B: Necessary effective filter cloth width (m)
Q: Sludge treatment quantity (kg/d)
V: Filtration speed (kg/m- h)
t: Daily operating time (h/d)

$$N = \frac{B}{b}$$

Where,
N: Number of units
b: Effective filter cloth width per unit (m/unit)

The necessary effective width of filter cloth is sought via the above equation upon determining the filtration speed based on the results of testing, operating record of the belt press dewatering machine and **Table 6-2-8**. It is desirable to adopt a comfortable filtration speed upon examining the impact of changes in the state of sludge in Buchner funnel testing. Filtration speed in the above equation refers to the amount of solid dewatered sludge (kg) obtained each hour by dewatering supplied sludge with filter cloth measuring 1 m across.

Filtration speed in the belt press is limited by the amount of gravity filtration dewatered sludge that can be fitted on the filter cloth.

In other words, the maximum filtration speed is the amount of treatment that can be achieved just prior to the occurrence of side leaks during the belt press pressing process.

Pressing of dewatered sludge is carried out by roll pressure caused by tension of the filter cloth, and this pressure is determined by the following equation according to the cloth tension and roll diameter.

$$P = \frac{T}{\gamma + L}$$

Where,
P: Surface pressure of filter cloth (kgf/cm^2){Pa}
T: Tension per 1 cm of filter cloth width (kgf/cm)
γ: Roll radius (cm)
L: Thickness of dewatered sludge (cm)

Based on existing equipment, the effective width of filter cloth in a belt press dewatering machine varies between 0.5~3.0 at intervals of 0.5 m, and this is selected upon considering the installation area, etc.

The dewatering machine operating time is set upon considering the preparation time until sludge and chemicals are fed to the machine and the time required for dewatered sludge removal and filter cloth washing, while also taking the scale of treatment facilities and operation management setup into account.

As a rule at least two dewatering machines including a spare unit are installed in readiness for maintenance, inspections, breakdowns and filter cloth replacement.

The water content of dewatered sludge is assumed to be 79~83% in standard type machines and 76~80% in high-efficiency machines.

The water content of dewatered sludge varies according to the type of sludge and sludge properties such as concentration and organic content, etc. and operating conditions such as the type and dosage of chemicals, the filter cloth tension and belt speed, etc.

It is desirable to set the water content of dewatered sludge as low as possible, however, it should be set appropriately while considering the properties of sludge, the methods of treating and disposing of dewatered sludge and economic viability. **Table 6-2-8** shows standard dewatering performance with respect to general sludge.

Table 6-2-8 Example of Belt Press Dewatering Machine Performance (standard type)

Sludge type		Gravity thickening Mixed raw sludge	Mechanical thickening Mixed raw sludge	Anaerobic digested sludge
Sludge properties	TS	1.5~2.5%	Approx. 3.5%	2.0~2.5%
	VTS	75~80%	75~80%	60~65%
Chemical dosing rate		1.0~1.3%	1.0~1.3%	1.1~1.3%
Filtration speed		90~120 kg/m-h	Approx. 130 kg/m-h	70~90 kg/m-h
Dewatered sludge water content		80~83%	79~82%	81~83%
SS collection rate		93% or higher	93% or higher	90% or higher

High-efficiency belt press dewatering machines are being adopted in response to sludge that is not conducive to dewatering and with the objective reducing dewatered sludge water content and thereby cutting sludge disposal costs.

In the high-efficiency type, because effective dewatering time in the machine is long and the maximum surface pressure for pressing sludge is high, dewatering performance is improved by roughly 3% compared with standard type machines. Accordingly, in terms of structure, there are more rollers and filter cloth contributing to the dewatering performance.

(c) Features

(c)-1 Merits

- Not much power is needed.
- There is hardly any noise or vibration.
- It has a good track record.

(c)-2 Demerits

- It requires a lot of washing water.
- Treatment capacity is small (maximum 20 m^3/h)
- Package installation is possible but odor is emitted.
- Filter cloth replacement is necessary.

d) Centrifugal Dewatering Machine (high-efficiency type)

(a) Dewatering mechanism

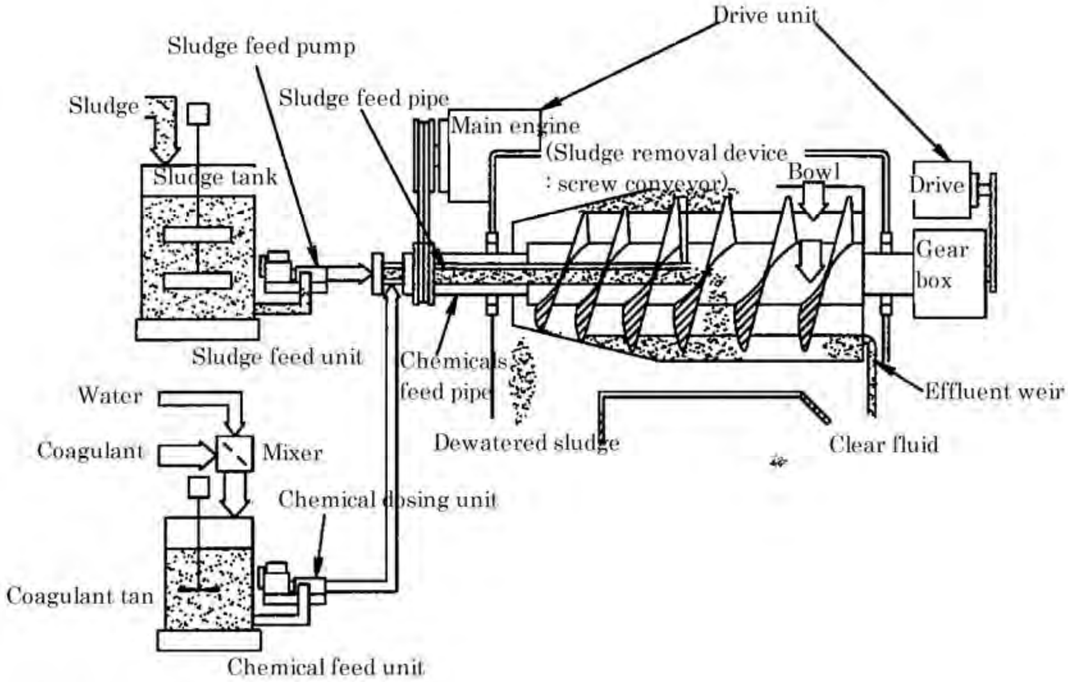
In the centrifugal dewatering machine, sludge dosed with organic coagulant is subjected to a centrifuge equivalent to 1,500~3,000 times the acceleration of gravity in order to conduct rapid solids-liquid separation. The horizontal centrifugal dewatering machine like that shown in **Figure 6-2-27** is frequently used.

The supplied sludge is mixed with chemicals to form sludge floc, and this is subjected to centrifugal force in a spinning drum that leads to solids-liquid separation.

The separated solids are discharged as dewatered sludge while being compacted along a screw conveyor, which is driven by a speed differentiating unit at a slower rate than the drum revolution speed. An overflow dam is often used for removing the separated liquid.

Separation of solids is enhanced the slower the discharge speed of separated liquid, the longer the time needed to pass through the separating drum and the greater the centrifugal effect.

Figure 6-2-27 Horizontal Centrifugal Dewatering Machine

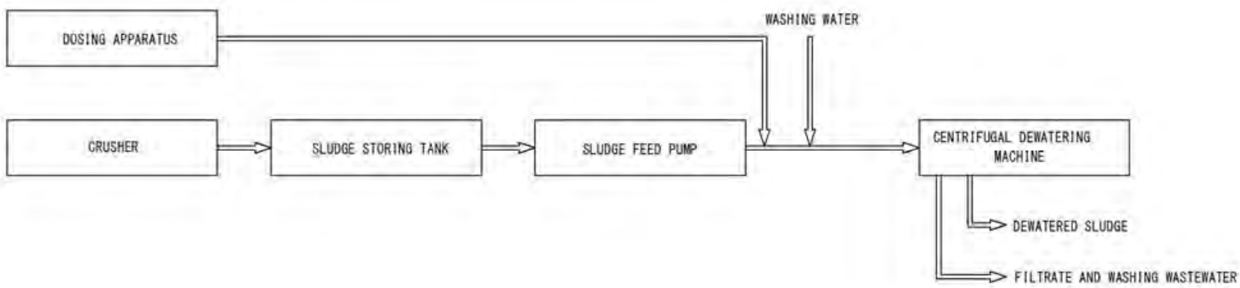


Since sand and foreign materials in the sludge can lead to abrasion and blockage of the dewatering machine, it is necessary to remove and destroy such objects in advance.

Chemicals can be dosed by mixing with sludge outside of the machine or by mixing inside the machine upon supplying through a separate pipe from the sludge. The latter approach is adopted more frequently in recent times.

Figure 6-2-28 shows an example flow of the centrifugal dewatering machine.

Figure 6-2-28 Example Flow of the Centrifugal Dewatering Machine



(b) Capacity of the centrifugal dewatering machine

The capacity and number of units of the centrifugal dewatering machine are sought upon considering the following items.

(b)-1 Capacity is expressed as the treated quantity of sludge (m^3/h).

Dewatering conditions and performance such as centrifugal effect, differential speed, optimum chemical dosing rate and dewatered sludge water content, etc. can be determined in operation testing using a test device, test-tube centrifugal separation testing or from the operating record of existing centrifugal dewatering machines, etc. Capacity of the centrifugal dewatering machine is not defined like in the case of filtration speed as seen in other dewatering machines.

In practical terms, it is expressed as the amount of sludge fed to a single machine. The potential feed quantity is determined up to the point where the solids recovery rate undergoes sudden change so as to satisfy the solids load obtained at the target water content.

Since the concentration of settled sludge inside the revolving container is linked to the retention time of the sludge (as in the case of thickening), enough retention time to reach the target concentration is needed. The load is controlled according to the following equation, and when load in excess of this is occurs, the separated (settled) sludge flows out to the separated liquid side thus diminishing the solids recovery rate.

$$FCo = CtS = Ct \frac{Vs}{Tt}$$

Where,
F: Sludge feed quantity (m^3/h)
Co: Fed sludge concentration (%)
Ct: target concentration (%)
S: Sludge removal speed (m^3/h)
Vs: Capacity of the thickening layer in the cylinder (m^3)
Tt: Time to reach Ct (h)

(b)-2 The number of units is determined according to the following equation:

$$N = \frac{Q}{Q\ t}$$

Where,
N: Number of units
Q: Sludge treatment quantity (m^3/d)
q: Capacity per unit (m^3/h)
t: Daily operating time (h/d)

Centrifugal dewatering machines must undergo autonomous inspection once per year. Moreover, it is necessary to inspect and repair parts that are subject to wear and tear (screws and dewatered sludge removal outlet) following long-term operation, and machines are often taken to the manufacturing plant for this purpose. In order to respond to such mechanical problems, at least two units including a spare shall be installed.

The dewatering machine operating time is set upon considering the preparation time until sludge and chemicals are fed to the machine and the time required for dewatered sludge removal and machine washing, while also taking the scale of treatment facilities and operation management setup into account.

(b)-3 The water content of dewatered sludge is assumed to be 80~84% in standard type machines and 77~81% in high-efficiency machines.

The water content of dewatered sludge varies according to the sludge properties, fed quantity of sludge, centrifuge effect, type and quantity of chemicals, etc., and it is desirable to set it according to test results and operating performance, etc. of the treatment plant.

It is desirable to set the water content of dewatered sludge as low as possible, however, it should be set appropriately while considering the properties of sludge, the methods of treating and disposing of dewatered sludge and economic viability. **Table 6-2-9** shows standard dewatering performance with respect to general sludge.

Table 6-2-9 Example of Centrifugal Dewatering Machine Performance (standard type)

Sludge type		Gravity thickening Mixed raw sludge	Mechanical thickening Mixed raw sludge	Anaerobic digested sludge
Sludge properties	TS	1.5~2.5%	Approx. 3.5%	2.0~2.5%
	VTS	75~80%	75~80%	60~65%
Chemical dosing rate		1.0~1.3%	1.0~1.3%	1.1~1.3%
Dewatered sludge water content		80~83%	80~83%	82~84%
SS collection rate		95% or higher	95% or higher	95% or higher

In cases when dewatering highly concentrated sludge (for example, machine thickened sludge) by centrifuge, there is a risk that the solids load in the dewatering machine will exceed the permissible load, leading to solid particles leaking onto the side of the separated liquid and dramatically reducing the SS collection rate. Accordingly, the inserted amount of sludge is generally kept below the standard level when operating the machine.

Furthermore, high-efficiency centrifugal dewatering machines are being developed in order to deal with non-conducive sludge and to achieve lower water content of dewatered sludge with lower costs. High-efficiency type machines entail longer retention time and have larger liquid depth and compaction pressure than standard types. As a result, the dewatered sludge water content can be reduced by a further 3% or so.

(b)-4 Make the differential speed variable.

The centrifugal dewatering machine rotating drums are composed of an outer drum (bowl) and inner drum (screw conveyor). The screw conveyor turns at high speed at a differential of around 2~10min^{-1} compared to the bowl. This differential rate is a major influencing factor on performance of the dewatering machine. In specific terms, when the differential rate becomes smaller, the dewatering time becomes longer and the water content of dewatered sludge falls. Moreover, since the SS collection rate tends to deteriorate, it is necessary to set appropriately according to the properties of sludge and operating conditions.

The differential rate can be controlled by the hydraulic method or the gear method. In the hydraulic method, a direct hydraulic motor drives the screw conveyor while imparting a rotating disparity with the bowl, whereas in the gear method, the rotating disparity is imparted by an inverter motor working through a gear unit comprising planet gears, etc.

(c) Features

(c)-1 Merits

- It has a proven track record.
- Automatic operation is easy.
- Large-scale treatment is possible.
- There are no blockages.
- Washing isn't necessary.
- The machine structure is closed.
- The SS recovery rate is high.

(c)-2 Demerits

- Motor capacity is large.
- Screw repairs are needed.
- There is a lot of noise.

e) Dry bed

Solar drying is economical because it utilizes natural energy and doesn't require dehydrating agents; moreover, there is no need for complicated maintenance as seen in mechanical dewatering; however, manual labor is required in order to scrape away the dried sludge.

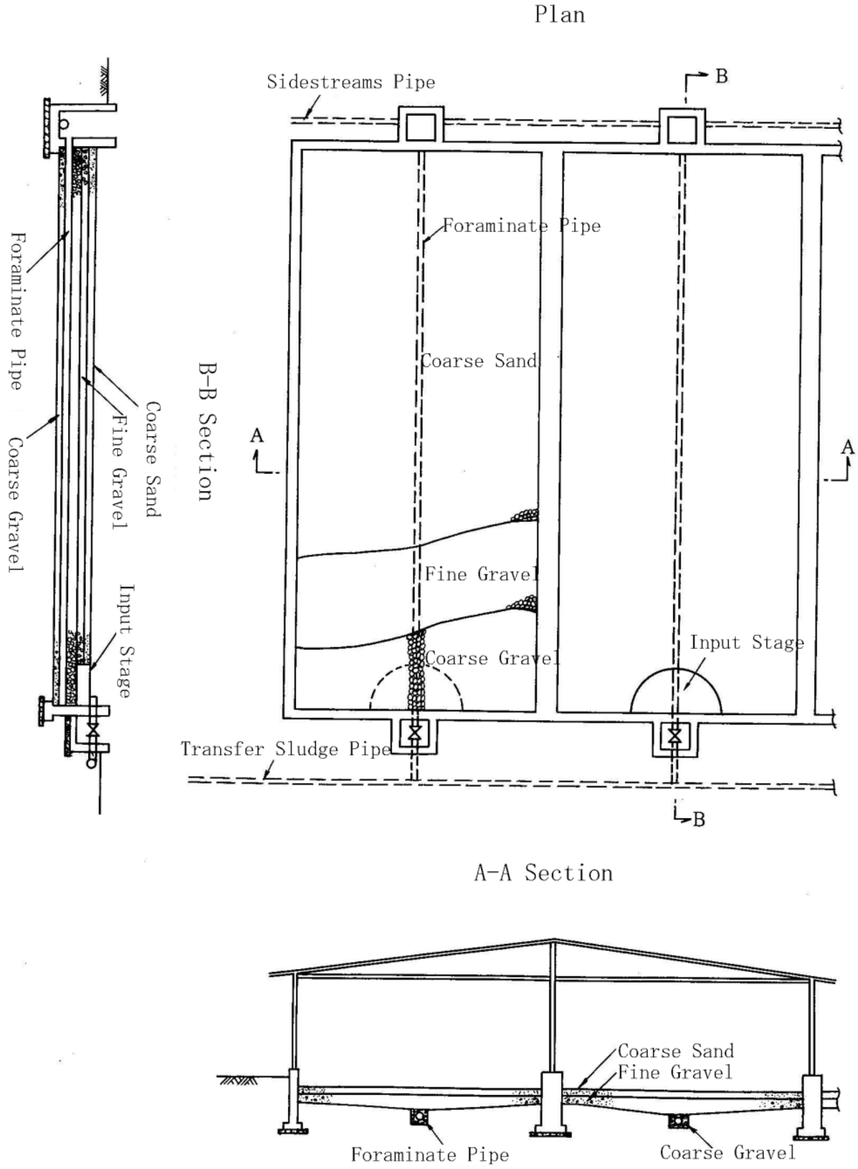
In the case of a small-scale treatment plant, there is a good chance that a broad site can be secured, and if the site is in a location where there is little risk of the surrounding area being affected, adoption of solar dry beds is a possibility. **Figure 6-2-29** shows the dry bed system.

Sludge dry beds are generally suited to digested sludge. In the case of raw sludge or insufficiently digested sludge, a larger area dry bed is required and there is risk of secondary pollution being caused by odor and flies, etc. In this case, it becomes necessary to stabilize the sludge with caustic lime or to accelerate the water penetration rate through using caustic lime or coagulant to prevent odor.

The necessary area of the dry bed is determined according to the properties and quantity of the inserted sludge, the number of drying days which depends on the local weather conditions, and the load and depth of the inserted solids, etc. In Japan, as a rule the inserted solid load is limited to no more than 4.0 kg/m2, the inserted depth to 0.2 m and the number of drying days to 20 days.

The filter bed of the sludge dry bed basically comprises a gravel layer (roughly 200~300 mm) and a coarse sand layer (roughly 150~300 mm, grain size α7~2.0 mm). Under the gravel layer, inclined channels are provided to drain away the filtrate, and a water collecting system (with gradient of around 1%) that uses perforated pipes of around 100~200 mm is installed at the deepest part. Moreover, in order to prevent impact by rainfall, a fixed or moving roof is installed as required upon examining economy and durability.

Figure 6-2-29 Example of Dry Bed System



6.2.2 Form of Sludge Final Disposal

Sludge can be effectively utilized on green spaces and farmland, for energy and as construction materials, etc.

On green spaces and farmland, sludge is utilized as dewatered sludge, dried sludge and compost. In the interests of improving stability and safety, it is desirable that dewatered sludge and dried sludge first undergo digestion.

Dried sludge and compost have low water content and are easy to handle. In particular, use as compost is becoming more and more frequent because of improved sanitary safety.

Concerning energy uses, sludge can be converted to a coal substitute energy through fuel conversion, while sludge-digestion gas can be used to heat sludge digestion tanks or as a fuel in power generation. From the viewpoint of building a low-carbon society, it will be necessary to vigorously advance such uses. Moreover, from the viewpoint of promoting resources and energy recycling based around local sewage treatment plants, it will be important to also accept biomass such as raw waste, etc. and combine it with sewage sludge for use as energy, etc.

Concerning uses as construction materials, dewatered sludge can be used as a raw material for cement; incineration ash can be used in cement, soil improving agent, roadbed material, lightweight aggregate, bricks, tiles, water permeable blocks, concrete aggregate and earthenware pipes, etc.; and molten slag can be used in roadbed material, concrete aggregate and water permeable blocks, etc. There are still numerous research and development issues to be overcome in order to further enhance economy and sales channels, etc. in future.

Different forms of sludge utilization are described in the following paragraphs.

1) Dewatered sludge

Possible uses for dewatered sludge are restoration to green spaces and farmland, land reclamation, ocean disposal and conversion to construction materials. It is difficult to directly utilize dewatered sludge straight from the dewatering equipment on green spaces and farmland because 1) it contains a lot of organic substances that haven't undergone sufficient maturation, 2) it has a high pH value if lime has been used for coagulant, and 3) it is difficult to handle sludge having water content of 70~80%. Accordingly, it is necessary to fully adjust the water content and nutrients of dewatered sludge and to adequately till (mix) it into soil before growing crops and so on. Moreover, because dewatered sludge has a strong odor, care is needed when using on farmland near urban areas.

In terms of application to construction materials, dewatered sludge can be used as a raw material for cement, etc. Cement is made by using limestone, silica, iron raw materials and clay. Of these materials, since the major inorganic components of clay and sewage sludge are similar in nature, sludge can be used in large quantities in cement manufacture.

2) Sewage sludge compost

Because sewage sludge is composed of fertilizing components such as nitrogen and phosphorous as well as various organic and inorganic components, it is valuable as an organic supplement on green spaces and farmland. Sewage sludge can be used as compost, dried sludge, dewatered sludge or incineration ash, etc. on green spaces and farmland, however, sewage sludge compost is the most effective use in terms of fertilizing effect, ease of handling and sanitary considerations. Composting (fertilizer conversion) of sewage sludge entails decomposing (fermenting) the separable organic matter in sludge in an aerobic environment and stabilizing its form and properties until it can be used on green spaces and farmland. Furthermore, the fermentation heat that is generated during the composting process destroys any pathogenic organisms remaining in the sludge, causes the sludge water content to evaporate and alters the sludge form from cake to pellets.

Unlike dewatered sludge and dried sludge, sewage sludge compost does not immediately break down after application and have a negative impact on vegetation growth, and it is also better for transporting, storage, handling and safety compared to dewatered sludge. It can thus be utilized on green spaces and farmland and as fertilizer.

3) Dried sludge

Sludge drying equipment is adopted with the aim of making sludge more amenable for various uses; for example, water content adjustment geared to utilizing sludge on green spaces and farmland; incineration, melting and carbonization geared to energy conservation and stabilization; water content adjustment of sludge geared to mixed combustion with garbage and so on.

Drying of dewatered sludge requires a lot of energy irrespective of the method adopted. Usually a lot of energy needs to be invested as latent heat for evaporating the water content. It is important to remove as much of the water content as possible in the preceding dewatering process in order to improve the efficiency of sludge drying.

The setting of water content in dried sludge differs according to the final purpose of use. When using the sludge on green spaces and farmland or as an agent for improving soil quality, in consideration of the ease of handling, in cases of drying as a prior treatment to incineration, melting and carbonization, the water content is adjusted through altering the type of furnace. Drying methods are divided into those that utilize natural energy and those that utilize machines.

Sun drying is a method that utilizes natural energy. Sun drying is suited to the drying of digested sludge and is economical in terms of power costs, etc., however, due to constraints in terms of installation area and odor in the surrounding area and so on, mechanical methods are frequently adopted.

Mechanical drying methods are broadly according to the heating method into direct heating methods and indirect heating methods. In both methods, the system composition flow and drying characteristics are different.

Accordingly, when deciding the drying approach, it is necessary to first generally consider the method of treatment in after-processes, the appropriate water content of sludge after drying, and the amount and type of heating energy that can be used for drying and so on. In either case, the exhaust gas containing removed water content that is discharged from the drying machine frequently contains high concentrations of odorous substances.

When drying is carried out, not only does this improve sludge properties for transporting, storage and handling, but the high temperature entailed in drying render pathogenic organisms in the sludge harmless.

The drying process is intended to evaporate the moisture content of dewatered sludge, but it does not reduce the organic content of sludge. Accordingly, when undigested sludge is dried, because its organic content is not sufficiently stabilized, rapid decomposition following application to land can harm the growth of crops. Accordingly, it is advisable to used digested sludge in drying.

The desirable water content of sludge when applying on green spaces and farmland is no more than 20% from the viewpoint of storage, although treating into moisturized pellets is also a viable alternative from the viewpoint of manual handling.

4) Incineration ash

Sludge incineration entails combusting through supplying air in excess of the theoretical air flow required to incinerate dewatered sludge in air pressure. The objectives of sludge incineration are weight reduction and stabilization. The combustion of organic matter and evaporation of water content in sludge lead to great weight reduction; moreover, the sludge is stabilized because the residue after incineration comprises only inorganic ash.

Sludge incinerators consist of fluidized bed furnace, multiple-hearth furnace, step grate stoker furnaces and rotary kiln according to the structure. Fluidized bed furnace are the most commonly adopted type by far.

Although not compliant with the objective of supplying organic materials to soil, incineration ash contains such essentials for plant growth as phosphorous, magnesium, iron and silicon, etc. and it is a valuable fertilizer. However, since incineration ash in its original form tends to fly away and is difficult to handle, it is usually necessary to improve handle-ability through moisturizing.

Since exhaust gases from incinerators and melting furnaces, etc. contain a lot of thermal energy, they are used for air preheating, preheating geared to preventing white smoke and drying of dewatered sludge. Moreover, because large amounts of wastewater are generated from ash washing, it is also necessary to examine its utilization. Examples of waste heat utilization include power generation utilizing steam from waste heat boilers and utilization of intermediate-temperature waste heat and low-temperature waste heat from ash washing waste water for heating pools, etc.

(1) Sludge melting

Sludge melting is adopted in cases where it is difficult to secure sufficient landfill sites for sewage sludge and cases of large cities or wide area sewage treatment areas where even incineration is not enough to sufficiently reduce volume. Sludge melting enables incinerated sludge to be reduced in volume, stabilized and recycled even more.

Sludge melting furnaces include the rotating melting furnace, coke bed melting furnace, surface melting furnace and slag bath melting furnace.

The objectives of sludge melting and effects on sludge can be summarized into the following three points:

(2) Sludge volume reduction

The extent to which volume of sludge can be reduced through melting differs greatly according to the properties (water content, organic content, etc.) of the target sludge and the shape of the produced slag. When organic sludge (dewatered sludge using organic coagulant) is melted down into slag, volume is reduced to between 1/15~1/20 compared to dewatered sludge and around 1/9 compared to dried and dewatered sludge (absolutely dry state). Compared to incineration ash, volume can be reduced to around 1/3.

(3) Sludge stabilization

When sludge is melted, all organic matter is totally oxidized and incinerated while the inorganic matter is turned to slag. Thus, the final product has stable composition. Moreover, heavy metals such as chrome, etc. contained in the molten slag are locked inside the slag and do not affect stability.

(4) Recycling of sludge (utilization of molten slag)

The slag production method in the sludge meting system is broadly divided according to the slag cooling method into rapid cooling and slow cooling. Depending on the cooling method, the cooling speed of molten liquid differs greatly and the properties of the produced molten slag greatly change. Furthermore, as a method for enhancing the value of slag, a slag crystallization process has been practically developed based on controlling the cooling speed or conducting reheating, etc. **Table 6-2-10** shows the differences between these cooling methods in the slag production process and indicates the features of the resulting slag product.

Table 6-2-10 Molten Slag Cooling Method, etc. and Slag Features

Type of molten slag			Contents of cooling and heating, etc.	Features of slag	Main uses
Rapidly cooled slag	Granulted blast	Direct water cooling	Cooling by contact with or steeping in water	Glassy and fragile fine sand or sand gritty	Roadbed material, backfill material, concrete secondary proucts (interlocking blocks), concrete aggregate, asphalt aggregate
		Indirect water cooling	Indirect cooling via a cooling medium such as water in a heat exchanger	Glassy but stronger than above. Gritty	
Slow cooled slag	Air cooling	Direct air cooling	Cooling in air	Mainly glassy but generally stronger than granulated slag	Roadbed material, backfill material, concrete secondary proucts (interlocking blocks), concrete aggregate
	Slow cooling	Cold insulation	Gentle cooling through controlling temperature or limiting heat discharge	Strength increases with crystallization. Rocky or like crushed rock in appearance	
	Crystallization	Slow cooling	Keeping rapidly cooled or directly air cooled slag in the range of 900～1,000℃ for a certain time	Strength increases with crystallization. Gritty, gritty lumps, stone shaped	Backfill material
		Reheating	Heat air cooled or granulated slag to 1,000℃～1,100℃ in order to crystallize.	Fine crystal gives high strength and good acid resistance. Gritty, gravelly, lumpy	

(5) Carbonized sludge

Carbonization is a pyrolytic technology, and wood charcoal, etc. based on pyrolysis is a technology that has been used since before Christ.

When sewage sludge is heated in a hypoxic or anoxic state, water content and adsorbed gases are discharged and pyrolysis (thermal decomposition) begins. After the decomposition gases (dry distillation gases) are released, carbides that are based on carbon are produced. This process is referred to as carbonization.

Since carbides are odorless and have good ventilation and permeation qualities, they can be used as carbonized products within treatment plants. Moreover, features of sewage sludge carbonized products are high phosphorous content and ease of supply to plants and so on. This is a feature not seen in other wood carbon or active carbon, and since carbonized sludge can also be used as a soil improvement agent and fertilizer on green and farm land, it is also available on the market as products. Carbonization is a technology having the potential to find new uses for sewage sludge, and a start has been made on using carbonized sludge as a solid coal-substitute fuel. In terms of sludge weight reduction, carbonization fits between drying and incineration of sludge and the resulting products can be stored over the long term. In carbonization furnace systems, the furnace temperature control and equipment differ according to how the carbonized products are utilized.

Carbonized sludge entails baking sewage sludge in a carbonization furnace, and its major constituents are carbon (C) and inorganic matter. Since it is perforated and has absorbing capacity, it has performance akin to wood charcoal. In view of such features, carbonized sludge has excellent water holding capacity and is conducive to the existence and propagation of microbes. As a result, it can be utilized as a soil improvement agent, phosphoric acid fertilizer and as an additive to gardening soil, etc. It is also used as a fertilizer and raw material for fertilizers.

6.3 Sewage Treatment Plant Operation and Maintenance System

6.3.1 Sewage Treatment Plant Operation

Sewage treatment plant operation and maintenance is an extremely important department in the treatment of sewage. This entails controlling installed facilities and equipment like indicators and conducting overall management to ensure that no problems occur.

The monitoring and control system monitors and controls the plant operations and processes operating information. The system is composed of 1) operating control equipment such as digital control instruments, on-site panels and auxiliary relays, etc., 2) monitoring and control equipment such as a central monitoring panel, operating panel. LCD (Liquid Crystal Display) console, instrumentation panel and monitoring controller, and 3) data processing equipment such as instruments for outputting categorized forms and a host controller, etc.

1) Monitoring and control system

The monitoring and control system, which is intrinsically related to the comprehensive management of sewage facilities, must be capable of rationally and efficiently operating and managing facilities. The monitoring and control format in this system comprises the following approaches decided upon considering the form of operation and maintenance (see **Table 6-3-1**). In all formats, it is necessary to secure this on the side of instruments.

(1) Individual monitoring and control method

Operations are generally conducted on-site or on the instrument side while directly monitoring the major instruments and treatment stages.

(2) Concentrated monitoring and individual control method

This approach combines the individual monitoring and control approach with a function for carrying out the centralized monitoring of operating conditions in the entire plant from a central monitoring room. Through providing feedback of monitoring information, it is possible to conduct overall rational management.

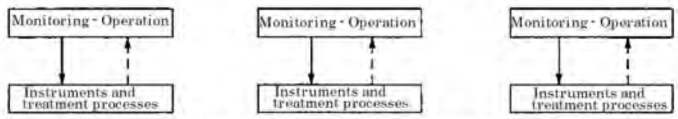
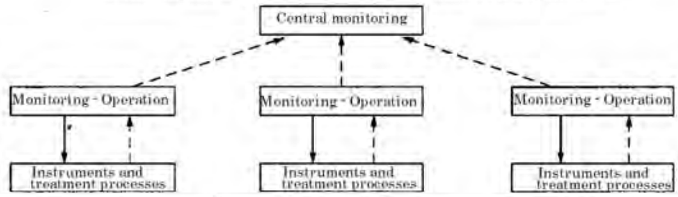
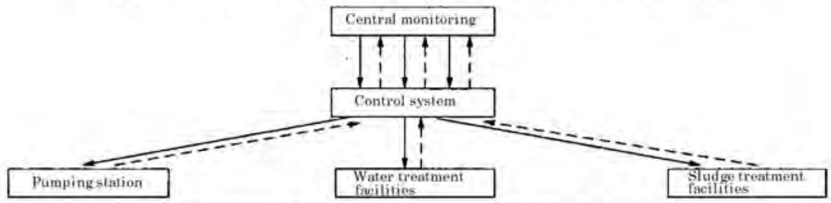
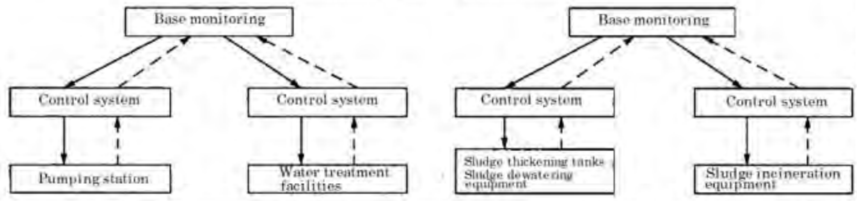
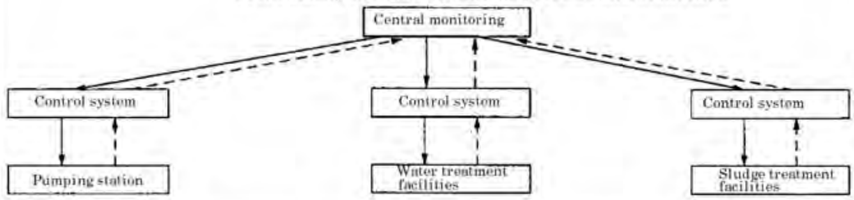
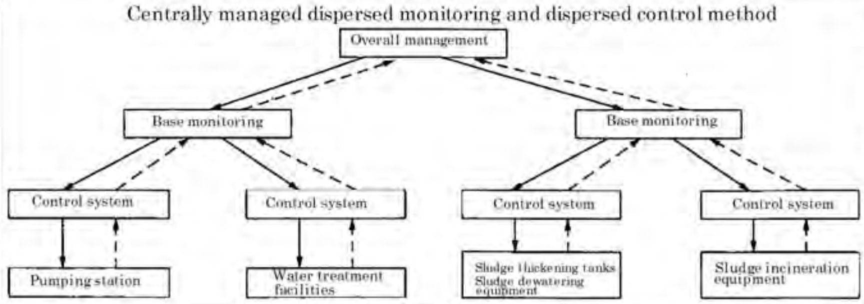
(3) Centralized monitoring and centralized control (operation) method

In this approach, a central monitoring room for performing monitoring and control of the entire plant is established, and centralized monitoring and control are carried out. Centralized control refers to the concentration of control hardware into a single location.

(4) Dispersed monitoring and dispersed control method

In this approach, base facilities are divided into a number of lines (XXX line and YYY line, etc.) or sub-systems (pumping station, water treatment facilities, sludge treatment facilities, etc.), a base monitoring and control center (monitoring room) is established for each division, and centralized monitoring and control is conducted for each base. Dispersed control refers to dispersing control hardware functions and equipment so that single failures do not spread to the entire system, thereby enhancing the overall system reliability.

Table 6-3-1 Control Methods in Monitoring and Control Systems

Monitoring and Control System Composition Diagram	Component Elements	A	B	C
Individual monitoring and control method  	On-site and equipment side (monitoring and operation functions)	●		
Concentrated monitoring and individual control method  	Central monitoring room (monitoring functions) On-site and equipment side (monitoring and operation functions)	●		
Centralized monitoring and centralized control (operation) method  	Central monitoring room (monitoring and operation functions) Electricity room (control functions) On-site	●	●	
Dispersed monitoring and dispersed control method  	Base monitoring rooms (monitoring and operation functions) On-site electricity rooms (control functions) On-site		●	●
Centralizing monitoring and dispersed control method  	Central monitoring room (monitoring and operation functions) On-site electricity rooms (control functions) On-site		●	●
Centrally managed dispersed monitoring and dispersed control method  	Base monitoring rooms (monitoring and operation functions) On-site electricity rooms (control functions) On-site			●

A:Small-Scale, B:Medium-Scale, C:Large-Scale

(5) Centralizing monitoring and dispersed control method

As in the centralized monitoring and centralized control (operation) method, monitoring and operations are concentrated into the central monitoring room, while control functions are dispersed as in the dispersed monitoring and dispersed control method.

(6) Centrally managed dispersed monitoring and dispersed control method

This method entails combining dispersed monitoring and dispersed control with overall management (from the central management room) of the entire facilities. In this approach, the centralized control functions of base monitoring rooms (local monitoring rooms) are treated as backup monitoring and control systems for central management and are not conducted around the clock.

If the operation monitoring of part of the facilities is contracted out, the local monitoring rooms are used by the contractor while the central management room becomes the directly managed monitoring room. In this case, constant monitoring is carried out in the local monitoring rooms while the central room adopts a standby status.

A variation on the dispersed monitoring and dispersed control method is to conduct dual base centralization, whereby overall management functions are conferred to one of the base monitoring rooms.

The monitoring and control system at pumping stations and treatment plants measures the condition of equipment, instruments and treatment processes, indicates them by displays, etc. and operates and controls than in the desirable direction.

When considering the monitoring and control system, the scale of facilities is determined not only by treatment capacity but also by the area of facilities and the number of instruments and control targets. Taking this point into account, **Table 6-3-1** shows the control method used in the monitoring and control system according to each facility size. (As a guide to treatment scale, small-scale refers to less than 10,000 m^3/day, medium-scale refers to 10,000~99,999 m^3/day, and large-scale refers to more than 100,000 m^3/day).

In particular, in small-scale facilities, in consideration of construction cost and maintenance setup, remote monitoring and automatic control are incorporated into the monitoring and control system from the viewpoint of labor saving.

Depending on the site conditions, even if the scale of facilities is the same, the layout of facilities and type of monitoring and control system will differ.

In cases where the administration block, grit chambers, pump block and sedimentation block functions are housed in a single building and cases where only the water treatment facilities are separated or situated far away from the central management room, the centralized monitoring and dispersed control approach is adopted in consideration of the frequency and urgency of monitoring and control. For example, in cases where the overall plant is divided by a road or a river and cases where the administration block, grit chambers, pump block and sedimentation block functions are extremely separated because the site is elongated, the dispersed monitoring and dispersed control approach is more suitable.

Moreover, even if treatment capacity is the same, it should be remembered that the degree of complexity of facilities differs according to the sewage treatment method (standard activated sludge method, oxidation ditch method, etc.) or sludge treatment method (dewatering, digestion, incineration or composting, etc.), the method of line sequencing and whether or not digestion gas power generation, deodorization and waste heating using equipment, etc. are installed.

Approaches to facilities maintenance include direct maintenance of the entire facility or maintenance by multiple organizations including subcontractors. The latter

case is frequently adopted in dispersed monitoring and dispersed control systems. Moreover, in the case of small-scale facilities, unmanned operation (at night only or around the clock) and remote monitoring are sometimes adopted.
Thus there are various types of facility maintenance systems, and the monitoring and control method should be selected upon taking these into account.

2) Treatment facilities control system

Pumping stations and treatment plants used various kinds of control systems according to differences in scale, operating method, management setup and so on. These control systems can be divided into a number of major blocks according to each equipment in the pumping station or plant.

Control links all elements, however, when considering contents, control blocks are usually displayed. The following paragraphs describe the treatment flow of control in general pumping stations and treatment plants.

(1) Grit chamber and pump control

Control in grit chambers comprises control of the sewage that is sent to the treatment facilities, etc. and control of the equipment that is installed in order to extract and remove foreign objects and sediment from sewage. This control is frequently very simple.

Control of pumps for transferring and removing the sewage coming from the grit chamber into the pump well requires care because not a lot of capacity can be secured in the pump well. Accordingly, it is necessary to adopt a control system that permits safe pumping upon fully considering the incoming sewage flow pattern and control system characteristics. It is also necessary to consider control that enables the energy saving operation of pumps, which account for a large share of power consumption in treatment plants.

(2) Water treatment control

Water treatment is generally conducted in initial sedimentation tanks, reaction tanks and final sedimentation tanks. Among these, since control inside the reaction tanks has a major impact on the quality of treated effluent, ample care is required. Moreover, since the electricity consumed by blowers in the reaction tanks accounts for a large share of the power consumption in treatment plants, it is necessary to control blowers so that the optimum air flow is secured.

The sludge generated in the sewage treatment is removed from the initial and final sedimentation tanks. In the case of the batch activated sludge method, since initial and final sedimentation tanks are not usually installed, the sludge is directly removed from the batch tanks). In either case, it is necessary to control the quantity and concentration of sludge upon considering that the properties of sludge settling in each tank are different.

(3) Sludge treatment control

Sludge treatment entails various processes, and the method of control also differs according to each treatment plant. Accordingly, the description here is restricted to control of typical sludge treatment processes.

(4) Main equipment control flow

Treatment facilities are composed of various kinds of equipment. As is shown in the List of Control Systems at Treatment Facilities in **Table 6-3-2**, various types of control are adopted for this equipment. Not only must control be conducted in each equipment flow, but also the control between each equipment must be harmonized so that the overall treatment plant operates smoothly.

Table 6-3-2 List of Control Systems at Treatment Facilities(1/4)

Division	No	Control target		Control system		Main related instruments	Remarks
		Equipment	Controlled instruments	Control group	Control contents		
Grit chamber	1	Incoming sewer	Influent gate	・Influent gate control	・ON-OFF control ・Emergency shutoff when the water level in the influent sewer becomes abnormally high.	・Influent sewer water level meter	・Emergency automatic shutoff ・Examination of inundation risk upstream of the influent sewer
	2	Screenings removal equipment	Mechanical screen Screenings remover Screenings washing machine Screenings dewatering machine	・Screen control	・Interlinked control ・Set daily intervals and operation continuation times with a schedule timer. ・Instruments are started and stopped according to the set order of starting and stopping.	・Incoming sewer water level meter ・Pump well water level meter	The start and stop order is decided according to the equipment flow. Control is sometimes implemented according to water level before and after screens.
	3	Grit removing	Grit scraper Grit remover Grit washing machine	・Grit removing machine control	・Ditto		
Pump facility	4	Main pump equipment	Sewage pump Rainwater pump Discharge power valve Lubrication auxiliary equipment Cooling auxiliary equipment	・Pump control	・Speed control Speed control of pumps with variable speed. Adjust speed according to changes in water level in the pump well. ・Control of number of units Control of the number of operating pumps Adjust the operating number of pumps according to changes in water level in the pump well. ・Interlinked control Start and stop auxiliary equipment by means of sequence control.	・Pump well water level meter ・Pump flow meter ・Pump speed meter ・Discharge valve opening meter	Conduct the following control by combining speed control with units control. ・Water level control ・Water level uniform width control ・Water level flow control
Primary sedimentation tank	5	Sludge scraping equipment	Sludge scraper	・Continuous operation control	・Automatic start of operation after power comes back on		・Steps for continuous
	6	Sludge removal equipment	Sludge pump Sludge removal valve	・Sludge removal control	・Continuous control ・Set daily intervals and removal continuation times with a schedule	・Sludge flow meter ・Sludge concentration meter ・Sludge interface gauge	・Control can also be done by presetting sludge concentration and flow.
	7	Scum removal equipment	Scum skimmer Scum drainage pump Scum washing machine Scum dewatering machine	・Scum removal control	・Set time control Operate the skimmer at set intervals.	・Scum drainage tank water level meter	・Consider control conditions at the scum drainage destination.
Reaction tank	8	Air supply equipment	Air flow control valve Hydraulic equipment	・Air flow control ・DO uniform control	・Opening control Control air valve opening according to the sewage flow or DO.	・DO meter ・Airflow meter ・ORP meter	・There is also control to keep air flow constant.

Table 6-3-2 List of Control Systems at Treatment Facilities(2/4)

Division	No	Control target		Control system		Main related instruments	Remarks
		Equipment	Controlled	Control group	Control contents		
Reaction tank	9	Blower equipment	Blower Suction valve Discharge valve Cooling water pump Lubricant pump Cooling tower Air filter	・Blower control	・Uniform control of air blow Control the suction flow and number of units of blowers to keep air pressure constant. ・Interlinked control Control based on linking air filters and cooling water pumps, etc. to the main motor	・Airflow meter ・Air pressure meter ・Suction thermometer ・Blow thermometer ・Suction vane opening ・Suction flow meter	Conduct speed control according to the blower model. Take care regarding control characteristics of the blowing equipment.
	10	Return sludge equipment	Return sludge adjustment valve Return sludge movable weir Return sludge pump Sludge removal valve	・Return sludge ratio control	・Ratio control Ratio control based on sewage flow. Concerning return pumps, control the number of units and speed. For control valves, etc., control the opening.	・Return sludge concentration meter ・Return sludge flow meter ・MLSS meter	There is also control to keep the return sludge quantity constant.
Final sedimentation tank	11	Sludge scraping equipment	Sludge scraper	・Continuous operation control	・Automatic start of operation after power comes back on		Steps for continuous scraping
	7	Scum removal equipment	Scum skimmer Scum drainage pump Scum washing machine Scum dewatering machine	・Scum removal control	・Set time control Operate the skimmer at set intervals.	・Scum drainage tank water level meter	Consider control conditions at the scum drainage destination.
	12	Excess sludge equipment	Excess sludge pump Sludge removal valve	・Excess sludge control	・Fixed interval control Transfer sludge at set times based on a schedule timer.	・Excess sludge flow meter ・Sludge interface gauge ・SV meter	Control can also be done by presetting sludge concentration and flow.
Disinfecting	13	Hypochlorite dosing equipment	Hypochlorite dosing pump Hypochlorite storage tank	・Hypochlorite dosing control	・Uniform dose control ・Dosing rate control Control the dose according to the amount of discharge.	・Hypochlorite dosing meter ・storage stank ・Liquid level meter ・Residual salt meter	Beware of excessive dosing.
Treated effluent	14	Miscellaneous water supply (Sand filter equipment, etc.)	Sand filter Auxiliary unit for above Water pump Foam pump Auto strainer	・Sand filters ・Washing process control ・Washing water flow control	・Sequence control After the sand filter operates for a set time, conduct washing in the prescribed order. Also wash according to the filter water head. ・Interlinked control Interlink the water pump and drainage valve, etc.	・Treated effluent flow meter ・Differential pressure gauge (Filter water head)	If the machine flow can be switched, take care regarding control.
Sludge thickening tank	15	Sludge thickening equipment (gravity thickening)	Sludge scraper Sludge removal valve Thickened sludge pump	Sludge removal control	・Interlinked control Control by interlinking the sludge removal valve (which operates at set intervals) and sludge pump. ・Set time control	・Sludge-liquid interface meter ・Thickened sludge flow meter ・Thickened sludge concentration meter	Control can also be done by presetting sludge-water interface, concentration and flow.

Table 6-3-2 List of Control Systems at Treatment Facilities(3/4)

Division	No	Control target		Control system		Main related instruments	Remarks
		Equipment	Controlled instruments	Control group	Control contents		
Sludge thickening	16	Centrifugal thickening	Centrifugal thickener Sludge supply pump Sludge stirrer	・Sludge insertion quantity control ・Sludge thickener interlinked control	・Sludge volumetric control Control the amount of sludge put into the thickener to a set level. ・Interlinked control Control the instruments in the sludge thickening process according to the set order.	・Removed sludge flow meter ・Thickening tank water level ・Sludge concentration meter	Take care to conform with controls on the machine side.
	17	Flotation thickening	Flotation unit Foaming unit Water pump Coagulant dosing pump Foaming agent dosing pump Sludge supply pump Sludge mixer	・Sludge insertion quantity control ・Chemical dosing control ・Sludge thickener interlinked control	・Sludge volumetric control Control the amount of sludge put into ・Chemical dosing ratio control Control in proportion to the amount of sludge put into the thickener. ・Interlinked control Control the instruments in the sludge thickening process according to the set order.	・Sludge flow meter ・Coagulant flow meter ・Inserted sludge concentration meter ・Thickening tank liquid level meter ・Chemical storage tank liquid level	Ditto
	18	Belt filtration thickening	Belt filtration thickener Coagulant dosing pump Sludge supply pump	・Sludge insertion quantity control ・Chemical dosing control ・Sludge thickener interlinked control	・Sludge volumetric control Control the amount of sludge put into the thickener to a set level. ・Chemical dosing ratio control Control in proportion to the amount of sludge put into the thickener. ・Interlinked control Control the instruments in the sludge thickening process according to the set order.	・Sludge flow meter ・Coagulant flow meter ・Sludge concentration meter	Ditto
Sludge digestion	19	Digestion tank	Gas stirrer Mechanical stirrer Sludge removal pump Gas stirring blower Sludge removal valve	・Sludge quantity control	・Inserted sludge control Control the quantity of sludge put into the digestion tank. ・Sludge transfer quantity control Control the quantity of sludge transferred from the primary to the secondary tank. ・Sludge removal quantity control Control the quantity of sludge removed from the digestion tank.	・Digested sludge flow meter ・In-tank pressure gauge ・pH meter ・In-tank thermometer ・Digestion tank water level meter ・Gas flow meter	If piping around the digestion tank can be switched, take care regarding control.
	20	Heating equipment	Burner Oil pump Gas boosting blower Forced fan Induction fan Water supply pump	・Boiler control	・Boiler combustion control Boiler ignition, combustion and stop control ・Interlinked control Start and stop the boiler auxiliary equipment according to the set order based on boiler start/stop commands.	・Steam flow meter ・Fuel flow meter ・Gas flow meter ・Boiler water level meter ・Fuel tank liquid level meter ・Gas holder level	If using both gas and heavy oil or in case of a remote monitoring boiler, control differs.
Sludge dewatering	21	Pressure insertion screw press dewatering equipment	Pressure insertion screw press Sludge supply pump Chemical dosing pump Sludge stirrer Chemical stirrer Belt conveyor Dewatered sludge hopper	・Sludge pressure insertion pressure ・Chemical dosing quantity control ・Sludge dewatering machine interlinked control	・Sludge pressure insertion uniform pressure control Adjust the amount of sludge while controlling the supply pressure to the dewatering machine. ・Chemical dosing ratio control Control in proportion to the amount of sludge put into the dewatering machine. ・Sequence control Control the instruments in the sludge dewatering process according to the set order.	・Sludge flow meter ・Sludge concentration meter ・Sludge pressure meter ・Chemical flow meter ・Sludge tank liquid level meter ・Hopper weighing machine	Since there are cases where operation needs to be controlled on the machine side, it should be able to conduct control on the machine side.

Table 6-3-2 List of Control Systems at Treatment Facilities(4/4)

Division	No	Control target		Control system		Main related instruments	Remarks
		Equipment	Controlled instruments	Control group	Control contents		
Sludge dewatering	22	Rotating pressurized dewatering equipment	Rotating pressurized dewatering machine Sludge supply pump Chemical dosing pump Sludge stirrer Chemical stirrer Belt conveyor Dewatered sludge hopper	・Sludge pressure insertion pressure ・Chemical dosing quantity control ・Sludge dewatering machine interlinked control	・Sludge pressure insertion uniform pressure control Adjust the amount of sludge while controlling the supply pressure to the dewatering machine. ・Chemical dosing ratio control Control in proportion to the amount of sludge put into the dewatering machine. ・Sequence control Control the instruments in the sludge dewatering process according to the set order.	・Sludge flow meter ・Sludge concentration meter ・Sludge pressure meter ・Chemical flow meter ・Sludge tank liquid level meter ・Hopper weighing machine	Since there are cases where operation needs to be controlled on the machine side, it should be able to conduct control on the machine side.
	23	Belt press dewatering	Belt press dewatering machine Sludge supply pump Chemical dosing pump Sludge stirrer Chemical stirrer Belt conveyor Dewatered sludge hopper	・Sludge quantity control ・Chemical dosing quantity control ・Sludge dewatering machine interlinked	・Inserted sludge control Control the quantity of sludge put into the dewatering machine. ・Chemical dosing ratio control Control in proportion to the amount of sludge put into the dewatering ・Sequence control Control the instruments in the sludge dewatering process according to the set order.	・Sludge flow meter ・Sludge concentration meter ・Chemical flow meter ・Sludge tank liquid ・Hopper weighing machine	Since there are cases where operation needs to be controlled on the machine side, it should be able to conduct control on the machine side.
	24	Centrifugal dewatering	Centrifugal dewatering machine Sludge supply pump Chemical dosing pump Sludge stirrer Chemical stirrer Belt conveyor Dewatered sludge hopper	・Sludge quantity control ・Chemical dosing quantity control ・Sludge dewatering machine interlinked	・Inserted sludge control Control the quantity of sludge put into the dewatering machine. ・Chemical dosing ratio control Control in proportion to the amount of sludge put into the dewatering ・Sequence control Control the instruments in the sludge dewatering process according to the set order.	・Sludge flow meter ・Sludge concentration meter ・Chemical flow meter ・Sludge tank liquid ・Hopper weighing machine	Ditto

3) Sewage System Maintenance

Maintenance of sewage systems involves efficiently managing and utilizing conduits, pumping stations and treatment plants, etc. in conformance with their purpose. The functions of facilities are realized and sustained through the accumulation of routine and minor maintenance tasks.

