THE REPUBLIC OF THE UNION OF MYANMAR
YANGON CITY DEVELOPMENT COMMITTEE (YCDC)

THE REPUBLIC OF THE UNION OF MYANMAR
DATA COLLECTION SURVEY FOR SEWERAGE SYSTEM DEVELOPMENT IN YANGON CITY

FINAL REPORT

FEBRUARY 2019

Japan International Cooperation Agency (JICA)

Nippon Koei Co., Ltd. (NK)

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Exchange Rate (May 2018)
JPY/USD = 110
MMK/USD = 1,320
JPY/MMK = 0.0833

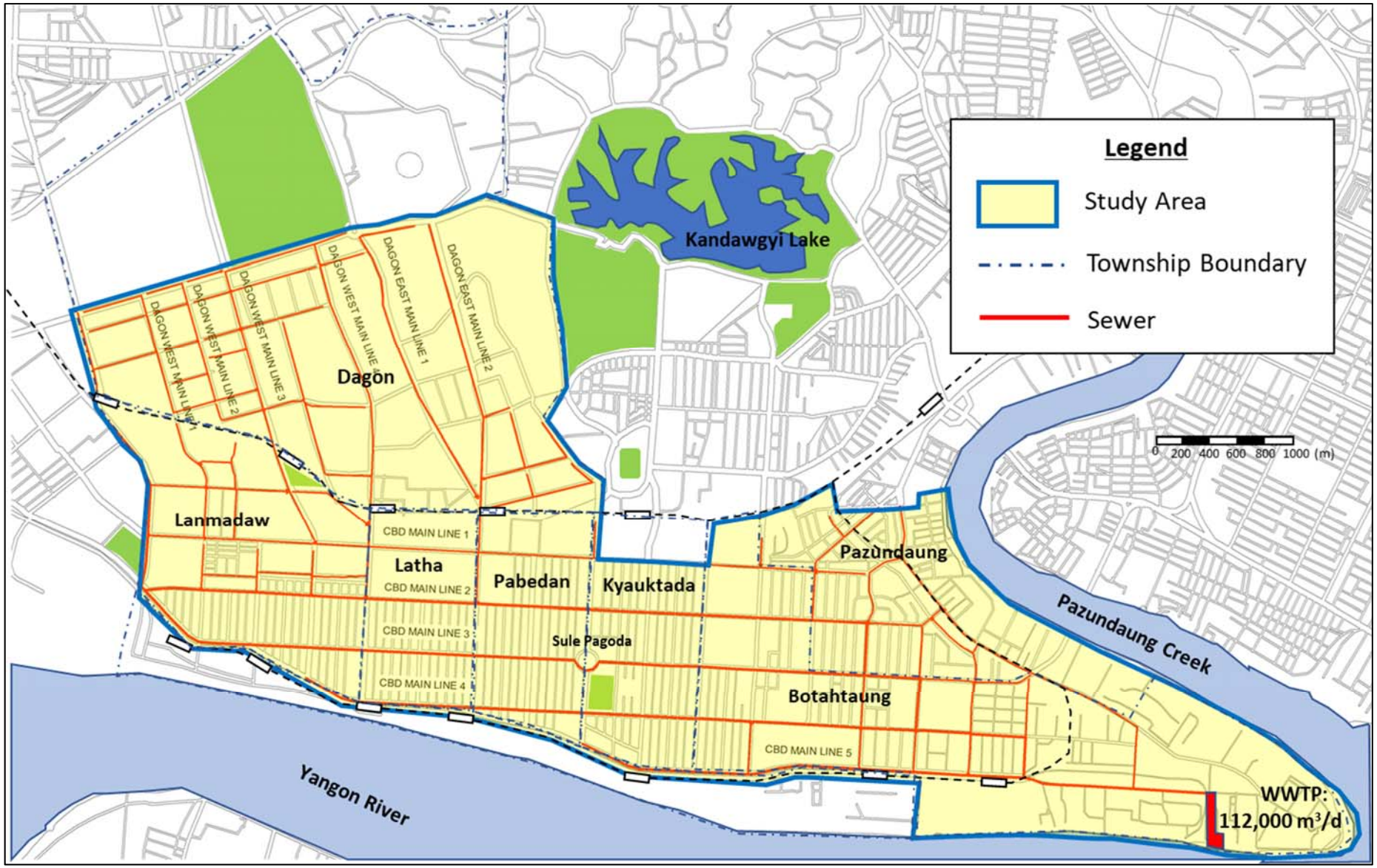
DIFINITION OF THE STUDY AREA

Administrative Boundary		Township Group	Township Name	Sewerage Zone	The Study Area
Yangon Region	Yangon City	CBD	Latha	W1	√
			Lanmadaw	W1	√
			Pabedan	C1	√
			Kyauktada	C1	√
			Botahtaung	C1	√
			Pazundaung	C1	√
		Inner Urban Ring	Ahlone	W1	
			Kyee Myin Daing	W1/W2	
			Sanchaung	W1	
			Dagon	W1	√[1]
			Bahan	C2/W1	
			Tarmwe	C2	
			Mingalar Taung Nyunt	C2	
			Seikkan		
			Dawbon	E3	
		Outer Ring	Kamaryut	W1/W2	
			Hlaing	W2	
			Yankin	C2	
			Thingangyun	C2	
		Northern Suburbs	Mayangone	C2/W2	
			Insein	N1	
			Mingalardon	N2	
		Older Suburbs	North Okkalapa	E1	
			South Okkalapa	C2	
			Thaketa	E3	
		South of CBD	Dala	S1	
			Seikgy ikhanaungto	W3	
		New Suburbs	Shwe Pyi Thar	N3	
			Hlaing Tharyar	W4	
			North Dagon	E1	
			South Dagon	E3	
			East Dagon	E2	
			Dagon Seikkan	E4	
	Outside of Yangon City		Kyauktan		
			Thanlyin		
			Hlegu		
			Hmawbi		
			Htantabin		
			Twantay		
			Taikkyi		
			Kawhmu		
			Kungyangon		
			Kayan		
			Thongwa		

1: Part of Dagon township is included in the study area

Source: JICA Study Team

Source: Myanmar Information Management Unit



Source: JICA Study Team

Sewerage Facility Development Plan for Study Area

THE REPUBLIC OF THE UNION OF MYANMAR
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Abbreviations

Abbreviation	English
B/C	Benefit per Cost
BDS	Back Drainage Space
BOD	Biochemical Oxygen Demand
CBD	Central Business District
CIP	Cast-Iron Pipe
COD	Chemical Oxygen Demand
CQHP	Committee for Quality Control of High-Rise Building Construction Project
DDA	Department of Development Affair
DIP	Ductile Iron Pipe
DMA	District Metered Area
E/N	Exchange of Notes
EDWS	Engineering Department of Water and Sanitation
ECC	Environment Conservation Committee
ECC	Environmental Compliance Certificate
EIA	Environmental Impact Assessment
ESC	Environmental and Social Considerations
F/S	Feasibility Study
FC	Foreign Currency
FDS	Final Disposal Site
FY	Fiscal Year
GPCD	Gallons Per Capita per Day
HHWL	Highest High Water Level
HWL	High Water Level
IEE	Initial Environmental Examination
IUR	Inner Urban Ring
JICA	Japan International Cooperation Agency
JST	JICA Study Team
Kyat	Myanmar Kyat
LPCD or(Lpcd)	Litters Per Capita per Day
LWL	Low Water Level
M&E	Mechanical & Electrical
M/P	Master Plan
METI	Ministry of Economy, Trade and Industry
MG	Million Gallons
MGD	Million Gallons per Day
MIP	Mingaladon Industrial Park
ML	Million Litters
MLD	Million Litters per Day
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOC	Ministry of Construction
MONREC	Ministry of Natural Resources and Environmental Conservation
MOFA	Ministry of Foreign Affairs
MOU	Memorandum of Understanding
MWL	Mean Water Level

N/A	Not Available
NCEA	National Commission for Environmental Affairs
NewSZ	New Suburbs Zone
NRW	Non Revenue Water
NS	Northern Suburbs
O&M	Operation & Maintenance
OldSZ	Older Suburbs Zone
ORZ	Outer Ring Zone
P/S	Pumping Station
PCCD	Pollution Control and Cleansing Department
PPP	Public-Private Partnership
PVC	Polyvinyl Chloride
R	Reservoir
RC	Reinforced Concrete
S/R	Service Reservoir
SCADA	Supervisory Control And Data Acquisition
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SHM	Stakeholder Meeting
SS	Suspended Solids
STF	Sludge Treatment facility
T-N	Total Nitrogen
T-P	Total Phosphorus
TS	Township
TS	Total Solids
US$, USD	United States Dollars
VAT	Value Added Tax
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant
WTF	Wastewater Treatment Facility
YCDC	Yangon City Development Committee
YRG	Yangon Regional Government

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Yangon City, the former capital city of the Republic of the Union of Myanmar, consists of 33 townships with a population of 5.21 million in 2014. The city is the economic center of the country. A volume of sewerage generation (human waste water, domestic waste water and industrial waste water) in the whole city was estimated to be 500,000 m^3 approximately as of 2011. The Central Business District, hereinafter referred to as CBD area, has a quarter million of people and generates about 55,000 m^3/day of sewage.

Currently the existing sewerage service area is limited within the CBD consisting of six townships out of 33 townships In British colonial era, the existing sewerage pipes for collection and disposal of human waste had been firstly constructed downtown in the 1880s, which is located in the southern part of the city covering about 9 km^2 service area and was expanded in 1929. A wastewater treatment plant was constructed in 2005 with a design capacity of 14,775 m^3/day. This existing sewerage service area is called the C1 area in the Study.

However, the sewerage service area has not been expanded yet. In addition, the existing sewerage pipes suffer from the problems such as water leakage due to the deteriorated old pipes, and failures of pressure pumps frequently identified. Therefore, the sewage influent volume to the wastewater treatment plant is currently 630 m^3/day, which is only about 4% of the design capacity of the existing wastewater treatment plant . In remaining 27 townships, 80% of human waste (black water) is treated by septic tanks and 15% is discharged to the existing storm water drainage pipes without any treatment. As domestic wastewater (grey water) and industrial wastewater are also discharged to storm water drainage pipes, water quality of rivers and lakes in the city has consequently deteriorated. Moreover, during the rainy season, the overflow of floodwaters including human waste from storm water drainages makes the sanitary condition worsened. In addition, the water supply system in the CBD will be developed (water supply amount upto 86,000 m^3/day) in the Greater Yangon Water Supply Improvement Project (Phase II) (Yen loan, Loan agreement signed in 2017) financed by the Japanese official development assistance (ODA) with the loan agreement (L/A) dated January 2017. The supply area will be expanded and water supply will improve thus accordingly, sewage volume will also be increased. The current situation of wastewater treatment not only brings forth deteriorating living conditions but also involves potential health risks.

Under the circumstances mentioned above, the development of sewerage systems in Yangon City is urgently required for the improvement of the level of sewerage services and living conditions.

In the past, the Japan International Cooperation Agency (JICA) implemented the development plan titled “Preparatory Survey for the Improvement of Water Supply, Sewerage and Drainage

System in Yangon City" in March 2014 (hereinafter called as "JICA MP 2014"). The study was conducted to prepare a sewerage system development plan targeting the year 2040.

Based on the JICA MP 2014, the Yangon Regional Government (YRG) requested JICA to conduct this data collection study for sewerage system development in Yangon City (hereinafter referred to as the "Study").

1.2 Objectives of the Study

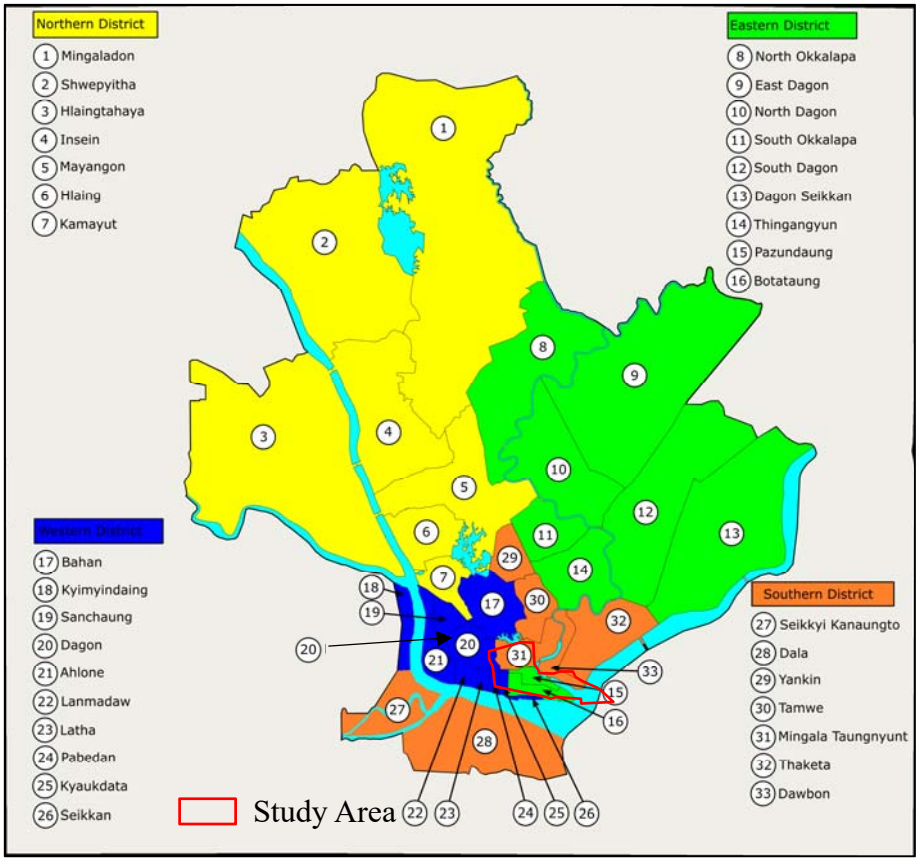
The objectives of the Study is to conduct the preparation of the project for development of the sewerage system in the priority area in Yangon City by the Japanese ODA in order to contribute to economic development and to improvement of living environment of the city.

In the process of the Study, results of the following project studies under the Japanese assistance conducted in the past are referred.

- Project for the Strategic Urban Development Plan of the Greater Yangon, (JICA, 2013)
- Preparatory Survey for the Improvement of Water Supply, Sewerage, and Drainage System in Yangon City (JICA, 2014)
- Study on the Improvement of Wastewater Treatment in Yangon City (Ministry of Economy, Trade and Industry, Japan (METI), 2017)
- Study on Development of Sewerage System in in Yangon City (Ministry of Land Infrastructure, Transport and Tourism, Japan (MLIT), 2017)

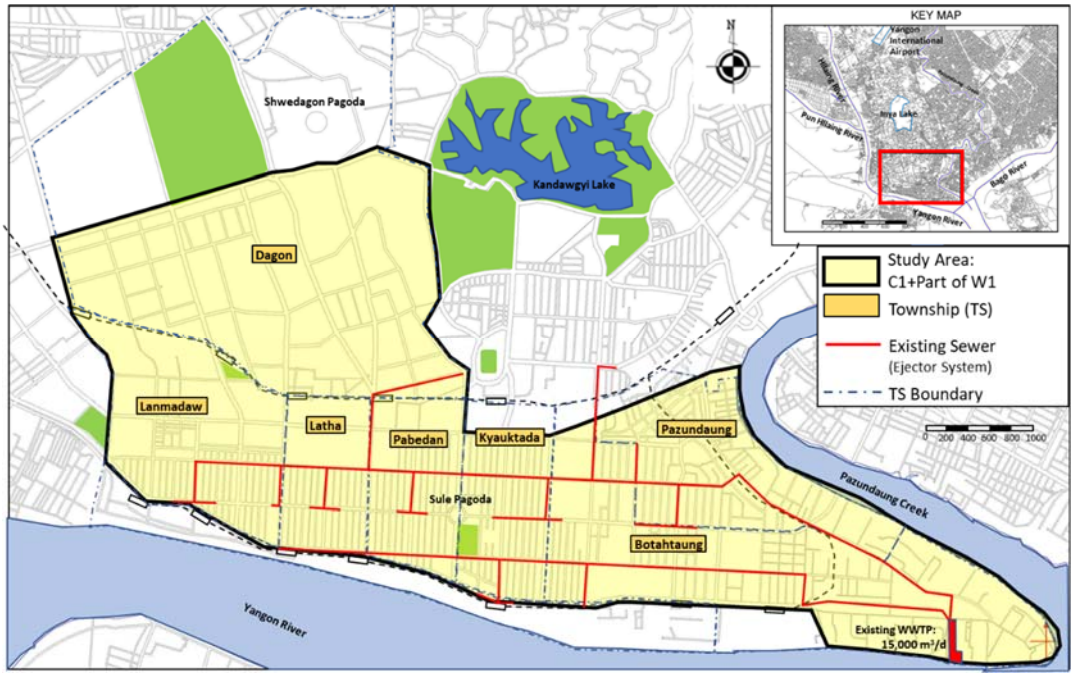
1.3 Study Area

Figure 1.3.1 shows the location of the study area in Yangon City. The study area targeted is C1 area plus part of W1 area (part of Dagon Township) of Yangon City including six townships within the city. Pazundaung, Botahtaung, Kyauktada, Pabedan, Latha, Lanmadaw, and Dagon as shown in Figure 1.3.2 where are the first prioritized to develop the sewerage system agreed with the Yangon City Development Committee (YCDC) before the commencement of the Study.



Source: JICA Study Team

Figure 1.3.1 Location of the Study Area in Yangon City



Source: JICA Study Team

Figure 1.3.2 Study Area

1.4 Target Year

The target year for the Study is set as 2040 based on the master plan.

CHAPTER 2 OUTLINE OF THE STUDY AREA

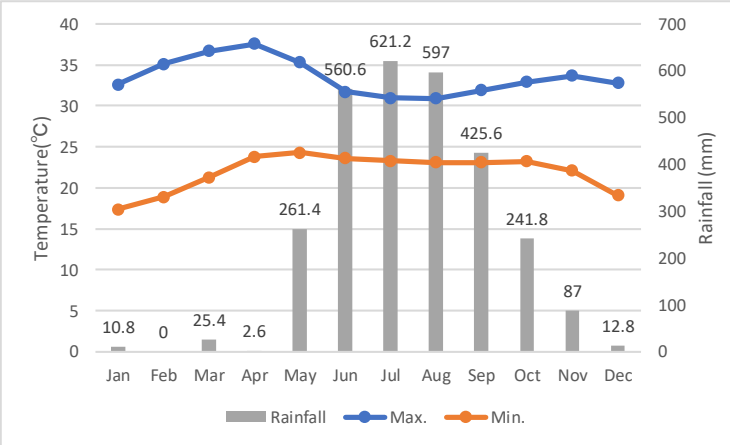
2.1 Natural and Physical Conditions

2.1.1 Climate

Yangon has a tropical monsoon climate which consists of three seasons as listed below.

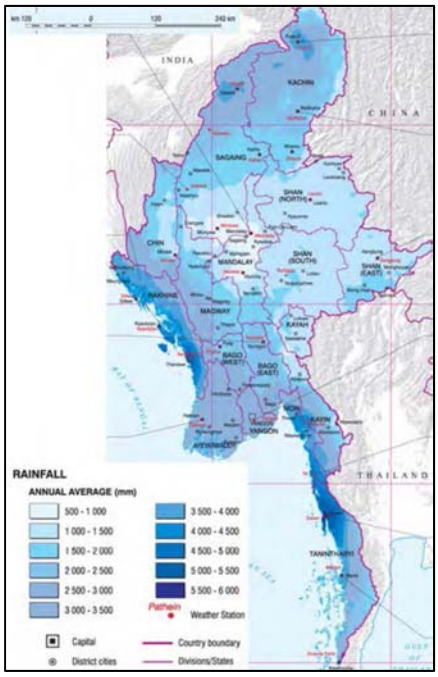
- Summar seaon: From March to middle of May
- Rainy season: From Middle of May to October
- Dry season: From October to February

It has an annual rainfall of 2,840 mm, an average temperature of 27.4 ºC, a maximum mean temperature of 37.6 ºC, and minimum mean temperature of 17.4 ºC as shown in Figure 2.1.1. The difference between the monthly maximum and monthly minimum temperatures is around 15 degrees from December to April and around 10 degrees from June to August. About 95% of the total annual rainfall occurs during the rainy season from May to October.



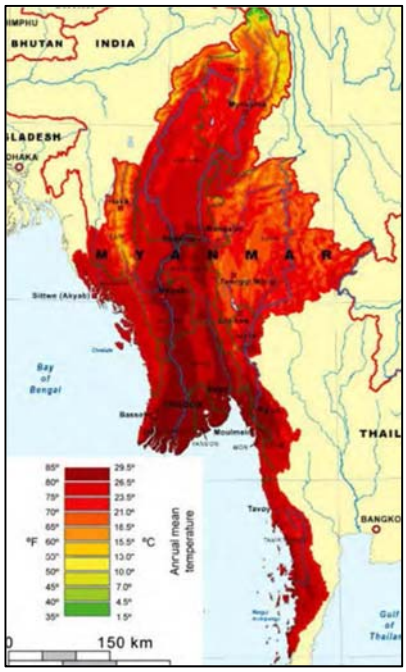
Source: YCDC
1) Temperature:
-Data 2011-2017 Meteorology and Hydrology Department, Kaba-aye Station, Yangon
2) Rainfall:
- Data 2010-2014: Data Collection Survey Report for Improvement of Navigation Channel of Yangon Port, 2016, JICA
- Data 2015-2017: Meteorology and Hydrology Department, Kaba-aye Station, Yangon

Figure 2.1.1 Climate Condition in Yangon City



Source: YCDC

Figure 2.1.2 Annual Average Rainfall

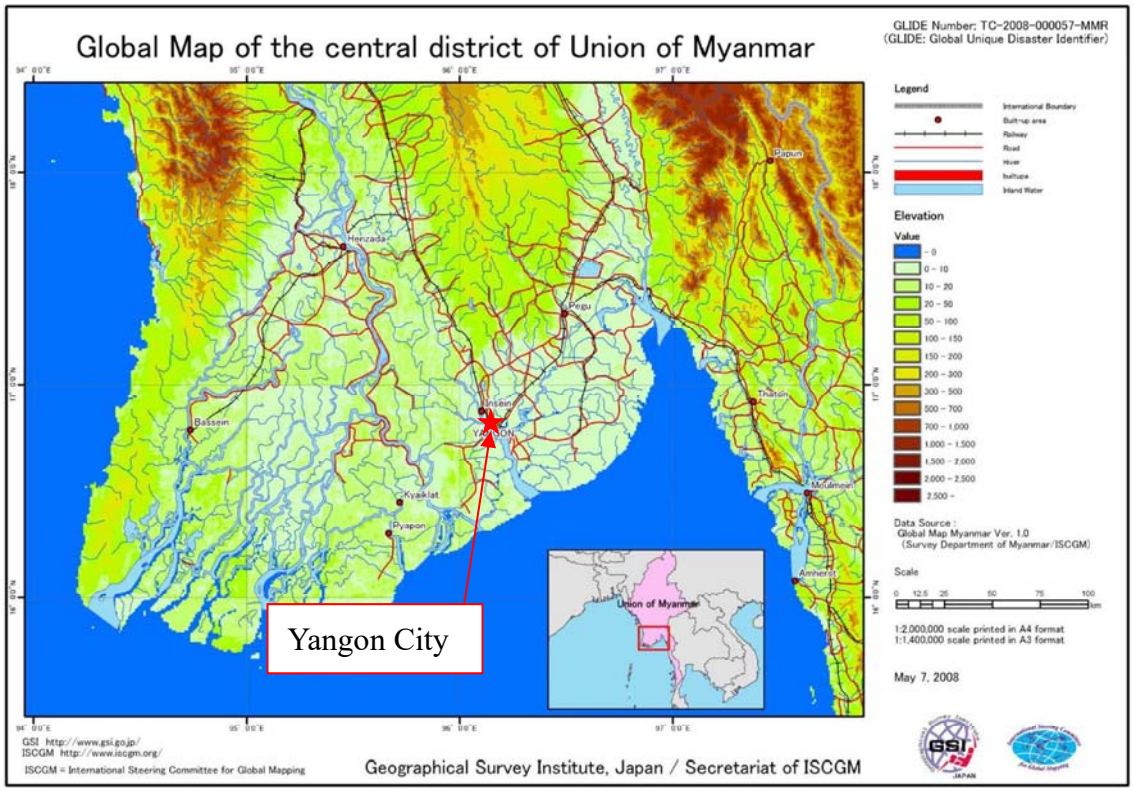


Source: YCDC

Figure 2.1.3 Annual Average Temperature

2.1.2 Topography

Yangon City is situated 34 km inland from the mouth of the Yangon River which traverses parts of the Ayeyarwady Delta. The relief of the city varies from flat plains to lowland hills in the central part as shown in Figure 2.1.4. Flat plains are extensive and occur mostly in the eastern and western parts as wide flat bottoms along the rivers. These flat lands are formed by delta deposits, areas of which are swampy and almost occupied by paddy fields with elevation between about 3 m (10 ft) to 6 m (20 ft) above mean sea level.



Source: YCDC

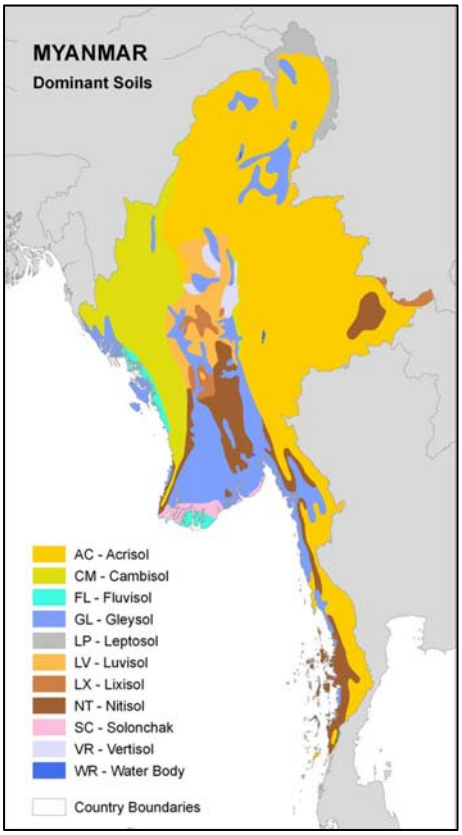
Figure 2.1.4 Global Map of the Central District of the Union of Myanmar

2.1.3 Geology

The geological map of Myanmar is presented in Figure 2.1.5. The geological structure of the city is attributed to moderate lowland hills. The rocks of the tertiary age contain well-consolidated marine sandstone and shale of the Pegu Group and semi-consolidated, continental deltaic, and marginal marine deposits of the Ayeyarwady Formation.

The synclinal valley west of the Yangon anticlinal ridge is filled with unconsolidated water laid deposits of quaternary age. Delta sediments consist of sands and gravels, remarkably free from clayey materials and lay upon the eroded surface of Ayeyarwady series.

Recent alluvium consists of gravels, clay, silt, and laterite. These deposits are widely distributed surrounding the main city area.



Source: JICA Urban Plan Study, 2012, and The Geology of Burma (Myanmar): An Annotated Bibliography of Burma's Geology, Geography and Earth Science, September 2008

Figure 2.1.5 Geological Map of Yangon Area

2.1.4 Hydrology

(1) River

Figure 2.1.6 shows a map which contains the rivers, lakes and reservoirs surrounding Yangon City. Yangon City lies at the confluence of the Bago River and the Hlaing River. The two rivers downstream of the confluence is called the Yangon River, which is connected to the Gulf of Mottama. The Pan Hlaing River and Twantay Canal, which converge and flow downstream the Yangon River, as well as the Kokkowa River, which connects to the Hlaing River, all obtain its water from the Ayeyarwady River.

Yangon City has lowland hills at the center, commonly known as the faulty zone ponds with artificial dams, namely, Kandawgyi Lake, Inya Lake, Hlawga Reservoir, Gyobyu Reservoir, and Phugyi Reservoir, which used to be or are the main sources of the water supply system for the Yangon City Development Committee (YCDC).

Source: JICA Study Team

Figure 2.1.6 Rivers, Lakes, and Reservoirs Surrounding Yangon City

(2) Tides

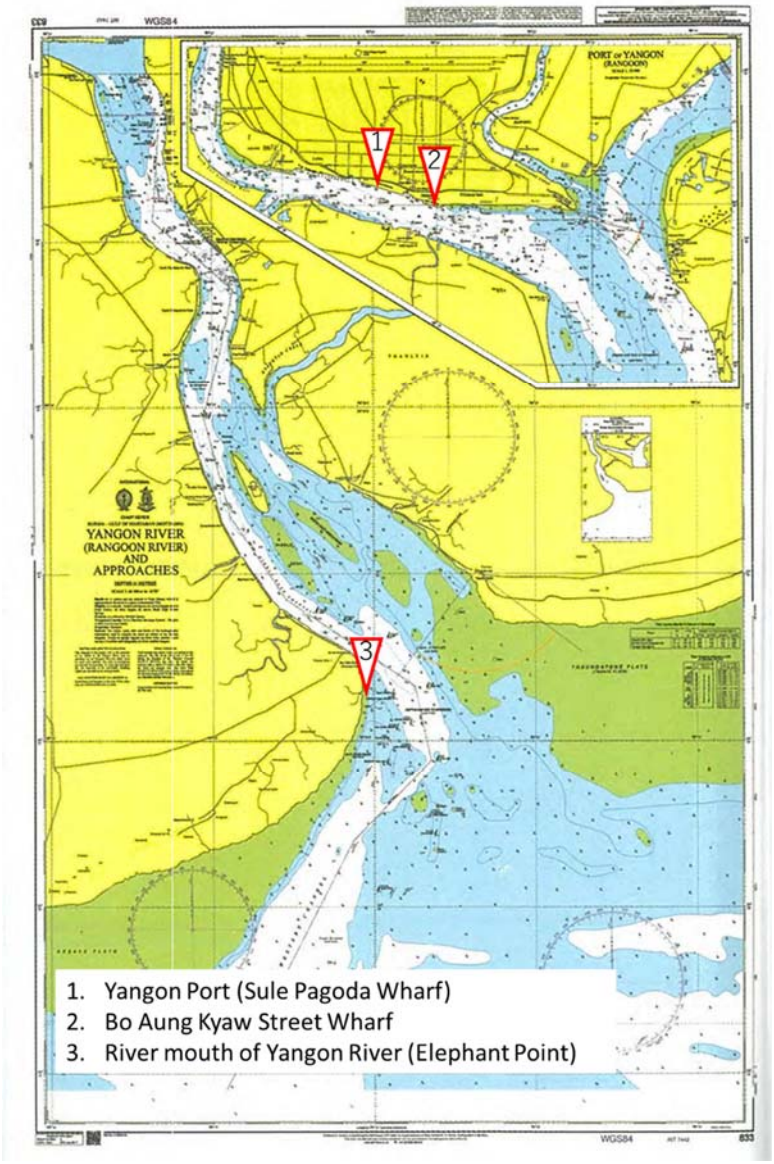
The rivers in Yangon City are all tidal rivers. Table 2.1.1 shows available tidal information taken from the Myanmar Port Authority (MPA). The data in Table 2.1.1 indicates the tidal list in 2018. The information is based on past observation records at Yangon Port (Sule Pagoda Wharf) and the river mouth of the Yangon River (Elephant Point). At Yangon Port, the highest high water level (HHWL) including tidal condition is +6.74 m and mean water level (MWL) is +3.121 m. Ground elevation is normally assumed as MWL, and the difference between HHWL and MWL around Yangon Port is approximately + 3.619 m (= HHWL + 6.74 - MWL + 3.121 m) on ground elevation basis.

Table 2.1.1 Tidal Information in Yangon Port 2018

Items	Tidal Height (m)	Date Observed
Highest High Water Level (HHWL)	+6.74	September 1899
Mean Water Level (MWL)	+3.121	Up to 1936
Lowest Low Water Level at Bo Aung Kyaw Street Wharf	-0.24	December 1902
Indian Spring Low Water Mark	+0.338	-

Source: Myanmar Port Authority (MPA)

Figure 2.1.7 shows the observation points at the Yangon Port and Yangon River.



Source: JICA Study Team

Figure 2.1.7 Tidal Observation Point

(3) Setting Water Level at Discharge Point of WWTP

1) Study on water level at discharge point of WWTP

The setting of a water level at a point where treated wastewater discharged is one of the essential factors to decide the level of wastewater treatment facilities. In general, the point where wastewater flows into a WWTP is lower than the ground level. The lift pump is installed at the wastewater inflow point and then the wastewater in the treatment plant flows down and is discharged by gravity. Therefore, the water level of a discharge point serves as the basis for setting the level of treatment facilities.

The Yangon River, to which the treated water is discharged from the treatment plant in this study, is a tidal river, with the water level varying from 2.00 m to 3.00

m at a maximum due to the influence of tide. In addition, it is affected by climate conditions such as typhoons. Accordingly, as for the design of the WWTP, HWL is defined considering the past tide level statistics, and the level of facilities shall be decided by adding some margins so that the functions can be maintained even when the water level of the discharge point becomes high.

For the WWTP in this study, the facility level is decided considering the HWL of the Yangon River, which is a discharge destination so as to keep stable treatment even when the water level of the Yangon River is high.The details are described below.

2) Conversion of tidal level in Yangon River to the ground benchmark (BM)

There are several tidal points in Yangon River. One is the Elephant Point, which is the closest to the estuary, and the others are Monkey Point and Sule Pagoda, which are located upstream of the WWTP. HWL of the discharge point for the design shall be based on the observation point of Sule Pagoda, which is the closest to the WWTP.

The past observation results of the river tide levels show that HHWL is +6.740 m and MWL is +3.121 m (the mean level since 1936).

The water level is used for the river and different from the ground BM.

Regarding the difference with the ground B.M., it is confirmed from “Myanmar Port Authority Tide Table 2018” as described in the table below.

Table 2.1.2 Chart Datum Level and Ground Elevation

Items	Elephant Point	Monkey Point (Close to Sule Pagoda)
Chart Datum Level (CDL)	+0.00 m	N/A
Ground Elevation at Benchmark (BM)	CDL+2.979 m	CDL+2.814 m

Source: Myanmar Port Authority Tide Table 2018

3) HWL of Discharge Point at WWTP

The above mentioned CDL can be converted to BM as follows:

HHWL= +6.74 m - 2.814 m = +3.926 m

MWL= +3.121 m - 2.814 m= +0.307 m

The water level of the discharge points for the six treatment plants planned in “The Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City (JICA MP 2014) is set to +3.700 m; however, the locations of the treatment plants are different and even though the value is mostly reasonable, it is more appropriate to set HWL of the water level of Yangon River to which the treated water is discharged to +3.950 m based on the abovementioned basis.

The survey results of the current ground level of the sewage treatment plant is +4.3 m to +4.7 m

and this can be considered as appropriate since inundation to the facility site can be prevented with this water level.

2.2 Site Conditions

2.2.1 Administrative Boundary (Township)

The administrative boundaries of YCDC have been gradually expanding, incorporating urbanizing townships in the peripheral area, and 33 townships are included in the YCDC area as of 2018 as shown in Table 2.2.1. In the future, parts of the other six townships surrounding the Yangon City might be incorporated with the YCDC administrative area, but at present, it is under the administration of the Yangon Regional Government (YRG).

The area for the study includes six townships as shown in Figure 2.2.1.

Table 2.2.1 Administrative Boundary and Definition of The Study Area

Administrative Boundary		Township Group	Township Name	Sewerage Zone	The Study Area
Yangon Region	Yangon City	CBD	Latha	W1	√
			Lanmadaw	W1	√
			Pabedan	C1	√
			Kyauktada	C1	√
			Botahtaung	C1	√
			Pazundaung	C1	√
		Inner Urban Ring	Ahlone	W1	
			Kyee Myin Daing	W1/W2	
			Sanchaung	W1	
			Dagon	W1	√[1]
			Bahan	C2/W1	
			Tarmwe	C2	
			Mingalar Taung Nyunt	C2	
			Seikkan		
			Dawbon	E3	
		Outer Ring	Kamaryut	W1/W2	
			Hlaing	W2	
			Yankin	C2	
			Thingangyun	C2	
		Northern Suburbs	Mayangone	C2/W2	
			Insein	N1	
			Mingalardon	N2	
		Older Suburbs	North Okkalapa	E1	
			South Okkalapa	C2	
			Thaketa	E3	
		South of CBD	Dala	S1	
			Seikgy ikhanaungto	W3	
		New Suburbs	Shwe Pyi Thar	N3	
			Hlaing Tharyar	W4	
			North Dagon	E1	
			South Dagon	E3	
			East Dagon	E2	
			Dagon Seikkan	E4	
	Outside of Yangon City		Kyauktan		

		Thanlyin		
		Hlegu		
		Hmawbi		
		Htantabin		
		Twantay		
		Taikkyi		
		Kawhmu		
		Kungyangon		
		Kayan		
		Thongwa		

1: Part of Dagon township is included in the study area

Source: JICA Study Team

Source: Myanmar Information Management Unit

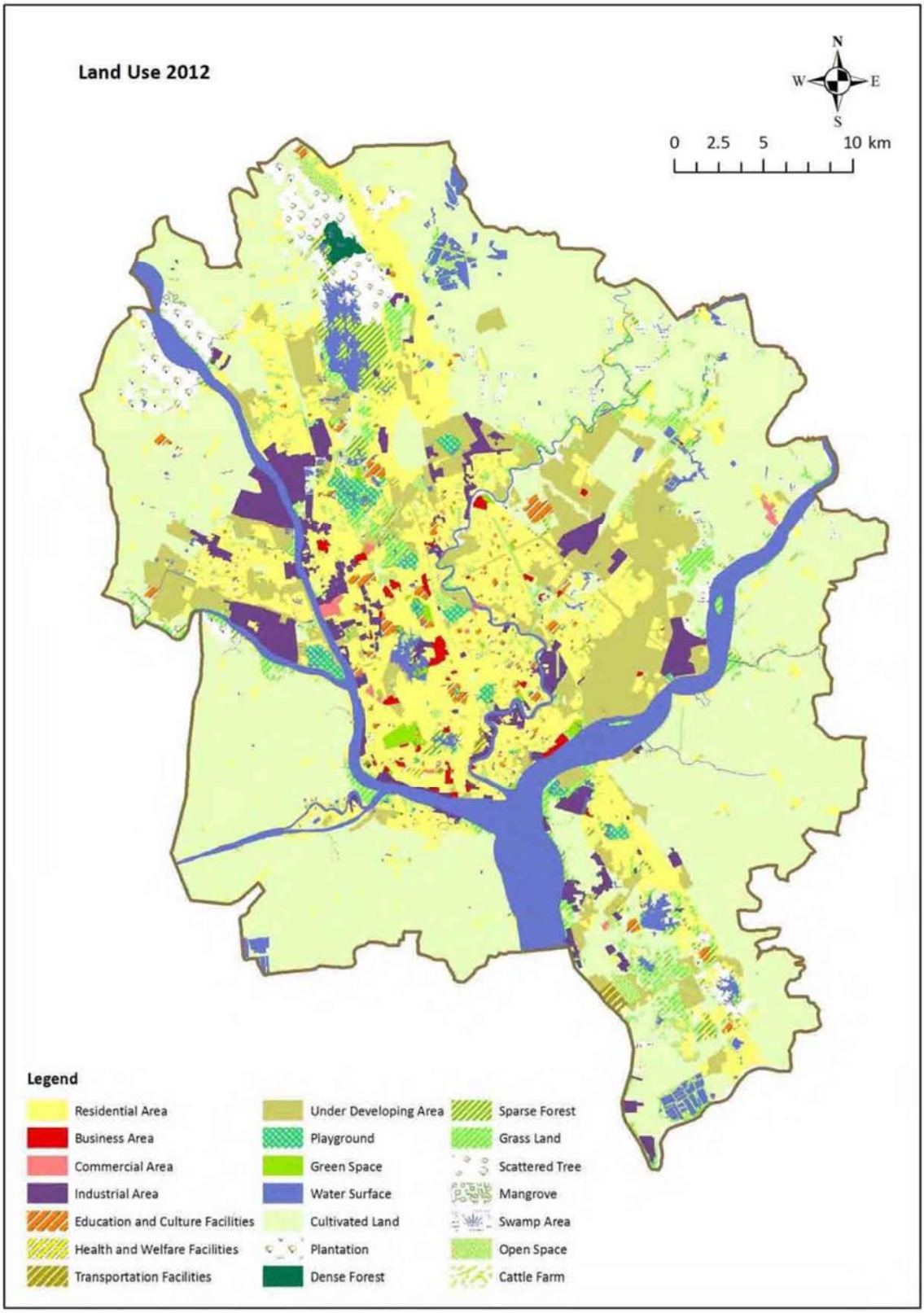
Figure 2.2.1 Administrative Boundary (Township) of Yangon City and Yangon Region

2.2.2 Present Land Use

Yangon City started its history from the current Central Business District (CBD) area, developed as the capital of lower Myanmar by Great Britain in 1885. Urbanization expanded northward during the 1950s to accommodate redevelopment of houses after the devastation of houses and mitigation of developed slums and illegal settlements after the Second World War. New urban areas are township groups of Inner Urban Ring, Outer Ring Zone, and Northern Suburbs Zone. After 1959, older suburbs were developed in the low-lying areas.

The land use pattern prevailing in the study area in 2012 was developed in the JICA urban development study based on the analysis of satellite imagery. Looking at the land use in 2012, the YCDC area was already developed or undergoing development while most of the area outside the YCDC boundary are agricultural lands except in the parts of Thanlyin and Kyauktan, which are situated on the hilly areas seemingly extending from the central hills of Yangon.

Currently, industrial zones seem to disperse throughout the Greater Yangon even in the inner urban, while some of the large-scale zones are located along trunk roads in the suburb area.



Source: The Project for the Strategic Urban Development Plan of the Greater Yangon, 2012

Figure 2.2.2 Present Land Use of Yangon City

2.2.3 Present Population and Population Projection

(1) Present Population in Yangon City

Population as of 2014 and the past population statistics together with the city area are shown in Table 2.2.2. The average population growth rate from 1993 to 2014 is 238.2%. Population of 0.73 million in the 1950s increased to 0.94 million in the 1960s. Afterwards, together with the city area expansion, population increased to 2 million in 1973, 3 million in 1993, 4 million in 2003, and 5.14 million in 2011. The present population as of 2014 is 7.36 million.

Table 2.2.2 Population Growth

Year	Area (km^2)	Density (person/km^2)	Population (million)
1953	123.3	5,925	0.73
1963	164.2	5,725	0.94
1973	221.4	9,077	2.01
1983	346.0	7,254	2.51
1993	603.5	5,120	3.09
2003	794.3	5,161	4.10
2011	794.3	6,471	5.14
2014	1,036.0	7,104	7.36

Source: JICA Study Team based on The Project for the Strategic Urban Development Plan of the Greater Yangon, 2012

(2) Population Projection of Yangon City

Population projection has been updated in the Data Collection Survey for the Project for Updating the Strategic Urban Development Plan of the Greater Yangon by JICA in 2017 from the project Preparatory Survey on the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City, which was formulated by JICA in 2014. It is observed that population growth in the CBD area is not estimated, and the current population in 2017 will be kept until 2040. However, the population in Dagon Township will increase with an average yearly increasing ratio of 3.2%.

Table 2.2.3 Population Projection for Yangon City

	2017	2020	2025	2030	2035	2040
Yangon City	5,558,858	6,003,820	6,825,971	7,760,706	8,823,442	10,031,707

Source: JICA Study Team based on the Data Collection Survey for the Project for Updating the Strategic Urban Development Plan of the Greater Yangon by JICA in 2017

Table 2.2.4 Population Projection for the Study Area in 2040

Township	Area (ha)	2017	2020	2025	2030	2035	2040
Latha	61	25,057	25,057	25,057	25,057	25,057	25,057
Lanmadaw	131	47,160	47,160	47,160	47,160	47,160	47,160
Pabedan	62	33,336	33,336	33,336	33,336	33,336	33,336
Kyauktada	70	29,853	29,853	29,853	29,853	29,853	29,853
Botahtaung	260	40,995	40,995	40,995	40,995	40,995	40,995
Pazundaung	107	48,455	48,455	48,455	48,455	48,455	48,455
Dagon	299	28,222	30,999	36,325	41,651	45,201	48,751
Total	990	253,078	255,855	261,181	266,507	270,057	273,607

Source: JICA Study Team based on the Data Collection Survey for the Project for Updating the Strategic Urban Development Plan of the Greater Yangon by JICA in 2017

2.2.4 Socioeconomic Scale and Industrial Structure in Yangon Region

(1) Socioeconomic Scale

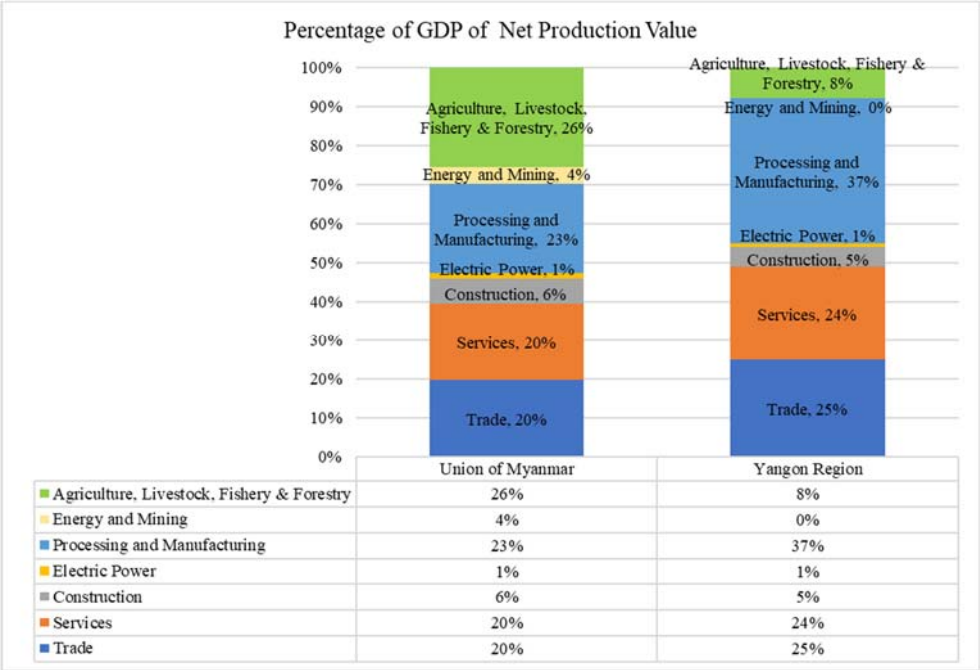
The Yangon Region had a population of 7,361,000 at the end of 2016-2017. It represented approximately 12 % of the national population as shown in Figure 2.2.3. As for the economic scale, the net production value of the Yangon Region was MMK 10,936,414 million in 2016-2017, accounting for approximately 18% of the country's gross domestic product (GDP). For this reason, Yangon is referred to as "the Economic Center of Myanmar".

Source: JICA Study Team based on Myanmar Statistical Yearbook 2018

Figure 2.2.3 Socioeconomic Scale of Yangon Region

(2) Industrial Structure

The industrial structure in Myanmar comprised the agriculture, livestock, fishery, and forestry sectors (26%); trade sector (20%); process and manufacturing sector (20%); and services sector (20%). Meanwhile, the industrial structure in Yangon Region composed of the processing and manufacturing sector (37%); trade sector (25%); and services sector (24%). The agriculture, livestock, fishery, and forestry sector accounted only 8% of the total production value.



	Union of Myanmar	Yangon Region
Agriculture, Livestock, Fishery & Forestry	26%	8%
Energy and Mining	4%	0%
Processing and Manufacturing	23%	37%
Electric Power	1%	1%
Construction	6%	5%
Services	20%	24%
Trade	20%	25%

Source: JICA Study Team based on Myanmar Statistical Yearbook 2018. Data in YRG is as of 2010

Figure 2.2.4 Industrial Structure of Yangon Region

2.3 Standards for Sewerage Works in Yangon City

2.3.1 Law and Standards for Water and Sewerage Works

The laws and regulations regarding water have been established long ago and independently in Yangon City, and the following legal system has been effective because the administration of water and sewerage works in each city has been outside of the jurisdiction of the Federal Government.

- Yangon Waterworks Act （1885）：the law related to water supply in Yangon City
- The City of Yangon Municipal Act （1922）：the law related to administration of Yangon City and improvement of infrastructures, also regulating drainage facilities, sewage works and waterworks (water source preservation).
- Water Power Act （1927）：the law related to hydroelectric power generation
- Underground Water Act （1930）：the law related to groundwater preservation
- The City of Yangon Development Law （1990）：the law describing the responsibilities of YCDC regarding waterworks, reservoirs, piping, and sanitation in Yangon City

The Myanmar National Building Code (equivalent to a part of the enforcement orders or the enforcement regulations of the building standards act), which the construction department of the Ministry of Construction (MOC) is in-charge of, was created with the assistance of the Myanmar Engineering Society (MES) as a United Nations' Habitat project, which was supported by the United Kingdom (UK) in 2014 and was established after obtaining consent of the cabinet.

Yet the Building Control Law, which regulates the contents of the Building Code, has not been established as it needs to be passed at the parliament. The Building Code was reviewed in 2016 without the enactment of the law.

Chapter 5 in the Building Code is about "Part 5D Water Supply, Drainage and Sanitation" which relates to water and sewerage facilities of buildings. This covers the basic requirements of a water supply system for buildings, requirements for connection with the public water utility, and necessary matters for the design of public water supply systems. In addition, it describes the requirements for design, layout, construction, and management of drain pipelines of wastewater from buildings, surface water, ground water, and sewage. Specifically, it is intended for plumbing, manholes, and sanitary chamber (septic), which connects to the sewer pipes in buildings or sewer pipes outside buildings.

In addition, there is no registrations which relates to the investment for the sewerage sector by Japanese/foreign companies in Myanmar.

2.3.2 Standard for Effluent Water Quality

(1) YCDC Effluent Water Quality

In Myanmar, the Environmental Conservation Department (ECD) of the Ministry of Environmental Conservation and Forestry (MOECAF) has developed the Environmental Impact Assessment Law, the Environmental Preservation Law, and the effluent water quality guideline since 2012 with the support of the Asian Development Bank (ADB). The Environmental Preservation Law and the Environmental Preservation regulations were formulated in 2012 and 2014, respectively, and the guideline for environmental standards and effluent standards for the whole country was established in 2015.

While the guideline for environmental standards and effluent standards for the whole country was established, the Pollution Control and Cleaning Department (PCCD) of YCDC has set out the effluent standard for public waters, which is practically applied to the areas under control of YCDC. (Refer to Table 2.3.1)

Table 2.3.1 YCDC Standard for Effluent Water Quality

Parameter	Standard Value
pH	6~9
BOD	Less than 60 mg/L
COD_{Cr}	Less than 200 mg/L
TSS	Less than 2,000 mg/L
SS	Less than 500 mg/L

Source: YCDC

The YCDC Water and Sanitation Department requires properties in the YCDC areas to install a septic tank or equivalent, setting the standard for sewer discharged from nine-storey buildings or

higher (excluding industrial buildings such as a factory or a plant). (Refer to Table 2.3.2)

The treated wastewater is discharged to public waters in the area where the sewage treatment system has not yet been improved, while it is instructed that the treated wastewater can be released to either a sewer or public waters in the area where the sewage treatment system has been improved.

The YCDC Water and Sanitation Department provides guidance for improvement when the effluent quality exceeds the standard, and in some cases, it requests operators to transport the sludge to a sewage treatment plant using a vacuum truck at the operators' cost as part of the improvement steps. They seem to be selectively monitoring the CBD and the areas around Lake Kandawgyi and Lake Inya.

Table 2.3.2 YCDC Standard for Effluent to Sewer

Parameter	Standard Value
BOD	Less than 20 mg/L
COD_{Cr}	Less than 60 mg/L
SS	Less than 30 mg/L

Source: YCDC

Note: Applies only to buildings with more than nine stories

(2) CQHP Effluent Standard for Treated Raw Sewage (Black Water)

As for the four to eight-storey buildings, YCDC is guided to treat only raw sewage (black water) in a septic tank and to set the guideline parameters for the biochemical oxygen demand (BOD) of 200 to 250 mg/L for discharging to a sewer. However, it is not strictly implemented.

In the CQHP guideline (sanitation) created by the Committee for Quality Control of High-rise Building Construction Projects (CQHP), the effluent standard for raw sewage (black water) is defined as indicated below. Appendix 14 shows the CQHP guideline. This standard is less restrictive than the YCDC standards (Table 2.3.3).

Table 2.3.3 CQHP Effluent Standard for Raw Sewage (Black Water)

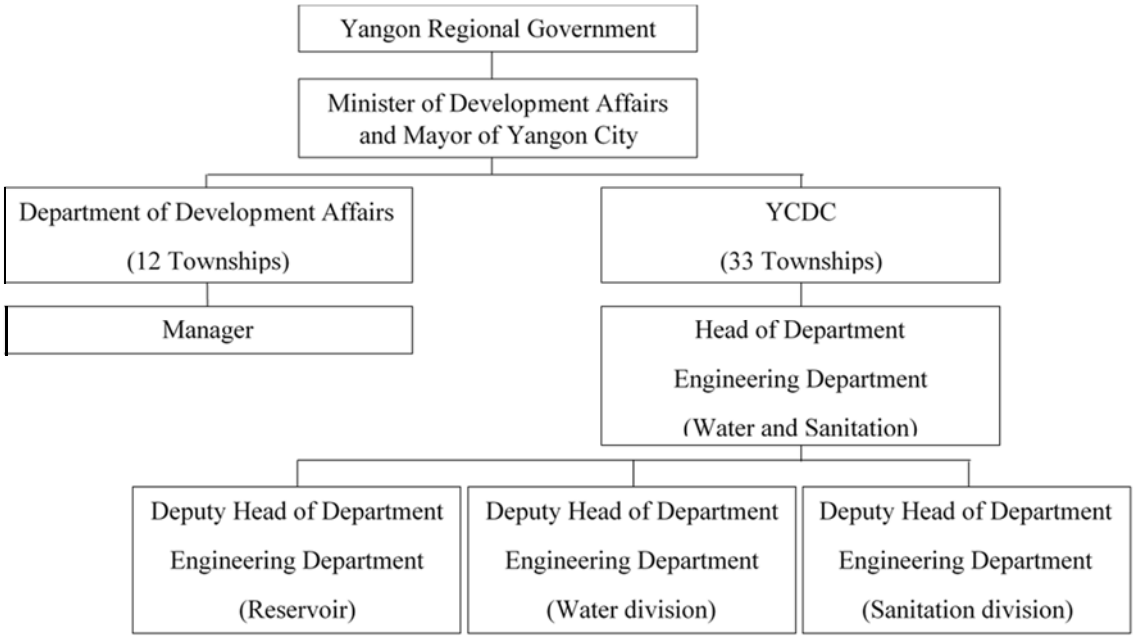
Parameter	**Standard for Discharge to Public Water**	**YCDC Standard for Discharge to Sewer**
BOD	Less than 50 mg/L	Less than 150 mg/L
COD_{Cr}	Less than 100 mg/L	Less than 200 mg/L
SS	Less than 50 mg/L	Less than 150 mg/L

Source: Guidelines for high-rise building construction projects (water supply and sanitation), CQHP

CHAPTER 3 INSTITUTIONAL ASPECTS RELATED TO WATER AND SEWERAGE SECTOR

3.1 Yangon Regional Government

The Constitution stipulates that construction, maintenance, and management of agricultural drainage is the role of the country, regional governments, and/or state governments. On the contrary, the governing body for construction and management of water/sewerage and urban drainage is not clearly defined. However, it can be assumed that waterworks should be within the scope of the development department of regional governments as shown in Figure 3.1.1 because it is stated that regional/state governments have the authority to collect water tax, which can be considered as the water rates, as one of their roles. This department of development affairs is under control of the Yangon Regional Government (YRG) together with Yangon City Development Committee (YCDC).