However, the environment surrounding sewage system maintenance is undergoing great change and it is becoming necessary to systematize overall maintenance work, compile medium-term and long-term policies and plans and develop setups whereby everyday activities can be implemented in a planned and efficient manner from the long-term viewpoint. It will take a relatively long time for concrete differences to appear between this kind of planned maintenance and stopgap maintenance, however, it is necessary to take effective measures before problems become manifested. For this reason, it is necessary to appropriately record the results of inspections, investigations and maintenance, etc. and actively utilize such data and make an ongoing effort with a view to realizing planned and efficient maintenance.

Since sewage systems cover a variety of specialties such as civil engineering, building, machines, electricity and water quality, etc., it is important to comprehensively and efficiently build the required organization, personnel setup and facilities. The personnel involved with maintenance should aim to achieve better maintenance through understanding each field and sharing information. Only after fully understanding the systems, structures and functions, etc. of sewerage facilities and mastering appropriate operation and maintenance and water quality control methods can personnel carry out the effective maintenance of facilities. It is also important to properly control poor quality drainage, which can cause damage to sewage system, facilities and impede treatment functions. For this reason, it is necessary to gauge and monitor plants and business establishments inside treatment areas and clarify responses to troubles. Furthermore, it is important to build trust relations with local residents through disclosing and providing information to and conducting dialog with business owners and citizens.

(1) Objectives of Maintenance

The objectives of maintenance in sewage systems are to efficiently operate and fully realize the functions of conduits, pumping stations and treatment plants, etc., and to sustain and extend those functions. To this end, it is necessary to compile comprehensive maintenance plans and advance planned maintenance activities.

(2) Comprehensive maintenance plans

Maintenance is not only intended to operate and maintain facilities, but it also entails investigating efficiency and subcontracting from the viewpoint of business management and building rust relations with users who pay sewerage charges. In order to efficiently operate sewage facilities, it is necessary to compile a comprehensive maintenance plan covering all areas of maintenance work and advancing each maintenance activity from the medium and long-term viewpoints.

The basic functions of sewage systems lie in 1) improving the living environment through removing and appropriately treating sewage and 2) improving the water environment at discharge destinations; however, it is also becoming necessary to consider energy and greenhouse gas issues, etc. in the sewerage utility. Accordingly, it is necessary to systematize the overall maintenance work activity and to set targets and compile a schedule of activities for facility operation upon considering local characteristics, level of importance and urgency and cost effectiveness.

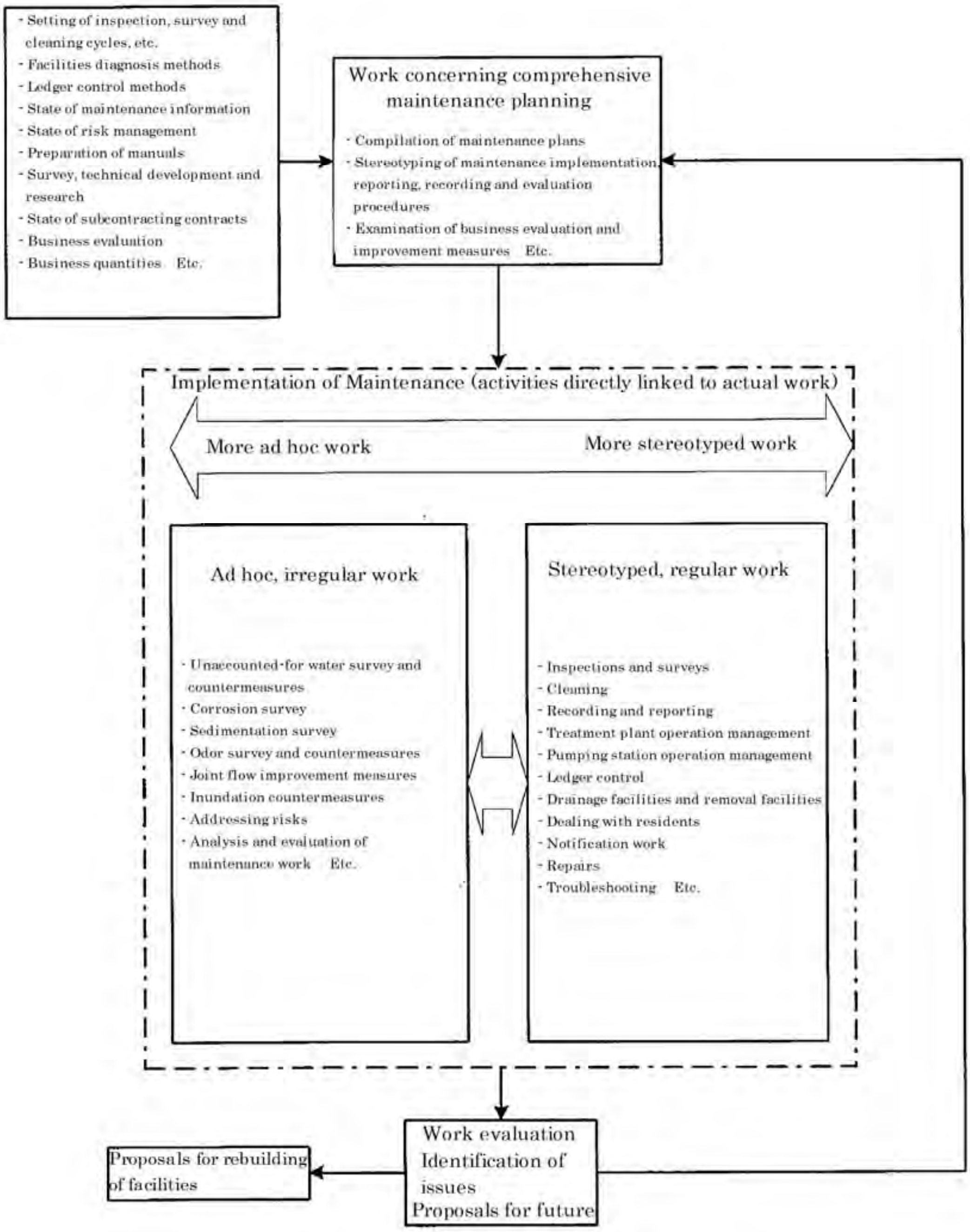
(3) Planned maintenance of facilities

Planned maintenance of facilities refers to carrying out planned and appropriate maintenance with a view to extending the service life of facilities and reducing overall costs. Concerning conduit facilities, necessary repairs and improvements can be promptly implemented through setting rational cycles for inspections, investigations and cleaning, etc. and recording and analyzing results. Concerning pumping stations and treatment plants, planned facilities management can be achieved based on the rapid discovery of troubles through analysis of repair records, maintenance and inspections.

(4) Contents of maintenance

The contents of maintenance can be broadly divided into items related to maintenance planning and actual work activities such as conduit inspections, surveys and cleaning and treatment plant operation. These are shown in **Figure 6-3-1**.

Figure 6-3-1 Contents and Flow of Maintenance



(5) Facilities management

Facilities are composed of various types and it is necessary to fully understand their functions.

Typical conduit facilities are as follows: 1) sewers, 2) manholes, 3) culverts and laterals, 4) inverted siphons, 5) rainfall infiltration facilities, and 6) other conduit facilities (storm overflow chambers, outfalls and open sewers, etc.).

Pumping stations and treatment plants are also composed of various civil engineering, building, machine, electricity and water quality facilities, etc. and they too require appropriate management.

(6) Planned maintenance

Managers of sewage system facilities need to carry out planned maintenance in order to prevent sudden accidents and breakdowns with causes in facilities before they occur and to extend the service life of facilities.

Examples of sudden accidents arising from sewage system facilities are vehicles falling into collapsed roads and flooding caused by blocked sewers, etc. and both of these cases impact the safety of citizens.

Planned maintenance is a technique that entails accurately surveying and inspecting the condition of facilities, deciding the techniques and priority of cleaning and repairs, etc. found to be necessary, and efficiently implementing such work in order to prevent sudden accidents from arising and extend the service life of facilities.

Planned maintenance also involves spending maintenance expenses in a preventive manner so as to limit outlay on repairs or compensation arising from sudden accidents and thereby limit the overall maintenance cost.

(7) Compliance with laws and submission of documents

Much of the maintenance work for sewage system facilities is regulated by legislation. Facilities managers must comply with these laws and submit necessary documents to the competent government offices based on them.

(8) Responding to accidents

Facilities managers need to conduct preventive maintenance in order to prevent suspension of functions at pumping stations and treatment plants as a result of accidents in conduit facilities and equipment failures. In the event of emergencies, they must be appropriately responded to by means of stopgap measures.

a) Responding to accidents in conduit facilities

Facilities managers need to take preventive measures to stop accidents from occurring. Moreover, when accidents do occur, they need to take appropriate stopgap measures.

The kinds of accident that occur in conduit facilities are as follows:

- Accidents caused by detachment of manhole covers and inundation
- Accidents caused by road cave-in
- Accidents caused by toxic gas, etc.

b) Responding to accidents in pumping stations and treatment plants

In order to prevent failure and accidents in equipment and instruments and so that they are always in a useable state, it is necessary to implement planned maintenance on a routine basis. Such maintenance activities for equipment and instruments are referred to as preventive maintenance. However, even when preventive maintenance is conducted, sudden and unavoidable accidents still occur in equipment and instruments.

Since the suspension of functioning of pumping stations and treatment plants can lead to sewage overflows and flooding of roads and houses and deterioration in the quality of treated effluent, care must be taken in maintenance to ensure that equipment breakdowns do not arise and cause such situations. When unforeseen situations arise, it is necessary to switch to backup equipment, obtain power from generating equipment or take other appropriate steps:

- Equipment failure
- Response during accidents

In addition to equipment failures, various accidents occur in relation to work, and many such accidents originate from lack of attention by employees. Therefore, before starting work, it is necessary to conduct ample discussions on procedures and to advance work while giving appropriate instructions. In addition, the tendency to overlook risks or cut corners in safety confirmation after becoming accustomed to work must be firmly guarded against.

Moreover, when employees are newly assigned to workplaces, it is necessary to educate and training them about work methods and caution items in the most dangerous spots.

Accidents in pumping stations and treatment plants are classified into the following types:

- Human accidents
- Electrical accidents
- Fires
- Damage to buried objects
- Inflow of foreign materials
- Others

(9) Handover of facilities

When new conduit facilities, pumping stations or treatment plants are constructed, it is necessary for the construction department to eventually hand them over to the maintenance department. Similarly, when sewage system facilities are constructed as part of residential or industrial area developments, it is necessary for the private or public authority developers to hand the facilities over to the managers. When performing such handover work, it is necessary to survey and confirm the state of facilities to ensure that problems will not arise at a later date.

(10) Contents of maintenance work

Maintenance work for sewage system facilities covers a wide scope of activities including clerical management such as general affairs, budget execution and assets control, resident-related services such as advertisement of start of services, setting of charges, guidance on drainage equipment and monitoring of drainage from business establishments, maintenance of conduit facilities, pumping stations and treatment plants, water quality control and other related activities. **Table 6-3-3** indicates these contents.
Taking consideration MWSS, MWSI and MWCI current conditions and situations, enhancing plan of the organizations shall be made.

Table 6-3-3 Contents of Maintenance Work(1/2)

Work Area		Main Work Contents
1.General affairs		Establishment of sewage ordinances, general affairs, personnel affairs, salary, budget, settlement, welfare, public information, etc.
2.Budget execution		2-1 Materials purchasing and management (fuel, chemicals, fixtures, expendables) 2-2 Works contracts 2-3 Subcontracting contracts
3.Assets control		Fixed assets management (property management), repairs
4.Advertisement of start of services, etc.		Disclosure, public viewing, designation of city sewers
5.Adjustment of charges, etc.		User surveys, charge adjustment (including recognition of usage), charge levying, survey of unpaid charges
6.Guidance on drainage equipment, etc.		6-1 Installation guidance, inspection and survey of drainage equipment and flush toilets 6-2 Designation and training of approved works operators 6-3 Subsidization of flush toilet remodeling costs, etc. 6-4 Notification of start of services in public sewage system
7.Monitoring and guidance of wastewater from business establishments, etc.		7-1 Review of specific facilities installation notifications, etc. (including loan affairs) 7-2 Guidance on installation of industrial pretreatment facilities 7-3Notification of start of services in public sewage system 7-4Implementation of on-site inspections concerning water quality regulations in factories, etc. 7-5Guidance on maintenance of industrial pretreatment facilities 7-6Guidance on improvement of specific facilities and industrial pretreatment facilities
8.Maintenance of conduit facilities		8-1Planning, design implementation and supervision of inspections and surveys of conduit facilities 8-2Planning, design implementation and supervision of cleaning and dredging of conduit facilities 8-3Planning, design implementation and supervision of repairs and rebuilding 8-4Preservation and protection of conduit facilities 8-5Authorization work
9.Maintenance of urban storm drainage systems		9-1Planning, design implementation and supervision of inspections and survey of urban storm drainage systems 9-2Planning, design implementation and supervision of cleaning and dredging of urban storm drainage systems 9-3Planning, design implementation and supervision of repairs and rebuilding 9-4Preservation and protection of urban storm drainage systems
10.Maintenance of pumping stations and treatment plants		
	(1) Activities relating to operation	10-1Compilation of sewage and sludge treatment plans 10-2Compilation of pumping station and treatment plant equipment operation plans 10-3Preparation, design, supervision and implementation of plans for pumping station and treatment plant equipment operation management work 10-4Disposal planning of grit, screenings, sludge and incineration ash, and design, supervision and implementation of transportation and disposal 10-5Design, supervision and implementation of building and vegetation cleaning work, etc.

Table 6-3-3 Contents of Maintenance Work(2/2)

Work Area		Main Work Contents
10.Maintenance of pumping stations and treatment plants		
	(1) Activities relating to operation	10-6 recording and organization of pumping station and treatment plant operation management conditions (daily, monthly and annual reports) 10-7Instructions and operations at times of abnormality and emergency
	(2) Activities relating to maintenance and inspections	10-8Compilation of maintenance and inspection plans and guidelines for machines and electrical equipment 10-9 Design, supervision and preparation and implementation of plans for maintenance and inspection of machines and equipment
	(3) Activities relating to repairs and rebuilding	10-10 Preparation, design, supervision and implementation of plans for repair works
11.Activities relating to water quality control		11-1 Preparation of plans on water quality testing, survey and research, etc. 11-2 Implementation of water quality tests and sludge tests 11-3Implementation of activated sludge tests 11-4Implementation of industrial wastewater tests 11-5Implementation of survey and research 11-6Data organization and analysis and preparation of reports 11-7Preparation of operation management guidelines 11-8Troubleshooting 11-9Adjustment of water quality measuring instruments 11-10Implementation of on-site inspection cross-checking (environmental department)
12.Ledger control		12-1 Ledger preparation and archiving 12-2 ledger amendment and public viewing 12-3Drawings and documents control (general floor plans, profiles, drainage area drawings, electric system drawings, pipe system drawings, etc.)
13.Activities relating to environmental conservation		13-1Compilation and implementation of plans concerning atmospheric measurement 13-2Compilation and implementation of plans concerning noise and vibration measurement 13-3Compilation and implementation of plans concerning odor measurement 13-4Compilation and implementation of plans concerning water quality measurement in discharge rivers 13-5Compilation and implementation of plans concerning dioxins
14.Other activities		14-1Reporting to supervisory government agencies, etc. 14-2Gauging and improvement of safety and hygiene conditions 14-3On-site observation of works by other companies 14-4Survey and research concerning sewage systems 14-5Guidance of visitors 14-6education and dissemination activities 14-7Employee and staff training

3) Water Quality Test Laboratory and Accessory Instruments

(1) STP Effluent Standards of DENR

a) Effluent Standards

According to DENR Administrative Order No. 35 (Revised Effluent Regulations of 1990), effluent standards are stipulated for each classification of water body. Water body classifications are provided in DENR Administrative Order No. 34 (Section 68. Water Usage and Classification).

In the Project, the treatment plants that will be targeted by these regulations will all discharge effluent into rivers, and the water body will be classified as Class C according to the standard for (a) Fresh Surface Waters (rivers, lakes, reservoirs, etc.). Moreover, according to Class C in TABLE 2A - Effluent Standards: Conventional and Other Pollutants in Protected Water in this standard, discharged effluent from treatment plants must not exceed COD100mg/L, BOD50mg/L or SS70mg/L. **Table 6-3-4** shows the DENR Effluent Standards TABLE 2A - Effluent Standards: Conventional and Other Pollutants in Protected Waters (Category I and II and in Inland Waters Class C[a]), and **Table 6-3-5** shows the DENR water body classifications.

Table 6-3-4 DENR Effluent Standards "TABLE 2A - Effluent Standards: Conventional and Other Pollutants in Protected Waters（Category I and II and in Inland Waters Class C）

Parameter	Unit	Protected Waters				Inland Waters	
		Category I		Category II			
		(Class AA & SA)		(Class A,B & SB)		Class C	
		OEI	NPI	OEI	NPI	OEI	NPI
Color	PCU	b	b	150	100	200[c]	150[c]
Temperature (max rise in deg. Celsius in RBW)	℃ rise	b	b	3	3	3	3
pH (range)		b	b	6.0-9.0	6.0-9.0	6.0-9.0	6.5-9.0
COD	Mg/L	b	b	100	60	150	100
Settleable Solids (1-hour)	Mg/L	b	b	0.3	0.3	0.5	0.5
5-Day 20 ℃ BOD	Mg/L	b	b	50	30	80	50
Total Suspended Solids	Mg/L	b	b	70	50	90	70
Total Dissolved Solids	Mg/L	b	b	1,200	1,000	-	-
Surfactants (MBAS)	Mg/L	b	b	5.0	2.0	7.0	5.0
Oil/Grease (Petroleum Ether Extract)	Mg/L	b	b	5.0	5.0	10.0	5.0
Phenolic Substances as Phenols	Mg/L	b	b	0.1	0.05	0.5	0.1
Total Coliforms	MPN/100mL	b	b	5,000	3,000	15,000	10,000

NOTES for Table 2A and Table 2B:

1. In cases where the background level of Total Dissolved Solids (TDS) in freshwater rivers, lakes, reservoirs and similar bodies of water is higher than the Water Quality Criteria, the discharge should not increase the level of TDS in the receiving body of water by more than ten percent of the background level.
2. The COD limits in Tables 2A and 2B generally apply to domestic wastewater treatment plant effluent. For industrial discharges, the effluent standards for COD should be on a case to case basis considering the COD – BOD ratio after treatment. In the interim period that this ratio is not yet established by each discharger, the BOD requirements shall be enforced.
3. There are no effluent standards for chloride except for industries using brine and discharging into inland waters, in which case the chloride content should not exceed 500 mg/L.
4. The effluent standards apply to industrial manufacturing plants and municipal treatment plants discharging more than thirty (30) cubic meters per day.

Table 6-3-5 Classification of Type of Water：(a) Fresh Surface Waters (rivers, lakes, reservoirs, etc.)

Classification	Beneficial Use [1]
Class AA:	Public Water Supply Class I. This class is intended primarily for waters having watersheds which are uninhabited and otherwise protected and which require only approved disinfection in order to meet the National Standards for Drinking Water (NSDW) of the Philippines.
Class A:	Public Water Supply Class II. For sources of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the NSDW.
Class B:	Recreational Water Class I. For primary contact recreation such as bathing, swimming, skin diving, etc. (particularly those designated for tourism purposes).
Class C:	1) Fishery Water for the propagation and growth of fish and other aquatic resources; 2) Recreational Water Class II (Boatings, etc.) 3) Industrial Water Supply Class I (For manufacturing processes after treatment).
Class D:	1) For agriculture, irrigation, livestock watering, etc. 2) Industrial Water Supply Class II (e.g. cooling, etc.) 3) Other inland waters, by their quality, belong to this classification.

[1] In general, this refers to current best beneficial use that is expected to last, at least, for thenext 10 to 20 years. In special cases when dictated by political, economic, social, public health, environmental and other considerations, certain waters may be classified according to the intended or future beneficial use (e.g. Pasig River, Tullahan-Tenejeros, etc.)

b) Standards related to Sewage Sludge Disposal

Standards relating to sludge disposal are contained in REPUBLIC ACT NO. 9003 (year 2000). The related items are described as follows.

The most significant legislation on solid waste management, Republic Act (“RA”) No. 9003, or the Ecological Solid Waste Management Act of 2000 (“Solid Waste Act”) and its implementing rules, was signed into law on January 26, 2001.

Under the Solid Waste Act, the DENR sets guidelines and targets to reduce the volume of solid waste through various waste reduction measures. These measures include the proper segregation, collection, transport, storage, treatment, and disposal of solid waste, as well as composting, recycling and re-using of solid waste. In coordination with local government units (“LGUs”), self-regulating waste generators and other private sector groups, the DENR was designated to be the primary enforcer of the Solid Waste Act.

The Solid Waste Act prohibits the following acts:

- Dumping waste materials in public places such as roads, canals or sidewalks;
- Open burning of solid waste;
- Permitting the collection of non-segregated waste;
- Squatting in open dumps and landfills;
- Open dumping in flood-prone areas;
- Mixing of source-separated recyclable material with other solid waste in any container for solid waste collection;
- Operating open dumps outside the provisions of the law;
- Manufacturing or distributing non-environmentally acceptable packaging materials;
- Importing consumer products in non-environmentally acceptable packaging materials;

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- Importing toxic wastes misrepresented as recyclable;
- Transporting and dumping in bulk of collected domestic, commercial, industrial, and institutional wastes outside of designated centers or facilities;
- Preparing, expanding, constructing or operating waste management facilities without an Environmental Compliance Certificate and without conforming to the land use plan of the LGU;
- Constructing any establishment within 200 meters from open or controlled dumpsites or sanitary landfills; and
- Constructing or operating any landfills or waste disposal facility on any area or portion of an aquifer, water reservoir or watershed.

In order to achieve these DENR standards, it is necessary to conduct water quality and sludge tests, and the techniques for such tests are described below.

(2) Outline of Water Quality Test

Water quality management in sewage systems refers to all tests, operations and work implemented with the aims of appropriately maintaining treatment facility functions, obtaining good treated water quality and ensuring the proper treatment and disposal of sludge.

Water quality tests include sewage tests, activated sludge tests, general sludge tests, gas tests, biological tests and bacteriological tests, etc.

- Tests on each treatment process necessary for monitoring the quality of incoming effluent and appropriately maintaining water treatment facilities and sludge treatment facilities, and water quality tests implemented based on surveys or legal regulations
- Operations on airflow, return sludge quantity, excess activated sludge quantity, digested sludge removal quantity, etc. based on the results of water quality tests and routine inspections, etc.
- Various tasks that have a direct or indirect impact on discharge effluent quality, for example, scum removal work, washing of filter cloth in sludge water separation equipment and so on

(3) Types of water quality test

Water quality tests are described variously according to the targets, objectives and methods, etc. of tests. Below are given some examples.

a) Classification according to test items

(a) DENR standards

DENR stipulates water quality test methods in DENR ADMINISTRATIVE ORDER No. 34 as shown in **Table 6-3-6**.

Table 6-3-6 DENR ADMINISTRATIVE ORDER No. 34 Table 4 - Approved Methods of Analysis

PARAMETER	METHOD OF ANALYSIS
ARSENIC	Silver Diethyldithiocarbamate Method (Colorimetric)
BOD_5	Azide Modification (Dilution Technique)
BORON	Carmine Method (Colorimetric Method)
CADMIUM	Atomic Absorption Spectrophotometry (West ashing with concentrated HNO3, + HCl
CHLORINATED HYDROCARBONS	Gas Chromatography (ECD)
CHROMIUM (Hexavalent)	Diphenyl Carbazide Colorimetric Method
COLOR	Visual Comparison Method (Platinum Cobalt Scale)
CYANIDE	Specific Ion Electrode Method
DISSOLVED OXYGEN	Azide Modification (Winkler Method), Membrane Electrode (DO meter)
FECAL COLIFORMS	Multiple-Tube Fermentation Technique or Membrane Filter
LEAD	Atomic Absorption Spectrophotometry
NITRATE AS NITROGEN	Bruccine Method for Saline Waters, specific Ion Electrode Meter for Fresh Water
OIL AND GREASE	Gravimetric Method (Petroleum Ether Extraction)
ORGANO PHOSPHORUS COMPOUNDS	Gas Chromatography (FPD)
POLYCHLORINATED BIPHENYL (PCB)	Gas Chromatography (ECD)
pH	Glass Electrode Method
PHENOLIC SUBSTANCES	Chloroform Extraction Method
PHOSPHATE AS PHOSPHORUS	Stannous Chloride Method
SETTLEABLE SOLIDS	Imhoff Cone Method
SURFACTANTS (MBAS)	Methylene Blue Method (Colorimetric)
TEMPERATURE	Use of Mercury-Filled Thermometer
TOTAL COLIFORMS	Multiple-Tube Fermentation Technique or Membrane Filter
TOTAL MERCURY	Cold Vapor Technique (Mercury Analyzer, AAS)
TOTAL SUSPENDED SOLIDS	Gravimetric Method

Note: Other methods found in the Philippine Standard Methods for Air and Water Analysis, the "Standard Methods for the Examination of Water and Waste Waters", published jointly by American Public Health Association (APHA), the American Waterworks Association and the Water Pollution Control Federation of the U.S. or in accordance with such other method of analyses as the DENR may prescribe.

The test items are as indicated in the above-mentioned **Table 6-3-4**.

(b) Recommendation of Laboratory Testing

The following categorization of Laboratory tests would be recommended.

- Physical/chemical tests

  Physical/chemical tests-----Water temperature, transparency, pH, phosphorous, chlorine, phenol, evaporation residue, SS, COD, nitrogen, iodine consumption, extractive substance in normal hexane, etc.

  Biochemical tests --------- BOD

Instrument analysis --------Heavy metals, organic phosphorous compounds,
organic chlorine-based compounds, (PCB,
trichloroethylene, tetrachloroethylene)

- Bacteriological tests
  General bacteriological tests
  Coliform bacteria tests

These tests are largely used to estimate the bacteriological infection of water, sanitary safety and treatment effect of sewage, etc.

- Biological tests
  Biological qualitative tests and quantitative tests
  Toxicity tests----------------Bio-assay

Biological tests are used in order to determine the degree of purification functions and existence of impediments and toxic substances, etc. in treatment facilities.

b) Classification according to test frequency and items, etc.

Tests are customarily classified into the following types according to the objectives and frequency of tests, test items and method of sampling, etc.

(a) Routine tests

These are simple tests carried out at specified times every day on air temperature, water temperature, transparency, pH, COD and other items necessary for maintenance and everyday management of treatment plants.

(b) Intermediate tests

These are tests implemented in order to gauge the overall quality if influent sewage and treated effluent. Test items comprise the routine test items with the addition of BOD, SS and nitrogen, etc.

(c) Precision tests

These target intermediate test items as well as phosphorous and heavy metals, etc. and they are also used as statutory tests prescribed by laws and regulations, etc.

(d) All-day tests

These are implemented with the objective of gauging hourly concentration fluctuations, mean concentration and load of influent sewage and treated effluent throughout the day, and they are an important type of test in conducting plant maintenance.

Water samples are taken and tested every one or two hours or at appropriate intervals in consideration of fluctuations in the quantity and quality of incoming sewage to a treatment plant.

In many cases, water quality tests on hourly samples are implemented according to the items of intermediate tests.

Water quality tests are implemented immediately after taking samples.

Table 6-3-7 Examples of Water Quality Test Frequency by Type of Test

Routine test	Every day, set times or composite sampling
Intermediate test	Around once/week, composite sampling
Precision test	Around once or twice/week, composite sampling
All-day test	Around once/month ~ 3 locations per test/month

c) Others

Other test items are as follows depending on the form of samples and targets of tests, etc.

(a) Sewage quality tests

These are tests conducted on influent sewage in sewers, pump stations and treatment plants, etc. and treated effluent from treatment plants.

(b) Activated sludge tests

These are tests that target activated sludge. They include physical/chemical tests targeting SV, MLSS, MLVSS and MLDO, etc. and biological tests such as qualitative and quantitative tests on activated sludge living organisms.

(c) General sludge tests

These are tests that target initial sedimentation tank sludge and sludge inserted into sludge treatment facilities.

The test items include sludge pH, evaporation residue, ignition residue, ignition loss and alkalinity, etc.

(d) Digestion gas tests (anaerobic treatment)

Digestion gas tests entail analyzing digestion gas generated in sludge digestion tanks and target items such as methane, carbon dioxide, hydrogen, oxygen, nitrogen and hydrogen sulfide, etc.

(4) Test items according to water treatment facilities

The test items used in water treatment facilities are summarized in **Tables 6-3-8** and 6-**3-9**.

These items are measured according to classification as routine tests, intermediate tests, precision tests and all-day tests, etc.

Also indicated are examples of the types and frequencies of water quality tests in each facility in a standard treatment plant.

(5) Test items according to sludge treatment facilities

The test items used in sludge treatment facilities are summarized in **Table 6-3-10** Of these items, those that are routinely tested for water quality management are tested between 2~4 times a month.

Concerning analysis for disposal of sludge cake, tests of content including heavy metals, etc. are implemented according to actual conditions at each treatment plant based on legal criteria.

Table 6-3-8 Recommendable of Guidelines for Sewage and River Water Tests

Item \ Test	Routine tests (intermediate tests)					A-T mixture	Return sludge	Precision tests				All-day tests				River tests
	STP influent	Initial sedimentation tank influent	Initial sedimentation tank effluent	Final sedimentation tank effluent	Discharge effluent			STP influent	Initial sedimentation tank influent	Initial sedimentation tank effluent	Final sedimentation tank effluent	STP influent	Initial sedimentation tank influent	Initial sedimentation tank effluent	Final sedimentation tank effluent	
Air temperature				1D							4Y				4Y	4Y
Water temperature	1W	1W	1W	1W		1D		4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y
Transparency				1D							4Y				4Y	4Y
pH	1D	1D	1D	1D		1D	1D	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y
Evaporation residue								4Y	4Y	4Y	4Y					4Y
Ignition residue								4Y	4Y	4Y	4Y					
Ignition loss							1W	4Y	4Y	4Y	4Y					
Suspended solids	1W	1W	1W	1W		3W	3W	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y
Dissolved solids								4Y	4Y	4Y	4Y					
Chlorine ion				1W				4Y	4Y	4Y	4Y					4Y
BOD	1W	1W	1W	1W	1W			4Y	4Y	4Y	4Y					
ATU-BOD				1W							4Y					
COD	1D		1D	1D	1D			4Y	4Y	4Y	4Y					
TOC											4Y					
Sedimentation rate						1D	1D									
Dissolved oxygen						3W										4Y
Living organisms						1D										
Coliform bacteria	1W			1W	1W			4Y		4Y	4Y	4Y		4Y	4Y	4Y
Enterococcemia																4Y
General bacteria																4Y

Table 6-3-9 Recommendable of Guidelines for Sewage and River Water Tests

Item \ Test	Intermediate tests				Precision tests				River tests
	STP influent	Initial sedimentation tank influent	Initial sedimentation tank effluent	Final sedimentation tank effluent	STP influent	Initial sedimentation tank influent	Initial sedimentation tank effluent	Final sedimentation tank effluent	
Total nitrogen	2M		2M	2M	4Y	4Y	4Y	4Y	4Y
Ammonia nitrogen			2M	2M	4Y	4Y	4Y	4Y	4Y
Nitrite-nitrogen				2M	4Y		4Y	4Y	4Y
Nitrate nitrogen				2M	4Y		4Y	4Y	4Y
Total phosphorous	2M		2M	2M	4Y	4Y	4Y	4Y	4Y
Dissolved total phosphorous					4Y	4Y	4Y	4Y	
Positive phosphorous, acidic phosphorous								4Y	4Y
Negative ion active-surface agent					4Y		4Y	4Y	4Y
Extractive substance in normal-hexane				2M	4Y		4Y	4Y	4Y
Phenols				2M	4Y			4Y	
Total cyan				2M	4Y			4Y	
Cadmium				2M	4Y			4Y	
Lead				2M	4Y			4Y	
Hexavalent chrome				2M	4Y			4Y	
Total chrome				2M	4Y			4Y	
Copper				2M	4Y			4Y	
Zinc				2M	4Y			4Y	
Nickel				2M	4Y			4Y	
Dissolved iron				2M	4Y			4Y	
Dissolved manganese				2M	4Y			4Y	
Arsenic					4Y			4Y	
Total mercury					4Y			4Y	
Alkyl mercury								4Y	
Organic phosphorous								4Y	
Fluorine ion					4Y			4Y	
Trichloroethylene, etc.					4Y			4Y	
PCB								2Y	
Hue	2M		2M	2M					4Y
Odor	2M		2M	2M					4Y

(Remarks)

1 .Test frequency symbols are as follows:

1D: Once/day

1W: Once/week

2M: 2 times/month

4Y: 4 times/year

2.Alkyl mercury, trichloroethyleneand PCB are spot sampledat 11:00.

PCB is tested in summer and winter.

3.BOD in final effluent is spotsampled during chlorine disinfecting, etc.

4.Conduct for mixed samples of ATU-BOD, etc. in effluent from the final sedimentation tank in all-day testing.

5.Conduct routine tests and precision testson composite samples using an automatic sampler.

Table 6-3-10 Recommendable of Sludge Test Guidelines (1/2)

Item \ Sample	Precision tests																											
									Anaerobic digestion					Wet oxidation				Fenton oxidation treatment					Incineration ash, etc.					
	Adjusted sludge	Adjustment tank separated liquid	Night soil	Centrifuge thickened supplied sludge	Centrifuge thickened sludge	Centrifuge thickening separated liquid	Dewatering filtrate	Return water	Transfer fluid	Supernatant liquor	Digested sludge	Washed sludge	Washing tank separated liquid	Raw sludge	Softened sludge	Oxidized mixture	Ash residue	Raw water	Biological treatment water	Secondary treatment water	Coagulated sludge	Neutralized sludge	Incineration ash, etc. ZPCake		Dried sludge		Dewatered cake	
																							Content	Elution	Content	Elution	Content	Elution
Ca hardness														4Y	4Y													
COD*	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y		4Y					4Y	4Y	4Y								
COD**															4Y	4Y	4Y	4Y										
BOD	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y		4Y		4Y	4Y	4Y	4Y	4Y	4Y								
Volatile organic acid	4Y		4Y	4Y	4Y	4Y		4Y	4Y		4Y																	
Total nitrogen	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y		4Y		4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y		4Y		4Y	
Ammonia nitrogen	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y		4Y		4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y						
Total phosphorous	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y		4Y		4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y		4Y		4Y	
Dissolved total phosphorous	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y		4Y		4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y						
Extractive substance in normal																							4Y		4Y		2Y	
Total cyan	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Alkyl mercury	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Organic phosphorous	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Total chrome	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Lead	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Hexavalent chrome	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Arsenic	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Total mercury	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Cadmium	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Copper	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Zinc	2Y																						4Y	4Y	4Y	4Y	2Y	2Y
Calium																									4Y			
Natrium																									4Y			
Calcium																									4Y			
magnesium																									4Y			
PCB																							2Y	2Y	2Y	2Y	1Y	1Y
Trichloronitromethane, etc.																								1Y		1Y		1Y

Note) COD*:Oxygen consumption by KMnO in 100% acid

COD**Oxygen consumption by K2Cr20

Table 6-3-10 Recommendable of Sludge Test Guidelines (2/2)

Item \ Sample	Routine tests																	
											Anaerobic digestion							
	Initial sedimentation tank	Adjusted sludge	Adjustment tank	Night soil	Centrifuge thickened	Centrifuge thickened	Centrifuge thickening	Dewatered cake	Dewatering filtrate	Return water	Transfer fluid	Supernatant liquor	Digested sludge	Washed sludge	Washing tank separat	Digestion gas		Digestion tank concentration spread
pH	1W	1W		1W	2W	2W	2W		1W	3W		1W	1W	1W	1W			
Evaporation residue	1W	1W		1W	2W	2W	2W	1W	1W	3W	1W	1W	1W	1W	1W			2Y
Ignition loss	1W	1W		1W	2W	2W		1W			1W	1W	1W	1W				
Suspended solids							2W		1W	3W								
Total alkalinity													1W	1W				
Total hardness																		
Ca hardness																		
COD*							2W		1W	3W								
COD**																		
Total nitrogen																		
Ammonia nitrogen																		
Hydrogen sulfide																1W		
Methane																4Y		
Carbon gas																4Y		
Specific gravity							4Y											
3-hour sedimentation rate																		

(Remarks)

1 Test frequency symbols are as follows:

1D: Once/day

1W: Once/week

2M: 2 times/month

4Y: 4 times/year

2 Dewatering filtrate

Conduct at the sludge treatment center.

3 For total alkalinity and digestion tank concentration spread, omit the sludge treatment center.

4 Adjustment tank sludge interface is subject to constant monitoring.

Item \ Sample	Precision tests																			
									Anaerobic digestion						Incineration ash, etc.					
	Adjusted sludge	Adjustment tank separated liquid	Night soil	Centrifuge thickened supplied sludge	Centrifuge thickened sludge	Centrifuge thickening separated liquid	Dewatering filtrate	Return water	Transfer fluid	Supernatant liquor	Digested sludge	Washed sludge	Washing tank separated		Incineration ash, etc.	ZP cake	Dried sludge		Dewatered cake	
															Content	Elution	Content	Elution	Content	Elution
pH	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y			4Y		4Y		4Y
Evaporation residue	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y		4Y		4Y		4Y	
Ignition loss	4Y		4Y	4Y	4Y				4Y	4Y	4Y	4Y			4Y		4Y		4Y	
Suspended solids			4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y	4Y							
Total alkalinity											4Y	4Y								
Total hardness																				

(6) Sampling

Generally speaking, since water quality tends to fluctuate between different times and places, mixed samples are used in order to obtain the mean water quality. When preparing mixed samples, in cases where flow fluctuations are extreme, consideration should be given to the flow ratio when taking each sample.

When preparing a mixed sample from single samples taken at uniform time intervals, the amount of each sample is determined in proportion to the flow rate at each sampling time.

When preparing mixed samples over a long period in hot weather during the summer and so on, it is necessary to keep the samples in a cool, dark place such as a refrigerator.

(7) Test method

Standards of Test method are defined by DENR (refer Table 4-3-6). **Table 6-3-11**shows the test methods generally applied in Japan for reference.

Table 6-3-11 Test Methods of Japan

Test item	Test method	Test item	Test method
[Water quality tests]		Arsenic	Diethyl dithiocarboxylic acid absorption method
Air temperature	Mercury thermometer	Total mercury	Atomic absorption method
Temperature	Mercury thermometer	Alkyl mercury	Gas chromatograph method
Transparency	Transparency meter	PCB	Gas chromatograph method
pH	Glass electrode method	Trichloroethylene	Gas chromatograph method
BOD	General dilution	Tetrachloroethylene	Gas chromatograph method
Carbonaceous BOD	ATU dosing	Extractive substance in normal-hexane	Liquid extraction by Hexane method
COD	Potassium permanganate method at 100℃	Phenols	4—amino antipyrine absorption method
Residue on evaporation	Evaporation dry solids method	Copper	Atomic absorption method
Ignition residue	600℃ ignition ash method	Zinc	Atomic absorption method
Ignition loss	(Residue on evaporation - Residue on ignition)	Soluble iron	Atomic absorption method
SS	Glass fiber filter paper method	Soluble manganese	Atomic absorption method
Dissolved solids	(Residue on evaporation - SS)	Total chrome	Atomic absorption method
DO (dissolved oxygen)	Winkler natrium azide transformation method	Fluorine	Lantern alizarin conblexon absorption method
Oxygen saturation rate	(DO ÷DO saturation amount x 100)	Nickel	Atomic absorption method
Total nitrogen	(Kjeldahl nitrogen + nitrite-nitrogen + Nitrate-nitrogen)	Boron	Methylene blue absorption method
Ammonium-nitrogen	Neutral titration method	[Activated sludge tests]	
Nitrite-nitrogen	N-(1-napthyl) ethylene diamine absorption method	Temperature	Mercury thermometer
Nitrate-nitrogen	Brucine method	Sludge settling rate	30 minute sludge settling rate
Organic nitrogen	(Kjeldahl nitrogen - Ammonium-nitrogen)	SS	Centrifugal separation
Iodine demand	Sodium subsulfite titration method	Organic SS	(SS—600℃ ignition residue)
Chlorine ion	Caustic silver titration method	SVI	(Sludge settling rate x 10^4÷SS)
Total phosphorous	Sodium peroxoborate decomposition and molybdenum blue (ascorbic acid) absorption method	SDI	(100÷SVI)
Orthophosphoric acid	Filter paper 5C filtration and molybdenum blue (ascorbic acid) absorption method	DO	Winkler natrium azide transformation method
Alkalinity	Total alkalinity method	[Sludge tests]	
Coliform bacteria	Desoxycol acid culture method	Temperature	Mercury thermometer
Dissolved BOD	GF/B filtrate BOD	pH	Centrifugal separation and glass electrode method
Dissolved COD	GF/B filtrate COD	Residue on evaporation	Dry weight method
Anionic surfactant	Methylene blue absorption method	Ignition loss	(Residue on evaporation—800℃ ignition residue)
Cadmium	Atomic absorption method	SS	(Residue on evaporation—Dissolved solids)
Total cyanide	Villigene-villazoron absorption method	Dissolved SS	GF/B liquid residue on evaporation
Organic phosphorous compounds	Gas chromatograph method	Alkalinity	Centrifugal separation and total alkalinity method
Lead	Atomic absorption method	Organic acid	Centrifugal separation and direct titration method
Hexavalent chrome	Atomic absorption method		

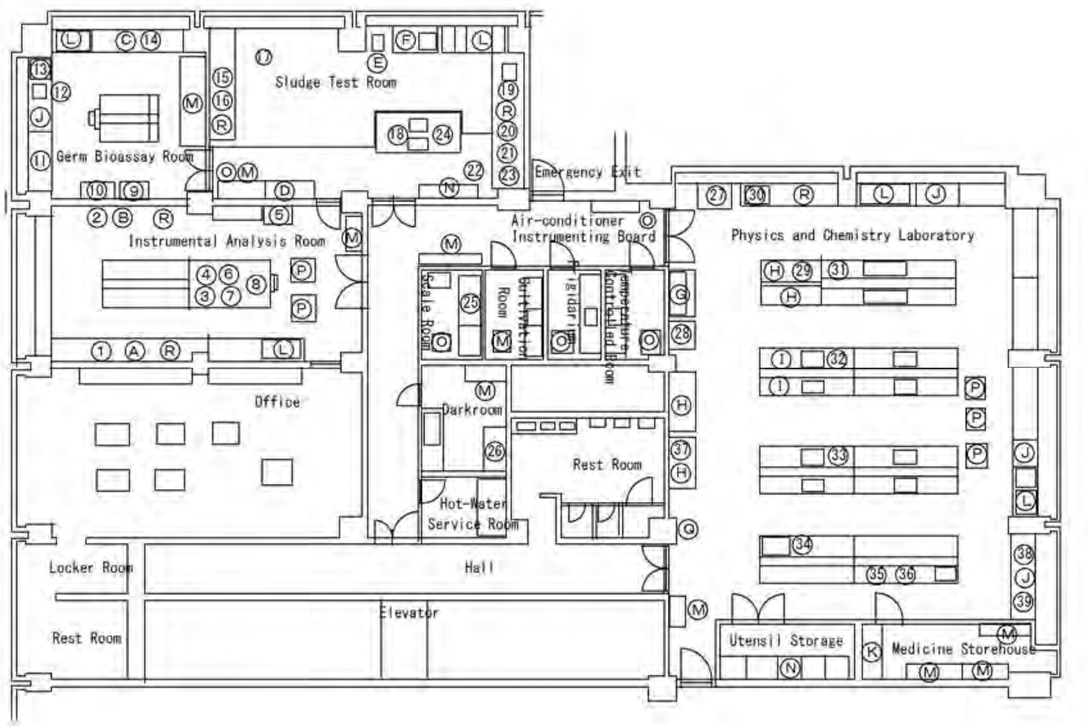
(8) Recommendable of layout and structure of test laboratory

Figure 6-3-2 shows the case where the water quality test laboratory is established in the central research laboratory and tests are conducted by expert staff in water quality analysis.

Figure 6-3-3 shows the case where the laboratory is installed in each treatment plant and conducts routine tests for conducting everyday operation management.

Table 6-3-12 shows an example of laboratory dimensions.

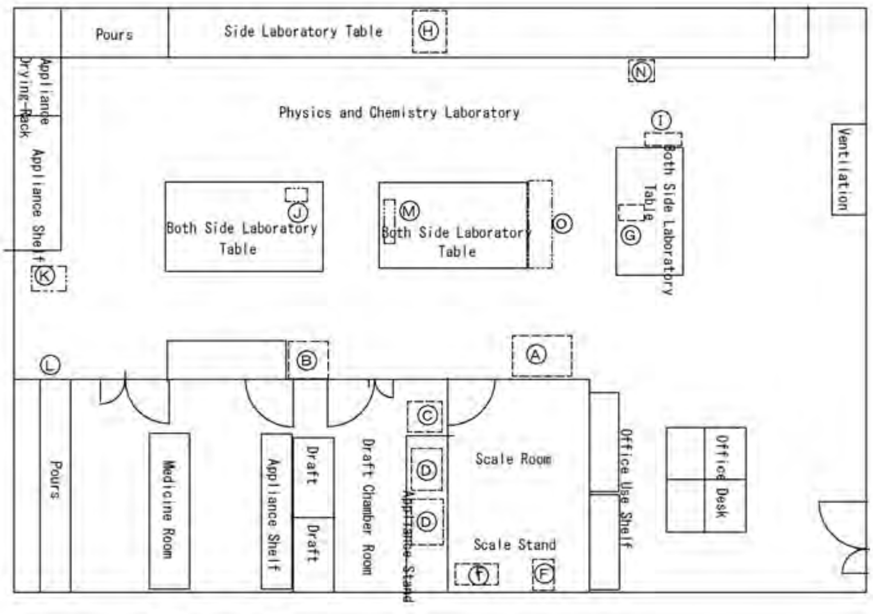
Figure 6-3-2 Water Quality Test Laboratory (Inside Central Research Laboratory)



No	Instrument	No	Instrument	No	Instrument	No	Instrument
1	Atomic absorption analyzer	11	Clean bench	21	Electric furnace	31	Dissolved oxygen meter
2	Gas chromatograph mass spectrometer	12	Dry heat sterilizer	22	Vacuum pump	32	Shaker
3	Absorptiometer	13	Steam under pressure sterilizer	23	Centrifugal separator	33	Thickener (heavy metals)
4	Infrared analyzer	14	Microscope	24	Conductance meter	34	Ammonium distilling machine
5	Electric refrigerator	15	Jar tester	25	Directly pointing scales	35	Cyan distilling machine
6	Total organic carbon meter	16	Leaf tester	26	Dark room unit	36	Fluorine distilling machine
7	Ion meter	17	Elution shaker	27	High speed centrifuge	37	Organic matter analyzer
8	Turbidity meter	18	pH meter	28	20℃ thermostatic chamber	38	Pure water plant
9	37℃ thermostatic chamber	19	Bath	29	COD bath	39	Ultrasonic cleaner
10	Refrigerated chemicals cabinet	20	Fixed temperature desiccator	30	Fixed temperature desiccator		

No	Test bench, etc.	No	Test bench, etc.
A	Atomic absorption test bench	K	
B	Gas chromatograph test bench	L	Instruments washing sink
C	Microscope table	M	Chemicals cabinet
D	Work bench	N	Equipment cabinet
E	Dirty objects sink	O	Mobile test bench
F	Sample preparation table	P	Wagon
G	Titration bench	Q	Fire extinguisher
H	Draft chamber	R	Artificial marble test bench
I	Organic solvent test bench	S	Combustion gas cylinder room

Figure 6-3-3 Water Quality Test Laboratory (Inside Each Treatment Plant)



Symbol	Instrument
A	Thermostatic chamber
B	Electric refrigerator
C	Electric furnace
D	Electric desiccator
E	Spectrophotometer
F	Directly pointing scales
G	Microscope
H	High purity water sampler
I	Ultrasonic cleaner
J	pH meter
K	Separated liquid coat shaker
L	Centrifugal separator
M	Socksun extractor
N	Vacuum pump

When planning the layout of a test laboratory, as a rule attention is given to the efficiency of test work. In other words, it is necessary to fully examine the contents of work conducted in each laboratory, to gauge work traffic lines and design the layout that enables work to be performed in the most efficient way.

Figure 6-3-4 shows the primary connections between laboratories based on the contents of test work. As can be seen in this figure, the large proportion of test work in a treatment plant is conducted in the physical/chemical test laboratory, while many of the other rooms are used in connection with this laboratory. Accordingly, the physical/chemical test laboratory should be situated in the middle and other rooms should be arranged around this when designing the layout of the facilities.

Figure 6-3-4 Connection between Each Laboratory Room

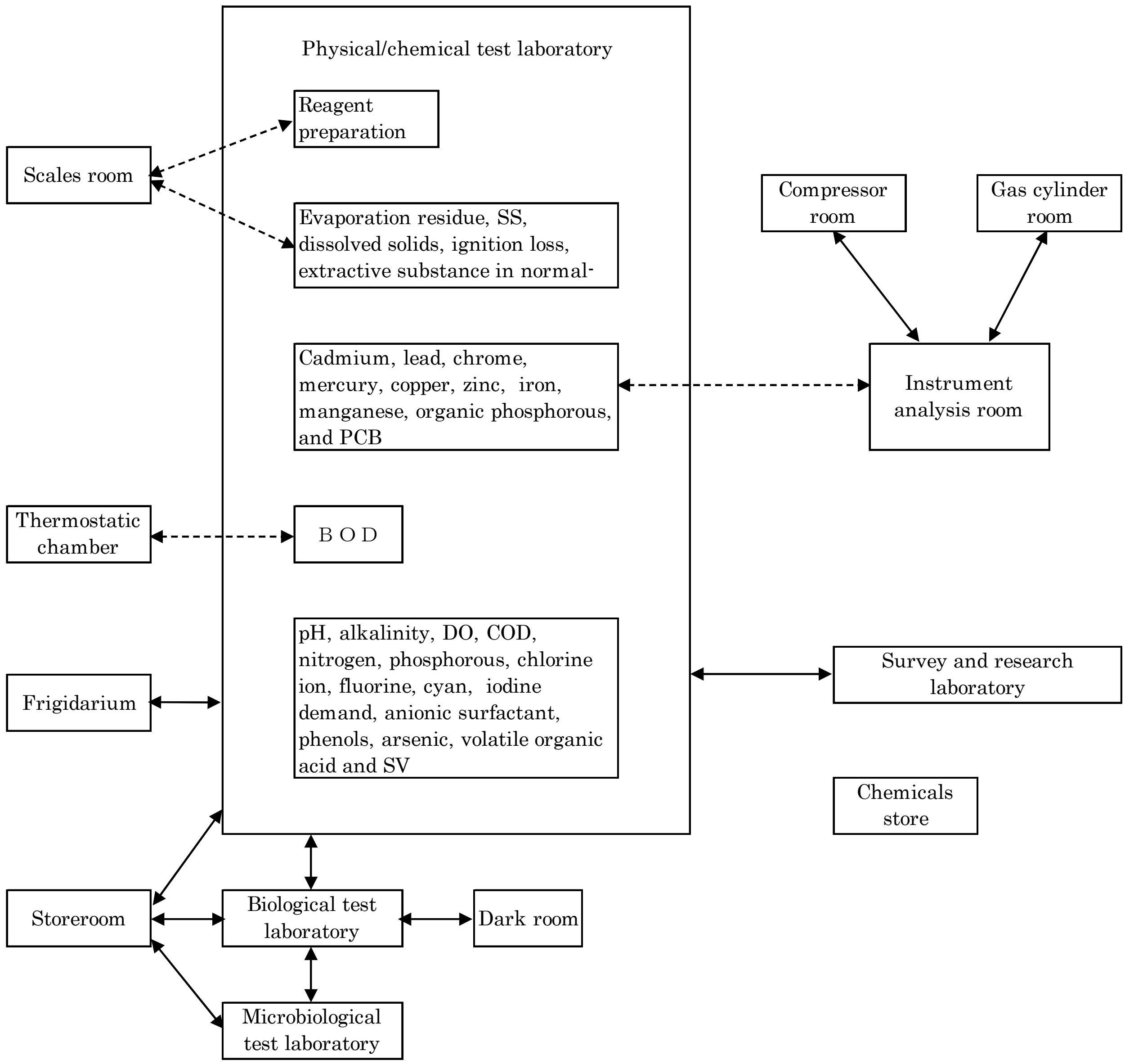


Table 6-3-12 Example of Laboratory Dimensions

Room	Area (m^2)	Room	Area (m^2)
Office	20~40	Dark room	5~15
Physical/chemical test laboratory	40~300	Thermostatic room	2~10
Instrument analysis room	15~70	Frigidarium	2~10
Biological test laboratory	10~30	Compressor room	0~5
Microbiological test laboratory (preparatory room and culture room)	10~40	Gas cylinder room	2~5
		Special experiment laboratory	20~50
Scales room	5~15		
Storeroom (chemicals store and equipment store)	10~20		

(9) Test Instruments

Tables 6-3-13 and **6-3-14** show the main types of test instruments used in each laboratory.