Source: YCDC

Figure 3.1.1 Yangon Regional Government

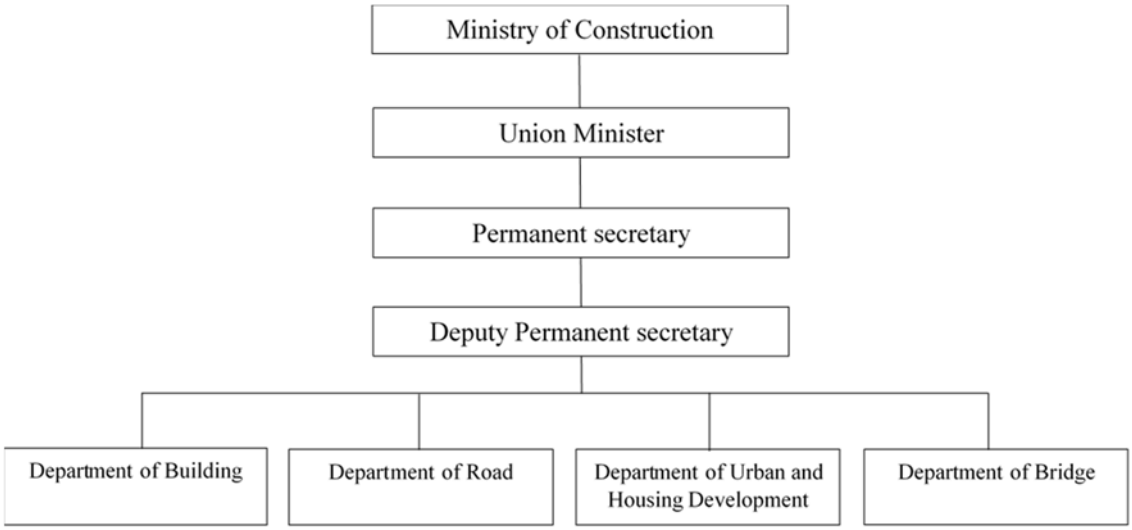
The budget of regional government had been included in that of the federal government before 2011; however, it was separated since 2012 and decided with the vote of the regional congress. The budget law is passed at the congress of each regional government every fiscal year, and it requires approval from the federal government. The allocation of the national budget is added up in the revenue of the YRG as a subsidy, and it is reallocated to YCDC from the YRG, as necessary. Moreover, the federal government can issue bonds, but the regional governments have no authority to do so.

3.2 Ministry of Construction

The Ministry of Construction (MOC) of the federal government consists of the Building Department, the Public Roads Department, the Urban and Housing Development Department, and the Bridges department as shown in Figure 3.2.1. The Buildings Department is in-charge of the construction of structures other than dwellings (design and orders), as well as the development of the legal system including the building code. The Urban and Housing Development Department takes charge of housing development such as condominiums and rental houses, playing a similar role to that of the Japanese Housing and Urban Development Corporation in the past. The Public Roads Department and the Bridges Department take care of public roads and bridges, respectively.

Among the departments mentioned above, the Buildings Department and the Urban and Housing Development Department relate to sewage works. The Building Department has the water and sewer division which takes care of the improvement of sewage treatment facilities accompanying construction of government buildings (including hospitals under the control of the Ministry of Health). The Urban and Housing Development Department has a responsibility to improve sewage treatment facilities in new urban developments.

On the other hand, water and sewage in each city is outside the control of MOC. Therefore, the urban development committees have been established for major cities such as Yangon City, Mandalay City, and Naypyidaw City. The committees are responsible for the administration of water and sewage services. The urban development committee is formed under the regional government, not under MOC. The department in-charge of water and sewage in MOC and the YCDC have no hierarchical relationship.



Source: YCDC

Figure 3.2.1 Organization Structure of Ministry of Construction

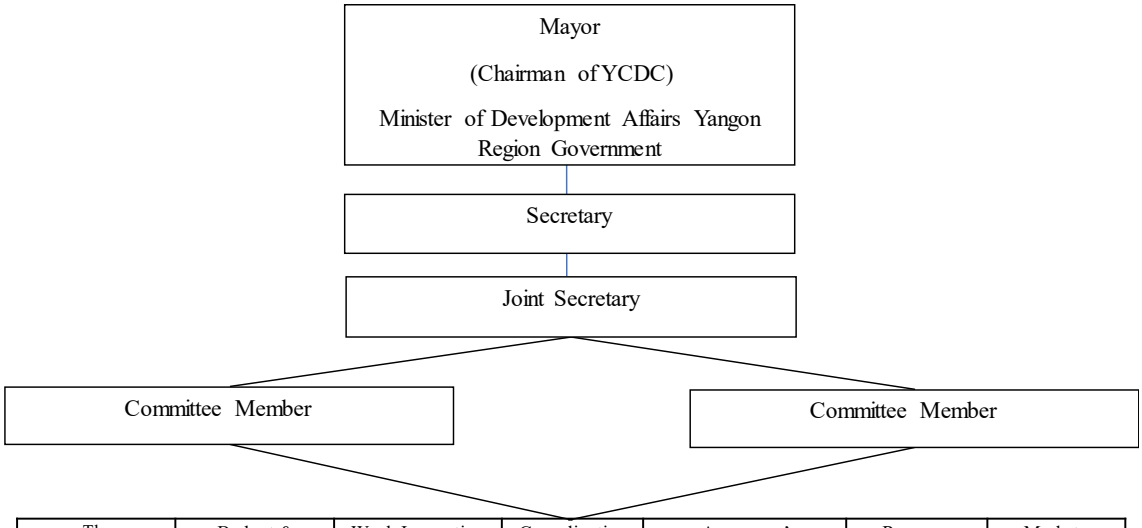
3.3 Yangon City Development Committee (YCDC)

YCDC was established in accordance with the City of Yangon Development Law with the aim of self-motivated promotion of development of Yangon City. A similar law has been introduced to the second largest city, Mandalay, and the capital, Naypyidaw. The City of Yangon Development Law authorizes YCDC to execute their own projects with self-financing. However, it does not necessarily mean that the authority can be fully exercised since regulatory approval from the regional government is required for such projects, and the objectives and contents of the projects need to match with the administrative activities planned in the national budgetary framework.

The organization of YCDC is shown in Figure 3.3.1. With the Mayor as the head of YCDC (serving concurrently as the minister of development of the regional government), there are the positions of secretary and joint secretary under the head. The committee consists of the mayor, the secretary, the joint secretary, and two committee members.

The water, sewage, sanitation, and rainwater drainage works for 33 out of 45 townships in the area under the jurisdiction of YRG are included in the roles of YCDC. The law defines the responsibilities to create plans, execute, and manage these water-related works. The Water and Sanitation Department is the responsible party for water/sewage and sanitation works, and it is the role of the Roads and Bridges Department to control the rainwater drainage works.

Although the individual budget for YCDC is reserved, it is included in the budget of the YRG, and the decision-making regarding budgeting requires approval from the regional government and the federal government. YCDC does not receive any subsidy from the regional government and the federal government, and its operating expenditures are fully born by its own financial sources. It is operated with revenues from the services and taxes in Yangon City. More specifically, it gains income from the tolls of roads and bridges, parking fees, real estate development business with private companies, water service, waste disposal, real estate tax, and stamp tax. However, these revenues (including income from the water services) are included in the budget of the YRG, and these cannot be used at the discretion of YCDC.



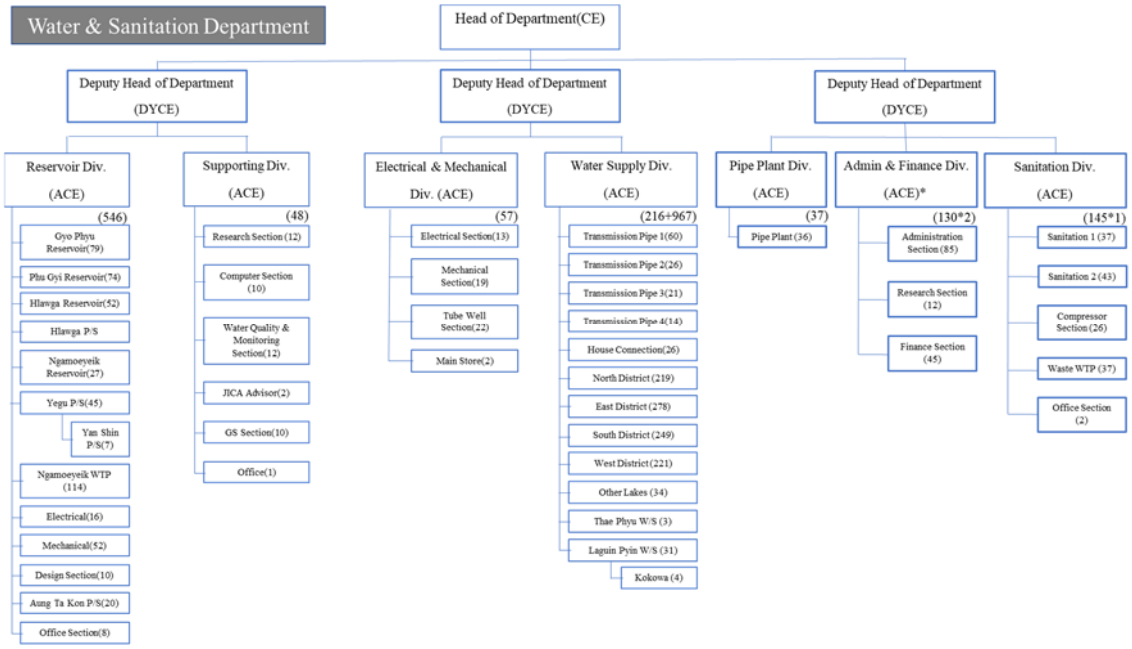
The Administration Department	Budget & Accounts Department	Work Inspection Department	Co-ordination Department	Assessors' Department	Revenue Department	Markets Department
Veterinary & Slaughter House Department	Pollution Control & Cleansing Department	Engineering Department (Roads &Bridges)	Engineering Department (Buildings)	Engineering Department (Water & Sanitation)	Motor Transport & Workshop Department	Central Stores Department
Playgrounds, Parks & Gardens Department	Security & Disciplinary Department	City Planning and Land Administration Department	Health Department	Public Relations and Information Department	Production Department	Committee Office

Source: YCDC

Figure 3.3.1 Organization of YCDC

3.4 Water and Sanitation Department in YCDC

The organizational chart of the Water and Sanitation Department is shown in Figure 3.4.1. It is comprised of one head of the department and three deputy heads of the department, and under which there are seven divisions. The total number of staff members is 2,152 as of December 2017. Currently, they are considering reorganization with the support of the ongoing Japan International Cooperation Agency (JICA) technical cooperation project The Project for Improvement of Water Supply Management of Yangon City Development Committee (YCDC).



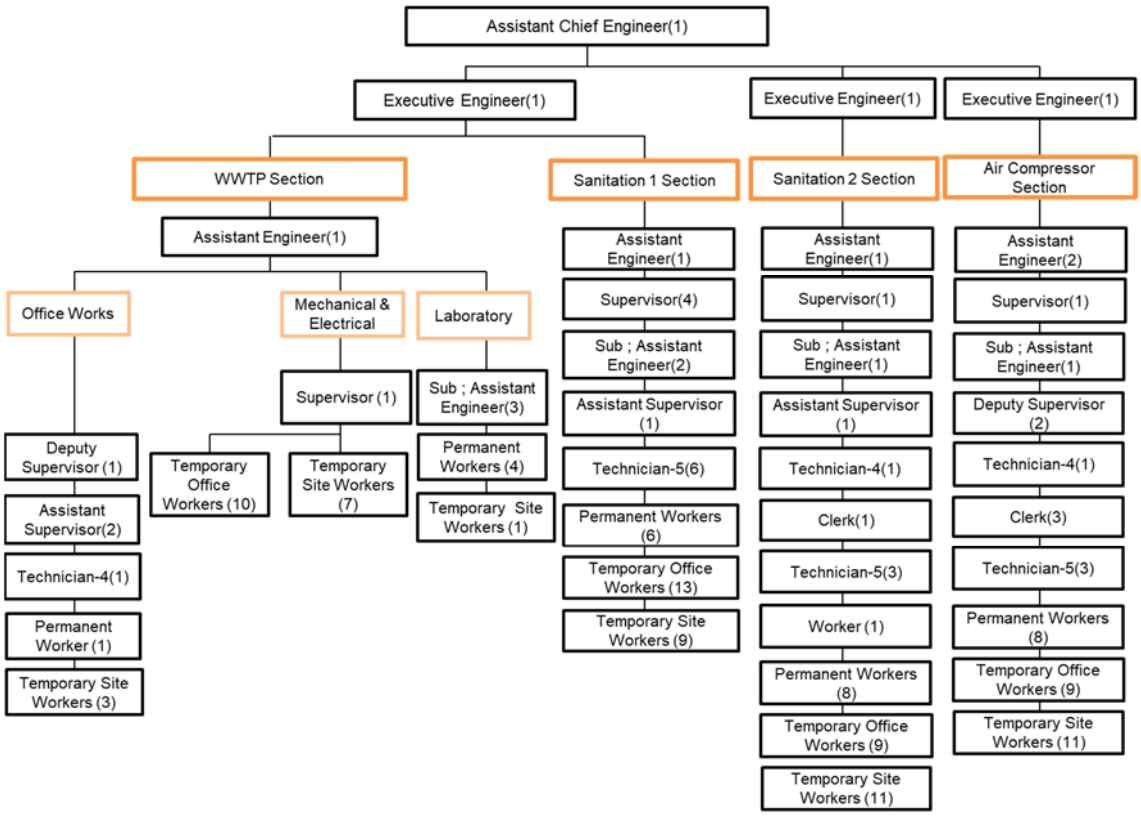
Source: YCDC

Figure 3.4.1 Organization of YCDC Water and Sanitation Department

The organizational chart of the Sanitation Division is shown in Figure 3.4.2. The party in-charge of sewers and sewage treatment in YCDC is the sanitation division, which has 145 staff members, and its main responsibilities are as follows:

1) Cleaning of sewers
2) Operation and maintenance of compressors, ejectors, and sewage treatment plants
3) Creation of expansion plan for sewer pipes and operation plan
4) Radical improvement of sewage treatment system
5) Purchase of facilities, equipment, and modern machinery

According to YCDC, it was scheduled that a new organization structure would be established in April 2018. However, the schedule is still tentative since the detailed structure is still being considered by YRG.



Source: YCDC

Figure 3.4.2 Organization of Sanitation Division in YCDC Water and Sanitation Department

3.5 Road and Bridge Department in YCDC

While the drainage sector is closely related to the Water and Sanitation Department of YCDC, the sector actually belongs to the Road and Bridge Department.

The improvement work of the back drainage space (BDS), which mainly aims to improve the surface pavement of BDS, is being conducted by the Administration Department.

According to the information from YCDC, the Sanitation Division of the Water and Sanitation Department and the Drainage sector of the Road and Bridge Department will be merged into one department in the near future.

CHAPTER 4 CURRENT CONDITION OF SEWERAGE AND SANITATION SYSTEM IN THE STUDY AREA

4.1 Outline of Current Sewerage System and Sanitation System

4.1.1 Current Condition of Sewerage Systems

(1) Existing Ejector System

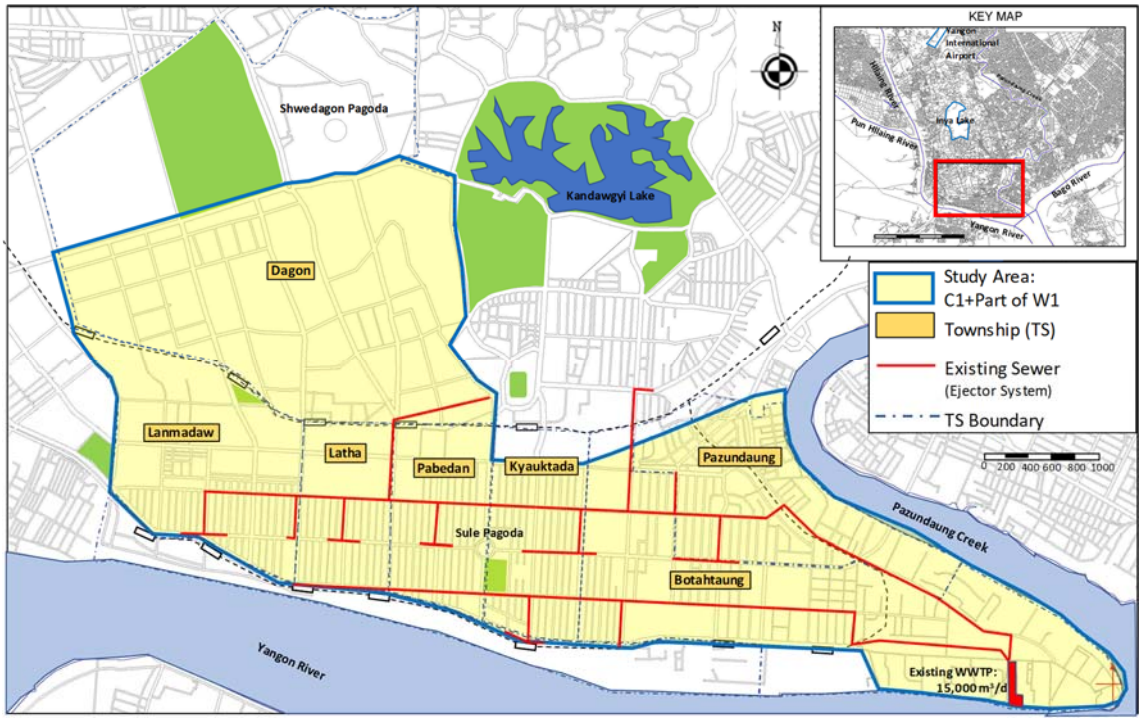
The existing sewerage system in Yangon City is an ejector system introduced in 1888 under the British sovereignty. It collects wastewater (i.e., only raw sewage) coming from eight townships which are in the central business district (CBD). Miscellaneous wastewater is discharged to the Yangon River without treatment through the storm water drains.

This system is unique in that wastewater is conveyed by the air pressure from an ejector station (ES) to one of the two sewage ejector pipes running east and west. Initially, 40 ESs were installed in the treatment zone, and 35 of those are currently in service. This system has been used for 120 years by continuously making improvements and modifications. Table 4.1.1 describes the outline of the existing system, and Figure 4.1.1 shows the ejector system.

Table 4.1.1 Existing Sewerage System in the CBD Area

Item	Description
Completion	1888
Planned population	40,000 persons
Planned service area	8 townships Lanmadaw, Latha ,Panbedan, Kyauktada, Botadaung, Puzondaung (part), Dagon (part), Mingalataungnyunt (part)
Contractor	Hughes & Lancaster
Manufacturer	Shone Hydro-Pneumatic Ejector
Construction cost	INR 2.3 million (loan from the Indian Government)
Length of force main	North: 5.55 km, South: 5.03 km, Total: 10.58 km
Diameter of force main	North: 300 to ~1,200 mm, South: 300 to ~600 mm
Material of force main	Cast iron
Number of ejector stations	40 stations; out of which, 35 are currently in operation
Number of manholes	2,114

Source: JICA Study Team based on Information from YCDC



Source: JICA Study Team

Figure 4.1.1 Ejector System in the CBD Area

(2) Existing Wastewater Treatment Plant (WWTP)

After the sewer pipes were installed, the sewage had been collected from residence and commercial building in the CBD and discharged to the Yangon River without treatment. Treatment of the collected sewage only started when the wastewater treatment plant was completed in January 2005. Yangon City Development Committee (YCDC) conducted the design and construction of the sewage treatment plant. Construction funds were raised by several ministries, including the Ministry of Construction (MOC).

The design served population is 300,000 people. Since only raw sewage is collected, the sewage quantity per person/day is 50 litters, and the design treatment capacity of the WWTP is 15,000 m^3/day (maximum daily capacity). Long-term aeration method is used for sewage treatment, and effluent is discharged to the Yangon River. Air-drying (sun-drying) after gravity thickening is used for sludge treatment. The plant receives 150 m^3/day of septage from households as well. This septage is thrown into equalization tank. Supernatant liquid and solid are respectively transported to grit chamber and drying bed. Table 4.1.2 describes the outline of the sewage treatment plant, and Figure 4.1.3 shows the layout of the sewage treatment plant.

YCDC explains that the treated effluent from the existing treatment plant has been managed so that pH should be around 6 to 8, BOD should be 60 mg/L or less, COD 100 mg/L or less, and TSS 70 mg/L or less. Currently, however, there is no regulated value in terms of operation by any official organization.

Table 4.1.2 Outline of Wastewater Treatment Plant

Items	Description
Site area	2.25 ha (5.56 acres)
Start of construction	April 2003
Completion	January 2005
Design served population	300,000 persons
Design capacity	14,775 m^3/day (3.25 MGD)
Construction cost	USD 1.96 million（MMK 2,065.7 M）
Characteristics of wastewater	BOD 600 mg/L, SS 700 mg/L (design)
Characteristics of treated effluent	BOD 60 mg/L, SS 40 mg/L (design)

Source: JICA Study Team based on the information from YCDC

The treatment process implemented is the extended aeration activated sludge process. The treatment flow of the wastewater is shown. Mechanical type surface aerators are applied for aeration. Sludge was planned to be treated by aerobic digestion process and dewatered by belt-press. These facilities were eventually installed. Sludge is drawn from mixing tank and transported to drying bed, and gravity thickener, aerobic digestion tank and belt press currently don't work.

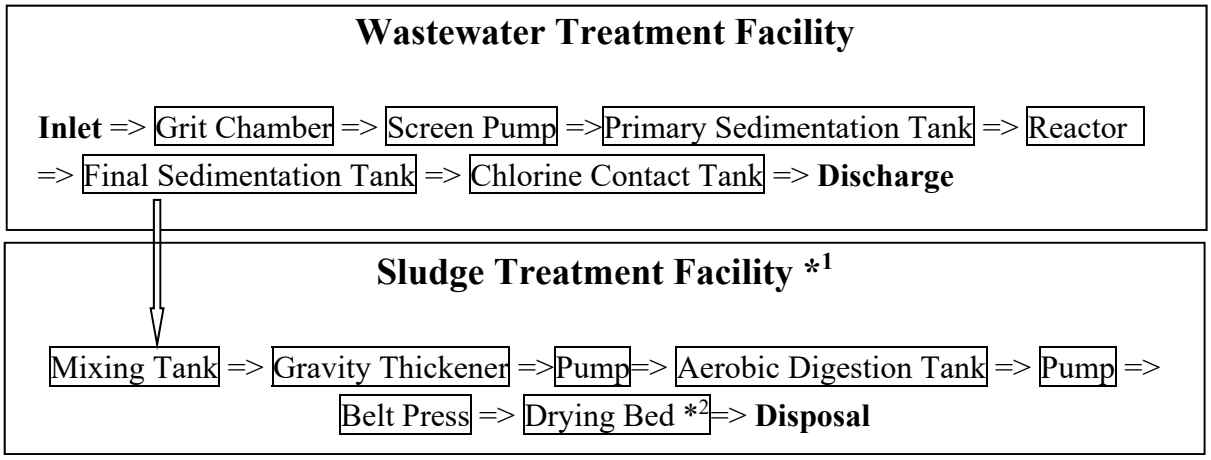
The wastewater treatment plant seems to have operated intermittently, two hours in the morning and two hours in the afternoon. That is, the total operating hours is only four hours a day, and the amount of sewage inflow is much less than the capacity of the plant. According to the latest measurement, the influent wastewater volume is 630 m^3/day, which is much smaller compared to the capacity of the plant; therefore, one of the two treatment facilities has been inactive.

Long-term aeration is used for the design of the aeration tank at the treatment plant, and the aeration time is 20 hours. The retention time in the aeration tank is calculated from the current inflow; 20 hours x 14,775/630 = 469 hours (about 19.5 day). However, the automatic controller of the sewage pump has been out of order, and a huge amount of wastewater has been loaded in a short time at the discretion of the operator. Therefore, the instantaneous load fluctuation is high.

In terms of the operation and maintenance, it has not been properly operated since the water level indicator and the water level controller are broken, and the quality of water and the temperature of water have not been measured. Furthermore, the repair parts and chemicals have not been procured, and this situation needs to be improved.

Photo 4.1.1 C1 WWTP

Photo 4.1.2 C1 Aeration Tank

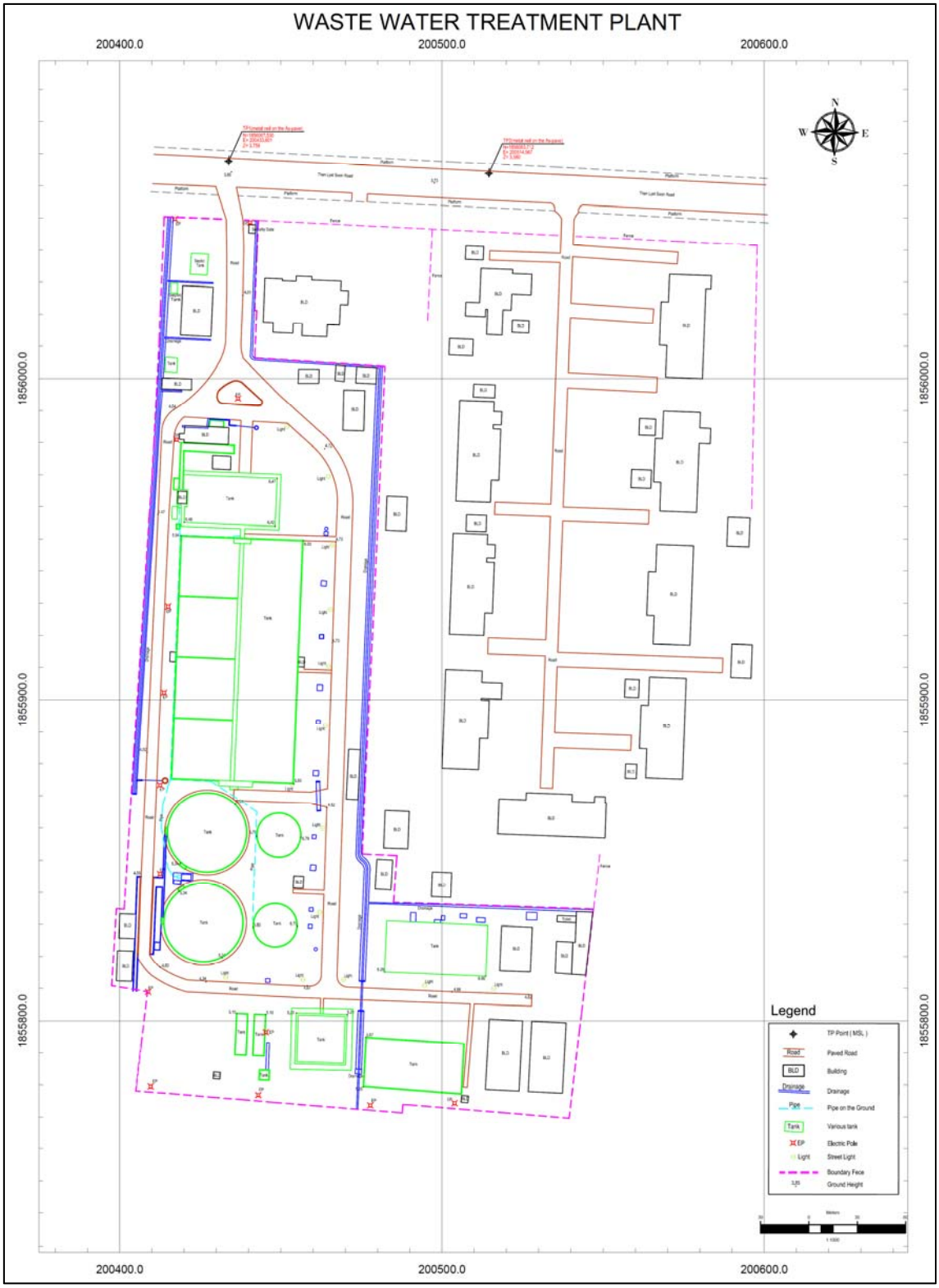


Source: JICA Study Team

*1 Sludge treatment facility is not being used currently.

*2Bypass from mixing tank to drying beds is installed and being used.

Figure 4.1.2 Process Flow of Wastewater Treatment Facility and Sludge Treatment Facility



Source: JICA Study Team

Figure 4.1.3 Existing Wastewater Treatment Plant (C1 WWTP)

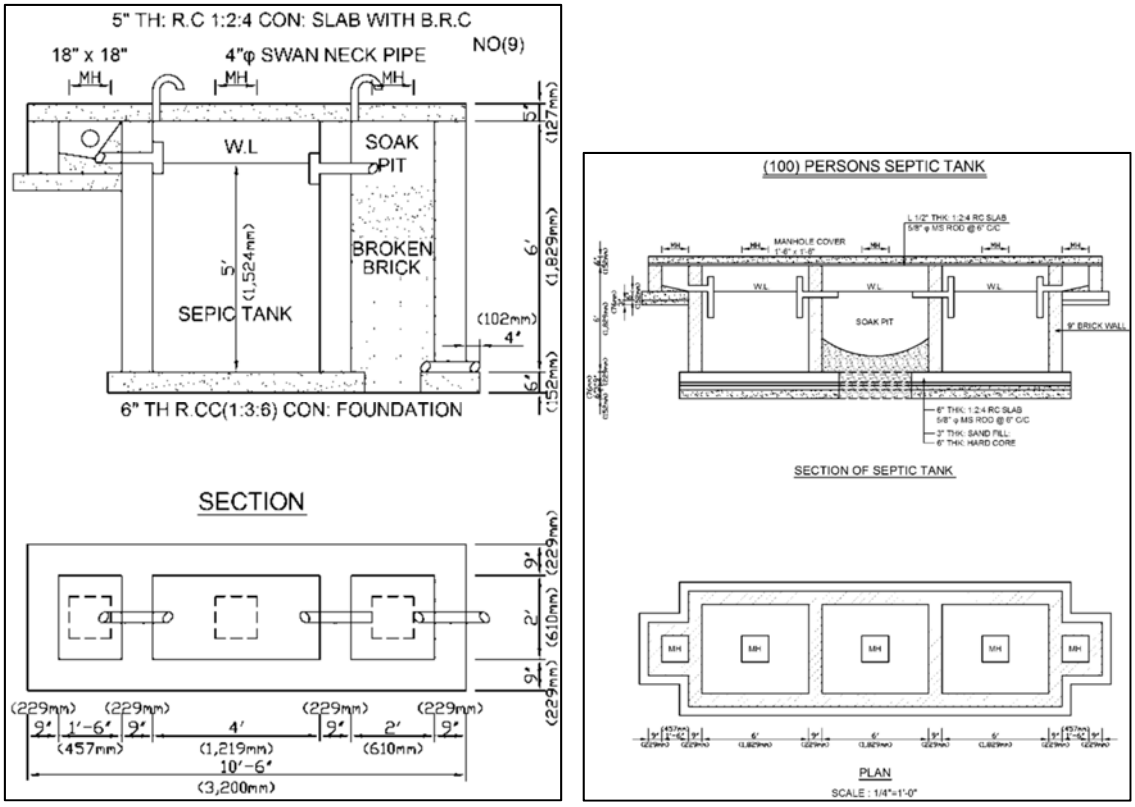
4.1.2 Current Condition of Sanitation System

(1) Structure of Septic Tank

YCDC prescribes a utilization of septic tank system as a wastewater treatment except for the catchment area where wastewater collection system is available. The septic tank treats only toilet wastewater (black water), while grey water from kitchen, laundry, and so on is discharged directly to storm water drains without treatment. The owner of a house or a building requires to submit an application to the Sanitation Division, Engineering Department of Water and Sanitation (EDWS) and must obtain a permission before the construction. YCDC has the authority to approve applications for up to 8-story buildings. In case of high buildings with more than 9-story, approval from the Committee for Quality Control of High-Rise Building under the Ministry of Construction is required. A type of septic tank to be installed is depending on the story of the house or the building as below.

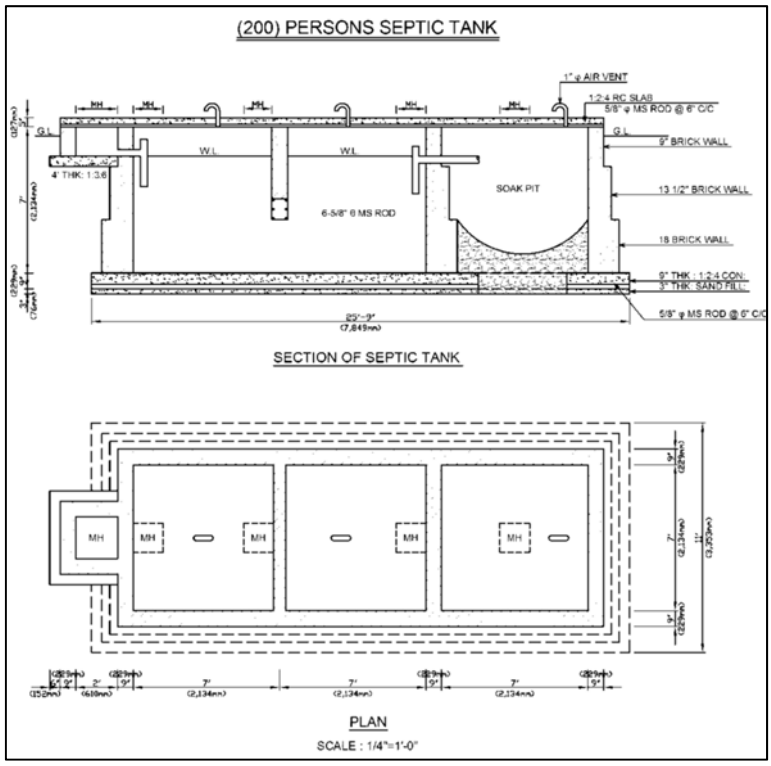
- Up to three-storey: soak pit type
- More than four-storey: up-flow filter type

The CBD covered by the existing sewerage system is prohibited to be installed septic tank. However, the large-scale building, e.g. hotel and shopping mall, has its own septic tank due to lack of the capacity of the existing sewerage system. YCDC has a standard structure for the septic tank. Figure 4.1.4 and Figure 4.1.5 show the standard structures of soak pit septic tanks for 10 persons, 100 persons, and 200 persons, respectively. As shown in the figures, effluent from septic tank infiltrates underground and is not being discharged to the storm water drain. Figure 4.1.6 shows the standard structure for the septic tank with up-flow filter. Effluent from the septic tank is discharged to road side drains.



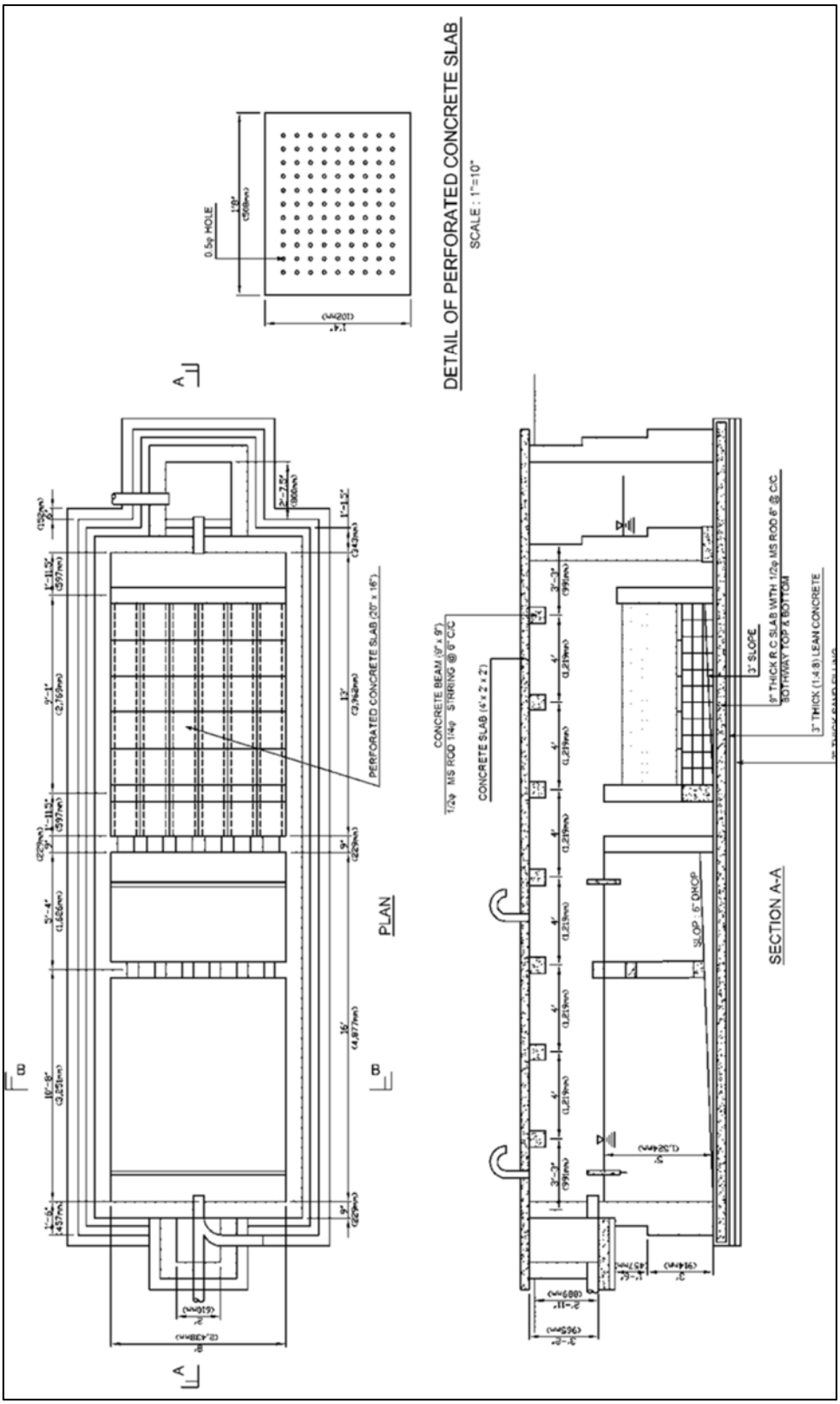
Source: YCDC

Figure 4.1.4 Septic Tank (Left: 10 persons, Right: 100 persons)



Source: YCDC

Figure 4.1.5 Septic Tank (200 persons)

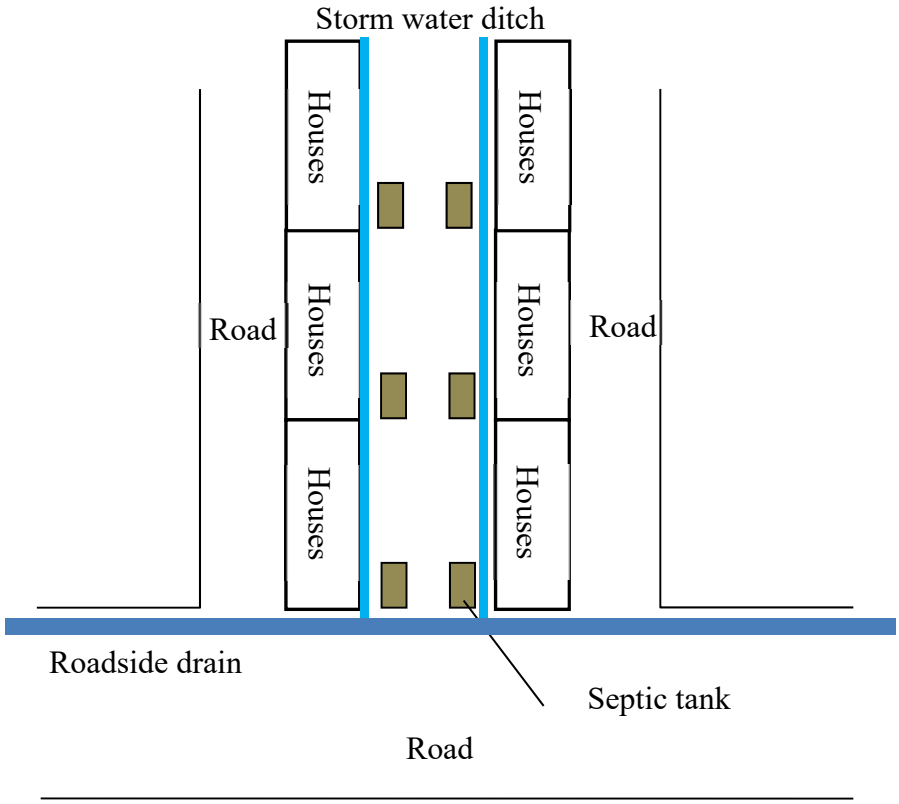


Source: YCDC

Figure 4.1.6 Septic Tank with Up-flow Filter

In the CBD and the Inner Urban Ring areas, back drainage space (BDS) is mostly provided in the backyard of buildings as shown detail in Section 4.1.4. BDS is classified into two types: 1) sewer for collection of black water exists and it is connected to the existing sewerage system, and 2) septic tank is installed. The BDS is not only space, it includes storm water drains, buried pipe and pavement in the space. The width of the BDS is usually 10 to 15 feet (3.0 to 4.5 m), and septic tanks for buildings at both sides are constructed in halves of the BDS. The typical arrangement of septic tanks in the BDS is shown in Figure 4.1.7. Usually, storm water drains with a width of 1.0 to 1.5 ft (30 to 45 cm) are provided on both sides or center of the BDS into which storm water is discharged. YCDC owns the BDS and bear O&M cost for the BDS. The building owner should pay the construction cost of the septic tank.

For detached houses, gray water together with storm water is discharged through small drains in the building owner's property (mostly open drain made of brick structure, rarely pipes) to roadside drains. The septic tank is installed in the area where the BDS does not exist and the existing sewerage system does not cover in the CBD.



Source: JICA Study Team

Figure 4.1.7 Typical Layout of Septic Tanks in BDS Area

YCDC has set a standard for the capacity of a septic tank and has given approval based on the standard. The capacity standard of a septic tank is described below:

1) In the case that BDS exists (CBD area where the density is relatively high), it should be 2.25 ft^3/person (0.06075 m^3/person)

2) In the case that BDS does not exist (CBD where the density is low as stand-alone houses are built), it should be 4.0 ft^3/person (0.108 m^3/person)

According to YCDC, the number of residents is calculated assuming that there are five people per household.

(2) Maintenance of Septic Tank

In Yangon City, the Department of Motor Transportation Workshop collects septage in septic tanks upon request of the household owner and transports the collected septage to the existing WWTP. Frequency of the septage collection service is once or twice a year in each household. The department has 45 operational vacuum trucks (1,200 gallons: 10 trucks, 800 gallons: 20 trucks, 400 gallons: 15 trucks), and 6 trucks are damaged and out of service. There was a total of 23,133 collection times in 2017 (Jan. 2017 to Dec. 2017) according to the department. The collection fee includes fuel fee, labor cost, and car maintenance cost.

A private company collects septage from a part of the townships; however, any detail is not available with YCDC.

Table 4.1.3 Septage Collection Fee

	Townships	Collection Fee / time	
		1,200-Gallon Truck	Others
1	Hlaing Thar Yar, Palal, Wayarlat, Htauk Kyaut, Shwe Pyi Thar, Padamyamyothit	MMK 41,000 including fee for 5 gallons gasoline	MMK 32,000 including fee for 4 gallons gasoline
2	Mingalardon, Insein, Mayankone, North/Oakalarpa, Shwepaukkan, Thanlan, Dagon (South/North/East/Seik Kan)	MMK 33,000 including fee for 3 gallons gasoline	MMK 26,000 including fee for 2.5 gallons gasoline
3	Hlaing, Kamaryut, San Chaung, Kyaumyinttaing, Tharkayta, South Oakkalarpa	MMK 30,000 including fee for 2.5 gallons gasoline	MMK 24,000 including fee for 2 gallons gasoline
4	Dagon, Tarmwe, Daw Paw, Pazuntaung, Botataung, Pabaedan, Latha, Kyauktadar, Lanmataw, Mingalartaungnyut	MMK 29,000 including fee for 2 gallons gasoline	MMK 22,000 including fee for1.5 gallons gasoline

Source: JICA Study Team

4.1.3 Influent Wastewater Quality into C1 WWTP

The average influent wastewater quality (BOD) from March 2017 to March 2018 is shown in Table 4.1.4, which was provided by YCDC. The influent wastewater includes the sewage collected by the existing ejector system and sewage from the septic tank collected by vacuum trucks. The maximum BOD in the effluent was 98 mg/L recorded in 4th May 2017.

Table 4.1.4 Average Water Quality (BOD) in from March 2017 to March 2018

	Septage from Septic Tank	Influent of WWTP	Treated Wastewater (Effluent)
	5,030 mg/L	2,040 mg/L	59 mg/L

Source: JICA Study Team based on the data from YCDC

Photo 4.1.3 Septage into C1 WWTP by Vacuum Truck

4.1.4 Back Drainage Space (BDS)

(1) Current Condition of BDS

Raw sewage from each household in the CBD goes to a pipe installed at the BDS and reaches the sewage treatment plant after going through an ejector station and a main pipeline. Grey water and storm water go to a storm water drain in the BDS before flowing into the Yangon River. Under the Mayor's direction, the following improvement of the BDS environment has started from the fiscal year 2015. The pollution control and cleaning department (PCCD) of YCDC has carried out cleaning of ground surface of the BDS (visible area), and EDWS has performed cleaning and repairing of pavement of the BDS. As of February 2018, 69 of the 182 BDSs have been improved. Currently, the sanitary situation at the BDS has been undesirable due to dumped wastes in the storm water drains and overflowing grey water caused by piled up wastes in the drains. It is preferable that not only YCDC but also the residents will maintain the environment for fundamental improvement of the sanitary condition in the future.

YCDC has been currently bearing the cost for the BDS improvement activity and wants the BDS improvement including replacement of the sewer for black water installed underground at the same time because the sewage collection system in the BDS has been used for 128 years and is aging accordingly. Regarding the existing pipes for black water in the BDS, some of them require frequent cleaning, perhaps every other week, by YCDC staff.

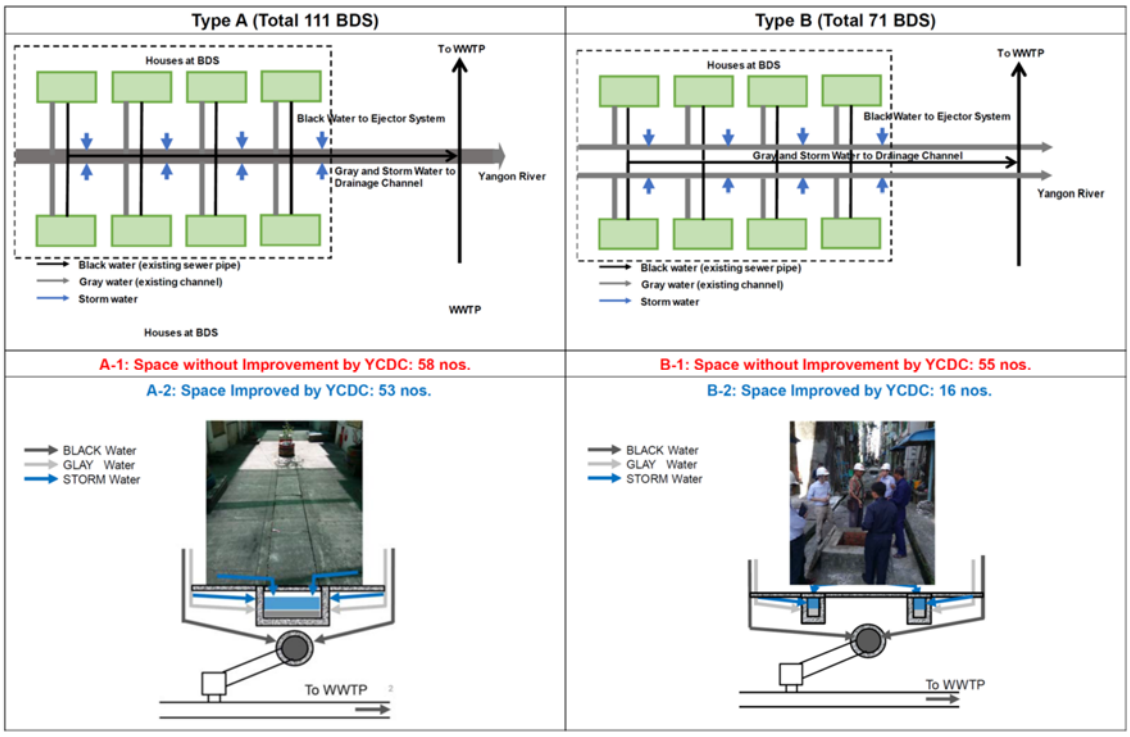
Photo 4.1.4 Existing BDS

Photo 4.1.5 Existing Drain Pile (Rainwater and Graywater)

(2) Type of BDS in the CBD

There is no BDS that has the septic tanks in the CBD. The BDS is classified into two types: 1) one drainage channel exists at the center, and 2) drainage channels exist at both sides, as shown below.

Table 4.1.5 Type of BDS

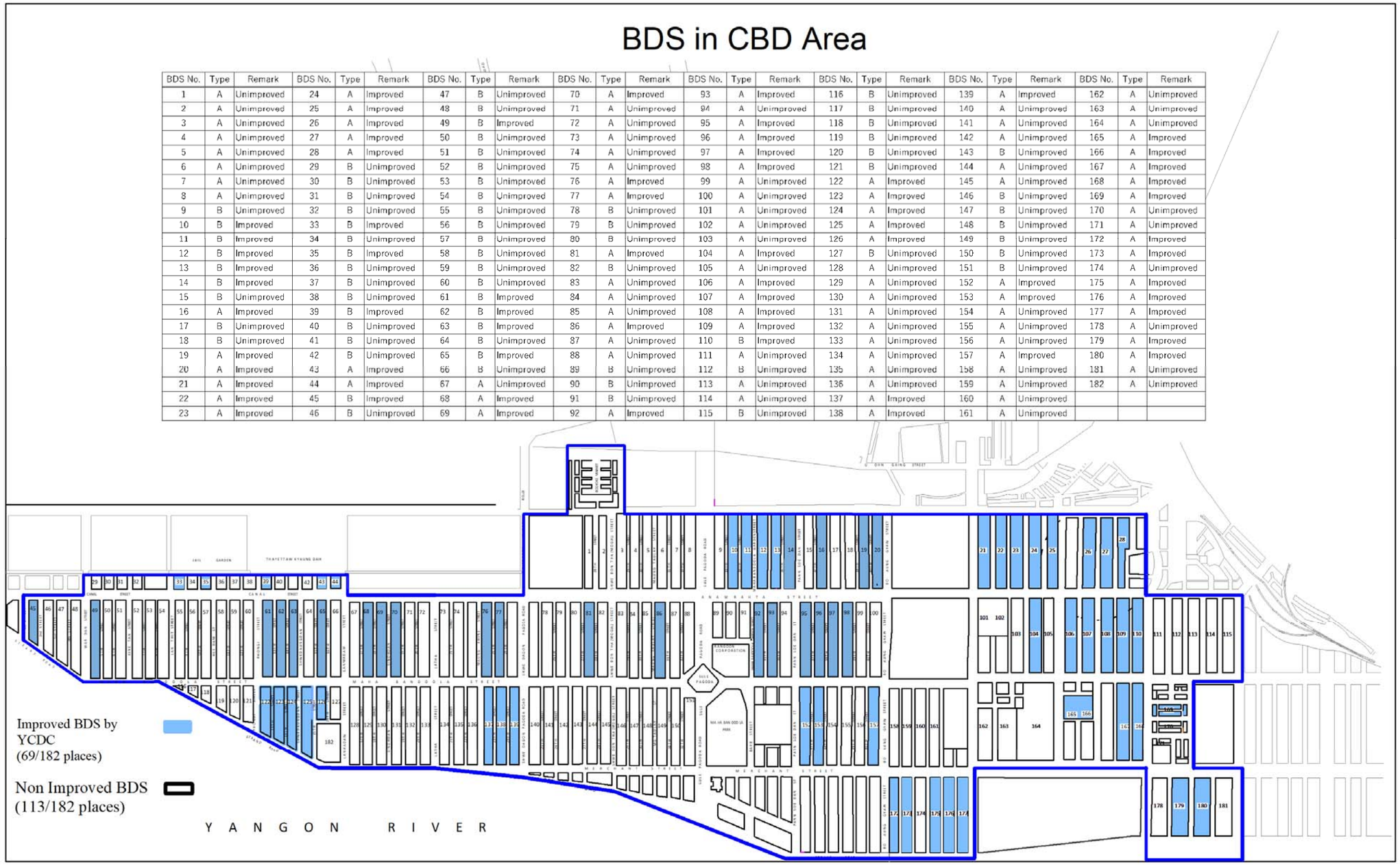


Source: JICA Study Team

At present, YCDC is conducting the improvement work of the BDS in the manner of additional concrete pavement on the existing one. It means that no improvement work for the drainage, sewer, etc. is carried out. Figure 4.1.8 shows current location and improvement status of the BDS.