Table 6-3-13 Fixed Laboratory Equipment

Room	Fixed Equipment
Physical/chemical test laboratory	Double-sided test benches, side tables, instrument tables, draft chamber and cabinets
Instrument analysis room	Side tables, instrument tables and cabinets
Biological test laboratory	Double-sided test benches, microscope stands, side tables and cabinets
Microbiological test laboratory	Side tables, instrument tables and cabinets
Scales room	Scales stands and cabinets

When planning the main items of equipment, particular consideration should be given to the following items.

a) Test benches

Work tops should be resistant to acid, alkali and heat. Usually, lacquer-coated, aniline-coated and melanin resin-lined tops are used, however, strengthened timber infused with various types of compound resin are also used.

Test benches with sinks on a single side or both sides are easy to use. When the sink is located in the middle of the test bench, the available space on top of the bench is restricted and efficiency deteriorates.

Moreover, depending on the floor surface, it is sometimes better to install large numbers of small benches rather than just a few large-size benches.

b) Cabinets

Since large quantities of instruments, chemicals and objects are used in laboratories, it is necessary to install ample cabinet space. Cabinets are fixed to floors and walls to prevent falling during earthquakes, and it is also desirable to take steps to prevent objects from falling out. Moreover, direct sunlight should be avoided in order to prevent chemicals from becoming altered or deteriorating.

c) Draft chamber

Draft chambers are installed in order to enable tests that entail generation of harmful gases or odors. The number of draft chambers should be determined upon considering the space required to install a water bath, hot plate, thermal degrader and other permanent equipment as well as the space to implement other test operations that are suited to the draft chamber environment.

Since the inner walls of a draft chamber need to have heat and corrosion resistance, it is preferable to adopt stainless steel plate, Teflon or lead sheeting. Moreover, gas, water and electricity supply and exhaust equipment (anti-corrosive) are required inside the draft chamber, and it should be possible to control these from outside. Exhaust vents should be located in well ventilated locations that don’t have a negative impact on the surrounding area, and structure should be designed in such a way that no wind or rain enters the draft chamber.d) Instrument tables

Since the instruments used in a laboratory include very heavy items, when using over-the-counter side tables and so on, warping sometimes occurs and this adversely affects the precision of instruments and sliding smoothness of drawers.

Moreover, on tables that are fitted with desiccators and electric ovens, since problems exist in terms of weight an fire prevention, it is better to adopt concrete lining or polished surfaces.

e) Scales stands

Concrete lined or polished scales stands are the best type and are also effective for dealing with seismic vibration. If using over-the-counter scales stands, it is necessary to attach seismic dampers.

Table 6-3-14 Main Fixed Instruments

Instrument	Purpose of Use	Attached Equipment			
		Electric	Gas	Plumbing	Ventilation
pH meter	ｐＨ	○			
Directly pointing scales	Common	○			
Spectrophotometer	Common	○			
Atomic absorption analyzer	Heavy metals	○	Special ○	○	○
Gas chromatograph (ECD)	ＰＣＢ, alkyl mercury and organic phosphorous	○	Special ○		○
Gas chromatograph (TCD/FID)	Odor and exhaust gas	○	Special ○		○
Microscope	Living organisms	○			
Thermostatic desiccator	Common	○			
Dry-heat sterilizer	Bacteria	○			○
High-pressure steam sterilizer	Bacteria	○		○	○
Thermostatic water bath	SS, COD and residue on evaporation		○	○	○
Pyrolytic unit	Kjeldahl nitrogen		○		○
Electric furnace	Ignition loss and VSS	○			○
Thermostatic chamber	BOD	○			
Thermostatic chamber	Bacteria	○			
Pure water manufacturing plant	Common	○		○	
Centrifugal separator	SS and MLSS	○			
Vacuum pump	SS	○			
Distilling machine	Kjeldahl nitrogen	○		○	○
Distilling machine	Cyan	○		○	○
Distilling machine	Phenols	○		○	○
Distilling machine	Fluorine	○		○	○
Refrigerator	Common	○			
Shaker	Pretreatment of ABS and heavy metals	○			
Shaker	Elution tests	○			
Mercury decomposition device	Mercury	○		○	○

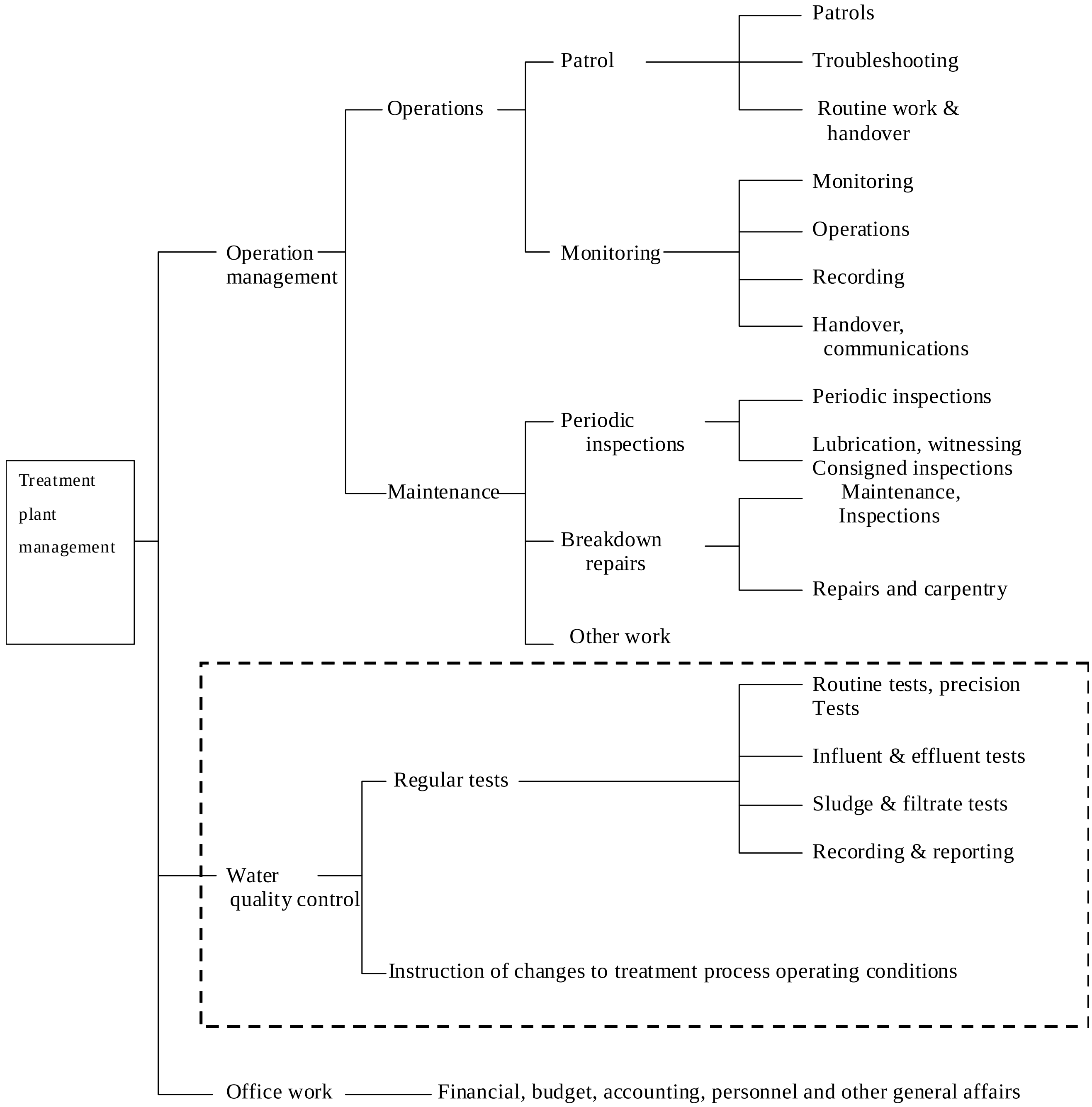
Note 1. ○ marks in the attached equipment column indicate necessary equipment.
2. Gases marked as special are used for purposes other than fuel.
3. Thermostatic water bath and pyrolytic unit sometimes run on electricity without using gas.
4. High pressure steam sterilizer and distilling machines sometimes run on electricity without using gas.

(10) Operation and maintenance setup of treatment facilities

Table 6-3-15 shows the operation and maintenance setup for treatment facilities. Operation and maintenance of treatment facilities comprise the following activities:

- Operation of treatment plant
- Operation of facilities (sewage treatment, sludge treatment and disposal)
- Maintenance and inspection of facilities
- Water quality control

Table 6-3-15 Treatment Plant Management Work



Note: [dashed box] shows water quality test group。

(11) Division of roles between treatment plant laboratories and the central research laboratory

Central research laboratory
- Plant laboratory (1) ex. activated sludge treatment, digestion tank
- Plant laboratory (2) ex. lagoons
- Plant laboratory (3) ex. septic tanks

- In each treatment plant laboratory, relatively basic tests necessary for everyday operation and maintenance are implemented.
  Based on such tests, appropriate operation is conducted and daily reports on water quality are sent to the central research laboratory.
- The central research laboratory compiles plans on the intermediate tests, precision tests and all-day tests implemented by each treatment plant, and it gives instructions on how to perform such tests to the respective laboratories as well as assisting and cooperating with the work. (Composite sampling is carried out, and samples are sent by refrigerated transport to the central research laboratory for analysis regarding items that cannot be analyzed at each plant's laboratories).
- The central research laboratory organizes the reports on intermediate tests, precision tests and all-day tests, compiles annual reports on water quality (for all facilities including aerobic treatment, anaerobic treatment and sludge treatment facilities, etc.) and uses them for the following objectives.
  A. These annual reports on water quality are analyzed from various angles and provide important materials for improving operating methods at each facility and investigating measures for addressing problems.
  B. These annual reports on water quality are useful for securing appropriate budgets and personnel for securing good quality of treated effluent and improving plant operations in relation to the operating state of equipment (periodic inspections, cleaning, use of spare units, etc.) and maintenance of facilities including consumption of electricity and chemicals, operating personnel, operating times of dewatering machines, digestion tank boilers and generators, etc.
  C. These annual reports on water quality compile changes over time in influent water quality and statistics on operating methods and treated water quality trends, etc., and they contribute to the examination of future plant extensions and expanded treatment systems, etc. (including long-term plans and annual plans on the national scale, etc.).
- The central research laboratory is always working to support research geared to future improvements, for example, targeting new treatment methods suited to the incoming sewage quality, impacts of problematic industrial wastewater on treatment plants and so on.

Table 6-3-16 summarizes the relationships that exist between these various activities.

Table 6-3-16 Role of Divisions between Treatment Plant Laboratories and the Central Research Laboratory

Treatment plant laboratories	Central Research Laboratory	
1. Routine tests and reports	1. Compilation of test plans	4. Other work, preparation of annual reports on water quality
2. Intermediate tests	2. Prompt analysis of incoming samples	Examination and instruction of improvements to operating methods
3. Precision tests	3. Planning, instruction and cooperation with the above work	Examination of data for preparing budget
4.All-day tests	Analysis work apart from that for routine test items	Examination of data for future plans and research tasks

(12) Reference materials

a) Water quality control records

In order to clarify water quality control performance, the following water quality control records are prepared.

These water quality control records are not simply achieved but they should be used to compare plans with actual conditions so that the improvements in plant operation can be quickly reflected in the planning and design departments.

- Routine test results sheet
- Intermediate test results sheet
- Precision test results sheet
- Aeration tank test results sheet
- Sludge test results sheet
- Return water test results sheet
- Digestion gas test results sheet
- Sludge content test results sheet

b) Recommendable Contents of water quality test items

The contents of water quality test items are prescribed in the DENR standards, however, the following items are recommended in consideration of greater treatment flow and sophistication of standards in the water body in future.

(a) Water temperature

Water temperature is related to the existence of DO and living organisms, etc. in sewage. For example, when water temperature declines, the propagation rate of living organisms and decomposition rate of organic matter slow down. Moreover, concentration of saturated DO increases in line with decline in water temperature.

(b) Transparency

This refers to the clearness of incoming sewage and treated effluent, etc. Higher transparency means that water is clearer.

Since the same type of incoming sewage and treated effluent often displays a correlation with the SS and BOD included in water, it is generally possible to estimate the extent of turbidity from the quality of transparency.

(c) pH

pH is expressed as the customary logarithm of the reciprocal of the hydrogen ion concentration in water. A pH of 7 indicates a neutral state, while less than 7 indicates an acidic state, and more than 7 indicates an alkaline state. In many cases, influent sewage displays a stable neutral or slightly alkaline state, however, large-scale inflow of industrial wastewater can cause fluctuations, while putrefaction of accumulated sludge inside sewers can generate organic acid and cause the pH value to fall below the normal level. Moreover, in cases where nitrification reaction inside reaction tanks advances, alkaline consumption occurring in line with the nitrification reaction can sometimes cause pH to drop to around 6.0.

(d) Residue on evaporation, SS and dissolved solids

Residue on evaporation refers to residual substances that occur when influent sewage, treated effluent or sludge is evaporated and dried at temperatures between 105~110℃. SS refers to the substances that remain on when influent sewage or treated effluent, etc. is passed through a piece of filter paper of uniform standard (pore diameter of 1μm), and these are suspended in water. Moreover, dissolved solids comprise dissolved sugars or saline substances, etc. When sea water infiltrates the influent sewage, the amount of dissolved solids increases dramatically.

Residue on evaporation and SS are used when calculating the generated amount of sludge in a treatment plant and they are important test items for maintenance purposes. Moreover, in cases where the amount of dissolved solids in sludge

Furthermore, in cases where the quantity of dissolved solids in sludge is far smaller than the quantity of SS, the residue on evaporation is sometimes used as SS.

(e) Ignition residue and ignition loss

Ignition residue refers to the substances that remain after residue on evaporation is ignited to 600℃ and turned into ash, and the amount of solids that is lost when doing this is called the ignition loss. Generally speaking, ignition residue expresses inorganic matter while ignition loss expresses organic matter. Organic content can be expressed as ignition loss/residue on evaporation.

(f) Alkalinity

Alkalinity refers to the alkaline content of sewage and sludge comprising carbonate, hydrogen carbonate and hydroxides expressed in terms of the mg/l of the calcium carbonate (C_aCO_3) corresponding to these substances. Alkalinity is consumed by the nitrification reaction and produced by the denitrification reaction. It has been chemically demonstrated that the amount consumed is equivalent to 7.14 times the amount of nitrified nitrogen while the amount produced in equivalent to 3.57 times the amount of denitrified nitrogen.

(g) DO (dissolved oxygen)

DO (dissolved oxygen) is influenced by atmospheric pressure, water temperature and salt content, etc. In turbid water, since the consumed amount of DO is high, DO content is low, however, as water becomes clearer, the DO level approaches the saturated amount at that temperature. DO sometimes reach a super-saturated state in cases where there is sudden increase in the water temperature or there is rapid propagation in algae. DO is essential for the self purifying ability of water and waterborne living organisms, etc. in water.

(h) BOD

BOD (biochemical oxygen demand) expresses as mg/l the amount of oxygen depletion that occurs when organic matter and dissolved oxygen in water is broken down by aerobic microbes over five days at a temperature of 20℃. BOD, together with SS, is one of the most important test items used in the design and maintenance of treatment plants. Influent sewage is not normally affected by nitrifying bacteria, however, since the biologically treated effluent at treatment plants where nitrification is occurring contains nitrifying bacteria, ammonium-nitrogen exists in the treated effluent. Accordingly, in BOD tests, nitrification occurs in tandem with organic decomposition over the five days of culture, and the amount of oxygen used in nitrification (N-BOD) is added to that used in decomposing organic matter (C-BOD) and is also counted as BOD. In such a measurement method, since it is difficult to determine the functions of sewage treatment mainly geared to removing organic pollutants, BOD should be regarded as an indicator of organic pollution while measurement should target the C-BOD. In cases where it is necessary to measure C-BOD, steps are taken to limit nitrification.

(i) COD

COD (chemical oxygen demand) expresses as mg/l the amount of oxygen (O) required for oxidizing substances in water to be oxidized using oxidant under uniform conditions. As in the case of BOD, COD largely refers to organic pollutant substances in water and there is frequently a relationship between both elements. Generally speaking, when the BOD/COD ratio is high, it is easy to conduct treatment using activated sludge, but if the ratio is low treatment becomes more difficult.

COD is widely used in treatment plant routine tests and industrial wastewater tests because measurement can be performed in a relatively short time, the analysis method is easy and measurement is not hindered much by industrial wastewater, etc.

However, in this COD analysis approach, reducing substances such as nitrite-nitrogen become oxidized, causing the COD value to increase. When 1 mg/l of nitrite-nitrogen exists, the COD value increases by approximately 1.1 times the nitrogen concentration.

(j) Nitrogen

Nitrogen takes the following forms.

- Total nitrogen
  Ammonium-nitrogen, nitrite-nitrogen and nitrate-nitrogen are referred to as inorganic nitrogen, and this combines with organic nitrogen to give total nitrogen.
- Ammonium-nitrogen
  Ammonium-nitrogen expresses ammonium and ammonium salt in water in terms of the nitrogen content. The existence of this is general sewage derives from night soil.
- Nitrite-nitrogen
  Nitrite-nitrogen expresses nitrites in terms of the nitrogen content. This is

produced when ammonium-nitrogen in water is biochemically oxidized. Since this is relatively unstable, when it is subjected to oxidation, it becomes nitrate-nitrogen, and when it is biochemically reduced, it changes into nitrogen gas.

- Nitrate-nitrogen
  Nitrate-nitrogen expresses nitrates in terms of the nitrogen content. This is produced when ammonium-nitrogen in water passes through nitrite-nitrogen, etc. and becomes oxidized due to the action of nitrifying bacteria. In treatment based on the activated sludge method, nitrification advances and nitrate-nitrogen is sometimes detected in treated effluent depending on the conditions of DO and SRT (solids retention time), etc.
- Organic nitrogen
  Organic nitrogen refers to the nitrogen content of amino acids, proteins and other various organic compounds. The organic nitrogen of sewage becomes oxidized as treatment progresses and it changes into ammonium-nitrogen, nitrite-nitrogen and nitrate-nitrogen.

(k) Phosphorous

Phosphorous in sewage originates from infiltration by night soil, industrial wastewater and fertilizers, etc. Phosphorous exists either in the form of inorganic phosphates such as orthophosphoric acid, metaphosphoric acid and pyrophosphoric acid, etc. or organic phosphorous compounds such as phosphoric ester and phospholipids, etc. Phosphorous compounds are prone to change and largely turn into PO_4－P as a result of microbial action. Since activated sludge is a synthesis of living organisms, it also requires phosphorous, however, the required amount usually exists in sewage and excess phosphorous remains in treated effluent. Accordingly, phosphorous in water is a cause of eutrophication in the ocean, rivers, lakes and marshes, etc. and it is used as an indicator of water pollution.

(l) Chlorine ion

Chlorine ion refers to the chlorine of dissolved chloride salts in water.

Chlorine ion in water is mainly natrium chloride (salt) and is contained in large concentrations in domestic wastewater and night soil. Generally the chlorine ion concentration of influent sewage is 50~100 mg/l, and when this mixes with seawater or industrial wastewater, etc., the concentration of chlorine ion increases. High concentrations of chlorine ion accelerate the corrosion of metals.

(m) Fluorine

Fluorine is used in the manufacture of Freon gas (catalysts used in refrigerators), surface treatment of metals and delustering of glass, etc. Fluorine in water mainly originates from such industrial processes. Because it has extremely strong combining power, the fluorine contained in water mainly exists in the form of low toxicity or harmless fluorine compounds.

(n) Cyanide

Cyanide in water mainly originates from industrial wastewater, in particular plating and metal quenching and refining processes, and it is included in cyan ion and cyan complex ion, etc. Such substances are highly toxic even minute amounts can impede sewage treatment; moreover, existence in large quantities can cause harm to maintenance personnel working in sewers, etc.

When wastewater containing cyanide mixes with acid, highly toxic hydrocyanic acid is produced. Therefore, particular care is needed when conducting surveys of factory wastewater, etc.

(o) Iodine demand

Iodine demand refers to the amount of iodine that is consumed by reducing substances such as mainly sulfides, ferrous salt and unstable organic matter, etc. Since measurement is easy, iodine demand is frequently used for measuring the strength of reduction capability and quantity of hydrogen sulfides in samples. Incidentally, 1 mg of hydrogen sulfide is equivalent to approximately 7.5 mg of iodine demand.

(p) Extractive substance in normal-hexane

Extractive substance in normal-hexane refers to substances extracted in hexane, which is a type of solvent, and usually includes oils, wax and mineral oil, etc. in water.

Extractive substance in normal-hexane is a cause of scum and also has a harmful impact on sewage system operations and sludge digestion processes.

(q) Anionic surfactant

Anionic surfactant is an active constituent of household synthetic detergents.

Anionic surfactants comprise hard types (ABS) and soft types (LAS), and most detergents on sale today comprise soft types. Anionic surfactant causes foaming in aeration tanks and discharged effluent. More than 90% of the soft type anionic surfactant is decomposed in aeration tanks.

(r) Phenols

Phenols refer to carbolic and various phenolic compounds, and the phenols contained in water largely originate from wastewater from chemical factories such as coal-gas plants, pharmaceutical plants and synthetic resin plants, etc. as well as from hospitals and clinics, etc.

Phenols are a cause of bad odor when they exist in large quantities, and they also have negative effects on treatment processes in treatment plants.

(s) Organic phosphorous compounds

Organic phosphorous compounds in sewage tests mainly refer to four types of organic phosphorous used in agricultural chemicals, i.e. the highly toxic parathion, methyl parathion, EPN and methyl demeton.

(t) Heavy metals

Heavy metals describe metals with a specific gravity of 4 or higher.

Not only do heavy metals cause grave impacts in biological treatment but they also hinder the treatment of sludge when they accumulate in sludge.

- Cadmium
  Cadmium in water generally originates out of the wastewater of plating, metal refining and chemical plants, etc. Cadmium has extremely strong toxicity with respect to activated sludge and leads to the deterioration of treated effluent quality. It also hinders utilization of sludge on green spaces and farmland.
- Lead
  Lead in water generally originates out of wastewater from pigment manufacturing plants, pottery making, dyeing and printing and plate making, etc. Lead has lower toxicity with respect to activated sludge than other heavy metals and it has only

minor impact on the transparency and SS of treated effluent, however, it causes hardly any change in BOD and COD removal rates.

- Chrome (total chrome and hexavalent chrome)
  Chrome in water generally originates out of the wastewater from plating, metals, pigment manufacturing, printing and late making, leather tanning and chemical plants, etc.
  Chrome compounds range from monovalent to hexavalent but stable compounds are trivalent chrome and hexavalent chrome compounds, and it is this latte one that has a much bigger impact on biological treatment. Generally speaking, cases where the impacts of hexavalent chrome are chronically sustained are rare, however, temporary inflow causes clear impacts to become manifest.
- Arsenic
  Arsenic is used in alloys and semiconductors, while its compounds are used in insecticides and agricultural chemicals, etc. Arsenic has extremely high toxicity in the human body. Arsenic in water mainly originates from groundwater and wastewater from agricultural chemical plants and metal refineries, etc. It can hinder the utilization of sludge on open spaces and farmland.
- Total mercury (all mercury compounds including mercury and alkyl mercury)
  Mercury in water originates out of the wastewater from inorganic mercury compound manufacturing, electrical appliance and instrument manufacturing, hospitals, thermometers and other measuring device manufacturing processes, etc. Mercury imparts a major impact on sewage treatment: in the case of the activated sludge process, it prevents removal of organic matter and hinders the utilization of sludge on open spaces and farmland.
- Copper
  Copper in water generally originates out of wastewater from plating, metal processing and synthetic textile manufacturing plants, etc. Compared to other metals, copper has a large impact on treatment.
- Zinc
  Zinc in water generally originates out of wastewater from plating, alloys, type printing, dye and pigment manufacturing processes, etc. When zinc builds up in activated sludge, it can hinder the utilization of sludge on open spaces and farmland.
- Iron (soluble)
  Iron in water mainly originates from groundwater, industrial wastewater and iron pipes, etc. When ferric ion exists in large quantities in water, it causes discoloration of treated effluent.
- Manganese (soluble)
  Manganese in water mainly originates out of wastewater from ironworks, steelmaking, ferro-manganese manufacturing and manganese refineries, etc.

(u) PCB

PCB (polychlorinated biphenyl) was widely used in industry; however, its manufacture was stopped due to environmental problems. Accordingly, there is little likelihood of large amounts of PCB causing water pollution in the future, however, there is still risk that it will leak into influent sewage from old papers, electrical appliances and other existing or used products.

(v) Trichloroethylene, etc.

Trichloroethylene, etc. refers to two substances, i.e. trichloroethylene and tetrachloroethylene. These are mainly used in metal washing agents and solvents, etc. Due to their negative impact on humans, groundwater contamination by trichloroethylene, etc. is a problem. Control items are prescribed for 1, 1, 1- trichloroethane and carbon tetrachloride.

(w) General bacteria

General bacteria refer to live bacteria that form communities in standard agar media. They include various types of aerobic and facultative anaerobic bacteria.

(x) Coliform bacteria

Coliform bacteria refer to Gram-negative and asporogenic Brevibacillus brevis, which generate acid and more than a set amount of gas when they decompose lactose over a certain time.

Similar to general bacteria, since coliform bacteria rapidly diminish as purification advances, they are used as an indicator for determining the treatment effect of treatment facilities and securing sanitary safety following treatment.

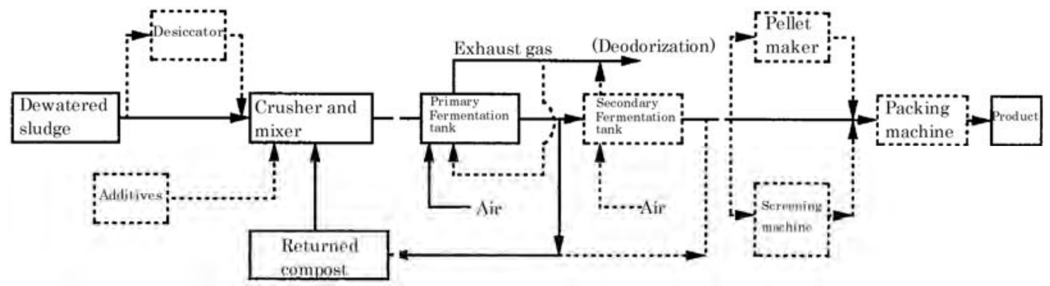
6.4 Sewage Sludge Effective Utilization

Sewage sludge could be used as materials for production of fertilizer or construction materials, otherwise as bio-energy for boiler or power generation systems by methane gas generated in the process of degrading the sludge. The variable utilizations of the sewage sludge are described here under.

6.4.1 Compost

As was mentioned earlier, since sewage sludge is composed of fertilizing constituents such as nitrogen and phosphorous and various other organic and inorganic components, it has high value for use as an organic supplement on green spaces and farmland. Composting (fertilizer conversion) of sewage sludge entails decomposing (fermenting) the separable organic matter in sludge in an aerobic environment and stabilizing its form and properties until it can be used on green spaces and farmland. **Table 6-4-1** shows the basic processes and main equipment in composting facilities.

Table 6-4-1 Basic Processes and Main Equipment of Composting Facilities

	Pre-adjustment	Fermentation	Product conversion
Basic processes			
Main equipment	- Hoppers - (Desiccator) - Weighing machine - Crusher and mixer	- Fermentation tanks -(Deodorization equipment) - Cutting unit - Blower - Removal and return equipment	- Removal equipment - (Return equipment) - Hopper - (Sieve) - Weighing machine - (Pellet maker) - Packing machine

In the pre-adjustment process, ventilation is improved, water content is adjusted and pH adjustment is carried out in order to promote the manufacture of good quality compost. For that purpose, return compost and sub-materials such as chaff and sawdust, etc. are added to the dewatered sludge that is the primary raw material, crushing and mixing are carried out and the mixture is put into the fermentation tanks. In the fermentation process, organic matter decomposition and water content evaporation take place and these reactions are generally divided into primary fermentation and secondary fermentation. In primary fermentation, rapid temperature increase and water content evaporation take place, while the secondary fermentation process is more sedate. During this fermentation stage, necessary oxygen is fed (ventilation) and the fermenting mixture is appropriately mixed (turned) in order to accelerate the reaction. Aerobic microbes break part of the organic matter (carbohydrates, protein, fats, etc.) down into glucose, amino acid and fatty acid, etc. in an environment suited to life (temperature, pH, water content, aerobic atmosphere, etc.), and they eventually decompose it into carbon dioxide, ammonium, water and mineral salts. Almost all the generated carbon dioxide and ammonium are dissipated into the atmosphere, while the water content of dewatered sludge evaporates due to the heat generated in decomposition (fermentation heat).

The main effects of stabilization arising from this fermentation reaction are as follows:

- Decomposition of the organic matter of sludge by microbes reduces the quantity of sludge and prevents odor and growing impediments (root rot, pH damage) caused by saprogenous gases.

- The calorific value generated in line with the decomposition of organic matter causes the water content of sludge to evaporate, thereby leading to quantity reduction; moreover, the reduced water content of the final compost product makes it more useable as a fertilizer (when applying and storing, etc.).
- At fermentation temperature of 65℃ or more (sometimes reaching as high as 80℃), bacterial pathogens, pest larvae and seeds of weeds that have been carried into the sludge by sewage are destroyed or rendered inert, thereby securing safety in the compost.

Fermentation equipment is intended to conduct these activities efficiently. Through preparing environmental conditions suited to microbial reaction, it is important to accelerate the fermentation process and thereby shorten the fermentation period and improve efficiency of water content evaporation.

In the product manufacturing process, sifting, pellet making and packing into bags are carried out in order to improve handle-ability in shipping, application and storage, etc. of the compost product.

Materials and products retention and storage equipments are important for buffering the intermittent flow of materials and products in the compost plant. Moreover, deodorization equipment is important for addressing corrosion of equipment and impacts caused by generated gases in the local environment.

1) Generated quantity of compost

The scale of composting facilities should be determined according to the forecast demand for compost. Accordingly, the target demand and product quality are set based on market survey that takes local characteristics into account, while the design quantity of dewatered sludge for composting is set based on the material balance.

The relationship between the design quantity of dewatered sludge for composting and the quantity of compost product can be expressed by the following equation, assuming that there is no decomposition of additives.

Where,

Q: Quantity of compost product (t/d)

Q_o: Design quantity of dewatered sludge for composting (t/d)

W_o: Water content of dewatered sludge (%)

D: Decomposition rate of organic matter (%)

V_c: Organic content of dewatered sludge (%)

Q_A: Quantity of additives (t/d)

W_A: Water content of additives (%)

W: Water content of compost product (%)

2) Type of fermentation tanks

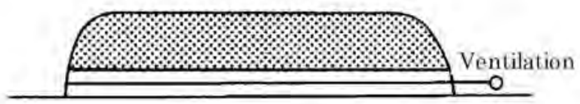
Types of fermentation tank are the sedimentary type, horizontal type and standing type, and selection of the type is made upon fully considering the capacity of facilities, properties of raw materials, ease of maintenance, economy, environmental impact (working environment and local environment) and track record, etc.

The features of each type are described below and in **Table 6-4-2**. Generally speaking, in the primary fermentation process, since fermentation advances rapidly and there are a lot of generated gases, the standing type is often adopted because it is suited to taking odor countermeasures. In the comparatively sedate secondary fermentation process, the sedimentary and horizontal types of tank are frequently adopted.

(1) Sedimentary fermentation tank

This types doesn’t require as much equipment as the standing and horizontal types, however, it needs a wide site area and is prone to the effects of weather conditions. Many such tanks have no ventilation equipment and have a long fermentation period (see **Figure 6-4-1**).

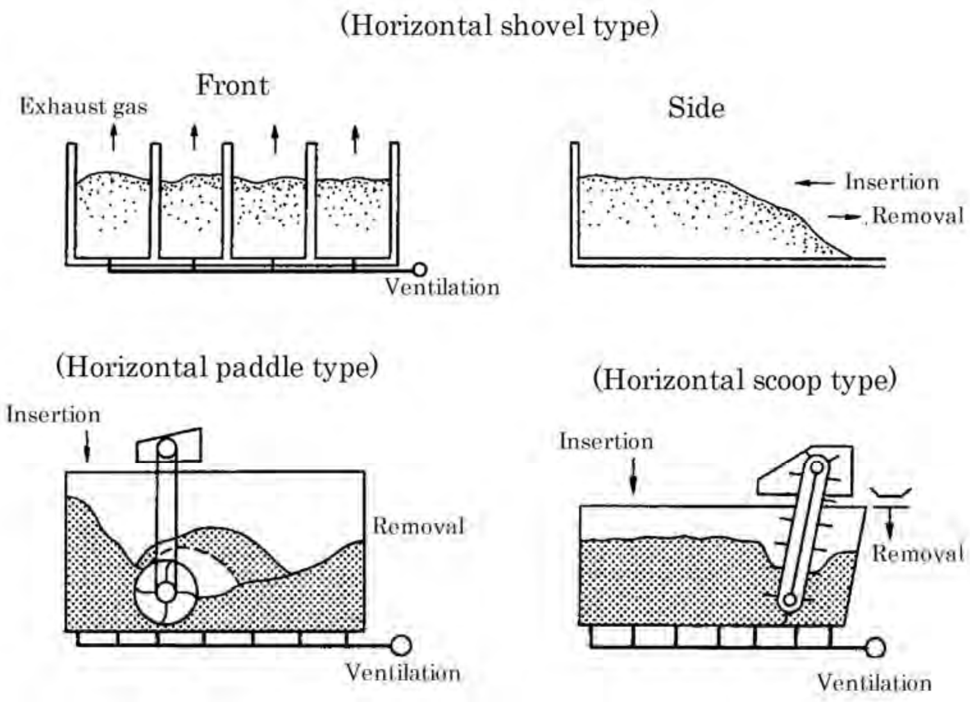
Figure 6-4-1 Sedimentary Fermentation Tank



(2) Horizontal fermentation tank

Horizontal fermentation tanks comprise the type in which materials are inserted, turned and moved by shovel and the type in which these tasks are performed by auxiliary equipment. The fermentation conditions and turning equipment can be monitored directly. Compared to the standing type, treatment capacity per unit area of tank is small. Care is required in order to manage odor, dust and steam, etc. (see **Figure 6-4-2**).

Figure 6-4-2 Horizontal Fermentation Tanks



(3) Standing fermentation tank

The mixture is inserted from the top and sinks to the bottom by its own weight while being turned by an attached device. Since the structure is closed, the work environment stays good; there I less loss of fermentation heat than compared to the open structure of horizontal tanks and so on, and it is easier to deal with odor. Compared to the other types, the tank equipment is a little more complex (see **Figure 6-4-3**).

Figure 6-4-3 Standing Fermentation Tank

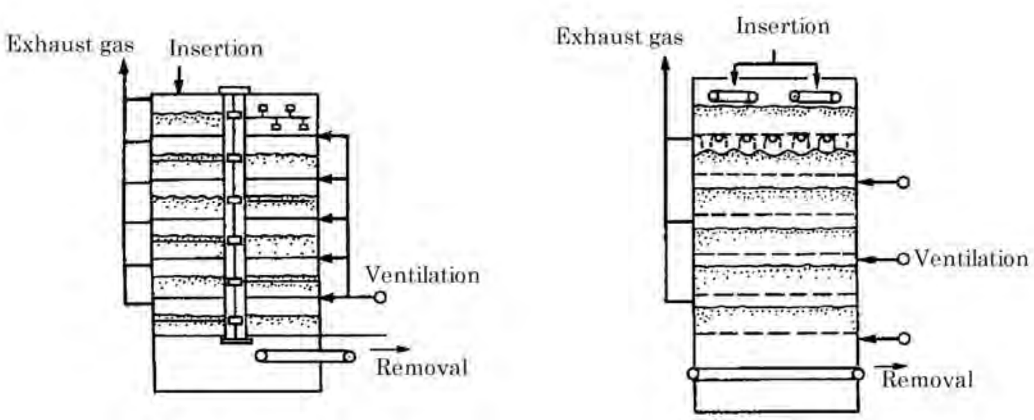


Table 6-4-2 Types and Features of Fermentation Tanks

<table>
<tr><th colspan="2">Tank Type</th><th>Structure</th><th>Frequency of mixture movement and turning</th><th>Ventilation method</th><th>Merits</th><th>Demerits</th></tr>
<tr><td rowspan="2">Sedimentary type</td><td>Natural ventilation</td><td rowspan="2">Flat floor with no partitions or enclosure</td><td rowspan="2">Perform by tractor shovel, etc. Around once/week</td><td>–</td><td rowspan="2">Facilities and simple and can be operated at a low price. High level technology is not required.</td><td rowspan="2">Ventilation is impeded by lumps.
The fermentation period is long.
A large site area is needed.
It is hard to obtain a uniform fermented product.
The tank is impacted by weather conditions.</td></tr>
<tr><td>Forced ventilation</td><td>Done by ventilation pipes on the floor of the tank.</td></tr>
<tr><td rowspan="3">Horizontal type</td><td>Shovel type</td><td>Top and single side closed type Rectangular tank</td><td>Perform by tractor shovel, etc. Around once/week</td><td rowspan="3">Done by ventilation pipes on the floor of the tank.</td><td>Facilities and simple and can be operated easily.
Since it is open, visual monitoring is possible.</td><td>Deodorization equipment becomes cumbersome.
Dust countermeasures are dificult to implement.
Ventilation is impeded by lumps.
It is hard to obtain a uniform fermented product.</td></tr>
<tr><td>Paddle type</td><td rowspan="2">Top open rectangular type</td><td>Movement and cutting by zigzag operation (front, back, across) of paddle.
Around once/day</td><td>Paddle cutting stops lumps from occurring and is good for ventilation. The fermentation period is short. Large-size fermentation tanks can be operated.</td><td>Deodorization equipment becomes cumbersome.</td></tr>
<tr><td>Scoop type</td><td>Movement and cutting by moving scoop.
2~6 times/week</td><td>Paddle cutting stops lumps from occurring and is good for ventilation.</td><td>Deodorization equipment becomes cumbersome.
Even the largest possible fermentation tank is small.</td></tr>
<tr><td rowspan="2">Standing type</td><td>Paddle type</td><td>Closed circular type</td><td>Simultaneous mixing and movement by rotating paddle on each stage so that mixture is moved to the opposite side of the paddle and continuously moves downwards.
Around once/day</td><td>Air is ventilated from each stage floor and is exhausted from the top of the tank.</td><td>Fermenting materials are mixed by the rotating paddle and are not compressed. Ventilation resistance is low and not much power is needed. Only small-scale deodorization equipment is needed.</td><td>The multi-stage system means that machine costs are expensive.</td></tr>
<tr><td>Trap door type</td><td>Closed circular type</td><td>Continuous movement downwards while mixing through opening and closing the trap door in each stage.
Once/2~4 days</td><td>Ventilation and exhaust are alternately conducted in each stage.</td><td>Site area is small.</td><td>Since mixing is done by natural dropping, appropriate crushing and ventilation cannot be anticipated.
Structure is relatively complicated.
The multi-stage system means that machine costs are expensive.</td></tr>
</table>

3) Fermentation period

The fermentation period is composed of the number of days required for the inserted mixture to pass through the fermentation tank and the number of days for fermentation of the return compost. Here, the generally adopted number of days that inserted materials spend inside the fermentation tank is used. Based on past experience, the standard fermentation period is as shown in **Table** 6**-4-3**.

Table 6-4-3 Fermentation Period

Process		Fermentation Period (Days)
Primary fermentation		10～14
Secondary fermentation	Natural ventilation	30～60
	Forced ventilation	20～30

6.4.2 Construction Materials from Melting

Sludge melting, as was mentioned earlier, is being introduced as a method for treating sewage sludge in large cities. It enables further volume reduction, stabilization and positive recycling as construction materials in addition to the benefits of sludge incineration.

The construction materials and other products obtained from melting differ greatly according to the slag cooling method adopted in the sludge melting system. **Table 6-2-10** section 6.2 showed the features of each cooling method and slag in sludge melting.

The typical types of sludge melting furnace are the rotatory melting furnace, the coke bed melting furnace and the surface melting furnace, and the principles of each type are described in the following paragraphs.

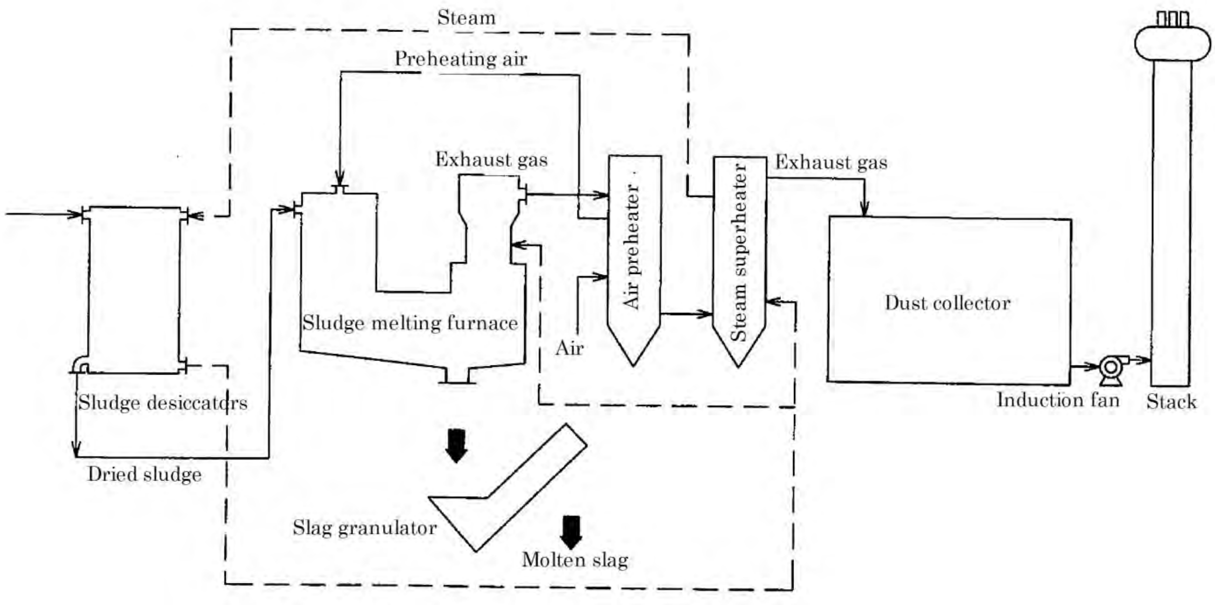
1) Rotatory Melting Furnace

There are various types of rotatory melting furnace in operation depending on the furnace model, the tilt of the furnace body and the process adopted in the pretreatment equipment. **Figure6-4-4** shows the flow of a typical rotatory melting furnace, while **Table 6-4-4** outlines the structure of each melting method.

The rotatory melting furnace generates a forceful rotating motion by blasting sludge pellets and combustion air into the cylindrical furnace at high speeds. In the case of a dried sludge melting system, the sludge pellets vaporize and gasify in the suspended state and combustion takes place in a short time. Larger size pellets receive centrifugal force and are captured by molten slag in the furnace walls; organic content combusts and is broken down into gas and char (carbon substance formed during thermal decomposition gasification), while inorganic content melts and becomes slag. Temperature inside the melting furnace is held at between 1,200~1,500℃ and this type of furnace ensures that the final slag contains no un-melted contents. In the case of an incineration ash melting system, since the organic content of sludge cannot be utilized, the heat obtained from exhaust gas is used together with auxiliary fuel in order to maintain the temperature inside the furnace.

There are various types of this kind of furnace, for example, standing rotatory melting furnace, tilted rotatory melting furnace, tilted melting furnace equipped with pre-combustion unit (cyclone pre-combustion section).

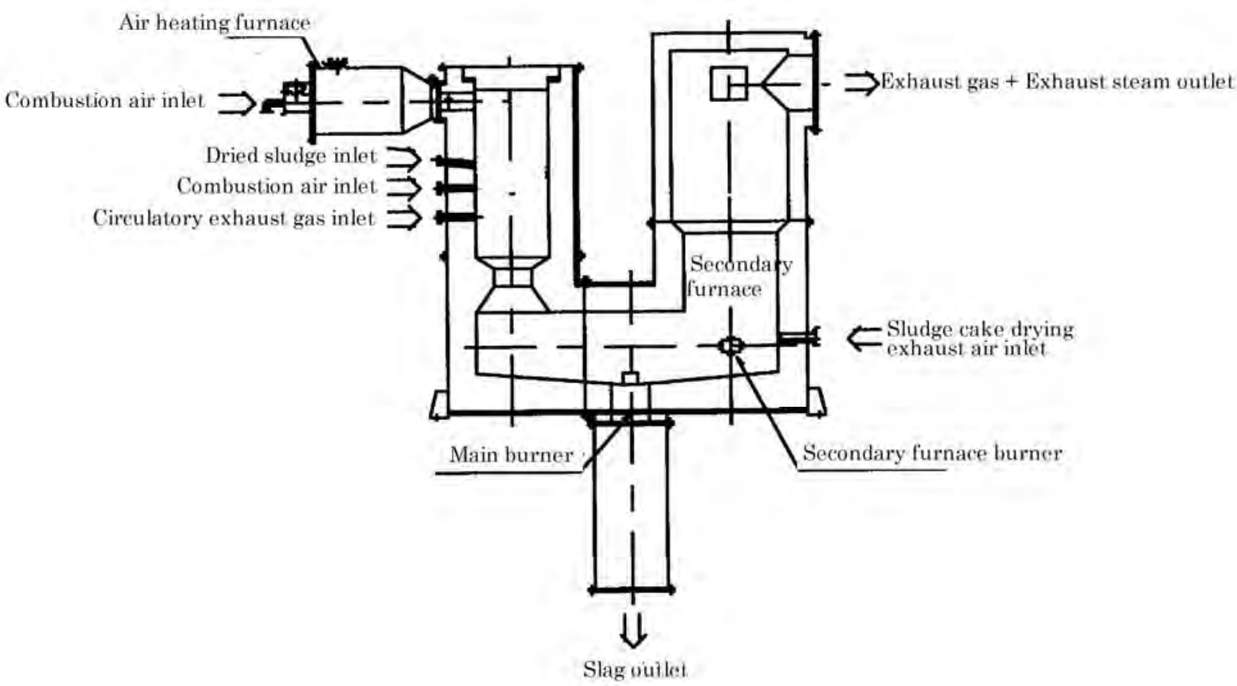
Figure 6-4-4 Flow of Rotatory Melting Equipment (Example of a Dried Sludge Melting System)



The above figure shows a typical equipment flow of the rotatory melting furnace, however, the composition of the pretreatment unit differs according to the condition of the materials put into the furnace. **Figure 6-4-4** shows a dried and dewatered sludge melting system, in which dried and dewatered sludge is first crushed before insertion. In the incineration ash melting system, an ash hopper is installed before the melting furnace, while a combustion air preheater (heat collector), exhaust gas treatment equipment and slag generation equipment are installed after the furnace. The exhaust gas treatment equipment behind the incineration ash melting furnace is sometimes combined with combustion equipment.

Figure 6-4-5 outlines the structure of the melting furnace body.

Figure 6-4-5 Outline Structure of the Rotatory Melting Furnace



2) Coke Bed Melting Furnace

As is shown in the flow in **Figure 6-4-6**, the coke bed melting furnace has a pretreatment unit in front of the furnace and also comprises a dewatered sludge volumetric feeder for giving a stable supply of materials to the furnace, a conveyor, desiccators, dried dewatered sludge forming machine, a coke (fuel) feeder, and units for feeding the basicity adjustment agents of limestone and crushed stone.

Behind the furnace are installed a combustion air preheater for recovering heat, and a waste heat boiler for supplying steam to the desiccator in the pretreatment system. Also there are an exhaust gas treatment system comprising a scrubber, etc. for making the exhaust gas suitable for discharge and a slag production system for cooling and hardening the molten liquid from the melting furnace and turning it into slag.

The steel plate outer shell of the coke bed melting furnace is internally lined with fireproof material and the structure is composed of the raw materials insertion section, the melting zone section and the free board section. The dry dewatered sludge (water content 30~40%) is transferred to the top of the structure with coke and is inserted into the furnace from the insertion section.

The base of the melting furnace is a coke bed heated with primary air to 1,500℃. In this heat, the sludge is dried and heated, and any combustible content is thermally decomposed, gasified and totally combusted in the freeboard section by the secondary air. Meanwhile, the ash content of sludge becomes molten slag that flows out while passing through the coke bed. **Figure 6-4-7** outlines the structure of the melting furnace body.

Figure 6-4-6 Outline Flow of the Coke Bed Melting Furnace

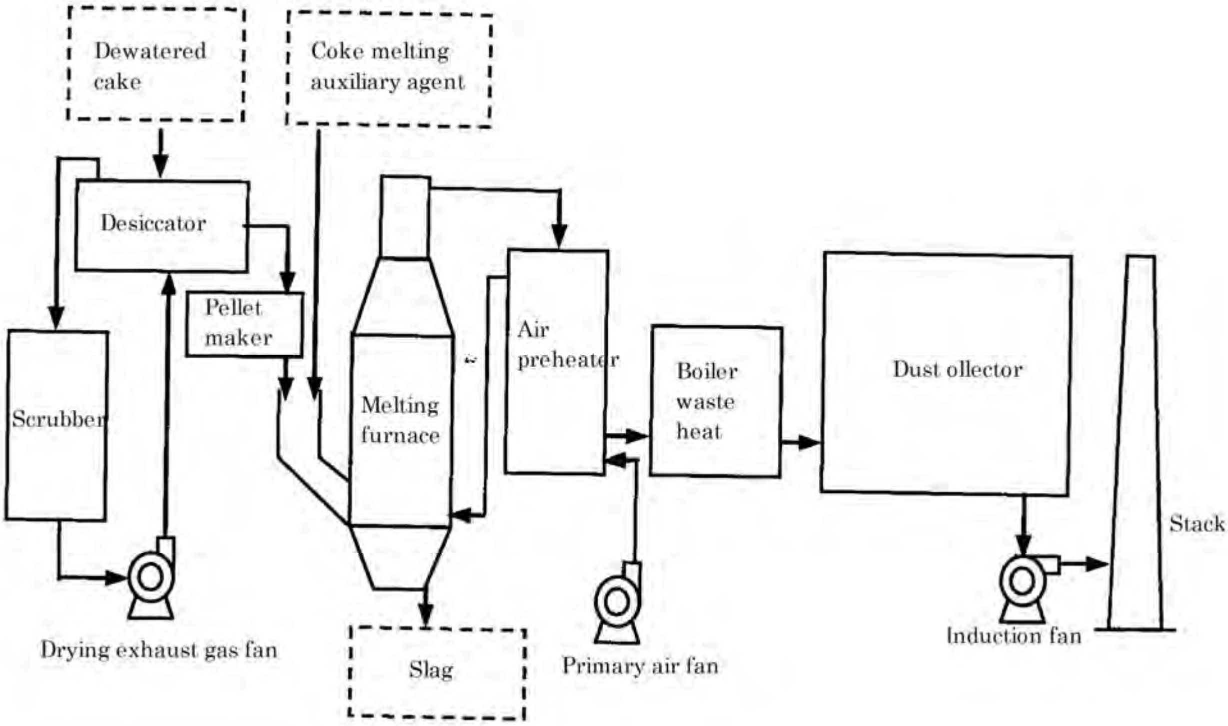
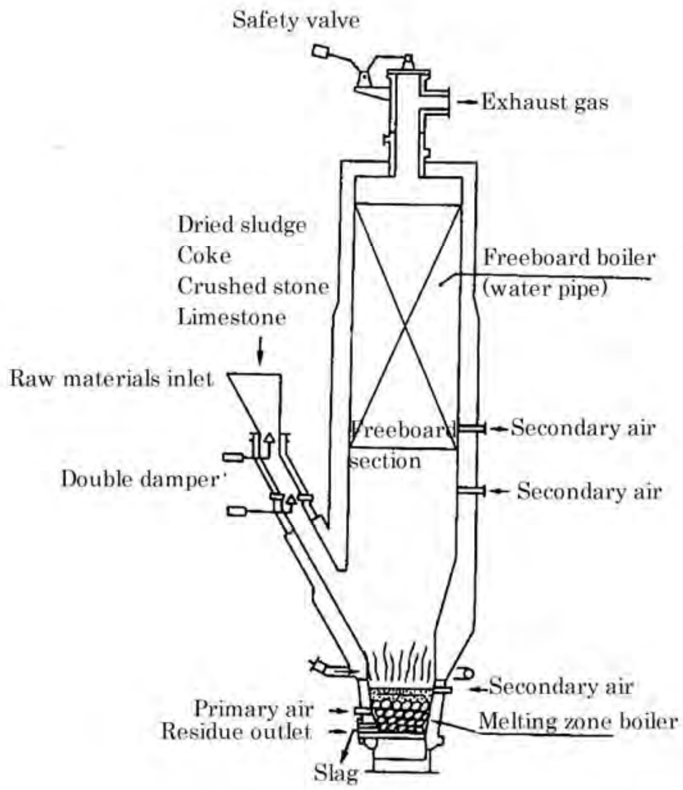


Figure 6-4-7 Outline Structure of the Coke Head Melting Furnace



3) Surface Melting Furnace

Figure 6-4-8 shows a typical equipment flow of the surface melting furnace. As pretreatment equipment in front of the furnace, there are a dried sludge storage hopper, volumetric feeder, conveyor and desiccators for ensuring a stable supply of materials to the furnace. Behind the furnace are installed a combustion air preheater for recovering heat, and a waste heat boiler for supplying steam to the desiccator in the pretreatment system. Also there are an exhaust gas treatment system for making the exhaust gas suitable for discharge and a slag production system for cooling and hardening the molten liquid from the melting furnace and turning it into slag.