BDS in CBD Area

BDS No.	Type	Remark	BDS No.	Type	Remark	BDS No.	Type	Remark	BDS No.	Type	Remark	BDS No.	Type	Remark	BDS No.	Type	Remark	BDS No.	Type	Remark	BDS No.	Type	Remark
1	A	Unimproved	24	A	Improved	47	B	Unimproved	70	A	Improved	93	A	Improved	116	B	Unimproved	139	A	Improved	162	A	Unimproved
2	A	Unimproved	25	A	Improved	48	B	Unimproved	71	A	Unimproved	94	A	Unimproved	117	B	Unimproved	140	A	Unimproved	163	A	Unimproved
3	A	Unimproved	26	A	Improved	49	B	Improved	72	A	Unimproved	95	A	Improved	118	B	Unimproved	141	A	Unimproved	164	A	Unimproved
4	A	Unimproved	27	A	Improved	50	B	Unimproved	73	A	Unimproved	96	A	Improved	119	B	Unimproved	142	A	Unimproved	165	A	Improved
5	A	Unimproved	28	A	Improved	51	B	Unimproved	74	A	Unimproved	97	A	Improved	120	B	Unimproved	143	B	Unimproved	166	A	Improved
6	A	Unimproved	29	B	Unimproved	52	B	Unimproved	75	A	Unimproved	98	A	Improved	121	B	Unimproved	144	A	Unimproved	167	A	Improved
7	A	Unimproved	30	B	Unimproved	53	B	Unimproved	76	A	Improved	99	A	Unimproved	122	A	Improved	145	A	Unimproved	168	A	Improved
8	A	Unimproved	31	B	Unimproved	54	B	Unimproved	77	A	Improved	100	A	Unimproved	123	A	Improved	146	B	Unimproved	169	A	Improved
9	B	Unimproved	32	B	Unimproved	55	B	Unimproved	78	B	Unimproved	101	A	Unimproved	124	A	Improved	147	B	Unimproved	170	A	Unimproved
10	B	Improved	33	B	Improved	56	B	Unimproved	79	B	Unimproved	102	A	Unimproved	125	A	Improved	148	B	Unimproved	171	A	Unimproved
11	B	Improved	34	B	Unimproved	57	B	Unimproved	80	B	Unimproved	103	A	Unimproved	126	A	Improved	149	B	Unimproved	172	A	Improved
12	B	Improved	35	B	Improved	58	B	Unimproved	81	A	Improved	104	A	Improved	127	B	Unimproved	150	B	Unimproved	173	A	Improved
13	B	Improved	36	B	Unimproved	59	B	Unimproved	82	B	Unimproved	105	A	Unimproved	128	A	Unimproved	151	B	Unimproved	174	A	Unimproved
14	B	Improved	37	B	Unimproved	60	B	Unimproved	83	A	Unimproved	106	A	Improved	129	A	Unimproved	152	A	Improved	175	A	Improved
15	B	Unimproved	38	B	Unimproved	61	B	Improved	84	A	Unimproved	107	A	Improved	130	A	Unimproved	153	A	Improved	176	A	Improved
16	A	Improved	39	B	Improved	62	B	Improved	85	A	Unimproved	108	A	Improved	131	A	Unimproved	154	A	Unimproved	177	A	Improved
17	B	Unimproved	40	B	Unimproved	63	B	Improved	86	A	Improved	109	A	Improved	132	A	Unimproved	155	A	Unimproved	178	A	Unimproved
18	B	Unimproved	41	B	Unimproved	64	B	Unimproved	87	A	Unimproved	110	B	Improved	133	A	Unimproved	156	A	Unimproved	179	A	Improved
19	A	Improved	42	B	Unimproved	65	B	Improved	88	A	Unimproved	111	A	Unimproved	134	A	Unimproved	157	A	Improved	180	A	Improved
20	A	Improved	43	A	Improved	66	B	Unimproved	89	B	Unimproved	112	B	Unimproved	135	A	Unimproved	158	A	Unimproved	181	A	Unimproved
21	A	Improved	44	A	Improved	67	A	Unimproved	90	B	Unimproved	113	A	Unimproved	136	A	Unimproved	159	A	Unimproved	182	A	Unimproved
22	A	Improved	45	B	Improved	68	A	Improved	91	B	Unimproved	114	A	Unimproved	137	A	Improved	160	A	Unimproved			
23	A	Improved	46	B	Unimproved	69	A	Improved	92	A	Improved	115	B	Unimproved	138	A	Improved	161	A	Unimproved			



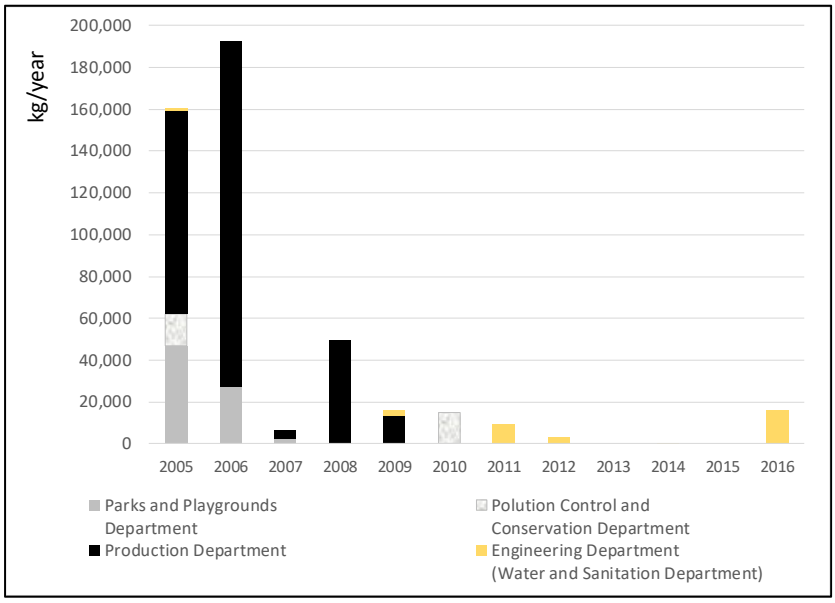
Source: JICA Study Team

Figure 4.1.8 Location and Improvement Status of Back Drainage Space (BDS)

4.1.5 Disposal for Generated Sludge after Wastewater Treatment

The amount of sludge produced from wastewater treatment has not been recorded by YCDC. The amount is not big because only the drying bed has been operated among the sludge treatment facilities. Currently, sludge is dried at the drying bed, and a portion of the dried sludge is irregularly used for some purposes such as fertilizer for street plants outside of the WWTP.

According to the record of sludge utilization in the WWTP, four departments of YCDC, i.e., EDWS, PCCD, Parks and Playgrounds Department, and Production Department have taken the dried sludge from the WWTP as shown in Figure 4.1.9 below. The record indicates that the demand of sludge utilization is not stable and tends to decrease since 2010. The utilized amounts in 2007 and 2012 to 2015 are very small compared to other years. EDWS is the only department that utilized the dried sludge after 2011. Even so, the amount of sludge is not a serious problem for YCDC because the amount is small. (See Appendix 1)

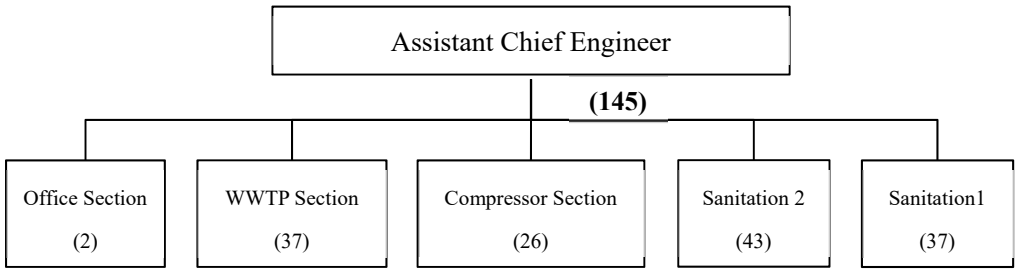


Source: JICA Study Team based on the information from YCDC

Figure 4.1.9 Estimated amount of Sludge Utilization Based on Record of YCDC

4.1.6 Operation and Maintenance

There are 145 staff members that belong to the Sanitation Division. The division consists of 26 staff members in the compressor section, 37 in the sewage treatment section, and 82 in the other sections. The work contents of Sanitation 1 and Sanitation 2 are the same, and the difference between them is the area of responsibility. They divide C1 area into two portions from the center line of Sule Pagoda. Sanitation 1 is in-charge of the area from the east side of Sule Pagoda, while Sanitation 2 is in-charge of the other side.



Source: YCDC

Figure 4.1.10 Sanitation Division of YCDC

4.2 Issues on Current Sewerage and Sanitation Works

4.2.1 Wastewater Treatment Plant (WWTP)

The following issues on the existing WWTP have been observed through site surveys and interviews with YCDC:

- Unexpected inflow of septage at the preparation of design for the existing WWTP and operation of the ejectors have affected the operation and management of the C1 wastewater treatment plant causing huge load fluctuation.
- Septage, which was not expected at the time of planning, has been dumped by a vacuum truck, and the load has significantly exceeded the planned load of wastewater inflow. As a result, some untreated wastewater is being discharged into the public water body and affects the environmental condition.
- Wastewater inflow depends on the operation of the ejectors (only daytime), and the inflow of septage takes place only during daytime, which causes the big fluctuation of the load onto the treatment plant.
- For sludge treatment, the thickener tank, the aerobic digestion tank, and the belt press type dehydrator have been out of service. As a result, the sludge cannot be removed from the final sedimentation tank, and the MLSS concentration in the reactor tank has been very high. Scum which is generated from septage dumped by the vacuum truck and is floating on the surface of the grit chamber is conveyed to the outside of the WWTP.

4.2.2 Sewerage System (Sewer and Ejector System)

The following issues on the existing sewer system (pipe network system) have been observed through site surveys and interviews with YCDC:

- The inflow to the sewage treatment plant is around 4% or less of the design wastewater flow, which is extremely low because of following reasons:
  1) The large-scale building, e.g. hotel and shopping mall, has its own septic tank and does

not connect to the existing sewerage system even in the CBD covered by the system.

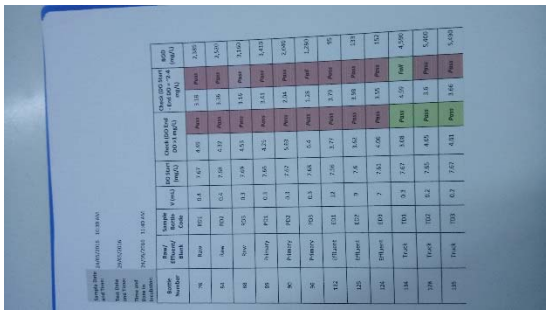
2) Sewage is discharged to the ditch due to misconnection in the BDS
3) Clogging of the existing sewer reduces the flow area

According to YCDC, there was an accident due to the bursting of the force main at Marchant Road in 2014, and it was repaired after digging out the road.

- Since the existing sewers are used only for collecting black water, grey water is discharged without treatment, and the environment in the city gets deteriorated consequently.
- The ejector system has been deteriorating since the operation started from March 1890, and necessary spare parts for repair are not available. So, special orders for the spare parts have been placed to a local company.
- According to YCDC, out of the 40 ejector stations, 2 have become unnecessary, 3 were broken and replaced with another system, and 35 are operating. Even the ejector stations in service frequently fail due to the inflow of plastics or rubber products.
- Also, the air tube, which sends pressure from the compressor station to each ejector station, has deteriorated, and an individual small-sized air compressor has been newly installed at 7 ejector stations.

4.2.3 Operation and Maintenance

The YCDC of EDWS sets up a laboratory with measurement equipment, but only measures pH and MLSS at the sewage treatment plant by using them. As for other monitoring, especially for quality of effluent, it was once performed for the purpose of research, but it is not conducted on a regular basis. Photo 4.2.1 shows the laboratory in the plant for measurement of effluent quality and its monitoring sheet.



Source: JICA Study Team

Photo 4.2.1 Laboratory and Monitoring Sheet

The primary function of the sanitation division is quite limited to the O&M of the existing ejector system and the existing treatment plant. The staff have no skills and ability in planning and design. In addition, the numbers of the staff are not enough for the O&M of the new sewerage system which is larger-scale compared with the existing system.

4.2.4 Disposal for Generated Sludge after Wastewater Treatment

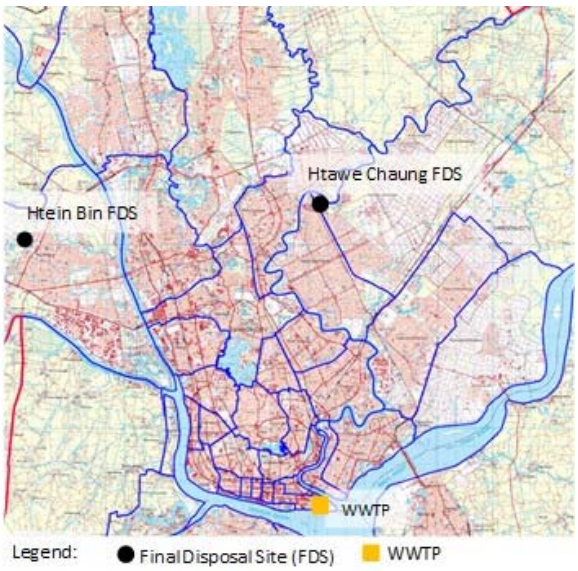
(1) Necessity of disposal site

The EDWS envisages that they would, as much as possible, utilize sludge generated from the new WWTP enhanced by the project instead of simply disposing of it as solid waste. The amount of dried sludge generated from the new WWTP is preliminarily estimated at about 46 t/day (moisture content: 35%) in its full operation years, which is equivalent to more than 60 times the volume utilized in 2006, as shown in Figure 4.1.9. (Refer to Appendix 4 for calculation of the amount of dried sludge.) While the JICA Study Team respects their idea, it's much difficult to utilize sludge effectively because the estimated amount of sludge utilized decreased sharply after 2007. Therefore, it is necessary to find and secure such facility to prepare for sludge generation in the future since EDWS has not disposed of the sludge of the WWTP to the disposal facility.

(2) Possible site for sludge disposal

Currently, solid waste generated in the target area is transported and disposed of into the existing final disposal sites (FDSs). YCDC operates two FDSs, namely Htein Bin FDS, located in Hlaingthaya Township, and Htawe Chaung FDS, located in East Dagon Township. Htein Bin FDS has been operating for 17 years since 2002. The location and the existing conditions of both FDSs are shown in Figure 4.2.1 and Figure 4.2.2. Disposal of the sludge from WWTP to FDS is practiced and commonly observed in other countries.

It is said, and it is obvious that Htawe Chaung FDS is already full and should be closed soon. The piled solid waste forms a hill, even in Htein Bin FDS. The remaining area of the Htein Bin FDS is estimated to be about 60 ha against 120 ha of the total area. According to PCCD, more than 800 tons of solid waste is being hauled and disposed of at the FDS every day, while the amount of solid waste generation in Yangon increases in accordance with the city development.



Source: YCDC

Figure 4.2.1 Location of Studied Final Disposal Site

(Htein Bin FDS)

(Htawe Chaung FDS)

Source: JICA Study Team

Figure 4.2.2 Conditions of the Existing Final Disposal Sites in Yangon City

4.2.5 Financial

- It is an urgent need to discontinue the aging ejector system and develop a new sewage collection system. However, it is difficult to secure financial resources by themselves without assistance from foreign aid agencies.
- The waterworks and sewage works are not separated in YCDC. Furthermore, the sewage charge is not collected.
- Regarding the accounting system, costs such as depreciation are not calculated. Thus, the revenues and expenditures should be clarified, and the increase of the revenues should be ensured at the same time.

4.3 Related Projects in the Target Area

4.3.1 Drainage Project by World Bank

The drainage improvement project to be funded by World Bank is scheduled to commence. It includes detailed design, tender assistance, and succeeding construction. YCDC has applied for a credit of USD 116 million equivalent from the International Development Association (IDA-World Bank Group) to finance the Myanmar Southeast Asia Disaster Management Project, which includes a component for an integrated urban flood risk management

Source: YCDC

Figure 4.3.1 Catchment for the Drainage Project

estimated at approximately USD 71 million. The project is co-funded with a grant of USD 1 million from the Southeast Asia Disaster Risk Insurance Facility (SEADRIF), a multi-donor trust fund. Stage-1 in the project started from December 2018.

Under Stage-1, the selected consultant will support the preparation of detailed engineering designs, cost estimates, and bidding documents for priority drainage improvement works in six townships based on criteria such as subproject readiness, availability of land, planning requirements of other utilities especially sewerage networks, etc. The subprojects expected to be prioritized for design and procurement readiness are: the storm water drainage infrastructure (main channels, drains, manholes, outfalls, storm pumps, combined storm overflow chambers, etc.) and the flood protection facilities, especially safety gates and tidal gates. The preparation of environmental and social impact assessments for the drainage plans and the prioritization of a list of priority investments for the six townships are also part of the services to be delivered in Stage-1. It will be undertaken for an eight-month period for the preparation of design/bidding documents, and a subsequent phase of ten weeks for the bidding process, which shall result in a number of awarded civil work contracts for the priority drainage works covering all six target townships. This stage will finish in July 2019.

Stage-2 shall consist of construction supervision and contract management for the works of a number of priority bid packages and assistance during the defects liability period. The total duration of services for Stage-2 will be 36 months.

4.3.2 Survey for Existing Sewerage System by DFID

(1) Objective of the Survey

The Department for International Development (DFID) under the government of the United Kingdom (UK) provided the consultant's expert for the survey of the current condition of the existing sewerage system in Yangon City, which were installed in 1888.

The survey includes the inspection of the existing ejector station, sewers (pressured), manholes, and C1 WWTP. Also, a detailed survey using closed-circuit television (CCTV) camera for the sewer was conducted in the BDSs.

Although the survey aims to provide results with an independent perspective into the existing sewerage system, it will be helpful in planning the new sewerage system in Yangon City.

(2) Summary of the Survey Results

The summary of the survey results is reported as follows. It is also a reference for the planning of a new sewerage system.

1) Collection System in BDS
   - The collection system currently collects black water from housing and commercial properties, and grey water discharges into the surface water network of shallow

channels.

- Some black water overflows into the surface water channels because of siltation and solid waste blockage in the sewers.
- From a limited sample of CCTV surveys, the cast iron pipes appear to be in a fair condition considering their age, with only a 5-15% loss of capacity.

It is acknowledged from the result above that additional CCTV survey will be required in the detailed design stage for improvement of the collection system in the BDSs.

2) Compressor and Ejector Station

- There were some restrictions on the survey due to carbon monoxide gas levels, groundwater ingress, and silt levels within the chamber.
- At least 6 out of 33 functioning ejector stations are reported to discharge black water into the surface water network or river for a number of reasons.
- In most ejectors, only one ejector is being operated, and spare parts have been cannibalized from the other ejector.

According to YCDC, since it will be limited technically to rectify the stations, the main compressor station will be renovated in the future as the sewerage history museum for public awareness activities.

3) Sewer System

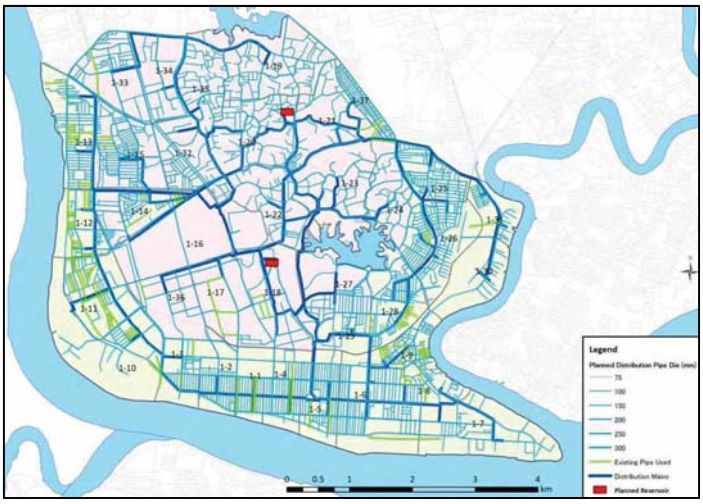
- The north and south force mains have sufficient capacity to carry black water only.
- The south force main has sufficient capacity to carry both black and grey water without a significant rise in pressures at the ejectors; however, the north force main does not appear to have the capacity to carry the additional grey water, and this could prevent the operation of western ejectors.
- There is a degree of internal corrosion/tuberculation resulting in 10-20% loss of area.
-

4.3.3 Greater Yangon Water Supply Improvement Project (Phase-2)

YCDC is implementing Greater Yangon Water Supply Improvement Project Phase-2 funded by JICA since May 2018. The project scope includes detailed design and construction of new water treatment plant with the capacity of 272,800 m^3/day, transmission pipeline, distribution pipelines, reservoirs and booster pumping station etc. mainly. Raw water will be taken from Kokkowa River and convey a treated water by transmission pipe with a diameter of 1600mm. Further water distribution will be made to water distribution Zone-1 and Zone-9. Zone-1 as shown in Figure 4.3.2 includes the CBD area. Therefore, it is necessary to coordinated with this water supply project to avoid any conflict of each alignment of water supply and sewer.

Detailed design of this package for distribution pipes in Zone-1 has being implemented since June

2018 and to be completed by the middle of 2019. Then, succeeding bidding and construction is planned to commence after the 4th quarter of 2019.



Source: YCDC

Figure 4.3.2 Distribution Network in Zone-1

4.3.4 Dala Bridge Project

Dala Bridge is a bridge project which plans to connect downtown and Dala township which is currently only possible to travel using a ferry across the river. The bridge will span between Bo Min Yaung Road in Dala and Phone Gyi Street in Lanmadaw. The Yangon Regional Government is planning urban development in the western and southern parts of the Yangon River, and the construction of the Dara bridge will support the urban development. The bridge was initially planned as a South Korean-Myanmar friendship symbol in 2012 with the cost to be borne by South Korea. The project stalled due to insufficient funding and rocketing land prices in 2013. In late 2014, the Ministry of Construction announced that the bridge project will continue by means of a loan from South Korea. The project is now due to begin in December 2018 and to be completed by 2022. The project cost was estimated at around JPY 20.7 billion.

Source: YCDC

Figure 4.3.3 Image of Dala Bridge

CHAPTER 5 DEVELOPMENT POLICIES FOR SEWERAGE SYSTEMS

5.1 Sewerage Collection System

5.1.1 Catchment Boundary for the Study

The JICA MP 2014 defined the catchment boundary for C1 and W1. However, at the beginning of the Study, the C1 Wastewater Treatment Plant (WWTP) was planned to treat wastewater from part of W1 in order to maximize the capacity of the C1 WWTP within the available land for the plant. This was desirable due to the scarcity of available land for the W2 WWTP. The net result was that wastewater from a portion of the W1 area, namely Latha Township, Lanmadaw Township and the southern part of Dagon Township, is to be conveyed to the C1 WWTP. The boundary of C1 and part of W1 is shown in Figure 5.1.1. Therefore, the C1 and W1 catchments have been updated with an area of 990 ha and 1,163 ha, respectively, as shown in Table 5.1.1.

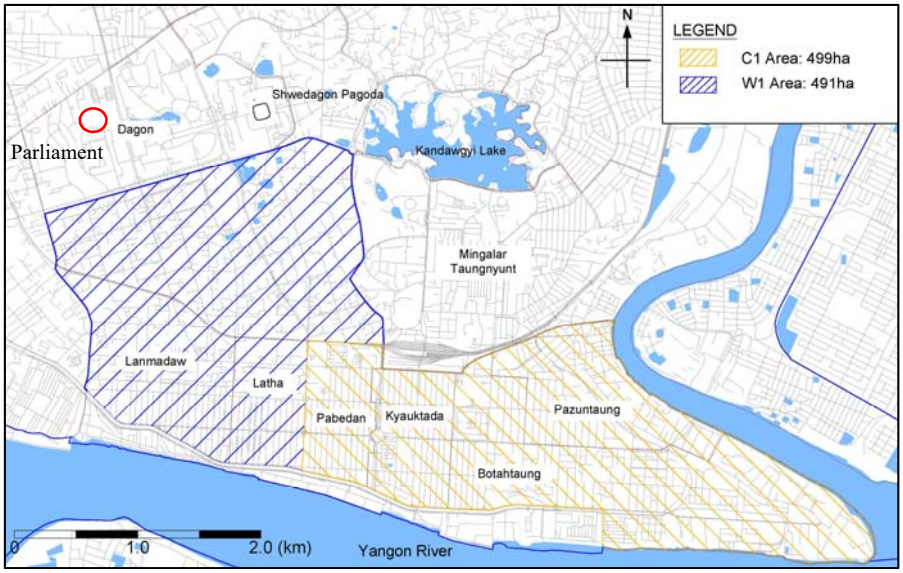
According to the Yangon City Development Committee (YCDC), wastewater from the Parliament now discharges into part of the W1 area, and in the future, this will be conveyed into the C1 area. Therefore, wastewater from the Parliament, which is estimated at 333 m^3/d (approximately for 1,000 persons), will be treated by the C1 WWTP. Also, the septic tanks, which are installed around the Shwedagon Pagoda, treat sewage from the pagoda and the surrounding park. Therefore, this area will not be covered by the development of the sewage collection sewage collection system.

Table 5.1.1 Sewerage Zone Defined in the JICA MP 2014 and Catchment Area

<table>
<tr><th rowspan="2">Township Name</th><th rowspan="2">Township Group</th><th rowspan="2">Sewerage Zone</th><th rowspan="2">Study Area</th><th colspan="2">Catchment Area (ha)</th></tr>
<tr><th>JICA MP 2014</th><th>This Study</th></tr>
<tr><td>Pabedan</td><td rowspan="6">Central Business District (CBD)</td><td>C1</td><td>√</td><td rowspan="4">499</td><td rowspan="7">990</td></tr>
<tr><td>Kyauktada</td><td>C1</td><td>√</td></tr>
<tr><td>Botahtaung</td><td>C1</td><td>√</td></tr>
<tr><td>Pazundaung</td><td>C1</td><td>√</td></tr>
<tr><td>Latha</td><td>W1</td><td>√</td><td rowspan="8">1654</td></tr>
<tr><td>Lanmadaw</td><td>W1</td><td>√</td></tr>
<tr><td>Dagon</td><td rowspan="5">Inner Urban Ring (IUR)</td><td>W1</td><td>√*1</td></tr>
<tr><td>Ahlone</td><td>W1</td><td></td><td rowspan="5">1163</td></tr>
<tr><td>Kyee Myin Daing</td><td>W1</td><td></td></tr>
<tr><td>Sanchaung</td><td>W1</td><td></td></tr>
<tr><td>Bahan</td><td>W1</td><td></td></tr>
<tr><td>Kamaryut</td><td>Outer Ring (OR)</td><td>W1</td><td></td></tr>
</table>

Note: *1 The study area includes southern part of Dagon Township

Source: JICA MP 2014 and YCDC



Source: JICA Study Team

Figure 5.1.1 Boundary of C1 and Part of W1

5.1.2 Type of Sewage Collection System and Characteristics

(1) Existing Sewerage System

As shown in Section 4.1.1, an ejector system, or a force main sewage system introduced in 1888, is installed in the central business district (CBD) and part of inner urban ring area and collects only black water from households in these areas. The existing WWTP is installed in Botahtaung Township, located in the east part of the CBD, and treats black water sent by the ejector system. In the Dagon Township, the available sewerage facility is a septic tank.

(2) Sewage Collection System

A sewage collection system will be determined considering the topography, meteorology, and present condition of the existing system. It is commonly recognized that sewage collection systems are classified into two types, which are: 1) combined sewer system and 2) separated sewer system. The characteristics of these sewer collection systems are summarized inTable 5.1.2.

Table 5.1.2 Features of Sewer Systems

Sewage Collection System	Combined Sewer		Separated Sewer
	Combined Sewer	Interceptor Sewer	
Feature	- To collect sewage and storm water through a single pipe	- To utilize the existing drainage system and to collect sewage	- To collect sewage by a sewer, separately from storm water
Construction	- Construction period and cost can be reduced because only one pipe is installed. - The pipe diameter of a combined sewer will be larger than that of a separated sewer since both sewage and storm water are collected in one pipe.	- Construction period and cost will be reduced because the existing drainage system is utilized. - Interceptor chambers are required at some discharge points of the drainage system.	- Construction period and cost will be increased because two pipes, collecting sewage and storm water, are required. - The pipe diameter of a separated sewer can be minimized.
Operation	- In the dry season, sedimentation will easily occur inside the		- Sediment deposition in sewer

and Maintenance	pipes. - In the rainy season, flashing by storm water can be expected, but overflow will occur easily. - Regular checking and cleaning will be easier.		pipes is less than that of combined sewers or storm water pipes. - Management for both sewer pipe and storm water pipe is required. - The installation depth of the sewer will be deep.
Protection of Water Environment	- Combined sewer overflow (CSO) will be discharged to water bodies without any treatment. - Initial storm water, which contains a lot of pollutants, can be treated at the WWTP.		- Sewage will not be discharged to water bodies. - Initial storm water, which contains a lot of pollutants, will be discharged to water bodies without any treatment.
House Connections	- Required.	- Not required	- Required.

Source: JICA Study Team

5.1.3 Selection of Sewage Collection System for Target Area

(1) Comparison of Sewer System

The wastewater collection method is selected after consideration of pros and cons, taking into account the features of both the combined sewer and the separated sewer as shown in Table 5.1.3. As a result of the discussion with YCDC, it was decided that a separated system shall be applied for the Project since it is not desirable for a combined system to discharge wastewater to Yangon River even if it is diluted with storm water.

Table 5.1.3 Comparison for Separated and Combined System

Item	Separated System		Combined System	
Collection of Black and Grey Water	Collected by new sewer	◎	Collected by new sewer with larger-size	○
Collection of Storm Water	Collected by drainages in CBD to be improved by World Bank. Drains in Dagon township are being constructed by YCDC.	○	Collected by new sewer with larger-size excess of storm water beyond the capacity of the sewer will overflow to the existing water bodies at CSO	◎
Pollution Load	Rainwater on the surface of road or residential land will be discharged without any treatment at the initial rainfall. After the improvement, no wastewater will be discharged to Yangon river.	○	Pollution load in dry season will be decreased, overflowed water mixed with rain water will be discharged into Yangon River. YCDC prefer to avoid any pollution to Yangon River.	△
BDS Improvement	Environmental condition will be better since rainwater, greywater and black water can be separately collected. Diversion chamber to collect greywater will be constructed. Replacement of the existing pipe for black water will be implemented in 6 BDSs as pilot scheme.	◎	Keep the existing condition and YCDC will do the improvement work. Grey water will be discharged to existing drain together with rain water.	○

Workability	New construction is only for main sewer. Rain water will be discharged through existing drain to Yangon River.	◎	Although larger size of sewer will be required than separated system, there is no problem for the construction space. It might be difficult to design the invert elevation of weir at combined sewer overflow (CSO).	△
O&M	O&M for drainage will be in charged by Road and Bridge department, and that for sewer will be in charged by Water and Sanitation department. Therefore, the responsibility of each facility will be clearly separated.	◎	Normally, related department for drainage and sewer is different, Water and Sanitation department has to be in charge for combined sewer.	○
Construction Cost	Existing drain will be used for rain water. World Bank is planned to implement the improvement work in CBD. Diameter of sewer will be smaller than combined system.	◎	Construction cost will decrease in case interceptor sewer installs along Yangon River, combined sewer will require almost same length as separated sewer taking into consideration existing collection system.	○
Effectiveness	Although it is necessary to separate rain water and grey water, only construction of drain in BDS which covers large area of the whole catchment can complete the system.	○	Project effectiveness will find earlier than separated system since existing BDS will utilize.	◎
Construction Period	Normally, it takes longer construction period than combined system. Total length of the sewer might be almost the same, however, improvement of BDS will require additional period.	○	If interceptor sewer is applied, construction period can be remarkably shorter than combined system. This is not considered the improvement work of BDS.	◎

Note: ◎: Better, ○:Good, △: Fair

Source: JICA Study Team

(2) Sewage conveyance to WWTP

Generally, a sewage conveyance system to a WWTP has either gravity flow or pressure flow. Gravity flow is normally selected for a sewerage plan from the viewpoint of operation and maintenance cost. However, the selection of a sewage transportation system shall also consider the topographic condition of the catchment.

For gravity flow, the sewer system will be economical, and the sewer connection is simple. In addition, its maintenance work will be easier than pressure flow. However, the installation depth of the sewer in gravity flow will be deeper than in pressure flow since a lengthy sewer needs a lower depth with a certain slope. Therefore, some pumping stations may be required to avoid deeper installation of sewers. On the other hand, for pressure flow, the installation depth of the sewer can be shallow regardless of topography, but the connection of sewers and maintenance work will be more complex and difficult than that of gravity flow systems.

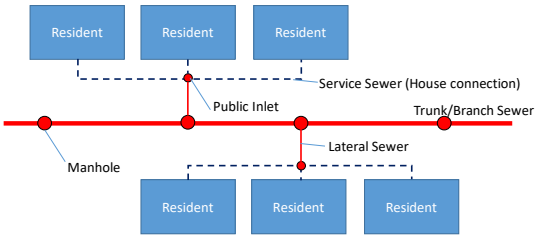
The ground elevation of the CBD is almost flat, and the existing sewer is applied for pressure flow. However, the ground elevation of Dagon, which is located upstream of the CBD, declines toward the CBD area. In addition, it was observed that a pumping station was not required in the middle in case gravity flow is applied because the deepest earth covering was identified as around

14 m at the pumping station in the WWTP. Therefore, it can be said clearly that operation and maintenance are much easier in gravity flow than in pressure flow. Considering the above, gravity flow will be applicable for the sewer system in the CBD and in Dagon, in accordance with the theory.

5.1.4 House Connection in Target Area

A house connection shall be considered separately whether the back drainage space (BDS) is currently available or not since BDS has already been equipped with a sewer, storm water pipe, and grey water pipe from each residence in the apartment building, although grey water and storm water are finally mixed and collected by the ditch. Therefore, for the improvement and new installation of a house connection in the Project, the house connection method shall be different to suit the current available facilities, taking into consideration the construction cost and implementation period.

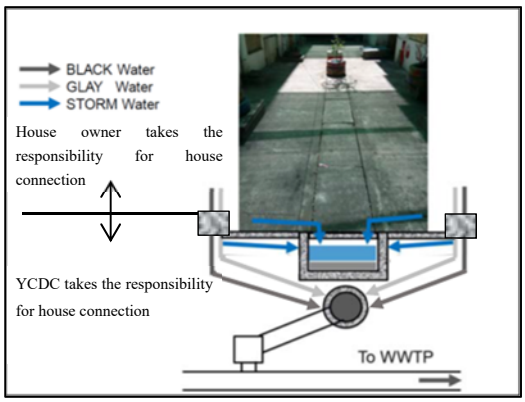
House owners are obliged normally to connect with the sewage collection system individually through their own service pipe connecting a public inlet in adjacent to the border between public and private. The public sector should provide the public inlet and lateral sewer for collecting sewage into the trunk/branch sewer.



Source: JICA Study Team

Figure 5.1.2 House Connection

A steady implementation of house connection is essential issue because project effectiveness of the sewerage development will not be obtained until sewage reaches the WWTP by the house connections. Therefore, prior to the implementation of the Project, YCDC is required to implement the house connections by making it obligatory, formulating the legal system relating to the sewerage and operating these systems properly.



Source: JICA Study Team based on information from YCDC

Figure 5.1.3 House Connection in BDS

(1) CBD with BDS

House owners currently bear the installation cost of the pipes from the apartment building to the public inlet on the surface of the ground. On the other hand, YCDC bear the installation cost for the inlet and required facilities to connect the inlet with the ejector station, i.e. buried connection pipes, BDS sewer and the manhole. In this study, each responsibility for the house connection will be the same as the current situation.

(2) CBD with non BDS and Dagon area

House owners will install the service sewer from household to the public inlet. The public inlet and other facilities will be installed under the project as shown in Figure 5.1.2.

5.2 Sewerage System Development Plan

5.2.1 Water Supply Served Population Projection

In principle, the basic condition for a sewerage system shall be prepared in accordance with the planning concept in the JICA MP 2014. However, the population projection until 2040 has been updated in the 'Data Collection Survey for the Project for Updating the Strategic Urban Development Plan of the Greater Yangon' by JICA in 2017. Therefore, the updated population projection is used for the Study. To calculate wastewater volume, the water supply service ratio and the served population in each year is estimated as shown in Table 5.2.1.

Table 5.2.1 Water Supply Service Ratio and the Served Population

Township	2017		2020		2025		2030		2035		2040	
Latha	91%	22,802	97%	24,305	100%	25,057	100%	25,057	100%	25,057	100%	25,057
Lanmadaw	76%	35,842	82%	38,671	92%	43,387	100%	47,160	100%	47,160	100%	47,160
Pabedan	94%	31,336	100%	33,336	100%	33,336	100%	33,336	100%	33,336	100%	33,336
Kyauktada	98%	29,256	100%	29,853	100%	29,853	100%	29,853	100%	29,853	100%	29,853
Botahtaung	99%	40,585	100%	40,995	100%	40,995	100%	40,995	100%	40,995	100%	40,995
Pazundaung	100%	48,213	100%	48,455	100%	48,455	100%	48,455	100%	48,455	100%	48,455
Dagon	53%	14,958	59%	18,290	69%	25,064	79%	32,904	89%	40,229	100%	48,751
Total		**222,991**		**233,905**		**246,147**		**257,760**		**265,085**		**273,607**

Source JICA Study Team

5.2.2 Wastewater Generation Volume

Wastewater generation volume is mainly composed of domestic wastewater, commercial wastewater, industrial wastewater, and groundwater infiltration. Sum of the commercial wastewater and the industrial wastewater is defined as non-domestic wastewater.

(1) Domestic and Non-Domestic Wastewater Volume

JICA MP 2014 defined the domestic and non-domestic unit water supply consumption until 2040 which categorization was different from the above. There is no industrial park in the target area, therefore, wastewater volume is calculated based on the premise that no industrial wastewater will be generated. It leads that non-domestic wastewater volume is the same volume with commercial wastewater volume in the Study. Domestic water consumption was estimated as 150 lpcd in 2025 and 200 lpcd in 2040. Domestic and non-domestic water supply consumption were estimated with the ratio of 60:40, which is based on the current water consumption in Yangon as

mentioned in Section 4.3.7, Chapter 4, Volume III of JICA MP 2014. Therefore, the domestic and non-domestic unit water supply consumption was estimated as 250 lpcd in 2025 and 333 lpcd in 2040 as shown in Table 5.2.2.

Table 5.2.2 Unit Water Consumption

Unit: lpcd

Area	2014	2017	2020	2025	2030	2035	2040
C1 and part of W1	**185**	**203**	**220**	**250**	**278**	**305**	**333**
Domestic				150			200
Non-Domestic				100			133

Source: Section 4.3.7 Chapter 4 Volume III of JICA MP 2014

(2) Industrial Wastewater Volume

No industry uses a large volume of water in the target area. In case a large scale of industries consumes a large volume of water supply, the industry is requested to treat water at WWTPs individually to meet the industrial effluent quality standards. In Yangon City, there is currently no standard for receiving wastewater by sewerage facility, however, MONREC and YCDC are strengthening guidance on environmental management improvement including improvement of wastewater treatment. The establishment of the Environmental Management Plan (EMP) to mainly for the business operator with high pollution load and the improvement of the wastewater treatment are implemented, and primary treatment by the factory is also implemented as appropriate. Therefore, industrial wastewater volume was not considered in the Study.

(3) Groundwater Infiltration

It is difficult to accurately estimate the amount of groundwater infiltration without investigation since the groundwater infiltration is mainly caused by poor connection, deterioration of sewer, and high groundwater level. Therefore, the Study adopted 10 m^3/ha/day as the groundwater infiltration volume which was estimate with reference to the other southeast Asian Cities defined by the JICA MP 2014.Daily average wastewater volume was calculated equivalent to 100% of the daily average water supply consumption plus groundwater infiltration. A peak factor of 1.1 was applied to the daily average wastewater volume to calculate the daily maximum wastewater volume. Hourly maximum wastewater volume is calculated as 1.5 times of daily maximum wastewater volume. JICA MP 2014 defined the peak factor after reviewing the values in Bangkok and in major cities in Japan. The calculated wastewater volume in each township is shown from Table 5.2.3 to Table 5.2.5.

Table 5.2.3 Wastewater Generation Volume (Daily Average Maximum)

Unit: m^3/d

Township	2017	2020	2025	2030	2035	2040
Latha	5,222	5,952	6,869	7,565	8,261	8,957
Lanmadaw	8,568	9,818	12,157	14,411	15,721	17,031
Pabedan	6,964	7,953	8,953	9,879	10,805	11,731
Kyauktada	6,626	7,270	8,165	8,994	9,824	10,653
Botahtaung	10,820	11,621	12,851	13,989	15,128	16,267
Pazundaung	10,831	11,728	13,181	14,527	15,873	17,219
Dagon	6,023	7,018	9,260	12,134	15,287	19,245
Total	**55,056**	**61,359**	**71,437**	**81,500**	**90,898**	**101,102**

Source: JICA Study Team

Table 5.2.4 Wastewater Generation Volume (Daily Maximum)

Unit: m^3/d

Township	2017	2020	2025	2030	2035	2040
Latha	5,744	6,547	7,556	8,322	9,087	9,853
Lanmadaw	9,425	10,800	13,373	15,852	17,293	18,734
Pabedan	7,661	8,748	9,848	10,867	11,885	12,904
Kyauktada	7,289	7,996	8,982	9,894	10,806	11,718
Botahtaung	11,902	12,783	14,136	15,388	16,641	17,894
Pazundaung	11,914	12,900	14,499	15,980	17,461	18,941
Dagon	6,626	7,720	10,186	13,348	16,815	21,169
Total	**60,561**	**67,495**	**78,581**	**89,650**	**99,988**	**111,213**

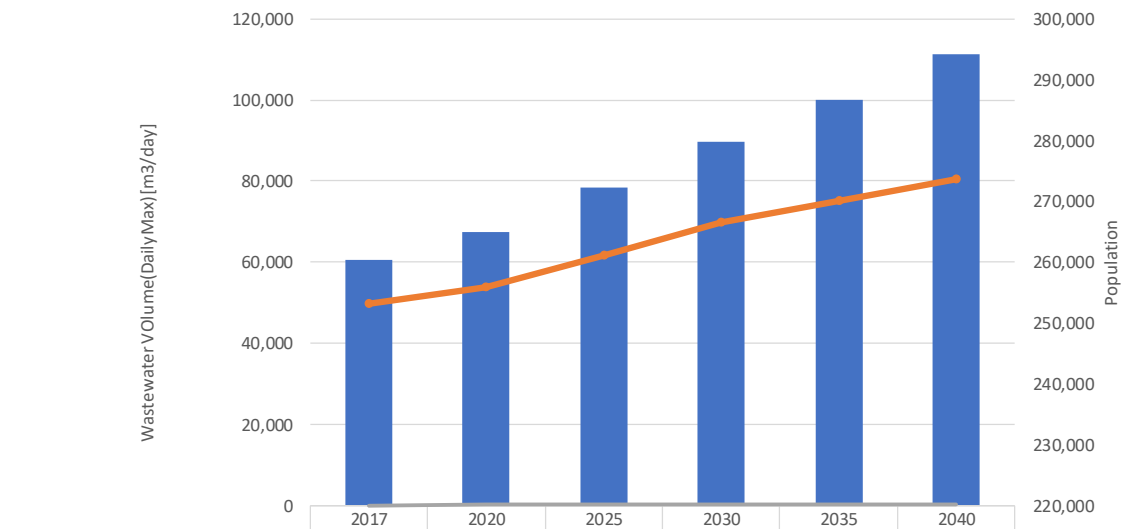
Source: JICA Study Team

Table 5.2.5 Wastewater Generation Volume (Hourly Maximum)

Unit: m^3/d

Township	2017	2020	2025	2030	2035	2040
Latha	8,617	9,821	11,334	12,482	13,631	14,779
Lanmadaw	14,138	16,200	20,060	23,777	25,939	28,100
Pabedan	11,491	13,122	14,772	16,300	17,828	19,356
Kyauktada	10,933	11,995	13,472	14,841	16,209	17,577
Botahtaung	17,854	19,174	21,204	23,083	24,961	26,840
Pazundaung	17,870	19,351	21,749	23,970	26,191	28,412
Dagon	9,938	11,580	15,280	20,022	25,223	31,754
Total	**90,842**	**101,243**	**117,871**	**134,475**	**149,982**	**166,819**

Source: JICA Study Team



	2017	2020	2025	2030	2035	2040
Wastewater Volume (Daily Max)	60,561	67,495	78,581	89,650	99,988	111,213
Daily Average Wastewater Counumption(lpcd)	203	220	250	278	306	333
Population	253,078	255,855	261,181	266,507	270,057	273,607

Source: JICA Study Team

Figure 5.2.1 Population Growth and Wastewater Volume (Daily Max) until 2040

5.2.3 Sewerage Development Plan for 2040

The general planning conditions of the sewerage developments are summarized as follows:

a) The target year is 2040;
b) The covered area is 990 ha, including 499 ha of the C1 area and 491 ha of the Dagon Township;
c) The sewerage-served population in 2040 is 273,607 people;
d) The daily average wastewater volume is estimated at 102,000 m^3/d;
e) The daily maximum wastewater volume is estimated at 112,000 m^3/d;
f) The hourly maximum wastewater volume is estimated at 167,000 m^3/d;
g) Separated system is applied; and
h) The current ejector system including sewer pipes, the ejector station, and an air pipe should be switched to the new sewerage system after the completion of the Project.

The planning conditions above were used as the basis for the design of the sewerage system including the sewers, WWTPs and associated works in the Study. The JICA Study Team has discussed a scenario of the development of the WWTP based on the improvement steps of the sewers and house connections. It is tentatively set in two step-wise development plans, first with the new WWTP construction followed by the upgrading of the existing WWTP because of continuous wastewater treatment service. The construction of trunk and branch sewers, as well as service sewers, shall be continuously implemented throughout the Project period.

In consideration of Loan Agreement, procurement of consultant, detailed design, and bidding

period, the timing of the commencement of construction is set to the middle of 2021. Improvement of sewer, wastewater treatment plant, and BDS improvement will be major component of the Project as mentioned in detail in Chapter 6. The sewerage development plan was formulated taking into account the progress of each construction work.

Development plan for the installation of sewer was divided into the three area where the BDS is available in CBD, not available in CBD, and the Dagon area. In the area where the BDS is available in CBD, it was considered that it is possible to collect wastewater relatively quickly by installation of the trunk sewer by the Project since there is a certain level of sewer system available in BDS. Also, in the area without BDS in CBD and the Dagon area, it is planned to take into account the period of each house connection since stepwise house connection after installation of the trunk sewer is required.

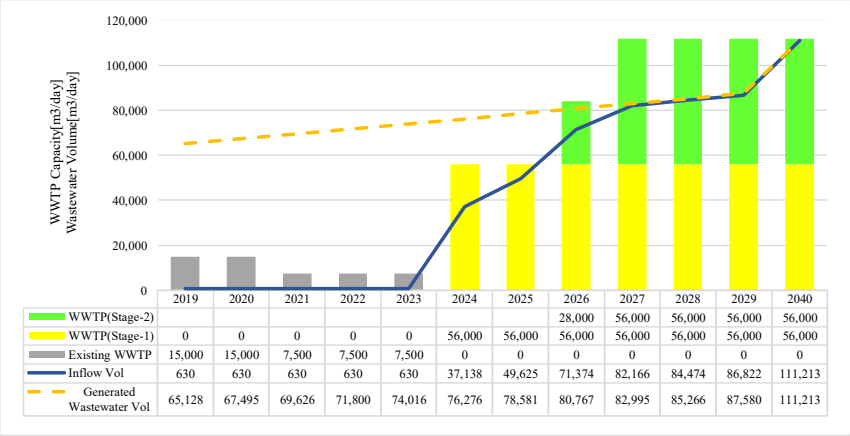
The existing WWTP has a capacity of 15,000 m^3/d; however, actual influent volume was recorded at an average of around 630 m^3/d. Therefore, only one out of two lanes are being operated with a capacity of 7,500 m^3/d. Sewage, which will be collected from the CBD area, where BDS is currently available will be conveyed and treated at the WWTP. The construction of the sewer and the WWTP with a capacity of 56,000 m^3/d will take three years. After the WWTP with the capacity of 56,000 m^3/d starts operation in 2024, sewer collection system will be replaced by new system instead of existing ejector system. To fill the gap between the generated wastewater volume and the sewage volume to be treated at the WWTP, further construction of sewers where BDS is currently not available and Dagon area, increasing the number of house connections, and expansion of the WWTP from 56,000 m^3/d to 84,000 m^3/d and 112,000 m^3/d will be required by 2026 and 2027 respectively. It should be noted that house connections in the future development areas, where no utilization takes place for the time being, have to be implemented by the house owner or the developer after 2027 in order to accomplish 100% service coverage. Sustained implementation of house connections will be required until 2040 in Dagon area because house connection ratio in 2029 will be 77%. The reason why house connection ratio in the area is lower than the other are is that the house connection will increase together with increase of the water supply coverage ratio.

The blueprint of the project implementation schedule is shown in Figure 5.2.2.

Period		Year												
		1	2	3	4	5	6	7	8	9	10	11	-	22
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	-	2040
		Pre-con. Stage			Construction Stage (6years)						DNP			
CP-1 (Sewer)														
a) CBD (BDS)		Procure Consultant, D/D and BID			Pipe installation									
b) CBD (No BDS)						Pipe installation		House connection						
c) Dagon (Part of W1)					Pipe installation			House connection						
CP-2 (WWTP)														
a) WWTP (New: 56,000m^3/d x 2)		Procure Consultant, D/D and BID			56,000m^3/d (half)			56,000m^3/d (half)						
					Existing under Operation									

		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	-	2040
a) CBD (BDS)	Sewer Inst. Ratio (%)	0%	0%	17%	50%	83%	100%	100%	100%	100%	100%	100%	-	100%
	House Connection (%)	95%	97%	97%	97%	98%	98%	99%	99%	99%	100%	100%	-	100%
	Collection Vol (m^3/d)※1	630	630	630	630	630	34,289	35,185	35,997	36,812	37,633	38,458	-	46,151
	Served Pop.	109,064	110,431	110,927	111,423	111,918	112,414	112,910	113,292	113,673	114,055	114,436	-	114,436
	Total Pop.	114,436	114,436	114,436	114,436	114,436	114,436	114,436	114,436	114,436	114,436	114,436	-	114,436
b) CBD (No BDS)	Sewer Inst. Ratio (%)	0%	0%	0%	0%	25%	75%	100%	100%	100%	100%	100%	-	100%
	House Connection (%)	0%	0%	0%	0%	0%	0%	25%	74%	99%	100%	100%	-	100%
	Collection Vol (m^3/d)※1	0	0	0	0	0	0	8,330	25,576	34,887	35,676	36,470	-	43,893
	Served Pop.	0	0	0	0	0	0	27,237	81,987	109,684	110,052	110,420	-	110,420
	Total Pop.	110,420	110,420	110,420	110,420	110,420	110,420	110,420	110,420	110,420	110,420	110,420	-	110,420
c) Dagon	Sewer Inst. Ratio (%)	0%	0%	17%	50%	83%	100%	100%	100%	100%	100%	100%	-	100%
	House Connection (%)	0%	0%	0%	0%	0%	22%	46%	71%	73%	75%	77%	-	100%
	Collection Vol (m^3/d)※1	0	0	0	0	0	2,849	6,110	9,801	10,467	11,165	11,894	-	21,169
	Served Pop.	0	0	0	0	0	7,875	16,709	26,547	28,072	29,640	31,251	-	48,751
	Total Pop.	30,074	30,999	32,064	33,130	34,195	35,260	36,325	37,390	38,455	39,520	40,585	-	48,751
Inflow Volume to WWTP(m3/d):Daily Max		630	630	630	630	630	37,138	49,625	71,374	82,166	84,474	86,822	-	111,213
WWTP Capacity (m3/d):Daily Max		15,000	15,000	7,500	7,500	7,500	56,000	56,000	84,000	112,000	112,000	112,000	-	112,000
Total Served Population		109,064	110,431	110,927	111,423	111,918	120,289	156,856	221,826	251,429	253,747	256,107	-	273,607
Total Population		254,930	255,855	256,920	257,986	259,051	260,116	261,181	262,246	263,311	264,376	265,441	-	273,607
Sewerage Service Ratio	Total Served Pop./Total Pop. x 100	43%	43%	43%	43%	43%	46%	60%	85%	95%	96%	96%	-	100%

※1 : Sewage Vol. from 2019 to 2023 was observed volume including sewage transported by Vacuum Truck



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2040
WWTP(Stage-2)								28,000	56,000	56,000	56,000	56,000
WWTP(Stage-1)	0	0	0	0	0	56,000	56,000	56,000	56,000	56,000	56,000	56,000
Existing WWTP	15,000	15,000	7,500	7,500	7,500	0	0	0	0	0	0	0
Inflow Vol	630	630	630	630	630	37,138	49,625	71,374	82,166	84,474	86,822	111,213
Generated Wastewater Vol	65,128	67,495	69,626	71,800	74,016	76,276	78,581	80,767	82,995	85,266	87,580	111,213

Source: JICA Study Team

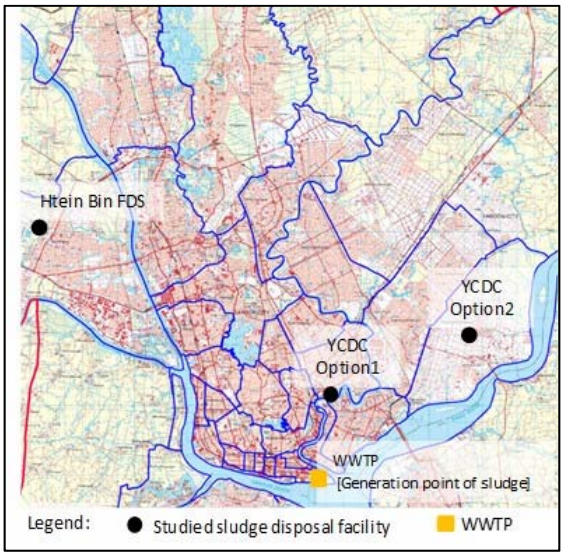
Figure 5.2.2 Development Plan for Construction of Sewer and WWTP by 2040

5.3 Precondition on Planning of Wastewater Treatment Plant Requested by YCDC

5.3.1 Background of the Request

(1) Lack of Disposal Site in Yangon City

Upon query of the JICA Study Team about the possible location of the sludge disposal facility, YCDC considered and proposed two lands owned by YCDC. However, both lands are evaluated as inappropriate by the JICA Study Team because it is surrounded by residential areas. It is difficult to make a consensus among stakeholders because they may complain about the development of the disposal facility and the offensive odour from the sludge.



Source: JICA Study Team

Figure 5.3.1 Location of the Proposed Sites for Sludge Disposal

The JICA Study Team suggested EDWS to confirm the possibility of disposing of the sludge to the final disposal site (FDS) of solid waste, Htein Bin FDS, managed by PCCD because it is practiced and commonly observed in other countries.

It is estimated that 60 ha is available for the Htein Bin FDS, assuming a layer thickness of 5.0 m, the remaining capacity of the site is estimated as about 3 million m^3 and it is not sufficient for the rapidly increasing amount of solid waste generated from the city. It is an urgent issue for YCDC to immediately find and secure a new site for solid waste disposal.

(2) Fire Incident at Htein Bin FDS

In the field survey, the fire at the sprawling Htein Bin FDS, located in the outer northwest of the Hlaing Tharyar Township, began on 21 April and spread quickly until it consumed more than half of the site. According to the Pollution Control and Cleansing Department (PCCD) of YCDC, the blaze was fuelled by the methane produced from decaying biodegradable organic waste. The fire was not under the complete control until 14 May. (Source: information from YCDC and Myanmar Times)

Source: YCDC

Figure 5.3.2 Fire Incident at Htein Bin FDS (April 2018)

In response to this incident, YCDC decided to consider carefully disposal of waste to this site in

the future. Initially, PCCD, the department of YCDC in charge of solid waste management, concluded that the dewatered sewage sludge generated in the wastewater treatment plant of this project shall be disposed in Htein Bin FDS. However, after this incident, PCCD did not agree to dispose dried sludge containing organic component into Htein Bin FSD and strongly requested the JICA Study Team to conduct a technical study on further treatment options in the wastewater treatment plant in order to reduce the volume of generated sewage sludge and to convert sludge into a form which would not produce methane gas, consequently reducing the risk of occurrence of a similar incident in the future. In addition, there is no vacant capacity in the other YCDC's FDS currently, so the Yangon Regional Government (YRG) intend to improve and develop the FDS in order for YCDC to appropriately and safely dispose and manage solid waste and sewage sludge generated from Yangon City, including this study area.

5.3.2 Preconditions for Study on Wastewater Treatment Plant

From the aforementioned situation, YCDC requested the JICA Study Team the following preconditions for planning of the wastewater treatment plant:

(1) Sludge Treatment Process and Facilities

- The sludge treatment process shall be i) thickening, ii) dewatering, and iii) drying.
- A mechanical drying method shall be implemented, but not a sun-drying method because this method needs a huge space and may affect the environmental condition around the sewage treatment plant due to odours, etc.
- The sludge treatment facility should be designed as compact as possible so that sludge incineration facilities and other components can be installed and so that an appropriate facility layout plan can be prepared in the future.
- The above requests from YCDC were made based on the consideration of the limitation of the area for sludge disposal site in Yangon city, but not only in the target study area. The sludge will be generated more with the increase of population from entire Yangon city. Therefore, currently, YCDC has a plan to construct sludge incineration facility in the existing WWTP area in order for minimizing the sludge volume and reducing the environmental impact.

(2) Utilization of the Existing Sewage Treatment Plant during Construction Works

- The existing sewage treatment plant shall be utilized until the operation of the new treatment facilities.
- The existing sewage treatment plant shall be demolished after the construction of new treatment facilities to secure space for future facilities including incineration facility.

The JICA Study Team conducted the study in accordance with the preconditions given by YCDC after confirming their validity in Chapter 6.

CHAPTER 6 PLANNING OF IMPROVEMENT AND DEVELOPMENT OF SEWERAGE SYSTEMS

6.1 Planning of Sewage Treatment Plant

6.1.1 Design Water Quality

(1) Design Influent Water Quality

The design influent water quality is shown in Table 6.1.1. Values were set based on the discussion with Yangon City Development Committee (YCDC) experts, considering the process of modification from the current sewer collection system.

Table 6.1.1 Design Influent Water Quality

Items	Design Value (mg/L)
BOD	250
SS	250

Source: YCDC

In the present sewerage system, the influent biochemical oxygen demand (BOD) value is recorded at around several thousand mg/L because only septage flows into the existing wastewater treatment plant (WWTP). Domestic wastewater will be collected and treated together with the septage when the new WWTP is installed.

During the discussion, YCDC proposed the design influent quality to have values of 250 mg/L for BOD and 250 mg/L for suspended solids (SS), which are referred to the values used in other members of the Association of Southeast Asian Nations (ASEAN) such as Kuala Lumpur, Manila, and Singapore, for the future development of Yangon City.

Based on Japanese design standards, a value of 54 g per capita per day is applied for both BOD and SS.

Accordingly, the validity of these design standards proposed by YCDC can be proved based on the following calculation:

Assuming that the operation of the new treatment plant is commenced in 2023, the estimated sewerage volume generated per person per day will be 242.5 L. Therefore, the influent BOD value will be 220 mg/L. (54 g per capita per day / 242.5 L per person per day x 1,000 = 220 mg/L)

Thus, the proposed design influent BOD and SS value of 250 mg/L is reasonable, including some margin due to fluctuation. YCDC and the JICA Study Team agreed in this regard.

(2) Design Effluent Water Quality

The design effluent water quality, which was set based on the value confirmed with YCDC in the past study (MLIT's Study in 2016), is shown in Table 6.1.2. The guideline for national effluent standards was established in Myanmar. However, the following limits are commonly used for treated effluent by the activated sludge process.

Table 6.1.2 Design Effluent Water Quality (YCDC Internal Guideline)

Items	Design Value (mg/L)
BOD	Less than 20
SS	Less than 30

Source: YCDC

6.1.2 Area for Sewage Treatment Plant

In the past studies, the area of the existing wastewater treatment plant was expected to be expanded by YCDC as shown in Figure 6.1.1.

However, according to YCDC, the area cannot be expanded due to the following reasons:

1) The area belongs to Myanmar Port Authority (MPA), not YCDC. Although YCDC has been negotiating with the authority for over five years to obtain the area, it was concluded not to be provided.
2) A lot of residents who have relatives in the Myanmar Navy live in the area. It will be impossible to resettle all of them.

Therefore, YCDC and the JICA Study Team confirmed that the sewage treatment plant study shall be conducted within the area of the existing treatment plant as shown in Figure 6.1.1.

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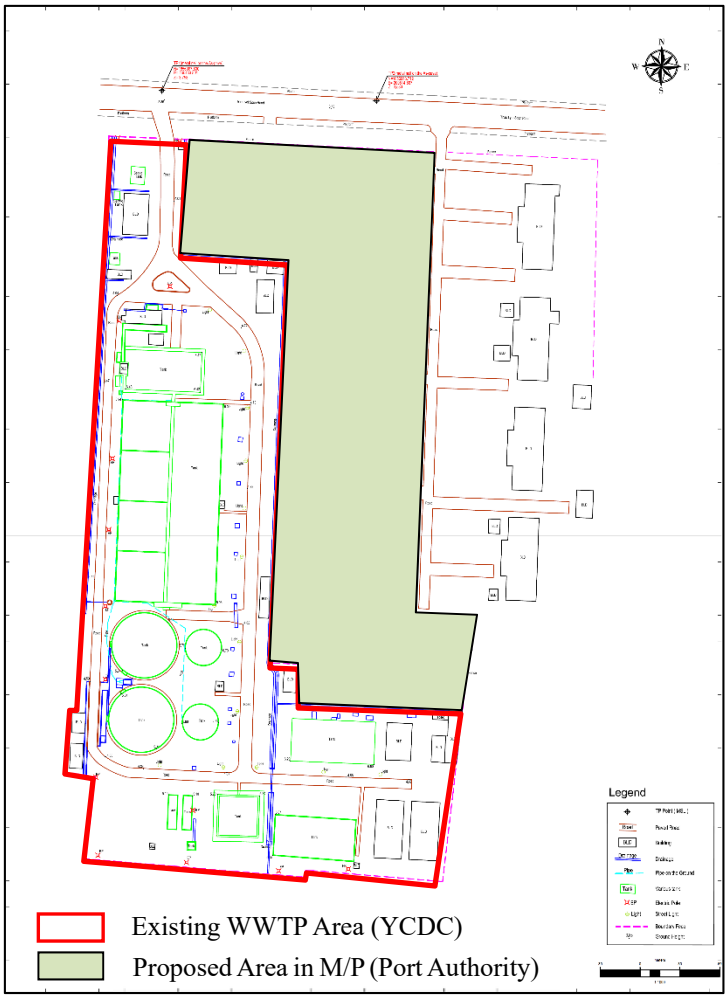


Source: JICA Study Team

Figure 6.1.1 Area of Existing Sewage Treatment Plant

6.2 Study for Wastewater Treatment Facility (WTF)

6.2.1 Primary Comparative Study for the Selection of Wastewater Treatment Process

The primary comparative study was conducted for six wastewater treatment processes which are the major processes applied in the world as shown in Table 6.2.1.

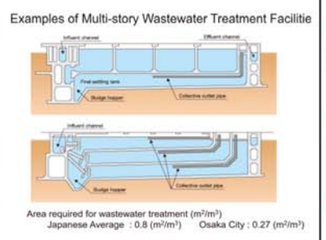
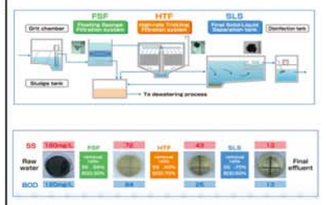
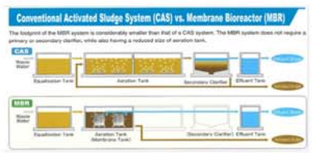
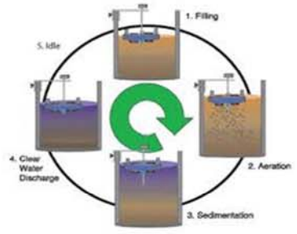
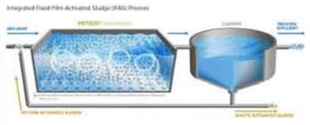
In this study, the applicability of the Advanced Treatment Method in the future will be one of the conditions for the selection of the treatment process with the following reasons:

- A higher effluent water quality standard will be considered in the future to maintain the water quality of the rivers in Yangon City due to further increase in population and development of Yangon City, similar to other Southeast Asian countries such as Singapore, Malaysia, Philippines, Thailand, Vietnam, etc. (The treatment process in some WWTPs in these countries were selected for modification into the Advanced Treatment Method in the future.)
- The study conducted by the Asian Development Bank (ADB) for the environmental

guideline (National Environmental Quality (Emission) Guidelines) in Myanmar recommended to remove nitrogen and phosphorus in the future.

- The Water Front Project of the Yangon River is being planned and will be implemented in the near future. Further, high water quality of the Yangon River might be required.
- The available land for WWTP is limited in Yangon City. It will be difficult to find another additional land in the future, even if required. Therefore, treatment processes which can be modified into the Advanced Treatment Method should be studied.

Table 6.2.1 Primary Comparative Study for the Selection of Wastewater Treatment Process

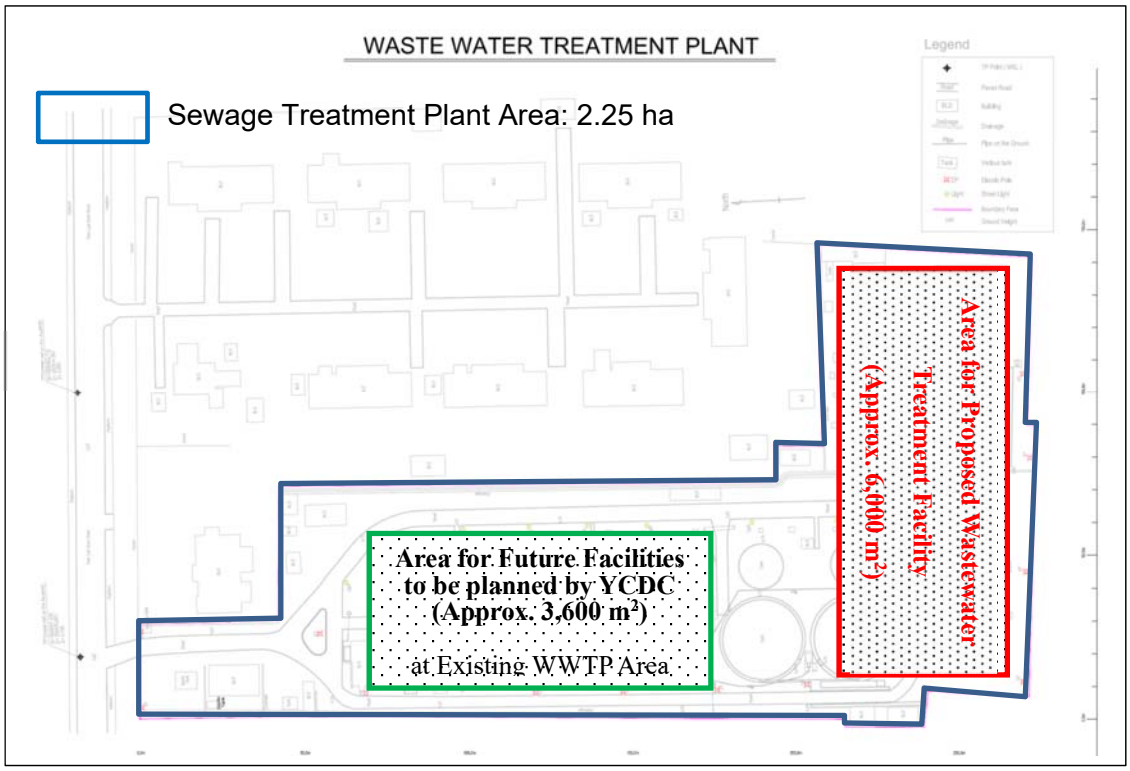
No.	Subject	Wastewater Treatment Process					
		CAS (incl. deep type)	**PTF (Pre-treated Trickling Filter)**	**MBR (Membrane Bioreactor)**	**SBR (Sequencing Batch Reactors)**	**OD (Oxidation Ditch)**	**IFAS (Integrated Fixed-Film Activated Sludge)**
	Process Image						
0	**Feature**	The deep type conventional activated sludge process, which uses a multi-layered sedimentation tank and a deep layer reactor, is a method which has been developed in 1960's. It is applicasble in case available land/space is limited. It can be applied for advanced treatment and several technologies/equipment which contribute to saving power consumption. This method is appllied in the major cities such as Tokyo, Osaka, Japan.	The PTF method is a treatment method developed for ASEAN nations and has the advantage that the power consumption is lower compared to the conventional methods. Considering the limited construction sites and high power cost in the target area, this method will be a very effective technology because the facility with this method will be compact and can save power consumption. However, this technology cannot support advanced treatment.	A technology which uses a space-saving and compact treatment method and supports advanced treatment is required for the treatment plant planning. MBR method can fulfill the both requirements. With the MBR method membrane units are set in a reactor tank and no final sedimentation tank will be necessary. As the primary sedimentation tank is not mandatory, this treatment method can greatly save space.	SBR is considered a fill-and-draw activated sludge system. The processes of equalization, aeration, and clarification are all achieved in the same tank, unlike a conventional activated sludge system, in which the same processes are accomplished in separate tanks. However, this process is not suitable for advanced treatment. (Skilled technique is required for the operation.)	The oxidation ditch (OD) is a sort of equipment used for a long-term aeration. It consists of a long channel of an elliptical or circular shape equipped with an aeration equipment called a rotor for generating a water flow and stirring water in the channel to supply oxygen. Thought it requires a relatively large area, it has a simple structure and can be easily operated as well as being able to remove nitrogen easily. Thus, it has recently been widely used in relatively small wastewater treating plants.	The Integrated Fixed-Film Activated Sludge (IFAS) process is typically installed as a retrofit solution for conventional activated sludge systems that are at or beyond capacity. IFAS upgrades offer an extremely cost-effective retrofit solution to municipal wastewater plant expansion, taking full advantage of existing systems, equipment, process knowledge, training, and operator skills. The technology is compatible with plug flow and complete mix configurations; IFAS hybrid processes are designed for complete compatibility with fine bubble aeration systems, providing demonstrated long-term operational cost savings.
1	**Operation Skill**	Fair	Easy	Fair	Fair	Easy	Fair
2	**Generated Sludge Volume (ratio to CAS)**	1	0.8	0.8	0.9	0.75	1.1
3	**Unit Energy Consumption (kWh/m^3)**	0.3	0.15	0.5	0.45	0.9	0.3
4	**Required Land Area for Typical Layout**	Small to Middle	Small to Middle	Small	Middle	Large (Difficult to place in the area)	Small to Middle
5	**Applicability to Advanced Treatment**	Applicable	Not Applicable	Applicable	Applicable, but treatment capacity is halved. (Operational adjustment is necessary)	Applicable, but treatment capacity is halved. (Operational adjustment is necessary)	Applicable
	Selection for Primary Comparative Study	*Selected*		*Selected*			*Selected*

6.2.2 Secondary Comparative Study for the Selection of Wastewater Treatment Process

(1) Applicable Space for Wastewater Treatment Facilities (WTFs)

Following the result of the primary comparative study, the secondary comparative study for the selection of wastewater treatment process shall be carried out taking into account the conditions mentioned in Section 5.3.

Therefore, the new WTF is only required to be placed within the area shown in Figure 6.2.1 considering the area for STF because the existing WTF will be operated until completion of the construction works of the new WTF, and the area will be used for future facilities which will be planned by YCDC.



Source: JICA Study Team

Figure 6.2.1 Applicable Space for Wastewater Treatment Facilities (WTF)

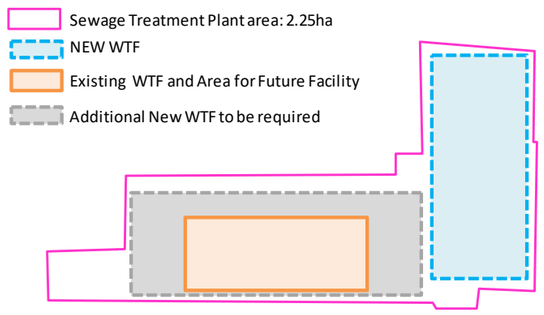
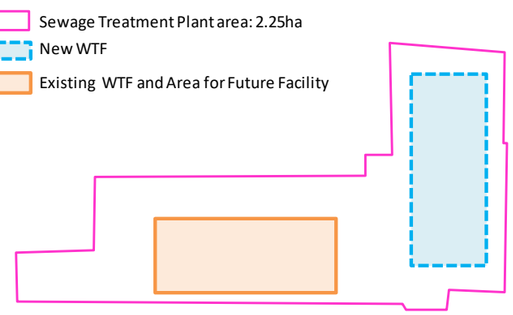
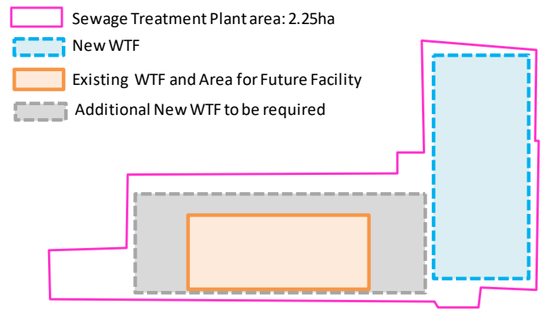
Therefore, only the treatment process which can be placed in the area will be applicable for this project.

(2) Selection of Wastewater Treatment Process

The study on the general layout plan of the WTFs was conducted as shown in Table 6.2.2

As a result, only the MBR process can be adopted to satisfy the conditions under which the existing treatment facilities shall be operated during the construction work, and the area shall be secured for future facilities as requested by YCDC.

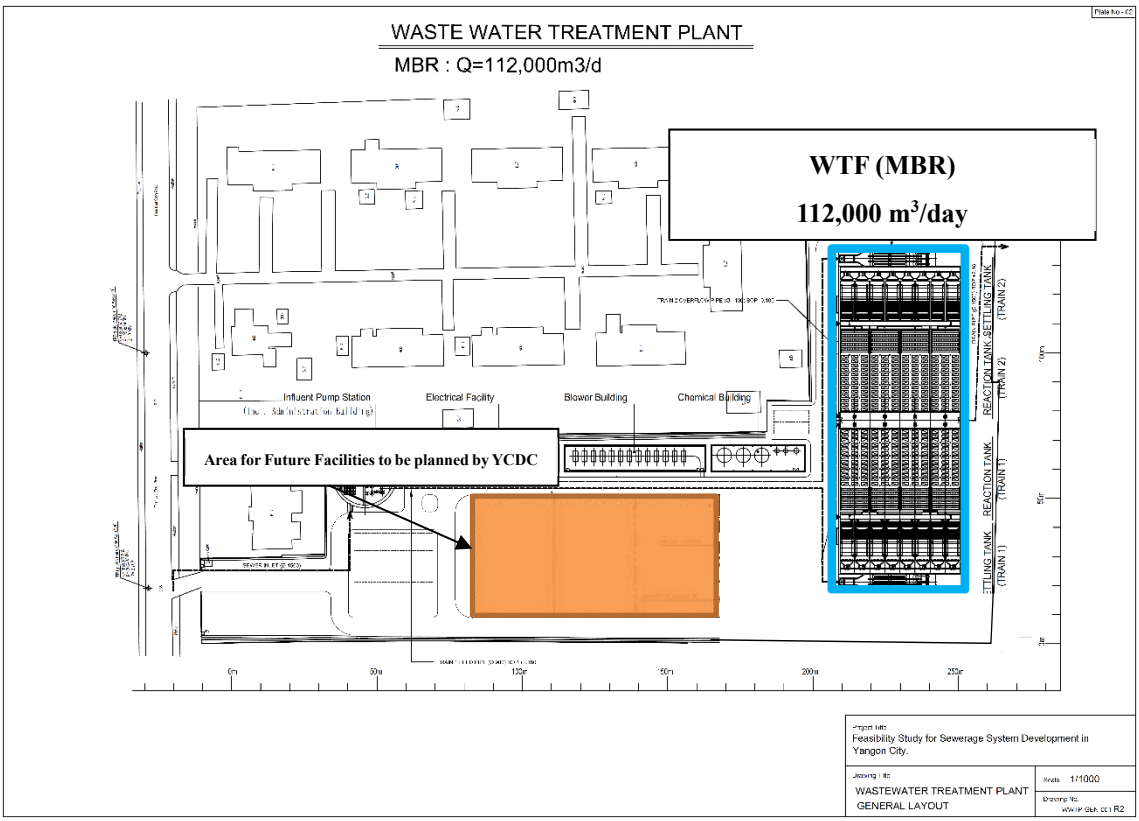
Table 6.2.2 Secondary Comparative Study on Wastewater Treatment Process

Subject		General Facility Layout Plan of Wastewater Treatment Facilitiy (WTF)		
		Option 1 : CAS (Deep Type)	**Option 2 : MBR**	**Option 3 : IFAS (Deep Type)**
General Facility Layout				
Features		**Dimension**	**Dimension**	**Dimension**
		Appcable Treatment Capacity (South) / **Less than 56,000m3/day**	**Appcable Treatment Capacity** / **112,000m3/day**	**Appcable Treatment Capacity** / **Less than 56,000m3/day**
		Primary Sedimentation Tank (2 Stories) / L=23m, B=55m(25*2), H=8m(4*2)	Primary Sedimentation Tank (2 Stories) / L=35m, B=55m(25*2), H=4m	Primary Sedimentation Tank (2 Stories) / L=23m, B=55m(25*2), H=8m(4*2)
		Reactor (Deep Type) / L=46m, B=55m(25*2), H=10m	Reactor / L=35m, B=55m(25*2), H=4m	Reactor (Deep Type) / L=40m, B=55m(25*2), H=10m
		Final Sedimentation Tank (2 Stories) / L=42m, B=55m(25*2), H=8m(4*2)	Final Sedimentation Tank (2 Stories) / -	Final Sedimentation Tank (2 Stories) / L=42m, B=55m(25*2), H=8m(4*2)
		Additional New STP / **Cannot be placed**		**Additional New STP** / **Cannot be placed**
		Not satisfied the design capacity	**Satisfied the design capacity**	**Not satisfied the design capacity**
Adaptability of Precondition required by YCDC	**WTF**	Need to demolish the existing WTF	**New WTF can be placed without demolition of the existing WTF**	Need to demolish the existing WTF
	STF	No space is available for sludge treatment facility (STF)	**Spece is available for sludge treatment facility (STF)**	No space is available for sludge treatment facility (STF)
	Existing WTF	Existing WTF cannot be operated during the constrcution work	**Existing WTF can be operated during the constrcution work and the area can be used for future facilities**	Existing WTF cannot be operated during the constrcution work
	Area for Future Facilities	Cannot be secured because the area of existing WTF will be required for an additional WTF	**Can be sedured because an additional WTF is not required**	Cannot be secured because the area of existing WTF will be required for an additional WTF
Maintenance		Maintenance road is difficult to place	**Maintenance road can be placed**	Maintenance road is difficult to place
Evaluation		**Area is insufficient for complete WWTP**	**Only MBR Method can be applicable with satisfaction of the technical conditions and the requirement of YCDC**	**Area is insufficient for complete WWTP**
		Not Applicable	**Applicable**	**Not Applicable**

6.2.3 Proposed Wastewater Treatment Facilities

As a result of the comparative study, the MBR process shall be applied for the project as it is the most appropriate. The facility layout plan is shown in Figure 6.2.2

The capacity calculation of the WTF is shown in Appendix 4.



Source: JICA Study Team

Figure 6.2.2 General Layout of Proposed Wastewater Treatment Facilities

6.2.4 Outlet

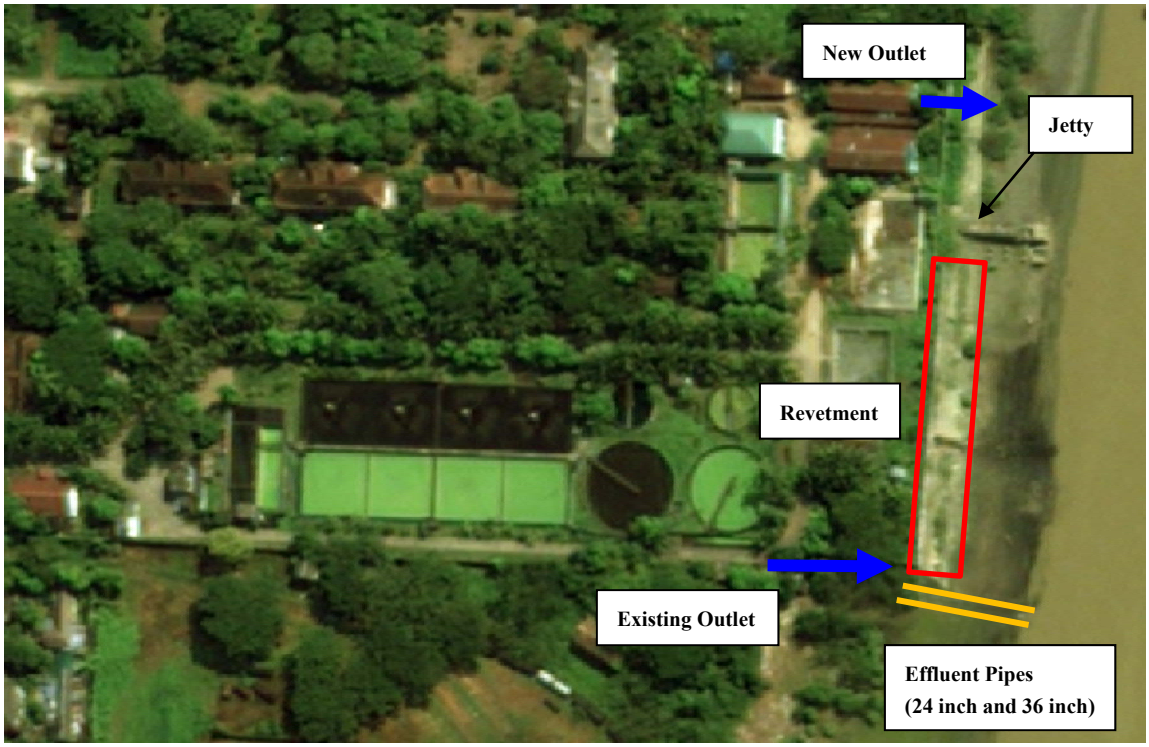
Revetments along the WWTP and jetty are removed so that a new outlet of the WWTP can be constructed. A part of the revetment and jetty is not an obstacle to the outlet construction. However, these structures should be removed because of the following reasons:

- The existing revetment is getting older, and part of it has already collapsed.
- Removal of the jetty is required to remove revetment for construction.

Revetment

Jetty

In addition, effluent pipes used for direct discharge of wastewater collected by the ejector system should be removed because it is unnecessary for the new sewage system. However, the area surrounding the revetment and some structures, e.g., revetment and jetty, belong to the MPA. Therefore, negotiation on the WWTP construction and the recovery of existing facilities with MPA will be required in the detailed design stage.



Source: JICA Study Team

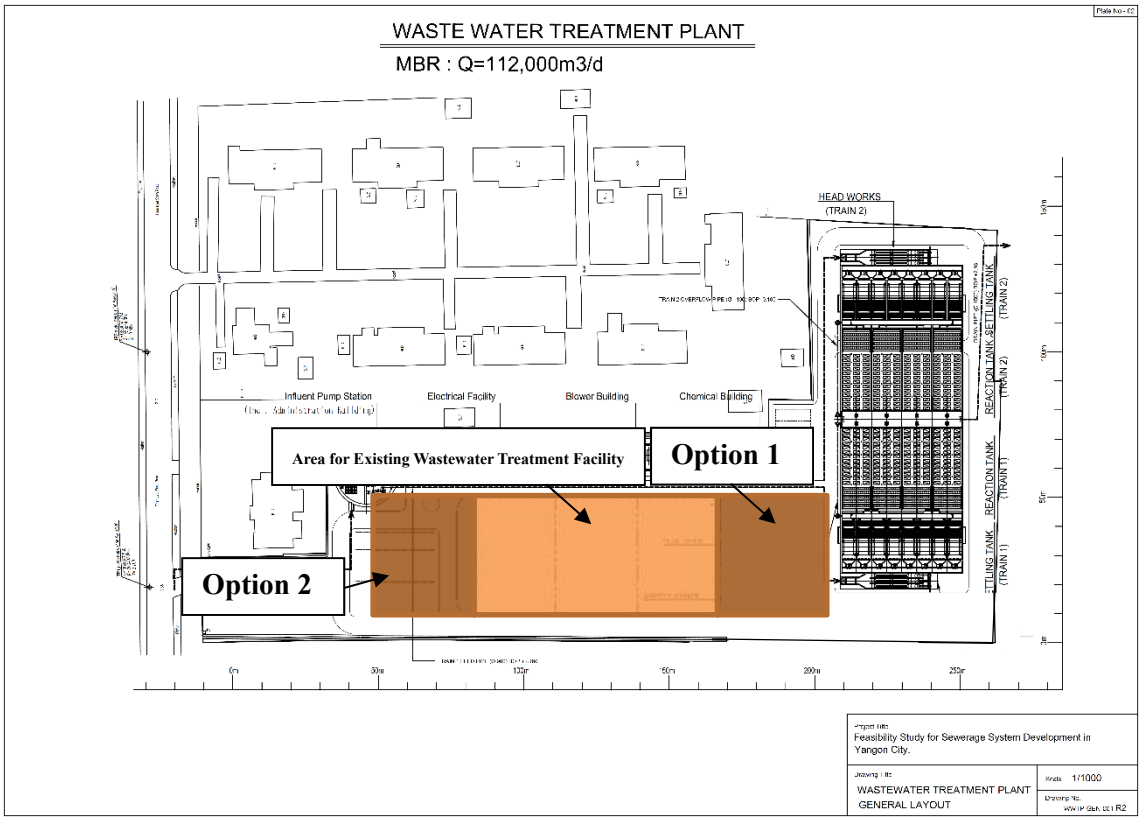
Figure 6.2.3 Location of Existing Facilities Relating to Outlet

6.3 Study for Sludge Treatment Facility (STF)

In this section, the STF is studied and planned as follows:

6.3.1 Available Area for Sludge Treatment Facility

As planned in Section 6.2, the two options considered for the STF area are shown in Figure 6.3.1.



Source: JICA Study Team

Figure 6.3.1 Options of Area for STF

Option 1 is considered to have better processing efficiency because it is closer to the water treatment facility. In addition, maintenance work is easier because the two facilities are adjacent to each other.

Therefore, Option 1 is selected for planning of STFs.

6.3.2 Comparative Study for Selection of Applicable Sludge Treatment Process

After wastewater treatment, excess sludge will be generated. Although the quantity of sludge generated in the C1 WWTP is currently small because it receives only a limited amount of wastewater, a large quantity of sludge will be generated as the new sewerage system is developed.

Sludge treatment is a combination of unit processes which comprises mostly of the reduction of volume and stabilization of sludge.

The optimum combination of the processes is dependent on the type of disposal method including the recycle policy. The following shows representative examples of the combination.

In this study, the following alternatives are considered in accordance with the preconditions requested by YCDC mentioned in Section 5.3, and the comparative study was conducted as shown in Section 6.3.3. (The option which treats the sludge only by dewatering process is not included in the followings from the points of view on the sludge volume, recycling and environmental conditions, etc.)

Option 1: Thickening + Dewatering + Sun Drying
Option 2: Thickening + Digestion + Dewatering + Sun Drying
Option 3: Thickening + Dewatering + Mechanical Drying
Option 4: Thickening + Dewatering + Incineration

As explained in Section 5.3, sludge drying should be conducted in the existing WWTP site, and dried sludge will be disposed of at suitable sites which will be developed by YCDC.

As a result, Options 1 and 2 are not applicable because the sludge drying bed, which will occupy an area of 6,600 m^2 (85% sludge moisture content for 30 days drying period), cannot be placed within the area as identified in Section 5.3. Also, it is not recommended to install a sun-drying bed, in consideration of the environmental impact to the surrounding residential area.

Also, maintenance work for the sun-drying bed is very difficult for the staff because the area is very large, and safety is a concern due to the bad environmental conditions.

On the other hand, Option 4, which requires the installation of incinerators, is planned by YCDC in the future after conducting the study of integration of sludge management with efficient construction and operational plan for whole Yangon city. Therefore, YCDC has the idea of constructing the incineration facility within the area of the existing WTF in the future as one of the additional facilities if it is required.

Accordingly, although the area for the additional facilities in the future will be secured in this study, installation of facilities for the incineration process for this project shall not be planned.

6.3.3 Proposed Sludge Treatment Facilities

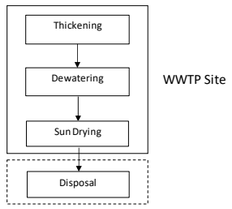
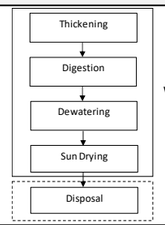
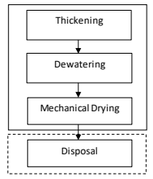
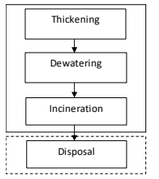
As a result of the comparative study in Section 6.3.1, Option 3 is recommended. In this section, the STFs including the mechanical drying process are studied.

(1) Type of Mechanical Sludge Drying Machine

There are three main types of dryers, which are listed as follows:

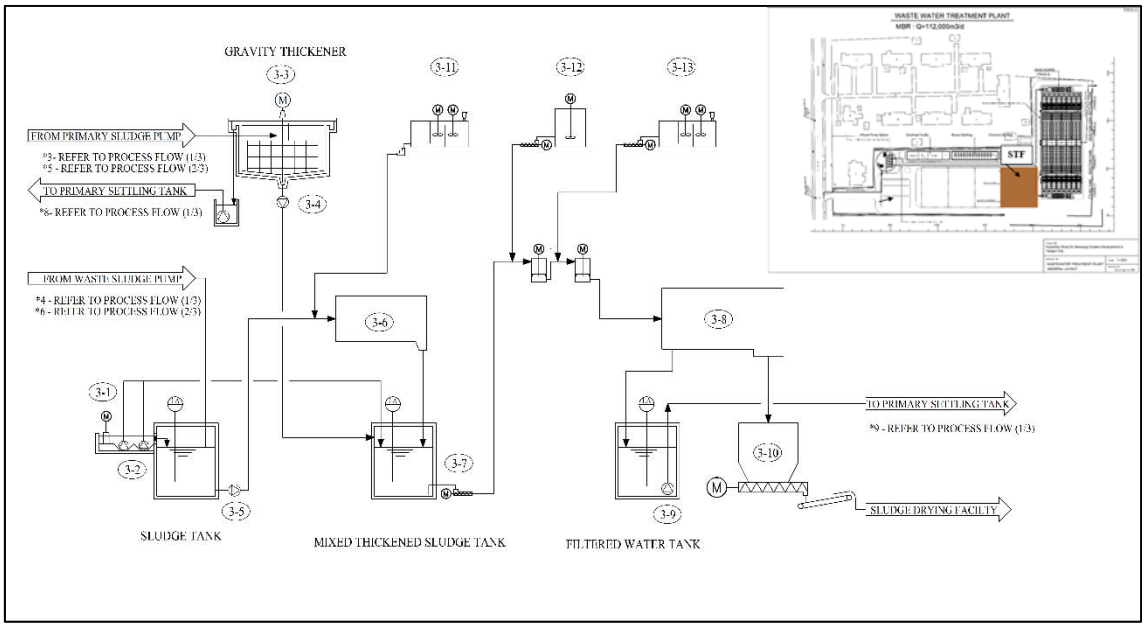
1) Disc Dryer Type
2) Hot Air Dryer Type
3) Band Dryer Type

Table 6.3.1 Comparative Study on Sludge Treatment Facility

		Option 1	Option 2	Option 3	Option 4
		Thickening + Dewatering +Sun Drying	**Thickening + Digestion + Dewatering + Sun Drying**	**Thickening + Dewatering + Mechanical Drying**	**Thickening + Dewatering + Incineration**
Process Flow					
Overview	**Thickening** *Outputted sludge Moisture* (97.5 %)	Raw sludge of about 2% concentration and excess sludge of about 0.8% concentration are mixed and fed as mixed sludge into the gravity thickener. After being thickened to a concentration of 2.5% in a gravity thickener, sludge is loaded into the Dewatering Equipment.	Raw sludge of about 2% concentration and excess sludge of about 0.8% concentration are mixed and fed as mixed sludge into the gravity thickener. After being thickened to a concentration of 2.5% in a gravity thickener, sludge is loaded into the digester.	Same as Option 1	Same as Option 1
	Digestion *Outputted sludge Moisture* (99%)	No digestion process applicable to Option 1	The organic content in sludge is reduced and the volume of sludge is stabilized in the digester. The odour from sludge is also reduced in this process and the digested sludge of about 2.5% concentration is loaded into the sludge dewatering machine.	No digestion process applicable to Option 3	No digestion process applicable to Option 4
	Dewatering *Outputted sludge Moisture* (82%)	Being dewatered, sludge cake with about 82% water content by using mechanical dewatering equipment, sludge is disposed offsite.	Same as Option 1	Same as Option 1	Same as Option 1
	Drying (Natural or Mechanical) Sludge Moisture (60%)	Being delivered to the existing dumping site (Htein Bin Fial Disposal Site), then being dried for about 30 days on the sludge drying bed, sludge reaches down to 40 % of water content approximately. Sludge Drying time is 30 days.	Same as Option 1	Mechanical Drying inside the territory of existing WWTP reduces the dewatered sludge volume.	No Drying process applicable to Option 4
	Incineration	No incenertion process applicable to Option 1	No incenertion process applicable to Option 1	No incenertion process applicable to Option 3	To reduce drastically the dewatered sludge volume by introducing incineration process to the other process
General Features of Process		- Since the dewatered sludge contains a large quantity of undissolved organic, it is volatile and generates odor. - Sludge drying is a process with the objective of further enhancing handling of sludge so that the moisture content in sludge can be further reduced and stabilized and it can be used in agricultural land applications.	- Possible to reduce solid waste volume in digested sludge by drying bed and improve the volatility - Large space for the premises is necessary - Sludge drying is a process with the objective of further enhancing handling of sludge so that the moisture content in sludge can be further reduced and stabilized and it can be used in agricultural land applications.	- Possible to reduce sludge volume - Space for the premises is necessary	- Possible to extremely reduce solid waste volume - Large space for the premises is necessary
Required Space in WWTP		N/A (7,200m2 (Drying bed cannot be placed))	N/A (9,500m2 (Drying bed cannot be placed))	1,500m2	2,800m2
Sludge Volume		After Dewatering: 200t/day, Drying: 46m3/day	After Dewatering: 100t/day, Drying: 46t/day	After Dewatering: 200t/day, Mechanical Drying: 46t/day	After Incineration: 9t/day
Initial Cost		**N/A**	**N/A**	32 million USD (42,800 million MMK)	62 million USD (83,000 million MMK)
Running Cost		**N/A**	**N/A**	3.5 million USD (4,600 million MMK)	4.0 million USD (5,200 million MMK)
Advantages		**N/A**	**N/A**	- As YCDC requested, drying process can be placed within WWTP site, so, the sludge generation volume can be reduced. - Duration for mechanical drying process is much shorter than sun-drying process. - Odor impact is much less than sun-drying process.	- The generated sludge volume will be much less than Option 3. - Transportation cost to dumping site will be reduced less than Option 3.
Disadvantages		**N/A**	**N/A**	- Running cost is higher than sun-drying process.	- Running cost is higher than Option 3 because fuel will be necessary for incineration. - Moisture content should be reduced for efficient incineration. (i.e. to add drying process, however, sun-drying process cannot be placed due to land limitation as mentioned in Option 1 and 2.)
Selection		- As YCDC's given condition, sludge drying process will be accommodated in WWTP site. However, the sun drying bed cannot be placed because the huge area is required. - The sun dring process is not recommended considering the environmental impact surround the area.	- As YCDC's given condition, sludge drying process will be accommodated in WWTP site. However, the sun drying bed and digestion facility cannot be placed because the huge area is required. - The sun dring process is not recommended considering the environmental impact surround the area.	- As YCDC requested, the sludge drying process can be accommodated in WWTP site. - The drying machine can be used for a part of incinerator if it is inslatted in the future by YCDC.	- YCDC would like to install an integrated incineration facility in future. (A study on the integrated sludge management plan for the entire Yangon city will be conducted separately from this study for future installation of incineration process.) - Therefore, incineration facilities will be installed in future by YCDC after the study.
		NOT APPLICABLE	**NOT APPLICABLE**	**SELECTED**	-

(2) Process Flow Diagram of STFs

The process flow diagram of the STF is shown in Figure 6.3.2. The installing place of dewatering building and mechanical sludge dryer is shown in Figure 6.3.3.

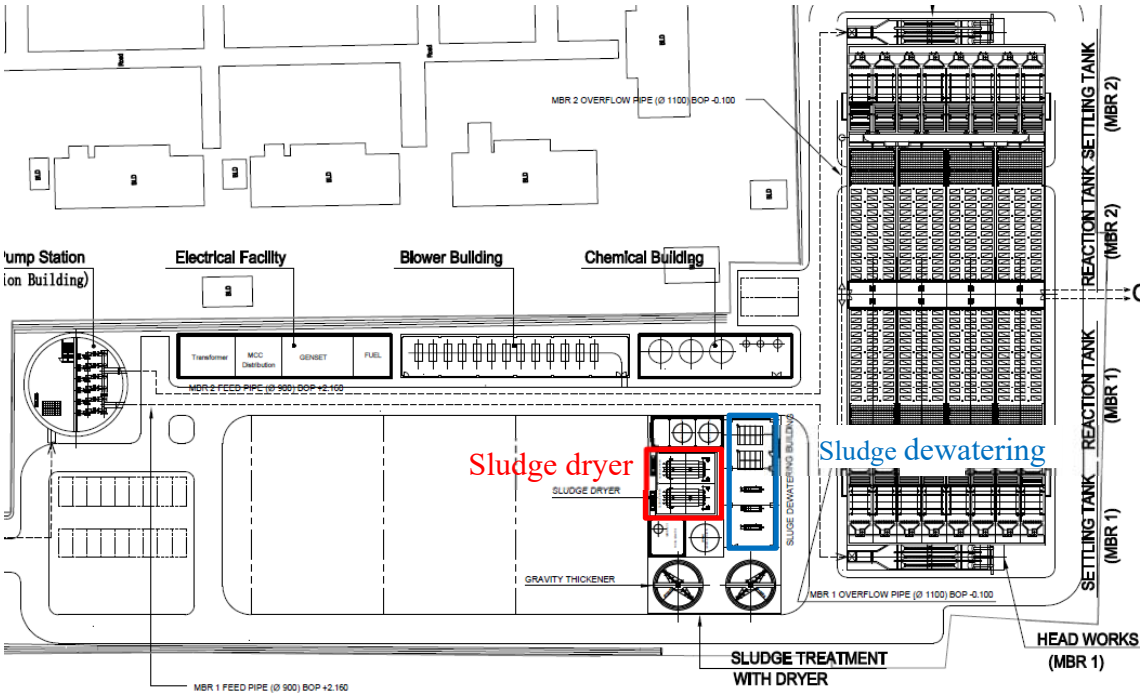


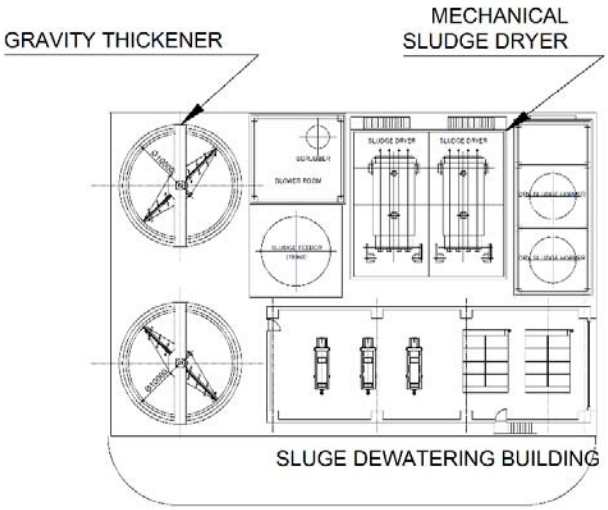
Source: JICA Study Team

Figure 6.3.2 Process Flow Diagram of Sludge Treatment Facilities

(3) General Layout of STFs

In accordance with the study results, the general layout of STFs is planned as shown in Figure 6.3.3.





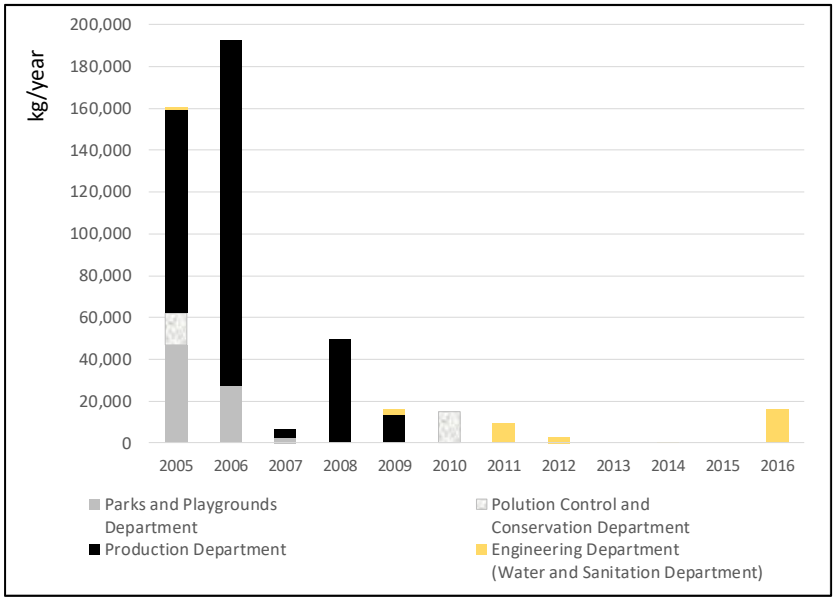
Source: JICA Study Team

Figure 6.3.3 General Layout of Sludge Treatment Facilities

(4) Necessity of Disposal Facility for the Future

The EDWS envisages that they would, as much as possible, utilize sludge generated from the new WWTP enhanced by the project instead of simply disposing it as solid waste. While the JICA Study Team respects their idea, it may not be possible to utilize all of the sludge from the new WWTP considering the amount of dried sludge utilized in the past years. The amount of dried sludge generated from the new WWTP is preliminarily estimated at about 46 t/day (moisture content: 35%) in its full operation years, which is equivalent to more than 60 times the volume utilized in 2006 as shown in Figure 6.3.4.

Therefore, it is necessary to find and secure such facility to prepare for future sludge generation since sludge which will not be utilized in the future have to be disposed appropriately.



Source: YCDC

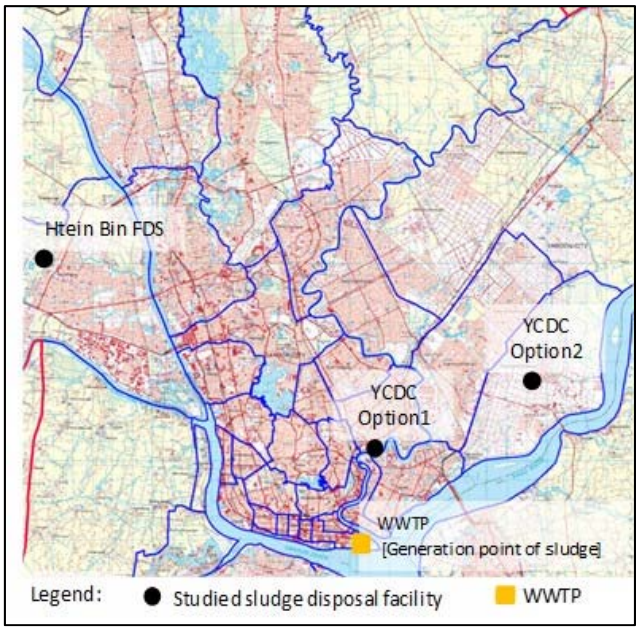
Figure 6.3.4 Estimated Amount of Sludge Utilized, Based on Record of YCDC

(5) Possible Site for Sludge Disposal

Upon query by the JICA Study Team about the possible location of the sludge disposal facility, YCDC considered and proposed two lands owned by YCDC. However, both lands are evaluated as inappropriate by the JICA Study Team because they are surrounded by a residential area. It is difficult to make a consensus among stakeholders because they may complain about the development of a disposal facility, especially due to the offensive odour from the sludge.

The JICA Study Team suggested EDWS to confirm the possibility of disposing of the sludge to the final disposal site (FDS) of solid waste, i.e., Htein Bin FDS, managed by PCCD of YCDC because this practice is commonly observed in other countries. Htein Bin FDS has been operated for 15 years since 2002. The remaining area of the FDS is estimated to be about 60 ha out of the total 120 ha. According to PCCD, more than 800 tons of solid waste is being hauled and disposed of at the FDS every day, while the amount of solid waste generation in Yangon increases in accordance with city development. Figure 6.3.5 shows the studied candidate disposal site.

After a series of meetings between relevant officials including those from EDWS and PCCD, it was agreed that YCDC will consider with YRG to prepare a proper FDS for the dried sludge as solid waste.



Source: YCDC

Figure 6.3.5 Location of the Studied Final Disposal Facility of Sludge

6.4 Adjustment of Existing Wastewater Treatment Plant for Utilization during Construction Work

6.4.1 Conditions

As mentioned in Section 5.3, the existing WTF will be operated until the commencement of operations of the new WTF from the viewpoint of effective utilization of existing facilities as

requested by YCDC.

As explaining in Chapter 8, the WWTP, which capacity is 112,000m3/day, is scheduled to build one by half of capacity, 56,000m3/day, considering the required sewage treatment volume generated. The existing wastewater treatment facility will be operated until completion of the half and stop the operation after starting the operation of half of the new WWTP.

In this section, the necessary adjustment of the facility is studied as follows.

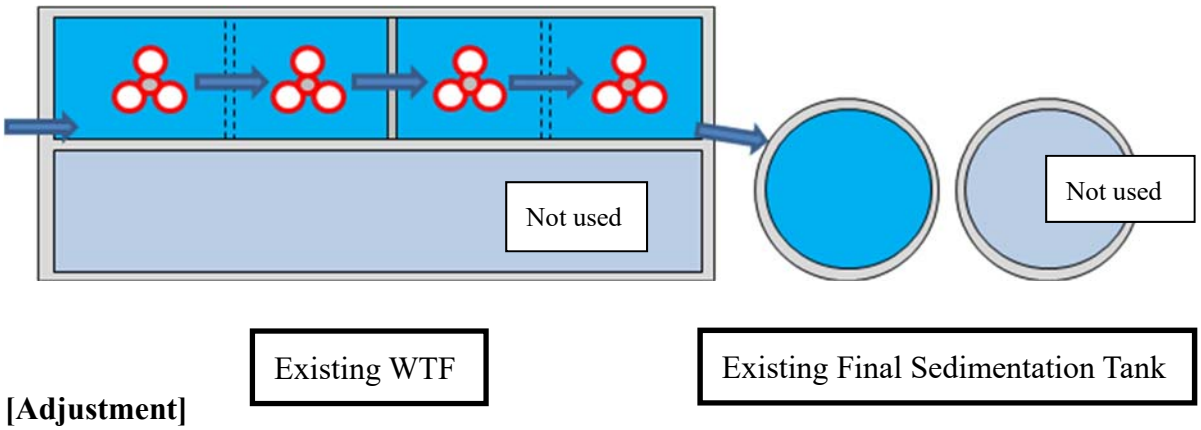
6.4.2 Necessary Adjustment of Existing Wastewater Treatment Plant

(1) Method for Adjustment

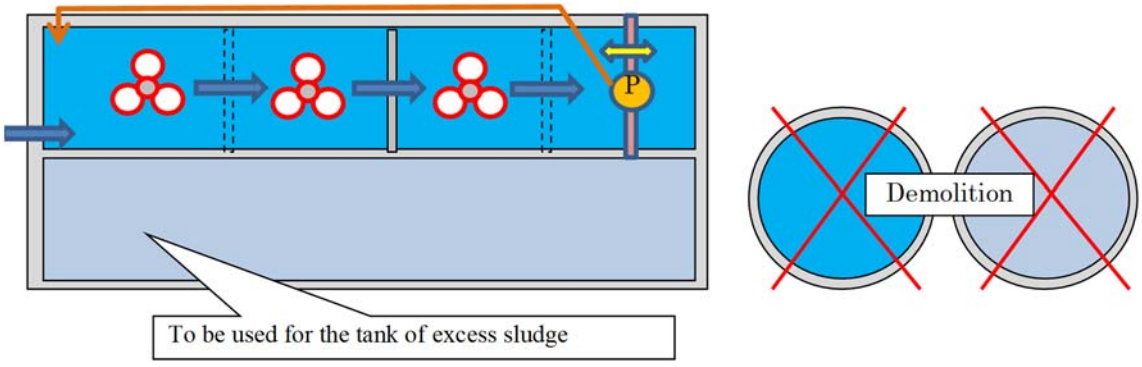
The capacity of the existing WTF is 15,000 m^3/day (actual influent volume is 500~2,000 m^3/day, BOD is approx. 600 mg/L). Currently, only the half stream, which corresponds to a capacity of 7,500 m^3/day, is being operated and is required to operate during the construction works.

Therefore, the following adjustment of the facility is proposed and recommended in order to ensure the proper wastewater treatment as a temporary countermeasure.

[Existing]



[Adjustment]



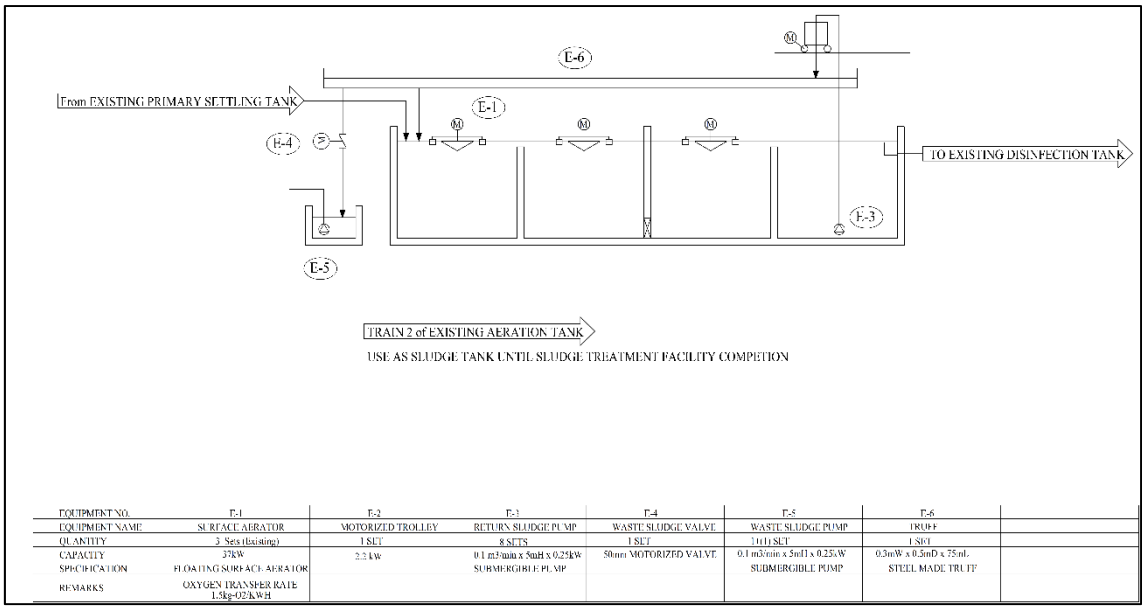
Source: JICA Study Team

Figure 6.4.1 Adjustment Method of Existing Wastewater Treatment Facility

One of the existing final sedimentation tanks, which has a diameter of 24.5 m and an area of 471.40 m^2, is not being used at present.