The surface melting furnace is composed of the main combustion chamber and secondary combustion chamber. The main combustion chamber is an inverted shape comprising the ceiling section equipped with combustion support unit and the sludge targeted for melting, and the combustion heat from the sludge is used as the heat source for melting. The furnace is a vertical rotating structure consisting of an inner cylinder and outer cylinder, and the supply of sludge to the main combustion chamber is kept uniform by rotation of the outer cylinder.

Moreover, vertical motion of the cylindrical ceiling of the main combustion chamber causes the volumetric capacity of the combustion chamber to vary, thereby enabling the furnace to adjust to the treatment load.

The dried sludge (water content 15~25%) forms an inverted melting face in the main combustion chamber and is subjected to evaporation, thermal decomposition, combustion and melting. The melting surface receives radiant heat from the furnace ceiling, causing water content to evaporate and organic content to thermally decompose, and the gases from thermal decomposition are combusted by the preheating air so that temperature inside the main combustion chamber is held at 1,200~1,500℃ and exhaust gas is discharged from the slag port. The ash content of sludge is turned into molten slag by radiant heat from the furnace ceiling and combustion gas, and this runs out from the slag port.

Figure 6-4-9 outlines the structure of the melting furnace body.

Figure 6-4-8 Outline Flow of the Surface Melting Furnace

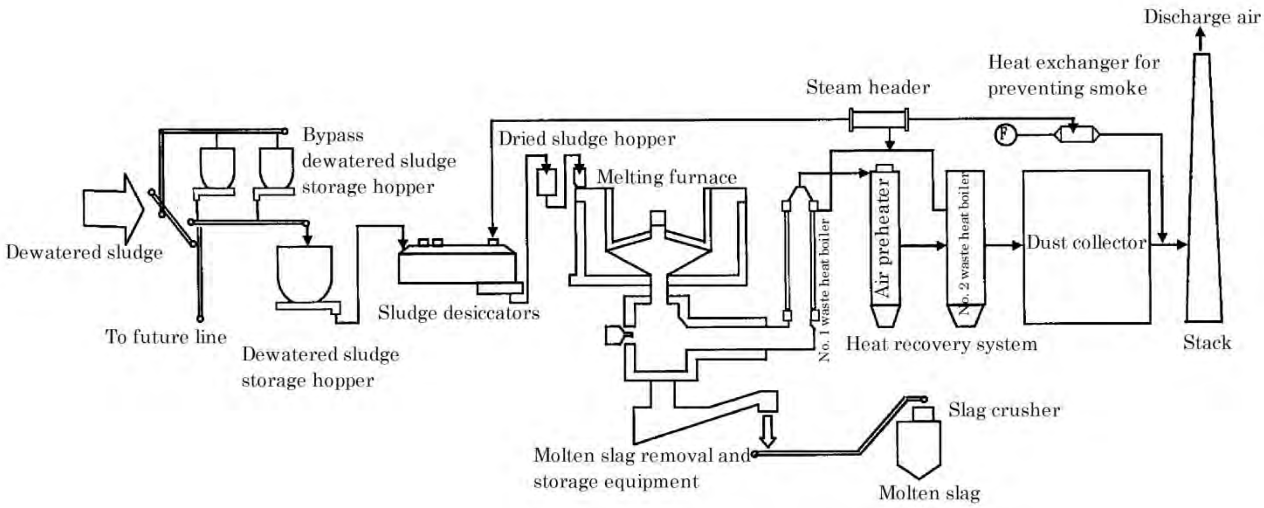


Figure 6-4-9 Outline Structure of the Surface Melting Furnace

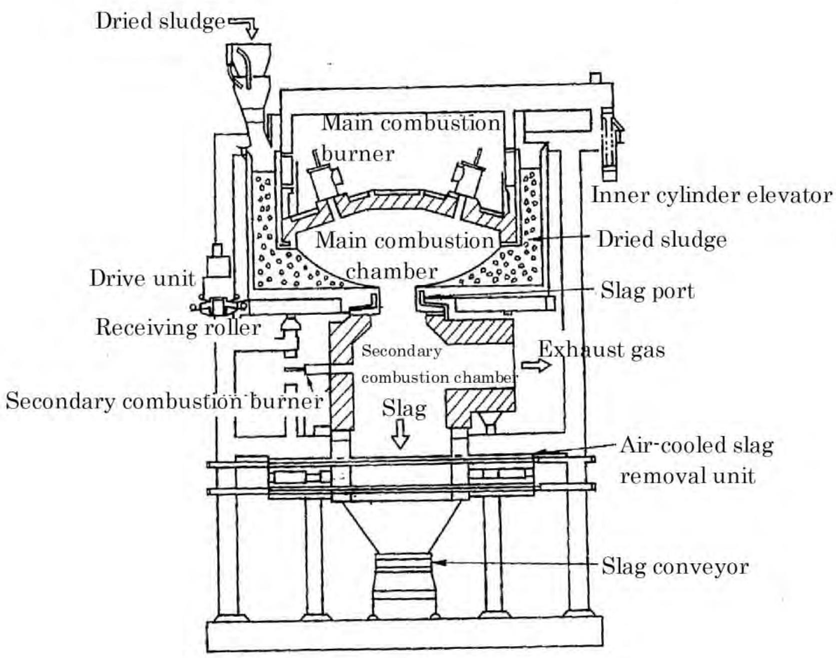


Table 6-4-4 Outline of Structure in Each Melting System

		Rotatory melting furnace	Coke bed melting furnace	Surface melting furnace
Structure and materials	Structure	Furnace is self-standing and has a structure capable of withstanding tare, live load, wind pressure and seismic force, etc.	Furnace is a self-standing cylindrial shape and has a structure capable of withstanding tare, live load, wind pressure and seismic force, etc.	Furnace is self-standing rotatory typ with inner and outer cylinders and has a structure capable of withstanding tare, live load, wind pressure and seismic force, etc.
		Structure and furnace inner diamter and length are such that uniform rotating flow is formed, total combustion takes place inside the furnace, molten liquid and exhaust gases are totally separated, and molten slag can be stably removed.	Structure is composed of the lower melting zone, upper freeboard section and insertion section.	The inner cylinder is equipped with auxiliary fuel system and moves up and down, while the supply of sludge to the main combustion chamber is kept uniform by rotation of the outer cylinder.
	In-furnace temperature	1,200～1,500℃	Roughly 1,500℃	Main combustion chamber 1,200～1,500℃ Secondary combustion chamber 950～L100℃
	Volumetric thermal load	Case of dry sludge 7,100～8,400MJ/(m3・h) Case of ash melting 8,400～16,700MJ/(m3・h)	Coke bed 4,000～13,000MJ/(m3・h) Freeboard 210～300MJ/(m3・h)	Main combustion chamber 1,300～2,500MJ/(m3/h)
	Fireproof materials	The fireproof materials should have sufficient fire resistance and high temperature resistance as well as resistance to corrosion and abrasion.		
	Emergency opening mechanism	Install an emergency opening valve in the event of problems.		
Pretreatment system	Pretreatment system	(1)Dewatered sludge feeder (2) Dewatered sludge desiccator or incinerator (3) Regulator insertion unit (as needed)	(1) Dewatered sludge feeder (2) Dewatered sludge desiccator and forming machine (3) Coke insertion unit (4) Regulator insertion unit	(1) Dewatered sludge feeder (2) Dewatered sludge desiccator or incinerator (3) Regulator insertion unit (as needed)
Heat recovery system	Heat recovery system	Collect heat from waste gas, etc. with a view to cutting auxiliary fuel costs, etc.		
Exhaust gas treatment system	Exhaust gas treatment system	Since exhaust gases include sulfur oxides, particulate, nitrogen oxides and hydrogen chloride, etc., a system to remove these substances is needed.		
Slag production system	Slag production system	Detrmine the slag production system upon considering the following: (1) Install a unit for cooling and solidifying molten liquid continuously running from the furnace. (2) Install a storage hopper or slag accumulation area for holding slag that is coole		
Auxiliary fuel system	Auxiliary fuel system	The auxiliary fuel system is intended to raise temperature in the main and secondary combustion chambers and to totally combust uncombusted items. Also a supplementary oil (or gas) burner is fitted.	―	The auxiliary fuel system is intended to raise temperature in the main and secondary combustion chambers and to totally combust uncombusted items. Also a supplementary oil (or gas) burner is fitted.
Fuel feeder	Fuel feeder	(1) Usually heavy oil, kerosene, digestion gas or city gas are used as auxiliary fuels. (2) Set capacity of the heavy oil and kerosene storage tanks to between 3~10 days of the consumption amount.	(1) Coke is used as the heat source for melting. (2) The coke pit usually has enough capacty for 3~10 days supply.	(1) Usually heavy oil, kerosene, digestion gas or city gas are used as auxiliary fuels. (2) Set capacity of the heavy oil and kerosene storage tanks to between 3~10 days of the consumption amount.

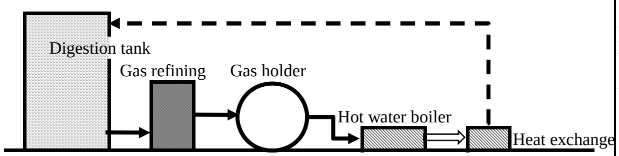
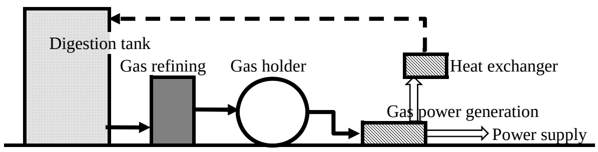
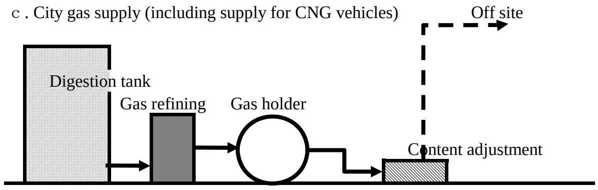
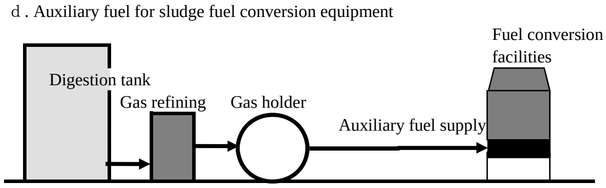
6.4.3 Sludge-Digestion Gas Utilization

In the case where a sewage treatment plant adopts anaerobic digestion as the sludge treatment method, the organic matter of generated sludge is reduced in molecular weight and turned into liquid and gas through the action of anaerobic microbes inside the sludge digestion tank maintained in an anaerobic state. The amount of sludge-digestion gas generated at this time is estimated to be 600 Nm3 per ton of inserted organic matter to the tank. Accordingly, if the amount of organic matter inserted into the digestion tank increases, the amount of sludge-digestion gas and the amount available for effective utilization also increase.

This sludge-digestion gas is generally used as fuel for the boiler that heats the sludge digestion tank, while excess gas is combusted in the excess gas combustor and dissipated into the atmosphere. If there is a large amount of excess gas, it is possible to effectively utilize the energy contained in this in order to realize energy saving over the entire system. When considering the utilization of this unused gas, it is better to adopt a simple and efficient system providing that there is demand to use gas directly as sludge incineration auxiliary fuel, boiler fuel (hot water supply and heating) and so on.

In recent times, there are more power generating facilities based on gas engines and other types of thermal engine. Moreover, in addition to the power generated in gas engines, heat is increasingly recovered from exhaust gases and cooling water in an effort to further enhances efficiency. However, it is necessary to examine construction costs and maintenance if systems become over-complicated. **Table 6-4-5** shows the methods for effectively utilizing digestion gas.

Table 6-4-5 Digestion Gas Utilization Methods

Effective Uses of Digestion Gas	Features	Refining Level	CO_2 Reduction Index
a . Fuel for digestion tank heating equipment 	Boiler fuel can be reduced. Usage is limited and excess gas is incinerated.	Sulfur oxides removal	1.60 Kg-CO_2/m^3 (Heavy oil conversion)
b . Fuel for gas power generation 	On-site power consumption can be reduced. Through recovery of waste heat, fuel can be reduced in the digestion tank heating boiler.	Sulfur oxides removal Siloxane removal (CO2 removal)	1.70 Kg-CO_2/m^3 Electric power conversion (generating efficiency 32%) + Heavy oil conversion (heat recovery rate 52%)
c . City gas supply (including supply for CNG vehicles) 	Revenue is obtained from sales to gas companies. Refining to the level of city gas is required.	Sulfur oxides removal Siloxane removal (CO2 removal) Content adjustment	1.06 Kg-CO_2/m^3 (City gas conversion)
d . Auxiliary fuel for sludge fuel conversion equipment 	When converting sludge to fuel and using as incinerated and melted slag, it can replaced auxiliary fuels.	Sulfur oxides removal	1.60 Kg-CO_2/m^3 (Heavy oil conversion)

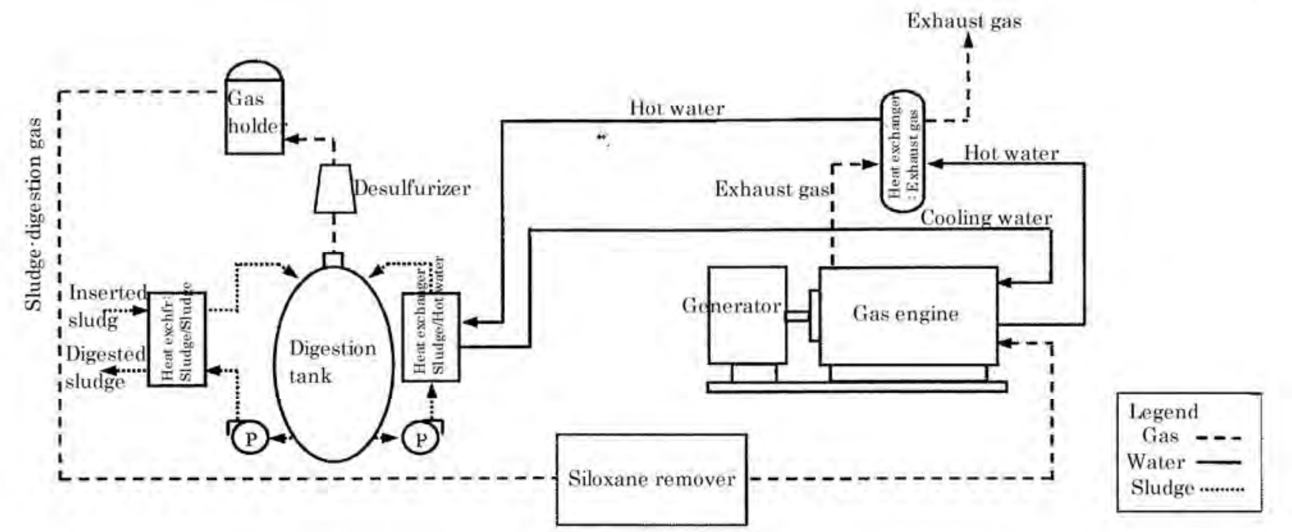
“Study Report of Sewerage Sludge Energy Utilization” 2010, JSWA

When utilizing the digestion gas obtained from anaerobic fermentation of sewage sludge, traces of siloxane in the gas attach to the plugs and inner cylinder walls of gas engines and cause ignition failure or abnormal firing. Steps to counter siloxane are thus needed. Since silicon, which is the source of siloxane generation, is used a lot in shampoos and rinses, concentrations have recently been growing in sewage. Siloxane vaporizes at room temperature, however, because the amount vaporized increases as temperature grows, a lot of siloxane transfers to digestion gas as a result of heating in digestion tanks. The concentration of siloxane in digestion gas is between 10~100 mg/Nm^3.

Recent research has found that a large part of this siloxane content can be removed through conducting activated carbon adsorption treatment. Moreover, other effective uses of digestion gas as energy have been practically developed in the form of fuel cells, micro gas turbines and car fuel gas.

Figure 6-4-10 shows the flow of digestion gas power generation (gas engine approach).

Figure 6-4-10 Flow of Sludge-Digestion Gas Power Generation



1) Recovery of Methane Gas from Anaerobic Digestion

As was mentioned earlier, when sludge undergoes anaerobic digestion, the organic matter is broken down by anaerobic microbes, leading to polymer breakdown and generating liquid and gas. Since this digestion gas is a carbon-neutral energy, it should be collected and effectively utilized.

2) Increasing Gas through Receiving Raw Waste

Looking at the environment that surrounds sewage systems today, climate change is growing increasingly serious and the limitation of greenhouse gas mitigation has become an international top priority issue. Moreover, due to worsening in the economic environment, it is necessary to reduce treatment costs through securing even more efficient and effective ways of utilizing facilities.

Figure 6-4-11 shows a schematic of the biomass receiving system. Raw waste from food biomass and night soil, etc., which are typical examples of the biomass received in such a system, have the following features.

- Raw waste characteristics

  - Raw waste is a form of biomass that possesses useful energy, and the incineration disposal of such waste currently leads to emissions of greenhouse gases.

  Since raw waste is a carbon-neutral biomass, discharge of greenhouse gases (CO,) in line with incineration is not included in emissions, however, the greenhouse gases emitted from the auxiliary fuel used for incineration are included in emissions.

  Moreover, in the case where waste is landfilled, because methane gas is emitted in line with the decomposition of organic matter in the waste, methane gas proportional to the decomposed quantity of landfill waste is added to greenhouse gas emissions.

  Accordingly, because the incineration and landfilling of waste not only consume energy but also emit greenhouse gases, it is necessary to reduce waste disposal quantities.

  - Through separating raw waste, it is hopefully possible to reduce the quantity of waste treatment and thereby reduce the number of waste treatment facilities in renewal and promoting the recycling of waste.

  Food waste including raw waste has potential for recycling as fertilizer and livestock feed, etc. as well as conversion into heat and electric energy, however, until now it has been incinerated from the viewpoint of sanitary management, etc.

  However, with a view to supporting formation of a recycling-oriented society, the utilization of methane gas from raw waste as energy should be vigorously promoted in order to promote conversion from diminishing resources to recyclable resources, to address climate change and to secure higher added value through reuse.

- Characteristics of night soil, etc.

  - Amid forecasts that the treated amount of night soil will decline in line with the spread of sewage systems, the issue of treating sludge from septic tanks is a problem and it is desirable to receive night soil, etc. in sewage systems.

  It is expected that night soil and the population using septic tanks will decline as sewage systems spread, however, they will not disappear totally. Therefore, since it will continue to be necessary to treat night soil and septic tank sludge, it will be necessary to examine more efficient sewage treatment systems including sharing of treatment with other facilities from the viewpoints of economy and environment.

  In this respect, sewage treatment plants have the potential to economically utilize raw waste in the manner described below.

- Characteristics of sewage treatment plants

  - Sewage treatment plants possess digestion tanks (methane fermentation tanks) capable of drawing out the inherent energy of biomass.

  - Since sewage treatment plants possess water treatment facilities, unlike the case of solid waste treatment facilities, there is no need to newly install facilities for treating the wastewater generated in line with biomass utilization.

Furthermore, through jointly treating raw waste, etc. in sewage treatment plants, costs can be reduced compared to the case of individual treatment (utilization).

To sum up, not only does receiving of raw waste by sewage treatment plants contribute to lower costs and limitation of greenhouse gas emissions, it also has the possibility to resolve issues in raw waste treatment. Accordingly, it is proposed that biomass be received and jointly treated at the sewage treatment plants in this project.

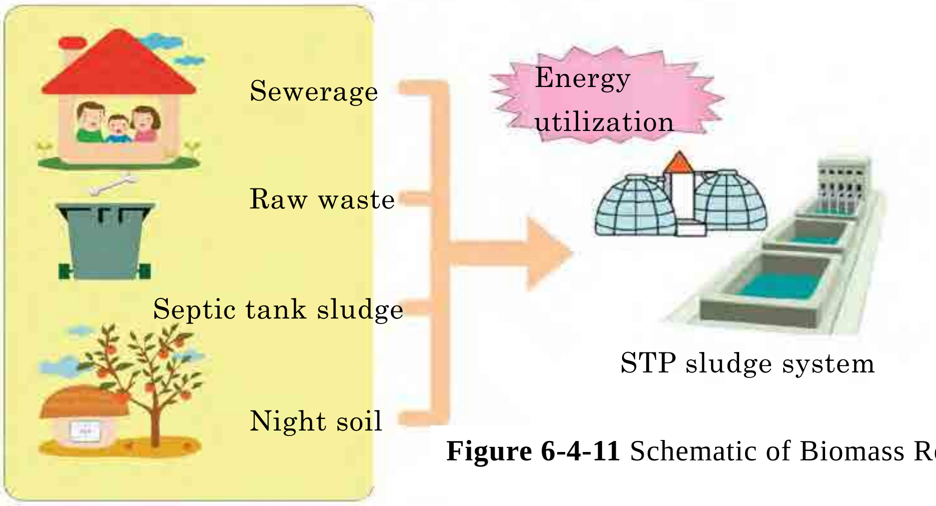


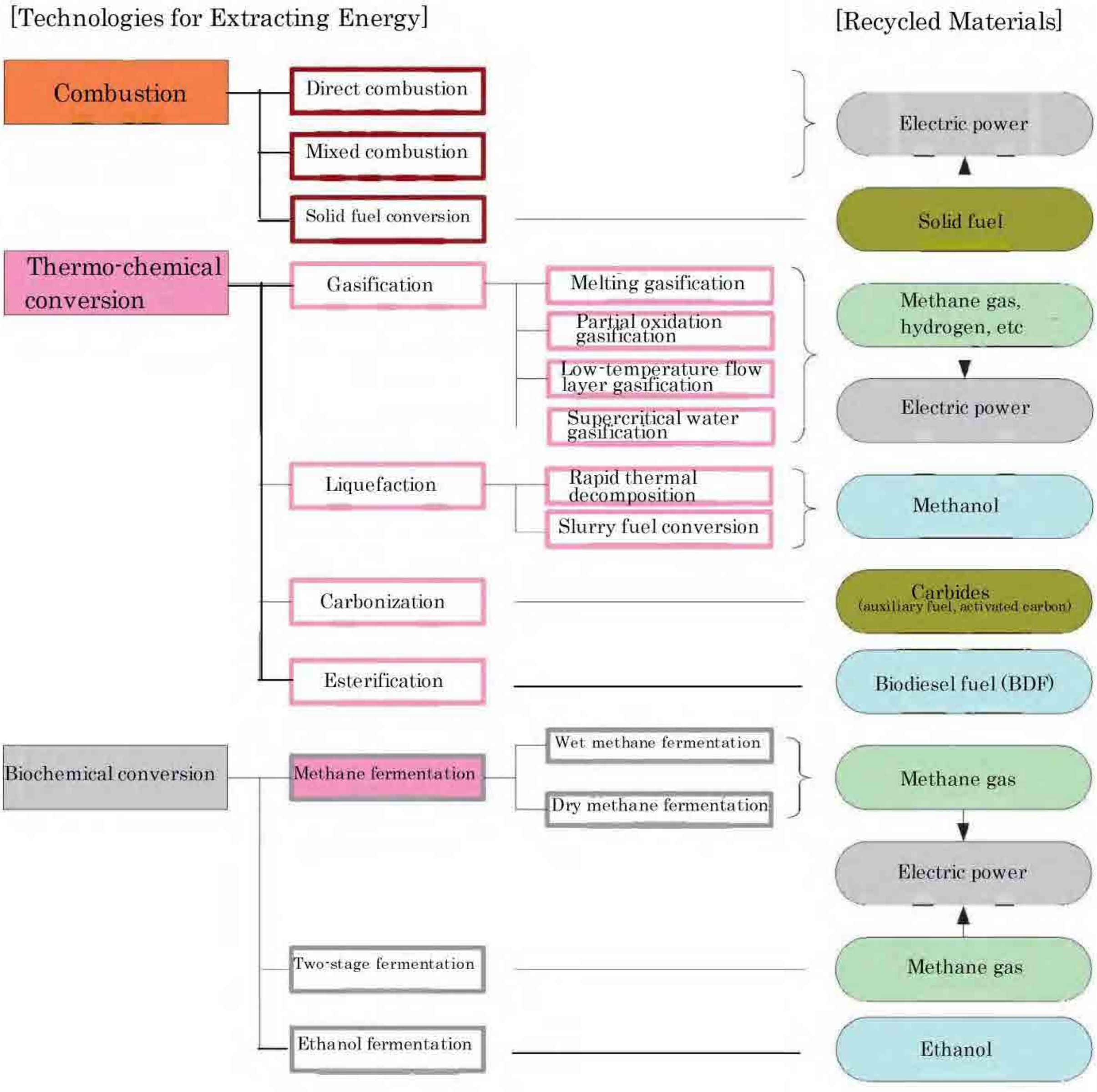
Figure 6-4-11 Schematic of Biomass Receiving

(1) Biomass utilization technology

Figure 6-4-12 shows the structure of biomass energy utilization technologies. There are numerous technologies for extracting biomass energy and these are broadly divided into direct combustion, thermo-chemical conversion (gasification, carbonization, etc.) and biochemical conversion (methane fermentation, etc.).

Methane fermentation not only allows biomass energy to be effectively extracted, but also it has the advantage of enabling anaerobic digestion tanks, which are methane fermentation facilities, to be planned as part of the sludge treatment system at sewage treatment plants. Therefore, as the biomass energy utilization technology in the project, it is proposed that treatment technology based on methane fermentation be adopted.

Figure 6-4-12 Structure of Biomass Energy Utilization Technologies (Biomass Energy Introduction Guidebook, 2nd Edition, NEDO, with additions)



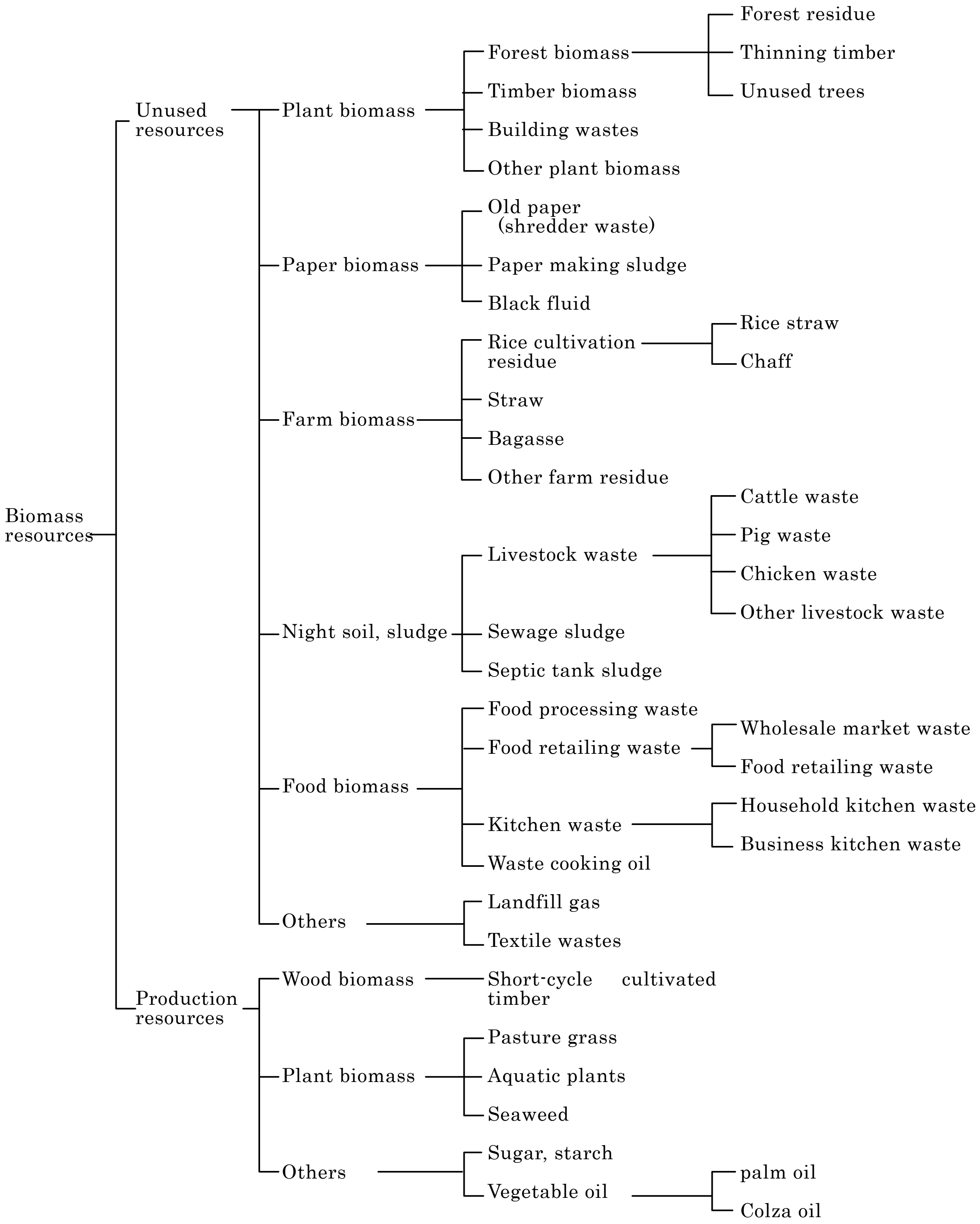
(2) Type of received biomass

Figure 6-4-13 shows the structured breakdown of biomass resources. The main types of biomass suited to methane fermentation are night soil, septic tank sludge, raw waste, livestock excreta, plant biomass and old paper, etc.

Of these, septic tank sludge has large potential for acceptance into sewage systems. Environmental authorities are also interested in receiving raw waste in sewage systems.

Accordingly, out of the biomass capable of being received in sewage systems, in the project, it is proposed that raw waste and night soil, etc. (human waste, septic tank sludge) be received.

Figure 6-4-13 Structure of Biomass Resources (Colored parts are biomass proposed in this project) (Biomass Energy Introduction Guidebook, 2nd Edition, NEDO, with partial additions)



(3) Biomass collection methods

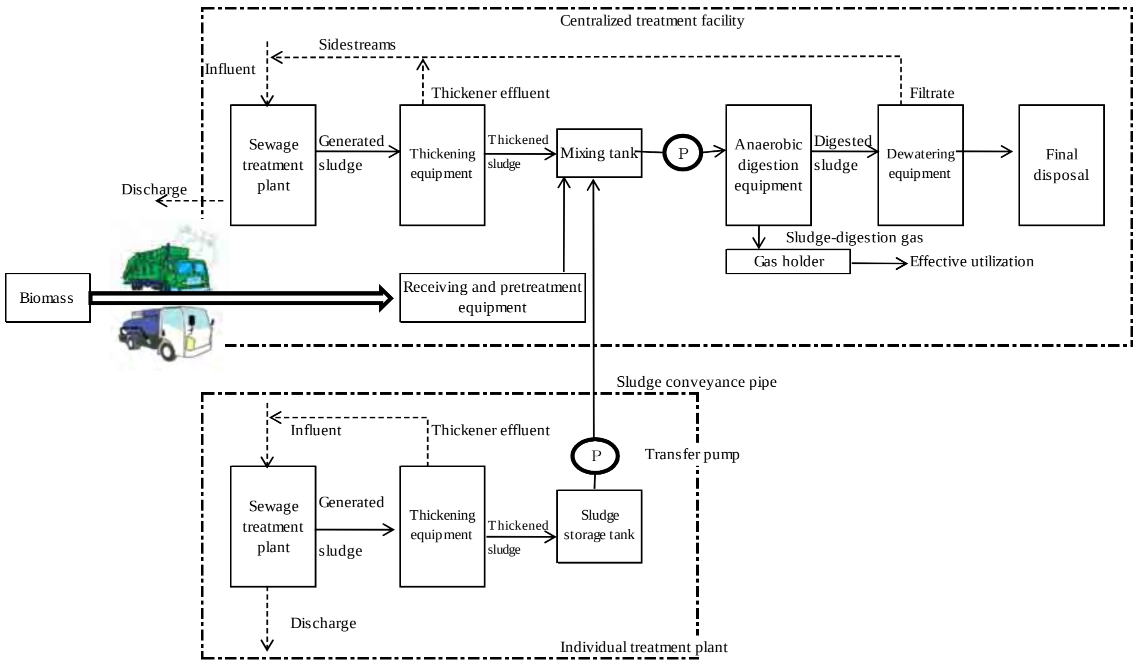
Figure 6-4-14 shows a schematic view of biomass collection methods. Biomass can be collected by hacker trucks and vacuum trucks directly carrying biomass to centralized treatment facilities. In cases where such vehicles are deemed to impart too much of an impact on residents living around treatment plants, an alternative approach is to establish receiving facilities at each plant and convey biomass to centralized facilities through sewers, etc.

Concerning raw waste, separate collection and collection by disposers are possible methods, however, since the costs of disposer installation need to be borne by individuals, it would take a long time for them to spread. Accordingly, separate collection is more suited to this project.

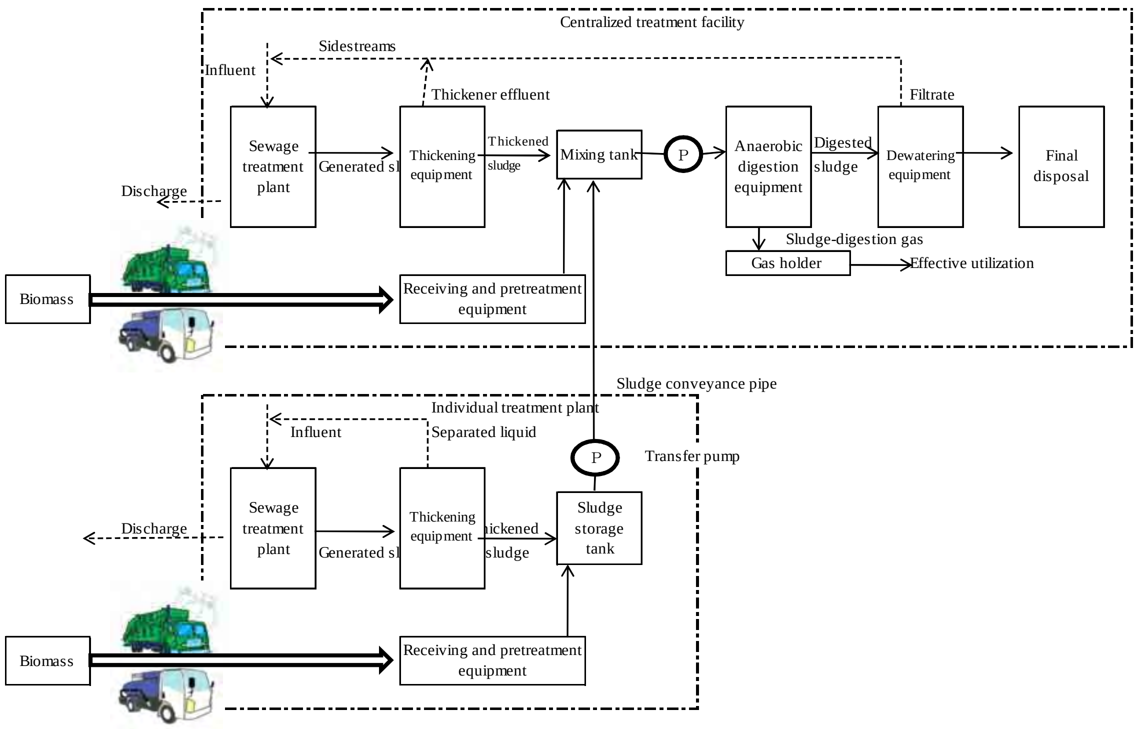
Moreover, since raw waste transportation distances would become long in the case of directly carrying to a centralized treatment facility, , due to problems of odor and putrefaction, etc., it is more appropriate to adopt a system for receiving raw waste at individual sewage treatment plants.

Figure 6-4-14 Biomass Collection Methods

Direct carrying to a centralized treatment facility



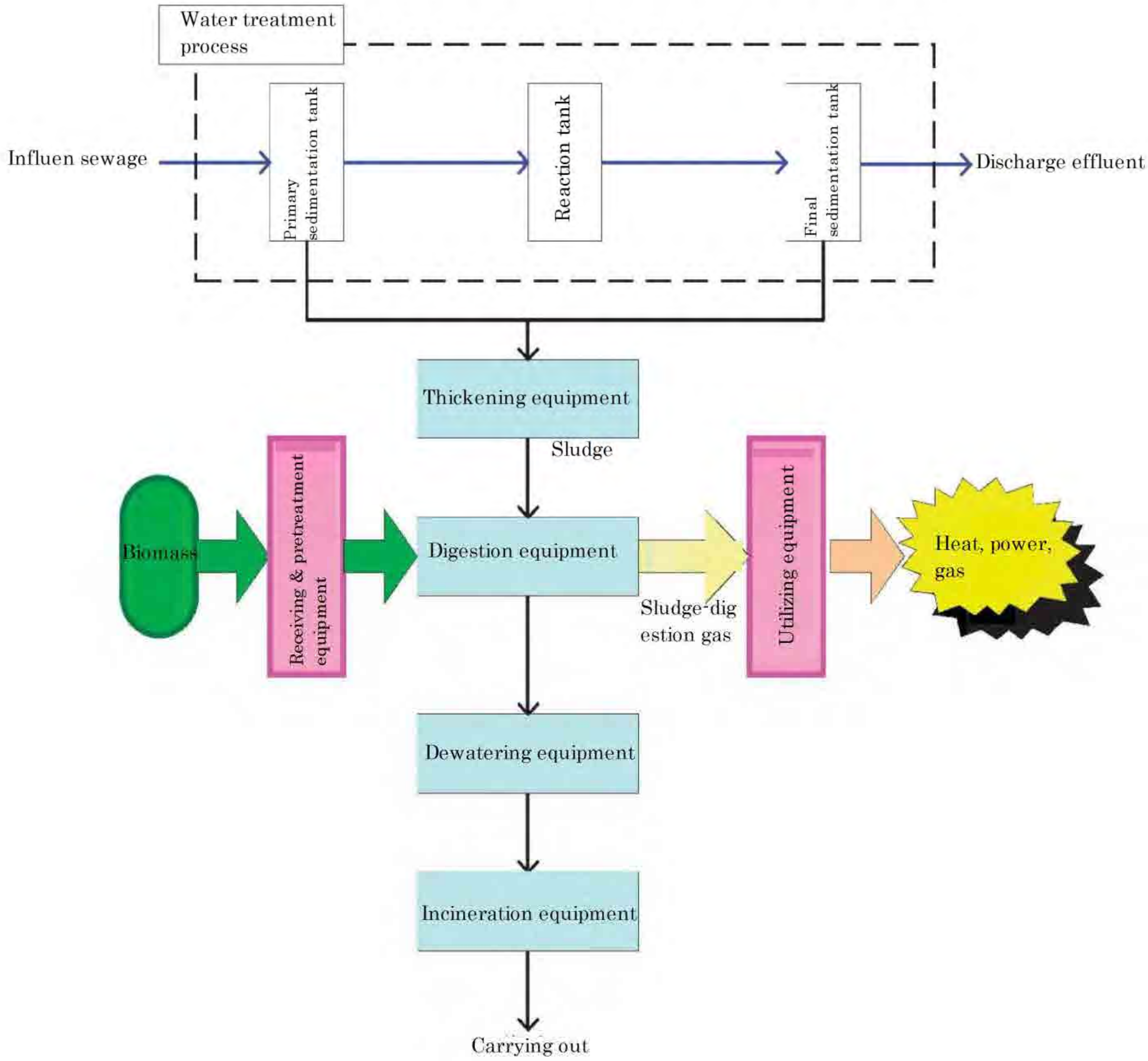
Receiving at individual treatment plants



(4) Basic flow of biomass receiving

The basic flow of biomass receiving is as shown in **Figure 6-4-15**. After being received and undergoing the necessary pretreatment (removal of foreign materials, etc.) in the pretreatment equipment, the biomass is passed onto the energy extraction equipment (utilizing methane fermentation that can effectively extract energy from biomass), and finally methane gas is utilized in power generating facilities, etc.

Figure 6-4-15 Basic Treatment Flow from Biomass Receiving to Digestion Gas Generation



(5) Receiving and pretreatment equipment

Figure 6-4-16 shows the basic flow of pretreatment equipment. This is composed of the raw waste receiving hopper, crusher and separator, etc.

The incoming raw waste is received in the hopper and is successively sent to the crusher and separator by a cutting device. In the crusher and separator, the raw waste is divided into items suited to fermentation (raw waste) and foreign materials. The foreign materials are taken out of the plant, while the raw waste is sent to the mixing tank, where it is mixed with sewage thickened sludge and, if necessary, adjusted for thickness by adding water. Moreover, concerning raw waste, a solubilization system is sometimes installed in front of the mixing tank in order to decompose fats, etc.

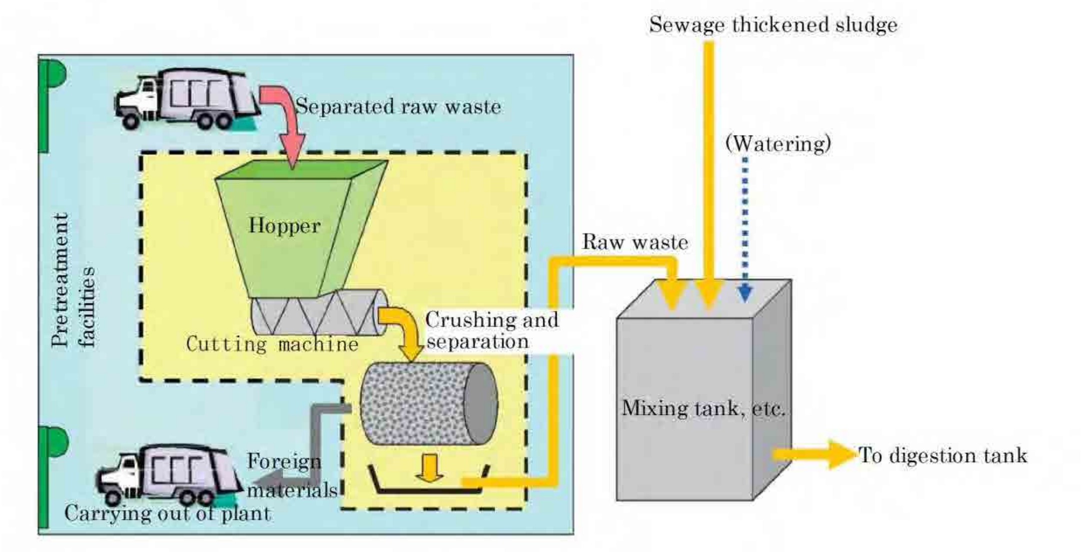


Figure 6-4-16 Basic Flow of Pretreatment Equipment

(The above flow is a typical example. Depending on the system maker, watering is sometimes conducted in the hopper, the mixing tank is used for storing mixed waste only, and the raw waste and sewage thickened sludge are put into the digestion tank separately).

(6) Biomass effective utilization technology

Various research and development is being carried out with the objective of realizing technology that can utilize sewage sludge resources and energy at low cost. Green sludge energy technologies are technologies for effectively utilizing biomass from raw waste, etc. and can be applied to the receiving of biomass at sewage treatment plants.

As an example of green sludge energy technology for generating electricity from sewage sludge biomass, the technology for receiving biomass and generating digestion gas is described below.

a) Energy collection based on simultaneous treatment of sewage sludge and biomass

The features of this system are as follows:

- Raw waste is received from outside of the sewage treatment plant and is inserted into sludge digestion tanks.
- Through conducting solubilization of sludge (ultrasonic treatment), the sewage sludge digestion efficiency is increased and an effect is realized in terms of reducing solids and increasing generation of digestion gas.
- The generated quantity of digestion gas is increased, thereby enabling merits of scale to be achieved in the digestion gas power generation equipment.
- Since the reduction in the cost of raw waste appropriate treatment is viewed as system revenue, power generation costs are reduced.

Figure 6-4-17 shows the schematic view of the system, and **Table 6-4-6** shows an explanation of the component elements.

Figure 6-4-17 System Schematic

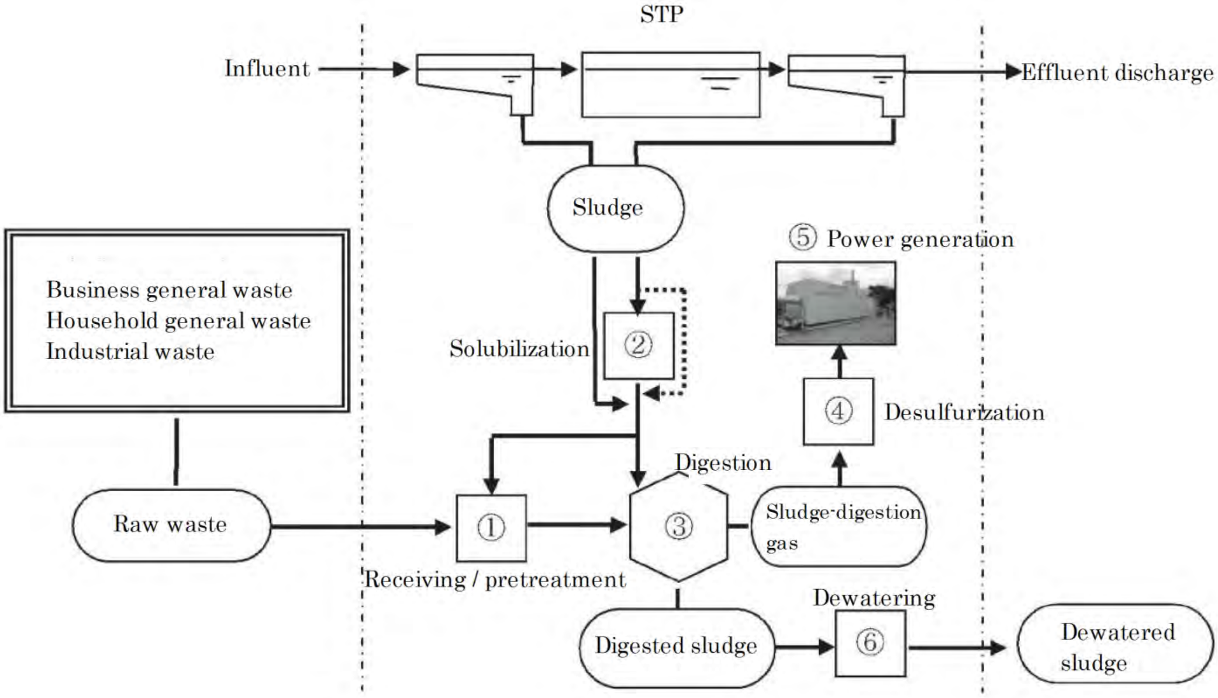


Table 6-4-6 Component Elements

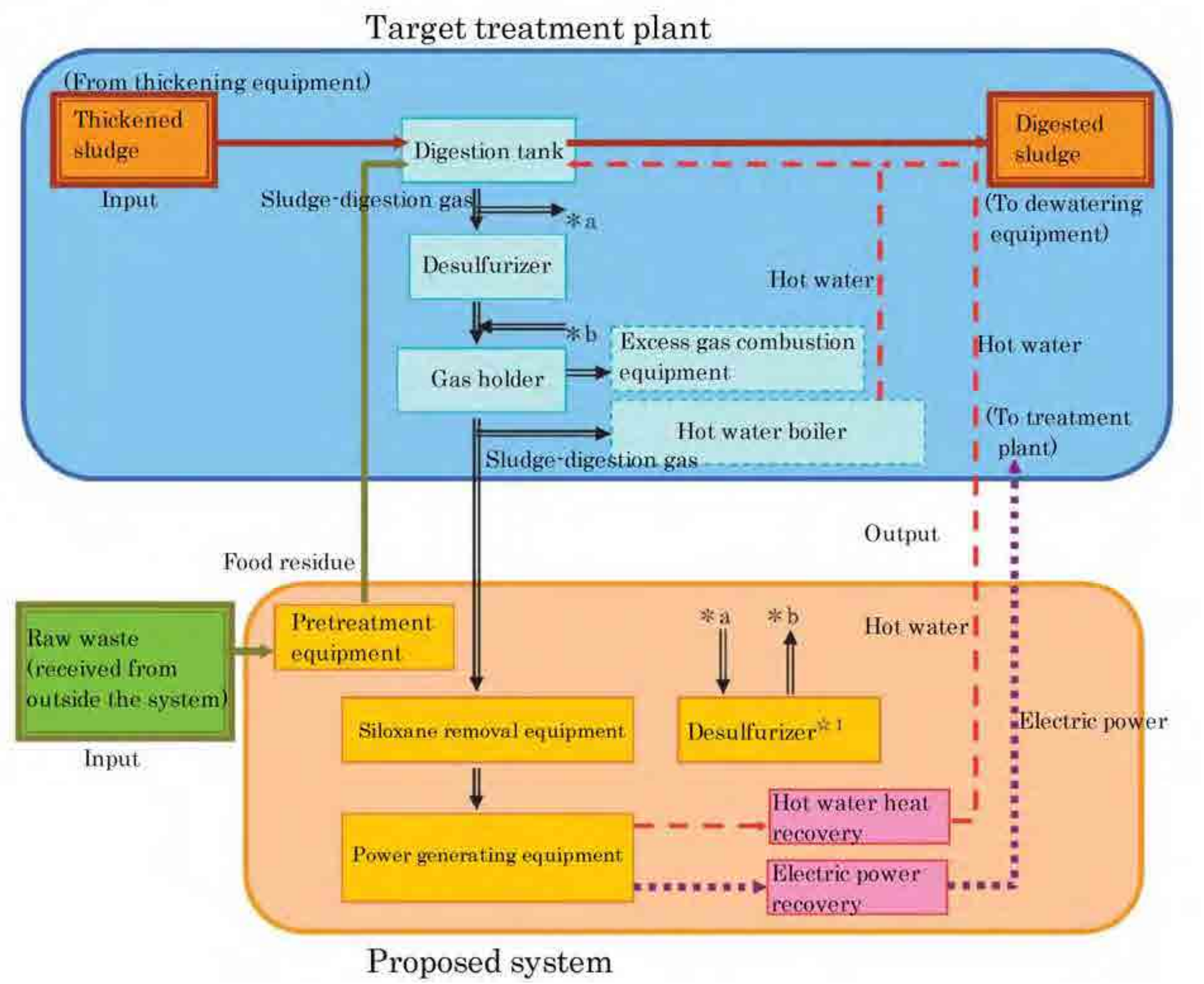
No.	Name	Function
①	Receiving and pretreatment equipment	Raw waste is received from outside of the sewage treatment plant, foreign materials are removed, it is then mixed and crushed with sludge, and the mixture is inserted into sludge digestion tanks.
②	Sludge solubilization equipment	Through conducting ultrasonic treatment, the sewage sludge is made more amenable to digestion.
③	Existing digestion tanks	Sludge and raw waste are simultaneously treated (digested as a mixture).
④	Digestion gas refining equipment	Hydrogen sulfide is removed through dry desulfurization (including existing facilities).
⑤	Digestion gas power generating equipment	Electric power and heat (hot water) are manufactured.
⑥	Existing dewatering equipment	Digested sludge is dewatered.

b) Mixed digestion gas power generation system with low running cost

Through appropriately carrying out the pretreatment of received raw waste, this technology makes it possible to increase the amount of digestion gas generated in the digestion tank. Furthermore, through applying bio-desulfurization, it can refine the generate digestion gas more cheaply than in conventional technologies, and through combining this with siloxane removal, it improves the reliability of digestion gas power generation.

Through combining these technologies, it is possible to reduce power generating costs compared to conventional technologies that entailed power generation only. **Figure 6-4-18** shows the outline flow of the technology.

Figure 6-4-18 Outline Flow



☆1 Case A: Install dry desulfurization for the increase in gas quantity derived from raw waste only.
Case B, C, D: Substitute all gas including that from sewage sludge into bio-desulfurization.

c) Biomass methane fermentation, power generation and activated carbon system

This technology aims to recover more methane gas and secure waste treatment costs through receiving wet biomass (raw waste, etc.); moreover, through actively carbonizing dewatered sludge and selling it as a valuable resource rather than disposing it as industrial waste, it greatly improves economy of the overall system.