As shown in Figure 6.4.1, the reactor is divided into four tanks, so the final tank, which temporary submergible pump facility is placed, is adjusted to be used as a final sedimentation tank. The sedimentation tank can be used without dewatering in the existing tank by installing a temporary submergible pump on the beam across the tank. A half of the existing wastewater treatment facility will be used for excess sludge which will be generated during the operation because the existing sludge drying yard cannot be utilized at that time.

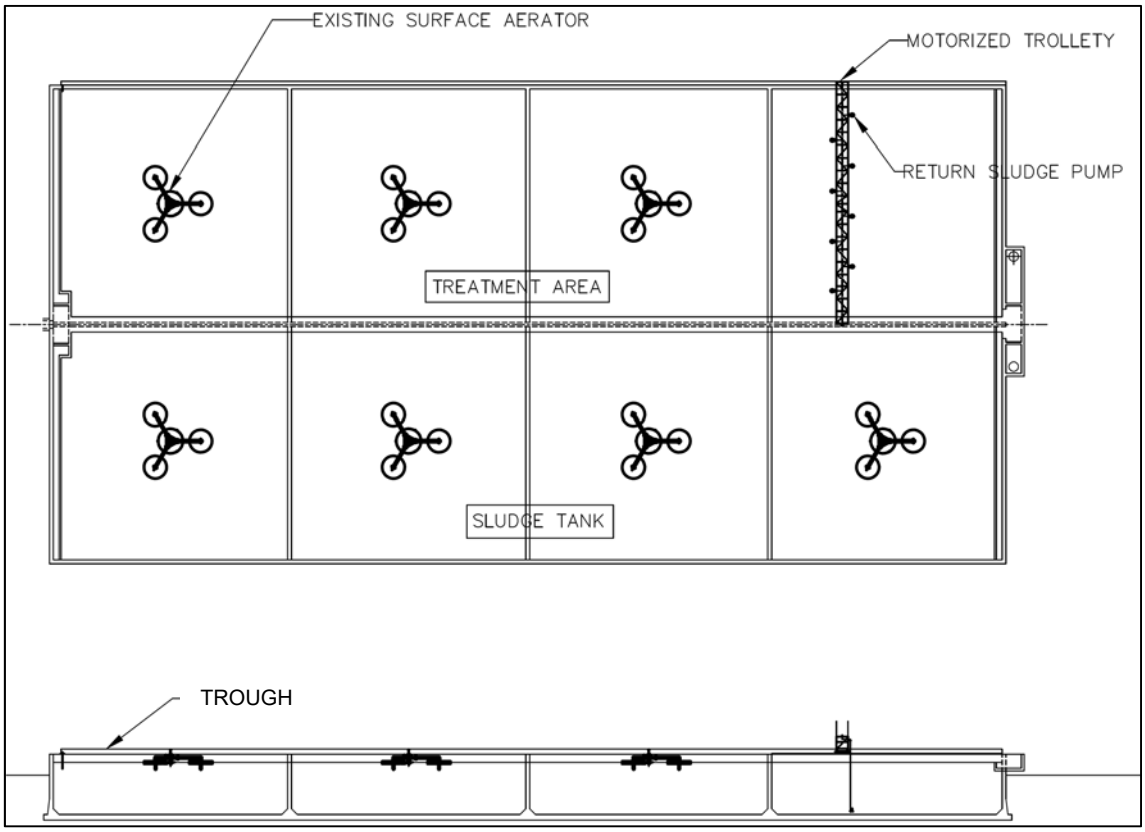
The process flow and general layout are shown in Figure 6.4.2 and Figure 6.4.3.



EQUIPMENT NO.	E-1	E-2	E-3	E-4	E-5	E-6	
EQUIPMENT NAME	SURFACE AERATOR	MOTORIZED TROLLEY	RETURN SLUDGE PUMP	WASTE SLUDGE VALVE	WASTE SLUDGE PUMP	TRUFF	
QUANTITY	3 Sets (Existing)	1 SET	8 SETS	1 SET	1+(1) SET	1 SET	
CAPACITY	37kW	2.2 kW	0.1 m3/min x 5mH x 0.25kW	50mm MOTORIZED VALVE	0.1 m3/min x 5mH x 0.25kW	0.3mW x 0.5mD x 75mL	
SPECIFICATION	FLOATING SURFACE AERATOR		SUBMERGIBLE PUMP		SUBMERGIBLE PUMP	STEEL MADE TRUFF	
REMARKS	OXYGEN TRANSFER RATE 1.5kg-O2/kWH						

Source: JICA Study Team

Figure 6.4.2 Process Flow of Adjusted Existing WTF



Source: JICA Study Team

Figure 6.4.3 General Layout of Adjusted Existing WTP

The capacity calculation sheet is attached in Appendix 5.

(2) Operation Method

The operation method is proposed below.

1) Eight submergible pumps, which are installed at the final (4th) tank, are operated to remove the sludge.
2) The return sludge is sent by using a trough.
3) The excess sludge is removed by the electric valve.
4) The second stream is used for the excess sludge tank. (The excess sludge will be 2 m^3/day*. The capacity of second stream is approx. 5,400 m^3, so it can be used for two or three years. Even if the sludge overflows from the second stream, its volume will be very small, so it can be returned to the treatment process.)

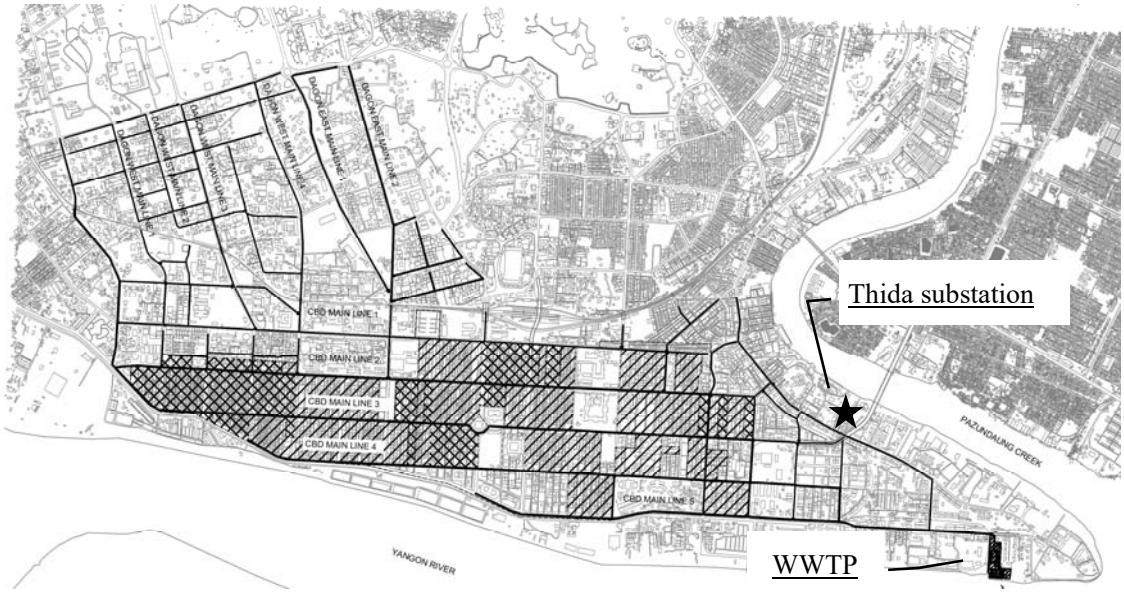
*Design Flow (2,000m^3/day) x BOD (600mg/L) / 1,000 / Concentration (0.6%) /1,000

5) The adjustment/modification of the facility can be completed without suspending operations.

6.5 Electric Supply Plan to WWTP

JICA Study team and Yangon Electricity Supply Corporation (YESC) agreed that Thida substation will supply electric power required for the operation of the WWTP. The voltage and the capacity of main transformer in the substation is 66/33 kV and 20 MVA respectively. The YESC is planning to increase power supply to Yangon city in order to meet the future demand.

YESC recommends that power cable shall be installed underground in the CBD because it can obstruct other construction works. Therefore, it was decided that the power cable from the substation to the WWTP should be installed underground in the study. In addition to the above, YCDC will bear the installation cost of the power cable. The Thida substation is located in Botahtaung township which is 2 km far from the WWTP as shown in Figure 6.5.1.



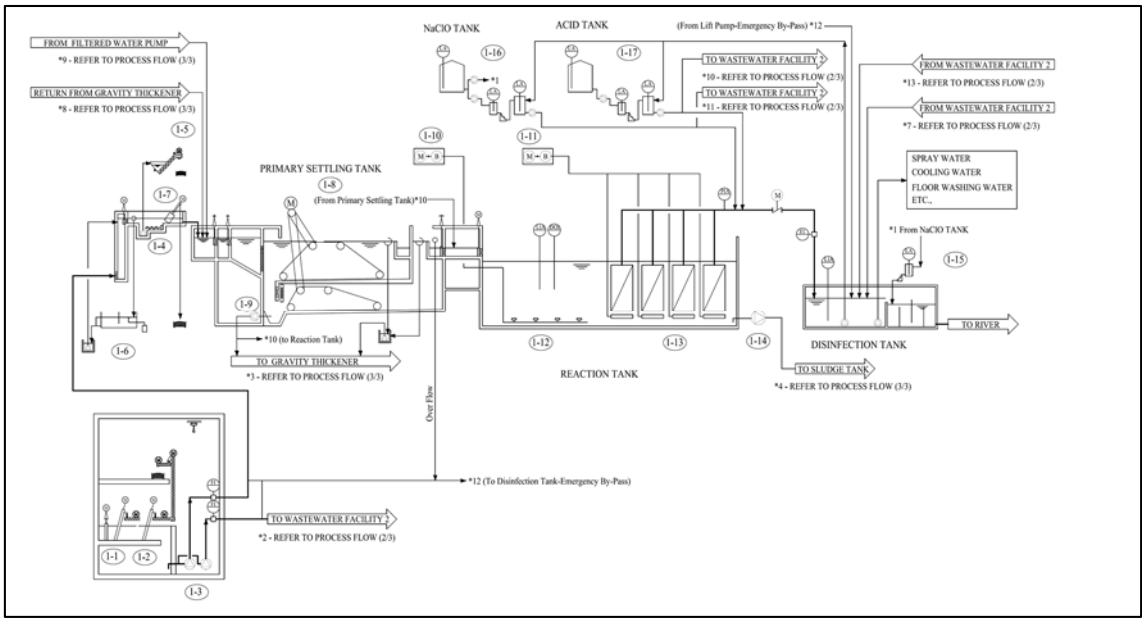
Source: JICA Study Team

Figure 6.5.1 Location of Thida Substation

6.6 General Facility Layout Plan of Wastewater Treatment Plant (WWTP)

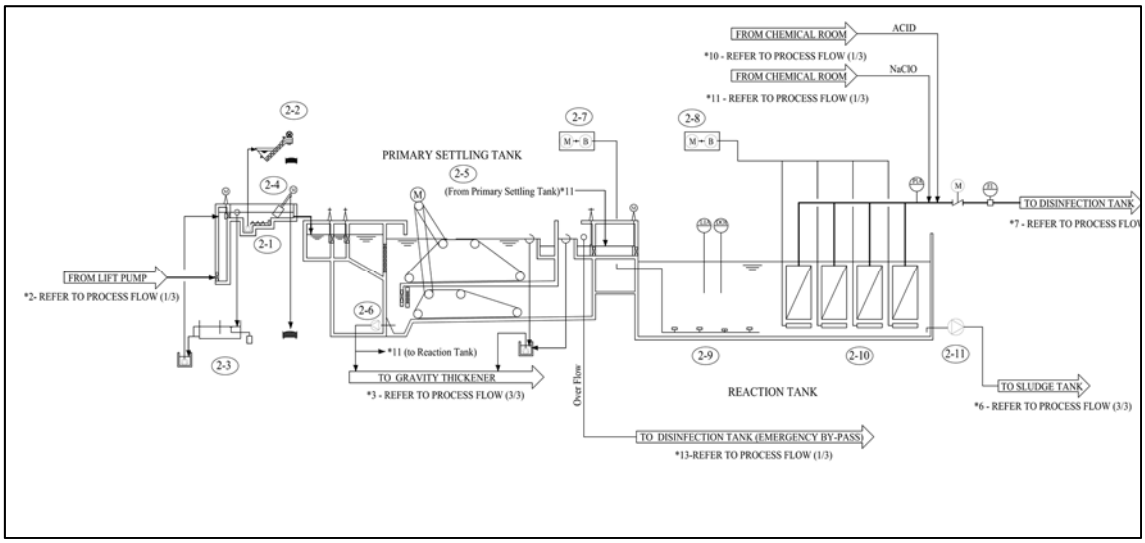
(1) Process Flow

The diagrams of the wastewater treatment and sludge treatment processes are shown in Figure 6.6.1, Figure 6.6.2, and Figure 6.6.3. The installing place of dewatering building and mechanical sludge dryer is shown in Figure 6.3.3



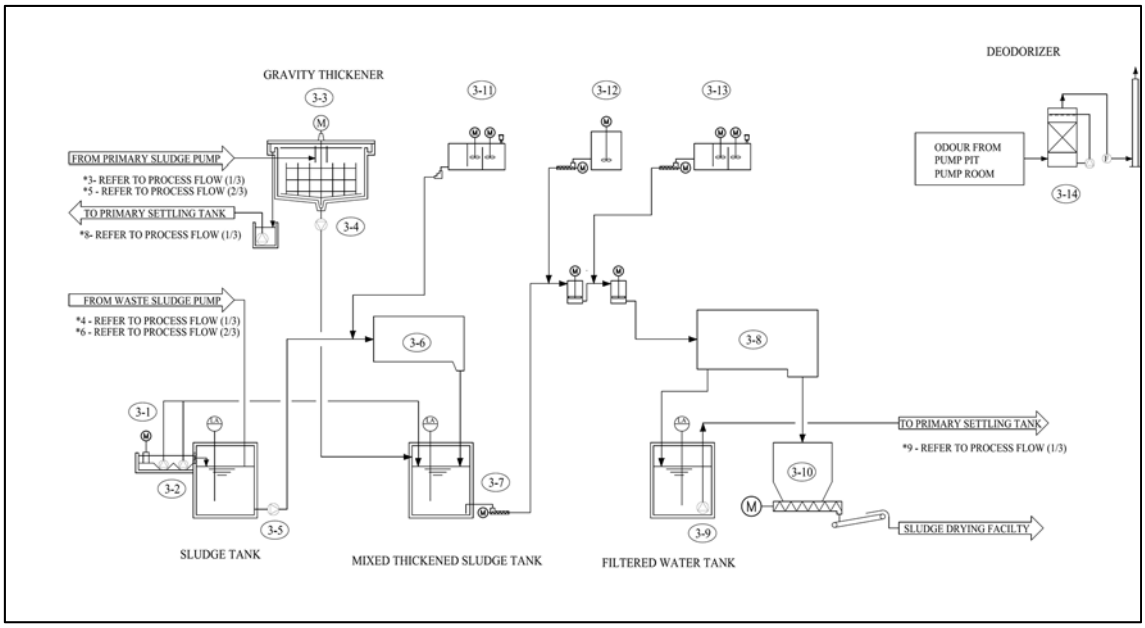
Source: JICA Study Team

Figure 6.6.1 Process Flow Diagram 1



Source: JICA Study Team

Figure 6.6.2 Process Flow Diagram 2

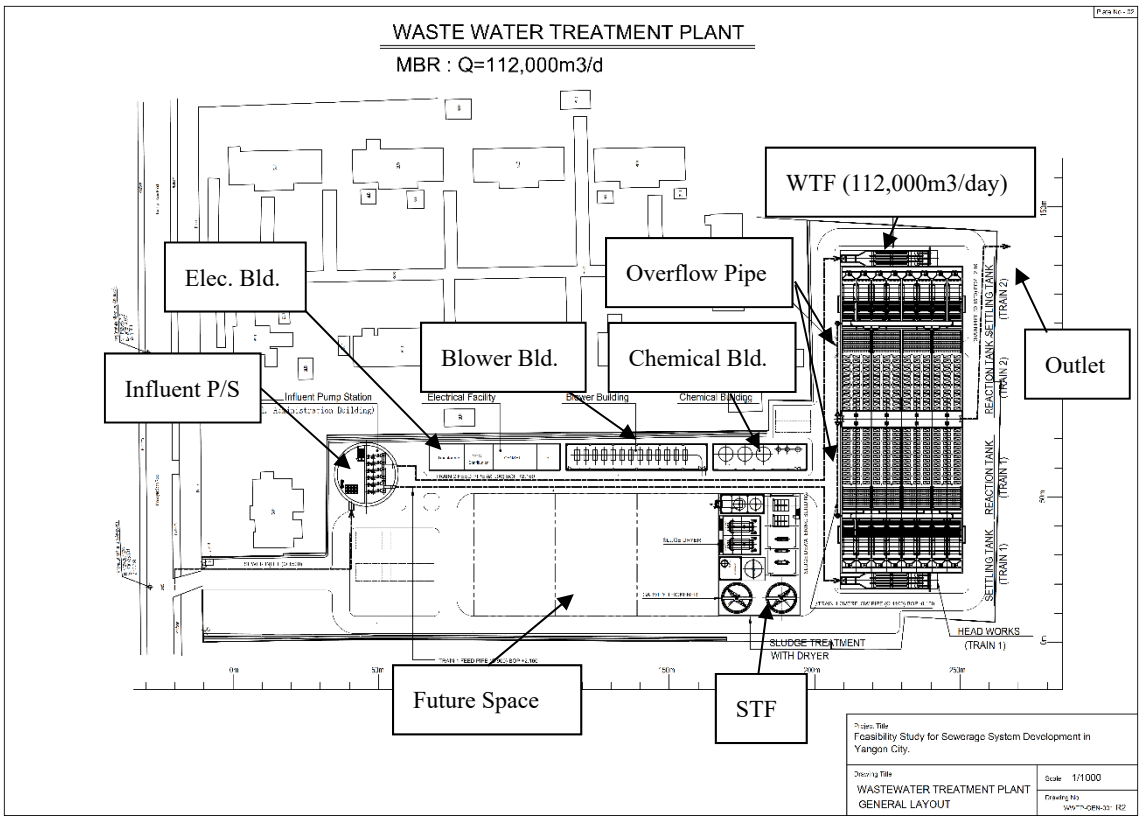


Source: JICA Study Team

Figure 6.6.3 Process Flow Diagram 3

(2) General Facility Layout Plan of the WWTP

The general facility layout plan of the WWTP is shown in Figure 6.6.4.



*The new electrical transmission line will be installed from THIDA substation (33 kV) to the WWTP

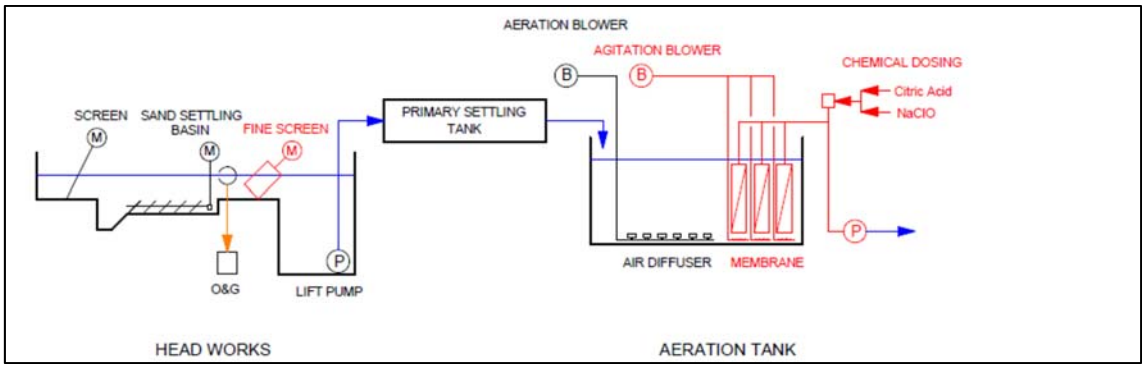
Source: JICA Study Team

Figure 6.6.4 General Facility Layout Plan of the WWTP

6.7 Operation and Maintenance of the WWTP

In this section, O&M of the MBR are described.

The equipment marked as red in Figure 6.7.1 are the main facilities which should be noted in the O&M.



Source: JICA Study Team

Figure 6.7.1 Diagram of MBR Process

6.7.1 Important Points of Operation of WWTP

Important points of the operation of MBR are shown in Table 6.7.1.

Table 6.7.1 Important Points of Operation of MBR

Important Points	Matters on Operation	Method/Countermeasure
To Avoid Membrane Fouling	Bacteria, calcium, etc., will adhere on the surface of the membrane and will clog in membrane pores. Prolonged adherence in pores becomes difficult to remove. Thus, membrane flux reduces.	Periodic chemical cleaning is required. Normally, it should be done every 3 months. Chemicals used are citric acid and NaClO.
To Avoid Flocculant Leak	When there is an overdose of flocculant for the dewatering unit, residual flocculant will leak to the aeration tank. If flocculant adheres on the membrane, flux will reduce.	Flocculant for the dewatering unit shall be properly adjusted. Never drain unused flocculant solution.
To Avoid No-Flow Agitation	If there is no filtering but agitation is still continuous, the membrane will be damaged physically. (for flat type)	While there is no filtering done, agitation shall be operated intermittently. MBR shall operate always. Avoid low flow rate of control operation for the membrane.
Agitation Air Pipe	Diffusers of agitation air will be clogged	Diffuser cleaning-flush shall be

Drain	by sludge accumulated at the bottom of the membrane unit. If diffuser is clogged and there is less agitation, membrane fouling will occur faster.	done manually daily to remove accumulated sludge.
Fine Screen	The membrane will be clogged in case there is no coarse and fine screen. The membrane requires 1-2 mm of opening screen before the aeration tank.	Proper maintenance for fine screen as well as coarse screen is needed.
Oil & Grease Removal	If oil attaches on the membrane surface, it will not be removed easily. Sometimes, special cleaning is required.	An oil separator, which is placed before membrane, shall operate properly. Separated oil shall be transferred to the dumping site.

Source: JICA Study Team

In order to continue proper operations for stable treatment, the following additional back-up measures will be necessary and is proposed to be discussed in the detailed design stage.

Table 6.7.2 Proposed Additional Back-up

Proposed Additional Back-up	Description
Training	Operator's training for membrane treatment conducted by manufacturer is recommended. Example: • Two to three months off-shore on job in-hand training for O&M team
Manufacturer's Inspection	Manufacture inspection is recommended. Example: • One year later after commissioning. • Every two years • Internet data transfer and checked and commented by manufacturer
Instrument Engineer	Instrument engineer shall join in O&M team. • MBR system is 90% automatically operated. • Programming of operation is in PLC and/or SCADA. • In case a circuit board in PLC/SCADA is multifunctional, the instrument engineer shall rectify it.

Source: JICA Study Team

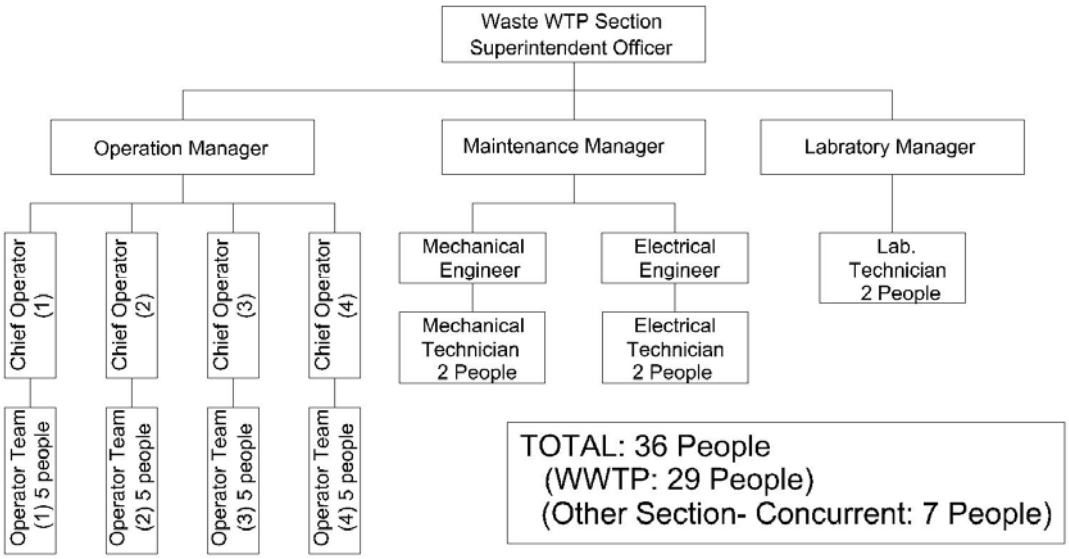
6.7.2 Proposed O&M Structure for WWTP

This section describes organization requirements for O&M works for the new WWTP.

(1) Recommended O&M Structure

There are three parties involved for WWTP O&M works as follows:

a. Operation Team
b. Maintenance Team, and
c. Laboratory Team



Source: YCDC

Figure 6.7.2 Recommended O&M Structure

(2) O&M Consideration

Main considerations of the O&M method are as follows:

1) Overall

a. Problem identification of any kind shall be done by the Operation Team.
b. Repairing and rectification shall be done by the Maintenance Team.

2) Emergency System

a. When an emergency occurs, the Superintendent Officer and the Operation Manager shall lead to take actions.
b. The Emergency Organization shall be made.

3) Role of Each Team

a. The Superintendent Officer shall work as the leader of the entire O&M Team. All information shall be conveyed to the Superintendent Officer and the Operation Manager.

b. The Operation Manager shall work as the leader of the Operation Team as well as an assistant to the Superintendent Officer. If the Superintendent Officer is absent, the Operation Manager shall act in behalf of the Superintendent Officer.
c. The Operation Team shall operate all equipment and check treatment conditions with the cooperation of the Laboratory Team.
d. The Laboratory Team shall analyse raw and treated water contents periodically and inform the Superintendent Officer and the Operation Manager.
e. Also, the Laboratory Team shall check required chemical amounts through a Jar Test for sludge treatment and inform the Operator to adjust the chemical dosing rate accordingly.
f. The Maintenance Team shall conduct periodical routine maintenance.
g. Also, the Maintenance Team shall rectify/repair mechanical/electrical machines as soon as possible upon request of the Superintendent Officer/Operation Manager.

(3) Roles and Tasks of Each Personnel

The roles and tasks of each personnel are shown in Table 6.7.3.

Table 6.7.3 Roles and Tasks of Each Personnel

No.	Position	Required Skill	Station	Roles and Tasks	Report to
1	Superintendent Officer	Full knowledge of processes and mechanical works (Univ. Level)	WWTP	- Overall responsible person for WWTP O&M - To organize and lead O&M teams - To organize and lead the emergency system	Deputy Head of Department
2	Operation Manager	Full knowledge of processes and mechanical works (Univ. Level)	WWTP	- To lead operators for smooth operation - To find problems and report to each related personnel - To adjust machines/valves according to information received from other teams - To record and check operation conditions	Superintendent Officer
3	Maintenance Manager	Knowledge of mechanical equipment, especially rotating machine, and basic knowledge of electrical works and instruments (Univ. Level)	YCDC Office	- To lead the Maintenance Team - To conduct routine maintenance according to the O&M Manual - To receive information from the Operation Manager regarding defective items - To rectify and repair defective items and/or inform manufacturer/supplier regarding repair works or spare parts	Superintendent Officer
4	Laboratory Manager	Full knowledge of analysis method (Univ. Level)	WWTP	- To lead the Laboratory Team - To check analysis results and inform the Operation	Superintendent Officer

				Manager - If treated water analysis results are over the expected values, inform related personnel including the Superintendent Officer	
5	Chief Operator (four teams, eight-hour shifts)	Basic knowledge of processes and mechanical works (Polytechnic Level)	WWTP	- To record operation data as routine works - To check operation conditions and report to the Operation Manager - To conduct a Jar Test with the Lab. Team and adjust chemical dosing rate for sludge dewatering unit - To check dewatered sludge conditions and record data	Operation Manager
6	Operator (four teams, eight-hour shifts)	Basic knowledge of operation method	WWTP	- To monitor sludge dewatering unit - To record daily routine works - To check sludge volume observation condition and record - To identify problems of process/equipment and inform the Chief Operator - Cleaning for plant.	Chief Operator
7	Mechanical Engineer	Full knowledge of mechanical machines (Polytechnic Level)	YCDC Office	- To conduct routine maintenance - To check and repair machines	Maintenance Manager
8	Mechanical Technician	Knowledge of routine maintenance works and repairing works	YCDC Office	- To conduct periodic maintenance work for machines - Repairing small defects at the site - Piping repair, etc.	Maintenance Manager and Operation Manager at site
9	Electrical Engineer	Full knowledge of electrical panel and machines (Polytechnic Level)	YCDC Office	- To conduct routine maintenance - To check and repair panel/machine	Maintenance Manager
10	Electrical Technician	Knowledge of routine maintenance works and repairing works	YCDC Office	- To conduct periodic maintenance work for machines - Repairing small defects at the site - Piping repair, etc.	Maintenance Manager and Operation Manager at site
11	Laboratory Technician	Knowledge of laboratory test	WWTP	- To conduct regular laboratory test - Preparation of laboratory test result	Maintenance Manager and Operation Manager at site

Source: YCDC

The capacity development for O&M of the WWTP is described in Chapter 11.

6.8 Study on Main Sewer

6.8.1 Design Condition

Design conditions for the installation of the sewer are defined in reference to Japanese standards as follows since there is no applicable design standard in Myanmar.

Table 6.8.1 Design Conditions for Installation of Sewer

Items	Parameter	Remarks
Minimum Diameter of Sewer	Trunk sewer and branch sewer: 200 mm Service sewer: 150 mm for CBD where existing sewerage system is available 100 mm for CBD where existing sewerage system is not available, and Dagon township.	Taking into consideration operation and maintenance such as cleaning, inspection, and new connection, each diameter is defined as the minimum diameter of the sewer.
Connection Type	Pipe top connection	Pipe top connection type makes wastewater flow smoothly and maintains hydraulically safety.
Minimum Earth Covering	3.0 m	Minimum earth covering is defined for ensuring enough depth of the sewer to cross underneath the existing drains installed between houses including the BDS and the existing road
Calculation Formula	Manning's Formula $V = \frac{1}{n} R^{\frac{2}{3}} I^{\frac{1}{2}}$ n: friction factor = 0.013 (concrete pipe)	
Velocity	Min=0.6 m/s, Max=3.0 m/s	Minimum velocity for gravity flow is defined to avoid sedimentation inside the sewer. The maximum velocity is defined to avoid damage to the sewer and the manhole
Manhole Interval	$D < 600^{*1}$: <75 m (100 m) $600 \leq D < 700^{*1}$: 100 m (100 m) $800 \leq D < 1{,}000^{*2}$: 100 m (200 m) $1{,}000 \leq D \leq 1{,}500^{*2}$: 150 m (200 m) Note: Number in a parenthesis is maximum value	The interval is defined taking into account of construction cost and workability. *1: Maximum interval is 100 m considering maximum length of small diameter pipe-jacking with smaller than D700 and O&M. *2: Maximum interval is 200 m considering maximum length of medium and large diameter pipe-jacking with bigger than D800 and O&M.

Source: Design Standards for Sewerage Systems, Japan Sewerage Works Association

Hourly maximum wastewater flow was calculated by 1.5 times of daily maximum wastewater flow and was applied for the planning of the sewer system. Hydraulic calculation for all trunk sewers is shown in Appendix 6 and 7.

6.8.2 Study for the Alignment of Sewers

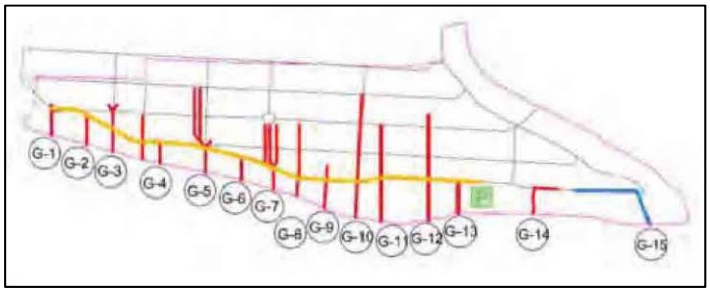
(1) Definition of Sewer

Sewers were classified into 1) trunk sewer, 2) branch sewer, 3) service sewer and 4) BDS sewer in the Study.

- Trunk Sewer: Sewer to be connected into WWTP
- Branch Sewer: Sewer to collect wastewater from service sewers in its catchment and to be connected with the trunk sewer
- Service Sewer: Sewer to connect each household with branch sewer
- BDS Sewer: Sewer installed inside BDS to collect sewage from the CBD covered by the existing sewerage system and to connect the service sewer

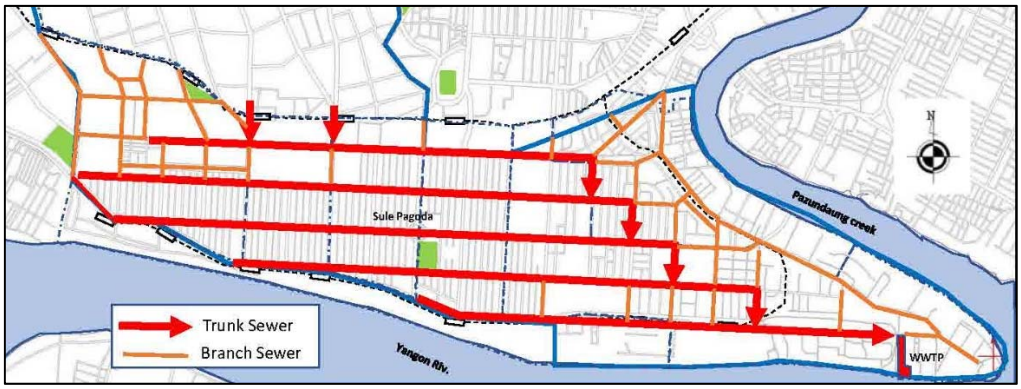
(2) Comparison Study for Trunk Sewer Line Route in CBD

The general concept on the trunk sewer line route, especially for the central business district (CBD) area, basically depends on the location of the outlet branch and the service sewer from the back drainage system (BDS). Three alternatives of trunk sewer routes were considered from the viewpoints of pipe length, number of vertical shaft, construction cost, workability, and compatibility with drainage line as shown in Appendix 3. The existing drainage in the CBD area will be improved by the World Bank with a target of 14 drainages as priority project as shown in Figure 6.8.1. The 14 existing drainages flow from north to south and finally discharge storm water into the Yangon River; therefore, the trunk sewer shall cross those drainages since the trunk sewer alignment is from west to east, and the branch sewers also require connection to the trunk sewer. To compare the alternative trunk sewer routes, compatibility with the World Bank project should also be taken into account from the viewpoint of crossing. The number of trunk sewers of two routes, three routes, and five routes were compared. The total length of the trunk sewer will be longer if the number of routes was increased; however, the length of the branch sewer can be less. While the total length of the trunk sewer will be less if two routes are applied, the length of the branch sewer will be longer in order to collect sewage and convey it to the trunk sewer. It is observed that two routes are not recommended considering the total length of sewer and its high construction cost. To select between three routes and five routes, pros and cons of each alternative are compared and contrasted. After discussing the pros and cons of both alternatives with YCDC, five routes was selected to be applied as shown in Figure 6.8.2



Source: JICA MP 2014

Figure 6.8.1 Storm Water Drainages to be Improved by World Bank Project



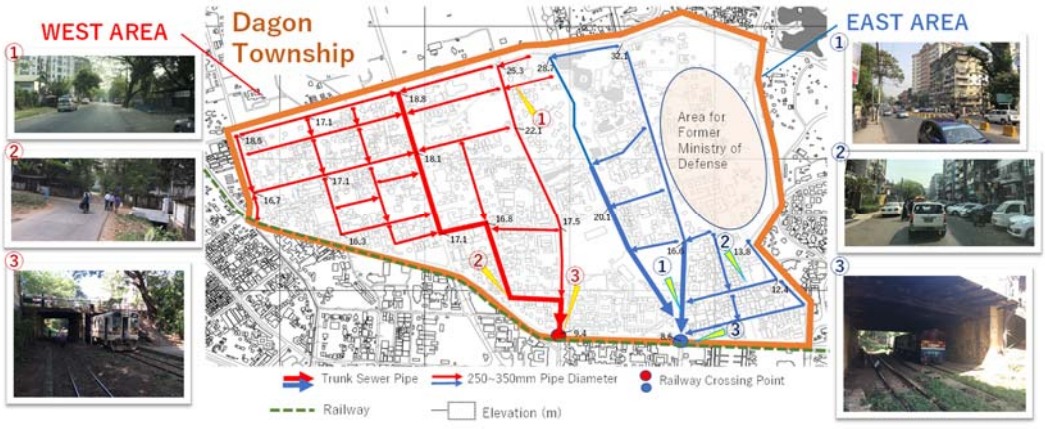
Source: JICA Study Team

Figure 6.8.2 Trunk Sewer Alignment in CBD Area

(3) Trunk Sewer Alignment for Dagon

The Dagon area is located upstream of the CBD. Ground elevation around the Dagon area is hilly toward the Shwedagon Pagoda and is relatively higher than the CBD area. Most of the sewerage customers in the Dagon area are individual houses or are part of the public sector, such as hospitals, schools, and embassy. The railway runs on the boundary of the CBD and the Dagon area; therefore, it is necessary to consider how the trunk sewer crosses the railway for minimizing the number of the crossings as much as possible to prevent interruption of the railway operation during the construction. Two locations of the railway crossing were selected taking into consideration the catchment area, the length of pipe, and the topographical condition in order not to install trunk sewer at a very low depth. The catchment in the Dagon area was divided into two sub-catchments, in the east and in the west.

The Ministry of Defence occupies the eastern Dagon with a total area of approximately 50 ha. Entry into the area is restricted. Wastewater from the area is not discharged into the existing drain around the area. According to YCDC, the area will be used for other purposes in the future, although specific uses cannot be defined yet. Therefore, in the Study, no sewer was planned in the area, and the invert elevation of the initial end of the sewer is set deep enough for future connection from the area.



Source: JICA Study Team

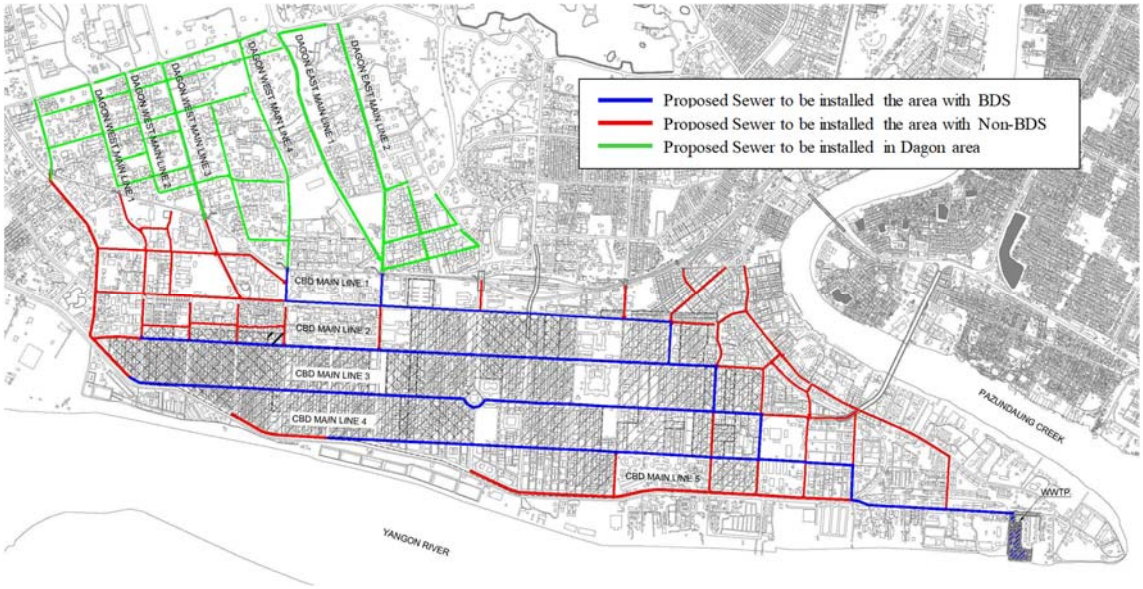
Figure 6.8.3 Trunk Sewer Alignment in Dagon Area

(4) Step-wise Implementation of Sewer

To ensure project effectiveness of the sewerage development as early as possible, sewer construction shall be commenced in the CBD area where BDS is available since the construction period for house connections can be relatively shorter than for the CBD with non BDS.

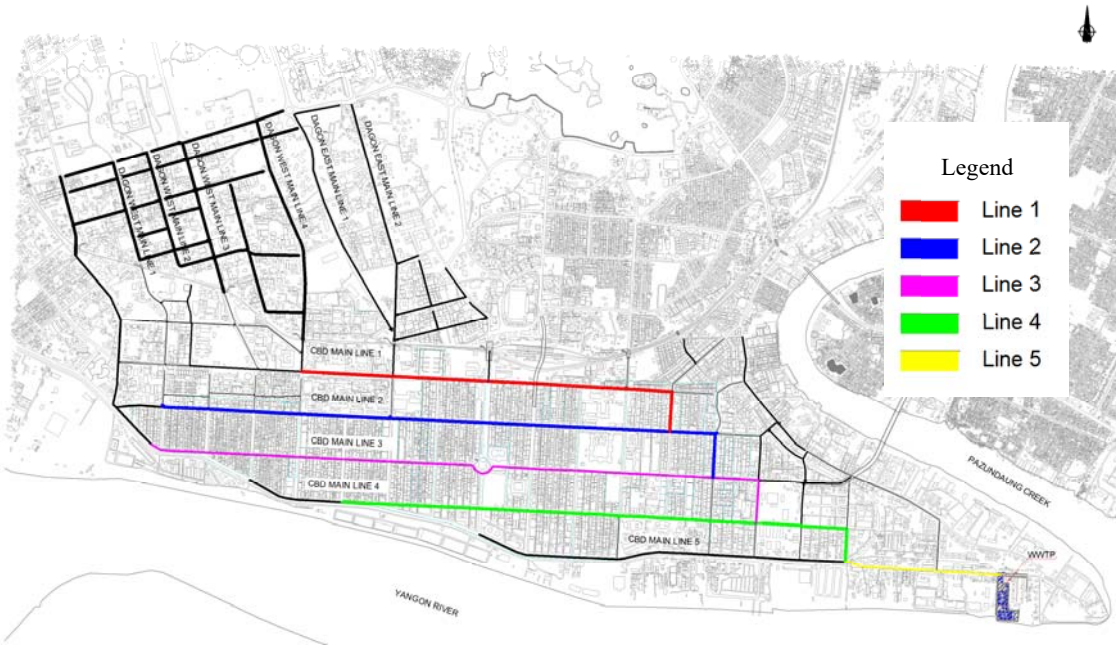
The installation of sewers in the Dagon area can be separately considered from the sewers in the CBD. The sewer construction in the Dagon area and the CBD with BDS will be implemented simultaneously from the beginning of the project because it will take a long time to proceed house connections. However, house connections should be implemented in the Dagon area after completion of the construction for the sewers in the CBD with BDS.

Therefore, it is proposed that sewers to be installed for the area with BDS and the Dagon area shall be the first priority, while sewers in the CBD with non BDS will be installed later on. Figure 6.8.4 shows the proposed sewers in each area. Figure 6.8.5 shows detail of proposed sewer to be installed in the CBD with BDS.



Source: JICA Study Team

Figure 6.8.4 Step-wise Implementation of Sewer



Source: JICA Study Team

Figure 6.8.5 Detail of Proposed Sewer to Be Installed in CBD with BDS

6.8.3 Related Sewerage Facilities

(1) Pipe Material

The proper material should be selected considering the sewer type and the laying environment of sewers. Table 6.8.2 shows a comparison of pipe materials. Reinforced concrete pipe (RCP) is applied for the planning of the sewerage system in the Study. However, HDPE pipe may also be acceptable since the material cost has been getting lower recently.

Table 6.8.2 Comparison of Pipe Materials

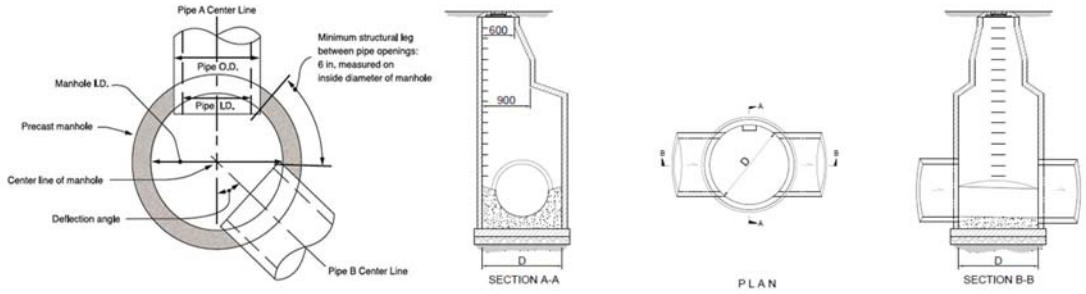
Material	Features	Applicability
Reinforced Concrete Pipe (RCP)	- RCP is divided into two types depending on the methods of compaction which are vibration and centrifugal force. - RCP made by vibrated compaction has advantages in work site construction and particular shapes. - RCP made by centrifugal force is called hume pipe (HP), and its quality is better than other types of RCP. - It requires countermeasures against corrosion by hydrogen sulphide.	【Method of Installation】 - Open cut - Pipe jacking - Shield tunnelling - Work site construction 【Sewer type】 - Gravity sewer
Polyvinyl Chloride Pipe (PVC)	- PVC has the advantages of lightweight for easing construction, but it has the disadvantage of less durability against vibration such as earthquake. - PVC is not fit for pressure sewer.	【Method of Installation】 - Open cut 【Sewer type】 - Gravity sewer
Polyethylene Pipe (PE) and High Density Polyethylene Pipe (HDPE)	- PE has the advantages of flexibility, contractibility, and abrasion resistance. - PE can be applied in the areas where land subsidence is anticipated, exposed by cold weather, and fast flow of sewage. - PE can be applied as both gravity sewer and pressure sewer. - Its cost is relatively high, but PE can last longer.	【Method of Installation】 - Open cut - Pipe jacking 【Sewer type】 - Gravity sewer - Pressure sewer
Ductile Iron Pipe (DCIP)	- DCIP is commonly used for pressure sewers. - DCIP is a flexible pipe with the advantages of pressure tightness, abrasion resistance, high mechanical strength, and toughness. - Depreciation period of DCIP is about 20 to 25 years with	【Method of Installation】 - Open cut - Pipe jacking 【Sewer type】 - Pressure sewer

	internal lining.	
Steel Pipe (SP)	- SP can be available in a wide range of pipe sizes. - SP is a flexible pipe with the advantages of water tightness, high strength, toughness, and extensibility. - SP is commonly applied in pressure sewers.	【Method of Installation】 - Open cut - Pipe jacking - Shield tunnelling 【Sewer type】 - Gravity sewer - Pressure sewer

Source: JICA Study Team

(2) Manhole

Manholes are constructed in a sewer system as a means of access to sewers for inspection, cleaning, and repairs. They are also employed as transition structures for changes in shape, size, grade, or alignment of sewers and as junction chambers for two or more sewers.



Source: JICA Study Team

Figure 6.8.6 Typical Manhole

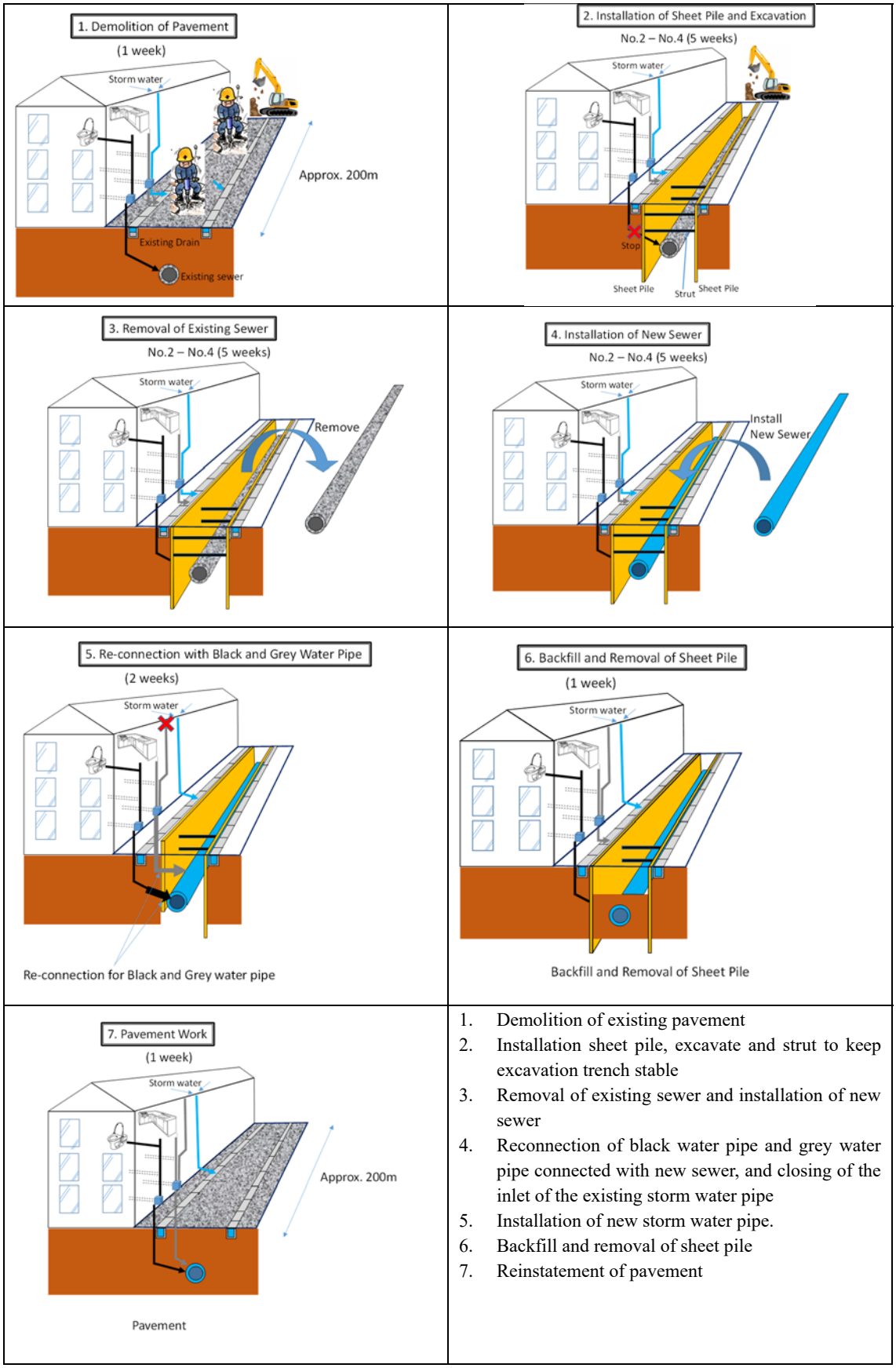
6.8.4 Construction Concept of Wastewater Collection

(1) CBD (BDS)

Black water from households goes to the ejector station by gravity flow through the BDS and the service sewer. Then, the collected black water is conveyed to the existing WWTP from the ejector station by pneumatic compression. One ejector station is collecting black water from several BDSs and conveys the collected black water by pump force. Grey water and storm water are being discharged to the water body through ditches on the surface of pavement in the BDS.

As mentioned in Section 4.1.4, YCDC is implementing periodic cleaning and repairing of pavement of BDS. However, the work just entails overlaying the pavement and does not include separation of grey water and black water, such as installation of new sewer or drain. Therefore, grey water and storm water are still mixed and discharged into the existing drain.

In case the existing sewer with D150mm in BDS shall be replaced although the existing sewer seems to be in an acceptable condition to convey black and grey water, it is necessary to improve the existing BDS in accordance with the following development steps as shown in Figure 6.8.7.



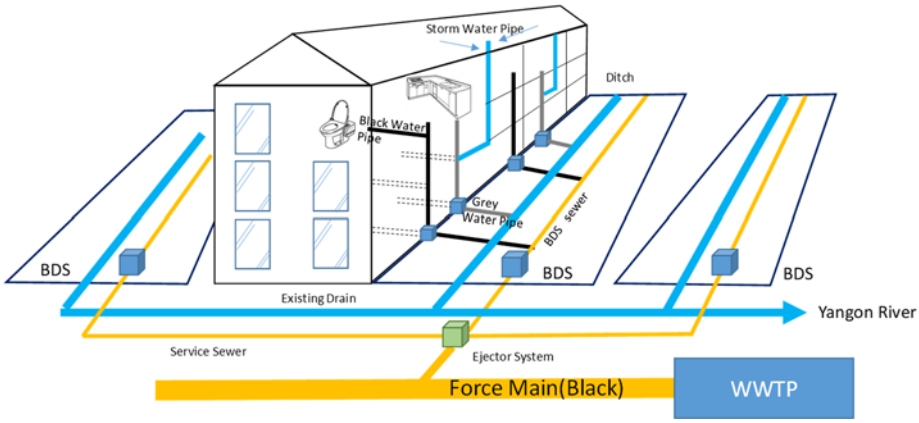
1. Demolition of existing pavement
2. Installation sheet pile, excavate and strut to keep excavation trench stable
3. Removal of existing sewer and installation of new sewer
4. Reconnection of black water pipe and grey water pipe connected with new sewer, and closing of the inlet of the existing storm water pipe
5. Installation of new storm water pipe.
6. Backfill and removal of sheet pile
7. Reinstatement of pavement

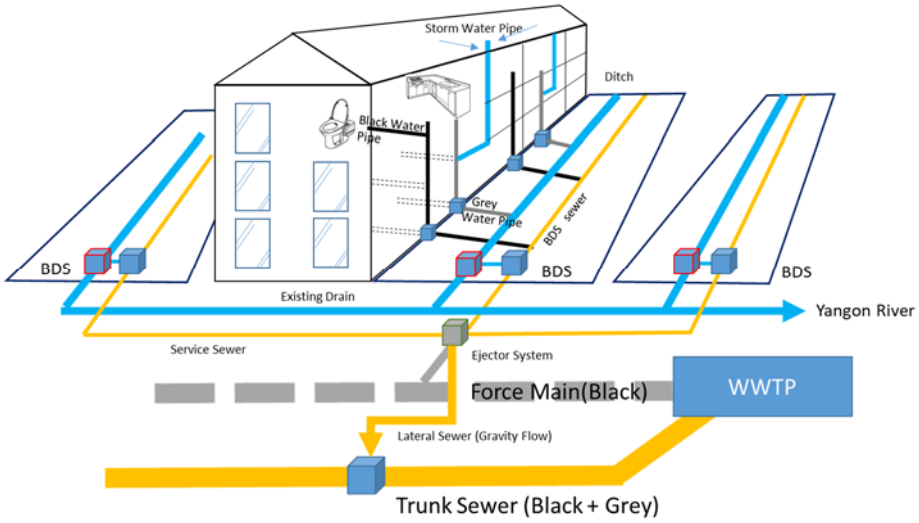
Source: JICA Study Team

Figure 6.8.7 Trunk Sewer Alignment in Dagon Area

It is suggested that the existing sewer for black water in BDS is kept as it is since it will take time to replace all existing sewers at the 182 BDSs. The assumed construction period for the work is around 2.5 months per BDS. There are 182 BDSs in the CBD area; therefore, it takes 455 months to complete all the works. The work volume shows that it takes more than six years even though six teams or BDSs will implement the work in parallel. Therefore, reconnection at the new trunk sewer shall be prioritized in order to achieve project effectiveness as early as possible. Then, the replacement of the existing sewer in BDS will be the next priority. In addition, limited space of the BDS and the aged buildings adjacent to the BDS make the replacement of the existing sewer difficult.