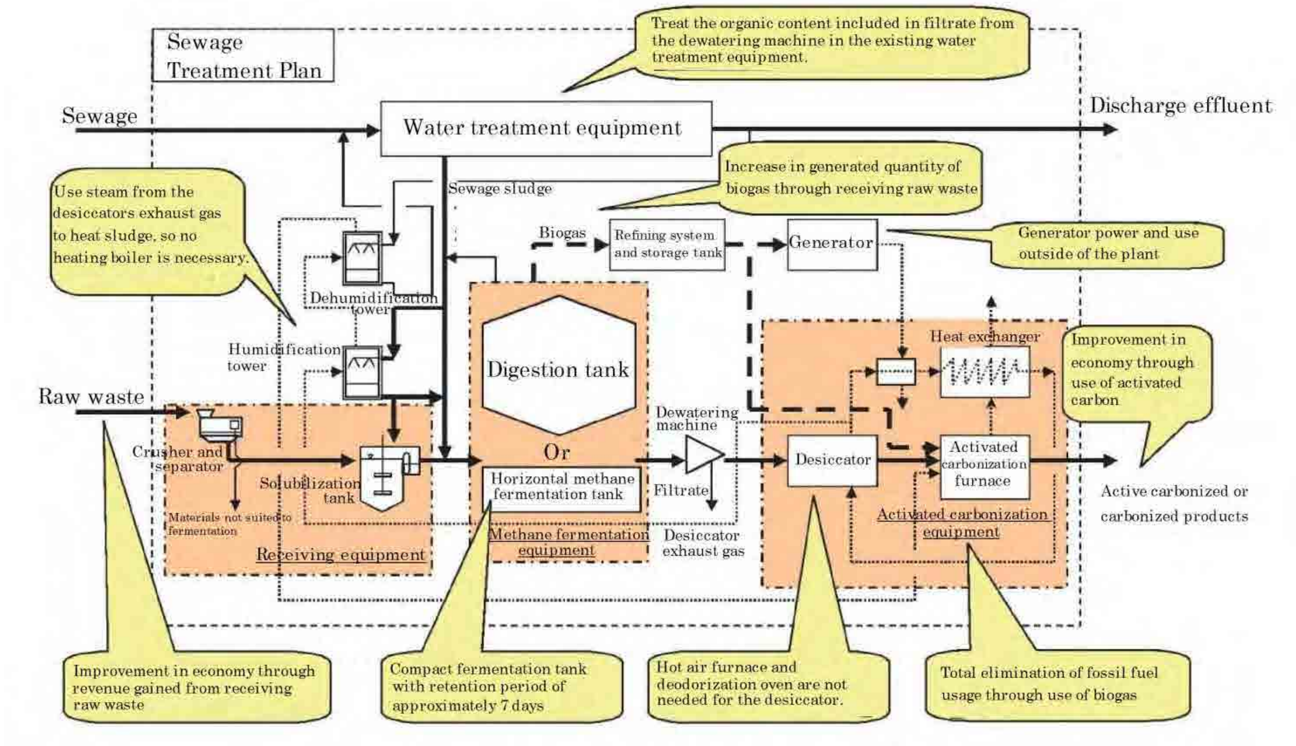
- Receive wet biomass such as raw waste, etc. into the sewage treatment plant → Securing of waste treatment costs
- Mix wet biomass and sewage sludge to ferment methane and use this as a biogas to conduct high efficiency power generation. → Increase in recovered quantity of biomass and decrease in purchased electricity
- Manufacture activated carbon product from dewatered sludge. → Reduction of dewatered sludge disposal costs and securing of revenue from sale of valuable resources

⇩

It is possible to greatly improve system economy.

Figure 6-4-19 shows the overall flow of the technology.

Figure 6-4-19 Outline Flow of the Technology



d) Biomass effective utilization technology

In the mixed digestion gas power generating system with low running costs, waste heat from the digestion gas generator is collected as hot water, which is used to heat the anaerobic digestion tank (hot water and sludge are circulated via a heat exchanger to heat the sludge, which is returned to the digestion tank, thereby raising temperature inside the tank) and improve digestion efficiency. Since this method reduces the amount of sludge and boosts the generated amount of digestion gas, it is suited to the project. Accordingly, the mixed digestion gas power generating system with low running costs is proposed as the biomass utilization technology in the project.

(7) Biomass receiving potential

In the case where large amounts of raw waste are received, the following can be expected: - impact on water treatment facilities due to increased return water load, - impact on sludge viscosity, and - impact on advance of digestion (hindering of digestion due to accumulation of organic matter).

a) Impact on water treatment

According to the results of research and development in Japan, the impact of sludge treatment return load arising from receiving raw waste is not large at treatment plants already conducting digestion providing that it is conducted within the usual scope (maximum thickened sludge: raw waste = 1: 0.43.)

Concerning the load from raw waste, for example, at a treatment plant having capacity of 10,000 m^3/day (where the quantity of thickened sludge is assumed to be roughly 50 m^3/day), in the case where 10 t/day of raw waste (having a ratio compared to thickened sludge of 20%)is received, assuming that the influent BOD concentration is 200 mg/l, the load originating from the influent is 2,000 kg/day, while the increased load from return water originating from raw waste is 7.2 kg (= 0.72 kg/t x 10 t/day), which represents a ratio of just 0.36%. Similarly, the nitrogen and phosphorous load is around 3%. Thus, the load placed on water treatment from raw waste is not great.

If biomass in excess of the above ratio is received, it will be necessary to fully examine the material balance and construct water treatment facilities upon considering the return water load. Alternatively, it will be necessary to take measures such as installing equipment for treating return water and returning it to the sewage treatment plant after treatment.

b) Impact on sludge treatment facilities

The impacts of receiving raw waste on the digestion and dewatering processes are described below. The viscosity of sludge can be adjusted by means of sewage thickened sludge or watering. Accordingly, when mixing sewage thickened sludge with raw waste, the raw waste receiving potential is calculated upon designing the sludge inserted into the digestion tank so as to satisfy the digestion tank retention time and organic load.

In the case of a digestion tank targeting sewage sludge, the digestion period is set at 20~30 days in medium temperature digestion and 10~15 days in high temperature digestion. Moreover, concerning the upper limit of organic load in the digestion tank, it is desirable to set it at 3.0 kg-VS/m^3/day.

Concerning the dewatering machine, it is necessary to ensure that the upper limit filtration speed and capacity are not exceeded upon referring to the conditions indicated in Table 3-3-2. As is shown in the table, it should be remembered that dewatering capacity declines when anaerobic digestion is carried out.

c) Receiving potential

Concerning the biomass receiving potential at the sewage treatment plant, it is proposed that a maximum thickened sludge to raw waste ratio of 1: 0.43 be adopted in consideration of impacts on the plant.

7. FACT FINDINGS AND EVALUATION OF INITIAL SITE SURVEY

The OEC Consultant Team conducted the initial project site surveys. This Section presents the current conditions that would be essential to study and recommend the most preferable, viable, effective, realistic and sustainable sewerage systems for consideration in the project target areas of Parañaque and Las Piñas cities. The survey items cover identification of topographical, geographical, hydrological, hydrographical and tidal conditions or situations including surface water quality analysis, sites candidate for sewage treatment plant(s) construction and initial evaluations. The flood situations of the Project target area were obtained from interviews with the MMDA and site residents.

The survey teams conducted the initial project site surveys. This chapter shows the current conditions that would be essential to study and recommend the most preferable, viable, effective, realistic and sustainable sewerage systems established here in the project target areas, Parañaque and Las Piñas City. The survey items cover identification of topographical, geographical, hydrological, hydrographical and tidal conditions or situations including surface water quality analysis, sites candidate for sewage treatment plant(s) construction and the first evaluations.

7.1 Waterways and Wastewater Discharging

The project areas are located in Parañaque Basin and are divided in 7 sub-basins. Each sub-basin is configured with a principal river or creek, and the wastewater generated in the basin is discharged in to the waterway transporting into Manila Bay. Each basin is ordinarily inclines from Southeast to Northwest. **Figure 7-1** shows the project area sub-basins and incline.

7.1.1 Wastewater Flow

The wastewater flows in the project areas are basically directing from inland to Manila Bay coastal areas. The wastewater carried by the rivers and creeks are finally discharged into Manila Bay through mainly three channel and rivers (refer **Figure 7-2**).

7.1.2 Wastewater Outfall Locations

The rivers and creeks of Parañaque and Las Piñas have a lot of rivers and creeks: there are 195 in Parañaque and 243 in Las Piñas. Many of the outfalls are sewers that combine sanitary sewage and storm water drainage functions, and they flow into creeks.

The wastewater in the project areas are collected, conveyed and discharged into receiving bodies through street drainage lines. The outfalls area located alongside the waterways, such as rivers, creeks, esteros, etc. Total 294 (173 in Parañaque, 121 in Las Piñas) outfalls were identified by our site surveys. **Table 7-1** and **Table 7-2** show receiving bodies of outfall discharges and the sub-basin geographical incline, and **Figure 7- 3** shows the outfall locations. All outfalls identifies are designated as ID names to clarify the conversion manhole locations and connection with sewage water flow directions to the interceptors. **Figure 7-4** and **Figure 7-5** show outfall location with ID names.

Appendix 1 and 2 show the detail locations of the outfalls and conversion manhole to be installed connecting the interceptor lines

Table 7-1 Discharging points of Outfalls

Receiving Body	Outfall Numbers
Parañaque City	
Baclaran channel	4
Baliwag Creek	12
Baloc-baloc Creek	6
Cutcut Creek	24
Don Galo Creek	3
Kayboboy Creek	13
Libho Creek	12
Merville Creek	5
Paete Creek	4
Parañaque Channel	16
Redemptorist Channel	2
Sapang Buwaya Creek	32
San Dionisio Creek	1
Villanueva Creek	38
Las Piñas City	
Almanza Creek	15
Balot River	4
Kay Almilantea Creek	50
Kay Kanti Creek	2
Las Piñas River	12
Manarigo Creek	12
Marulas Creek	15
Naga Creek	30
Pasong Baka Creek	23
Sin Nombre Creek	1
Talon Creek	40
Tartar Creek	14
Tung tong Creek	8
Zapote River	31

Figure 7-1 Sub-basins and Incline

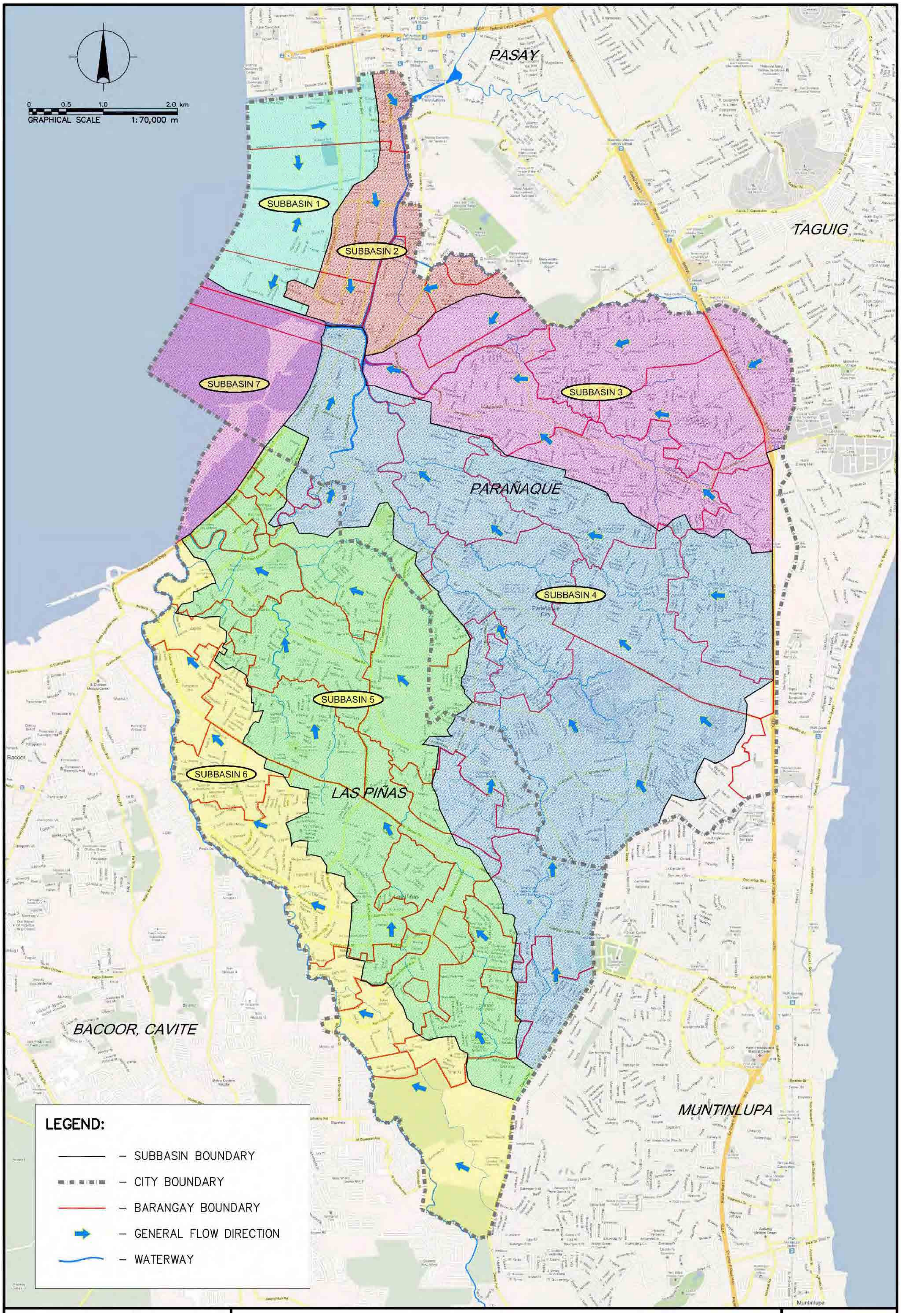


Figure 7-2 Wastewater Conveyance by Waterways into Manila Bay in the Project Area

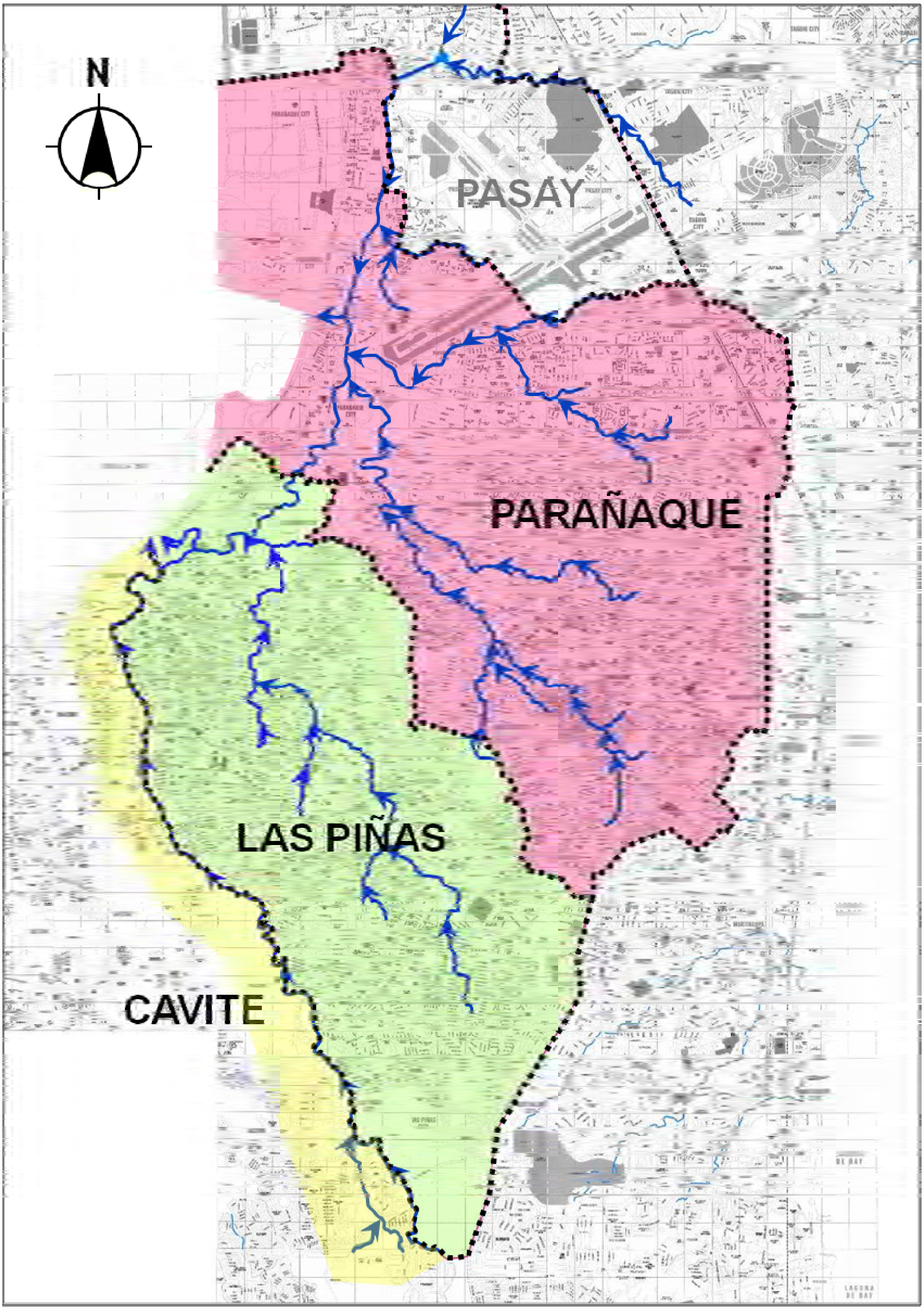


Figure 7-3 Outfall Locations

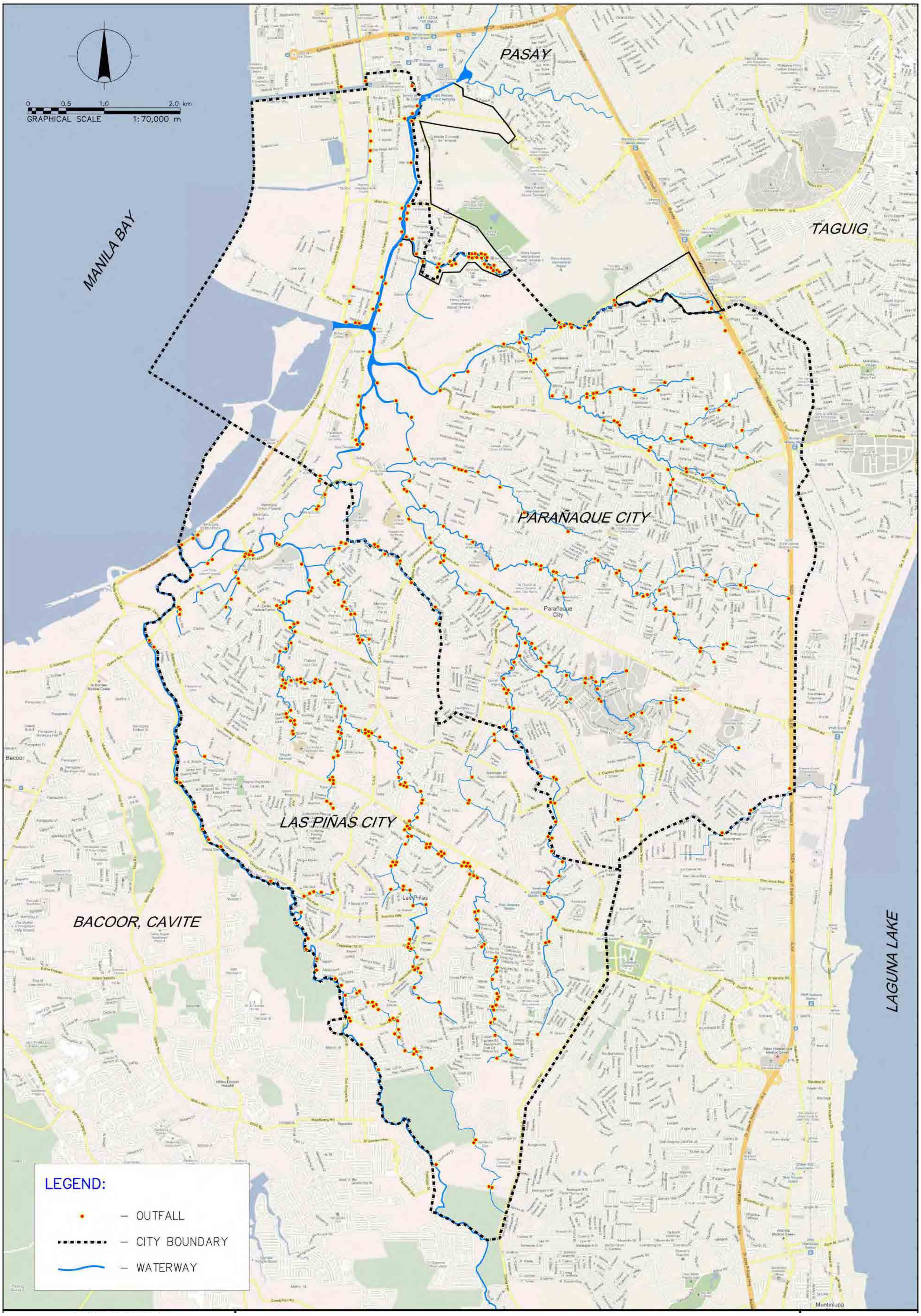
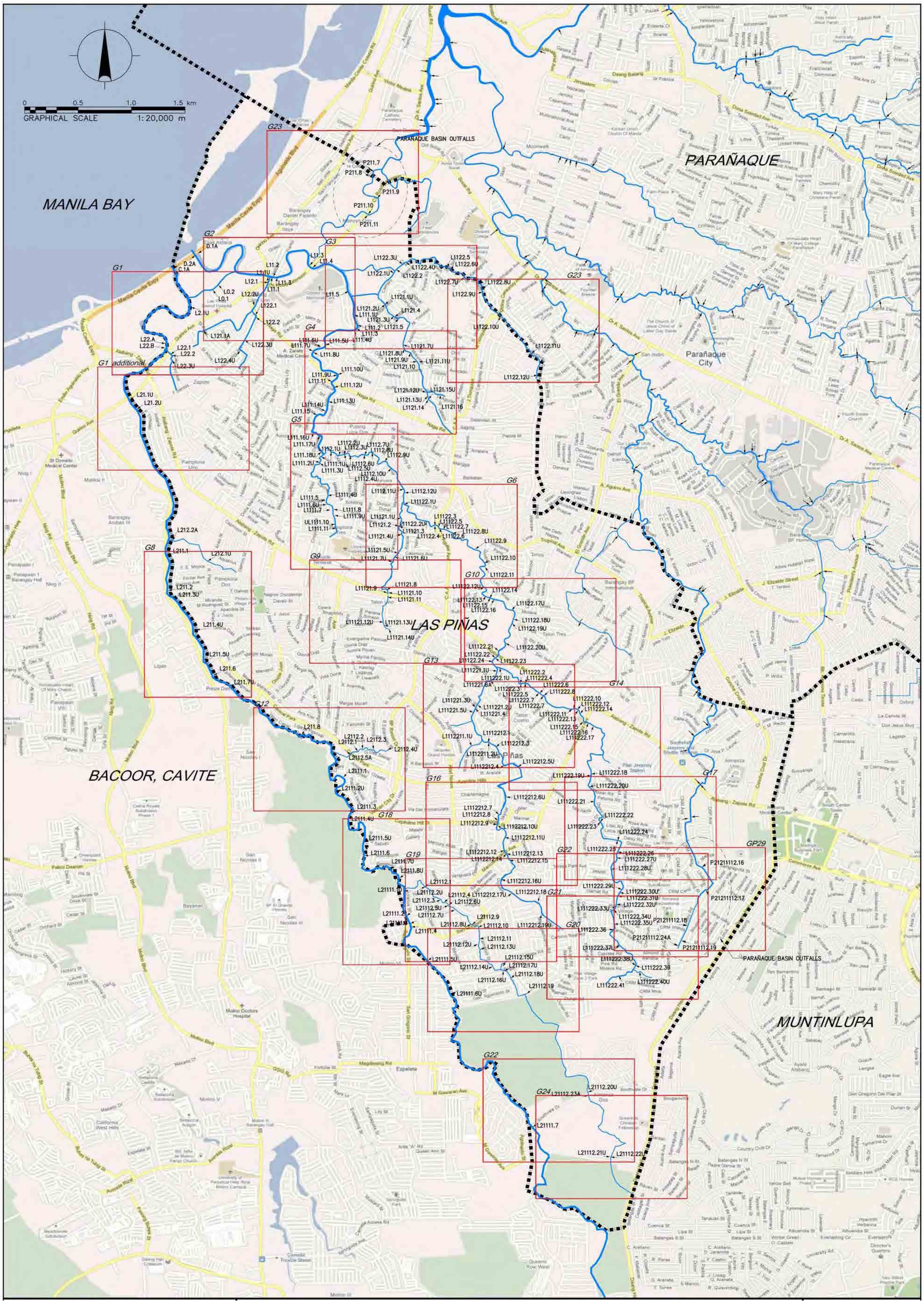


Figure 7-4 Outfall Locations with ID Names in Parañaque

7-5 Outfall Locations with ID Names in Las Piñas



7.1.3 Tidal Situations

The base height of the rivers or creeks in the project areas are generally low comparing with Manila Bay surface seawater level. Therefore the seawater is flowing upstream into the rivers and the tributaries when high tide.

Table 7-2 shows the tidal data in Manila Bay recorded by National Mapping and Resource Information Authority (NMRIA) in 2007. According to this data, Maximum height was 1.52 m in June 2007, and average was 0.41 to 0.64 m.

Based on a different report (Manila-Cavite Toll Expressway Design Sea Levels from 1984-1997 prepared by Maunsell McIntyre Pty. Ltd.), the maximum sea levels (above mean sea level) are 1.17±0.04, 1.34±0.09, 1.38±0.12, and 1.40±0.14 for 1, 20, 50, and 100-year storm return periods respectively. Thus, we could still assume the elevation of 1.50 meters as the highest tide level.

Figure 7-6 shows Manila Bay tidal extent into the rivers. Red colored parts show the tidal rivers. According to the map, Parañaque River, Zapote River and Las Piñas River and the tributaries would suffer from Manila Bay tidal extent. This situation will affect the sewage water discharge system by existing outfalls. Salty water reverse flow through interceptors to the sewage treatment plant would affect its treatment process.

7.1.4Current Water Quality Conditions

1) Water Quality Standards

DENR regulations regarding surface waters and discharging waters into the receiving bodies stipulate Water Quality Standards by Administrative Order Nos. 34 and 35. This administrative order classifies water bodies and this classification is very important components of water quality management since the application of effluent standards are dependent on this classification. This administrative order classifies water bodies into five (5) classes, i.e. AA, A, A, C for inland fresh waters and four (4) classes for marine and coastal water, i.e. SA, SB, SC and SD.

Table 7-3 shows the categories applied to the classifications. **Table 7-4** shows discharge water standards in each category and water quality standards by DENR Administrative Order No. 35. These areas belong to Class C.

According to the standards, class C of fresh surface water would be categorized for Parañaque and Las Piñas, and discharging water quality level in the project areas would be 50mg/l or less on the base of BOD_5.

Table 7-2 Manila Bay Tide and Current Table (year of 2007) (1/2)

JANUARY			FEBRUARY			MARCH			APRIL		
Day	Time	Heights	Day	Time	Heights	Day	Time	Heights	Day	Time	Heights
1	4:00	-0.19	1	5:34	-0.33	1	4:34	-0.24	1	4:18	0.07
MO	19:52	1.14	TH	21:22	1.19	TH	20:23	1.05	SU	10:22	0.47
										15:09	0.25
										21:56	0.78
2	4:52	-0.33	2	6:05	-0.30	2	5:02	-0.19	2	4:31	0.15
TU	20:37	1.13	FR	22:10	1.18	FR	21:18	1.05	MO	10:25	0.57
										16:05	0.16
										22:42	0.71
3	5:37	-0.36	3	6:34	-0.23	3	5:26	-0.12	3	4:36	0.23
WE	21:22	1.21	SA	22:55	1.18	SA	11:49	0.29	TU	10:36	0.67
							13:48	0.27		16:56	0.08
							22:05	1.02		23:24	0.62
4	6:19	-0.41	4	7:01	-0.14	4	5:45	-0.03	4	4:35	0.28
TH	22:08	1.27	SU	13:08	0.24	SU	11:35	0.34	WE	10:52	0.76
				15:05	0.22		15:08	0.23		17:47	0.00
				23:35	1.07		22:49	0.96			
5	6:58	-0.38	5	7:22	-0.04	5	6:01	0.06	5	0:06	0.52
FR	22:53	1.24	MO	13:10	0.31	MO	11:40	0.42	TH	4:29	0.30
				16:12	0.23		16:12	0.19		11:11	0.85
							23:28	0.87		18:34	-0.06
6	7:36	-0.30	6	0:12	0.97	6	6:12	0.14	6	0:50	0.41
SA	23:38	1.18	TU	7:38	0.05	TU	11:51	0.52	FR	4:21	0.30
				13:21	0.40		17:13	0.15		11:34	0.91
				17:19	0.25					19:24	-0.10
7	8:11	-0.21	7	0:46	0.83	7	0:05	0.75	7	1:42	0.32
SU			WE	7:46	0.13	WE	6:15	0.20	SA	4:10	0.28
				13:39	0.49		12:06	0.61		12:01	0.96
				18:34	0.27		18:12	0.12		20:16	-0.13
8	0:20	1.08	8	1:16	0.67	8	0:41	0.62	8	12:32	0.99
MO	8:41	-0.11	TH	7:46	0.18	TH	6:12	0.24	SU	21:16	-0.14
				14:02	0.58		12:27	0.70			
				20:06	0.27		19:14	0.09			
9	1:00	0.96	9	1:50	0.51	9	1:18	0.48	9	13:10	1.01
TU	9:05	-0.01	FR	7:36	0.21	FR	6:04	0.25	MO	22:32	-0.14
				14:28	0.66		12:51	0.77			
				21:49	0.24		20:16	0.06			
10	1:35	0.81	10	2:26	0.34	10	2:03	0.35	10	13:57	1.01
WE	9:19	0.07	SA	7:15	0.21	SA	5:48	0.24	TU		
	15:49	0.43		15:01	0.74		13:18	0.83			
	18:51	0.40					21:26	0.04			
11	2:09	0.64	11	0:12	0.16	11	13:52	0.87	11	0:02	-0.15
TH	9:23	0.14	SU	3:46	0.18	SU	23:00	0.00	WE	15:04	1.00
	16:14	0.53		6:06	0.17						
	22:28	0.39		15:43	0.81						
12	2:41	0.46	12	2:37	0.03	12	14:35	0.91	12	1:14	-0.16
FR	9:16	0.18	MO	16:41	0.87	MO			TH	16:24	0.99
	1645	0.63									
13	1:17	0.28	13	3:20	-0.11	13	1:10	-0.07	13	2:02	-0.15
SA	3:29	0.29	TU	17:49	0.95	TU	15:37	0.93	FR	17:45	0.96
	8:49	0.20									
	17:21	0.73									
14	3:04	0.11	14	3:56	-0.22	14	2:23	-0.15	14	2:36	-0.10
SU	18:04	0.83	WE	18:54	1.04	WE	16:59	0.97	SA	19:07	0.92
15	3:44	-0.05	15	4:29	-0.29	15	3:08	-0.21	15	3:06	-0.02
MO	18:47	0.93	TH	19:55	1.13	TH	18:18	1.02	SU	9:32	0.52
										13:50	0.32
										20:33	0.86

MAY			JUNE			JULY			AUGUST		
Day	Time	Heights	Day	Time	Heights	Day	Time	Heights	Day	Time	Heights
1	2:48	0.30	1	9:29	1.17	1	9:44	1.37	1	11:14	1.41
TU	9:27	0.80	FR	18:06	-0.17	SU	18:46	-0.16	WE	19:25	0.07
	16:29	0.07									
	22:42	0.49									
2	2:41	0.33	2	10:01	1.23	2	10:28	1.40	2	1:38	0.52
WE	9:44	0.90	SA	18:49	-0.21	MO	19:25	-0.14	TH	3:53	0.48
	17:14	-0.04								12:04	1.32
	23:33	0.49								19:50	0.18
3	2:33	0.34	3	10:36	1.27	3	11:14	1.40	3	1:50	0.62
TH	10:05	0.99	SU	19:32	-0.22	TU	20:04	-0.09	FR	5:17	0.49
	17:59	-0.12								12:53	1.18
										10:10	0.29
4	10:29	1.06	4	11:17	1.29	4	12:02	1.37	4	2:11	0.74
FR	18:43	-0.22	MO	20:19	-0.20	WE	20:41	-0.01	SA	5:58	0.50
										13:41	0.99
										20:21	0.39
5	10:57	1.10	5	12:01	1.28	5	12:53	1.29	5	2:36	0.88
SA	19:29	-0.22	TU	21:08	-0.16	TH	21:13	0.08	SU	8:49	0.46
										14:34	0.77
										20:19	0.46
6	11:30	1.13	6	12:50	1.25	6	13:42	1.16	6	3:12	1.01
SU	20:19	-0.22	WE	21:54	-0.10	FR	21:39	0.19	MO	10:41	0.39
										15:53	0.54
										19:49	0.48
7	12:08	1.15	7	12:43	1.16	7	4:08	0.66	7	3:56	1.13
MO	21:15	-0.21	TH	22:35	-0.02	SA	7:31	0.59	TU	12:54	0.27
							14:33	0.98			
							21:56	0.30			
8	12:51	1.14	8	14:41	1.07	8	4:32	0.79	8	4:52	1.22
TU	22:17	-0.18	FR	23:09	0.08	SU	10:11	0.55	WE	14:54	0.12
							15:32	0.77			
							22:03	0.39			
9	13:45	1.11	9	15:43	0.92	9	5:02	0.94	9	5:58	1.30
WE	23:19	-0.15	SA	23:34	0.19	MO	12:15	0.43	TH	15:53	-0.01
							17:14	0.56			
							21:56	0.44			
10	14:49	1.06	10	6:30	0.71	10	5:41	1.09	10	7:01	1.36
TH			SU	11:44	0.52	TU	14:04	0.25	FR	16:35	-0.07
				17:00	0.74						
				23:49	0.29						
11	0:11	-0.10	11	6:47	0.87	11	6:27	1.23	11	8:02	1.40
FR	16:01	0.98	MO	13:31	0.35	WE	15:32	0.08	SA	17:11	-0.90
				19:04	0.57						
				23:56	0.38						
12	0:50	-0.02	12	7:15	1.03	12	7:18	1.34	12	8:56	1.42
SA	17:17	0.87	TU	14:52	0.15	TH	16:32	-0.06	SU	17:45	-0.05
13	1:19	0.08	13	7:49	1.19	13	8:09	1.43	13	9:50	1.41
SU	8:10	0.62	WE	16:03	-0.03	FR	17:21	-0.15	MO	18:15	0.02
	13:00	0.42									
	18:51	0.75									
14	1:41	0.19	14	8:28	1.33	14	9:01	1.48	14	10:39	1.37
MO	8:17	0.77	TH	17:04	-0.17	SA	18:05	-0.17	TU	18:41	0.12
	14:28	0.23									
	20:37	0.64									
15	1:52	0.30	15	9:11	1.52	15	9:53	1.50	15	11:24	1.28
TU	8:35	0.94	FR	18:01	-0.26	SU	18:47	-0.14	WE	19:04	0.22
	15:37	0.04									
	22:03	0.54									

SEPTEMBER			OCTOBER			NOVEMBBER			DECEMBER		
Day	Time	Heights	Day	Time	Heights	Day	Time	Heights	Day	Time	Heights
1	0:30	0.54	1	0:02	1.17	1	1:10	1.20	1	2:02	1.03
SA	6:22	0.30	MO	8:00	-0.06	TH	10:45	-0.22	SA	10:59	-0.12
	12:57	0.91									
	18:43	0.44									
2	0:57	0.98	2	0:41	1.22	2	2:16	1.10	2	3:01	0.88
SU	7:45	0.25	TU	9:22	-0.07	FR	11:59	-0.15	SU	11:08	-0.01
	13:53	0.69									
	18:32	0.48									
3	1:29	1.09	3	1:31	1.22	3	3:32	0.99	3	4:01	0.71
MO	9:12	0.21	WE	11:06	-0.07	SA	12:54	-0.08	MO	12:05	0.09
										19:41	0.52
4	2:11	1.17	4	2:34	1.18	4	4:48	0.69	4	0:32	0.41
TU	11:02	0.16	TH	12:51	-0.09	SU	13:31	0.01	TU	5:14	0.55
										12:20	0.16
										19:31	0.62
5	3:06	1.21	5	3:56	1.12	5	6:04	0.78	5	2:00	0.25
WE	13:22	0.07	FR	13:57	-0.09	MO	13:56	0.10	WE	7:15	0.41
							20:49	0.54		12:23	0.25
										19:41	0.73
6	4:18	1.22	6	5:19	1.08	6	1:32	0.38	6	3:05	0.11
TH	14:42	-0.02	SA	14:40	-0.05	TU	7:26	0.69	TH	9:05	0.34
							14:13	0.19		12:09	0.29
							20:44	0.63		19:57	0.83
7	5:38	1.23	7	6:33	1.04	7	2:37	0.25	7	3:56	-0.03
FR	15:30	-0.06	SU	15:11	0.01	WE	8:44	0.60	FR	20:19	0.93
							14:21	0.26			
							20:49	0.73			
8	6:50	1.24	8	7:42	0.99	8	3:30	0.12	8	4:38	-0.16
SA	16:05	-0.05	MO	15:33	0.10	TH	9:46	0.53	SA	20:44	1.01
				21:57	0.52		14:20	0.32			
							21:02	0.83			
9	7:55	1.25	9	1:52	0.40	9	4:18	0.00	9	5:17	-0.25
SU	16:35	0.00	TU	8:45	0.93	FR	10:39	0.45	SU	21:12	1.07
				15:51	0.18		14:11	0.34			
				21:51	0.59		21:20	0.92			
10	8:52	1.23	10	2:58	0.30	10	5:02	-0.11	10	5:54	-0.32
MO	16:59	0.07	WE	9:40	0.86	SA	11:28	0.38	MO	21:44	1.12
	23:14	0.48		16:03	0.27		14:00	0.34			
				21:57	0.69		21:41	1.00			
11	1:42	0.44	11	3:53	0.21	11	5:44	-0.18	11	6:32	-0.34
TU	9:44	1.19	TH	10:28	0.77	SU	22:07	1.05	TU	22:18	1.14
	17:20	0.17		16:07	0.34						
	23:07	0.54		22:08	0.79						
12	2:59	0.39	12	4:43	0.12	12	6:26	-0.23	12	7:11	-0.34
WE	10:31	1.12	FR	11:11	0.67	MO	22:35	1.08	WE	22:56	1.15
	17:35	0.26		16:03	0.38						
	23:13	0.63		22:24	0.88						
13	4:05	0.34	13	5:33	0.05	13	7:10	-0.25	13	7:53	-0.32
TH	11:13	1.01	SA	11:54	0.56	TU	23:07	1.10	TH	23:35	1.13
	17:45	0.35		15:53	0.39						
	23:24	0.72		22:45	0.95						
14	5:06	0.30	14	6:20	-0.01	14	7:57	-0.25	14	8:37	-0.27
FR	11:52	0.88	SU	12:37	0.46	WE	23:42	1.09	FR		
	17:47	0.41		15:43	0.38						
	23:41	0.82		23:09	1.01						
15	6:08	0.26	15	7:10	-0.05	15	8:49	-0.23	15	0:19	1.09
SA	12:30	0.74	MO	13:34	0.36	TH			SA	9:19	-0.21
	17:38	0.43		15:29	0.34						
				23:37	1.04						

Table 7-2 Manila Bay Tide and Current Table (year of 2007) (2/2)

JANUARY			FEBRUARY			MARCH			APRIL		
Day	Time	Heights	Day	Time	Heights	Day	Time	Heights	Day	Time	Heights
16	4:17	-0.19	1	5:02	-0.32	1	3:43	-0.23	1	3:27	0.09
SA	19:32	1.03	TU	20:52	1.19	TU	19:31	1.06	FR	9:36	0.65
										15:12	0.15
										21:50	0.78
17	4:50	-0.30	2	5:33	-0.29	2	4:14	-0.20	2	3:43	0.21
SU	20:17	1.13	WE	21:50	1.22	WE	11:16	0.34	SA	9:51	0.81
							12:27	0.34		16:21	-0.02
							20:41	1.07		22:56	0.67
18	5:26	-0.36	3	6:02	-0.22	3	4:41	-0.12	3	3:50	0.31
MO	21:04	1.21	M33.1.0	22:46	1.19	TH	10:49	0.40	SU	10:15	0.97
							14:21	0.25		17:24	-0.16
							21:49	1.04		23:59	0.54
19	6:01	-0.39	4	6:29	-0.11	4	5:04	-0.01	4	3:46	0.37
TU	21:51	1.27	M33.1.0	12:20	0.37	FR	10:55	0.50	MO	10:43	1.12
				16:01	0.19		15:43	0.14		18:27	-0.26
				23:38	1.09		22:49	0.96			
20	6:37	-0.36	5	6:51	0.02	5	5:23	0.12	5	1:14	0.40
WE	22:41	1.28	M33.1.0	12:36	0.49	SA	11:10	0.65	M33.1.0	3:23	0.36
				17:20	0.15		16:56	0.03		11:19	1.21
							23:45	0.82		19:32	-0.31
21	7:12	-0.30	6	0:29	0.93	6	5:35	0.23	6	11:58	1.24
Low	23:31	1.23	Low Water	7:08	0.14	Low Water	11:31	0.80	Low	20:40	-0.31
Water				12:57	0.63		18:06	-0.06	Water		
				18:44	0.12						
22	7:45	-0.19	7	1:19	0.73	7	0:40	0.65	7	12:41	1.22
M33.1.0	14:02	0.28	M33.1.0	7:14	0.24	M33.1.0	5:35	0.31	M33.1.0	21:56	-0.27
	16:10	0.25		13:24	0.77		11:58	0.94			
				20:10	0.08		19:15	-0.12			
23	0:22	1.12	8	2:13	0.50	8	1:43	0.45	8	13:35	1.16
SA	8:13	-0.07	TU	7:01	0.29	TU	5:17	0.34	FR	23:16	-0.22
	14:16	0.38		13:56	0.88		12:30	1.04			
	17:33	0.27		21:43	0.05		20:28	-0.16			
24	1:10	0.95	9	3:40	0.28	9	13:10	1.09	9	14:37	1.07
SU	8:34	0.05	WE	6:04	0.26	WE	21:53	-0.16	SA		
	14:40	0.51		14:38	0.95						
	19:17	0.30		23:47	-0.01						
25	1:57	0.75	10	15:33	0.99	10	13:10	1.06	10	0:27	-0.17
MO	8:45	0.16	M33.1.0			TH	21:53	-0.17	SU	15:47	0.98
	15:08	0.65									
	21:23	0.27									
26	2:49	0.51	11	2:17	-0.11	11	14:55	1.04	11	1:18	-0.10
TU	8:41	0.23	M33.1.0	16:48	1.00	FR			MO	16:57	0.89
	15:44	0.78									
	23:33	0.19									
27	2:49	0.28	12	3:20	-0.20	12	1:26	-0.19	12	1:55	-0.02
WE	7:52	0.25	M33.1.0	18:09	1.01	SA	16:14	0.99	M33.1.0	18:08	0.79
	16:32	0.89									
28	2:10	0.03	13	4:01	-0.25	13	2:30	-0.19	13	2:20	0.07
Low	17:33	0.98	Low Water	19:19	1.03	Low Water	17:35	0.95	Low	9:26	0.52
Water									Water	13:34	0.42
										19:26	0.70
29	3:37	-0.14				14	3:09	-0.15	14	2:37	0.16
M33.1.0	18:36	1.06				M33.1.0	18:51	0.91	M33.1.0	9:13	0.60
										14:45	0.31
										20:45	0.53
30	4:22	-0.26				15	3:39	-0.09	15	2:47	0.24
SA	19:36	1.12				TU	20:00	0.88	FR	9:16	0.70
										15:40	0.19
										21:49	0.56
31	5:00	-0.32				16	4:01	-0.02			
SU	20:31	1.17				WE	10:34	0.40			
							13:56	0.34			
							21:02	0.84			
High Water		1.28	High Water		1.22	High Water		1.09	High Water		1.24
Low Water		-0.41	Low Water		-0.33	Low Water		-0.24	Low Water		-0.31
Average		0.42	Average		0.42	Average		0.42	Average		0.44

MAY			JUNE			JULY			AUGUST		
Day	Time	Heights	Day	Time	Heights	Day	Time	Heights	Day	Time	Heights
1	1:55	0.37	1	9:57	1.47	1	10:03	1.48	1	0:45	0.55
SU	9:02	1.11	WE	18:53	-0.28	FR	19:25	-0.07	MO	4:11	0.45
	16:41	-0.14								12:04	1.16
	23:21	0.45								19:19	0.31
2	1:46	0.40	2	10:46	1.47	2	11:34	1.42	2	0:58	0.65
MO	9:34	1.25	TH	19:43	-0.25	SA	20:00	0.03	TU	5:24	0.46
	17:42	-0.27								12:41	1.01
										19:26	0.39
3	10:12	1.34	3	11:37	1.43	3	12:20	1.32	3	1:17	0.75
TU	18:43	-0.34	FR	20:33	-0.18	SU	20:30	0.13	WE	6:47	0.46
										13:17	0.85
										19:24	0.44
4	10:55	1.38	4	12:29	1.35	4	2:56	0.49	4	1:41	0.84
WE	19:43	-0.35	SA	21:16	-0.08	MO	4:07	0.49	TH	6:16	0.45
							13:01	1.19		13:52	0.68
							20:52	0.24		19:08	0.45
5	11:41	1.37	5	13:19	1.25	5	2:59	0.58	5	2:09	0.92
TH	20:44	-0.31	M33.1.0	21:56	0.03	TU	5:37	0.55	FR	9:51	0.41
							13:39	1.03		14:34	0.52
							21:06	0.33		18:40	0.43
6	12:32	1.31	6	14:06	1.11	6	3:16	0.68	6	2:44	0.98
Low	21:44	-0.24	Low	22:25	0.14	Low	7:43	0.59	Low	11:59	0.34
Water			Water			Water	14:14	0.86	Water		
							21:08	0.39			
7	13:28	1.22	7	14:48	0.95	7	3:40	0.79	7	3:26	1.04
M33.1.0	22:41	-0.15	M33.1.0	22:45	0.23	M33.1.0	10:12	0.57	M33.1.0	14:04	0.22
							14:49	0.68			
							20:55	0.43			
8	14:24	1.11	8	6:12	0.64	8	4:11	0.88	8	4:22	1.09
SU	23:28	-0.05	WE	10:00	0.62	FR	12:27	0.47	MO	14:58	0.11
				15:30	0.78		15:40	0.51			
				22:55	0.32		20:24	0.43			
9	15:20	0.98	9	6:08	0.75	9	4:48	0.97	9	5:28	1.15
MO			TH	12:32	0.53	SA	14:33	0.33	TU	15:36	0.02
				16:24	0.61						
				22:50	0.41						
10	0:05	0.05	10	6:25	0.85	10	5:33	1.06	10	6:33	1.22
TU	16:14	0.84	FR	14:10	0.40	SU	15:32	0.19	WE	16:10	-0.04
				18:39	0.46						
				22:34	0.41						
11	0:30	0.15	11	6:50	0.96	11	6:20	1.14	11	7:31	1.29
WE	8:17	0.60	SA	15:23	0.25	MO	16:08	0.07	TH	16:41	-0.06
	12:23	0.53									
	17:17	0.70									
12	0:46	0.23	12	7:18	1.06	12	7:08	1.23	12	8:27	1.34
TH	7:57	0.69	M33.1.0	16:12	0.11	TU	16:42	-0.02	FR	17:11	-0.04
	13:56	0.41									
	18:50	0.56									
13	0:50	0.31	13	7:50	1.15	13	7:56	1.31	13	9:23	1.36
Low	8:03	0.80	Low	16:53	-0.10	Low	17:16	-0.08	Low	17:38	0.02
Water	15:04	0.28	Water			Water			Water	23:49	0.50
	20:41	0.47									
14	0:46	0.36	14	8:26	1.24	14	8:44	1.38	14	2:21	0.44
M33.1.0	8:17	0.91	M33.1.0	17:30	-0.09	M33.1.0	17:49	-0.10	M33.1.0	10:19	1.33
	15:57	0.14								18:04	0.12
	22:01	0.41								23:55	0.58
15	0:33	0.38	15	9:04	1.31	15	9:33	1.43	15	3:40	0.40
SU	8:37	1.01	WE	18:08	-0.14	FR	18:23	-0.08	MO	11:13	1.24
	16:43	0.01								18:23	0.24
	23:24	0.37									
16	0:09	0.37				16	10:22	1.44	16	0:09	0.70
MO	9:01	1.10				SA	18:56	-0.02	TU	4:59	0.35
	17:26	-0.09								12:05	1.10
										18:39	0.35
High Water		1.38	High Water		1.52	High Water		1.50	High Water		1.42
Low Water		-0.35	Low Water		-0.28	Low Water		-0.17	Low Water		-0.90
Average		0.49	Average		0.59	Average		0.63	Average		0.61

SEPTEMBER			OCTOBER			NOVEMBBER			DECEMBER		
Day	Time	Heights	Day	Time	Heights	Day	Time	Heights	Day	Time	Heights
1	0:04	0.90	1	8:02	-0.06	1	0:25	1.07	1	1:07	1.01
TH	7:08	0.23	SA			TU	9:50	-0.19	TH	9:58	-0.13
	13:10	0.59									
	17:26	0.43									
2	0:29	0.95	2	0:09	1.05	2	1:14	1.03	2	1:59	0.90
FR	8:11	0.20	SU	9:02	-0.07	WE	10:50	-0.16	FR	10:31	-0.04
	13:57	0.46									
	17:06	0.40									
3	1:00	1.00	3	0:49	1.05	3	2:16	0.96	3	2:58	0.74
SA	9:23	0.17	MO	10:18	-0.05	TH	11:42	-0.11	SA	10:55	0.06
										18:02	0.56
										23:23	0.40
4	1:36	1.03	4	1:38	1.03	4	3:29	0.87	4	4:15	0.55
SU	11:02	0.14	TU	11:47	-0.07	FR	12:22	-0.04	SU	11:10	0.16
										18:20	0.71
5	2:23	1.05	5	2:45	1.01	5	4:49	0.76	5	1:19	0.22
M33.1.0	12:56	0.07	WE	12:53	-0.08	M33.1.0	12:50	0.05	MO	6:37	0.37
							19:48	0.58		11:16	0.24
										18:49	0.88
6	3:27	1.06	6	4:05	0.99	6	0:53	0.37	6	2:40	0.00
Low	14:00	0.00	Low	13:36	-0.07	Low	6:27	0.64	Low	19:24	1.04
Water			Water			Water	13:10	0.15	Water		
							19:52	0.72			
7	4:45	1.09	7	5:24	0.96	7	2:13	0.17	7	3:46	-0.20
M33.1.0	14:44	-0.04	M33.1.0	14:11	-0.03	M33.1.0	8:19	0.54	M33.1.0	20:04	1.18
							13:22	0.25			
							20:09	0.89			
8	5:58	1.13	8	6:44	0.92	8	3:18	-0.04	8	4:43	-0.36
TH	15:18	-0.06	SA	14:38	0.05	TU	9:46	0.46	TH	20:48	1.29
				21:05	0.57		13:25	0.31			
							20:35	1.05			
9	7:07	1.16	9	1:38	0.36	9	4:18	-0.23	9	5:35	-0.45
FR	15:47	-0.03	SU	8:07	0.66	WE	11:02	0.38	FR	21:34	1.35
	22:48	0.49		14:58	0.15		13:21	0.33			
				21:09	0.70		21:08	1.20			
10	0:16	0.48	10	2:52	0.18	10	5:16	-0.37	10	6:26	-0.48
SA	8:13	1.16	MO	9:25	0.79	TH	21:46	1.30	SA	22:24	1.36
	16:12	0.04		15:12	0.25						
	22:22	0.54		21:23	0.85						
11	2:03	0.39	11	3:57	0.00	11	6:13	-0.45	11	7:14	-0.44
SU	9:18	1.13	TU	10:31	0.69	FR	22:26	1.35	SU	23:16	1.32
	16:35	0.14		15:18	0.34						
	22:28	0.65		21:46	1.02						
12	3:20	0.28	12	4:57	-0.15	12	7:12	-0.46	12	8:00	-0.36
M33.1.0	10:21	1.05	WE	11:34	0.56	M33.1.0	23:14	1.33	MO		
	16:50	0.26		15:15	0.39						
	22:42	0.79		22:14	1.16						
13	4:32	0.16	13	5:59	-0.26	13	8:11	-0.04	13	0:06	1.23
Low	11:19	0.92	Low	22:48	1.25	Low			Low	8:44	-0.25
Water	17:00	0.36	Water			Water			Water		
	23:02	0.94									
14	5:40	0.05	14	7:01	-0.31	14	0:06	1.26	14	0:57	1.11
M33.1.0	12:15	0.75	M33.1.0	23:28	1.29	M33.1.0	9:11	-0.33	M33.1.0	9:22	-0.13
	17:00	0.43									
	23:28	1.07									
15	6:49	-0.02	15	8:09	-0.31	15	1:03	1.16	15	1:43	0.95
TH	13:17	0.57	SA			TU	10:10	-0.23	TH	9:53	-0.01
	16:45	0.45									
			16	0:15	1.27				16	2:26	0.76
			SU	9:23	-0.27				FR	10:12	0.10
										17:09	0.47
										21:56	0.43
High Water		1.25	High Water		1.29	High Water		1.35	High Water		1.36
Low Water		-0.06	Low Water		-0.31	Low Water		-0.46	Low Water		-0.48
Average		0.55	Average		0.46	Average		0.44	Average		0.43

NOTE: MANILA SOUTH HARBOR LAT14°35'N LONG120°58'E

Figure 7-6 Tidal River Extent

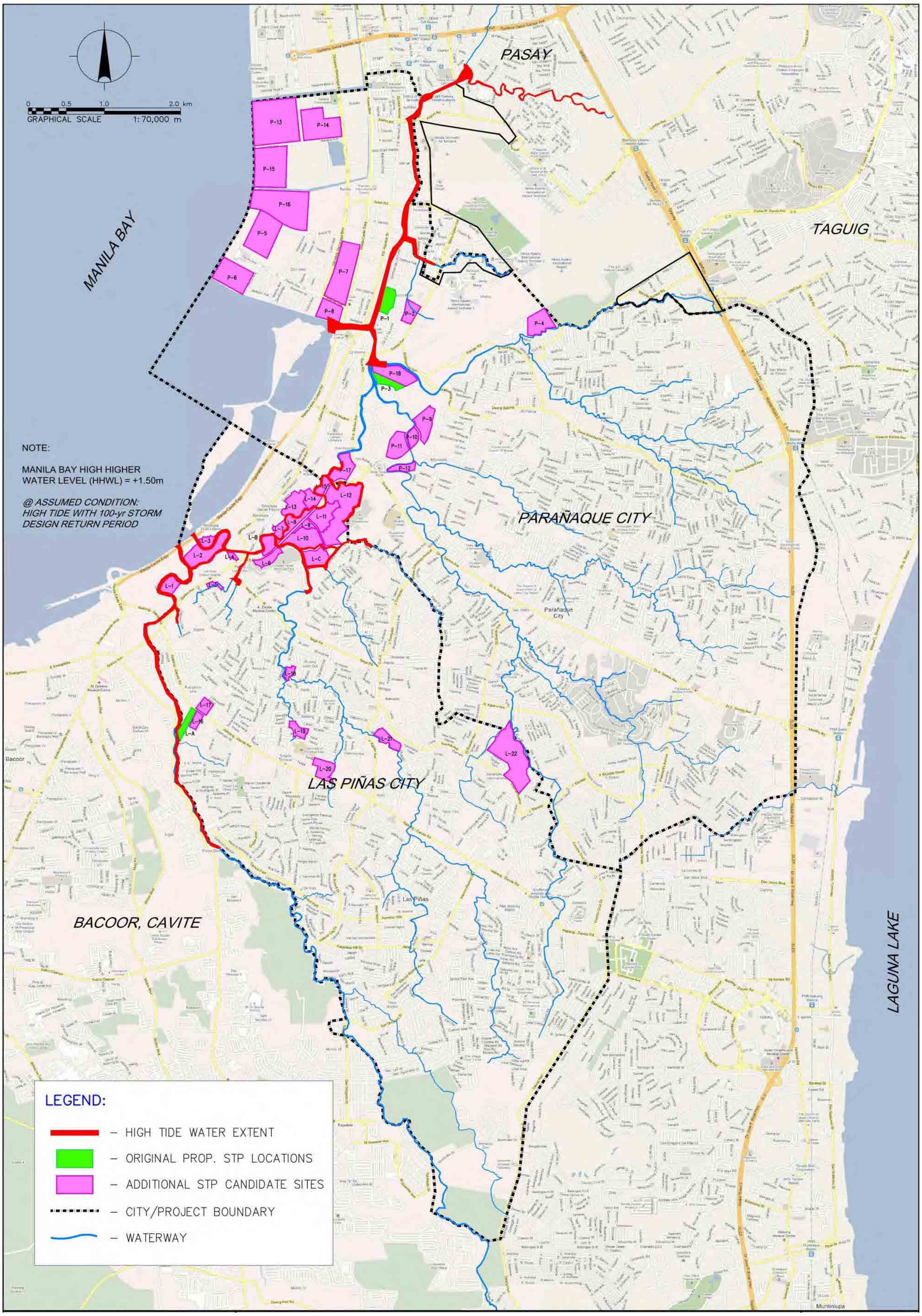


Table 7-3 Water Usage and Classifications

A) Fresh Surface Water (river, lakes, reservoir, etc.)