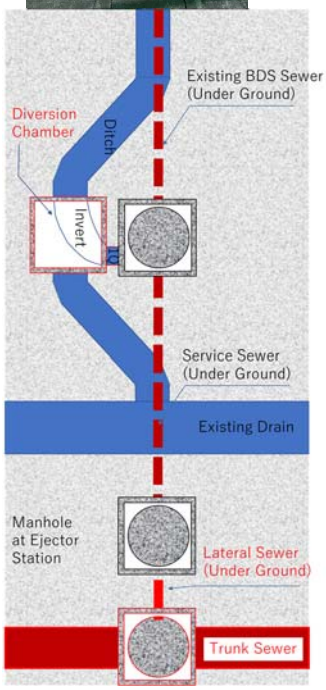
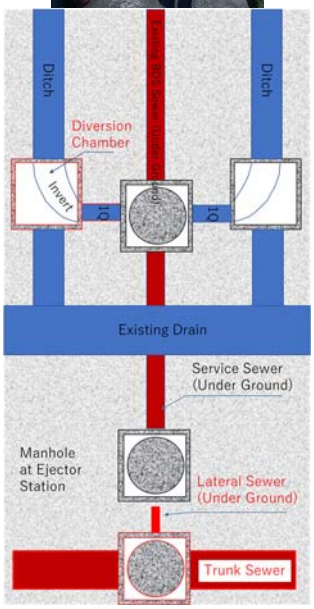
In the sewerage development, it is suggested that some extent of the replacement of the existing sewer in BDS should be implemented as a pilot project. Six locations of BDS will be selected by YCDC during the implementation stage. For the rest of the 176 BDSs, a diversion chamber which collects grey water at the exit of BDS will be temporarily installed at the end of the existing ditch to separate grey water and storm water as shown in Figure 6.8.8. Grey water collected in the diversion chamber will go to the manhole in the ejector station using this BDS sewer and service sewer and then go to the trunk sewer. Black water from each household will also go to the trunk sewer through the existing BDS sewer and conveyed into the manhole of the ejector station. In addition, YCDC will bear the construction cost for the diversion chamber and the lateral sewer in the project. Storm water, which is over the flow capacity of the connecting pipe of the diversion chamber and the existing sewer in BDS, will discharge into the existing drain eventually pouring into the Yangon River. The installation of the diversion chamber is a temporary measure and will not separate grey and storm water completely during the rainy season. Therefore, the replacement of the existing sewer with the reconnection of black and grey water for the rest of the 176 BDSs should be implemented in the latter stage accordingly.

Current Situation	

After Improvement (Separated System)	

Source: JICA Study Team

Figure 6.8.8 Current Situation and Concept of Sewage Collection in BDS

Type A (Total 111 BDS)	Type B (Total 71 BDS)
A-1: Space without improvement by YCDC: 58 nos	B-1: Space without improvement by YCDC: 55 nos
A-2: Space improved by YCDC: 53 nos	B-2: Space improved by YCDC: 16 nos
 	 

Note: Red colour is to be implemented by under JICA ODA loan.

Source: JICA Study Team

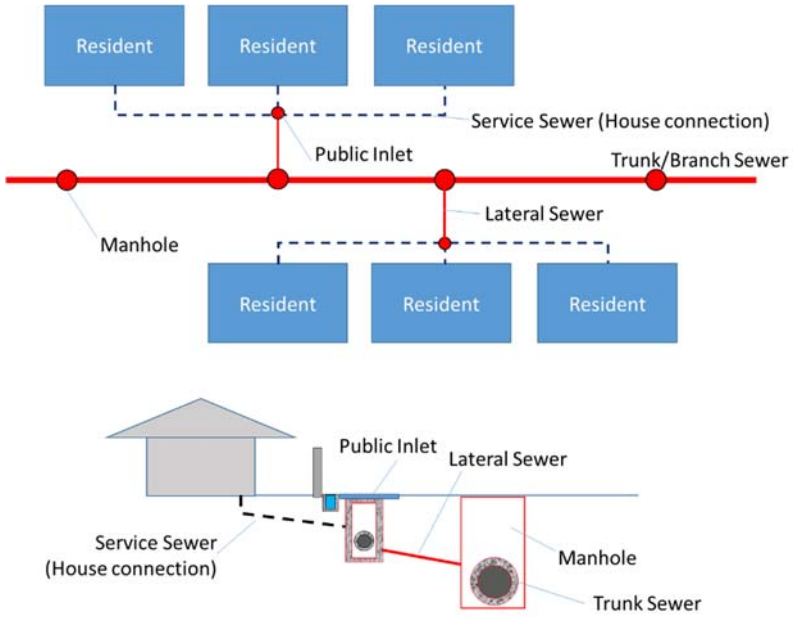
Figure 6.8.9 Improvement of Back Drainage Space

(2) Rest of CBD area and Dagon area

In the CBD area except the sewered area and the Dagon area, a septic tank is receiving wastewater from each household. Public inlets connected to the trunk sewer in the vicinity of each household shall be installed in the Project. However, resident shall connect sewer pipes from each house to the manhole.

Figure 6.8.10 shows the demarcation of sewer installation and sewage collection system in the Dagon area. There are individual houses and public compounds such as hospitals, schools, and embassies so that generated wastewater, i.e., black and grey water, from each house or compound will be brought to the public inlet through the service sewer. The public inlet has to receive the wastewater from several houses or compounds in order to convey the collected wastewater to the trunk sewer through the branch sewer. The trunk sewer, branch sewer, and public inlet will be implemented under Japanese ODA Loan. The resident will install and maintain the service sewer

and also bear these cost. The soak pit type septic tank is used for wastewater treatment up to three-storey building. Therefore, counter measure work (e.g. blockage of the bottom of the septic tank) is required to prevent effluent from infiltrating into the ground when house connection will be conducted in this kind of building. This demarcation is basically derived from the border of public and private lands.



Red color is to be implemented under JICA ODA Loan

Source: JICA Study Team

Figure 6.8.10 Concept of House Connection in the Rest of CBD area and Dagon Area

(3) Removal of existing ejector system and sewer.

1) Ejector system

There are 40 ejector stations in the study area, and 35 out of the 40 stations are still working. An ejector station mainly consists of a compressor, an air tank, a sewage tank, and a cast iron pipe. The compressor and the air tank are placed on the ground, while the sewage tank and the cast iron pipe are installed underground. These facilities will be unnecessary after the completion of the sewerage development. However, the manhole for the sewage tank and the cast iron pipe of the service sewer will be used for the sewage collection. The other facilities will need to be demolished.

Compressor and Air Tank

Sewage Tank in Manhole

2) Existing force main and air pipe

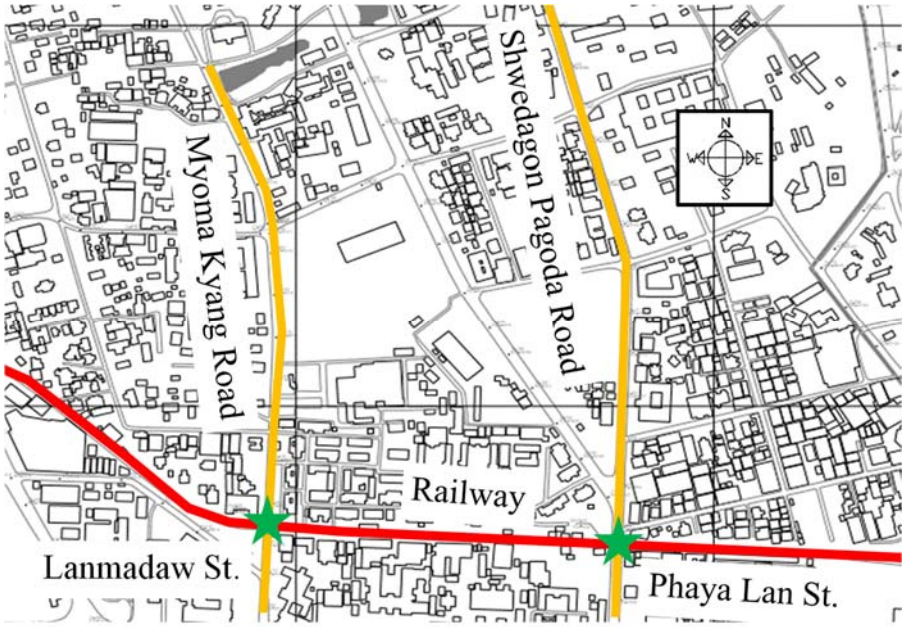
The existing force main and air pipe for the compressor installed will become unnecessary after completion of the sewer construction. From the site reconnaissance during the Study, it was confirmed that the existing sewer does not have enough capacity to convey sewage under the new sewerage system targeted for 2040. Also, it is not safe because it will lead to settlement and collapse of the existing road due to the corrosion of sewer. Therefore, the JICA Study Team recommended to fill the concrete inside the laid sewer for reinforcement at the completion of a new sewerage system. However, YCDC finally decided that it will be maintained by themselves in the future, and it shall not be included in the Yen loan project because of the following reasons: (1) the total length to be demolished is 35 km comprising 16 km force main including branch and 19 km air pipe, (2) the demolition work increases the project cost, (3) the demolition work makes traffic jams worse, and (4) the exact alignments of the force mains and air pipes are not recorded by YCDC.

Source: YCDC

Figure 6.8.11 Ejector Station and Existing Force Main and Air Main

6.8.5 Railway Crossing

The trunk sewers will cross the railway at two locations as described in Section 6.7.2. One is in Lanmadaw Station along Myoma Kyaung Road, and the other is in Phaya Lan Station along the Shwedagon Pagoda Road. At both locations, the sewer will be installed through the pipe jacking method because of the following reasons: (1) the railway should be operational during the construction, and (2) the railway is located two or three meters lower than the road. Therefore, sewer should be installed at an enough depth before crossing the railway in order to secure the earth cover above the sewer at the crossing.



Lanmadaw Station

Phaya Lan Station

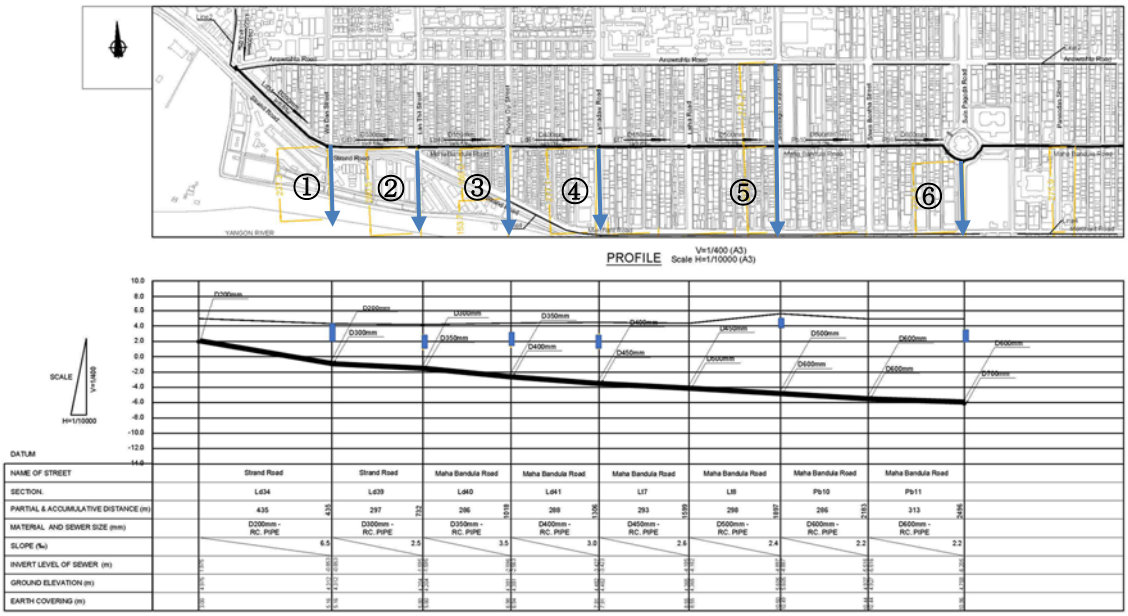
Source: JICA Study Team

Figure 6.8.12 Locations of Railway Crossings

6.8.6 Drainage Channel

In the CBD area, there are many drainage channels, including open channels and underground

box culverts, that flow from north to south toward the Yangon River. Storm water and grey water are discharged to the Yangon River through these channels currently. The new trunk sewer will cross the CBD area from east to west and will need to cross the existing drainage channels accordingly since the trunk sewer will need to pass underneath the existing drainage channels. The dimensions and the depth of the existing drainage channel at the trunk sewer crossing were confirmed. Section dimension and location of drainage channels in five townships are shown in Figure 6.8.13. It was found from the result of the study that existing channels would not interfere with the installation of the new sewer installation. However, World Bank is planning to improve these drainage channels as described in Section 4 of Chapter 3 in this report. The detailed design of this project will be completed in July 2019. Therefore, the detail of the project should be checked to determine the alignment of the new sewer in the detailed design stage of the Project. The layout plans of the existing drainage channels are shown in Appendix 8.



No.	Width (cm)	Height (cm)	Covering (cm)	Shape
1	76.2	152.4	0	Rectangle
2	152.4	152.4	137.16	Rectangle
3	167.64	152.4	121.92	Rectangle
4	152.4	152.4	152.4	Rectangle
5	106.68	-	289.56	Circular Pipe
6	91.44	106.68	137.16	Rectangle

Source: YCDC

Figure 6.8.13 Locations of Crossings at Existing Drainages

6.8.7 Installation Method

(1) Types of Pipe Installation Methods

1) Trunk and Branch Sewer

Pipe installation methods for the Project, with inner sewer diameter ranging from D200 mm to D1500 mm, are examined. The types of pipe installation methods are generally listed as follows:

- Open Cut Method
- Trenchless Method
  - Pipe Jacking Method (small pipe diameter and large to medium pipe diameter)
  - Shield Tunnelling Method

The two methods for the installation of new sewer pipelines are the open cut method and the trenchless construction method. The selection of method to be used depends on a number of factors including pipe diameter, installation depth, type of soil, depth of water table, available construction space on the surface, conflict with other underground utilities, and the volume of traffic. Table 6.8.3 shows a comparison of pipe installation methods.

i) Open Cut Method

The open cut method is the most common construction method for the installation of sewer in shallow depth. For safety purposes, temporary support should be required for excavating trench with a certain depth. In addition, this method is also difficult when the sewer has to be installed below the groundwater table as the trench needs to be kept dewatered while the sewer line is being installed. Open-cut method will also need to take precautions of working in the proximity of existing overhead electrical power/telecommunication cables, street lights/poles, and roadside trees, as well as underground utilities including underground water supply pipes, drainage culverts, and sewers. However, the potential risks to obstruct the work of open-cut method will remain inevitable even after taking into account the various efforts of collecting such information from utility agencies and from field survey.

Although this method is relatively straightforward and inexpensive, it will be inappropriate for installing the sewer at a considerable depth in the CBD since the work space is limited in the proximity of the existing utilities and/or heavy traffic is taking place. Moreover, the groundwater table in the CBD along the Yangon River has a high possibility to be high. According to the geo survey conducted in the study, ground water levels in the WWTP were 1.5 m and 4.0 m below from the surface. Dewatering in the trench would be required during the construction of the trunk and branch sewer because of following reasons: (1) the ground level in the CBD including the WWTP is almost flat and (2) minimum thickness of earth covering of the trunk and branch sewer is set at 3.0 m. Open-cut method can be applied to part of the Dagon where the depth of sewer can be kept shallow because the ground level become lower toward the CBD.

ii) Trenchless Method

The trenchless method is more cost effective and can overcome the major difficulties and constraints of the open-cut method for deep sewer lines below the groundwater table, particularly where space is limited and traffic disruption is likely to be significant. Therefore, the trenchless method shall be applied for the CBD area. For the Project, only the pipe jacking trenchless method can be applied as shown in Table 6.8.3 since the sewer diameter ranges from D200 mm to D1500 mm.

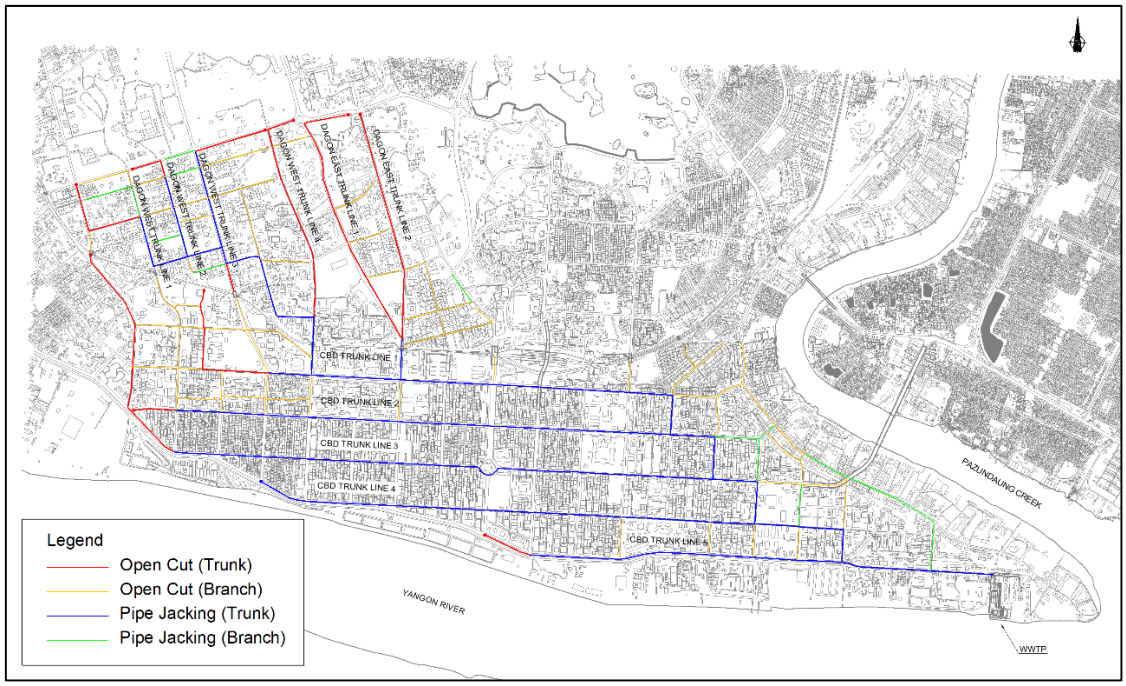
Figure 6.8.14 shows the sewer alignment section where the open-cut or trenchless method is proposed to be applied.

Table 6.8.3 Comparison of Pipe Installation Method

Method	Open-cut Method	Trenchless Method	
		Pipe Jacking	Shield Tunnelling
Description	- Trench is excavated by manual or mechanical. After sewer is laid on the bottom, trench is backfilled with suitable soil material and then ground surface is reinstated. - Trench timbering is required, depending on depth of trench and sol condition. - All works are conducted on the ground. - Applicable depth will be up to around 4 m.	- Vertical shafts (driving shaft and reception shaft) are excavated at both ends of work segment. - Prefabricated pipe segments are propelled underground successively by jack, starting from drive shaft and extending to reception shaft. - Soil inside propelled pipe segment is excavated out through driving shaft. - With special technique, shield machine can be driven for long distance and sharp curving. - For over 700 mm in diameter, it can be classified into two: open type and closed type. One is the open type applied for stable soils that can be excavated directly at the front of first propelled pipe segment. Another is the closed type applied for unstable soils that require the machine for stabilizing and excavating soil face at the front of first propelled pipe segment.	- Vertical shafts (driving shaft and reception shaft) are excavated at both ends of work segment. - Shield machine excavates soil face at the front of tunnel, carries excavated soil out, advances by jacking, and assembles prefabricated segments of tunnel successively. - With special technique, shield machine can be driven for long distance and sharp curving. - This method is suitable for long distance drive and large diameter pipe installation. - This method is classified into open and closed type.
Applicable Pipe Size	- Up to 3,000 mm	- 150 mm to 3,000 mm	- 1,350 mm to more than 10,000 mm - In Japan, 14,000 mm is maximum
Maximum Length	- Not limited	- Approximately 1,000 m by one drive - Commonly, 150 m to 500	- Approximately 2,000 m by one drive - Longer drive is possible

		m	using a particular machine
Construction Cost	- The most economical for installing sewer at a depth maximum of 4 m in general. - Construction cost increases when the installation depth needs to be deeper and/or a lot of temporary works are required in the proximity of existing utilities to be protected, relocated and reinstated.	- More economical than open trench method for installing sewer deeper than 4 m. - Construction cost increases for stabilizing unstable soil. - Temporary works to protect, relocate and reinstate existing utilities are minimized. - More economical than shield tunnelling method for installing sewer with a diameter of 2,000 mm or smaller in general.	- Construction cost is much higher than that of open trench method and pipe jacking method since it is applicable for considerable large diameter.
Impact to Ambient Surroundings	- Traffic jams are anticipated to be worsened due to work segment occupying traffic lane. - Excavation and trench timbering cause noise and vibration.	- Impact to traffic can be minimized. - Noise and vibration can be reduced except in sites for vertical shafts. - Precautionary measures should be taken into account for ground settlement anticipated due to unstable soils.	- Impact to traffic can be minimized. - Noise and vibration can be reduced except in sites for vertical shafts. - Precautionary measures should be taken into account for ground settlement anticipated due to unstable soils.
Difficulty of Construction Works	- Not difficult for installing sewer at a shallow depth. - It is easy to take countermeasures for changing soil condition. - Anticipated to be obstructed by existing underground utility which is not identified before construction. - Shallow groundwater table makes it hard to water-tighten and dewater the trench.	- Excavation amount is the smallest. - Required area for shafts is smaller than shield tunnelling method. - It takes time or requires advanced technique to cope with unexpected soil condition and underground utilities detected during pipe jacking operation.	- Required area for shafts and is larger than pipe jacking method. - It takes time or requires advanced technique to cope with unexpected soil condition and underground utilities detected during pipe jacking operation.
Construction Period	- Shorter than trenchless method in case there are no obstructions.	- Shorter than shield tunnelling since prefabricated pipe is used.	- Longer than pipe jacking method.
Others	- Not applicable for crossing rivers or large structures.	- Jacking method for smaller than 700 mm in diameter is called micro tunnelling method.	

Source: JICA Study Team



Source: JICA Study Team

Figure 6.8.14 Proposed Installation Method (Trunk Sewer and Branch Sewer)

2) Service Sewer and BDS Sewer

Open cut method will be applied to construct the service sewer and the BDS sewer because depth of these pipes is shallow.

(2) Pipe Jacking Method

There are several types of pipe jacking method. In the Project, the type of pipe jacking method is not identified. However, the pipe jacking distance and the required area of the site utilization plan for the vertical shaft depends on the type. Therefore, an applicable type of pipe jacking method will be identified in the detailed design stage through the detail surveys including topographic survey, geotechnical survey, and underground utility survey.

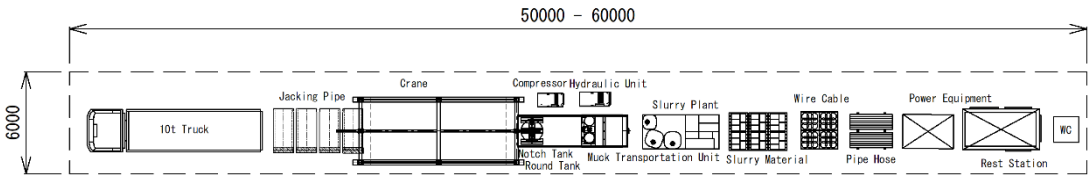
Long distance pipe-jacking is suitable for the CBD where traffic jams often occur. Construction period and occupied space by the sewer construction can be reduced since longer distance leads to reduce the number of the drive shaft. It can also reduce the construction cost of the sewer.

The length of the pipe jacking method with dia. 1500 mm was set to 400 m by referring Standard for Design and Cost Estimation (Long Distance and Curve Micro Tunnelling) published by Japan Micro Tunnelling Association. The manhole between the drive shaft and reception shaft will be laid by cutting in the new sewer.

(3) Vertical Shaft

The structure of the vertical shaft was selected based on the type of material and sheet piles for

departing and arriving vertical shafts. The size of the departing vertical shaft was determined based on the necessary dimensions for horizontal jacking, including the pressure bearing wall, jacks and their support, strut, push ring, driving machine setting, and entrance length for departing. Meanwhile, the dimension of the arriving shaft was determined based on the exit eye length, driving machine length, and enough room for machine removal from the shaft. In addition, the necessary dimensions for the construction of the manhole were also considered. The typical layout of plant, including the allocation of the vertical shaft, is shown in Figure 6.8.15. The typical plant requires an area of about 300-360 m^2.



Source: JICA Study Team

Figure 6.8.15 Typical Layout of Plant

CHAPTER 7 Applicable Japanese Sewerage Technologies for Yangon City

7.1 Overview of Japanese Sewerage Technologies

The technologies, which is applicable for Yangon city, have been selected as reported in the previous Chapters considering the several issues for the development of sewerage system in the target area. The main two issues are that pipeline will be constructed under the busy main street in central business district, and the space for wastewater treatment plant is very limited. Also, energy saving system is preferable for the equipment installed in the plant.

The Japanese sewerage technologies, which are appreciable in this study, are shown in Table 7.1.1. Details of technologies are described as follows.

Table 7.1.1 Categories of Applicable Japanese Sewerage Technologies Selected for the Project

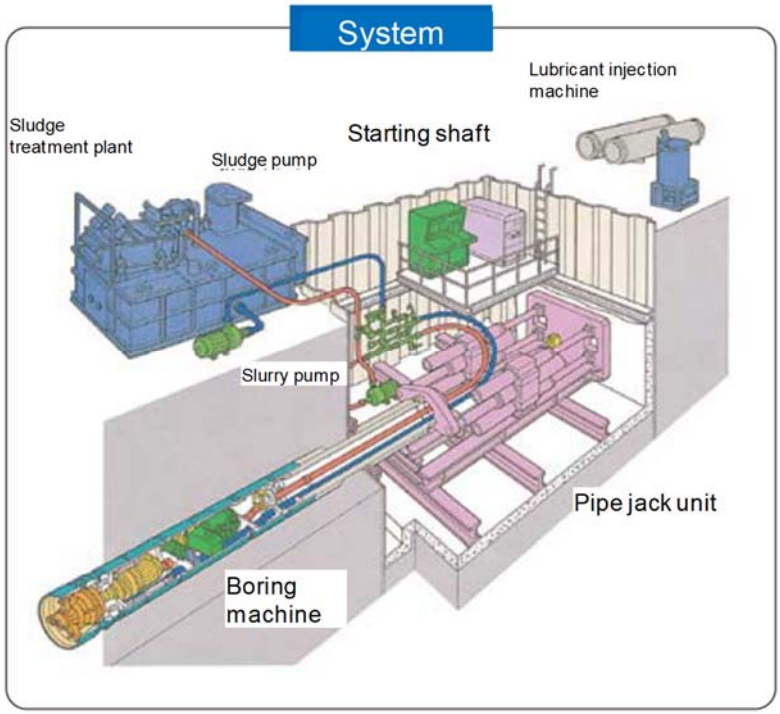
Category	Facility	Japanese technology
Sewer	Sewage pipeline in congestion area	Long-distance Pipe-jacking Method
Wastewater Treatment Facility (WTF)	Reactor	Membrane Bio Reactor
Sludge Treatment Facility (STF)	Dewatering	Energy-saving Dehydrator
	Dryer	Mechanical Dryer

7.2 Sewer

7.2.1 Long-distance Pipe-jacking Method

According to the pipeline development plan, main pipelines will be constructed under the main busy streets in the central business district. Large scale road occupation, which open cut method cannot avoid, causes heavy traffic congestion, and also construction noise, dust and vibration are problems too. Therefore, it was decided that pipe jacking method will be applied to the pipe installation for 26.3km.

The overview of pipe jacking system is shown in the following figure. Road occupation is only required around the starting and arrival shaft. This construction method contributes to not only avoiding heavy traffic congestion but also reducing the waste generated in construction works.



Source: Manufacturer's brochure

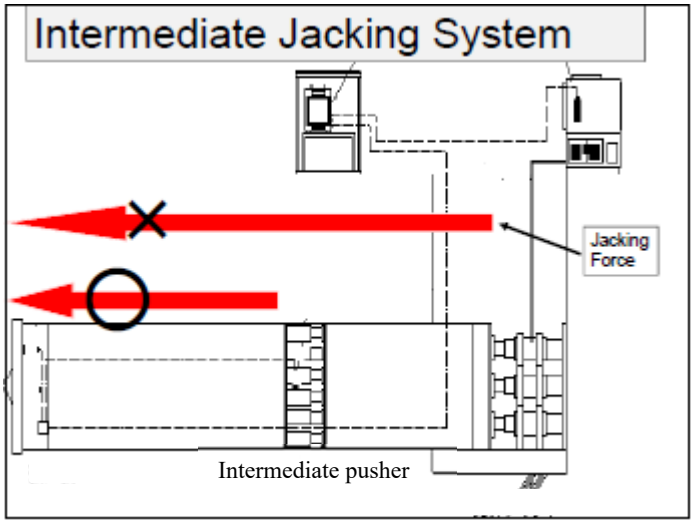
Figure 7.2.1 Overview of Sewer Installation by Pipe-jacking Method

One of the key factors to minimize adverse influences and risks caused by the pipe installation construction as mentioned above is reducing the number of shafts. Installing the intermediate pusher in the middle of pipes as shown in the figure below will make it possible. This method is called long-distance pipe-jacking method which Japan has expertise. One span can be over a couple of hundreds of meters, and it is able to be jacked by a propulsion force provided the intermediate pusher. This technology enables the number of shafts to be possibly reduced half, moreover the construction cost can be saved because construction period is shortened as a result compared with the ordinal pipe-jacking method.

However, this method requires technologies which Japan has sufficient successful experiences as described below.

Lubrication is used to push a pipe without damage, which has to appropriately be applied to the surface of a pipe. As countermeasure against it, automated lubricant injection system is installed to effectively control injection amount, points and time.

Also, propulsion at a curve is possible by using curve formulation unit and gyrocompass attached to boring machine.



Source: Manufacturer's presentation material

Figure 7.2.2 Image of Intermediate Pusher of Long-distance Pipe-jacking Method

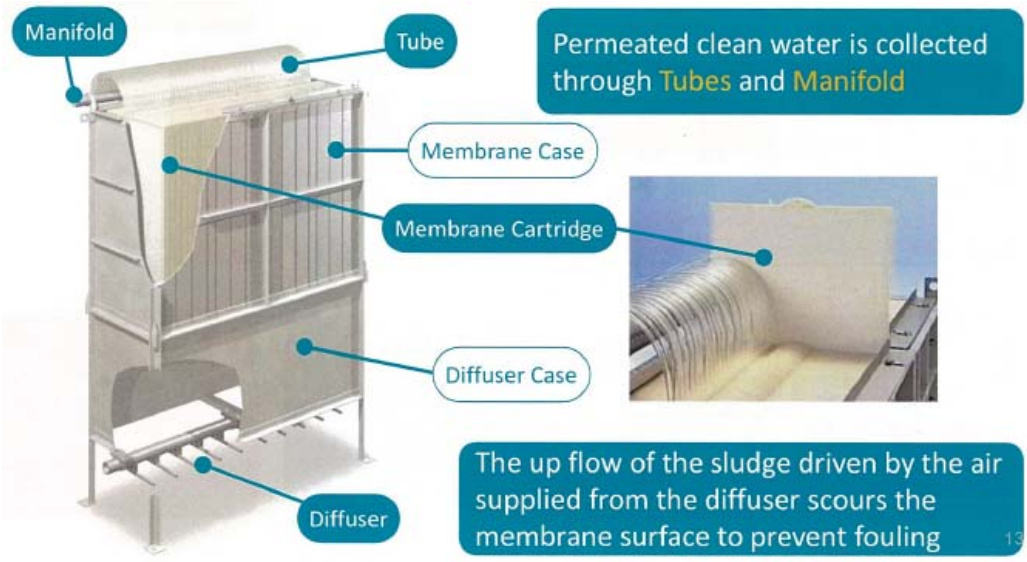
7.3 Wastewater Treatment Facility (WTF)

7.3.1 Membrane Bio Reactor

As mentioned in Chapter 6, Membrane Bio Reactor (MBR) method is selected as the wastewater treatment because of the space limitation. MBR system does not require a final sedimentation tank, while having a reduced size of reactor which has membranes. It makes it possible to operate MBR processes at higher MLSS compared to conventional activated sludge process, therefore, reactor capacity can be reduced.

It is also possible not to install a disinfection facility theoretically because coliform bacillus cannot pass through a membrane, but it is usually installed for emergency purposes such as power supply down.

Japan is strong on the market of membrane, and accounts for about 40 % share in the international market of membranes used for the MBR method (as of 2009) because of its high quality. Also, after the sales service provided by manufacture is important factor as selection criteria since MBR is composed of a lot of mechanical and electric equipment that need maintenance. For example, membrane requires cleaning for the removal of fouling about once everyone to two years per unit, that is, after sales service is crucial and it is even better that a brunch of manufacture that has sufficient experiences is located in the same country for the prompt action.



Source: Manufacturer's presentation material

Figure 7.3.1 Overview of Flat Sheet Membrane Unit

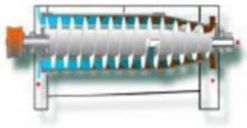
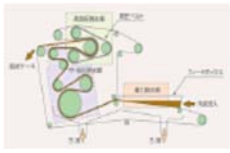
7.4 Sludge Treatment Facility (STF)

7.4.1 Dewatering/ Energy-saving Dehydrator

Sludge treatment is one of the most significant processes in this project because sludge disposal is the critical point. The amount of water that is dewatered by a dehydration machine has a large effect on the following sludge treatment process such as drying and incineration.

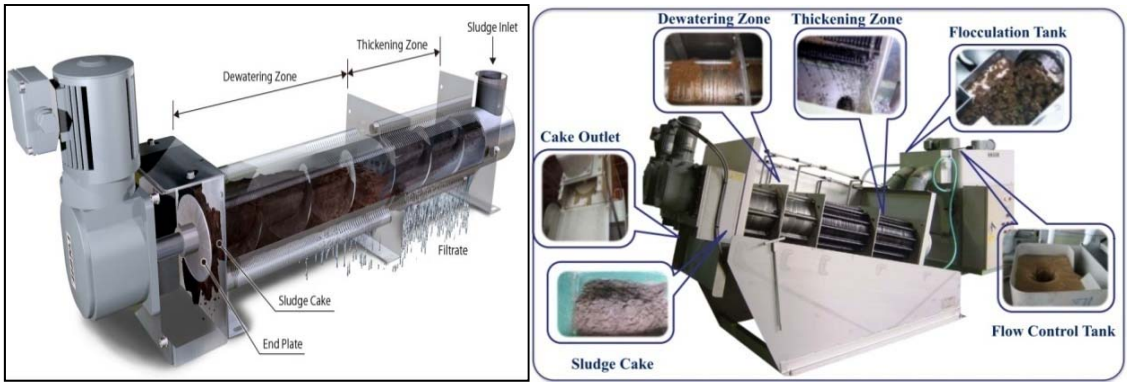
There are 4 types of dewatering equipment; screw press with multiple layered rings, centrifugal, screw press and belt press as shown in the following figure.

Table 7.4.1 Dewatering Equipment

	Screw press with multiple layered rings	**Centrifugal**	**Screw press**	**Belt press**
				
Foot print	Small	Large	Smallest	Largest
Energy consumption	Smallest	Largest	Small	Small
Initial cost	Smallest	Largest	Small	Largest
O&M cost	Smallest	Largest	Small	Largest
Ease of O&M	Easy	Not easy	Easy	Not easy

As a result of the comparison, screw press with multiple layered rings, which Japanese manufacture developed, would be the most suitable type for this project.

Sludge feed is regulated with the overflow pipe, returning excess volume to the sludge storage tank. Next, sludge is instantly thickened at the thickening zone, and dewatered at the dewatering zone in the subsequent stage under increasing inner pressure. Further pressure is applied from the outlet side with the end plate, discharging dewatered cake with 20±5%solides content.



Source: Manufacturer's presentation material

Figure 7.4.1 Energy-Saving Dehydrator (Screw Press with Multiple Layered Rings)

In summary Japanese screw press with multiple layered rings is compact, high performance and has the following characteristics;

- No clogging
- Easy maintenance
- Energy saving (low running cost)
- No thickened sludge storage tank required
- Continuous 24-hour unmanned operations

It has already been installed 3200 units in 70 countries; which shows the excellence of the product.

7.4.2 Mechanical Dryer

As described in chapter 6, mechanical dryer was selected for drying process. The overview of inclined disc dryer which is suitable type for this project is described below.

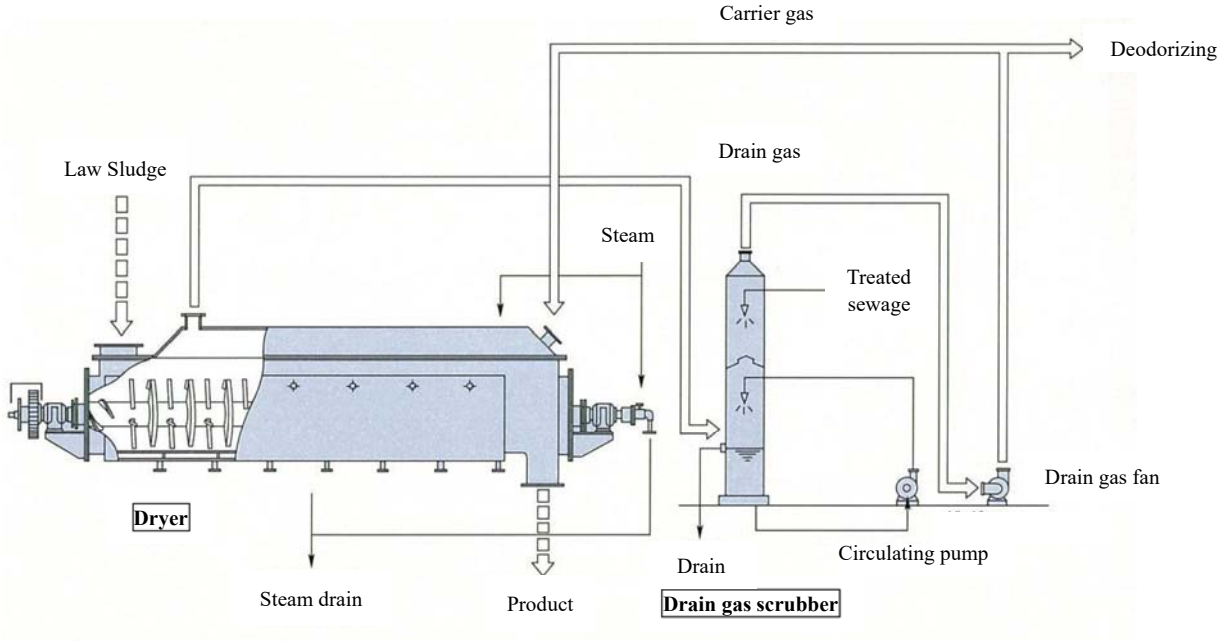
Sludge is usually dried until the moisture content reaches about 70 % in case an incinerator is installed on the following process. A large amount of energy as latent heat is required in the drying process regardless of drying method, which means energy saving technology is crucial.

Drying method can be divided into two types; direct heat dryer and indirect heat dryer. Inclined disc dryer is the latter and high heat transfer coefficient is materialized by its disc. Thermal efficiency is extremely high as heat losing area per effective heat transfer surface is small. These characteristics lead to save consumed energy. In addition, Japanese inclined disc dryer has self-

cleaning system by the inclined disc for heat transfer surface, so heat transfer efficiency will be kept high, which makes energy-saving property even higher compared to other countries' products.

Also, a small amount of carrier gas is used and it emits only a small volume of exhaust gas.

Japanese inclined disc dryers have been installed in many countries, for example China, and they have been running very well. Lifetime could be 15 years in case proper O&M is conducted.



Source: Manufacturer's presentation material

Figure 7.4.2 Flow of Inclined Disc Dryer

CHAPTER 8 CONSTRUCTION PLAN AND COST ESTIMATE

8.1 Conditions of Project Cost Estimation

8.1.1 Condition of Cost Estimation

(1) Basic Conditions

The project cost consists of construction cost, administration cost, consulting service cost, contingency (physical and price escalation), interest during construction, front end fee, and relevant taxes.

The project cost was estimated based on the following conditions:

- The project cost is divided into the local currency portion (LC) and the foreign currency portion (FC).
- Administration cost in the recipient country is assumed to be 5.0% of the construction cost.
- Consulting service cost is estimated based on the man-months of consulting services.
- Physical contingency is assumed to be 10.0% of construction work cost and 5.0% of engineering cost.
- Price escalation is at 1.83% per annum for FC and 5.0% per annum for LC.
- Base year for cost estimation: May 2018
- Exchange rate: USD 1 = JPY 110.0, USD 1 = MMK 1320, MMK 1 = JPY 0.0833
- Interest during construction is estimated considering that the Project is financed through Japanese ODA Loan. (Loan conditions: Interest rate for construction cost = 0.01%, Interest rate for consulting services = 0.01%, Repayment period is 40 years including grace period = 10 years)
- Front end fee is 0% because Myanmar is categorized as 'Least among Less Developed Countries' (LLDC).
- Customs rate of 10%, same as prepaid income taxes, is applied to imported goods in reference to the customs tariff of Myanmar, with customs and trade agreement acceded. Also, sales tax rate of 5% is applied to all imported and domestic goods, considering the value added tax rate of 5% in Myanmar.
- Construction cost, consulting service cost, and contingency (physical and price escalation) are portions eligible for ODA loan, while administration cost, interest during construction, and relevant taxes are portions non-eligible for ODA loan, considering that the Project is to be financed by Japanese ODA Loan.

8.1.2 Condition of Construction Cost

(1) Project Component

The Project consists of three types of facilities, namely i) Sewer, ii) WWTP and iii) BDS Sewer Connection, as shown in Table 8.1.1.

Table 8.1.1 Project Component

Component	Description
1. Sewer	
1) Sewer (open cut)	Pipeline: D200-400 mm, 26,320 m Manhole: 732 units for D250-1500 mm pipelines
2) Sewer (pipe jacking)	Pipeline: D250-1500 mm, 26,319 m Vertical Shaft: 732 sets for D250-1500 mm pipelines
3) Equipment	High-pressure washing machine: 3 sets CCTV for pipeline monitoring: 3 sets
2. WWTP	
1) Influent Pump Station	Dry Pit Submersible Pump (30 m3/min x 25mH)
2) Wastewater Treatment Facility (WTF) 1	Membrane Bio Reactor (MBR): treatment capacity 56,000 m^3/day (28,000m^3/day, 2lines)
3) WTF2	MBR: treatment capacity 56,000 m^3/day (28,000m^3/day, 2lines)
4) Sludge Treatment Facility	Thickener: Filter Type Thickener 2units, 90m3/h/unit Sludge dewatering facility: Sludge Dewatering Unit 2units, 880kg-dry sludge/h Sludge drying facility: Sludge drying machine 2units, 100m3/d
5) Effluent Channel	Effluent channel, emergency channel: D1,000 mm x 2, Length = 20 m
6) Electricity Connection	33 kV, 2 km
7) Operation and maintenance training	WTF1: 1.5years (6 months before operation including commissioning test period, 1year from operation start) WTF2: 15months (3 months before operation (commissioning test period), 1year from operation start)
8) Truck for Sludge Transport	10 tons, closed type carrier, 3 units
3. BDS	
1) BDS Sewer Connection	176 units, diversion chamber
2) Pilot BDS Sewers Replacement	6 units, improvement with sewer replacement
3) Sewage Ejector Removal	40 units

Source: JICA Study Team

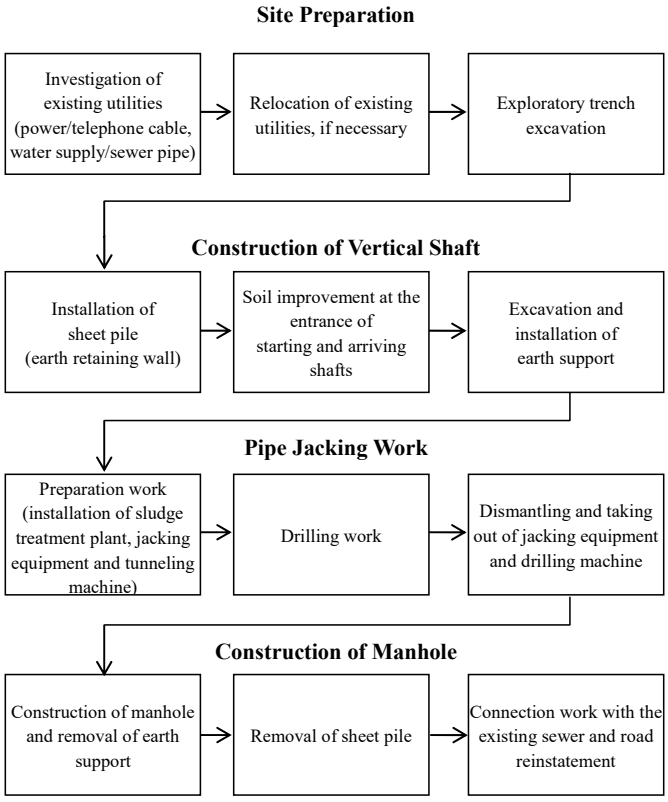
(2) Construction Method

1) Sewer

The sewer is planned to be constructed either by conventional open cut method or by microtunneling method. Construction of sewer by pipe jacking method consists of i) site preparation work, ii) construction of vertical shaft, iii) pipe jacking work, and iv) construction of manhole and connection with the existing sewer.

The vertical shaft will be constructed on the existing road. The location of existing utilities, such as power/telephone cables and water supply/sewer pipelines, must be confirmed beforehand, and such utilities shall be relocated if necessary. Prior to the installation of the sheet pile, exploratory trench excavation will be conducted to confirm non-existence of utility. The required area for the vertical shaft and temporary facility yard is 300 m^2. Thus, traffic lane control will be necessary. Safety measures including fencing of work site and installation of signboards will be undertaken. The contractor shall submit the abovementioned construction plan to the relevant authority to get permission for road occupancy for the construction works.

The process of construction of the interceptor by microtunneling method is shown in Figure 8.1.1.



Source: JICA Study Team

Figure 8.1.1 Construction Process of Sewer by Microtunneling Method

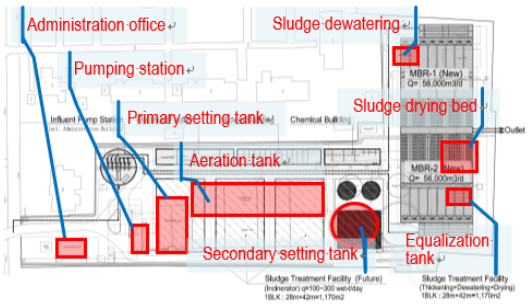
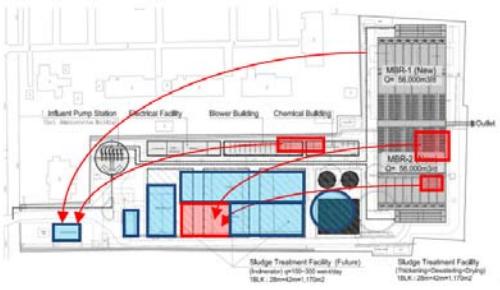
2) Wastewater Treatment Plant (WWTP)

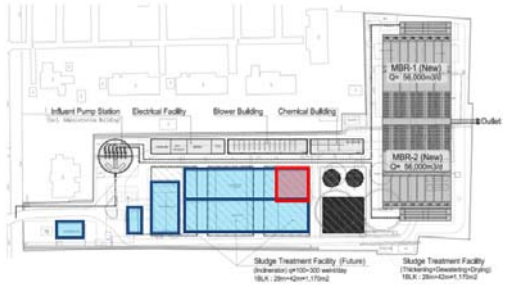
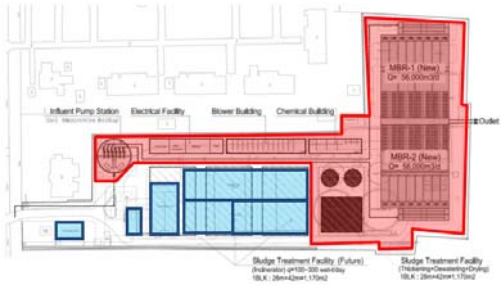
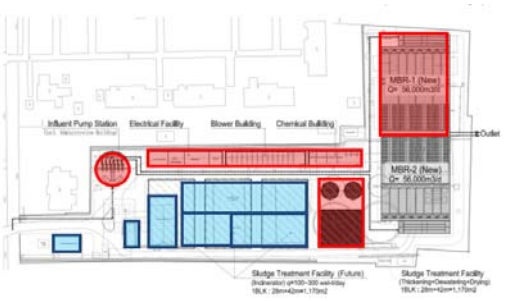
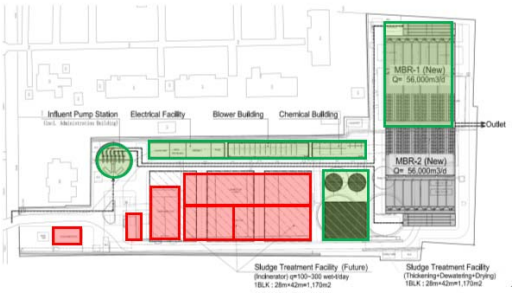
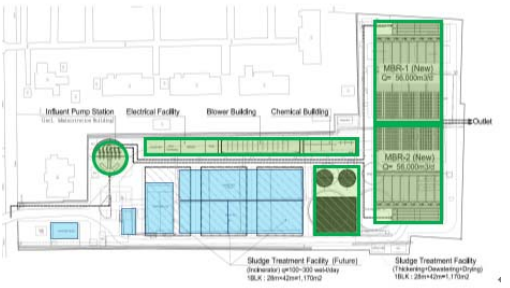
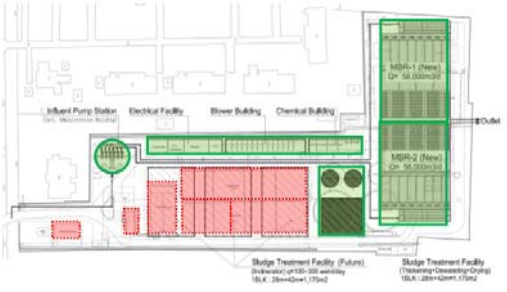
The construction site is in the premises of the existing WWTP which is being operated. The WWTP is planned to have an MBR for wastewater treatment. The WWTP consists of a water treatment facility (primary clarifier, reaction tank, MBR, and disinfection tank) and a sludge treatment facility. The influent pump station will be constructed in the premises of the WWTP. The concrete works and electrical and mechanical works of the pump station will be conducted after the arrival of the tunneling machine from the vertical shaft.

The anticipated steps for WWTP construction is shown in Figure 8.1.2. Some existing facilities will be relocated within the premises so that the existing WTF will remain operational until the commissioning of the new WTF-1. Other facilities located in the construction area of WTF-1 will be demolished and cleared. Then, WTF-1 and the facilities necessary for its operation will be constructed. It is planned for WTF-1 to commence its operation at the beginning of the 4th year from the start of construction. The construction of WTF-2, which has the same treatment capacity as WTF-1, will start at the same time as the commissioning of WTF-1. The capacity of waste water treatment of the facility will be increased stepwise; 56,000m^3/day at the operation start of WTF-1, 84,000m^3/day at the half capacity operation start of WTF-2, 112,000m^3/day at the full capacity operation start of WTF-2. The existing WTF will be demolished and removed once WTF-2 is ready for operation.

The construction work for each facility consists of civil works and electrical and mechanical works. The civil works will be commenced by driving the pile foundation, followed by the installation of the sheet pile for the earth retaining wall. It is assumed to adopt the Press-In Caisson method for the foundation of the influent pump station, which requires about 30 m depth and 20 m width of excavation, so that the influence of high groundwater level can be avoided and so that the foundation can be constructed in a relatively small area located closely to the neighboring buildings.

The electrical and mechanical facilities will be installed after the completion of the civil structures. After the completion of the commissioning test, the taking over certificate will be issued.