Classification	Beneficial Use
Class AA	Public Water Supply Class 1. This class is intended primarily for waters having watersheds which are uninhabited and otherwise protected and which require only approved disinfection in order to meet the National standards for Drinking Water (NSDW) of the Philippines.
Class A	Public Water Supply Class 2. For sources of water supply that will require complete treatment(coagulation, sedimentation, filtration, and disinfection) in order to meet the NSDW.
Class B	Recreational Water Class 1. For primarily contact recreation such as bathing, swimming, skin diving, etc. (particularly those designated for tourism purpose.)
Class C	a. Fishery Water for the propagation and growth of fish and other aquatic resources. b. Recreational water class 2 (boating, etc) c. Industrial Water supply class 1 (from manufacturing processes after treatment)
Class D	1. For agriculture, irrigation, live stocks watering, etc. 2. Industrial Water supply class 2 (e.g. cooling, etc.) 3. Inland waters by their quality belong to this classification.

B) Coastal and Marine Waters

Classification	Beneficial Use
Class SA	1. Waters suitable for the propagation survival and harvesting of selfish, for commercial purposes. 2. Tourist Zones and national marine parks and reserves established under Presidential Proclamation No. 1801; existing laws and/or declared as such by appropriate government agency. 3. Coral reef parks and reserves designated by law and concerned authorities. 4. Waters suitable for the propagation survival and harvesting of selfish, for commercial purposes. 5. Tourist Zones and national marine parks and reserves established under Presidential Proclamation No. 1801; existing laws and/or declared as such by appropriate government agency. 6. Coral reef parks and reserves designated by law and concerned authorities
Class SB	1. Recreational Water Class 1 (areas regularly used by the public for bathing swimming, skin diving, etc.) 2. Fishery Water class 3 (spawning areas for Chanos chanos or “Bangus” and similar species.
Class CS	1. Recreational Water class 3 (e.g. boating, etc.) 2. Fishery Water class 2 (commercial and sustenance fishing). 3. Marchy and/or mangrove areas declared as fish and wildlife sanctuaries
Class SD	1. Industrial Water supply class 2 (e.g. cooling, etc.) 2. Other coastal and marine waters, by their quality, belong to this classification.

Table 7-4 Effluent Water Quality Standard

TABLE 2A - Effluent Standards: Conventional and Other Pollutants in Protected Waters Category I and II and in Inland Waters Class C[a]

Parameter	Unit	Protected Waters				Inland Waters	
		Category I (Class AA & SA)		Category II (Class A, B & SB)		Class C	
		OEI	NPI	OEI	NPI	OEI	NPI
Color	PCU	b	b	150	100	200[c]	150[c]
Temperature (max rise in deg. Celsius in RBW)	°C rise	b	b	3	3	3	3
pH (range)		b	b	6.0-9.0	6.0-9.0	6.0-9.0	6.5-9.0
COD	Mg/L	b	b	100	60	150	100
Settleable Solids (1-hour)	Mg/L	b	b	0.3	0.3	0.5	0.5
5-Day 20 °C BOD	Mg/L	b	b	50	30	80	50
Total Suspended Solids	Mg/L	b	b	70	50	90	70
Total Dissolved Solids	Mg/L	b	b	1,200	1,000	-	-
Surfactants (MBAS)	Mg/L	b	b	5.0	2.0	7.0	5.0
Oil/Grease (Petroleum Ether Extract)	Mg/L	b	b	5.0	5.0	10.0	5.0
Phenolic Substances as Phenols	Mg/L	b	b	0.1	0.05	0.5	0.1
Total Coliforms	MPN/100mL	b	b	5,000	3,000	15,000	10,000

2) Water Qualities of Waterways and Discharging Out Falls

According to DENR, water quality of Parañaque-Zapote River system in 2006 is shown as **Table 7-5**.

Table 7-5 Water quality of the Parañaque-Zapote River System, 2006

Parameters	Value	DENR Standard	Assessment	Rating
DO ,mg/L	1.19	5	Failed	Poor
BOD ,mg/L	41.02	10	Failed	Poor
Suspended Solids change mg/L	41.02	30	Failed	Poor
pH	7.89	6-5-8-5	Failed	Poor
Temperature Change °C	0.92	3	Passed	Good

Source: DENR-Environmental Management Bureau (NCR) as cited in Las Piñas City Profile

Figure 7-7 shows Environmental Monitoring Stations for surface water and air in Parañaque and Las Pinãs City. These sampling numbers of the project areas would not be sufficient. 19 points for surface water quality sampling were selected by the survey team and water quality analysis and evaluation were done on the collected water samples. **Figure 7-8** shows surface water sampling points in the project areas selected by the team. Maricaban creek in Pasay City is the upstream of Parañaque River, Therefore the other 9 of surface water sampling positions in Maricaban Creek was selected and analyzed. **Figure 7-9** shows the sampling positions of Maricaban Creek. The study team additionally conducted the wastewater profile and quality survey in Parañaque and Las Pinãs of residential, commercial and industrial areas respectively on January 29, 2011 (in dry season). **Figure 7-10 (1/2) and (2/2)** shows the sampling stations of the survey.

(1) Sampling Procedures and Analyses

Representative samples of water were collected and preserved in an ice-filled cooler before sending to an independent laboratory for analysis. The parameters and methods of analyses used to determine the wastewater characteristics were presented in **Table 7-6**. The sampling procedures and analyses were in accordance with the prescribed methods in DENR AO 34 and American Public Health Association's (APHA's) Standard Methods for the Examination of Water and Wastewater.

Table 7-6 Parameters and Methods of Analyses

Parameters	Methodology
pH	Glass Electrode (in-situ)
Color	Platinum Cobalt-Colometric
Temperature	Digital Thermometer (in-situ)
Total Suspended Solids (TSS)	Gravimetric
Total Dissolved Solids (TDS)	Gravimetric
Oil and Grease (O&G)	Partition-Gravimetric
Biochemical Oxygen Demand (BOD)	Azide Modification (Dilution Technique)
Chemical Oxygen Demand (COD)	Closed Reflux, Colorimetric
Dissolved Oxygen (DO)	Membrane Electrode (DO Meter / in-situ)
Surfactants (MBAS)	Methylene Blue
Chloride	Argentometric
Nitrogen (N)	Palintest
Phosphorus (P)	Stannous Chloride
Fecal Coliform	Multiple Tube Fermentation
Total Coliform	Multiple Tube Fermentation

The water quality analysis and evaluations are described hereinafter. The suffixes put in the tables mean the followings.

a – Except as otherwise indicated, the numerical limits are yearly average values. Values enclosed in parentheses are maximum values

b – No abnormal discoloration from unnatural causes

c – The allowable temperature increases over the average ambient temperature for each month. This rise shall be based on the average of the maximum daily temperature readings recorded at the site but upstream of the mixing zone over a period of one (1) month

d – Not more than 30 mg/L increase

e – Applicable only to lakes or reservoirs, and similarly impounded water

f – When applied to lakes or reservoirs, the Phosphate as P concentration should not exceed an average of 0.05 mg/L nor a maximum of 0.1 mg/L

g –These values refer to the geometric mean of the most probable number of coliform organism during a three (3) month period and that the limit indicated shall not be exceeded in 20 percent of the samples taken during the same period

MPN – Most Probable Number

Figure 7-7 DENR Environmental Monitoring Stations

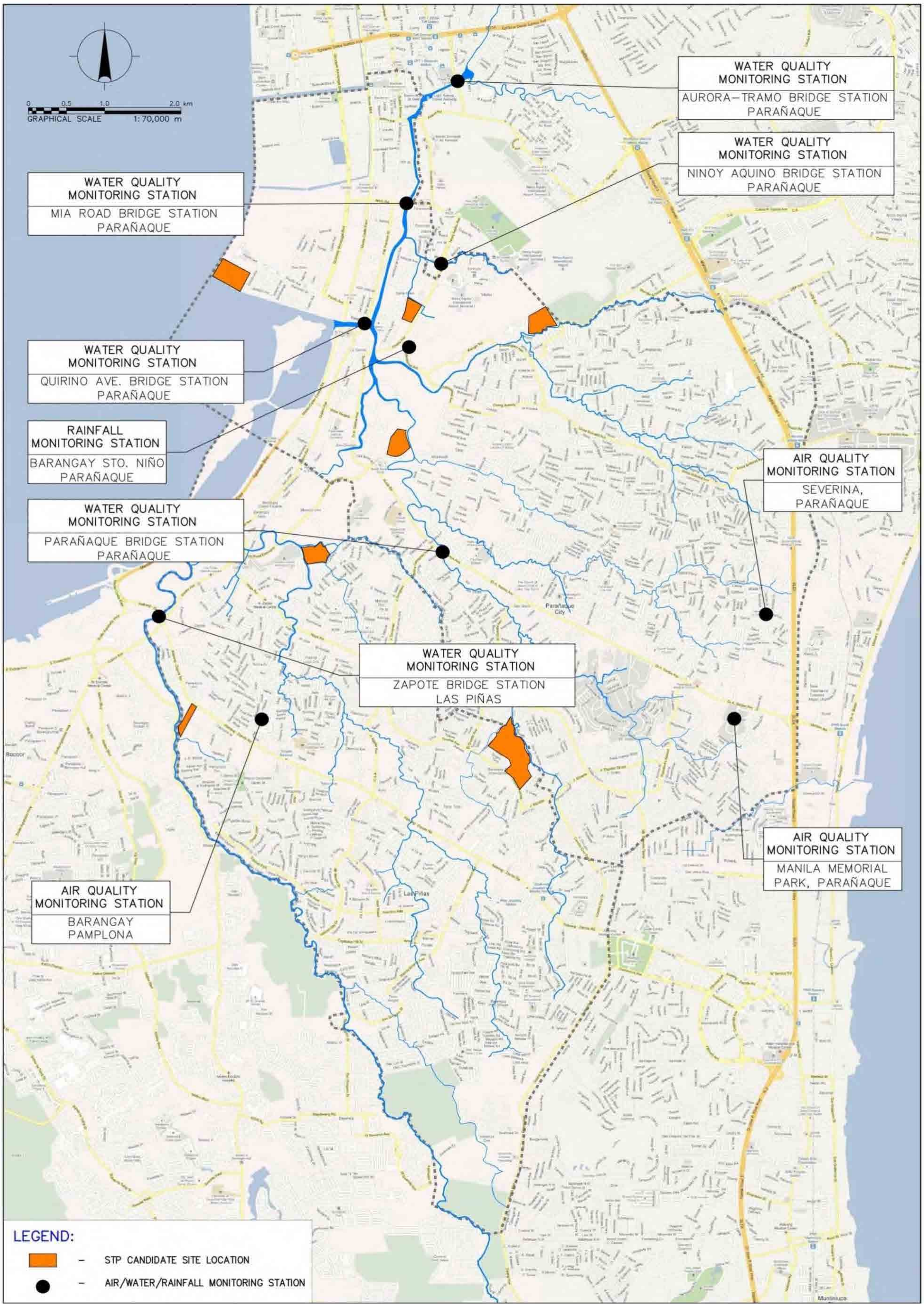


Figure 7-8 Surface Water Sampling Stations by Survey Team

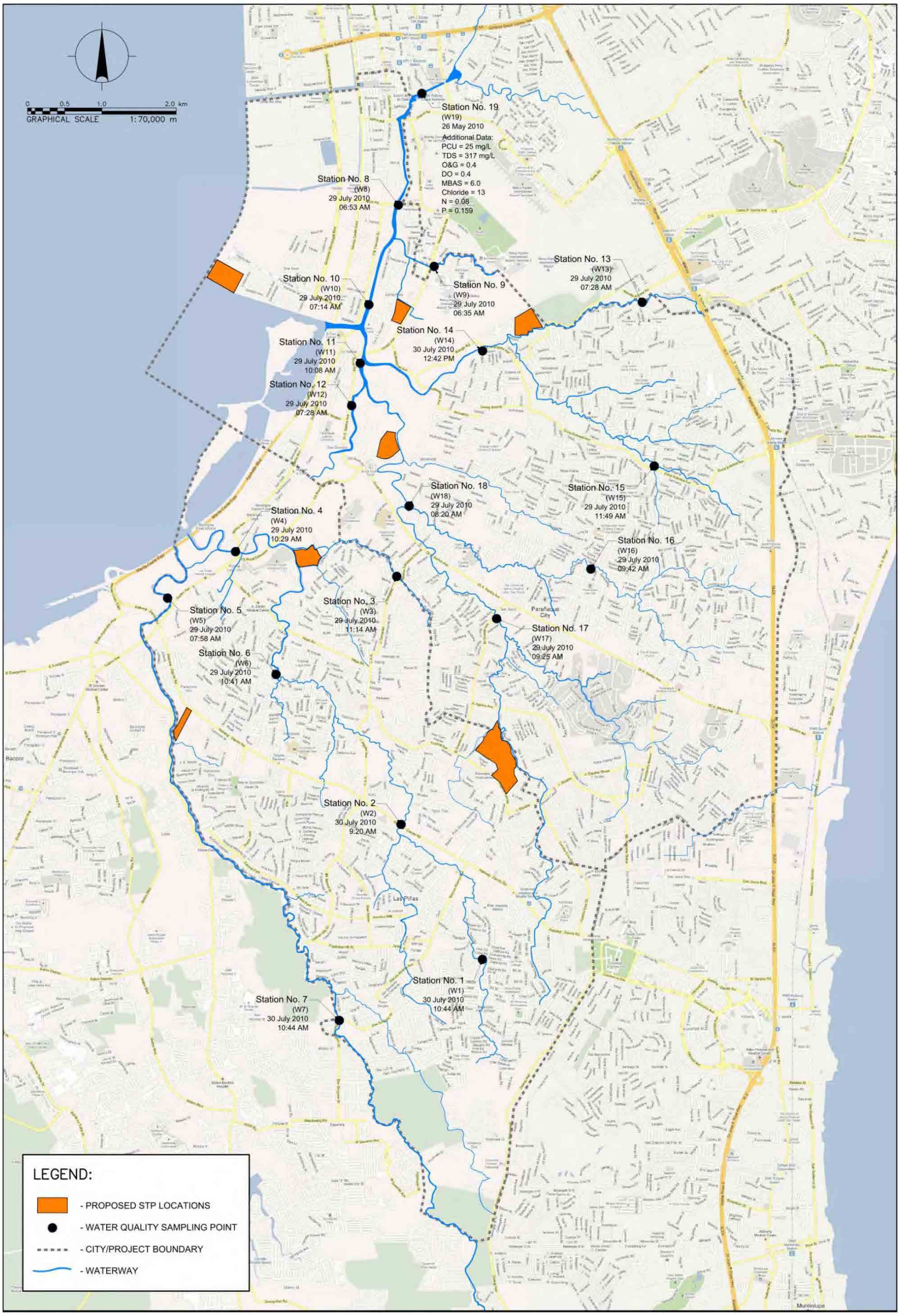


Figure 7-9 Water Quality Analysis Sampling Stations in Maricaban Creek by Survey Team

Figure 7-10 (1/2). Location of Effluent Wastewater Sampling Stations at Las Piñas

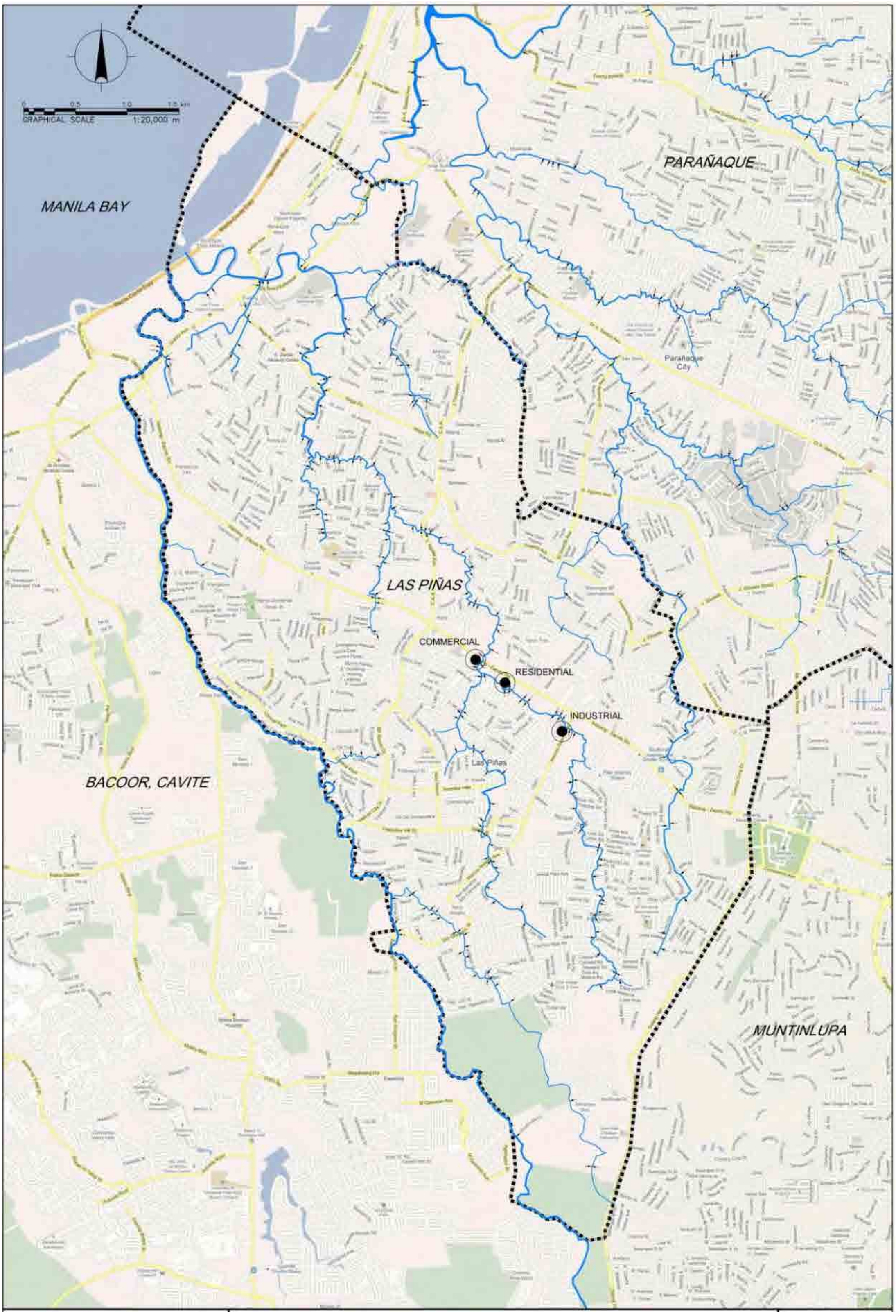
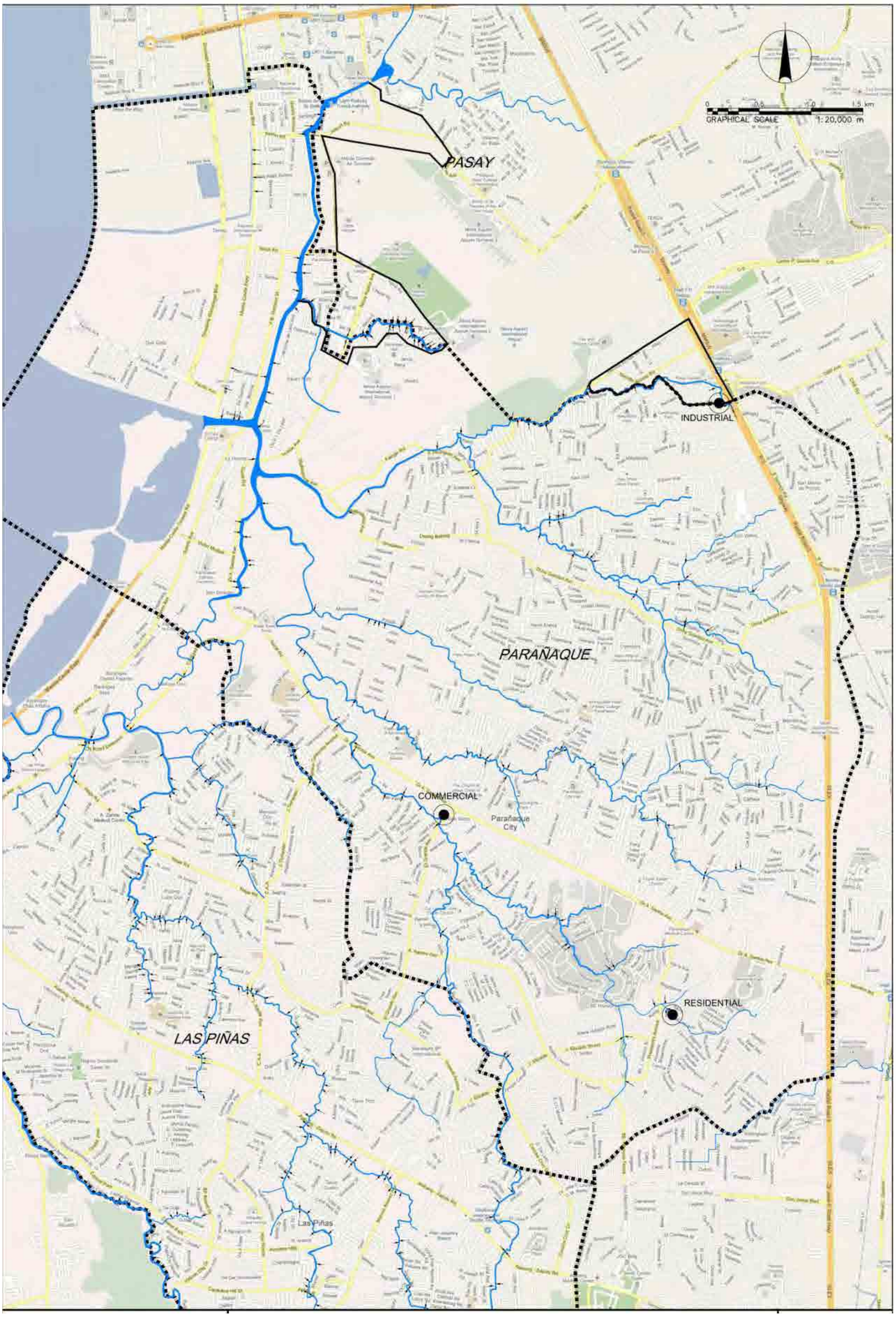


Figure 7-10 (2/2) Location of Effluent Wastewater Sampling Stations at Parañaque



(2) Survey Results and Evaluations of Fresh Water in Waterways

a) Maricaban Creek

Presented are the procedures and results of the water quality monitoring conducted on May 25 and 26, 2010 for the Maricaban Retarding Pond areas locating at upstream of Paranaque River in Pasay City. The detail repot is attached as Annex 2-3.

The results of the survey are shown in **Table 7-7**.

Table 7-7 Surface Water Quality in Maricaban Creek

Parameters	WW1 Upstream of Tripa De Gallina 26 May 2010 / 0942H	WW2 Mouth of Tripa De Gallina 26 May 2010 / 1012H	WW3 Creek near the Maricaban Creek (Left Side) 25 May 2010 / 0825H	WW4 Pipe Outfall via Maricaban Creek (Left Side) 26 May 2010 / 0720H	WW5 Pipe Outfall via Maricaban Creek (Left Side) 25 May 2010 / 0855H	Water Quality Criteria for Class C Waters
pH	7.52	7.49	0.419	7.5	7.44	6.5 – 8.5
Color (Apparent), PCU	25	40	40	25	25	[b]
Temperature, ˚C	30.1	30.3	30.8	30.2	30.3	3˚C max rise [c]
TSS, mg/L	12.2	38	88.4	55	22.5	[d]
TDS, mg/L	262	290	305	331	299	No Criteria
Oil and Grease, mg/L	0.8	0.8	13.6	1.2	0.8	2
BOD, mg/L	66	76	52	63	23	7 (10)
COD, mg/L	82	118	156	84	61	No Criteria
DO, mg/L	0.5	0.4	0.5	0.5	0.5	5.0 (Minimum)
Surfactants (MBAS)	2.3	2.6	4	2.6	5.9	0.5
Chloride, mg/L	75	73	60	81	60	350
Nitrogen (N), mg/L	0.18	0.26	0.18	0.16	0.33	10 [e]
Phosphorus (P), mg/L	0.163	0.203	0.419	0.285	0.203	0.4 [f]
Fecal Coliform, MPN/100mL	46×10^6	46×10^6	46×10^6	24×10^5	13×10^6	No Criteria
Total Coliform, MPN/100mL	46×10^6	70×10^6	46×10^6	24×10^5	24×10^6	5000 [g]
Parameters	**WW6 Pipe Outfall via Maricaban Creek (Right Side) 25 May 2010 / 0910H**	**WW7 Pipe Outfall via Maricaban Creek (Right Side) 26 May 2010 / 0810H**	**WW8 Inlet of Maricaban Creek to the Pond 25 May 2010 / 0825H**	**WW9 At the Farthest Point of the Pond 26 May 2010 / 0910H**	**WW10 Outlet of Parañ aque River 26 May 2010 / 1049H**	**Water Quality Criteria for Class C Waters**
pH	7.44	7.51	7.44	7.54	7.36	6.5 – 8.5
Color (Apparent), PCU	30	25	35	35	25	[b]
Temperature, ˚C	30.1	30.5	30.3	30.1	30	3˚C max rise [c]
TSS, mg/L	23.8	32	77.5	28.8	20	[d]
TDS, mg/L	287	308	308	299	317	No Criteria
Oil and Grease, mg/L	< 0.1	2	0.8	0.8	0.4	2
BOD, mg/L	32	43	46	69	38	7 (10)
COD, mg/L	67	78	93	102	98	No Criteria
DO, mg/L	0.4	0.4	0.4	0.5	0.4	5.0 (Minimum)
Surfactants (MBAS)	4.7	5.1	2.3	2.7	6	0.5
Chloride, mg/L	66	62	65	64	13	350
Nitrogen (N), mg/L	0.29	0.32	0.29	0.26	0.08	10 [e]
Phosphorus (P), mg/L	0.815	0.23	0.227	0.176	0.157	0.4 [f]
Fecal Coliform, MPN/100mL	13×10^6	46×10^6	13×10^7	54×10^6	54×10^6	No Criteria
Total Coliform, MPN/100mL	13×10^6	46×10^6	24×10^7	54×10^6	54×10^6	5000 [g]

Notes:

a – Except as otherwise indicated, the numerical limits are yearly average values. Values enclosed in parentheses are maximum values

b – No abnormal discoloration from unnatural causes

c – The allowable temperature increases over the average ambient temperature for each month. This rise shall be based on the average of the maximum daily temperature readings recorded at the site but upstream of the mixing zone over a period of one (1) month

d – Not more than 30 mg/L increase

e – Applicable only to lakes or reservoirs, and similarly impounded water

f – When applied to lakes or reservoirs, the Phosphate as P concentration should not exceed an average of 0.05 mg/L nor a maximum of 0.1 mg/L

g – These values refer to the geometric mean of the most probable number of coliform organism during a three (3) month period and that the limit indicated shall not be exceeded in 20 percent of the samples taken during the same period

MPN – Most Probable Number

Red figures in the table show the results over DENR standards.

b) Parañaque and Las Pinãs Waterways

Presented are the procedures and results of the water quality monitoring conducted on July 29 and 30, 2010 at 19 sampling stations in the waterways in Parañaque and Las Piñas Cities.

The detail repot is attached as Annex 2-2.

The results of the survey are shown in **Table 7-8**.

Table 7-8 Surface Water Quality in Waterways in Parañaque and Las Pinãs Cities

								Sampling Date: July 29 and 30, 2010		
	Station No.	Location	Sampling Date-Time	Analysing Items	pH	Temparature (℃)	TSS (mg/L)	BOD5(mg/L) (mg/L)	COD (mg/L) (mg/L)	Total Coliform (MPN100mL)
				DENR Standards	6.5 to 8.5	max rise 3	not more than 30mg/L increase	7 (max 10)	no criteria	5,000
Las Piñas	1 (W1)	Gold Stone cor. Dona Pilar Agurre Avenue	Jul.30-10:44am		7.40	27.6	5.6	44.0	91.0	22×10^6
	2 (W2)	Talon Bridge at Alaban-Zapote Road	Jul.30- 09:20am		7.50	28.9	9.2	20.0	38.0	14×10^6
	3 (W3)	Paalanyag	Jul.29-11:14am		7.15	28.7	5.7	17.0	27.0	49×10^5
	4 (W4)	Alido Bridge	Jul.29-10:29am		7.25	27.1	21.8	46.0	80.0	79×10^5
	5 (W5)	Dongalo Santo Niño	Jul.29-07:58am		7.30	25.9	23.3	13.0	25.0	35×10^6
	6 (W6)	Naga-Pulang Lupa	Jul.29-10:41am		7.20	27.9	1.1	22.0	51.0	33×10^5
	7 (W7)	Talon Singko	Jul.30-10:44am		7.60	26.5	14.4	13.0	22.0	23×10^5
Parañaque	8 (W8)	Cut-Cut Bridge	Jul.29-06:53am		7.00	26.8	12.2	15.0	31.0	49×10^5
	9 (W9)	Tambo Bridge	Jul.29-06:35am		7.00	27.4	17.2	14.0	26.0	33×10^5
	10 (W10)	Santo Niño Bridge	Jul.29-07:14am		7.30	26.3	8.2	19.0	28.0	35×10^6
	11 (W11)	La Huerta	Jul.29-10:08am		7.25	26.6	3.3	17.0	36.0	49×10^5
	12 (W12)	Kintetsu World Express	Jul.29-07:28am		7.50	27.0	9.4	16.0	30.0	17×10^6
	13 (W13)	Merville Access Road	Jul.29-12:45pm		7.50	30.6	25.0	39.0	71.0	92×10^6
	14 (W14)	Ibayo Airport View Subdivision	Jul.30-12:42pm		7.30	30.0	7.0	12.0	28.0	46×10^5
	15 (W15)	Doña Sledad	Jul.29-11:49am		7.20	29.4	12.9	22.0	30.0	33×10^5
	16 (W16)	SAV II Bridge	Jul.29-09:42am		7.20	16.9	< 0.1	12.0	26.0	35×10^6
	17 (W1)	Aberdee	Jul.29-09:25am		7.05	26.4	16.0	33.0	46.0	35×10^6
	18 (W18)	Paraaque National High School	Jul. 29-08:20am		7.40	26.7	< 0.1	16.0	48.0	13×10^6

Note: Red figures mean over DENR standards.

c) Target of Treated Water Quality Level

The fresh water quality survey was done on May (dry season) and July (rainy season) 2010. Judging from fresh water quality analysis in the project areas, most of the fresh water qualities except BOD_5 and number of total coliform are still kept in are under DENR standards, and water quality analysis conducted in parallel with the wastewater profile study in Parañaque and Las Pinãs show the similar patterns (refer **Table 5-5**), thus the main target of the sewage plant designs should be to clear the discharge water quality standards of BOD_5 and number of total coliform. This areas are categorized Class C, thus the effluent water quality level shall be of 50mg/l or less on DOD_5 level.

(3) Wastewater Profiling in Project Areas

a) Wastewater Discharging Profiling

Wastewater profiling study was conducted in dry season on January 29, 2011. The detail repot is attached as Annex 2-1. Wastewater discharging profiles were conducted in the areas categorized residential, commercial and industrial areas. The wastewater discharging rates are calculated from the filling time of wastewater in a testing bucket. The results are shown in **Figure 7-11, 7-12 and 7-13.**

Figure 7-11 Wastewater Discharging Profile (Residential Areas)

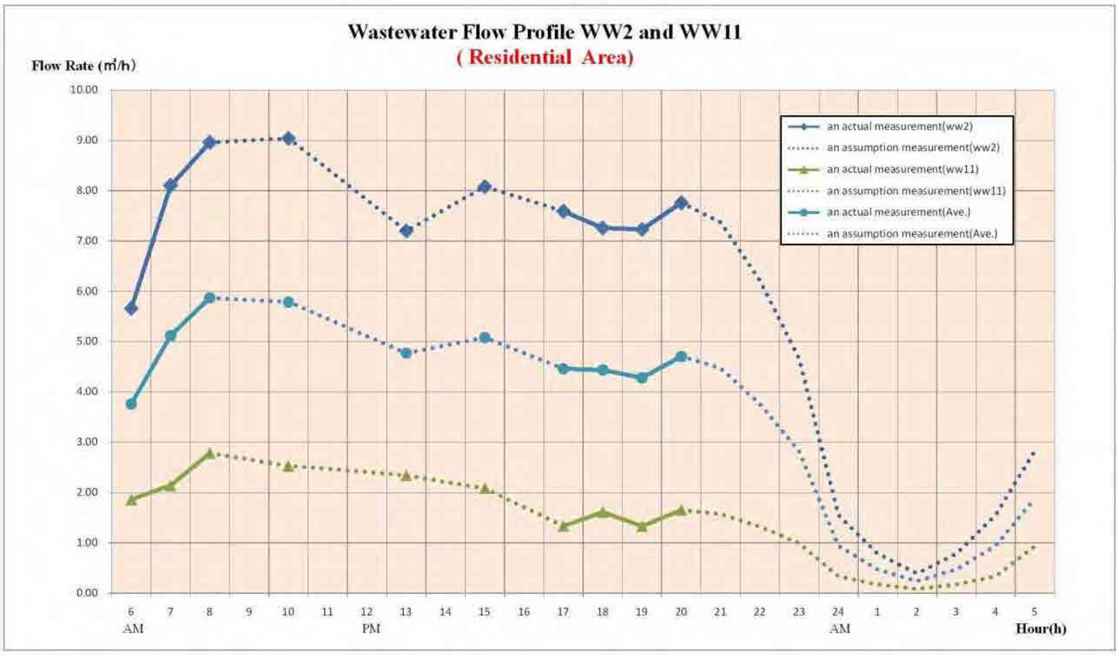


Figure 7-12 Wastewater Discharging Profile (Commercial Areas)

Figure 7-13 Wastewater Discharging Profile (Industrial Areas)

b) Evaluations on the Profile

(a) Water Profiles

Residential Areas: Maximum water use appears in the morning time, 7 to 8am, and the second peak emerges in the evening, 8 to 9pm. These shows the residents' life patterns.
Commercial Areas: Maximum water consumption emerges 20pm, and the second 13pm, and the third 8am. This means guests come to the restaurant in morning time, lunch time and after working time.

Industrial Areas: Water consumption is almost stable during working hours around 8 am to 5pm. The peak flow appear morning time and after working time around 6 to 7 pm. This maybe follows the factory activities.

(b) Wastewater influent profile into STPs would be studied with water consumption pattern in the residential areas. This assumption is done in Section 5.3.2 in Paragraph 5. The study results show that standard parameters used for sewerage design in Japan are also available in Philippines, that is;

Day maximum flow rate: 1.2 times average day flow rate
Hourly maximum flow rate: 1.5 times the day maximum rate
And these rates would justify the future wastewater per capita, 180 l/cap.day could be applied as the project design parameter for sewage treatment process.

7.2 Sub-basins and Water Flow Rate

Parañaque and Las Piñas are broadly divided into seven sub basins and 57 sub-sub basins. The largest sub-basins are Sub basin 4 (San Dionosio River), followed by Las Piñas Central, and next Sub basin 3 (Don Galo River). The combined population of Parañaque and Las Piñas in 2036 will be 1,393,608, of which approximately 90 percent will reside in Sub basins 3~6. The total sewage flow in both cities will be 250,849 m^3/d.

Sewerage treatment system shall be taken consideration the boundaries of sub or sub-sub basins when the interceptor line plans and selection of STP locations are designed (refer **Figure 7-1**).

The borders of the tub basins and sub-sub basins are shown in **Figure 7-14**

7.2.1 Sub Basins and Sub-sub Basins

Borderlines of the sub basins and the sub-sub basins are not always fallen in line with Barangay border lines. **Figure 7-15** shows sub and sub-sub basin border lines and Barangay lines. Sewage water collection shall basically be by gravity flow to avoid large cost of sewer installation cost, thus water collection shall be made in each sub-sub basin.

7,2.2 Population in Each Sub Basins

Because of border line difference of Barangay border lines and sub-sub basin borders, the water flow rate of each sub-sub basin shall be calculated from the population of the sub-sub basin. **Table 7-9** shows population on each sub-sub basin. Basically to say, this sub-sub basin unit population shall be used for the interceptor and conversion manhole sizes.

Figure 7-14 Sub Basin and Sub-sub Basin Border Lines

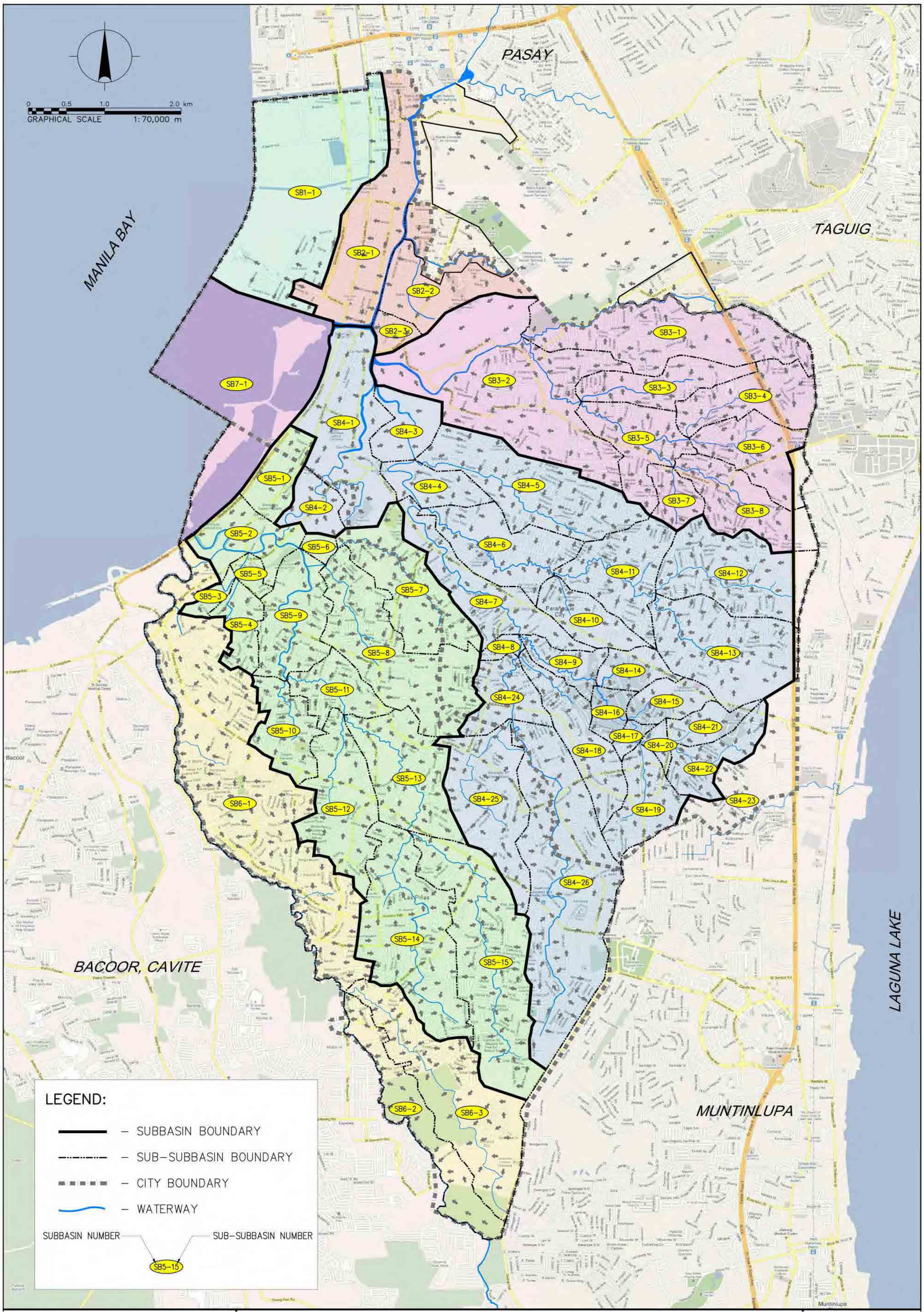


Figure 7-15 Border Lines of Sub-sub Basins and Barangays

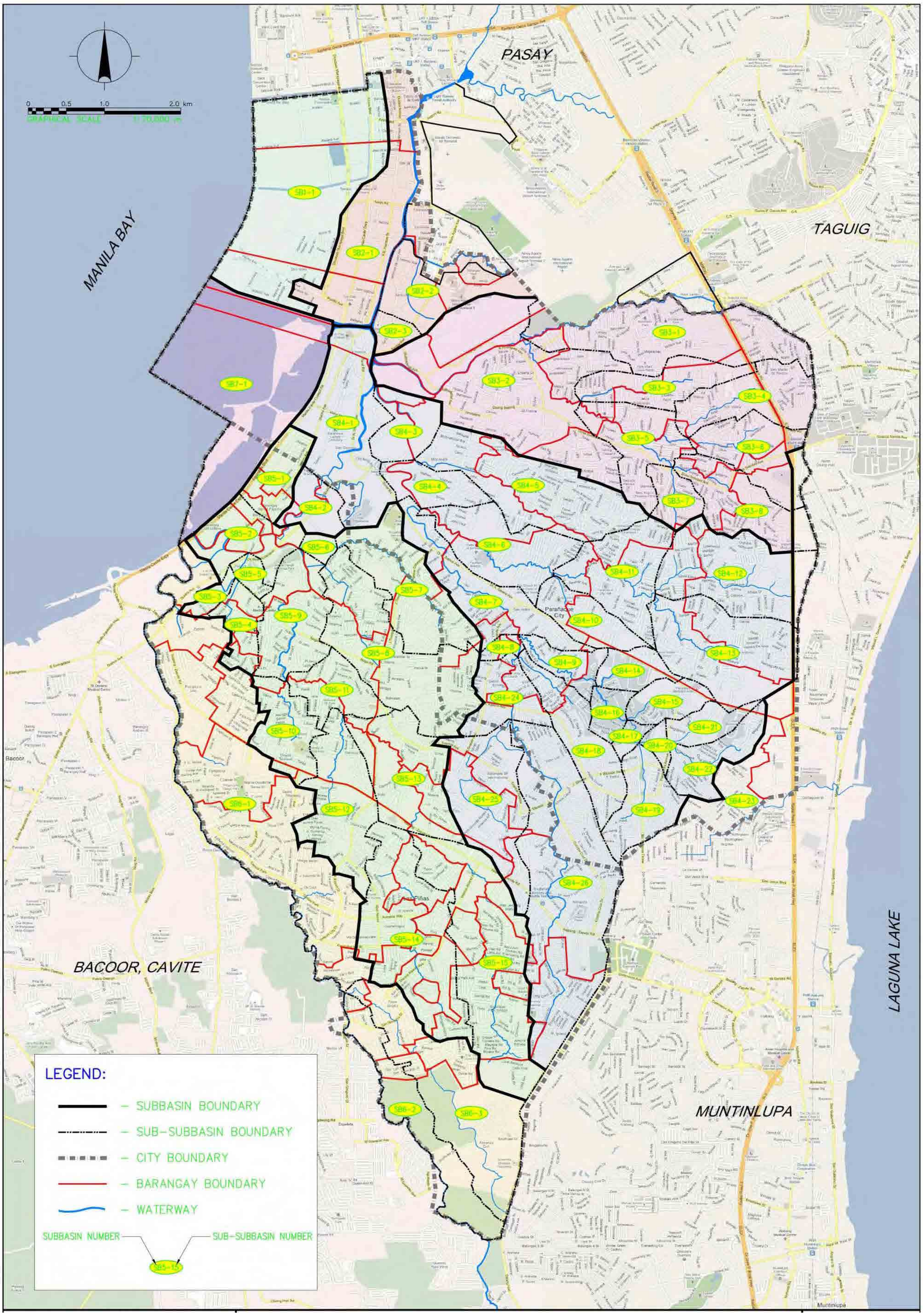


Table 7-9 (1/4) Populations in Sub-sub Basins 2036

City			Paranaque																Las Piñas		
Barangay			Baclaran	Tambo	Don Galo	La Huerta	Sto.Nino	Vitalez	San Dionisio	San Ishidro	San Antonio	BF	Sun Valley	Marcelo Green	Don Bosco	Merville	San Martin de Porres	Moonwalk	Almanza Uno	Daniel Fajardo	Elian Adana
Area (ha)			28,913	106,915	10,562	9,974	34,994	4,364	83,582	70,248	67,200	90,909	39,549	35,514	47,896	21,693	28,853	59,705	34,733	16,915	11,425
Population			63.72	662.56	23.22	53.72	245.97	57.20	309.69	365.22	287.19	769.50	177.75	306.19	384.75	304.40	155.65	377.28	250.00	25.00	35.00
Density (/ha)			453.75	161.37	454.87	185.67	142.27	76.29	269.89	192.34	233.99	118.14	222.5	115.99	124.49	71.26	185.37	158.25	138.93	676.6	326.43
Wastewater		/prsn	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Generation		/BGY	5,204	19,245	1,901	1,795	6,299	786	15,045	12,645	12,096	16,364	7,119	6,393	8,621	3,905	5,194	10,747	6,252	3,045	2,057
(m3/d)		/ha	81.67	29.05	81.87	33.41	25.61	13.74	48.58	34.62	42.12	21.27	40.05	20.88	22.41	12.83	33.37	28.49	25.01	121.80	58.77
Sub/Subsub Basin																					
SB.1	SSB	(Pop)	21,866	49,761	5,972																
	1-1	(ha)	48.19	308.37	13.13																
	Sub	(Pop)	21,866	49,761	5,972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	(ha)	48.19	308.37	13.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SB.2	SSB	(Pop)	7,047	32,099	4,590																
	2-1	(ha)	15.53	198.92	10.09																
	SSB	(Pop)		7,986			18,398	4,364													
	2-2	(ha)		49.49			129.32	57.20													
	SSB	(Pop)					4,380														
	2-3	(ha)					30.79														
	Sub	(Pop)	7,047	40,085	4,590	0	22,778	4,364	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	(ha)	15.53	248.41	10.09	0.00	160.11	57.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SB.3	SSB	(Pop)											983			13,495	7,465	1,665			
	3-1	(ha)											4.42			189.36	40.27	10.52			
	SSB	(Pop)		17,069		4,285	12,216								6,580	3,943		27,515			
	3-2	(ha)		105.78		23.08	85.86								52.86	55.33		173.87			
	SSB	(Pop)											9,630			3,547	95				
	3-3	(ha)											43.28			49.77	0.51				
	SSB	(Pop)											11,143		299		7,052				
	3-4	(ha)											50.08		2.40		38.04				
	SSB	(Pop)											5,534		8,104	708		1,182			
	3-5	(ha)											24.87		65.10	9.94		7.47			
	SSB	(Pop)											10,602	2,694	1,815		2,871				
	3-6	(ha)											47.65	23.23	14.58		15.49				
	SSB	(Pop)									152				4,993						
	3-7	(ha)									0.65				40.11						
	SSB	(Pop)											1,657	6,702	4,976		2,022				
	3-8	(ha)											7.45	57.78	39.97		10.91				
	Sub	(Pop)	0	17,069	0	4,285	12,216	0	0	0	152	0	39,549	9,396	26,767	21,693	19,505	30,362	0	0	0
	Total	(ha)	0.00	105.78	0.00	23.08	85.86	0.00	0.00	0.00	0.65	0.00	177.75	81.01	215.02	304.40	105.22	191.86	0.00	0.00	0.00
SB.4	SSB	(Pop)				3,955			45,236												
	4-1	(ha)				21.30			142.29												
	SSB	(Pop)																		2,889	
	4-2	(ha)																		4.27	
	SSB	(Pop)				1,734			7,754									4,031			
	4-3	(ha)				9.34			24.44									25.47			
	SSB	(Pop)							2,831									7,318			
	4-4	(ha)							9.20									46.24			
	SSB	(Pop)								1,081					16,218			11,343			
	4-5	(ha)								5.62					130.28			71.68			
	SSB	(Pop)							1,510	18,555								6,651			
	4-6	(ha)							4.76	96.47								42.03			
	SSB	(Pop)							8,005	17,875		1,865									
	4-7	(ha)							25.23	92.93		15.79									
	SSB	(Pop)								1,191		881									
	4-8	(ha)								6.19		7.46									
	SSB	(Pop)								6,369		1,795									
	4-9	(ha)								33.11		15.19									
	SSB	(Pop)								5,651	8,763	395									
	4-10	(ha)								29.38	37.45	3.34									
	SSB	(Pop)								4,183	18,099				4,193						
	4-11	(ha)								21.75	77.35				33.68						
	SSB	(Pop)									8,686			15,106	718		2,545				
	4-12	(ha)									37.12			130.24	5.77		13.73				
	SSB	(Pop)									23,951	180		11,012			499				
	4-13	(ha)									102.36	1.52		94.94			2.69				
	SSB	(Pop)									2,441	4,181									
	4-14	(ha)									10.43	35.39									
	SSB	(Pop)									1,069	5,614									
	4-15	(ha)									4.57	47.52									
	SSB	(Pop)										3,850									
	4-16	(ha)										32.59									
	SSB	(Pop)										1,744									
	4-17	(ha)										14.76									
	SSB	(Pop)								5,005		10,526									
	4-18	(ha)								26.02		89.10									
	SSB	(Pop)										10,911									
	4-19	(ha)										92.36									
	SSB	(Pop)										1,845									
	4-20	(ha)										15.62									
	SSB	(Pop)									449	4,923									
	4-21	(ha)									1.92	41.67									
	SSB	(Pop)									524	8,855									
	4-22	(ha)									2.24	74.95									
	SSB	(Pop)									3,066	8,700					6,304				
	4-23	(ha)									13.10	73.64					34.01				
	SSB	(Pop)								4,339		5,820									
	4-24	(ha)								22.56		49.26									
	SSB	(Pop)										158							2,833		
	4-25	(ha)										1.34							20.39		
	SSB	(Pop)										13,826							23,684		
	4-26	(ha)										117.03							170.47		
	Sub	(Pop)	0	0	0	5,689	0	0	65,336	64,249	67,048	86,069	0	26,118	21,129	0	9,348	29,343	26,517	2,889	0
	Total	(ha)	0.00	0.00	0.00	30.64	0.00	0.00	205.92	334.03	286.54	728.53	0.00	225.18	169.73	0.00	50.43	185.42	190.86	4.27	0.00