STEP-1: Q=7,500 m^3/d	**STEP-2:** Q=7,500 m^3/d
Present Operation	Transfer of the Existing Facilities
	

STEP-3: Q=7,500 m^3/d	**STEP-4:** Q=7,500 m^3/d
Alteration of the Existing Sedimentation Tank	Clearing the Existing Structures
	
STEP-5: Q=7,500 m^3/d	**STEP-6:** Q=7,500 m^3/d + 56,000 m^3/d = 63,500 m^3/d
Influent pump station, Blower room, Electrical Facility Building, WTF-1, Sludge Treatment Facility	Commissioning of Influent pump station, Blower room, Electrical Facility Building, WTF-1, Sludge Treatment Facility Operation Termination of the Existing WTF
	
STEP-7: Q=56,000 m^3/d	**STEP-8:** Q=56,000m^3/d＋28,000m^3/d
Construction of WTF-2	Commissioning of WTF-2 (Half capacity)
	
STEP-9: Q=84,000m^3/d＋28,000m^3/d	**STEP-10:** Q=112,000m^3/d
Commissioning of WTF-2 (Full capacity)	Removal of the Existing WTF
	

Source: JICA Study Team

Figure 8.1.2 Construction Steps of WWTP

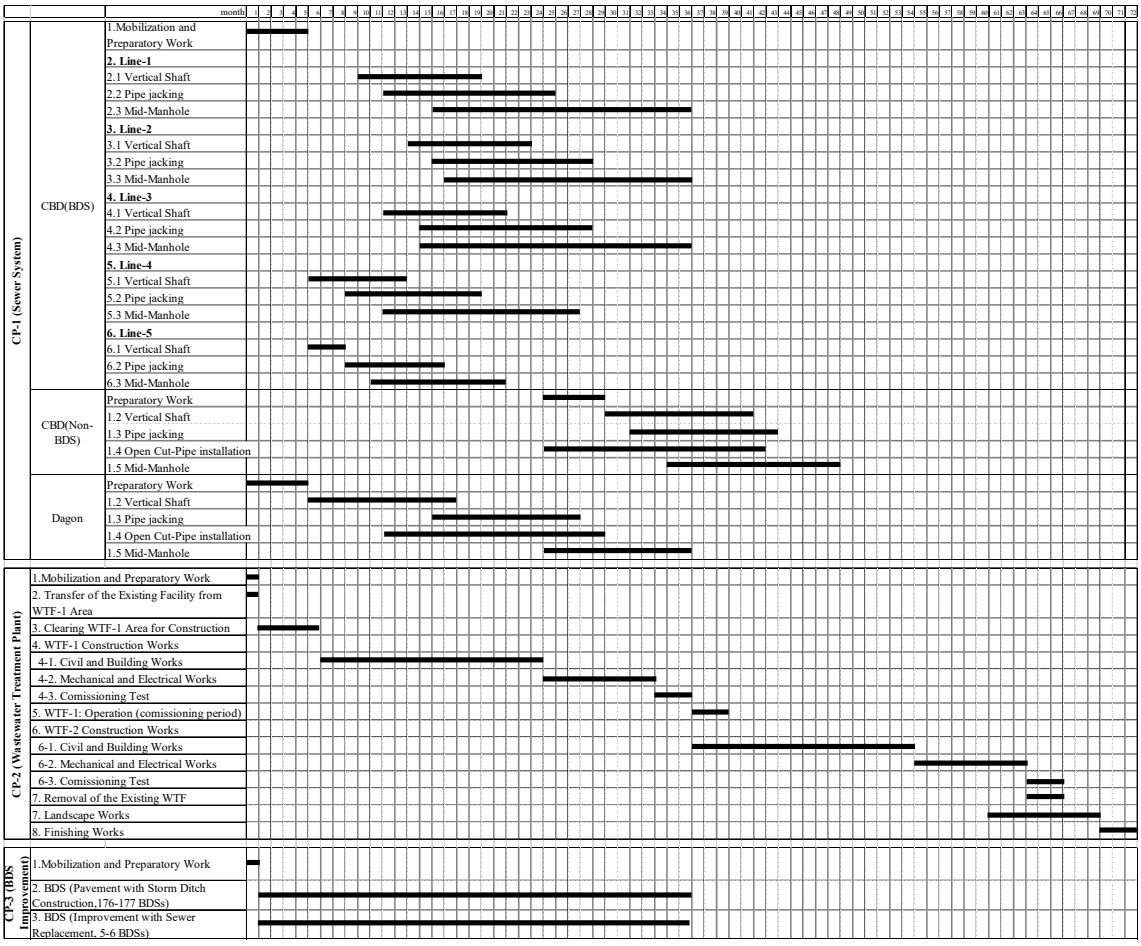
3) Back Drainage System (BDS)

The construction for BDS improvement is classified into two types: one is to improve the mixing condition of grey water and storm water in the BDS through the installation of a diversion chamber which separates grey water from storm water. The other one will be applied in 6 BDS as a pilot project which is to replace the existing sewer pipes for collecting grey water, which is currently discharged mixed with rainwater, and black water so as not to be discharged to an open water body.

(3) Construction Schedule

The construction schedule is shown in Figure 8.1.3. The estimated construction period for three components of the project is shown below. The construction of a WWTP takes the longest among the three components.

CP-1 Sewer: 4 years
CP-2 WWTP: 6 years
CP-3 BDS: 3 years



Note: Alignments of sewer lines in CP-1 are shown in Figure 6.8.5

Source: JICA Study Team

Figure 8.1.3 Construction Schedule

8.2 Procurement of Construction Materials and Related Machines/Equipment

Construction materials, construction machines, and equipment to be installed will be conveyed to a temporary site by land transportation. The site of the proposed WWTP is along the main road where accessibility is recognized as relatively good.

Materials to be imported will be unloaded at either Yangon Port or Thilawa Port after maritime transportation and will be conveyed from the port to the construction sites through inland transportation. According to the regulation of Yangon Region Government, which was issued in December 2016, during daytime, heavy vehicles are in principle restricted from passing through the city, and application and permit are required if you drive these vehicles in these hours. To address this, heavy vehicles will be required to operate during nighttime. Table 8.2.1 gives a summary of interviews to contractor(s) that have experience in construction in Yangon City as well as other parts of Myanmar. Based on this information, conditions for procurement of construction materials, machines, and equipment were analyzed and assumed.

Table 8.2.1 Summary of Interview Results to Contractors

Contractor	Interview Result
A	- No difficulty to procure cement in Yangon - Steel bars with performance guarantee are imported - Stock of steel sheet piles are not available and imported for each construction - Cast-in-place concrete pile is common in Myanmar
B	- Concrete pipe is imported from Thailand. Concrete pipe for pipe jacking is imported from Japan. - Local contractor does not have capacity for pipe jacking so that foreign contractor shall be responsible for the work. - PVC and polyethylene pipes are produced in Yangon following JIS. - Imported sheet pile was used for open cut piping. - Diaphragm wall is not common in Myanmar. - Bracing materials cannot be rented in Yangon. Materials are procured for each construction.
C	- Foundation pile: 35-40 cm square pile, ϕ 300-600 mm of span pile is available - Vibration hummer for piling is prohibited in CBD area - Use of ϕ 600 mm of ready-made pile is good to reduce cost - HDPE pipe is produced in Yangon, which is light and easy to use in construction work - Measures to avoid traffic jam should be taken for sewer construction especially in CBD

Source: JICA Study Team

(1) Construction Material

The main construction materials are concrete, soil, sand, reinforcing bars, temporary material, etc. According to the interview with experienced contractors, most of the construction materials can be supplied without delay.

- Concrete: cement and aggregate can be readily procured in Yangon City. A ready-mixed concrete manufacturer, which carries out adequate quality control, exists in Yangon.
- Reinforcing bar: Chinese products following British Standards (BS) are available in the domestic market.

- Temporary material: earth retaining material (such as steel sheet pile or bracing, etc.), shuttering material, scaffolding/supporting material, and heavy temporary material can be prepared in construction works in Yangon City, while some materials such as steel sheet piles have to be imported.

(2) Pipe Material

Based on the experience of Japanese grant aid project of "The Project for Urgent Improvement of Water Supply System in Yangon City (2013)", clay layer having sufficient cohesion exists predominantly on the surface in the city. Therefore, it is assumed that high strength shell is required for the pipe jacking method.

Since high quality concrete pipes for pipe jacking method are not produced in Myanmar at this moment, all materials shall be imported from Japan or neighboring countries.

(3) Mechanical and Electrical Equipment

Mechanical and electrical equipment are to be imported because of absence of related factories in Myanmar. The equipment will be procured from Japan or neighboring countries. Reliable products are desirable in order to use equipment for a long duration. For this purpose, the technical requirements for equipment are specified. Then, the equipment should be procured from reliable manufacturers who have long-term experience in good quality products.

(4) Construction Machine

At present, construction machines are widely used in construction works, such as hotels and housing complexes in Yangon City or in neighboring areas. WWTPs can be built by general machines except for some machines for specialized methods like the Press-In Caisson method, that are used for construction of the lift pumping station at the entrance of the WWTP. Machines for Press-In Caisson method and pipe jacking method are required to import for the construction.

(5) Local Workers and Constructors

The construction market has been very active in Myanmar in the recent years. Movement and recruitment of capable workers and skillful technicians is on the rise; therefore, rates vary frequently.

8.3 Conditions of Cost Estimation of the Project

1) Civil Works

The construction cost was estimated by multiplying the preliminary work quantities based on the preliminary facility plan with the unit cost of civil works. The estimated unit cost is composed of the current labor cost, material cost, and machine operation cost in Yangon.

The cost for pipe jacking including all machinery costs was estimated based on the quotation from

the potential Japanese contractors specializing in pipe jacking works. The cost of concrete pipe materials for pipe jacking was estimated based on the quotation from the manufacturer in Japan as well. It is assumed that pipes would be loaded on ships at the Yokohama Port and unloaded at Thilawa Port instead of Yangon Port because the volumes of pipes are so huge that enough temporary storage area would be necessary.

The cost for mobilization and common preparatory works is assumed at 10% of the construction cost. The cost of general administration is assumed at 25 % of the construction cost.

2) Mechanical and Electrical Works of WWTP

The cost for mechanical and electrical works of the WWTP, including installation cost and commissioning cost, was estimated based on the quotation from the potential contractors specializing in WWTP with experience in the MBR and mechanical sludge treatment. The quoted cost is composed of 1) mechanical facility, 2) electrical facility and instrumentation, and 3) installation work. The cost of general administration is assumed at 25 % of the construction cost.

3) Construction of BDS

The actual cost for BDS improvement executed by YCDC in the past was referred to as the approximate cost for construction. The cost of general administration is assumed at 10 % of the construction cost.

8.4 Consulting Services

Consulting services including the following will be required for the smooth implementation of the Project to assist YCDC, the executing agency of the project.

- Review of the feasibility study and preparation of definitive project features
- Field surveys of project sites and planned facilities, including topographic survey, geological survey, inventory survey of existing structures, underground utility survey, and household connection survey
- Preparation of detailed design based on the above survey results
- Preparation of bidding documents
- Assistance for pre-qualification, bid evaluation, and contract negotiation
- Supervision of construction works
- Assistance for social and environmental consideration including EIA and related procedures
- Technical transfer
- Assistance for enhancement of public awareness and utilization of sludge

The consultant team consists of international and local experts. International experts lead all activities of the consulting services with assistance by local experts. The proposed work schedule of the consultant shall be in accordance with the implementation schedule. The required international and local experts along with the man-months for consulting services for the implementation are presented in Table 8.4.1.

It is estimated that 427 man-months of international experts and 883 man-months of local experts

would be required to conduct consulting services. In addition, 587 man-months of administration staff members would be required to execute the services.

Table 8.4.1 Consulting Services

	International Expert	Local Expert
Consultant and Specialist		
Overall		
Project Manager	78	-
Co-Project Manager	-	93
Survey Engineer	7	-
O&M/Sludge Utilization Specialist	17	-
Environment Specialist	37	45
Procurement/Contract Specialist	17	-
Cost Estimator	8	187
Customer Information Specialist	17	-
Sewerage/Civil Engineer	-	232
Inspector	-	224
Geotechnical Engineer	-	12
Topographic Surveyor	-	12
CP-1 Sewer		
Deputy Project Manager/Sewer Network Engineer	47	-
Sewer Line Engineer/Pipe Jacking Specialist	41	-
CP-2 Quantity Surveyor		
Wastewater Treatment Engineer	46	-
Structural Engineer	21	-
Architectural Engineer	2	-
Mechanical Engineer	27	28
Electrical Engineer	22	26
Structure Engineer	-	24
CP-3: BDS		
Sewer Connection Specialist	40	-
Subtotal	**427**	**883**
Administration Staff		
Secretary	-	97
Accountant	-	97
Translator/Interpreter	-	130
CAD Operator	-	166
Office Keeper	-	97
Subtotal	-	**587**

Source: JICA Study Team

8.5 Project Cost

8.5.1 The Estimated Project Cost

The overall project cost is estimated based on the basic conditions given in Section 8.1.

8.6 Estimation of Operation and Maintenance (O&M) Cost

The O&M cost required for the project is estimated and summarized in Table 8.6.1. The O&M cost for the sewer is estimated by referring to the experience of YCDC for the existing sewers in the CBD. The one for the WWTP is estimated by referring to the existing facility and the estimation from suppliers that have experience on a similar technology of wastewater treatment. The annual O&M cost is estimated as 1,000 million/year.

Table 8.6.1 O&M Cost

Year	Item	O&M Cost (JPY million)
Sewer		
1	Energy (Electricity)	19
2	Manpower	40
3	Maintenance	191
	Subtotal	**250**
WWTP		
1	Energy Cost	323
2	Chemical Cost	10
3	Sludge Disposal Cost	7
4	Manpower Cost	28
5	Maintenance Cost	382
	Subtotal	**750**
Total		**1,000**

Note: Values in table are at the designed all capacity operation of WWTP.

Source: JICA Study Team

8.7 Remarks for Project Implementation

8.7.1 Selection Policy for Contractors

(1) Pre-Qualification (P/Q)

The pre-qualification procedure shall be taken prior to bidding to secure the quality of contractors' work and to achieve timely completion of this project. Pre-qualification of bidders needs to consider the following issues to evaluate candidate bidders' capability to undertake the scope of contract:

i) Experience and achievement in similar contracts
ii) Capability of staff and equipment
iii) Financial situation

(2) Bidding system

Two-envelope bidding could be appropriate for the selection of contractors, same as the case of the procurement of consultants. The bidding system requires submission of technical and cost proposals separately and simultaneously.

8.7.2 Contract Package

Considering the characteristics of the project components and the amount of works, it is proposed that the project be implemented in three contract packages. ICB is adopted to CP-1 and CP-2, while Local Competitive Bidding (LCB) is to CP-3 for the bidding method:

- Contract Package-1 (CP-1, ICB): Sewer
- Contract Package-2 (CP-2, ICB): WWTP
- Contract Package-3 (CP-3, LCB): BDS

As for CP-1, i.e., for the sewer, the package includes a vast length of pipe installation works by open cut method and pipe jacking method. The specialized companies for pipe jacking are usually not general contractors which can manage a large scale of construction. So, it is preferable for CP-1 that a general contractor arranges and supervises pipe installation works to be executed by subcontractors specialized for such works.

It is assumed for CP-2 that the main contractor, having international experiences and capable to manage the entire construction works of this package, will need to organize a joint venture or subcontract with other construction firms, including one having specialized techniques of MBR and mechanical sludge treatment.

CHAPTER 9 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

9.1 Purpose of the Considerations

With regard to environmental and social considerations (ESC), any project to be financed by the JICA assistance is required to comply with the JICA Guidelines for Environmental and Social Considerations (April 2010) (hereinafter referred to as "the JICA Guidelines") in addition to any existing laws and regulations in the recipient country.

ESC in the Study examines if the project complies or will comply with all the Japanese and Myanmar requirements. Furthermore, if any deficiency is found, the JICA Study Team will support the executing agency of the project in compliance with the entire requirements of the JICA Guidelines by proposing relevant actions to be taken by the executing agency.

9.2 General Requirement of the JICA Guidelines

9.2.1 Project Category by the JICA Guidelines

Requirements of the JICA Guidelines are dependent on "project categorization" of projects, which is stipulated in the JICA Guidelines (See Appendix 16 of this Report). Currently, the Project proposed by the "Data Collection Survey for Sewerage System Development in Yangon City" (the Project) has been classified as "Category B" by JICA.

9.2.2 Required Study for "Category B" Project

For a project classified in "Category B" by the JICA Guidelines, an "Initial Environmental Examination (IEE) level study" is required (See Appendix 16).

9.3 Environmental Management System of Myanmar

9.3.1 Major Legislative Framework on Environment Management

Major statute including National Constitution, Policy, Strategy and, Law and Regulation related to Environmental Management of Myanmar are shown in Table 9.3.1. With regard to EIA systems of Myanmar appears in Section 9.3.6.

Table 9.3.1 Major Statute on Environmental Management of Myanmar

Major Statute	Description
Constitution (2008)	The Myanmar's Constitution (2008) provides that "the Union is the ultimate owner of all lands and all-natural resources above and below the ground, above and beneath the water and in the atmosphere in the Union" and stipulates Articles on environment as shown below. - Article 45: The Union shall protect and conserve natural environment of the country. - Article 390: Every citizen has the duty to assist the Union in carrying out preservation and safeguarding of cultural heritage, Environmental conservation, striving for development of human resources, and Protection and preservation of public property
National Environmental Policy (1994)	The National Environment Policy (NEP) 1994 is the basis of the Myanmar's environmental statutory framework which is supported by the Constitution (2008) and empowers Government to conserve Myanmar's natural environment and enables Parliament to enact environmental laws. NEP emphasizes the following points; - To harmony and balance between these through the integration of environmental

Major Statute	Description
	considerations into the development process to enhance the quality of the life of all its citizens. - Responsibility of the State and every citizen to preserve its natural resources in the interest of present and future generation. - Environmental protection should always be the primary objective in seeking development.
National Biodiversity Strategy and Action Plan (2012)	The National Biodiversity Strategy and Action Plan (NBSAP) of Myanmar was adopted by the Cabinet on 03 May 2012 which contains 10 strategic directions as followings: - Strengthening conservation of priority sites; - Mainstreaming biodiversity into other policy sectors; - Implementing focused conservation actions for priority species; - Supporting local Non-Governmental Organization (NGOs) and academic institutions; - Creating capacity to coordinate conservation investment in Myanmar; - Scaling up implementation of in-situ and ex-situ conservation of agriculture, livestock and fisheries biodiversity and genetic resource management; - Expediting the process of implementing the. national bio-safety framework; - Promoting the initiative to manage IAS; - Facilitating the legislative process of environmental protection and environmental impact assessment; and - Enhancing communication, education and public awareness on biodiversity conservation.
Myanmar Agenda 21 (1997)	The Myanmar Agenda 21 was formulated in 1997 in response to the call of the United Nations Conference on Environment and Development (Earth Summit) held in 1992 to develop national strategies for the implementation of the Global Agenda 21.
National Sustainable Development Strategy (2009)	The Myanmar's National Sustainable Development Strategy (NSDS) was formulated in 2009 to meet its global commitment made at the Johannesburg Plan of Implementation (JPOI) in 2002, which covers the three pillars of environment, economic and social aspects of the country. Vision of Myanmar's NSDS is "Wellbeing and Happiness for Myanmar People". Three goals of NSDS identified are as follows: - Goal 1: Sustainable Management of Natural Resources - Goal 2: Integrated Economic Development - Goal 3: Sustainable Social Development.
Protection of Wildlife, Wild plants and Conservation of Natural Area Law (1994)	Protection of Wildlife, Wild plants and Conservation of Natural Area Law in1994, focuses on protecting wildlife including their habitats and formulating protected areas while stipulating penalties against offenses. The major objectives of the law are to implement the Government policy for wildlife protection as well as for natural areas conservation and to protect endangered species and their habitats.
Environmental Conservation Law (2012)	The Environmental Conservation Law, consists of 14 chapters and 42 articles, was signed by the President on 30th March 2012 which has eight objectives as shown below. - To enable to implement the Myanmar National Environmental Policy. - To enable to lay down the basic principles and give guidance for systematic integration of the matters of environmental conservation in the sustainable development process. - To enable to emerge a healthy and clean environment and to conserve natural and cultural heritage for the benefit of present and future generations. - To reclaim ecosystems as may be possible which are starting to degenerate and disappear. - To enable to manage and implement for decrease and loss of natural resources and for enabling the sustainable use beneficially. - To enable to implement for promoting public awareness and cooperation in educational programmes for dissemination of environmental perception. - To enable to promote international, regional and bilateral cooperation. - To enable to cooperate with Government departments, Government organizations, international organizations, non-government organizations and individuals in matters of environmental conservation.
Environmental Conservation Rule (2014)	Environmental Conservation Rules (ECR) was enacted on 5th June 2014. ECR 2014 stipulates the details on the environmental conservation including EIA system based on the Environmental Conservation Law (2012).
Environmental Impact Assessment Procedure (2015)	EIA Procedure (2015) (or EIA Notification No. 616/2015) came into force on December 2015 as the first legal framework of EIA in Myanmar.

Source: Directorate of Investment and Company Administration (DICA), Myanmar's changing landscape June 2014 coffey.com, National Sustainable Development Strategy 2009, Environmental Conservation Law 2012, EIA Portal Site in Myanmar MONREC, Current Environmental Situation in Myanmar April 2015 Mr. Hein Latt MOECAF, Environmental Safeguard and Environmental Impact Assessment System in Myanmar Dr. San Oo January 2015 MOCAF, Overview on Environmental Governance in Myanmar Hla Maung Thein June 2016 MONREC

9.3.2 Other Relevant Laws and Regulations on Environment

Table 9.3.2 shows other Relevant Laws and Regulations on environment in Myanmar.

Table 9.3.2 Other Policy, Law and Regulation related to Environment

Sector	Policy, Law and Regulation
Forestry	- Forest Law, 1992 - Forest Policy 1994 - National Code of Practice for Forest Harvesting 2000
Water	- National Water Policy 2014 - The Underground Water Act, 1930 - The Conservation of Water Resources and River Law, 2006
Health	- National Food Law, 1997 - Traditional Drug Law, 1996 - Prevention and Control of Communicable Diseases Law, 1995 - National Drug Law, 1992 - Union of Myanmar Public Health Law, 1972
Tourism	- Myanmar Hotel and Tourism Law, 1993
Industrial	- Private Industrial Enterprise Law, 1990 - Factory Act, 1951 - Oilfield (Workers and Welfare) Act, 1951 - Petroleum Act, 1934 - Oilfield Act, 1918
Livestock & Fisheries	- Animal Health and Development Law, 1993 - Freshwater Fisheries Law, 1992 - Myanmar Marine Fisheries Law, 1990 (Law Amending the Myanmar Marine Fisheries Law, 1993) - Law Relating to Aquaculture, 1989 - Law Relating to the Fishing Right of Foreign Fishing Vessels, 1989 (Law Amending the Law Relating to the Fishing Rights of Foreign Fishing Vessels, 1993)
Mining	- Myanmar Gemstone Law, 1995 - Myanmar Pearl Law, 1995 - Myanmar Mines Law, 1994 - Salt Enterprise Law, 1992 - Land Acquisition (Mines) Act, 1885
Science & Technology	- Science and Technology Development Law, 1994
Transportation	- Highways Law, 2000 - Motor Vehicles Law, 1964 (Law Amending the Motor Vehicles Law of 1964 enacted in 1989) - Myanmar Aircraft Act, 1934 - Island Steam Vessels Act, 1917 - Ports Act, 1908 - Defile Traffic Act, 1905 - Yangon Port Act, 1905 - Canal Act, 1905 - Obstruction in Fairways Act, 1881
Electricity	- State Law and Order Restoration Council (The Law Amending the Electricity Law, 1990) - Electricity Law (2014)

Source: Government of Myanmar, Tabulated by JICA Study Team

9.3.3 International Environmental Conventions/ Protocols/ Agreements

Myanmar as one of the parties signed more than 30 international and regional conventions and protocol on environment as shown in Table 9.3.3.

Table 9.3.3 International Agreements on Environmental Issues

	Title	Signature	Ratification	Member	Cabinet Approval
Regional	Plant Protection Agreement for the South-East Asia and the Pacific Region, Rome, 1956		4-11-1959 (Adherence)	4-11-1959	
	Agreement on the Networks of Aquaculture Centers in Asia and the Pacific, Bangkok, 1988		22-5-1990 (Accession)		
	Southeast Asia Nuclear Weapon Free Zone Treaty, Bangkok, 1995	15-12-1995	16-7-1996 (Ratification)		
	ASEAN Agreement on the Conservation of Nature and Nature	16/10/1997			

	Title	Signature	Ratification	Member	Cabinet Approval
	Resources, Kuala Lumpur, 1985				
	ASEAN Agreement on Transboundary Haze Pollution	10/6/2002	13-3-2003 (Ratification)		7/2003 27-2-03
International	Treaty Banning Nuclear Weapons Test in the Atmosphere in Outer Space and Under Water, Moscow, 1963	14/8/1963	15-11-1963 (Ratification)		
	Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea-Bed and Ocean Floor and in the Subsoil there of, London, Moscow, Washington, 1971	11/2/1971			
	Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons, and on their Destruction, London, Moscow, Washington, 1972	10/4/1972			
	International Convention for the Prevention of Pollution from Ships, London, 1973	(Accession)	undertakes to give effect to this Convention under para 1 & 2 of Article 1 of the Protocol of 1978		
	Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, London, 1973		4-8-1988 (Accession)	Except for Annexes III, IV and V of the Convention	
	United Nations Convention on the Law of the Sea, Montego Bay, 1982	10/12/1982	21-5-1996 (Ratification)		
	United Nations Framework Convention on Climate Change, New York, 1992 (UNFCCC)	11/6/1992	25-11-1994 (Ratification)		41/94 9-11-94
	Convention on Biological Diversity, Rio de Janeiro, 1992	11/6/1992	25-11-1994 (Ratification)		41/94 9-11-94
	Treaty on the Non-Proliferation of Nuclear Weapons, London, Moscow, Washington, 1968		2-12-1992 (Accession)		
	Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and their Destruction, Paris, 1993	14-1-1993			
	International Tropical Timber Agreement (ITTA), Geneva, 1994	6-7-1995	31-1-1996 (Ratification)		
	Vienna Convention for the Protection of the Ozone Layer, Vienna, 1985		24-11-1993 (Ratification)	22-2-1994	46/93
	Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal, 1987		24-11-1993 (Ratification)	22-2-1994	46/93
	London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, London, 1990		24-11-1993 (Ratification)	22-2-1994	46/93
	Convention for the Protection of the World Culture and Natural Heritage, Paris, 1972		29-4-1994 (Acceptance)		6/94 9-2-94
	ICAO ANNEX 16 Annex to the Convention on International Civil Aviation Environmental Protection Vol. 1 Aircraft Noise	(Accession)			
	ICAO ANNEX 16 Annex to the Convention on International Civil Aviation Environmental Protection Vol. II Aircraft Engine Emission	(Accession)			
	Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space Including the Moon and Other Celestial Bodies (Outer Space Treaty), London, Moscow, Washington, 1967	22-5-1967	18-3-1970 (Ratification)		
	Agreement on the Networks of Aquaculture Centres in Asia and the Pacific, Bangkok, 1988		22-5-1990 (Accession)		
	South East Asia Nuclear Weapon Free Zone Treaty, Bangkok, 1995	15-12-1995	16-7-1996 (Ratification)		
	United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and / or Desertification, Particularly in Africa, Paris, 1994 (UNCCD)		2-1-1997 (Accession)	2-4-1997	40/96 4-12-96
	Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington, D.C., 1973; and this convention as amended in Bonn, Germany,1979 (CITES)		13-6-1997 (Accession)	11-9-1997	17/97 30-4-97
	Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, New York, 1994		21-5-1996 (Accession)		
	Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, Rome, 1973		8-9-1994 (Acceptance)		
	Catagena Protocol on Biosafety, Cartagena, 2000	11/5/2001			13/2001 22-3-01

	Title	Signature	Ratification	Member	Cabinet Approval
	International Treaty on Plant Genetic Resources for Food and Agriculture, 2001		4-12-2004 (Ratification)	29-6-2004	
	Kyoto Protocol to the Convention on Climate Change, Kyoto, 1997		13-8-2003 (Accession)		26/2003 16-7-03
	Stockholm Convention on Persistent Organic Pollutants (POPs), 2001		18-4-2004 (Accession)	18-7-2004	14/2004 1-4-04

Source: NBSAP Myanmar

9.3.4 National Environmental Quality Guidelines

The National Environmental Quality (Emission) Guidelines (NEQG) was issued in December 2015 under the Ministry of Natural Resources and Environmental Conservation (MONREC) as summarized below.

- NEQS has basically been excerpted from the Environmental Health and Safety (EHS) of International Finance Corporation (IFC) of the World Bank Goup, as a guidance of pollution prevention to be used in developing countries.
- NEQG specifically applies to all project types listed in 'Categorization of Economic Activities for Assessment Purposes' of EIA Notification (2015).

9.3.5 Institutional Framework on Environmental Management

(1) National Environmental Conservation and Climate Change Central Committee (NECCCCC)

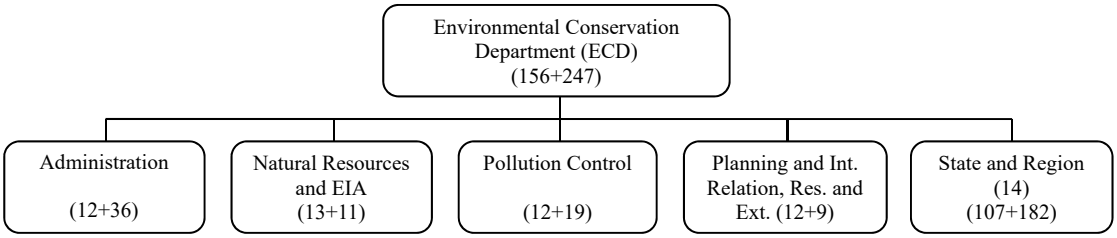
National Commission for Environmental Affairs (NCEA) was established in 1990 to i) advise the government on environmental policies; ii) act as a coordinating body for environmental affairs; and iii) promote environmentally sound sustainable development. NCEA was reorganized into the National Environmental Conservation Committee (NECC) in April 2011 based on Notification No.21/2011 of the Office of the President. (Source: REDD+ Myanmar, http://www.myanmar-redd.org/mm/)

In June 2016, the Government set up the National Environmental Conservation and Climate Change Central Committee (NECCCCC) by reorganizing of NECC at the highest level of Governmental committee on environment, chaired by the vice president and supported by six sub-committees.

(2) Ministry of Natural Resources and Environmental Conservation (MONREC)

"Ministry of Natural Resources and Environmental Conservation (MONREC)" which was founded by the merger between the former "Ministry of Environmental Conservation and Forest (MOECAF)", and the former "Ministry of Mines (MOM)" when the new Myanmar Government was launched in 2016, is the nodal governmental body of Myanmar for taking on administration of Environmental Management and EIA procedures in Myanmar.

The Environmental Conservation Department (ECD) of the MONREC is to take responsibility for the environmental conservation and management as well as EIA procedures in Myanmar which consists of five sub-divisions as shown in Figure 9.3.1.



Note: (12+36) the former is the staffs who are working + the latter is the staff to be appointed as of 2015.
Source: Sustainable Road Map for Myanmar by Dr. San Oo, Environmental Conservation Department, 2015, MONREC

Figure 9.3.1 Environmental Conservation Department (ECD) of MONREC

9.3.6 EIA System and Environmental Compliance Certificate (ECC)

(1) Legal Framework (EIA Notification (2015)) and Process

The first legal framework of EIA in Myanmar was established by the EIA Notification No.616 in 2015 (hereinafter referred to as "EIA Notification (2015)") which came into force on December 2015 as summarized below.

- EIA Notification (2015) defines the whole process of EIA and Environmental Compliance Certificate (ECC); terms, process and procedure, responsibilities of stakeholders, and so on.
- A proposed project will be categorized as one of the three categories (EIA, IEE or Non IEE/EIA type project) depending on the scale and significance of the impacts likely caused by the proposed project which process for categorizing is called as "Screening".
- At the first step of the EIA Procedure, the proponent shall submit a "Project Proposal (PP)" to the Environmental Conservation Department (ECD) at MONREC containing the project description and its likely impacts.
- ECD will determine the project type as "EIA", "IEE", or "Non IEE/EIA" based on the submitted PP, in accordance with Annex A "Categorization of Economic Activities for Assessment Purposes", and Article 25 and Article 28 (stipulating the specific factors for categorization).

(Source: EIA Portal Site in Myanmar, ECD Homepage at MONREC)

(2) EIA Type project

For the EIA type projects, the project proponent is required to submit "Terms of Reference (TOR)" and "Scoping Report" which include the proposed contents and the scope of the EIA investigation.

- At this timing, "Public Consultation" must be held by the proponent so as to collect opinions from stakeholders related to the proposed project.
- The proponent then undertakes the necessary investigation according to the approved TOR such as; data collection, impact analysis, consideration of mitigation measures and so on. An "EIA Report" and "Environmental Management Plan (EMP)" will be prepared based on all results of the investigation.
- The proponent must hold a "Public Consultation" at any timing during the investigation

process inviting to the relevant stakeholders including Project Affected Peoples (PAPs), NGOs, governmental bodies, and so on.

- The draft of EIA Report and EMP shall be updated for reflecting those comments from the participants of the Public Consultation.
- An "EIA Report Review Body", which consists of members from relevant ministries and experts, will review and assess the reports/documents submitted by the proponent.
- Based on the recommendations, the Minister makes a decision whether or not the submitted report should be approved.
- If approved, ECD issues an ECC" with necessary conditions to protect the environment, subject to payment of service fees as prescribed by ECD.

(Source: EIA Portal Site in Myanmar, ECD Homepage at MONREC)

(3) IEE Type project

IEE, "Initial Environmental Examination", means a process applied to any projects which would cause certain environmental/social impacts but not significant. (Source: EIA Portal Site in Myanmar, ECD Homepage at MONREC).

- IEE report and EMP shall be submitted to ECD, then those reports will be reviewed by ECD. Public consultation is also required at any timing during the investigation.
- ECC will be issued by MONREC upon successful review.

(Source: EIA Portal Site in Myanmar, ECD Homepage of MONREC)

(4) Non IEE or EIA Type Project

For the other case, no EIA/IEE is required; however, ECD may promote and support environmental management for these projects from a view of environmental and social safeguard.

(Source: EIA Portal Site in Myanmar, ECD Homepage of MONREC).

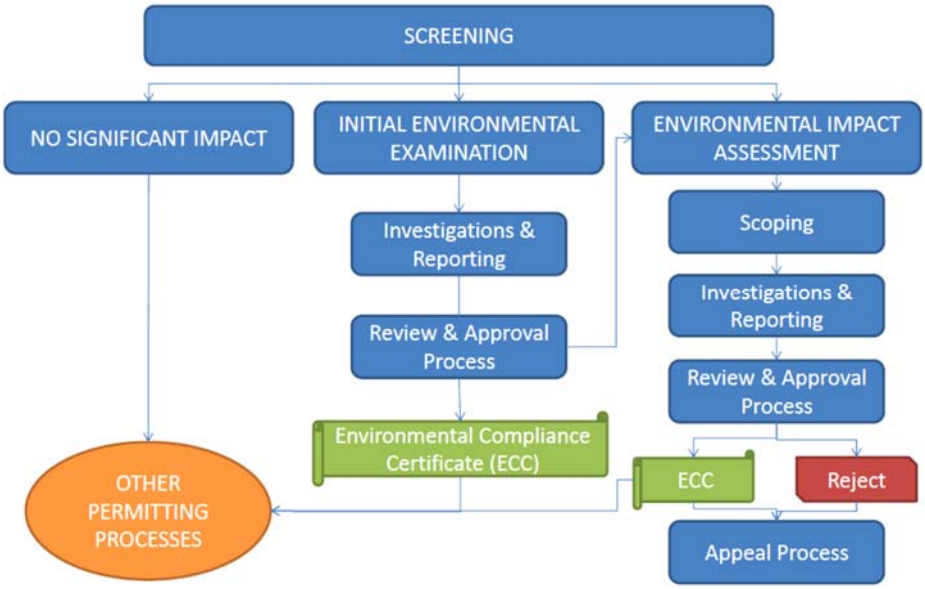
(5) Step and Action/Activity in EIA Process

Table 9.3.4 and Figure 9.3.2 summarize step, and action/activity of each project type.

Table 9.3.4 Major Action/Activity at Each Step by Project Type

Step	Action/Activity		
Before any EIA/IEE Study	Consultant Licensing		
EIA/IEE Process	Project Proposal (Screening)		
	EIA Type Project	IEE Type Project	Non IEE/EIA Type Project
	Organizing the study team for EIA type project	Organizing the study team for IEE type project	Close of the process
	Scoping	N/A	
	Investigation and review process of EIA type project	Investigation and review process of IEE type project	
	Preparation of EMP	Preparation of EMP	
	Issuance of ECC	Issuance of ECC	

Source: EIA Portal Site in Myanmar, ECD Homepage at MONREC, added by JICA Study Team

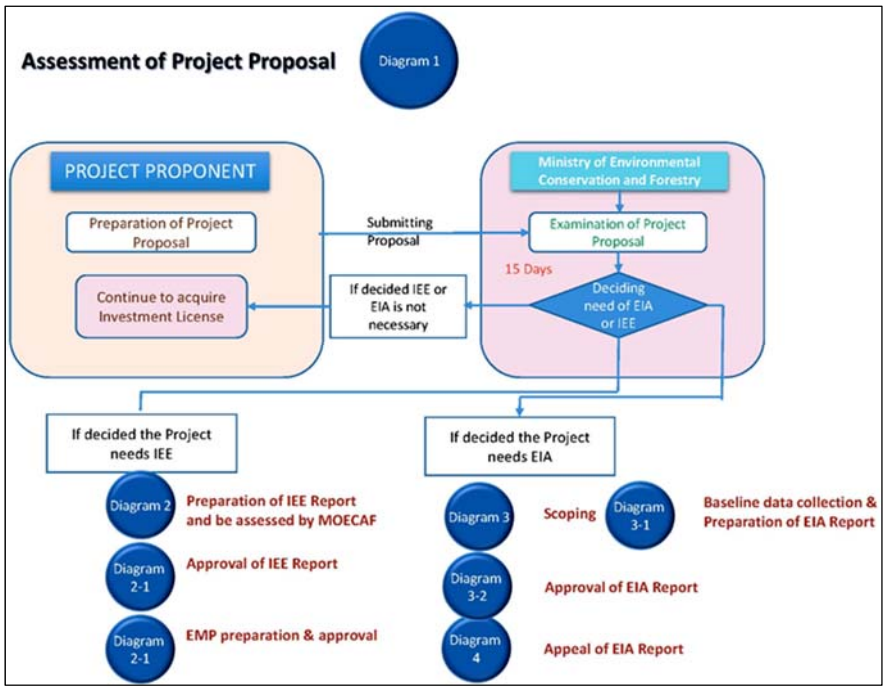


Source: EIA Good Practices in Myanmar Dr. San Oo Director ECD MONREC, 10 May 2016, ASIA EIA Conference Japan

Figure 9.3.2 Overview of Step and Action/Activity by Each Type Project

1) Screening Phase

The EIA procedure starts with the Screening process as shown in Figure 9.3.3.



Note: Ministry of Environment Conservation and Forest (MOECAF) in Figure is MONREC at present
Source: EIA Notification (2015), MONREC

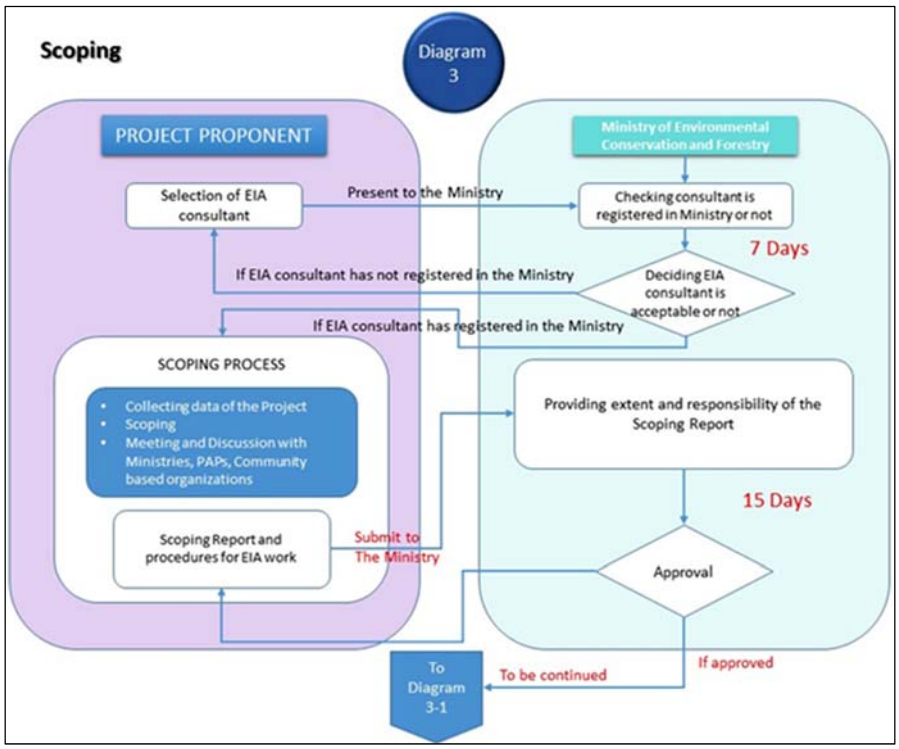
Figure 9.3.3 Screening Phase in EIA Procedure

- Guidance is provided as to which projects or activities should carry out an IEE or EIA, as presented in Annex A "Categorization of Economic Activities for Assessment Purposes" to EIA Notification (2015).
- The Annex shows for each type of economic activity, the criteria for selection of whether IEE or EIA apply to the proposed economic activity.

- MONREC determines whether the project is an IEE type project, or an EIA type project or if it is exempted from undertaking any environmental assessment.
- The project proponent might be required to submit a project proposal (completed in accordance with MONREC's guidelines) to ECD of MONREC for screening.
- Within 15 days from receiving the complete project proposal, MONREC shall determine the required type of environmental assessment (EIA, IEE, or none) and shall inform the Project Proponent in writing about its determination.
- In addition, the MONREC can change the status of an IEE Type Project to be an EIA Type Project if any of the above additional factors are relevant in this sense.

2) Scoping Phase

All EIA type projects are required to undergo the Scoping Phase as shown in Figure 9.3.4.



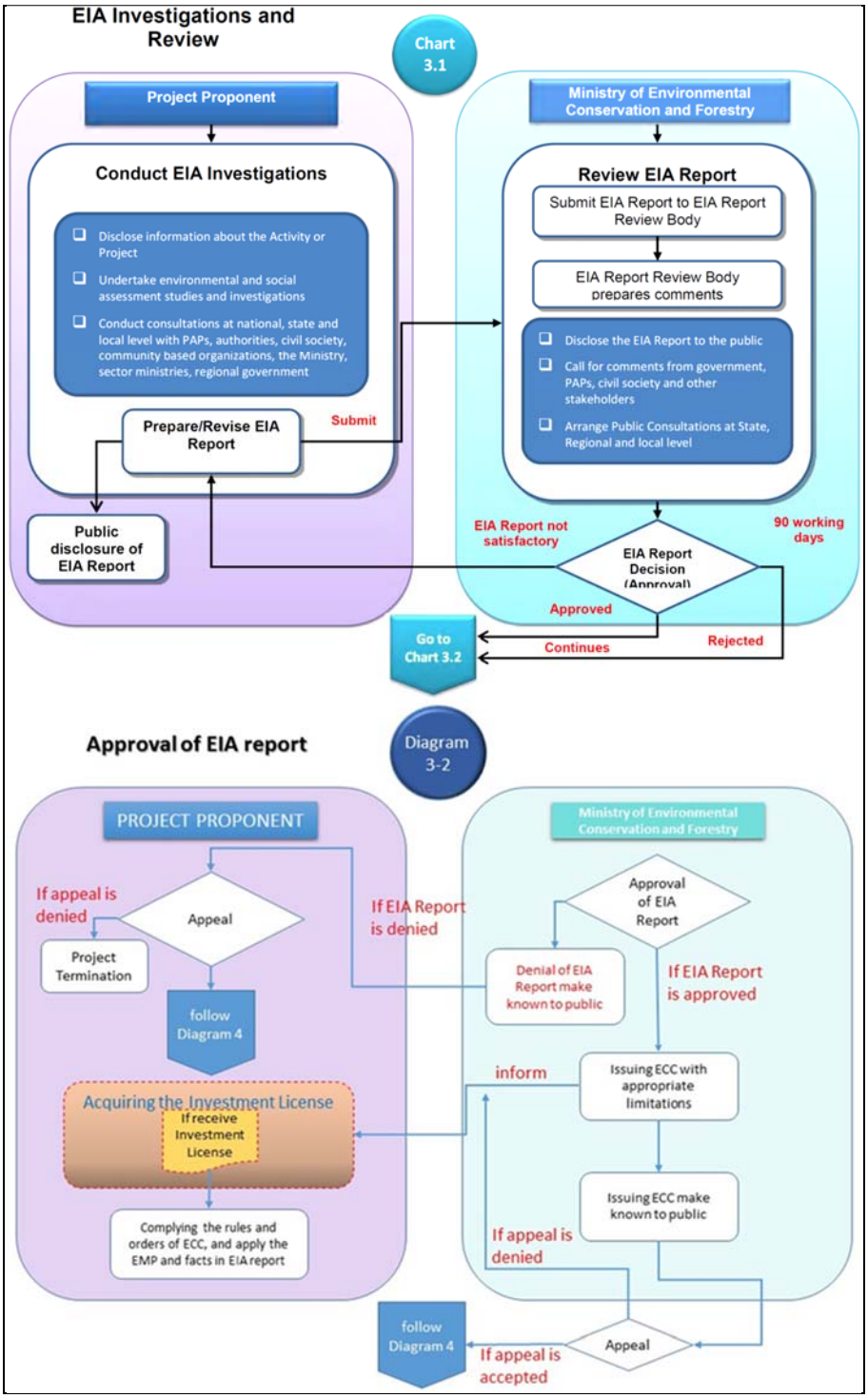
Note: Ministry of Environment Conservation and Forest (MOECAF) in Figure is MONREC at present
Source: EIA Notification (2015), MONREC

Figure 9.3.4 Scoping Phase in EIA Procedure

- The project proponent shall be responsible to ensure that the Scoping and the preparation of the Term of Reference (TOR) for the EIA report are undertaken in a professional manner and in accordance with any applicable guidelines issued or adopted by MONREC.
- As part of the scoping, the project proponent shall ensure that public consultation and participation process is carried out.
- The project proponent shall prepare a scoping report and TOR for the EIA investigation and submit the completed Scoping Report and TOR to MONREC for review and approval.

3) EIA Investigation, Report Preparation and Approval of EIA

Figure 9.3.5 shows EIA Investigation, Report Preparation and Approval of EIA procedure.



Note: Ministry of Environment Conservation and Forest (MOECAF) in Figure is MONREC at present
Source: EIA Notification (2015), MONREC

Figure 9.3.5 EIA Investigation, Report Preparation and Approval

- The project proponent has to ensure that the EIA investigation properly addresses all adverse impacts and is undertaken in accordance with the approved TOR.

- The project proponent is obliged to use, comply with and refer to applicable national standards, international standards adopted by the Government and/or MONREC, or, in the absence of relevant national or adopted international standards, such standards as may be agreed with MONREC.
- After completing all investigations and public consultation and participation processes required for EIA Type Projects, the project proponent shall submit the EIA Report to MONREC in both digital and hard copy, together with the required service fee.
- MONREC shall within 10 days after submission disclose the EIA Report to civil society, PAPs, concerned government organizations, and other interested stakeholders.
- MONREC shall submit the EIA Report to the EIA Report Review Body for comment and recommendations and also arrange for public consultation meetings at national and State/ Regional/ local levels where the project proponent shall present the EIA Report.
- All received comments and recommendations, including those of the EIA Report Review Board, will be collected and reviewed by MONREC prior to making a final decision on approval of the EIA Report.
- MONREC shall deliver its final decision within 90 days from the receipt of the EIA Report.
- Upon completion of its review of the EIA Report, MONREC will issue an ECC or inform the project proponent of its decision to reject the EIA Report and publicly disclose its decision.

(6) Time Frame in EIA Procedure

According to the review above, time frame in the EIA procedure can be summarized in Table 9.3.5.

Table 9.3.5 Required Time Frame in EIA Procedure

EIA Procedure		Period (working days)
IEE/EIA/NON- Proposal Screening		15
IEE Process	Approval of IEE experts	7
	IEE report preparation	-
	IEE report approval	60
EIA Process	Approval of EIA experts	7
	Developing EIA scoping report and TOR	-
	Scoping report and TOR approval	15
	Investigation/preparing EIA report	-
	EIA report approval	90

Source: EIA Notification (2015), edited and tabulated by JICA Study Team

(7) Social Considerations in EIA Procedure

With regard to social considerations in the EIA procedure, Table 9.3.6 shows social aspects specified in EIA Notification (2015).

Table 9.3.6 Social Considerations in EIA Procedure

Social Aspect	Requirement in EIA Notification
Involuntary Resettlement and Indigenous People	・ EIA Procedure does not address the social impacts of involuntary resettlement nor on indigenous people. ・ Separate procedures shall be issued by responsible ministries, and in the absence of such procedures all such projects shall adhere to international practice on involuntary resettlement and indigenous people.
Stakeholder, Public, Community and Individual	・ EIA Report shall consider the views, concerns, and perceptions of stakeholders, communities and individuals that could be affected by the project or who otherwise have an interest in the project. ・ EIA should include the results of public consultations and negotiations with the affected populations on the environmental and social issues. ・ Public concerns should also be taken into account in assessing impacts, designing mitigation measures, and selecting monitoring parameters.

Source: EIA Notification (2015), edited and tabulated by JICA Study Team

9.4 All Environmental Requirements for the Sewerage Project

9.4.1 Requirements for Category B project by the JICA Guidelines

As mentioned previously, the proposed project in the study has been classified as "Category B" by JICA. The followings are required based on the JICA Guidelines and for a Loan Agreement (L/A) with JICA (See Table 9.4.1 below).

- EIA report (Even though "Category B", if required by Myanmar side for the Project)
- ECC (Even though "Category B", if required by Myanmar side for the Project)
- Resettlement Action Plan (Land acquisition and/or Involuntary resettlement if required for the Project)
- IPP (Indigenous People Plan: if required for the Project)
- SHMs (Stakeholder Meetings: inducing the information disclosure, and public consultation with stakeholders)
- IEE level study
- Environmental Monitoring (YCDC shall submit the reports to JICA during the implementation period of the Project and two years after the completion of the Project)
- Others (depending on projects)

9.4.2 Requirements for the Project by EIA Notification (2015) of Myanmar

(1) Project Categorization

Based on Annex A "Categorization of Economic Activities for Assessment Purposes" of EIA Notification (2015), all projects in the field of sewerage are classified as "Waste Management" of Type of Economic Activity (See Appendix 17).

(2) Project Scope

The proposed project aims to develop the sewerage system in Yangon City as mentioned in

Chapter 1. As regards the sludge treatment in WWTP as one of the project components according to the Pollution Control and Cleansing Department (PCCD) of YCDC, the sludge is classified as non-hazardous waste in Myanmar.

(3) Requirements for the proposed project

In accordance with EIA Notification (2015) (See Appendix 17 of this Report) and the project components (regarded as the Waste Water Treatment Plant: centralized systems specified in the Appendix), it is recognized that the Project is subject to an EIA investigation and is required to obtain an ECC from ECD at MONREC.

Namely, the proponent for EIA for the project is YCDC as well as public consultations with stakeholders (Stakeholder Meetings) are required to be initiated and implemented by YCDC.

9.4.3 All Environmental Requirements for the Project to Satisfy Both Sides

As referred to the above, the requirements for the Project to satisfy both sides (of Myanmar and JICA) can be summarized in Table 9.4.1.

Table 9.4.1 All Environmental Requirements for the Project

Requirement	EIA Notification (2015)	The JICA Guidelines	Both Requirement
EIA Report	Yes (Project is categorized as Waste Management)	No	Yes
ECC	Yes (EIA is required for the Project)	Yes (ECC is to be obtained for the Project)	Yes
RAP	Yes (Households in existing WWTP)	Yes (Households in existing WWTP)	Yes
SHMs	Yes	Yes	Yes
IEE level Study	Not specified	Yes	Yes
Environmental Monitoring	Yes	Yes	Yes
Others (such as IPP)	If required	If required	If required

Source: JICA Study Team

9.4.4 Gap between the JICA Guidelines and the Environmental Management System of Myanmar

Table 9.4.2 summarizes gaps (inconsistencies) between the JICA Guidelines and the Environmental Management System of Myanmar, and includes actions to be taken to fill the gaps between the two different provisions and requirements.

With regard to land acquisition and involuntary resettlement, a comparative analysis between the JICA Guidelines and the relevant laws and regulations of Myanmar is shown in Table 9.7.2.

Table 9.4.2 Gap between the JICA Guidelines and Myanmar Environmental Management System

Item	JICA Guidelines	Environmental Management Systems of Myanmar	Gap evaluation (✓) and actions to be taken to fill the gap (➢)
Principles	- Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. - Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan. (Appendix 1 JICA Guidelines)	- Art. 3 of EIA Notification (2015) stipites that pursuant to Section 21 of ECL and Articles 52, 53 and 55 of ECR, all Projects (snip) are required to obtain Prior Permission in accordance with Section 21 of ECL and Art. 62 of ECR having the potential to cause Adverse Impacts, are required to undertake IEE or EIA or to develop an EMP, and to obtain an ECC in accordance with EIA Notification (2015). - Art. 35 and 36 of EIA Notification (2015) stipulate alternatives and mitigation measures as requirements of IEE report as well as Art. 51, 58, 60, 62 and 63 stipulate alternatives and/or mitigation measures as requirements of EIA report	✓ There is basically no gap. ➢ Based on Annex A "Categorization of Economic Activities for Assessment Purposes" of EIA Notification (2015), an EIA is required for this Project. ➢ YCDC initiated the next fiscal year's (2019) budgetary request for the EIA investigation for the Project.
Disclosure of Information	- EIA reports (which may be referred to differently in different systems) must be written in the official language or in a language widely used in the country in which the project is to be implemented. - When explaining projects to local residents, written materials must be provided in a language and form understandable to them; - EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. - The EIA reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted; (Appendix 2 JICA Guidelines)	- EIA Notification (2015) stipulates that the IEE Report (Art. 35), Scoping Report (Art. 51) and EIA report (Art. 62) shall be prepared either in the Myanmar language, or in the English language with an accompanying, accurate summary in the Myanmar language. - Art. 65 of EIA Notification stipulates that not later than fifteen (15) days after submission of the EIA Report to ECD, the Project Proponent shall disclose the EIA Report to civil society, PAPs, local communities and other concerned stakeholders: (i) by means of national media (i.e. newspapers); (ii) the website(s) of the Project or Project Proponent; (iii) at public meeting places (e.g. libraries, community halls); and (iv) at the offices of the Project Proponent.	✓ There is basically no gap. ➢ The official language of Myanmar is Myanmar language so that public notice, invitation and agenda, minutes of discussion and other documents are prepared in Myanmar language which are translated into English depending on circumstances.
Public Consultation / Meeting	- For projects with a potentially large environmental impact, especially, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of project plans. (Social Acceptability1, Appendix 1 of JICA Guidelines) - In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Records of such consultations must be prepared; - Consultations with relevant stakeholders, such as local residents, should take place if necessary throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared. (Appendix 2, JICA Guidelines)	- Art. 13 of EIA Notification (2015) stipulates the Project Proponent shall arrange for appropriate public consultation through all phases of the IEE and EIA process as required by Art. 34, 50, and 61.	✓ There is basically no gap. ➢ At the time of the F/S a total of 4 times stakeholder meetings (SHMs) for the Project were held from Mar. to May. of 2018 by YCDC as well as GAD (General Administration Department) initiatives depending on the Governmental Admiration System in cooperation with the JICA Study Team. ➢ In addition, in the F/S a Consultation Meeting was held on 16th May 2018 for those households live on the premises of the existing WWTP and whose family heads are YCDC staff work for the existing WWTP are required involuntary resettlement for the construction of new WWTP. ➢ Necessary documents on the SHMs and the Consultation meeting (such as agenda, participant lists and minutes of meetings and others) were prepared by YCDC or GAD in the local language of Myanmar.