Table 7-9 (2/4) Populations in Sub-sub Basins 2036

City			Paranaque																Las Pinãs		
Barangay			Baclaran	Tambo	Don Galo	La Huerta	Sto.Nino	Vitalez	San Dionisio	San Ishidro	San Antonio	BF	Sun Valley	Marcelo Green	Don Bosco	Merville	San Martin de Porres	Moonwalk	Almanza Uno	Daniel Fajardo	Elian Adana
Area (ha)			28,913	106,915	10,562	9,974	34,994	4,364	83,582	70,248	67,200	90,909	39,549	35,514	47,896	21,693	28,853	59,705	34,733	16,915	11,425
Population			63.72	662.56	23.22	53.72	245.97	57.20	309.69	365.22	287.19	769.50	177.75	306.19	384.75	304.40	155.65	377.28	250.00	25.00	35.00
Density (/ha)			453.75	161.37	454.87	185.67	142.27	76.29	269.89	192.34	233.99	118.14	222.5	115.99	124.49	71.26	185.37	158.25	138.93	676.6	326.43
Wastewater		/prsn	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Generation		/BGY	5,204	19,245	1,901	1,795	6,299	786	15,045	12,645	12,096	16,364	7,119	6,393	8,621	3,905	5,194	10,747	6,252	3,045	2,057
(m3/d)		/ha	81.67	29.05	81.87	33.41	25.61	13.74	48.58	34.62	42.12	21.27	40.05	20.88	22.41	12.83	33.37	28.49	25.01	121.80	58.77
Sub/Subsub Basin																					
	SSB	(Pop)							6,545											12,788	
	5-1	(ha)							20.63											18.90	
	SSB	(Pop)																		1,238	11,425
	5-2	(ha)																		1.83	35.00
	SSB	(Pop)																			
	5-3	(ha)																			
	SSB	(Pop)																			
	5-4	(ha)																			
	SSB	(Pop)																			
	5-5	(ha)																			
	SSB	(Pop)																			
	5-6	(ha)																			
	SSB	(Pop)							11,701	179		106									
	5-7	(ha)							36.88	0.93		0.90									
	SSB	(Pop)								5,820		4,734									
SB.5	5-8	(ha)								30.26		40.07									
	SSB	(Pop)																			
	5-9	(ha)																			
	SSB	(Pop)																			
	5-10	(ha)																			
	SSB	(Pop)																			
	5-11	(ha)																			
	SSB	(Pop)																			
	5-12	(ha)																			
	SSB	(Pop)																			
	5-13	(ha)																			
	SSB	(Pop)																	1,095		
	5-14	(ha)																	7.88		
	SSB	(Pop)																	4,571		
	5-15	(ha)																	32.90		
	Sub	(Pop)	0	0	0	0	0	0	18,246	5,999	0	4,840	0	0	0	0	0	0	5,666	14,026	11,425
	Total	(ha)	0.00	0.00	0.00	0.00	0.00	0.00	57.51	31.19	0.00	40.97	0.00	0.00	0.00	0.00	0.00	0.00	40.78	20.73	35.00
	SSB	(Pop)																			
	6-1	(ha)																			
	SSB	(Pop)																	1,275		
SB.6	6-2	(ha)																	9.18		
	SSB	(Pop)																	1,275		
	6-3	(ha)																	9.18		
	Sub	(Pop)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,550	0	0
	Total	(ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.36	0.00	0.00
	SSB	(Pop)																			
	7-1	(ha)							46.26												
SB.7	Sub	(Pop)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	(ha)	0.00	0.00	0.00	0.00	0.00	0.00	46.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		(Pop)	28,913	106,915	10,562	9,974	34,994	4,364	83,582	70,248	67,200	90,909	39,549	35,514	47,896	21,693	28,853	59,705	34,733	16,915	11,425
		(ha)	63.72	662.56	23.22	53.72	245.97	57.20	309.69	365.22	287.19	769.50	177.75	306.19	384.75	304.40	155.65	377.28	250.00	25.00	35.00

Table 7-9 (3/4) Populations in Sub-sub Basins 2036

City			Las Pinas																	Total
Barangay			Iiaya	Manuyo Uno	Pamplona Uno	Pulang Lupa Uno	Talon Uno	Zapote	Almanza Dos	B.F Interna-tional-CAA	Mnanuyo Dos	Pamplona Dos	Pamplona Tres	Pilar	Pulang Lupa Dos	Talon Dos	Talon Tres	Talon Kuatro	Talon Singko	
Area (ha)			6,848	14,570	18,730	39,659	31,656	20,101	73,844	81,401	37,820	10,261	35,395	35,403	36,499	54,556	29,242	23,497	40,182	1,393,608
Population			16.00	40.00	76.00	143.00	257.00	64.00	400.00	294.00	168.00	112.00	224.00	198.00	204.00	425.00	108.00	61.00	90.00	7,734.01
Density (/ha)			428	364.25	246.45	277.34	123.18	314.08	184.61	276.87	225.12	91.62	158.01	178.8	178.92	128.37	270.76	385.2	446.47	
Wastewater	/prsn		0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	
Generation	/BGY		1,233	2,623	3,371	7,139	5,698	3,618	13,292	14,652	6,808	1,847	6,371	6,373	6,570	9,820	5,264	4,229	7,233	
(m3/d)	/ha		77.06	65.58	44.36	49.92	22.17	56.53	33.23	49.84	40.52	16.49	28.44	32.19	32.21	23.11	48.74	69.33	80.37	
Sub/Subsub Basin																				
SB.1	SSB	(Pop)																		77,599
	1-1	(ha)																		369.69
	Sub	(Pop)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77,599
	Total	(ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	369.69
SB.2	SSB	(Pop)																		43,736
	2-1	(ha)																		224.54
	SSB	(Pop)																		30,748
	2-2	(ha)																		236.01
	SSB	(Pop)																		4,380
	2-3	(ha)																		30.79
	Sub	(Pop)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78,864
	Total	(ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	491.34
SB.3	SSB	(Pop)																		23,608
	3-1	(ha)																		244.57
	SSB	(Pop)																		71,608
	3-2	(ha)																		496.78
	SSB	(Pop)																		13,272
	3-3	(ha)																		93.56
	SSB	(Pop)																		18,494
	3-4	(ha)																		90.52
	SSB	(Pop)																		15,528
	3-5	(ha)																		107.38
	SSB	(Pop)																		17,982
	3-6	(ha)																		100.95
	SSB	(Pop)																		5,145
	3-7	(ha)																		40.76
	SSB	(Pop)																		15,357
	3-8	(ha)																		116.11
	Sub	(Pop)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180,994
	Total	(ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,290.63
SB.4	SSB	(Pop)									1,945									51,136
	4-1	(ha)									8.64									172.23
	SSB	(Pop)		5,821							6,646									15,356
	4-2	(ha)		15.98							29.52									49.77
	SSB	(Pop)																		13,519
	4-3	(ha)																		59.25
	SSB	(Pop)																		10,149
	4-4	(ha)																		55.44
	SSB	(Pop)																		28,642
	4-5	(ha)																		207.58
	SSB	(Pop)																		26,716
	4-6	(ha)																		143.26
	SSB	(Pop)																		27,745
	4-7	(ha)																		133.95
	SSB	(Pop)																		2,072
	4-8	(ha)																		13.65
	SSB	(Pop)																		8,164
	4-9	(ha)																		48.30
	SSB	(Pop)																		14,809
	4-10	(ha)																		70.17
	SSB	(Pop)																		26,475
	4-11	(ha)																		132.78
	SSB	(Pop)																		27,055
	4-12	(ha)																		186.86
	SSB	(Pop)																		35,642
	4-13	(ha)																		201.51
	SSB	(Pop)																		6,622
	4-14	(ha)																		45.82
	SSB	(Pop)																		6,683
	4-15	(ha)																		52.09
	SSB	(Pop)																		3,850
	4-16	(ha)																		32.59
	SSB	(Pop)																		1,744
	4-17	(ha)																		14.76
	SSB	(Pop)																		15,531
	4-18	(ha)																		115.12
	SSB	(Pop)																		10,911
	4-19	(ha)																		92.36
	SSB	(Pop)																		1,845
	4-20	(ha)																		15.62
	SSB	(Pop)																		5,372
	4-21	(ha)																		43.59
	SSB	(Pop)																		9,379
	4-22	(ha)																		77.19
	SSB	(Pop)																		18,070
	4-23	(ha)																		120.75
	SSB	(Pop)								2,428										12,587
	4-24	(ha)								8.77										80.59
	SSB	(Pop)					1,198			17,507							20,513			42,209
	4-25	(ha)					9.73			63.23							75.76			170.45
	SSB	(Pop)							16,270	8,960							214			62,954
	4-26	(ha)							88.13	32.36							0.79			408.78
	Sub	(Pop)	0	5,821	0	0	1,198	0	16,270	28,895	8,591	0	0	0	0	0	20,727	0	0	485,237
	Total	(ha)	0.00	15.98	0.00	0.00	9.73	0.00	88.13	104.36	38.16	0.00	0.00	0.00	0.00	0.00	76.55	0.00	0.00	2,744.46

Table 7-9 (4/4) Populations in Sub-sub Basins 2036

City			Las Pinas																	Total
Barangay			Iiaya	Manuyo Uno	Pamplona Uno	Pulang Lupa Uno	Talon Uno	Zapote	Almanza Dos	B.F Interna-tional-CAA	Mnanuyo Dos	Pamplona Dos	Pamplona Tres	Pilar	Pulang Lupa Dos	Talon Dos	Talon Tres	Talon Kuatro	Talon Singko	
Area (ha)			6,848	14,570	18,730	39,659	31,656	20,101	73,844	81,401	37,820	10,261	35,395	35,403	36,499	54,556	29,242	23,497	40,182	1,393,608
Population			16.00	40.00	76.00	143.00	257.00	64.00	400.00	294.00	168.00	112.00	224.00	198.00	204.00	425.00	108.00	61.00	90.00	7,734.01
Density (/ha)			428	364.25	246.45	277.34	123.18	314.08	184.61	276.87	225.12	91.62	158.01	178.8	178.92	128.37	270.76	385.2	446.47	
Wastewater		/prsn	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	
Generation		/BGY	1,233	2,623	3,371	7,139	5,698	3,618	13,292	14,652	6,808	1,847	6,371	6,373	6,570	9,820	5,264	4,229	7,233	
(m3/d)		/ha	77.06	65.58	44.36	49.92	22.17	56.53	33.23	49.84	40.52	16.49	28.44	32.19	32.21	23.11	48.74	69.33	80.37	
Sub/Subsub Basin																				
SB.5	SSB 5-1	(Pop)	2,427	8,749																30,509
		(ha)	5.67	24.02																69.22
	SSB 5-2	(Pop)	4,421			10,447					1,938									29,469
		(ha)	10.33			37.67					8.61									93.44
	SSB 5-3	(Pop)				5,142		44												5,186
		(ha)				18.54		0.14												18.68
	SSB 5-4	(Pop)				3,783		5,311					1,879		1,646					12,619
		(ha)				13.64		16.91					11.89		9.20					51.64
	SSB 5-5	(Pop)				5,059														5,059
		(ha)				18.24														18.24
	SSB 5-6	(Pop)									3,149									3,149
		(ha)									13.99									13.99
	SSB 5-7	(Pop)								13,595	8,246									33,827
		(ha)								49.10	36.63									124.44
	SSB 5-8	(Pop)								23,365	13,606				8,590					56,115
		(ha)								84.39	60.44				48.01					263.17
	SSB 5-9	(Pop)				7,003					2,290				16,781					26,074
		(ha)				25.25					10.17				93.79					129.21
	SSB 5-10	(Pop)										430	11,322		1,211	408				13,371
		(ha)										4.69	71.65		6.77	3.18				86.29
	SSB 5-11	(Pop)								853			3,892		8,271					13,016
		(ha)								3.08			24.63		46.23					73.94
	SSB 5-12	(Pop)					57						8,485			13,161				21,703
		(ha)					0.46						53.70			102.53				156.69
	SSB 5-13	(Pop)					6,775			14,693			1,763			972	8,515			32,718
		(ha)					55.00			53.07			11.16			7.57	31.45			158.25
	SSB 5-14	(Pop)					8,753							4,109		11,468		13,258	14,399	53,082
		(ha)					71.06							22.98		89.34		34.42	32.25	257.93
	SSB 5-15	(Pop)					6,134		6,960					25,113				10,239	10,608	63,625
		(ha)					49.80		37.70					140.45				26.58	23.76	311.19
	Sub Total	(Pop)	6,848	8,749	0	31,434	21,719	5,355	6,960	52,506	29,229	430	27,341	29,222	36,499	26,009	8,515	23,497	25,007	399,522
		(ha)	16.00	24.02	0.00	113.34	176.32	17.05	37.70	189.64	129.84	4.69	173.03	163.43	204.00	202.62	31.45	61.00	56.01	1,826.32
SB.6	SSB 6-1	(Pop)			18,730	8,225		14,746				9,831	8,054			28,547			10,260	98,393
		(ha)			76.00	29.66		46.95				107.31	50.97			222.38			22.98	556.25
	SSB 6-2	(Pop)					2,923		19,264										2,130	25,592
		(ha)					23.73		104.35										4.77	142.03
	SSB 6-3	(Pop)					5,816		31,350					6,181					2,785	47,407
		(ha)					47.22		169.82					34.57					6.24	267.03
	Sub Total	(Pop)	0	0	18,730	8,225	8,739	14,746	50,614	0	0	9,831	8,054	6,181	0	28,547	0	0	15,175	171,392
		(ha)	0.00	0.00	76.00	29.66	70.95	46.95	274.17	0.00	0.00	107.31	50.97	34.57	0.00	222.38	0.00	0.00	33.99	965.31
SB.7	SSB 7-1	(Pop)																		0
		(ha)																		46.26
	Sub Total	(Pop)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
		(ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.26
Total		(Pop)	6,848	14,570	18,730	39,659	31,656	20,101	73,844	81,401	37,820	10,261	35,395	35,403	36,499	54,556	29,242	23,497	40,182	1,393,608
		(ha)	16.00	40.00	76.00	143.00	257.00	64.00	400.00	294.00	168.00	112.00	224.00	198.00	204.00	425.00	108.00	61.00	90.00	7734.01

7.3 Site Candidate for Sewage Treatment Plants

Maynilad and MWSS will select the sewage treatment sites from the present vacant lands as their policy. Therefore as the first survey purposes, available vacant site candidate were investigated. The plant sites would preferably be located at the downstream of the waterways in the project areas. **Figure 7-16** shows possible vacant areas for STP construction in the project areas. All candidate areas are perfectly vacant and any structures or informal settlers were not found. **Figure 7-17** and **7-18** show the informal settlers' location for reference.

Figure 7-16 STP Site Candidate (Parañaque and Las Piñas)

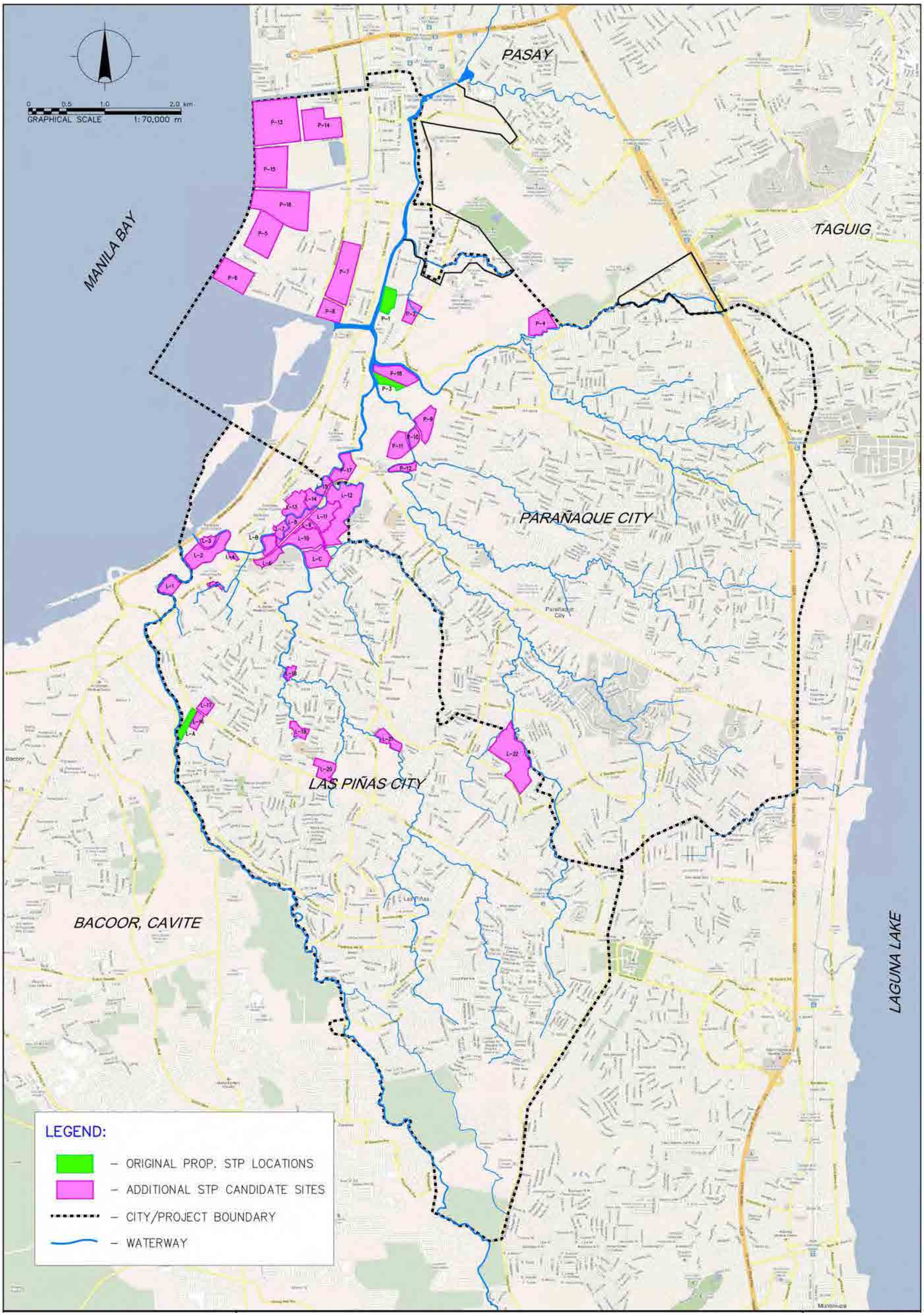


Figure 7- 17 Location of Informal Settlers (Parañaque)

Local Development Plan, City Planning & Development Coordinator's Office, City of Paranaque,2008. Interview, Urban Poor Office, City of Paranaque, 2010.

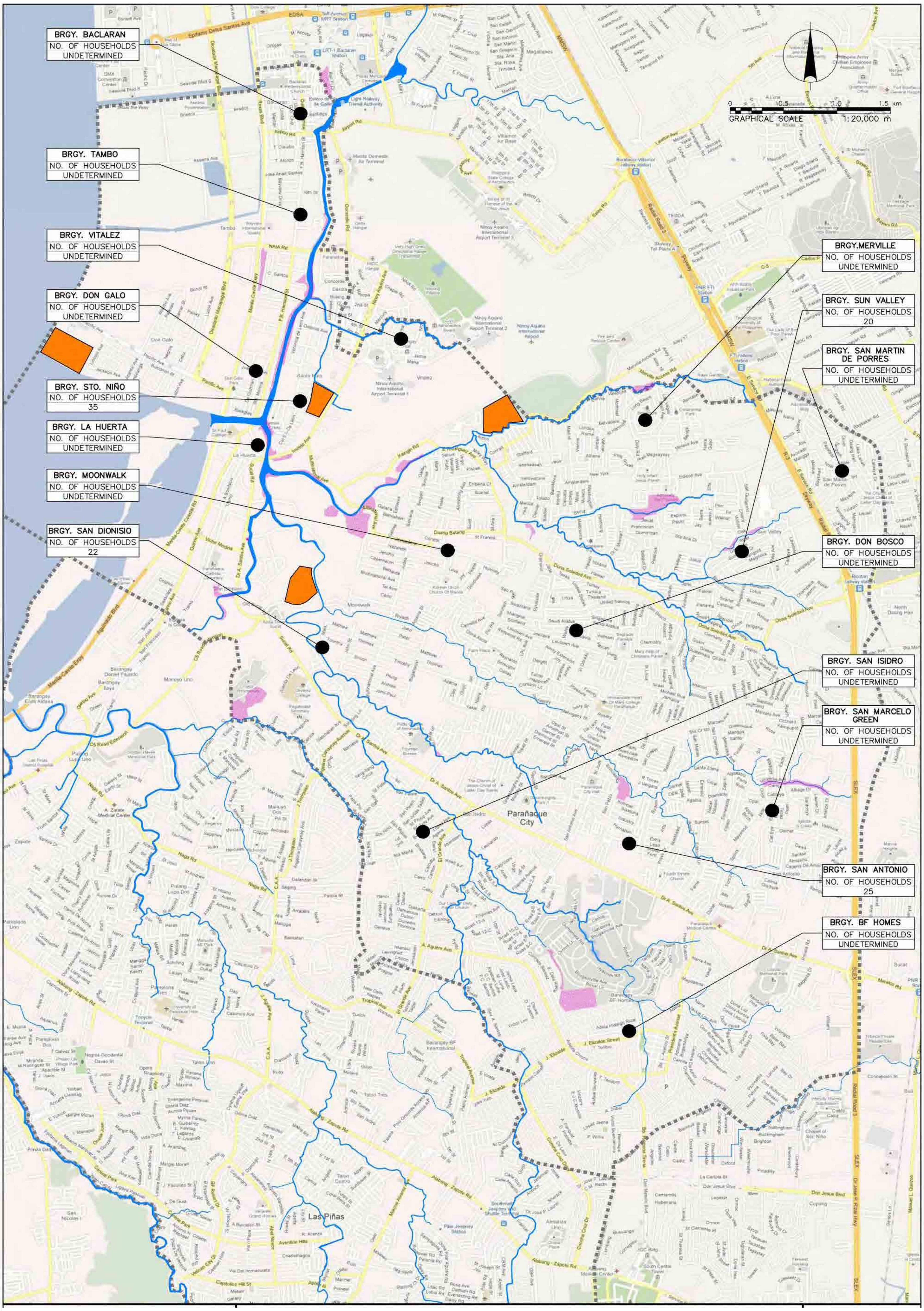
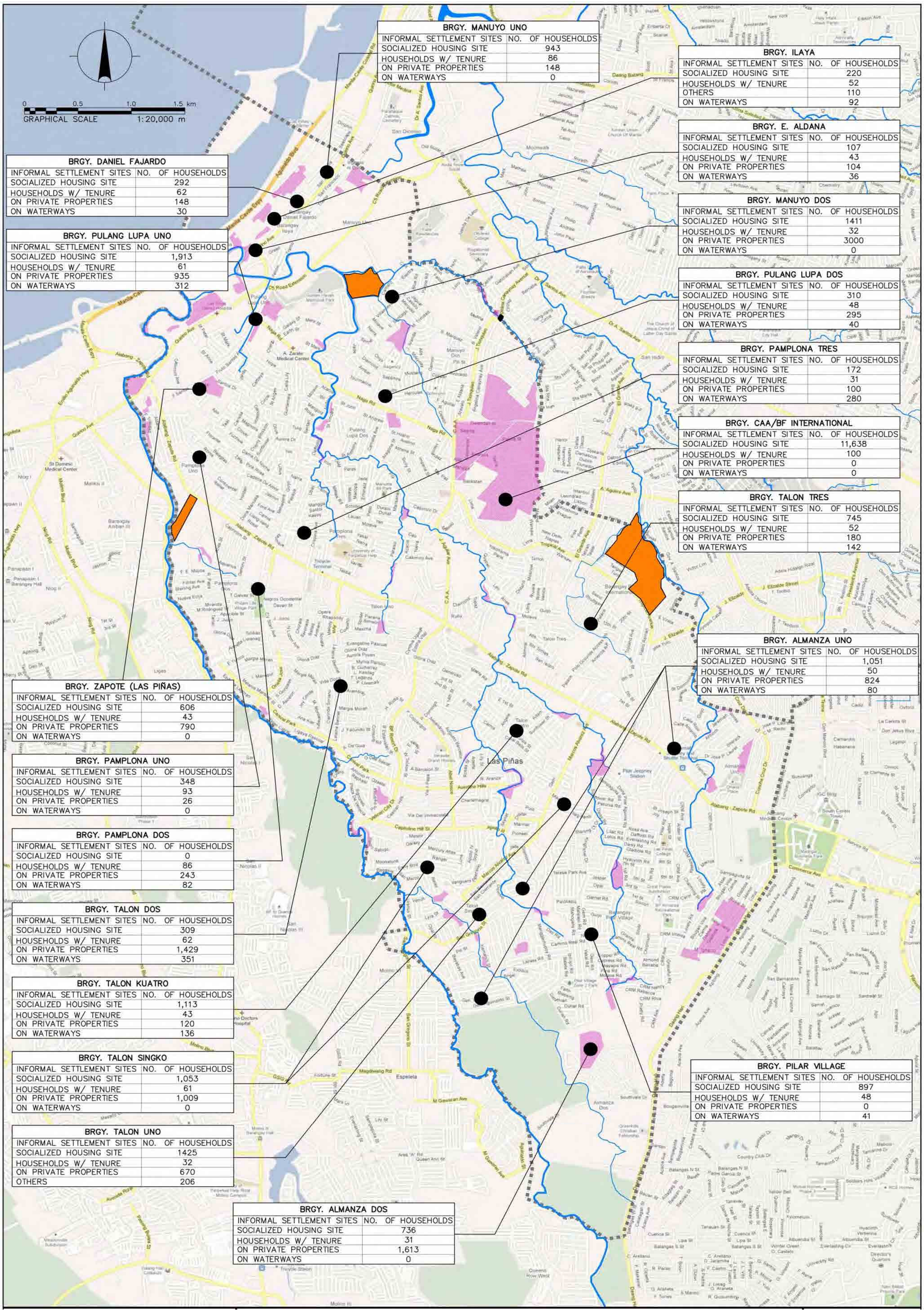


Figure 7- 18 Location Of Informal Settlers (Las Piñas)

Interview, City Planning & Development Office, City of Las Pinas, 2010. NSO, 2000.



BRGY. MANUYO UNO

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	943
HOUSEHOLDS W/ TENURE	86
ON PRIVATE PROPERTIES	148
ON WATERWAYS	0

BRGY. ILAYA

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	220
HOUSEHOLDS W/ TENURE	52
OTHERS	110
ON WATERWAYS	92

BRGY. DANIEL FAJARDO

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	292
HOUSEHOLDS W/ TENURE	62
ON PRIVATE PROPERTIES	148
ON WATERWAYS	30

BRGY. E. ALDANA

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	107
HOUSEHOLDS W/ TENURE	43
ON PRIVATE PROPERTIES	104
ON WATERWAYS	36

BRGY. PULANG LUPA UNO

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	1,913
HOUSEHOLDS W/ TENURE	61
ON PRIVATE PROPERTIES	935
ON WATERWAYS	312

BRGY. MANUYO DOS

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	1411
HOUSEHOLDS W/ TENURE	32
ON PRIVATE PROPERTIES	3000
ON WATERWAYS	0

BRGY. PULANG LUPA DOS

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	310
HOUSEHOLDS W/ TENURE	48
ON PRIVATE PROPERTIES	295
ON WATERWAYS	40

BRGY. PAMPLONA TRES

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	172
HOUSEHOLDS W/ TENURE	31
ON PRIVATE PROPERTIES	100
ON WATERWAYS	280

BRGY. CAA/BF INTERNATIONAL

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	11,638
HOUSEHOLDS W/ TENURE	100
ON PRIVATE PROPERTIES	0
ON WATERWAYS	0

BRGY. TALON TRES

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	745
HOUSEHOLDS W/ TENURE	52
ON PRIVATE PROPERTIES	180
ON WATERWAYS	142

BRGY. ALMANZA UNO

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	1,051
HOUSEHOLDS W/ TENURE	50
ON PRIVATE PROPERTIES	824
ON WATERWAYS	80

BRGY. ZAPOTE (LAS PIÑAS)

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	606
HOUSEHOLDS W/ TENURE	43
ON PRIVATE PROPERTIES	790
ON WATERWAYS	0

BRGY. PAMPLONA UNO

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	348
HOUSEHOLDS W/ TENURE	93
ON PRIVATE PROPERTIES	26
ON WATERWAYS	0

BRGY. PAMPLONA DOS

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	0
HOUSEHOLDS W/ TENURE	86
ON PRIVATE PROPERTIES	243
ON WATERWAYS	82

BRGY. TALON DOS

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	309
HOUSEHOLDS W/ TENURE	62
ON PRIVATE PROPERTIES	1,429
ON WATERWAYS	351

BRGY. TALON KUATRO

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	1,113
HOUSEHOLDS W/ TENURE	43
ON PRIVATE PROPERTIES	120
ON WATERWAYS	136

BRGY. PILAR VILLAGE

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	897
HOUSEHOLDS W/ TENURE	48
ON PRIVATE PROPERTIES	0
ON WATERWAYS	41

BRGY. TALON SINGKO

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	1,053
HOUSEHOLDS W/ TENURE	61
ON PRIVATE PROPERTIES	1,009
ON WATERWAYS	0

BRGY. TALON UNO

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	1425
HOUSEHOLDS W/ TENURE	32
ON PRIVATE PROPERTIES	670
OTHERS	206

BRGY. ALMANZA DOS

INFORMAL SETTLEMENT SITES	NO. OF HOUSEHOLDS
SOCIALIZED HOUSING SITE	736
HOUSEHOLDS W/ TENURE	31
ON PRIVATE PROPERTIES	1,613
ON WATERWAYS	0

7.3.1 Site Candidate Locations and Features

In Parañaque and Las Piñas, numerous rivers and creeks generally flow from east to west. Parañaque has Parañaque River, Dongalo River, San Dionisio River and nine creeks, Las Piñas is home to Las Piñas River, Zapote River, Kay Kanti River and 11 creeks. Sanitary sewage from households is drained into these rivers and creeks via sewers and side ditches. The candidate locations for sewage treatment plants and the scale of plants will be determined according to the size of treatment districts discussed in Section 7 (Sewerage Project Implementation Plan). Here, the candidate locations are selected upon considering the contents examined in Section 7. The criteria for selecting treatment plant locations are as follows.

(a) There is clearly no trouble in purchasing the site land.
(b) The location facilitates the collection of sewage.
(c) The site has sufficient area to construct the treatment facilities.
(d) A creek, etc. for discharging treated effluent is located close to the plant.
(e) There is an access road for the vehicles to be used for plant construction and maintenance.

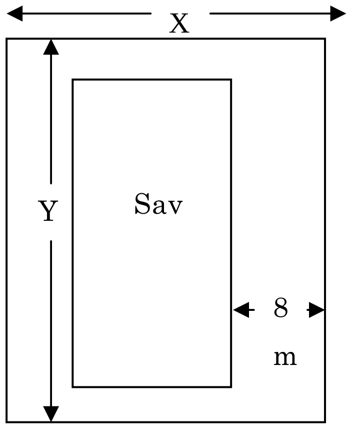
The above criteria were taken into account in selecting candidate locations for the treatment districts in Case 1~Case 8. The treatment plant locations in Parañaque are P-12 (7.00ha), P-4 (8.80ha), P-2 (4.20ha), P-6 (13.20ha) and P-1 (4.50ha), and the locations in Las Piñas are L-22 (19.00ha), L-A (3.25ha) and L-C (7.00ha).

Table 7-10 shows candidate sites for STPs with the location addresses, and **Table 7-11** shows candidate sites for pumping stations. **Table 7-12** and **7-13** show technical capabilities of each site, which capable capacity of treatment process, predicted sludge generation and possible biogas power generation rate are calculated of. **Figure 7-19** and **7-20** shows each site candidate map of Parañaque and Las Piñas, and the detail locations and features are shown in **Appendix 1 and 2.**

Regarding the site candidate capable dimensions of sewage treatment process, the following Parameters for assumption of sewage treatment plant site area required is used, however, when the final site location alternatives are recommended, detail calculations shall be required.

a) Available Land Size (Sav m^2)

Perimeter and Water Drainage (Ps m^2)



8 meter width at three fringes of the site border for drainage, fence, planting and maintenance

Assuming Y=1.5X (m)

Land Area Sc = XY = $1.5X^2$(m2)

Sav = Sa – Ps

Where: Sc means whole site area (m^2)

Sav = Sc – 8{(X – 16) + 2Y} = Sc -32X+ 128

X = $(Sc/1.5)^{1/2}$, thus:

Sav = Sc – 32 x $(Sc/1.5)^{1/2}$ + 128

Site Area (Sc m^2)

b) Sludge Treatment Process (Sp m^2)

a. Thickening Sludge Storage Tank	0.020 x If
b. Digesting Tanks	0.066I x f x 1.02
c. Gas Storage Tank	0.018 x If
d. Dewatering Facility	0.067 x If
e. Gas Generation Room	55m^2

Total Land Occupation Sp = a + b + c + d + e = (0.172 x If + 55) m^2

Where If means Sewage Influent Flow Rate (m^3/d)

c) Administrative and Management Facilities (As m^2)

- Administrative Area including Office and Utilities 80m^2
- Storage and Deposit Area 10m^2
- Laboratory 25m^2
- Parking and Entrance Gate 150m^2
- Stand-by Generator Room 50m^2
- Total Area Occupation (As) 315m^2

d) Optimum Sewage Treatment Capacity

Influent Sewage Water Rate applicable in the site candidates: If (m^3/d);

If = (Sav-Sp – As) x Qu = [{Sc-32 x $(Sc/1.5)^{1/2}$ + 128} – (0.172 x If + 55) – 315] x Qu

= {Sc – 32 x $(Sc/1.5)^{1/2}$ – 0.172 x If -242} x Qu;

Where Qu = Unit Treatment Capacity rate(m^3/m^2)

Case 1: All facilities to be equipped;

If = {Sc – 32 x $(Sc/1.5)^{1/2}$ – 242} x Qu/(1 + 0.172 x Qu)

Qu shall be provided for each treatment process,

that is, for OD, CAS, SBR, MBBR and MBR

Case 2: Digesting System and Gas Generator not to be provided.

If = (Sav – As) x Qu = (Sav – 315) x Qu

Case 3: Digesting System only to be provided.

Thus: If = {Sc – 32 x $(Sc/1.5)^{1/2}$ – 187} x Qu/(1 + 0.172 x Qu)

e) Unit Treatment Capacity Rate (Qu m^3/m^2 and Ql m^3/m^3)

The parameters for unit rate of sewage treatment capacity applicable for site candidate are introduced from past field data as follows;

Sewage sludge generation rates are calculated with the following expressions, and past field data.

$Qs = If \times (p - f) \times k \times Sq \times 10^{-6}$

$Ql = Qs \times 1/d$

Where;

- Qs: solid sludge rate (t/d)
- If: influent sewage water rate (m^3/d)
- p: average concentration of inlet SS (300)
- f: average concentration of effluent SS (50)
- k: sludge scrubbing coefficient (1.0)
- Sq: sludge producing coefficient (Table 1)
- Ql: liquid sludge rate scrubbed (m^3/d)
- d: sludge concentration rate (0.015)

Thus sewage sludge generation rate is

$Ql = If \times (300-50) \times 1 \times Sq \times 10^{-6}/0.015 = 0.16 \times If \times Sq$ (Sludge concentration: 98.5 %)

Unit Rates of Qu and Sq.

Process	Qu (m^3/m^2)	Sq
Oxidation Ditch Process (OD)	1.18	0.75
Conventional Activated Sludge Process (CAS)	4.70	1.00
Sequencing Batch Reactor (SBR)	4.59	0.75
Moving Bed Bio Reactor (MBBR)	5.80	0.93
Membrane Bio Reactor (MBR)	6.41	1.00

Table 7-10 (1/2) Site Candidate List for STPs (Parañaque)

ID No.	Location	Land Area	Service Capacity		Land Condition			Land Owner
		(ha)	STP (m^3/d) (*1)	Max. Population	Current	Temporal Use	Residents	
P-1	Brgy. Sto Niño	4.50	100,587	558,817	salt field	vacant	none	Shown Table 8.3.2
P-2	NAIA Road, Brgy. Sto. Niño	4.20	93,374	518,744	developed land	vacant	none	Shown Table 8.3.2
P-3	SM warehouse area, Brgy. La Huerta	3.70	81,393	452,183	developed land	vacant	none	Shown Table 8.3.2
P-4	NAIA, Brgy. Sto. Niño	8.80	205,218	1,140,100	developed land	vacant	none	Shown Table 8.3.2
P-5	Asia World City, Brgy. Tambo	18.60	447,564	2,486,467	developed land	vacant	none	Asia World City
P-6	Asia World City, Brgy. Don Galo	13.20	313,609	1,742,272	developed land	vacant	none	Shown Table 8.3.2
P-7	Macapagal Blvd cor. Pacific Ave., Brgy Don Galo	18.00	432,644	2,403,578	developed land	golf driving range	none	info unavailable
P-8	Coastal Road cor. Pacific Ave., Brgy. Don Galo	7.10	163,636	909,089	developed land	vacant	none	info unavailable
P-9	C5 Road Extension, SM warehouse, Brgy. Moonwalk	8.10	188,070	1,044,833	developed land	vacant	none	SM (Henry Sy)
P-10	C5 Road Extension, Brgy. Moonwalk	2.10	43,532	241,844	swamp/marshy land	vacant	none	info unavailable
P-11	C5 Road Extension, Brgy. San Dionisio	12.10	286,431	1,591,283	swamp/marshy land	vacant	none	Shown Table 8.3.2
P-12	TDI Multinational Village, Brgy. Moonwalk	3.40	74,231	412,394	swamp/marshy land	vacant	none	Shown Table 8.3.2
P-13	Aseana Ave., Aseana Business Park, Brgy. Baclaran	34.10	834,906	4,638,367	developed land	vacant	none	Alphaland
P-14	Aseana Ave., Aseana Business Park, Brgy. Baclaran	17.20	412,764	2,293,133	developed land	vacant	none	Alphaland
P-15	Aseana Ave., Aseana Business Park, Brgy. Tambo	20.90	504,824	2,804,578	developed land	vacant	none	PAGCOR
P-16	Asia World City, Brgy. Tambo	27.40	667,106	3,706,144	developed land	vacant	none	PAGCOR
P-17	Sucat Road cor. C5 Road Ext., beside SM Sucat, Brgy. San Dionisio	4.50	100,587	558,817	developed land	garbage dump area	none	portion is LRTA property; majority is privately owned
P-18	SM warehouse area, Brgy. La Huerta	9.10	212,577	1,180,983	salt field	vacant	none	info unavailable

Table 7-10 (2/2) Site Candidate List for STPs (Las Piñas)

ID No.	Location	Land Area (ha)	Service Capacity STP (m^3/d) (*1)	Service Capacity Max. Population	Land Condition Current	Land Condition Temporal Use	Land Condition Residents	Land Owner
L-A	Alabang-Zapote Road, Brgy. Pamplona Uno	3.25	70,660	392,556	developed land	vacant	none	Shown Table 8.3.2
L-B	C5 Road Ext., Brgy. Pulang Lupa Uno	3.40	74,231	412,394	developed land	vacant	none	Manny Villar
L-C	Brgy. Manuyo Dos	7.00	161,197	895,539	developed land	vacant	none	Shown Table 8.3.2
L-1	C5 Road Ext., Brgy. Pulang Lupa Uno	3.10	67,094	372,744	slightly vegetated	vacant	security guard & a few squatters	Banco Filipino (BF)
L-2	Brgy. Pulang Lupa Uno	9.90	232,227	1,290,150	leased as dump site	dump site	squatters	4 owners (private)
L-3	Brgy. Elias Aldana	1.70	34,246	190,256	grassy and marsh land	dump site	few squatters	info unavailable
L-4	Brgy. Pulang Lupa Uno	0.70	11,868	65,933	developed land	vacant	few squatters	info unavailable
L-5	C-5 Road Extension	1.10	20,565	114,250	grassland	vacant	none	Adelfa Properties
L-6	C-5 Road Extension	3.70	81,393	452,183	cleared land to be developed	vacant	none	Shown Table 8.3.2
L-7	C-5 Road Extension	2.50	52,908	293,933	grassland	vacant	none	Emma Brecewell/Manny Villar
L-8	C-5 Road Extension	3.30	71,850	399,167	grassland	vacant	none	Adelfa Properties
L-9	C-5 Road Extension	2.20	45,869	254,828	cleared land to be developed	vacant	none	Adelfa Properties
L-10	C-5 Road Extension	8.60	200,315	1,112,861	grassland	vacant	none	Adelfa Properties
L-11	C-5 Road Extension	6.80	156,323	868,461	grassland	vacant	none	Adelfa Properties
L-12	C-5 Road Extension	18.20	437,617	2,431,206	grassland	vacant	none	Adelfa Properties
L-13	C-5 Road Extension	5.80	132,009	733,383	grassland	vacant	none	Adelfa Properties
L-14	C-5 Road Extension	3.80	83,785	465,472	grassland	vacant	none	Adelfa Properties
L-15	C-5 Road Extension, Brgy. Manuyo Dos	2.50	52,908	293,933	grassland with swamp area near tramo side	vacant	squatters along the sides	Adelfa Properties
L-16	Alabang-Zapote Road, Brgy. Pamplona Uno	2.00	41,201	228,894	vegetated land	vacant	security guard only	San Fermin Corp.
L-17	Alabang-Zapote Road, Brgy. Pamplona Uno	2.70	57,622	320,122	developed land	vacant	security guard only	Phillips Electronics
L-18	St. Vincent St, Pulang Lupa Dos	1.50	29,646	164,700	grassland	vacant	squatters along the sides	Mayor Nene Aguilar and Manny Villar
L-19	Brgy. Pamplona Tres	1.80	36,558	203,100	grassland	vacant	none	info unavailable
L-20	Alabang-Zapote Road, Brgy. Pamplona Tres	5.10	115,059	639,217	grassland	vacant	none	info unavailable
L-21	Quebec St., Brgy. BF International	4.10	90,974	505,411	vegetated	vacant	squatters along creek	Phillips Electronics
L-22	Kirishima Road, Brgy. BF International	19.00	457,515	2,541,750	highly vegetated land	vacant	few squatters	Shown Table 8.3.2

Table 7-11 Site Candidate List for PS (Parañaque and Las Piñas)

ID No.	Location	Land Area (m^2)	Land Condition			Land Owner
			Current	Temporal Use	Residents	
PS-1	C-5 Extension Road cor Multinational Ave., Brgy. Moonwalk, Parañaque City	4795	swamp/marshy land	vacant	some squatters along the side	Shown Table 8.3.2
PS-2	Pedro Sabido St. cor R. Garcia St., Brgy. Talon Dos, Las Piñas City	544	developed land	vacant	none	Shown Table 8.3.2
PS-3	Opal St., Brgy. Talon Singko, Las Piñas City	457	developed land	vacant	none	Shown Table 8.3.2
PS-4	J. Aguilar Ave., Brgy. Pulang Lupa Dos, Las Piñas City	2040	developed land	small portion is used as auto repair shop and the other vacant	none	Shown Table 8.3.2
PS-6	Marcos Alvarez Ave., Brgy. Talon Uno, Las Piñas City	1988	developed land	temporary tents are being built	none	Shown Table 8.3.2

Table 7-12 (1/3) Applicable Capacity Variations of Sewage Treatment Plant at the Candidate Sites (Parañaque)

Applicable Capacity Variations of Sewage Treatment Plant at the Candidate Sites (1/3)									
Case 1: Sludge Digesting Process and Gas Generation Equipment to be provided.									Paranaque
Site No.	Available Area	Process Variations and Applicable Capacity of Sewage Treatment System (m^3/d)					Functional Services	Relative Equipment	
	(hr)	OD	CAS	SBR	MBBR	MBR		Digester	Generator
P 1	4.50	38,467	101,920	100,587	113,861	119,557	Treatment Capacity (m3/d)	Install	Install
		481	1,699	1,257	1,765	1,993	Sludge Generation (m3/d)		
		162	428	422	478	502	Gas Power Generation (kw)		
		213,706	566,222	558,817	632,561	664,206	Covering Population		
P 2	4.20	35,709	94,612	93,374	105,697	110,984	Treatment Capacity (m3/d)	Install	Install
		446	1,577	1,167	1,638	1,850	Sludge Generation (m3/d)		
		150	397	392	444	466	Gas Power Generation (kw)		
		198,383	525,622	518,744	587,206	616,578	Covering Population		
P 3	3.70	31,127	82,471	81,393	92,134	96,743	Treatment Capacity (m3/d)	Install	Install
		389	1,375	1,017	1,428	1,612	Sludge Generation (m3/d)		
		131	346	342	387	406	Gas Power Generation (kw)		
		172,928	458,172	452,183	511,856	537,461	Covering Population		
P 4	8.80	78,480	207,937	205,218	232,300	243,920	Treatment Capacity (m3/d)	Install	Install
		981	3,466	2,565	3,601	4,065	Sludge Generation (m3/d)		
		330	873	862	976	1,024	Gas Power Generation (kw)		
		436,000	1,155,206	1,140,100	1,290,556	1,355,111	Covering Population		
P 5	18.60	171,159	453,496	447,564	506,628	531,970	Treatment Capacity (m3/d)	Install	Install
		2,139	7,558	5,595	7,853	8,866	Sludge Generation (m3/d)		
		719	1,905	1,880	2,128	2,234	Gas Power Generation (kw)		
		950,883	2,519,422	2,486,467	2,814,600	2,955,389	Covering Population		
P 6	13.20	119,932	317,765	313,609	354,995	372,753	Treatment Capacity (m3/d)	Install	Install
		1,499	5,296	3,920	5,502	6,213	Sludge Generation (m3/d)		
		504	1,335	1,317	1,491	1,566	Gas Power Generation (kw)		
		666,289	1,765,361	1,742,272	1,972,194	2,070,850	Covering Population		
P 7	18.00	165,454	438,378	432,644	489,739	514,237	Treatment Capacity (m3/d)	Install	Install
		2,068	7,306	5,408	7,591	8,571	Sludge Generation (m3/d)		
		695	1,841	1,817	2,057	2,160	Gas Power Generation (kw)		
		919,189	2,435,433	2,403,578	2,720,772	2,856,872	Covering Population		
Notes:	1. Sewage Treatment Plant shall basically be provided sludge thickening tanks.								
	2. Sewage Treatment Process Variations			OD: Oxidation Ditch Process			MBBR: Moving Bed Bio Reactor		
				CAS: Conventional Activated Sludge Process			MBR: Membrane Bio Reactor		

Table 7-12 (2/3) Applicable Capacity Variations of Sewage Treatment Plant at the Candidate Sites (Parañaque)

Site No.	Available Area	Process Variations and Applicable Capacity of Sewage Treatment System (m^3/d)					Functional Services	Relative Equipment	
	(hr)	OD	CAS	SBR	MBBR	MBR		Digester	Generator
P 8	7.10	62,578	165,805	163,636	185,231	194,496	Treatment Capacity (m3/d)	Install	Install
		782	2,763	2,045	2,871	3,242	Sludge Generation (m3/d)		
		263	696	687	778	817	Gas Power Generation (kw)		
		347,656	921,139	909,089	1,029,061	1,080,533	Covering Population		
P 9	8.10	71,922	190,562	188,070	212,889	223,538	Treatment Capacity (m3/d)	Install	Install
		899	3,176	2,351	3,300	3,726	Sludge Generation (m3/d)		
		302	800	790	894	939	Gas Power Generation (kw)		
		399,567	1,058,678	1,044,833	1,182,717	1,241,878	Covering Population		
P 10	2.10	16,648	44,109	43,532	49,277	51,742	Treatment Capacity (m3/d)	Install	Install
		208	735	544	764	862	Sludge Generation (m3/d)		
		70	185	183	207	217	Gas Power Generation (kw)		
		92,489	245,050	241,844	273,761	287,456	Covering Population		
P 11	12.10	109,538	290,227	286,431	324,230	340,449	Treatment Capacity (m3/d)	Install	Install
		1,369	4,837	3,580	5,026	5,674	Sludge Generation (m3/d)		
		460	1,219	1,203	1,362	1,430	Gas Power Generation (kw)		
		608,544	1,612,372	1,591,283	1,801,278	1,891,383	Covering Population		
P 12	3.40	28,388	75,215	74,231	84,028	88,231	Treatment Capacity (m3/d)	Install	Install
		355	1,254	928	1,302	1,471	Sludge Generation (m3/d)		
		119	316	312	353	371	Gas Power Generation (kw)		
		157,711	417,861	412,394	466,822	490,172	Covering Population		
P 13	34.10	319,288	845,970	834,906	945,086	992,361	Treatment Capacity (m3/d)	Install	Install
		3,991	14,100	10,436	14,649	16,539	Sludge Generation (m3/d)		
		1,341	3,553	3,507	3,969	4,168	Gas Power Generation (kw)		
		1,773,822	4,699,833	4,638,367	5,250,478	5,513,117	Covering Population		
P 14	17.20	157,851	418,233	412,764	467,235	490,607	Treatment Capacity (m3/d)	Install	Install
		1,973	6,971	5,160	7,242	8,177	Sludge Generation (m3/d)		
		663	1,757	1,734	1,962	2,061	Gas Power Generation (kw)		
		876,950	2,323,517	2,293,133	2,595,750	2,725,594	Covering Population		

Notes: 1. Sewage Treatment Plant shall basically be provided sludge thickening tanks.

2. Sewage Treatment Process Variations

OD: Oxidation Ditch Process

CAS: Conventional Activated Sludge Process

SBR: Sequencing Batch Reactor

MBBR: Moving Bed Bio Reactor

MBR: Membrane Bio Reactor

Table 7-12(3/3) Applicable Capacity Variations of Sewage Treatment Plant at the Candidate Sites (Parañaque)

Site No.	Available Area (hr)	Process Variations and Applicable Capacity of Sewage Treatment System (m^3/d)					Functional Services	Relative Equipment	
		OD	CAS	SBR	MBBR	MBR		Digester	Generator
P 15	20.90	193,057	511,514	504,824	571,444	600,029	Treatment Capacity (m3/d)	Install	Install
		2,413	8,525	6,310	8,857	10,000	Sludge Generation (m3/d)		
		811	2,148	2,120	2,400	2,520	Gas Power Generation (kw)		
		1,072,539	2,841,744	2,804,578	3,174,689	3,333,494	Covering Population		
P 16	27.40	255,117	675,947	667,106	755,142	792,916	Treatment Capacity (m3/d)	Install	Install
		3,189	11,266	8,339	11,705	13,215	Sludge Generation (m3/d)		
		1,071	2,839	2,802	3,172	3,330	Gas Power Generation (kw)		
		1,417,317	3,755,261	3,706,144	4,195,233	4,405,089	Covering Population		
P 17	4.50	38,467	101,920	100,587	113,861	119,557	Treatment Capacity (m3/d)	Install	Install
		481	1,699	1,257	1,765	1,993	Sludge Generation (m3/d)		
		162	428	422	478	502	Gas Power Generation (kw)		
		213,706	566,222	558,817	632,561	664,206	Covering Population		
P 18	9.10	81,294	215,394	212,577	240,630	252,667	Treatment Capacity (m3/d)	Install	Install
		1,016	3,590	2,657	3,730	4,211	Sludge Generation (m3/d)		
		341	905	893	1,011	1,061	Gas Power Generation (kw)		
		451,633	1,196,633	1,180,983	1,336,833	1,403,706	Covering Population		
							Treatment Capacity (m3/d)	Install	Install
							Sludge Generation (m3/d)		
							Gas Power Generation (kw)		
							Covering Population		
							Treatment Capacity (m3/d)	Install	Install
							Sludge Generation (m3/d)		
							Gas Power Generation (kw)		
							Covering Population		
		1,974,476	5,231,475	5,163,053	5,844,407	6,136,757	Treatment Capacity (m3/d)	Install	Install
		24,681	87,192	64,538	90,588	102,280	Sludge Generation (m3/d)		
		8,294	21,971	21,685	24,547	25,774	Gas Power Generation (kw)		
		10,969,312	29,063,748	28,683,626	32,468,928	34,093,095	Covering Population		

Notes: 1. Sewage Treatment Plant shall basically be provided sludge thickening tanks.
2. Sewage Treatment Process Variations

OD: Oxidation Ditch Process
CAS: Conventional Activated Sludge Process
SBR: Sequencing Batch Reactor
MBBR: Moving Bed Bio Reactor
MBR: Membrane Bio Reactor

Table 7-13 (1/4) Applicable Capacity Variations of Sewage Treatment Plant at the Candidate Sites (Las Piñas)

Site No.	Available Area (hr)	Process Variations and Applicable Capacity of Sewage Treatment System (m^3/d) OD	CAS	SBR	MBBR	MBR	Functional Services	Relative Equipment Digester	Generator
L-A	3.25	27,022	71,596	70,660	79,984	83,985	Treatment Capacity (m3/d)	Install	Install
		338	1,193	883	1,240	1,400	Sludge Generation (m3/d)		
		113	301	297	336	353	Gas Power Generation (kw)		
		150,122	397,756	392,556	444,356	466,583	Covering Population		
L-B	3.40	28,388	75,215	74,231	84,028	88,231	Treatment Capacity (m3/d)	Install	Install
		355	1,254	928	1,302	1,471	Sludge Generation (m3/d)		
		119	316	312	353	371	Gas Power Generation (kw)		
		157,711	417,861	412,394	466,822	490,172	Covering Population		
L-C	7.00	61,646	163,334	161,197	182,470	191,598	Treatment Capacity (m3/d)	Install	Install
		771	2,722	2,015	2,828	3,193	Sludge Generation (m3/d)		
		259	686	677	766	805	Gas Power Generation (kw)		
		342,478	907,411	895,539	1,013,722	1,064,433	Covering Population		
L-1	3.10	25,658	67,983	67,094	75,948	79,748	Treatment Capacity (m3/d)	Install	Install
		321	1,133	839	1,177	1,329	Sludge Generation (m3/d)		
		108	286	282	319	335	Gas Power Generation (kw)		
		142,544	377,683	372,744	421,933	443,044	Covering Population		
L-2	9.90	88,809	235,304	232,227	262,873	276,022	Treatment Capacity (m3/d)	Install	Install
		1,110	3,922	2,903	4,075	4,600	Sludge Generation (m3/d)		
		373	988	975	1,104	1,159	Gas Power Generation (kw)		
		493,383	1,307,244	1,290,150	1,460,406	1,533,456	Covering Population		
L-3	1.70	13,097	34,700	34,246	38,765	40,705	Treatment Capacity (m3/d)	Install	Install
		164	578	428	601	678	Sludge Generation (m3/d)		
		55	146	144	163	171	Gas Power Generation (kw)		
		72,761	192,778	190,256	215,361	226,139	Covering Population		
L-4	0.70	4,485	11,883	11,727	13,275	13,939	Treatment Capacity (m3/d)	Install	Install
		56	198	147	206	232	Sludge Generation (m3/d)		
		19	50	49	56	59	Gas Power Generation (kw)		
		24,917	66,017	65,150	73,750	77,439	Covering Population		

Notes: 1. Sewage Treatment Plant shall basically be provided sludge thickening tanks.

2. Sewage Treatment Process Variations
- OD: Oxidation Ditch Process
- CAS: Conventional Activated Sludge Process
- SBR: Sequencing Batch Reactor
- MBBR: Moving Bed Bio Reactor
- MBR: Membrane Bio Reactor

Table 7-13 (2/4) Applicable Capacity Variations of Sewage Treatment Plant at the Candidate Sites (Las Piñas)

Site No.	Available Area (hr)	Process Variations and Applicable Capacity of Sewage Treatment System (m^3/d)					Functional Services	Relative Equipment	
		OD	CAS	SBR	MBBR	MBR		Digester	Generator
L-5	1.10	7,865	20,838	20,565	23,279	24,444	Treatment Capacity (m3/d)	Install	Install
		98	347	257	361	407	Sludge Generation (m3/d)		
		33	88	86	98	103	Gas Power Generation (kw)		
		43,694	115,767	114,250	129,328	135,800	Covering Population		
L-6	3.70	31,127	82,471	81,393	92,134	96,743	Treatment Capacity (m3/d)	Install	Install
		389	1,375	1,017	1,428	1,612	Sludge Generation (m3/d)		
		131	346	342	387	406	Gas Power Generation (kw)		
		172,928	458,172	452,183	511,856	537,461	Covering Population		
L-7	2.50	20,233	53,609	52,908	59,890	62,885	Treatment Capacity (m3/d)	Install	Install
		253	893	661	928	1,048	Sludge Generation (m3/d)		
		85	225	222	252	264	Gas Power Generation (kw)		
		112,406	297,828	293,933	332,722	349,361	Covering Population		
L-8	3.30	27,477	72,802	71,850	81,331	85,400	Treatment Capacity (m3/d)	Install	Install
		343	1,213	898	1,261	1,423	Sludge Generation (m3/d)		
		115	306	302	342	359	Gas Power Generation (kw)		
		152,650	404,456	399,167	451,839	474,444	Covering Population		
L-9	2.20	17,541	46,477	45,869	51,922	54,519	Treatment Capacity (m3/d)	Install	Install
		219	775	573	805	909	Sludge Generation (m3/d)		
		74	195	193	218	229	Gas Power Generation (kw)		
		97,450	258,206	254,828	288,456	302,883	Covering Population		
L-10	8.60	76,605	202,970	200,315	226,750	238,092	Treatment Capacity (m3/d)	Install	Install
		958	3,383	2,504	3,515	3,968	Sludge Generation (m3/d)		
		322	852	841	952	1,000	Gas Power Generation (kw)		
		425,583	1,127,611	1,112,861	1,259,722	1,322,733	Covering Population		
L-11	6.80	59,781	158,394	156,323	176,952	185,803	Treatment Capacity (m3/d)	Install	Install
		747	2,640	1,954	2,743	3,097	Sludge Generation (m3/d)		
		251	665	657	743	780	Gas Power Generation (kw)		
		332,117	879,967	868,461	983,067	1,032,239	Covering Population		

Notes: 1. Sewage Treatment Plant shall basically be provided sludge thickening tanks.

2. Sewage Treatment Process Variations

- OD: Oxidation Ditch Process
- CAS: Conventional Activated Sludge Process
- SBR: Sequencing Batch Reactor
- MBBR: Moving Bed Bio Reactor
- MBR: Membrane Bio Reactor

Table 7-13 (3/4) Applicable Capacity Variations of Sewage Treatment Plant at the Candidate Sites (Las Piñas)

Site No.	Available Area	Process Variations and Applicable Capacity of Sewage Treatment System (m^3/d)					Functional Services	Relative Equipment	
	(hr)	OD	CAS	SBR	MBBR	MBR		Digester	Generator
L-12	18.20	167,355	443,416	437,617	495,368	520,147	Treatment Capacity (m3/d)	Install	Install
		2,092	7,390	5,470	7,678	8,669	Sludge Generation (m3/d)		
		703	1,862	1,838	2,081	2,185	Gas Power Generation (kw)		
		929,750	2,463,422	2,431,206	2,752,044	2,889,706	Covering Population		
L-13	5.80	50,483	133,758	132,009	149,429	156,904	Treatment Capacity (m3/d)	Install	Install
		631	2,229	1,650	2,316	2,615	Sludge Generation (m3/d)		
		212	562	554	628	659	Gas Power Generation (kw)		
		280,461	743,100	733,383	830,161	871,689	Covering Population		
L-14	3.80	32,041	84,895	83,785	94,842	99,586	Treatment Capacity (m3/d)	Install	Install
		401	1,415	1,047	1,470	1,660	Sludge Generation (m3/d)		
		135	357	352	398	418	Gas Power Generation (kw)		
		178,006	471,639	465,472	526,900	553,256	Covering Population		
L-15	2.50	20,233	53,609	52,908	59,890	62,885	Treatment Capacity (m3/d)	Install	Install
		253	893	661	928	1,048	Sludge Generation (m3/d)		
		85	225	222	252	264	Gas Power Generation (kw)		
		112,406	297,828	293,933	332,722	349,361	Covering Population		
L-16	2.00	15,756	41,747	41,201	46,639	48,972	Treatment Capacity (m3/d)	Install	Install
		197	696	515	723	816	Sludge Generation (m3/d)		
		66	175	173	196	206	Gas Power Generation (kw)		
		87,533	231,928	228,894	259,106	272,067	Covering Population		
L-17	2.70	22,036	58,385	57,622	65,226	68,489	Treatment Capacity (m3/d)	Install	Install
		275	973	720	1,011	1,141	Sludge Generation (m3/d)		
		93	245	242	274	288	Gas Power Generation (kw)		
		122,422	324,361	320,122	362,367	380,494	Covering Population		
L-18	1.50	11,337	30,039	29,646	33,558	35,237	Treatment Capacity (m3/d)	Install	Install
		142	501	371	520	587	Sludge Generation (m3/d)		
		48	126	125	141	148	Gas Power Generation (kw)		
		62,983	166,883	164,700	186,433	195,761	Covering Population		

Notes: 1. Sewage Treatment Plant shall basically be provided sludge thickening tanks.

2. Sewage Treatment Process Variations

OD: Oxidation Ditch Process

CAS: Conventional Activated Sludge Process

SBR: Sequencing Batch Reactor

MBBR: Moving Bed Bio Reactor

MBR: Membrane Bio Reactor

Table 7-13 (4/4) Applicable Capacity Variations of Sewage Treatment Plant at the Candidate Sites (Las Piñas)

Site No.	Available Area	Process Variations and Applicable Capacity of Sewage Treatment System (m^3/d)					Functional Services	Relative Equipment	
	(hr)	OD	CAS	SBR	MBBR	MBR		Digester	Generator
L-19	1.80	13,981	37,042	36,558	41,382	43,452	Treatment Capacity (m3/d)	Install	Install
		175	617	457	641	724	Sludge Generation (m3/d)		
		59	156	154	174	182	Gas Power Generation (kw)		
		77,672	205,789	203,100	229,900	241,400	Covering Population		
L-20	5.10	44,001	116,584	115,059	130,243	136,758	Treatment Capacity (m3/d)	Install	Install
		550	1,943	1,438	2,019	2,279	Sludge Generation (m3/d)		
		185	490	483	547	574	Gas Power Generation (kw)		
		244,450	647,689	639,217	723,572	759,767	Covering Population		
L-21	4.10	34,791	92,179	90,974	102,979	108,131	Treatment Capacity (m3/d)	Install	Install
		435	1,536	1,137	1,596	1,802	Sludge Generation (m3/d)		
		146	387	382	433	454	Gas Power Generation (kw)		
		193,283	512,106	505,411	572,106	600,728	Covering Population		
L-22	19.00	174,965	463,578	457,515	517,892	543,798	Treatment Capacity (m3/d)	Install	Install
		2,187	7,726	5,719	8,027	9,063	Sludge Generation (m3/d)		
		735	1,947	1,922	2,175	2,284	Gas Power Generation (kw)		
		972,028	2,575,433	2,541,750	2,877,178	3,021,100	Covering Population		

Notes: 1. Sewage Treatment Plant shall basically be provided sludge thickening tanks.

2. Sewage Treatment Process Variations

OD: Oxidation Ditch Process

CAS: Conventional Activated Sludge Process

SBR: Sequencing Batch Reactor

MBBR: Moving Bed Bio Reactor

MBR: Membrane Bio Reactor

Figure 7-19 Site Candidate Map (Parañaque)

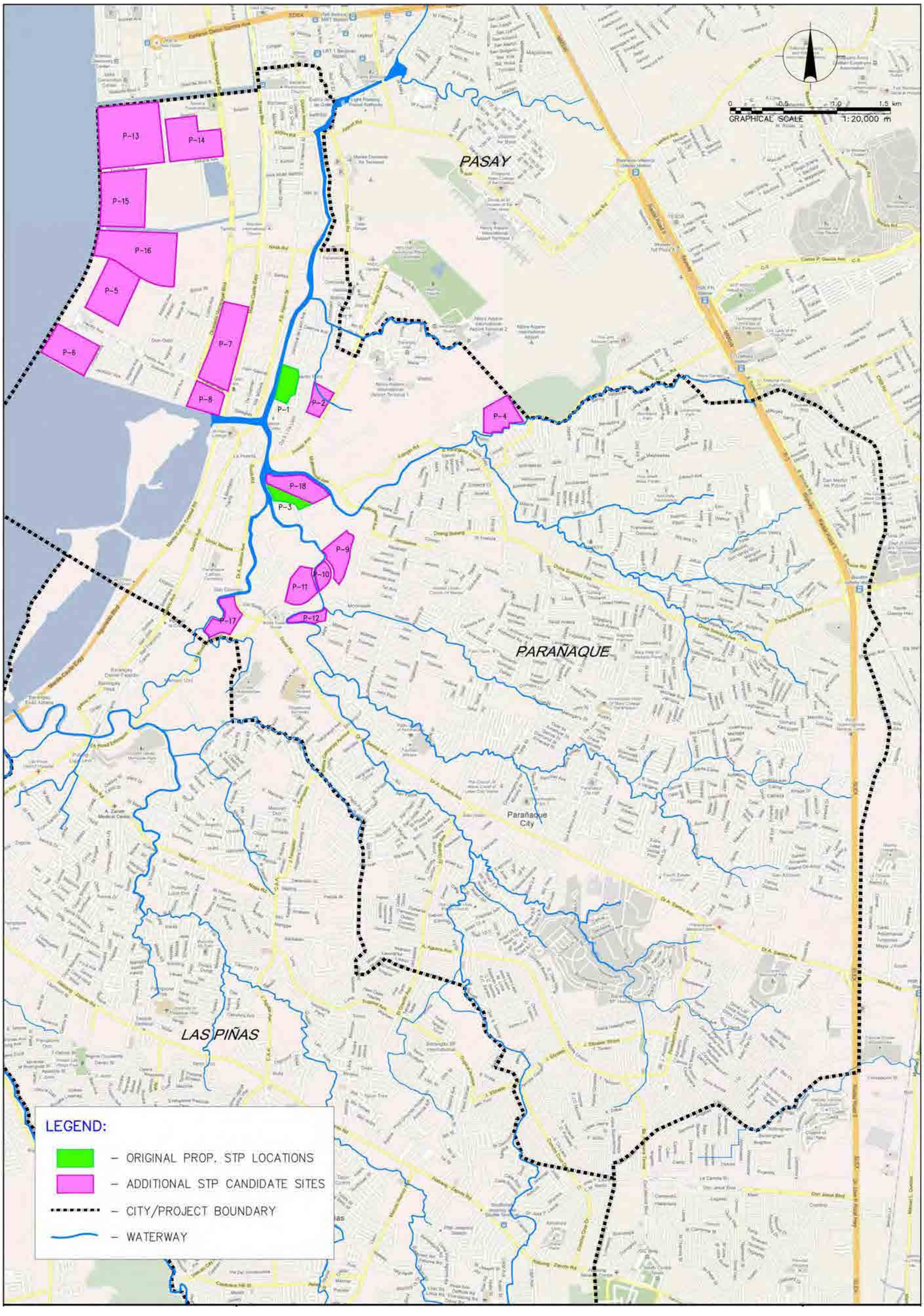
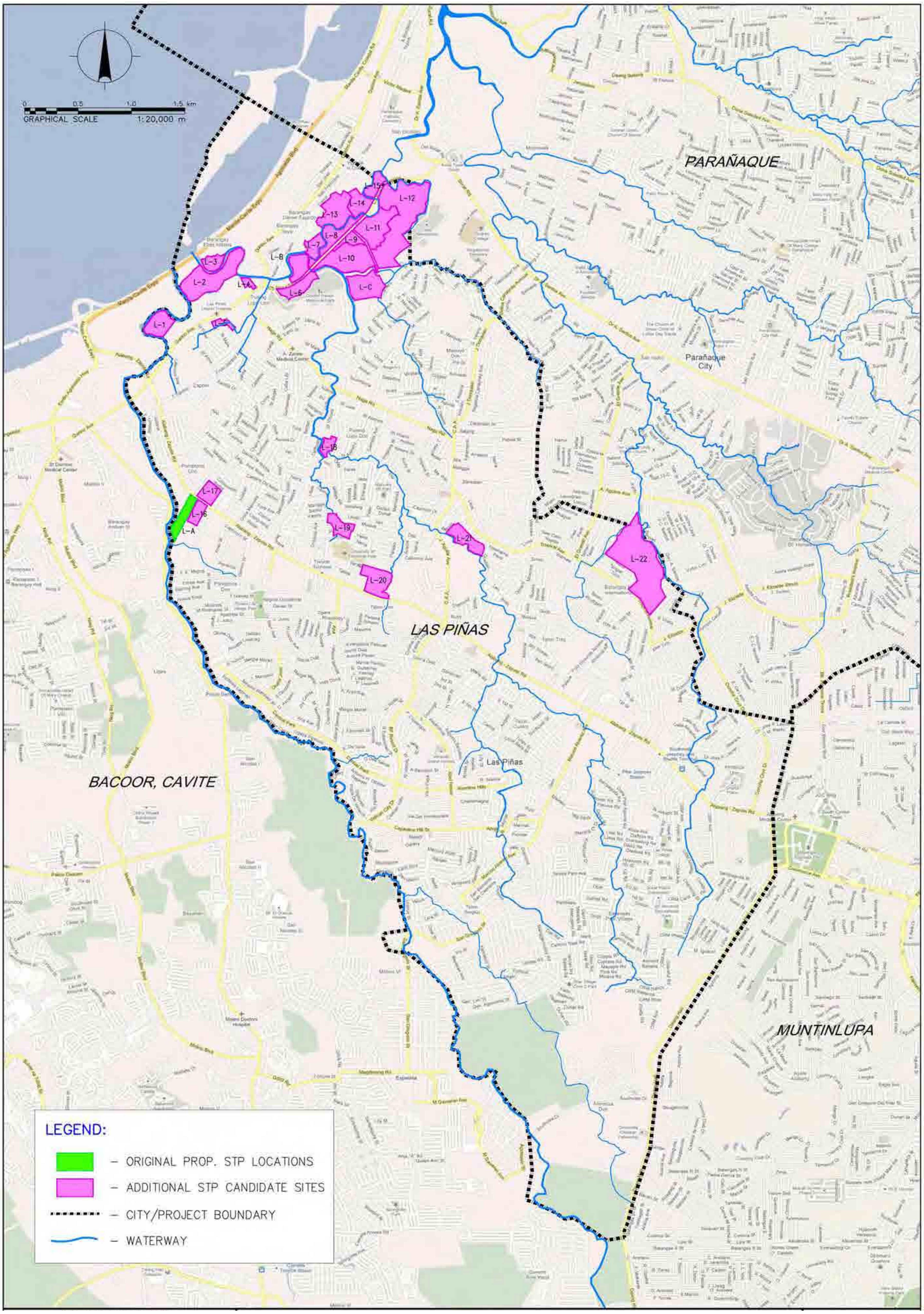


Figure 7-20 Site Candidate Map (Las Piñas)



7.3.2 Interceptor Installation Plan

The target area slopes from southeast to northwest, while a lot of small creeks combine and flow into Manila Bay. Sewers that collect sanitary sewage and storm water from the urban area drain into rivers and creeks, which constitute the trunk sewer lines. In the case of separate sewer systems in Japan, approximately 70 percent of the overall construction cost is spent on building sanitary sewage sewers. Since adopting a separate sewer system and installing sanitary sewage sewers along roads would entail huge construction costs, it is necessary to select a sewage collection system that is suited to the area. A commonly adopted sewage collection method in Southeast Asia is the method whereby water is directly obtained from creeks.

Since garbage is disposed into rivers and creeks making them prone to blockage in the target area, conversion manholes shall be installed near the end of sewers flowing into creeks, and the sanitary sewage separated by these shall be conveyed by interceptors to the sewage treatment facilities at the end of the stream.

While surveying the catchment areas of rivers and creeks and confirming the locations of outfalls in Parañaque and Las Piñas, we investigated the flood level in each area by interviewing residents. Section 7.4.2 describes water levels according to past flood records based on interviews conducted during the catchment area survey. The flood level, ranging from 0.1~0.3 m, covers a wide area stretching from the upper reaches to the lower reaches.

Interceptor routes shall be studied when the sewage treatment plant alternatives are assumed. The interceptors convey sewage water from the conversion manholes in the case of combined sewerage system, and the sizes are decided with sewage flow rate calculated from collected sub-sub basin populations. The interceptor route is principally to be chosen at the route as nearer to outfall positions as possible. The locations of conversion manholes and the interceptor flow directions shall be decided from precise gravity flow directions of wastewater in the catchment areas. The gravity flow directions were identified while site surveys.

Figure 7-21 shows overall gravity flow direction of wastewater in the project areas.

Figure 7-21 (1/4) Wastewater Gravity Flow Direction (Index)

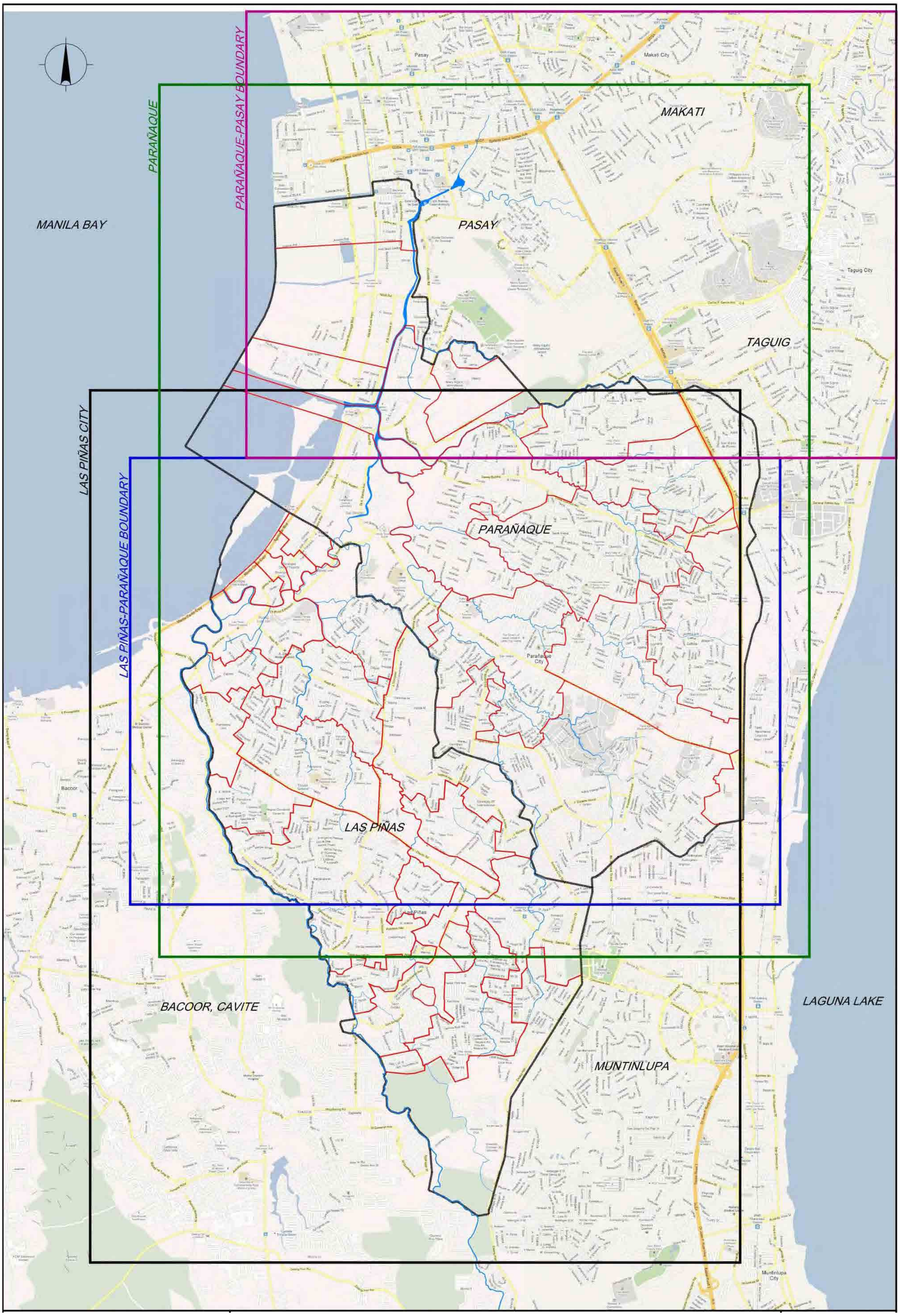


Figure 7-21 (2/4) Wastewater Gravity Flow Directions in Parañaque

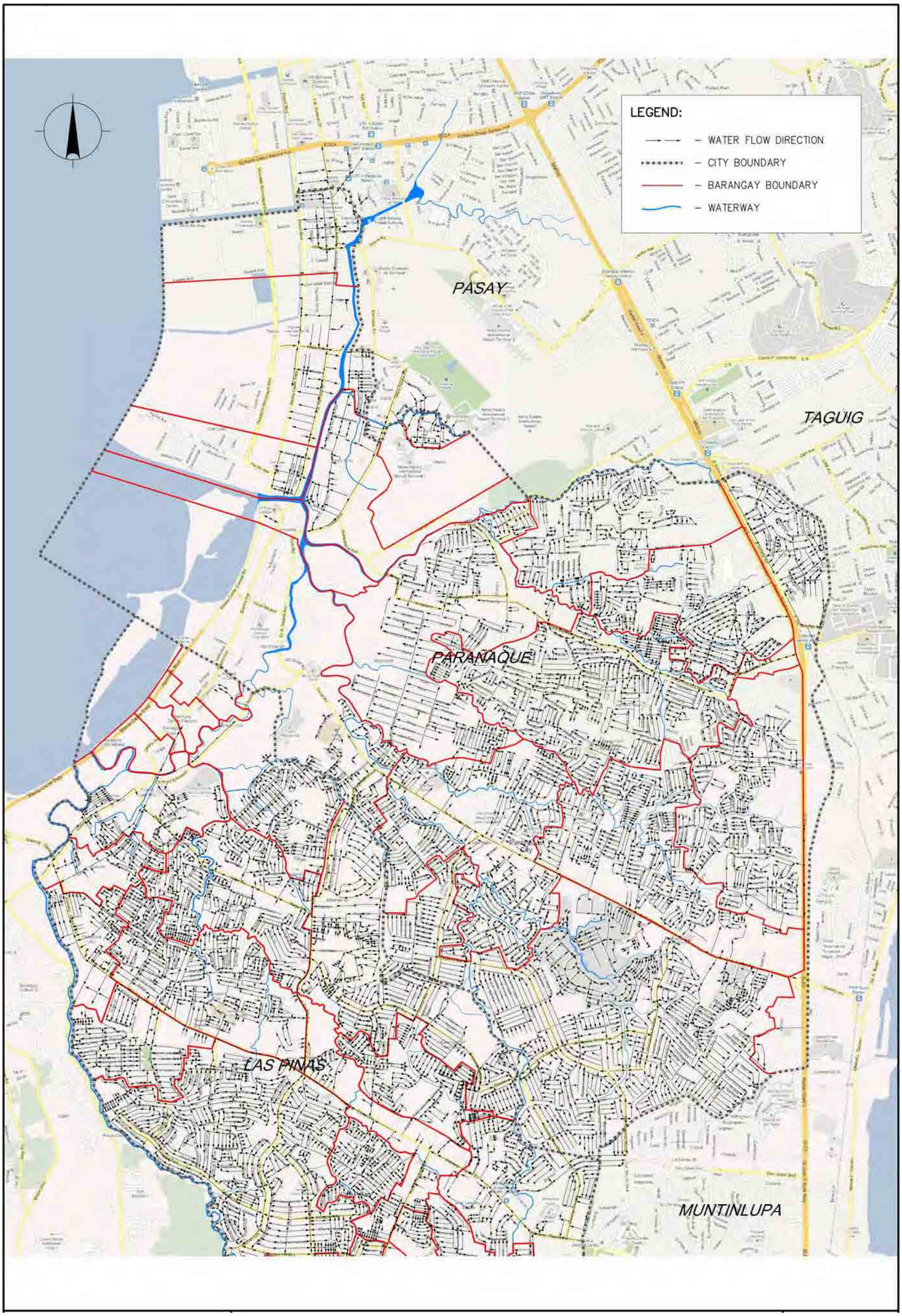


Figure 7-21 (3/4) Wastewater Gravity Flow Directions in Las Piñas

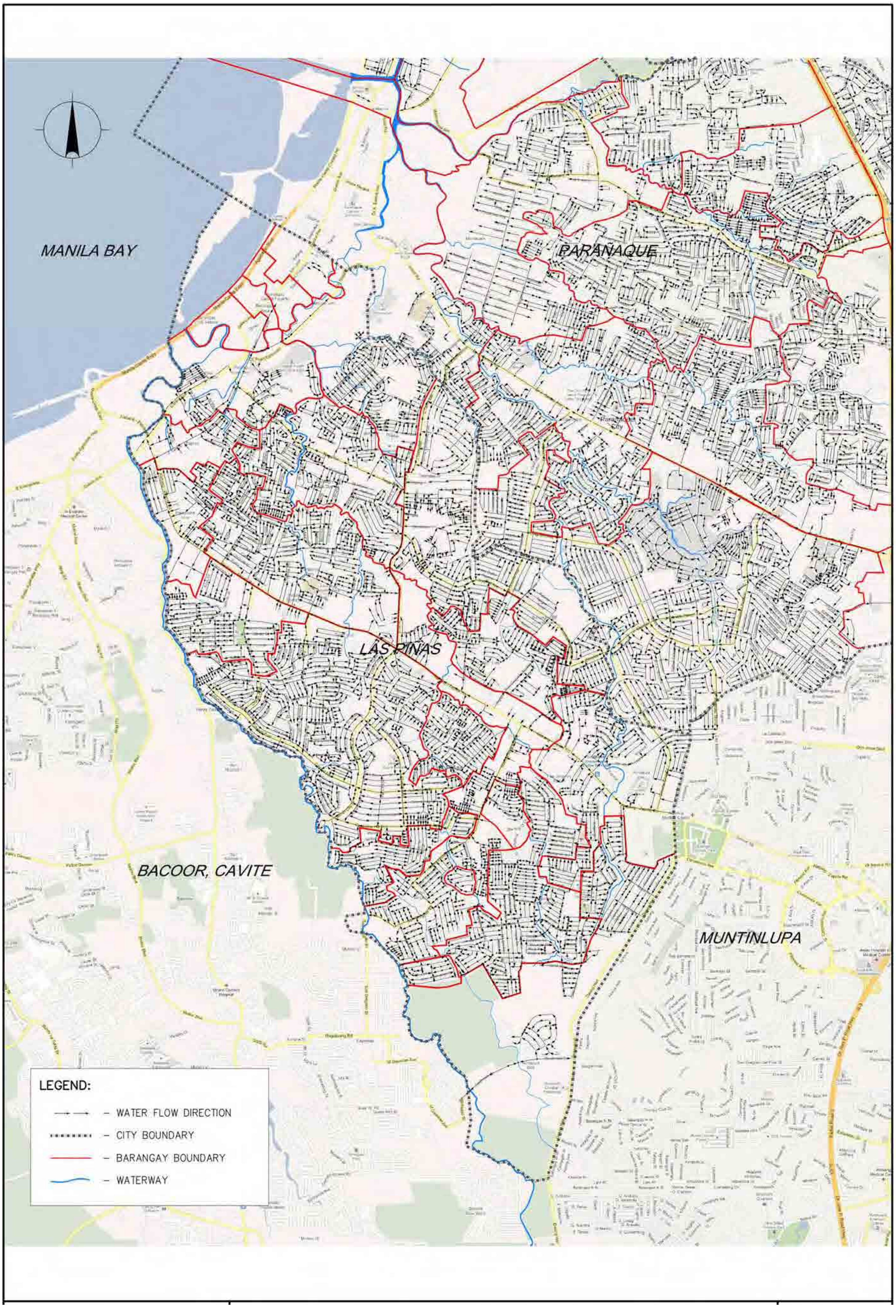
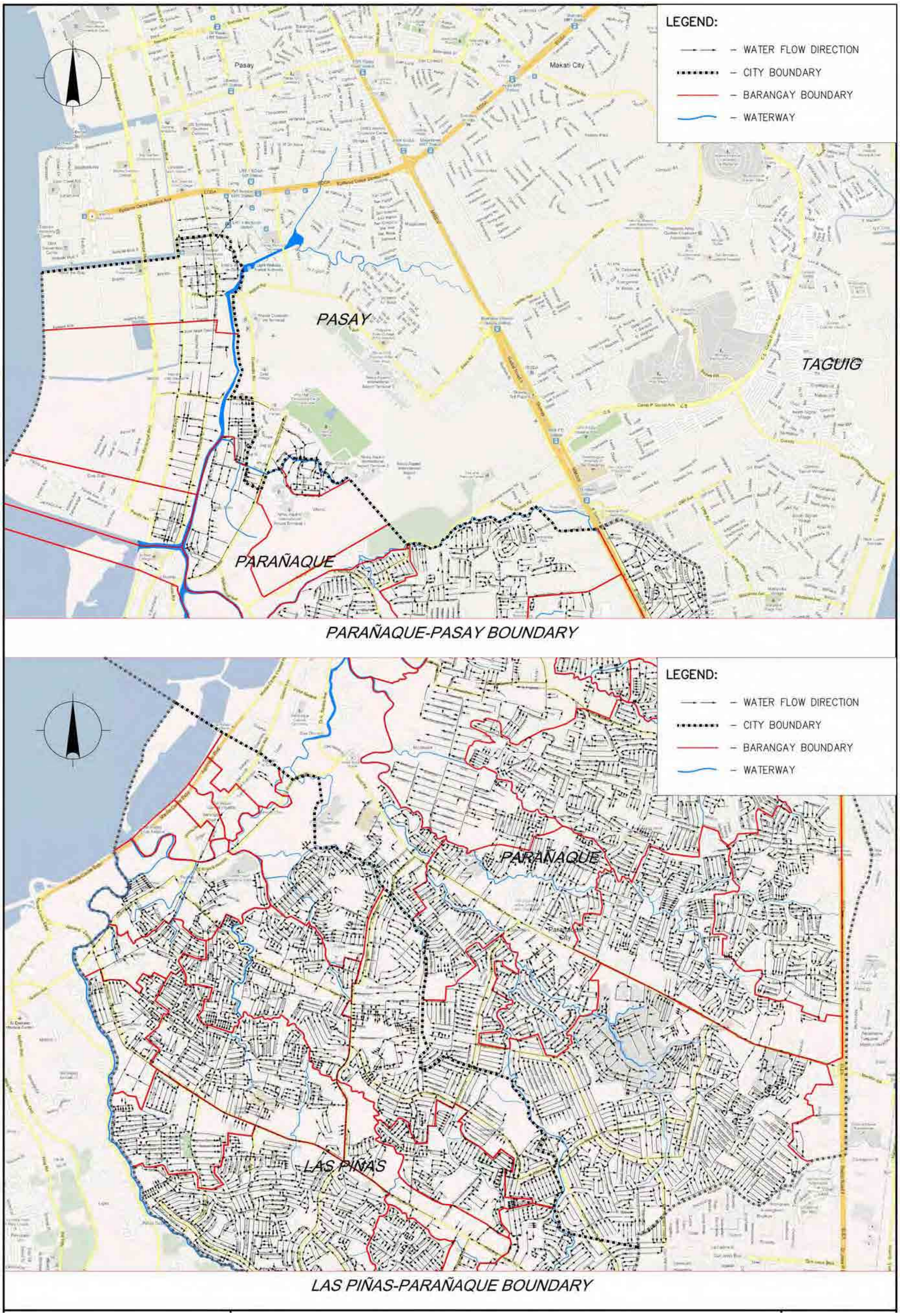


Figure 7-21 (4/4) Wastewater Gravity Flow Directions in the City Borders



7.4 Over Flood Situations

Coastal areas of the project sites are low lying grounds. There are often experienced over flooding in the areas. Provision shall be made for the sewage plant design to cater for over flood conditions.

The past over flood records are not available, therefore the over flood information in the project sites were collected by interviews to Government Authority and area residents during the site surveys. Judging from the information collected, the STP should address the flood height around 1 to 3 meters.

7.4.1 Interview to MMDA

Department: **Flood Control Operations**
Head: Ms. Norma Tamayo (0927-643-4389)

Areas in Parañaque, Las Piñas and Muntinlupa that are prone to flooding were identified. A map showing these points of interest was presented for better illustration of the site locations. Aside from flood prone areas, drainage maintenance areas, major outfalls, and location and names of waterways, are included in the map. Please refer to the encoded map on the following page.

Identified flood prone areas are as follows:

1) Parañaque City
    a. Quirino Avenue
        i. Fronting La Huerta
        ii. Kabihasnan - Saulog
    b. Sucat Road
        i. Corner 4th Estate
        ii. Sucat Road Interchange fronting Jollibee
        iii. East Service Road (Bicutan)
        iv. Baclaran Vicinity
        v. Ninoy Aquino Avenue fronting Duty Free
2) Las Piñas City
    a. Quirino Avenue
        i. Fronting 7-11 store near junction of Alabang-Zapote Road.
        ii. CAA Road cor Balikatan
        iii. Alabang-Zapote Road Fronting Lozada Market

Staff of the Flood Control said that they only monitor public roads for flooding, inundation depths of which are only about gutter level or knee level. Unfortunately, flood water levels are not recorded by MMDA. Areas inside the barangays and villages were not monitored by MMDA since most areas are private according to them. Information on the depths of flooding within these areas is possibly recorded by the respective barangay officials.

MMDA conducts declogging of drainage lines and dredging of waterways on a regular basis.

Department: **Pump Station Operations & Maintenance**
Head: Mr. Teofilo M. Baniqued (0906-665-1986)

During the super typhoon Ondoy last September 26, 2009, MMDA was able to record the upstream (Estero Tripa de Gallina) and downstream (Parañaque River) water levels of the Tripa de Gallina Pumping Station. Please refer to the following table:

Tripa de Gallina PS Operation Record during Typhoon "Ondoy," September 26, 2009 (Saturday)

Time	Upstream Water Level (Estero Tripa de Gallina)	Downstream Water Level (Parañaque River)	Remarks
1:00 AM	9.90 m	11.80 m	4 pumps operating
2:00 AM	10.10 m	11.90 m	5 pumps operating
3:00 AM	10.30 m	11.95 m	6 pumps operating
4:00 AM	10.35 m	11.95 m	7 pumps operating
5:00 AM	10.35 m	11.95 m	6 pumps operating
6:00 AM	10.35 m	11.90 m	6 pumps operating
7:00 AM	10.10 m	11.80 m	7 pumps operating
8:00 AM	9.85 m	11.55 m	5 pumps operating
9:00 AM	9.75 m	11.50 m	4 pumps operating
10:00 AM	10.70 m	11.70 m	6 pumps operating
11:00 AM	11.90 m	12.40 m	7 pumps operating
12:00 PM	12.70 m	12.80 m	7 pumps operating
1:00 PM	13.00m	13.00 m	7 pumps operating
2:00 PM	13.00m	13.00 m	7 pumps operating
3:00 PM	13.00m	13.00 m	7 pumps operating
4:00 PM	13.00m	13.00 m	7 pumps operating
5:00 PM	13.00m	13.00 m	flood gates open
6:00 PM	13.00m	13.00 m	flood gates open
7:00 PM	13.00m	13.00 m	flood gates open
8:00 PM	13.00m	13.00 m	flood gates open
9:00 PM	12.90 m	12.90 m	flood gates open
10:00 PM	12.70 m	12.70 m	flood gates open
11:00 PM	12.65 m	12.60 m	flood gates open
12:00 PM	12.50 m	12.50 m	flood gates open

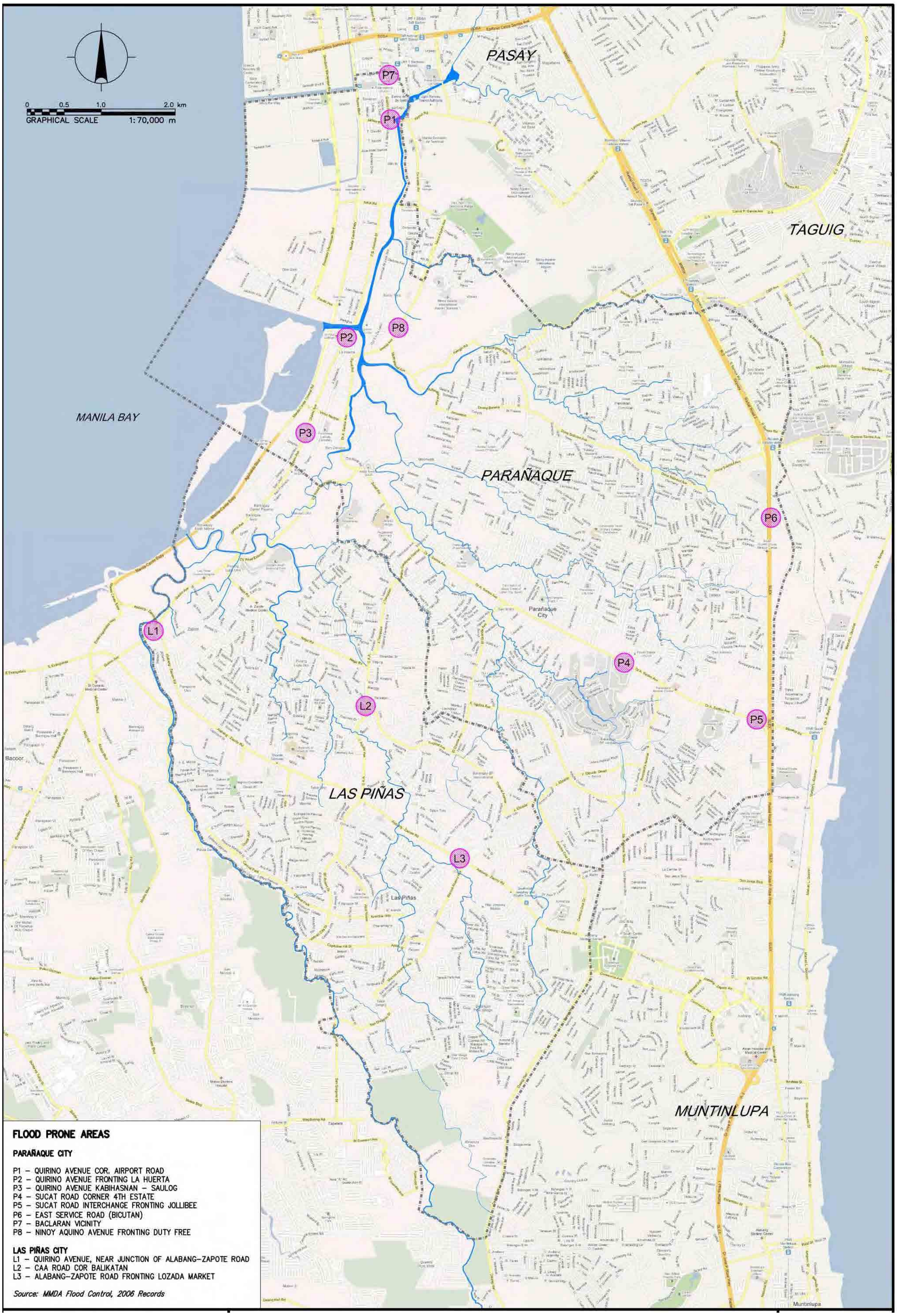
On a regular day basis, the Tripa de Gallina Pumping Station monitors and maintains an average upstream water elevation of 9.5 m (pumps stopped, gates opened). In the event of a rising water level reaching an elevation of 10.2 m, or during an expected storm, the pumps are started, and at times, the flood gates are closed until the water level goes back to the 9.5 m elevation.

Even at the start of the day of September 26, 2009, the pump station is already operating with 4 pumps utilized. Seven (7) out of the eight (8) pumps were utilized during the whole day phenomenon. Later that day, the water level exceeded the maximum elevation of 13.0 meters, still rising up to elevation of 13.5 to 14 meters (knee level of the estero banks (pump station ground level). Even after the rain had subsided, the upstream flow was too voluminous to be handled by the pumps, thus, the pump station stopped its operation and concentrated in protecting the facilities from flood water instead.

According to Mr. Baniqued, the water elevations indicated in the records are referenced to the sea water level.

These information is sum-up in **Figure 7- 22**

Figure 7-22 Flood Prone Map (by MMDA Interview)



7.4.2 Interview to Site Residents

<u>Site Visit Date: July 06, 2010</u>

Proposed STP Location near Sto. Niño – Dongalo Boundary Bridge, Parañaque

Based on the interview from a resident at the proposed STP location P – 1, the normal flood level reaches up to the knee. Maximum flood level may be estimated to about 1 meter during the typhoon Ondoy.

Parañaque River

Parañaque Channel

Interview

Ibayo Creek

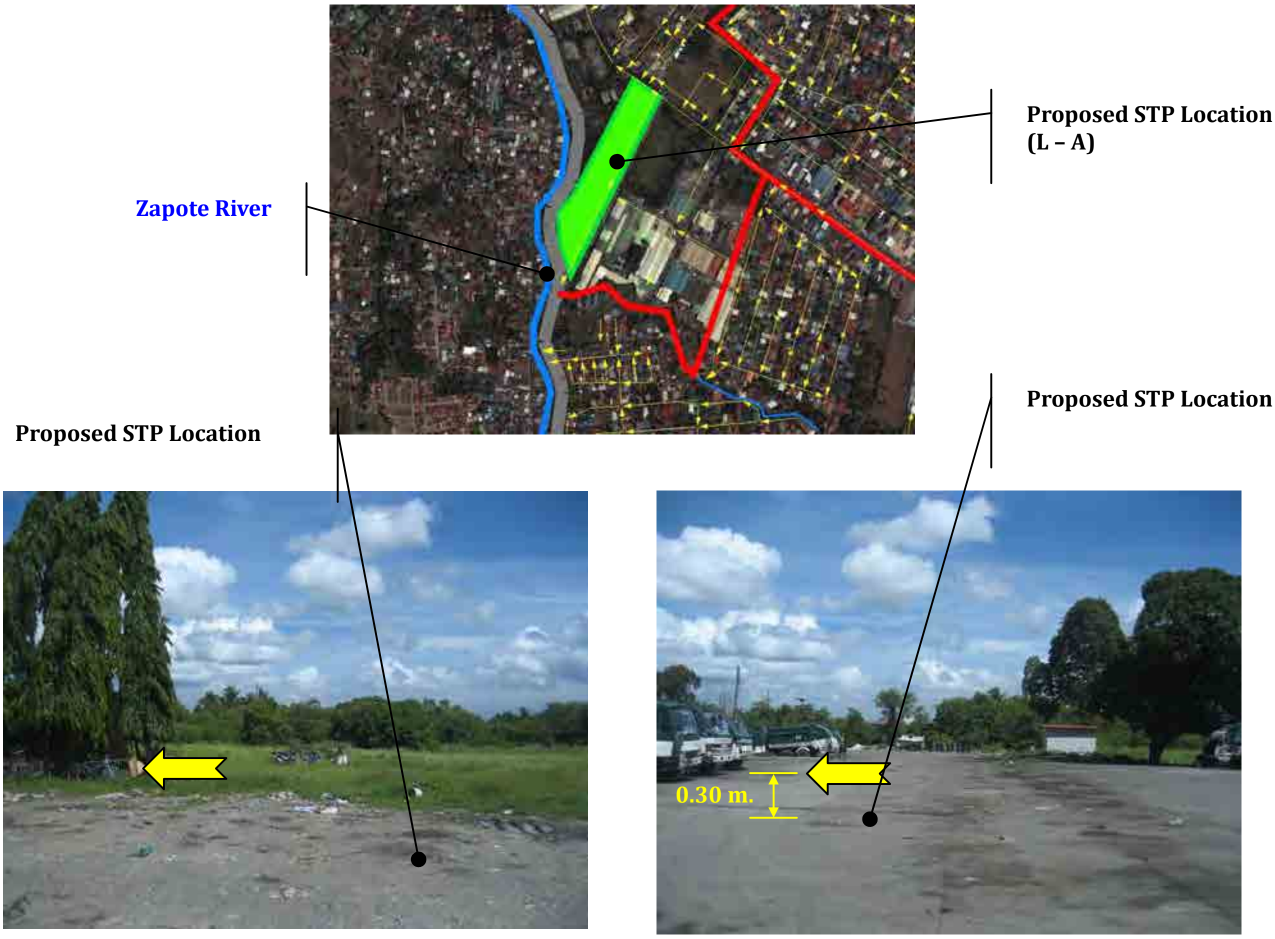
Proposed STP Location (P – 1)

Proposed STP Site at the back of fence

Site Visit Date: July 08, 2010

Proposed STP Location beside Republic Steel Compound, Pamplona Uno, Las Piñas

Based on the interview from a resident at the proposed STP location L – A, there is no flooding in the area during the normal rainy season. Maximum flood level may be estimated to about 0.30 meter (or below-knee level) during the typhoon Ondoy. The property is owned by Las Piñas Mayor Vergel A. Aguilar.



<u>Site Visit Date: July 08, 2010</u>

Proposed STP Location near SM Warehouse, San Dionisio, Parañaque

The group interviewed a man named Mr. Rey Mar Noriel, a resident at the proposed STP location P – 3. According to him, there is no record of flooding in the area during the typhoon Ondoy. The property is owned by SM (formerly by United Overseas Bank).

Kay Boboy Creek

Don Galo River

Proposed STP Location (P – 3)

San Dionisio Creek

Proposed STP Location

Proposed STP Location

Las Piñas Local Review for Flood Levels:

Location: Between San Marco & Pegasus Road, Brgy. Talon Singko
Depth: 1m

Location: Bridge along Marcos Alvarez Ave. near Zapote Road, Brgy. Talon Uno
Depth: 0.1m

Location: Bridge along Marcos Alvarez Ave. Brgy. Talon Singko
Depth: 0.5m (Top level of riprap)

Location: Bridge along Doña Pillar Aguirre Ave., Brgy. Pilar Village
Depth: 1m

Location: De Castro Compound near Champaca St parallel to Rosal St., Brgy. Almanza Dos
Depth: 0.2m (Top level of riprap)

Parañaque Local Review for Flood Levels:

Location: Lauren Drive, Savvy Village, Brgy. Marcelo Green
Depth: 2m

Location: San Antonio Valley-9, Brgy. San Antonio
Depth: 1m

Location: Nery St., Better Living Subd., Remmanville, Brgy. San Antonio
Depth: 1m

Location: Creek at J. Elizalde St.., BF Classic Homes Village Subd., Brgy. BF Homes
Depth: 1.2m

Location: Filinvest Classic Estate Subdivision (near PATTS College of Aeronautics), Brgy. San Isidro
Depth: 2m to 3m

Location: Circon St., San Antonio Valley-1 Subd., Brgy. San Antonio
Depth: 1.5m

Location: Bridge along Peru St. (near Parañaque Doctors Hospital), Brgy. Don Bosco
Depth: 1.2m

Location: Better Living Annex 41, Brgy. Sun Valley
Depth: 0.4m

Location: Better Living Annex 45, Brgy. Sun Valley
Depth: 0.6m above bridge deck

This information collected by the residents' interviews is sum-upped in **Figure 7--23**.

Figure 7-23 Flood Levels (by Residents' Interview)