Item	JICA Guidelines	Environmental Management Systems of Myanmar	Gap evaluation (✓) and actions to be taken to fill the gap (➢)
Scope of Impacts to be Assessed	- The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. (Scope 1, Appendix 1, JICA Guidelines) - In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent. It is also desirable that the impacts that can occur at any time throughout the project cycle should be considered throughout the life cycle of the project. (Scope 2, Appendix 1, JICA Guidelines)	- Art. 2 of EIA Notification (2015) stipulates that Environmental Impact means the probable effects or consequence on the natural and built environment, and people and communities of a proposed Project or businesses or activities or undertaking. Impacts can be direct or indirect, cumulative, and positive or adverse or both. For purposes of this Procedure, Environmental Impacts include occupational, social, cultural, socio-economical, public and community health, and safety issues. Moreover, social impacts include Involuntary Resettlement and relating to Indigenous People. - Art. 56 of EIA Notification (2015) stipulates that the EIA investigation shall consider all biological, physical, social, economic, health, cultural and visual components of the study area, together with all pertinent legal matters relating to the environment, people and communities (including land use, resources use, and ownership of and rights to land and other resources) that may be affected by the Project during all Project phases including pre-construction, construction, operation, decommissioning, closure, and post-closure, and shall identify and assess all Adverse Impacts, risks, Cumulative Impacts and Residual Impacts for environment, social and, if relevant, health that potentially could arise from the Project.	✓ There is basically no gap. ➢ In order to fulfill both requirements of Myanmar and the JICA Guidelines, the JICA Study Team provides necessary advices in the preparation of a Draft ToR for the EIA investigation, and presents appropriate recommendations to YCDC in the environmental and social considerations study done by the JICA Study Team as needed.
Monitoring, grievance adjustment and etc.	- Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders. (Monitoring 3, Appendix 1, JICA Guidelines) - When third parties point out, in concrete terms, that environmental and social considerations are not being fully undertaken, forums for discussion and examination of countermeasures are established based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems. (Monitoring 4, Appendix 1, JICA Guidelines)	- Art. 60 of EIA Notification (2015) stipulates that the EIA shall consider the views, concerns, and perceptions of stakeholders, communities and individuals that could be affected by the Project or who otherwise have an interest in the Project. The EIA shall include the results of consultations with the public, affected populations and other stakeholders on the environmental and social issues. The concerns raised during such consultations shall be considered in assessing impacts, designing mitigation measures, and in the development of management and monitoring plans. - Art. 106 of EIA Notification (2015) stipulates that the Project Proponent shall, during all phases of the Project (pre-construction, construction, operation, decommissioning, closure and post-closure), engage in continuous, proactive and comprehensive self-monitoring of the Project and activities related thereto, all Adverse Impacts, and compliance with applicable laws, the Rules, this Procedure, standards, the ECC, and the EMP. - Art. 110 of EIA Notification (2015) stipulates that within ten days of completing a monitoring report as contemplated in Art. 108 and Art. 109 in accordance with the EMP schedule, the Project Proponent shall make such report (except as may relate to National Security concerns) publicly available on the Project's website, at public meeting places (e.g. libraries, community halls) and at the Project offices. Any organization or person may request a digital copy of a monitoring report and the Project shall, within ten days of receiving such request, submit a digital copy via e-mail or as may otherwise be agreed upon with the requestor.	✓ There is basically no gap. ➢ In order to fulfill both requirements of Myanmar and the JICA Guidelines, JICA Study Team provides necessary advices in the preparation of a Draft ToR for the EIA investigation, and presents appropriate recommendations to YCDC in the environmental and social considerations study done by the JICA Study Team as needed.

Item	JICA Guidelines	Environmental Management Systems of Myanmar	Gap evaluation (✓) and actions to be taken to fill the gap (➢)
Ecosystem and Biota	Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests. (JICA Guidelines)	- Art. 18 of ECL stipulates that he relevant Government departments and Government organizations shall, in accord with the guidance of the Union Government and the Committee, carry out the conservation, management, beneficial use, sustainable use and enhancement of regional cooperation of the environmental natural resources. - Art. 36 of PWCNAL stipulates that whoever commits any of the following acts shall, on conviction be punished with imprisonment for a term which may extend to 7 years or with fine which may extend to kyats 50,000 or with both. (a) killing, hunting or wounding a completely protected wild animal without permission, possessing, selling, transporting or transferring such wild animal or any part thereof without permission; (b) exporting without the recommendation of the Director General a completely protected wild animal or a protected wild plant or any part thereof. - Art. 40 of FL stipulates that whoever commits any of the following acts shall, on conviction be punished with fine which may extend to kyats 5,000 or with imprisonment for a term which may extend to 6 months or with both: (a) Trespassing and encroaching in a reserved forest; (b) Pasturing domestic animals or permitting domestic animals to trespass in a reserved forest; (c) Breaking up any land, clearing, digging or causing damage to the original condition of the land without a permit in a reserved forest; (d) Causing damage to a water-course, poisoning in the water, using chemicals or explosives in the water in a reserved forest; (e) Catching animals, hunting or fishing in a reserved forest; (f) Kindling, keeping, carrying any fire or leaving any fire burning which may set fire to the forests in a reserved forest; (g) Moving forest produce without submitting to examination at the revenue station; (h) Violating any provision of the rule, procedure, order, directive or notification issued under this Law - Art. 25 of EIA Notification (2015) stipulates that an EIA is required in all cases where the Project will be located in or will have foreseeable adverse effects on any legally protected national, regional or state area, including without limitation: (i) a forest conservation area (including biodiversity reserved area); (ii) a public forest; (iii) a park (including marine parks); (iv) a mangrove swamp; (v) any other sensitive coastal area; (vi) a wildlife sanctuary; (vii) a scientific reserve; (viii) a nature reserve; (ix) a geophysically significant reserve; (x) any other nature reserve nominated by the Minister; (xi) a protected cultural heritage area; and (xii) a protected archaeological area or area of historical significance.	✓ It can be overinterpreted that there is basically no gap between both provisions on Ecosystem and Biota. ➢ Even though, there is no such critical natural habitats and critical forests in the Project area in urban areas in Yangon, the JICA Study Team provides necessary advices in the preparation of a Draft ToR for the EIA investigation, and presents appropriate recommendations to YCDC in the environmental and social consideration study done by the JICA Study Team as needed.
Indigenous Peoples	Any adverse impacts that a project may have on indigenous peoples are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures must be taken to minimize impacts and to compensate indigenous peoples for their losses. (JICA Guidelines)	- Art. 7 of EIA Notification (2015) stipulates that projects (snip) which may potentially have an Adverse Impact on Indigenous People shall comply with specific procedures separately issued by the responsible ministries. Prior to the issuance of any such specific procedures, all such Projects shall adhere to international good practice (as accepted by international financial institutions including the World Bank Group and Asian Development Bank) on (snip) Indigenous Peoples.	✓ There is no clear-cut rule on indigenous peoples in Myanmar. ➢ Even though, Myanmar is a multiethnic country, and there are no such inhabited areas of indigenous people in the Project area in urban areas in Yangon, the JICA Study Team provides necessary advices in the preparation of a Draft ToR for the EIA investigation, and presents appropriate recommendations to YCDC in the environmental and social consideration study done by the JICA Study Team as needed.

Note: Art.; Article, ECL; Environmental Conservation Law (2012), ECR: Environmental Conservation Rule (2014), PWCNAL; Protection of Wildlife and Conservation of Natural Areas Law (1994), ECC; Environmental Compliance Certificate, EMP; Environmental Management Plan FL; Forest Law (1992)
Source: JICA Guidelines, Forest Law (1992), Protection of Wildlife and Conservation of Natural Areas Law (1994), Environmental Conservation Law (2012), ECR: Environmental Conservation Rule (2014), EIA Notification (2015) and JICA Study Team

9.5 Environmental and Social Conditions in Yangon City

9.5.1 Pollution

(1) Air Quality

Ambien air quality was monitored in the study area (of trunk sewers and WWTP) of Yangon City as necessary bassline data for the proposed project.

1) Monitoring Item

Considering car traffic congestions in Yangon City, SO_2, NO_2, CO, $PM_{2.5}$, and PM_{10} were selected as parameters for the air quality monitoring survey.

2) Monitoring Location and Period

Locations for Air Quality including Noise and Vibration (See (2) below) monitoring are shown in Table 9.5.1.

Table 9.5.1 Location and Period for Air Quality, Noise and Vibration Monitoring

Location Number	GPS Coordinate	Description of Monitoring Location	Monitoring Period	Photograph
ANV-1	16° 46' 52.91"N 96° 9' 12.50"E	・ At the corner of Yawmingyi Road and Shwedagon Pagoda Road, Pabedan Township, Yangon. ・ ANV-1 is surrounded by many residential houses and closed to the Phayalan Railway Station. ・ Shwedagon Pagoda Road is highly traffic. ・ The emitted source, noise and vibration might be from the vehicular traffic.	Mar. 17th - 18th 2018 (24 hours)	
ANV-2	16° 46' 38.32"N 96° 8' 52.82"E	・ At the corner of Lanmadaw Road and Arnawyahtar Road, Latha Township, Yangon. ・ Arnawyahtar Road is more traffic than Lanmadaw Road. ・ The emitted source, noise and vibration might be from the vehicular traffic.	Mar. 18th - 19th 2018 (24 hours)	
ANV-3	16° 46' 17.12"N 96° 10' 3.51"E	・ At the Merchant Road, Botahtaung Township, Yangon. ・ Merchant Road is quite closed to the traffic junction point of Merchant Road and Theinphyu Road, Botataung Township, Yangon region. ・ Merchant Road is more traffic than Theinphyu Road. ・ The emitted source, noise and vibration might be from the vehicular traffic.	Mar. 16th - 17th 2018 (24 hours)	
A-4	16° 46' 3.32"N 96° 11' 25.05"E	・ Within the wastewater treatment plant compound, Pazuntaung Township, Yangon	Mar.15th - 16th 2018 (24 hours)	
NV-4	16° 46' 9.72"N 96° 10' 50.33"E	・ At the corner of Yarzardirit Road and Strand Road, Pazuntaung Township, Yangon. ・ NV-4 is surrounded by residential buildings. ・ Noise and vibration might be from the vehicular traffic.	Mar. 15th - 16th 2018 (24 hours)	

Source: JICA Study Team

3) Monitoring Method

Sampling and analysis of ambient air pollutants were conducted as shown in Table 9.5.2.

Table 9.5.2 Sampling and Analysis Method for Air Quality

Parameter	Sampling	Equipment	Analysis Method
Nitrogen dioxide (NO_2)	USEPA recommendation	Haz-Scanner EPAS	On site reading
Carbon monoxide (CO)	USEPA recommendation	Haz-Scanner EPAS	On site reading

Parameter	Sampling	Equipment	Analysis Method
Particulate matter 10 (PM_{10})	USEPA recommendation	Haz-Scanner EPAS	On site reading
Particulate matter 2.5 ($PM_{2.5}$)	USEPA recommendation	Haz-Scanner EPAS	On site reading
Sulphur dioxide (SO_2)	USEPA recommendation	Haz-Scanner EPAS	On site reading

Note: USEPA; United States Environmental Protection Agency, EPAS; Environmental Perimeter Air Station
Source: JICA Study Team

4) Monitoring Result

Average values of ambient gaseous levels for one-day monitoring are presented in Table 9.5.3.

Table 9.5.3 Ambient Air Quality Monitoring Result

Station	Hours	CO ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)
ANV-1	24	354	51	2	9	15
ANV-2	24	976	52	2	8	52
ANV-3	24	400	57	2	9	14
A-4	24	189	78	2	7	2
NEQG	24	(9ppm) *	200**	25	50	20

Note NEQG (National Environmental Quality (Emission) Guidelines)
* CO: USEPA Standard (8 hour-value), 1 ppm of CO≒1.146 mg/m≒1,146 $\mu g/m^3$, 9 ppm of CO≒10.314 $\mu g/m^3$
** NO_2: NEQG apply NO_2 of 200 of 1-hour value, (World Bank Standard: 24 hour-value of NO_2 is 150 $\mu g/m^3$)
Source: JICA Study Team

- The concentrations of particulate matter (PM) at all stations are less than NEQG.
- SO_2 concentrations at each station are lower than NEQG except at ANV-2.
- CO and NO_2 are less than USEPA and Wold Bank Standards (24 hour-value) respectively.

(2) Noise and Vibration

Noise and vibration levels were monitored in the study area (of trunk sewers and WWTP) of Yangon City as necessary bassline data.

1) Monitoring Item

Considering car traffic congestions in Yangon City, traffic noise of "A-weighted loudness equivalent (L_{Aeq})" and Vibration level "acceleration (dB)" were selected as the monitoring items.

2) Monitoring Location and Period

The noise and vibration monitoring surveys were conducted at the same locations and periods of Air Quality Monitoring as shown in Table 9.5.1 in the Air Quality section.

3) Monitoring Method

Table 9.5.4 shows instruments for noise and vibration measurements.

Table 9.5.4 Monitoring Method for Noise and Vibration Monitoring

Parameter	Instrument	Note
Traffic Noise (dB(A))	Sound level meter (Model:SL-4023SD, Manufacture: Lutron)	One-day L_{Aeq} was calculated by using the following array formula in the excel sheet. 10*LOG10(AVERGAE(10^((RANGE)/10))) The formula is firstly used for hourly L_{Aeq} and then for the 24 hours L_{Aeq}.
Traffic Vibration (dB)	Vibration level meter (Model: VB-8206SD, Manufacture: Lutron)	Recorded as 10 minutes of each hours and then averaged.

Source: JICA Study Team

4) Monitoring Result

a. Noise Level

Table 9.5.5 shows calculated results of the traffic noise level at each location.

Table 9.5.5 Noise Level Monitoring Result (L_{Aeq}) (dB(A))

Location	Day Time (7:00 AM – 10:00 PM)	Night Time (10:00 PM – 7:00 AM)
ANV-1	72	72
ANV-2	78	76
ANV-3	71	61
NV-4	74	60
NEQG (Myanmar Guidelines)	70	70

Source: JICA Study Team

- As the monitoring was conducted for traffic noise, the results were compared with noise level of "Industrial, Commercial areas" in the National Environmental Quality (Emission) Guidelines (NEQG) 2015 of Myanmar.
- Noise level in the Day time (L_{Aeq}) at all stations were shown higher than the standard because of those stations were located just beside of the road with high traffic.

b. Vibration Level

Table 9.5.6. shows results of the traffic vibration level at each location.

Table 9.5.6 Vibration (Acceleration) Monitoring Result (dB)

Station	Day Time (6:00 AM – 10:00 PM)	Night Time (10:00 PM – 6:00 AM)
ANV-1	54	30
ANV-2	54	36
ANV-3	50	24
NV-4	58	43
Japanese Request Limit*	65	60

Note *: Applied "Type 1: Residential Area"; The Vibration Regulation Law (Japan) (Law No.75 of 1995 (Not Environmental Standard but Request Limit Value on Vehicle Traffic Vibration stipulated by the Ministry of the Environment of Japan)
Source: JICA Study Team

- Due to the fact that there is no standard on vibration in Myanmar, the request limit on vehicle traffic vibration of Japan is indicated in the table as reference.

(3) Water Quality

A river water quality monitoring survey was conducted in "JICA Preparatory Survey for The Project for Construction of New Thaketa Bridge" in 2014. The survey data were utilized as the baseline for environmental considerations.

- The river water quality survey was conducted at four sampling points in the Pazundaung Creek pouring into the Yangon River.
- The four sampling points were located at about 2 km from the existing WWTP as summarized in Table 9.5.7.

Table 9.5.7 Locations of River Water Quality Sampling Points

Station	Sampling	Type of Sample	Sampling Point
TSW-1	7th Nov. 2013	Water Quality and Sediment (bottom layer) Quality	Pazundaung Creek leading into Yangon River which is about 2 km from the existing WWTP
TSW-2	7th Nov. 2013	Water Quality and Sediment (bottom layer) Quality	Pazundaung Creek leading into Yangon River which is about 2 km from the existing WWTP
TSW-3	7th Nov. 2013	Water Quality and Sediment (bottom layer) Quality	Pazundaung Creek leading into Yangon River which is about 2 km from the existing WWTP
TSW-4	7th Nov. 2013	Water Quality and Sediment (bottom layer) Quality	Pazundaung Creek leading into Yangon River which is about 2 km from the existing WWTP

Source: JICA Preparatory Survey Report for The Project for Construction of New Thaketa Bridge 2014

Table 9.5.8 shows the existing secondary data on water quality of the Pazundaung Creek pouring into the Yangon River. These data can be regarded as the baseline for environmental considerations.

Table 9.5.8 River Water Quality around the Project Site

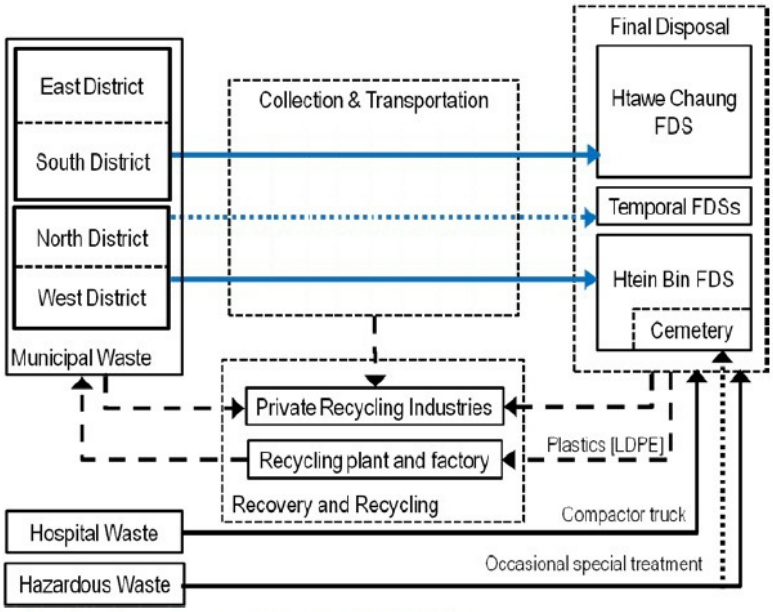
Parameter	Unit	TSW-1		TSW-2		TSW-3		TSW-4		Japan's River Water Quality Standards for Public Usage* Category D**
		Surface Layer	Bottom Layer	Surface Layer	Bottom Layer	Surface Layer	Bottom Layer	Surface Layer	Bottom Layer	
River Depth	m	12.9		8.1		12.9		5.2		-
Sampling Depth	m	0.5	11.5	0.5	6.5	0.5	10.1	0.5	4.0	-
Water Temp.	°C	28.27	28.24	28.38	28.35	28.44	28.42	28.63	28.60	-
Salinity	%	ND	ND	ND	ND	ND	ND	ND	ND	-
Turbidity	FNU	645	684	623	809	616	693	608	845	(5 NTU)***
SS	mg/L	78	65	67	66	62	61	63	61	100<**
pH	-	7.74	7.67	7.67	7.07	7.7	7.14	7.78	7.29	6.5~8.5**
DO	mg/L	3.89	3.65	3.71	3.60	3.63	3.60	3.45	3.43	>2**
BOD	mg/L	2.5	1.5	2	2.5	2	1.5	2	1	8<**
COD	mg/L	1.47	0.36	2.2	3.31	6.99	0.36	0.73	0.36	(250)****
Oil & Grease	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	(10)****
E. Coli	MPN/100 mL	0	$4x10^2$	0	0	0	$2x10^2$	0	0	-
F. Coli	MPN/100 mL	$7x10^2$	$3.6x10^3$	$6x10^3$	$2.4x10^4$	$3x10^3$	$5x10^3$	$2x10^3$	$4x10^2$	-
T. Coli	MPN/100 mL	$7x10^2$	$4x10^3$	$6x10^3$	$2.4x10^4$	$3x10^3$	$5.2x10^3$	$2x10^3$	$4x10^2$	(400)****
T-P	mg/L	0.0363	0.0396	0.0396	0.33	0.33	0.33	0.396	0.33	(2)****
T-N	mg/L	2.016	UDL	1.34	UDL	2.016	3.36	0.672	0.672	(20)*****

Note
*: "Environmental Standard for Water Pollution" #2 Water quality standard for conservation of living environment (1971)
** Category D: Industrial Water Grade 2 (special water purification is operated), Agricultural Water and Conservation of Environment
*** WHO Standard: NTU (Nephelometric Turbidity Unit) , NTU ≒ FNU (Forumajin Nephelometric Units)
**** NEQG (National Environmental Quality (Emission) Guidelines)
***** USEPA Standards for Discharge of Effluent (as reference)
Source: Preparatory Survey Report on The Project for Construction of New Thaketa Bridge, JICA, 2014 (amended by the JICA Study Team)

- Data of SS, pH, DO and BOD in Table 9.5.8 satisfy the Japan's River Water Quality Standards for Public Usage (Category D).
- Data of COD, Oil & Grease and T-P in Table 9.5.8 are less than NEQG.
- Data of Turbidity in Table 9.5.8 show higher values than the WHO standard. It is considered that the river water containing soil and sand caused by human and industrial activities in the urban and sub-urban areas of Yangon City, bigger vessels' transportation on the Rive, and deposited sand from the upstream may have influenced the turbidity.
- Data of T. Coli (Total Coliform) in Table 9.5.8 show higher values than NEQG and show almost same values of F. Coli (Faecal Coliform) data. Therefore, it is considered that excreta of human, animal and livestock in Yangon which are discharged to the River without any treatment, and the differences in river structure (some winding) and flow rate of the sampling points and depths may have influenced the Coliform data.

(4) Solid Waste

Solid waste in Yangon City is collected and transported to final disposal sites (FDSs) by the Pollution Control and Cleansing Department (PCCD) of YCDC. The flow of solid waste from generation to final disposal is illustrated in Figure 9.5.1.



Source: Strategic Urban Development Plan of the Greater Yangon, Apr. 2013, JICA

Figure 9.5.1 Flow of solid waste management in Yangon City

PCCD conducted waste generation surveys in Yangon City five times in the last 12 years from 2001 to 2011. In addition, PCCD conducted other surveys on the waste generation rate in Yangon City from 2015 to 2017. Table 9.5.9 shows those surveys' results.

Table 9.5.9 Waste generation rate in Yangon City (kg/person/day)

Year	2001-2002	2003-2004	2006-2007	2010-2011	2011-2012	2015-2016	2016-2017
Generation Rate	0.395	0.321	0.287	0.267	0.396	0.41	0.41

Note: - Data from 2012 to 2011 and data from 2015 to 2017 were based on different surveys' results by PCCD.
- Date from 2013 to 2014 are not available in PCCD.

Source: PCCD, YCDC

- The waste generation rates shown a range from 0.267 kg/day/person to 0.41 kg/day/person.

9.5.2 Natural Environment

(1) Meteorological Condition

1) Climate

The Greater Yangon is in tropical monsoon climate, characterized by three distinct seasons as summarized in Table 9.5.10.

Table 9.5.10 Three Seasons in Yangon

Season	Month
Summer	March - Middle of May
Rainy	Middle of May - Middle of October
Cool	Middle of October - February

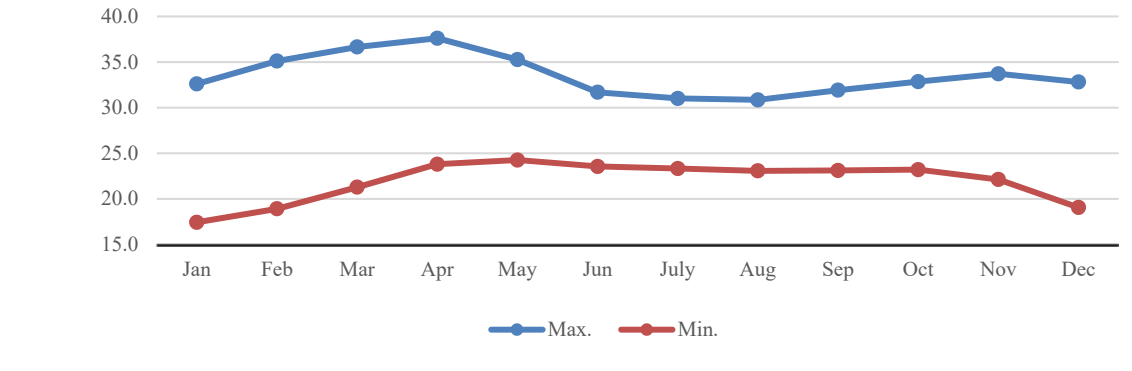
Source: JICA Study Team

2) Temperature

Table 9.5.11 shows data on monthly temperature from 2011 to 2017 in Yangon City.

Table 9.5.11 Temperature in Yangon (2011 - 2017) (°C)

Year	Range	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
2011	Max.	32.4	34.7	34.1	36.6	33.4	31.3	31.1	30.5	31.5	33.3	34.1	33.0
	Min.	18.5	19.6	21.8	24.2	24.7	24.8	24.1	23.7	23.6	23.5	21.4	19.8
2012	Max.	33.5	35.8	36.8	37.6	34.1	31.6	31.0	30.3	32.5	33.9	33.8	33.2
	Min.	17.1	18.6	21.8	24.4	24.7	23.6	22.8	22.4	22.5	22.9	22.2	17.6
2013	Max.	32.7	36.7	37.1	38.6	35.5	31.4	30.4	30.9	31.2	32.6	34.1	30.9
	Min.	15.8	19.2	19.9	21.9	22.4	22.1	24.1	24.2	23.9	23.7	22.9	17.6
2014	Max.	32.3	34.4	37.4	38.1	35.9	32.1	31.0	31.1	31.9	33.6	33.4	33.8
	Min.	16.1	17.8	20.0	23.8	23.7	22.8	21.8	21.3	21.0	22.6	21.9	19.5
2015	Max.	32.7	35.0	37.8	38.1	35.9	32.3	31.7	31.2	32.2	32.4	34.1	33.3
	Min.	18.9	18.8	21.8	23.9	24.9	24.5	24.4	24.3	23.9	23.5	22.0	19.4
2016	Max.	31.6	34.4	36.7	38.2	37.1	31.7	31.8	31.3	31.9	32.3	33.4	33.5
	Min.	15.7	18.8	22.1	24.1	24.2	23.2	22.9	22.6	23.9	24.0	22.8	21.4
2017	Max.	33.0	34.8	36.7	36.1	35.0	31.4	30.1	30.7	32.2	31.9	33.1	32.0
	Min.	19.9	19.6	21.6	24.3	25.2	23.9	23.2	23.0	23.0	22.2	21.7	18.1
Ave.	Max.	32.6	35.1	36.7	37.6	35.3	31.7	31.0	30.9	31.9	32.9	33.7	32.8
	Min.	17.4	18.9	21.3	23.8	24.3	23.6	23.3	23.1	23.1	23.2	22.1	19.1



Source: Meteorology and Hydrology Department, Kaba-aye Station, Yangon

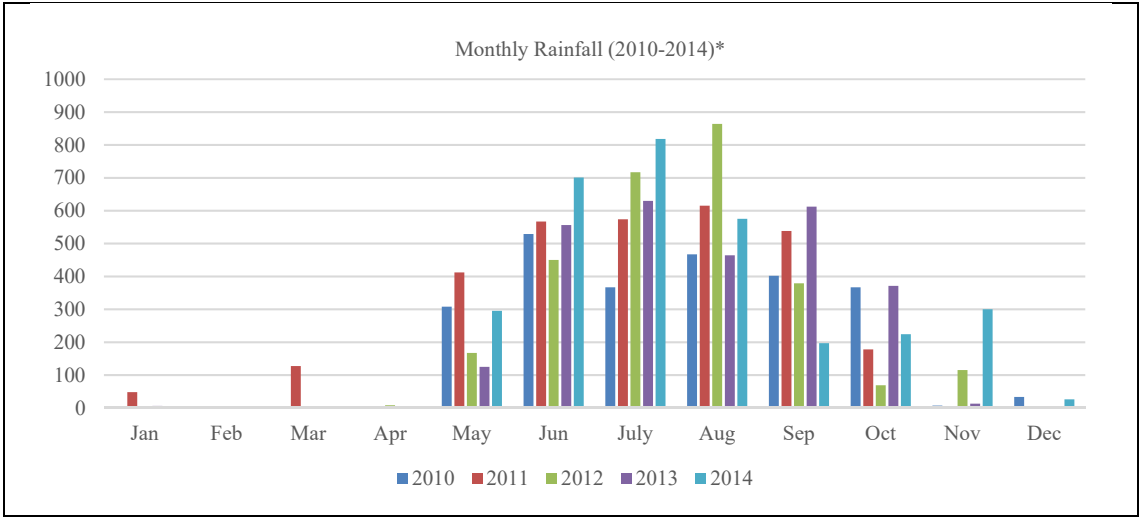
- The maximum average temperature was highest in April with 37.6°C.
- The minimum average temperature was lowest in January with 17.4°C.
- Except December, January and February, the minimum average temperatures were above 20.0°C in other months.

2) Rainfall

Table 9.5.12 shows data on monthly rainfall from 2011 to 2017 in Yangon.

Table 9.5.12 Monthly Rainfall in Yangon (2011-2014) (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
2010	0	0	0	0	308	529	367	467	402	367	7	33	2,480
2011	48	0	127	5	412	567	574	615	538	178	0	0	3,064
2012	0	0	0	8	167	450	717	864	379	69	115	2	2,771
2013	6	0	0	0	125	556	630	464	612	371	13	3	2,780
2014	0	0	0	0	295	701	818	575	197	224	300	26	3,136
2015	Trace	0	9	40	185	580	692	408	329	355	69	0	2,667
2016	23	0	0	0	288	386	618	526	543	227	1	0	2,612
2017	1	0	0	81	449	650	802	382	401	371	125	0	3,262



Note: * Due to the diffent data sources of the rainfall and existances of missind data from 2016-2017, the line graph was prepared from 2010 to 2014 only.
- Data 2016-2017: Depending on the day, rainfall data in each month could not be measured.
- Trace: No data

Source: - Data 2010-2014: Data Collection Survey Report for Improvement of Navigation Channel of Yangon Port, 2016, JICA
- Data 2015-2017: Meteorology and Hydrology Department, Kaba-aye Station, Yangon

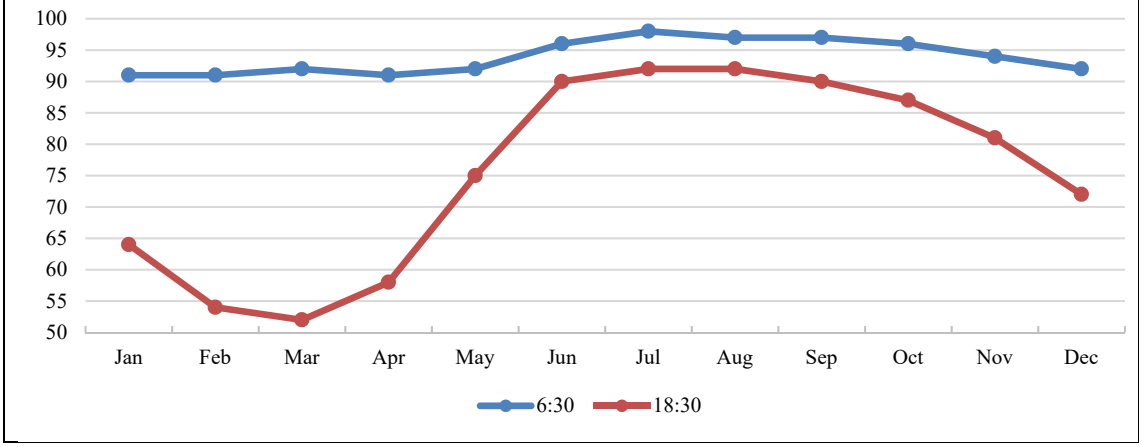
- The southwest monsoon wind is the main source of rain and Yangon City receives rain during the period from May to October.
- The annual average rainfall of Yangon City from 2010 to 2017 can be calculated as about 2,847 mm.
- Generally, the rain sharply decreases from December to April as shown in Table 9.5.12.

3) Relative Humidity

Figure 9.5.13 shows monthly average of relative humidity from 2012 to 2017 at Kaba-aye Meteorological Station in Yangon City.

Table 9.5.13 Relative Humidity in Yangon City (Mean monthly from 2012 to 2017) (%)

Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6:30	91	91	92	91	92	96	98	97	97	96	94	92
18:30	64	54	52	58	75	90	92	92	90	87	81	72



Note: The Kaba-aye Meteorological Station, managed by the Department of Meteorology and Hydrology, Ministry of Transport (DMH, MOT), has been observing meteorological conditions of Greater Yangon since 1968. Relative humidity has been recorded twice a day at 6:30 and at 18:30.
Source: Meteorology and Hydrology Department, Kaba-aye Station, Yangon

- From June to September, differences of mean relative humidity between the morning and evening were small.

- The annual mean relative humidity at 6:30 and at 18:30 was 93.9% and 75.6%, respectively.
- The maximum mean monthly relative humidity was 98.0 % at 6:30 of July, while the minimum mean monthly relative humidity was 52.0% at 18:30 of March.

4) Wind Speed

Figure 9.5.14 shows monthly maximum wind speed from 2010 to 2014 in Yangon.

Table 9.5.14 Monthly Maximum Wind Speed (2010 – 2014) (m/s)

Time	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
6:30	3.4	2.9	3.8	4.6	3.4	3.6	3.8	3.1	2.6	3.1	2.4	3.6
9:30	4.6	4.6	4.1	4.1	4.6	5	4.3	4.1	3.8	4.6	5	6
12:30	4.8	4.8	5	4.6	5.5	5.8	5.3	5.3	5.3	7.4	5	6
18:30	2.9	2.9	4.8	6.5	7.4	5	5.5	5.5	4.6	4.3	2.6	3.4

Source: Data Collection Survey Report for Improvement of Navigation Channel of Yangon Port, 2016, JICA

- Wind speeds were observed four times a day at 6:30, 9:30, 12:30 and 18:30.
- Monthly maximum wind speeds from 2010 to 2014 were collected and the tendency of wind speed at each time was confirmed.
- In some cases, wind speed increased by the occurrence of cyclone, but it can be seen that the largest wind speeds are observed at 12:30 for each month.

5) Wind Direction

Daily wind direction in Yangon in 2014 are described in Table 9.5.15.

Table 9.5.15 Daily wind direction at 18:30 hrs (2014)

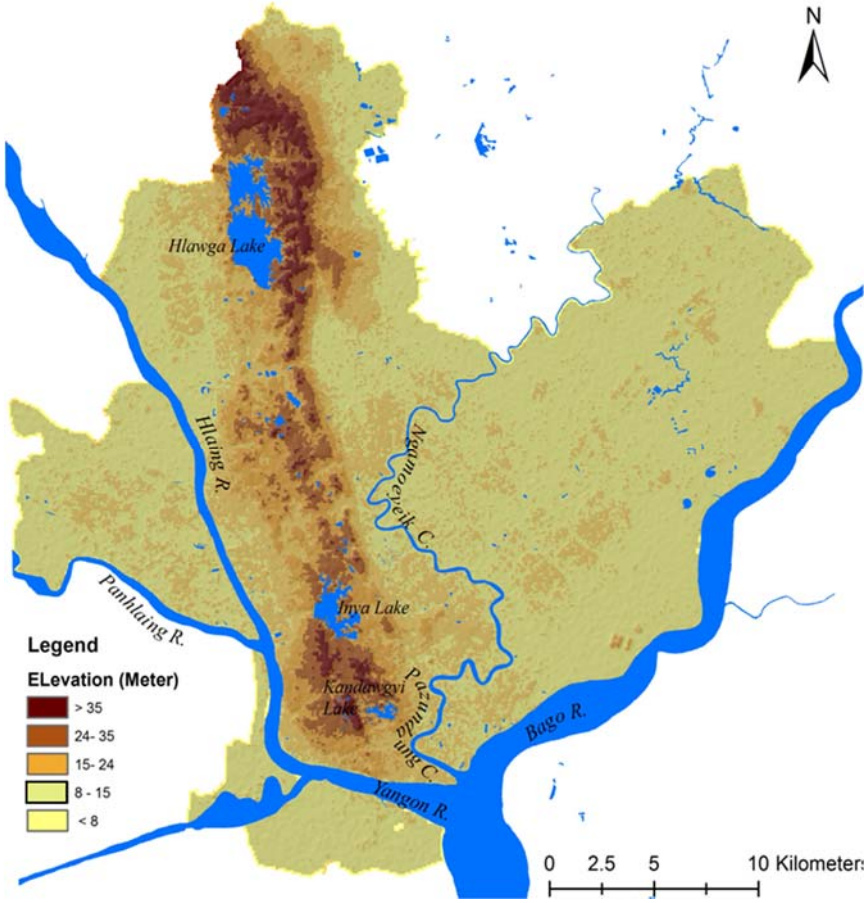
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	NW	S	Clam	SE	SW	SE	SW	SW	W	NW	N	SE
2	NW	SW	SW	SE	SW	SW	SW	S	SW	S	SW	SW
3	SW	SE	SW	SW	SW	SW	SW	SE	SW	NE	NW	SE
4	W	SW	SW	SW	SW	N	NW	SW	SW	SW	SE	NW
5	S	SE	NW	SE	SW	SW	SW	N	SW	NW	SW	SE
6	NE	SW	SW	SWSW	SW	SW	SW	SW	SW	Clam	NE	SE
7	NW	SE	SW	NW	SW	SW	SW	SW	N	SE	SE	SW
8	NW	SE	SE	SE	W	SW	SW	SW	NE	SE	NW	SE
9	W	SE	W	SW	Clam	NW	SW	SW	SW	SE	W	SW
10	SW	SW	SW	NW	SW	NW	SW	SW	SW	SW	SW	SW
11	W	SE	SW	SE	SE	SW	SW	S	SW	SW	Clam	SW
12	NW	SW	S	SW	SW	NW	NW	SW	SW	SW	W	NE
13	NW	SW	SW	N	S	S	NW	SW	NE	S	W	SW
14	SE	NW	NW	S	SW	SW	SW	SE	SW	W	NW	NW
15	SE	SW	SW	SW	SW	SE	S	NW	SE	Clam	NW	SW
16	SW	SW	Clam	NW	SW	SE	SW	SW	NW	NW	NW	NW
17	SE	SW	SW	S	SE	SW	SW	S	SW	NE	W	SE
18	SW	NW	SW	NW	SW	SE	SE	SE	SW	Clam	SE	NW
19	SE	SW	SW	SW	SW	NW	SW	SW	SW	N	SW	W
20	W	S	S	SW	SW	SW	SW	S	SW	SE	SW	SW
21	SE	SW	SW	SW	SE	SE	SE	SE	SE	SE	SE	NE
22	SE	NE	SW	NE	SW	SE	SW	SW	SE	SW	SW	SE
23	W	NW	SW	SW	SE	SW	SW	SW	SE	W	NW	Clam
24	W	W	SW	SE	SW	SW	NW	SW	SW	SW	NW	NW
25	SW	SE	SW	SW	SW	SW	SE	SW	NW	SW	NW	NE
26	E	SW	SE	SW	SW	SW	SW	W	SW	NW	W	Clam
27	SW	SW	SE	SW	SW	NW	NW	SW	SW	SWSW	NE	NW
28	NW	S	SE	S	S	W	SW	W	SW	NE	NE	SW
29	W	-	SW	SW	NW	SW	SE	W	NW	SW	NE	SW
30	Clam	-	SW	SW	SE	NW	S	SW	SE	SE	NE	NW
31	NW	-	SW	-	S	-	SW	SW	-	NW	-	S

Source: Data Collection Survey Report for Improvement of Navigation Channel of Yangon Port, 2016, JICA

- Wind directions were observed generally in the SW during the summer (March to middle of May) and the rainy (Middle of May to middle of October) seasons.
- NW in the cool season (Middle of October to February).

(2) Topography

Figure 9.5.2 shows a topographical (Relief and Drainage) map of Greater Yangon.



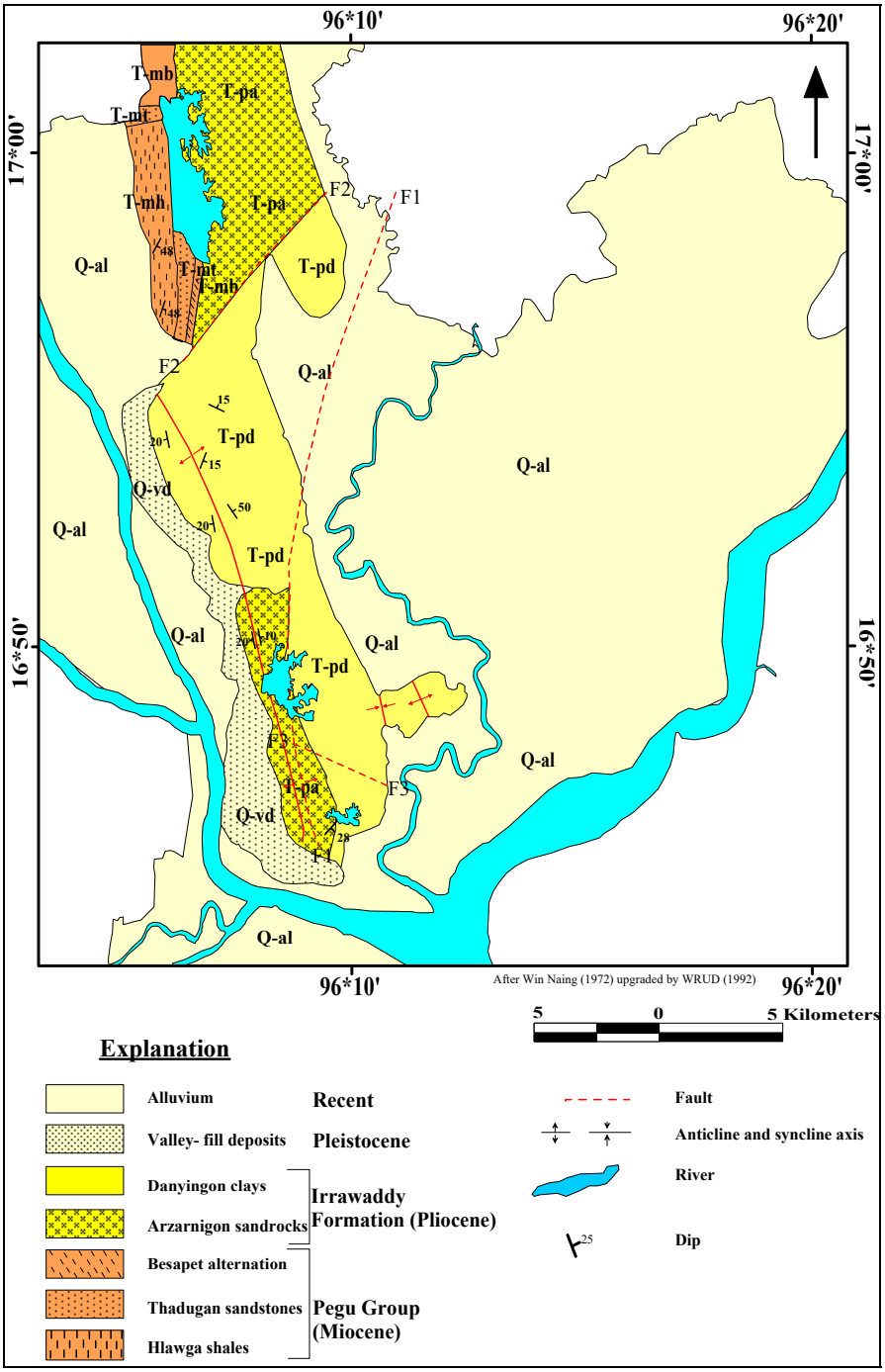
Source: Department of Geography, University of Yangon

Figure 9.5.2 Relief and Drainage Map of Yangon City

- The dominant physical feature of Yangon City is the Yangon-Mingaladon Ridge, an anticlinal ridge which morphologically looks like as a homoclinal ridge.
- At the north, the elevation is greater than 150 feet and the regional slope is towards the south.
- The base of the Shwedagon Pagoda is more than 100 feet with respect to the sea level.
- The other small ridge called the Thingangyun Ridge may be considered as the northern continuation of the Thanlyin-Kyauktan Ridge.

(3) Geology

Figure 9.5.3 shows a Geological map of Yangon City.



Source: Modified by Tint Lwin Swe (2006)

Figure 9.5.3 Geological Map of Yangon City

1) Undulation

Yangon City and its surrounding region include ridges and deltaic low lands, and extensional rolling region of Bago Yoma (mountain ranges) anticlinorium located in a N-S (North to South) trending sedimentary basin containing a thick Tertiary and Quaternary deposits.

- The Tertiary deposits belong to the Hlawga shale of lower Pegu Group, Thadugan sandstone (lower) and Besapet alternation (upper) of upper Pegu Group, and Arzarnigon sandrock (lower) and Danyingon clay (upper) of Irrawaddy Formation.
- Quaternary sediments of older and younger alluvium deposits are widely distributed

throughout Yangon City.

- The regional dip is toward the east having a low to moderate dip angle and the western dip slope is very narrow often covered by the younger alluvium.

2) Lithostratigraphic Unit

Regional lithostratigraphic units of Yangon City and Bago Yoma are shown in Table 9.5.16.

Table 9.5.16 Regional Lithostratigraphic Units of Yangon City and Bago Yoma

System	Series	Yangon Area	Bago Yoma
Quaternary	Recent	Young Alluvium	Alluvium
	Pleistocene	Valley-filled deposit	
Tertiary	Pliocene	Danyingon Clay	Irrawaddy Formation
		Arzanigon Sandrock	
	Miocene	Besapet Alternation	Obogon Formation
		Thadugan Sandstone	Kyaukkok Formation
	Oligocene	Hlawga Shale	(Unclear)

Note: ~~~ Unconformity
Source: Kyaw Htun (1996), Department of Geology, Yangon Technological University

3) Folding and Anticline

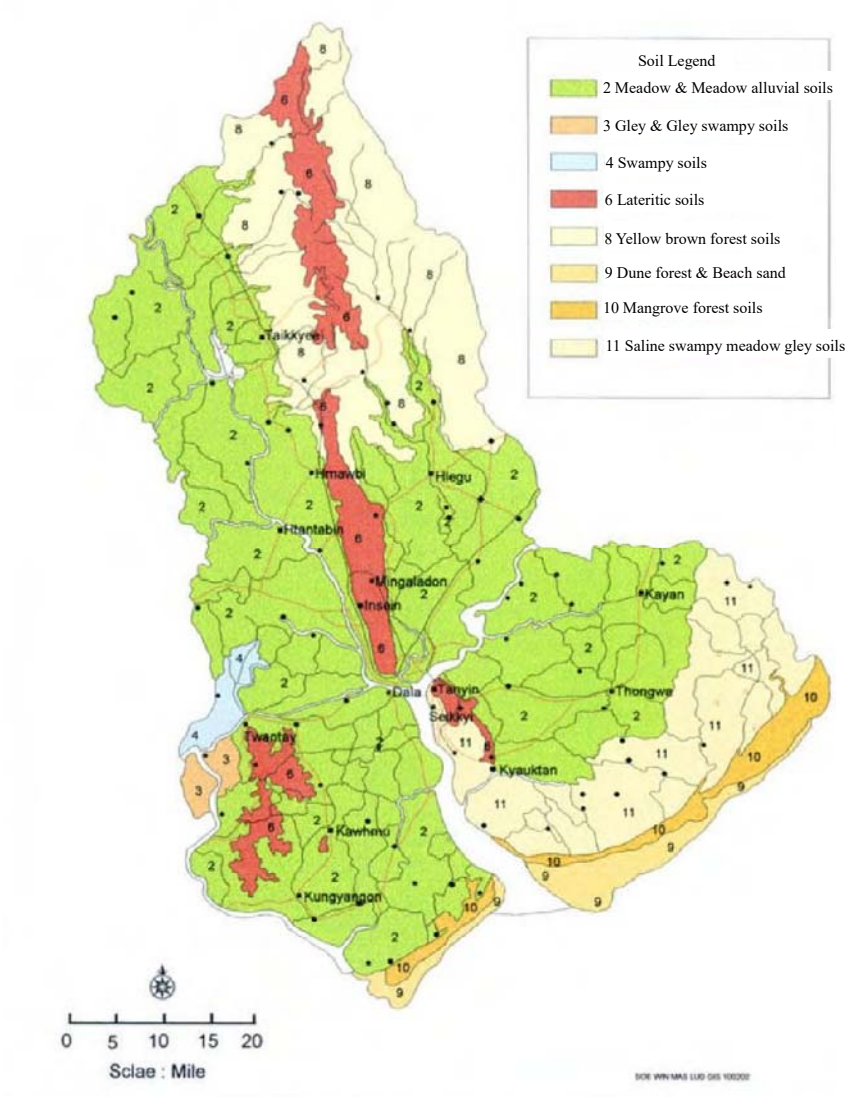
- Yangon City is complicated by numerous folding resulting in a characteristic an echelon folding system of rocks of Bago Yoma, regarded as Hlawga anticline, Yangon-Mingaladon anticline, Thingangyun-Thanlyin ancline and Twante anticline. These folded structures were strongly cut across by numerous faults trending nearly E-W to ENE-WSW.
- The Yangon-Mingaladon ridge is a long narrow anticlinal ridge of an anticlinal fold plunging definitely towards the north and the physiographic evidence of the nose of the anticline is observed at Danyingon. This Yangon-Mingaladon anticline is an asymmetrical rather than a symmetrical one.
- At its northern extremity, this anticlinal ridge extends toward north as the western flank of a regional syncline trending west of Hlegu, through Htaukkyant. The anticlinal structure of the ridge becomes distinct and identifiable at Danyingon and at the west of Mingaladon airport.

4) Fault

- The Sagaing Fault, a recently active dextral strike-slip fault is regional recognized as the possible marker for the Neogene structural development feature. It is a recently active dextral strike-slip fault and cross cutting the eastern central basin.
- The largest fault in Yangon City named as Mingaladon Fault is observed as a lineament in the paddy field east of Mingaladon airport. This fault is considered as a normal fault and the fault plane is estimated to be dipping in a southeast to east direction.
- Another distinct fault namely Danyingon Fault is recognized as a lithologic boundary between rocks of Upper Pegu Group and Irrawaddy Formation within the Hlawga anticline. This fault can be easily observed in the field due to the juxtaposition of two different rock units especially around Hlawga Lake.

(4) Soil

Figure 9.5.4 presents the soil distribution in Yangon Region.



Source: Ministry of Agriculture and Irrigation

Figure 9.5.4 Soil Map of Yangon Region

The Study Area is mainly composed of Meadow Soils and Meadow Alluvial Soil, and Lateritic Soil in some part of which features are summarized in Table 9.5.17.

Table 9.5.17 Soil Type in Study Area

Type	Description
Meadow Soil and Meadow Alluvial Soil	・ The meadow soils which occur near the river plains with occasional tidal floods are non-carbonate. ・ This kind of soil usually contain large amount of salts. Meadow alluvial soils can be found in the flood plains. ・ This type of soil has the texture of silty clay loam and has neutral soil reaction and richly available in plant nutrients.
Lateritic Soil	・ These soils occur mostly in the lower Myanmar in the lower slopes of the hills of Pegu Yoma, Rakhine Yoma, and Donna hill range. ・ These soils are found on well-drained low uplands and at the foot of low hills. ・ These usually occur at the elevation not higher than 90 m above sea level. ・ These are formed under the influence of the tropical forests under the conditions of wet tropical monsoon climate with 2000-5000 mm of rainfall. ・ Morphologically, yellow or yellow brown and reddish-brown colours characterize these soils. ・ The yellow and red colours of the soils are due to the presence of iron with oxidation and reduction processes. ・ In some places the horizons of pisolithic laterite are found at the depth of 457-508 mm, whereas, in other places these soils are not found even at the depth below 1.2 - 1.5 m. ・ The humus content of these soils in forest area is high but can be less in the deforested areas. ・ The soil reaction is acidic in the upper horizon and can be more acidic at the lower horizons.

Source: Ministry of Agriculture and Irrigation

(5) Hydrology

In Yangon City, the Yangon River is formed by the junction of the Panhlaing River (a distributary of the Ayeyarwady River) and Hlaing River (a river rising in the Bago Yoma) at a point about 8 miles upstream of the Monkey Point.

- Ngamoeyeik/Pazundaung Creek in the northern part of the city joins the Yangon River at the Monkey Point at south-eastern extremity of the city.
- The Bago River also joins the Yangon River just east of the city, from which point the Yangon River flows south for some 28 miles to the Gulf of Bengal.
- The rivers in Yangon are all tidal rivers.

Table 9.5.18 shows available tidal information on past observation at the Yangon Port (Sule Pagoda Wharf).

Table 9.5.18 Tidal Information in Yangon Port (Sule Pagoda Wharf)

Item	Tidal Height (m)	Date Observed
Highest High-Water Level (HHWL)	+6.74	Sept. 1899
Mean Water Level (MWL)	+3.121	Up to 1936
Lowest Low Water Level at Bo Aung Kyaw Street Wharf	-0.24	Dec. 1902
Indian Spring Low Water Mark	+0.338	-

Source: Myanmar Port Authority

(6) Flora and Fauna

1) Flora and Fauna in Greater Yangon

In the Greater Yangon, the vegetation cover consists of a mosaic of semi-evergreen, moist mixed deciduous, lower mixed deciduous and swamp/mangrove forests. Common trees include *Aporosa sp., Pteropermum semiagittatum, Eugenia megacarpa Rauvolfia ophiorrhizoides, Microcos paniculata, Markhamia stipulata* and *Casia sp.*etc. *Eupatorium sp., Miliusa roxburghiana, Connarus monocarpus* and *Jasminum sessiliflorum.*

A total of 554 animal and plant species has been recorded in the Greater Yangon during 2012-2017 as summarized in Table 9.5.19. (See Appendix 18)

Table 9.5.19 Summary of Flora and Faunal in Greater Yangon Recorded in 2012-2017

Taxonomic Group		Number of species
Flora	Plant	234
Fauna	Mammal	12
	Bird	161
	Reptile	16
	Amphibian	6
	Fish	55
	Invertebrate (Butterfly)	70
Total		554

Source: JICA Study Team

2) Threatened Species

A total of two (2) animal species and two (2) plant species have been recorded as threatened species among the 554-recorded species in the Greater Yangon area as shown in Table 9.5.20.

Table 9.5.20 Flora and Fauna in Greater Yangon recorded as Threatened Species (2017)

Category	Scientific name	Common name	Family	IUCN (2017)*
Flora	*Dipterocarpus alatus*	Kanyin-phyu	Dipterocarpaceae	Vulnerable
	Hopea odorata	Thin-gan	Dipterocarpaceae	Vulnerable
Fauna	*Indotestudo elongate*	Yellow tortoise	Testudinidae	Endangered

Category	Scientific name	Common name	Family	IUCN (2017)*
	Python molurus bivittatus	Burmese Python	Boidae	Vulnerable

Note*: IUCN (International Union for Conservation of Nature) classification of threatened species in 2017
Source: JICA Study Team

- Yellow tortoise (*Indotestudo elongate)* is exploited for local consumption and for the export to China, which cause the decline of their populations in natural habitats.
- Burmese Python (*Python molurus bivittatus)* becomes a vulnerable species mainly due to habitat loss attributed to human activities.
- The plant species (*Dipterocarpus alatus & Hopea odorata)* are overharvested in the country for local use and export.
- All these threatened species are protected by the Forest Law of Myanmar.

(7) Protected and Green Areas

1) Protected Area

The Hlawga Wildlife Park with an area of 624 ha includes a fenced core area of 327 ha situated in the Mingaladon Township of Yangon City. The eastern part of the park is bordered by the Yangon Pyay road, the southern part by the Hlawga Forest Reserve, the western part by paddy fields and the northern part by the Pe-Nwe-Gone Village.

2) Urban Greenery Area

The Kandawgyi Garden is a well-known greenery area, which can also be defined as public space. Park gardens are observed with natural and man-made vegetation. The commonly known greenery areas are the Kandawgyi Garden, the Inyar Lake greenery area, the Thadu Lake garden, the Mingalardon garden, the Myaing Hay Wun garden, the People's Park, View Point Amusement Park, and the Thakhinmya Park.

(8) Landscape

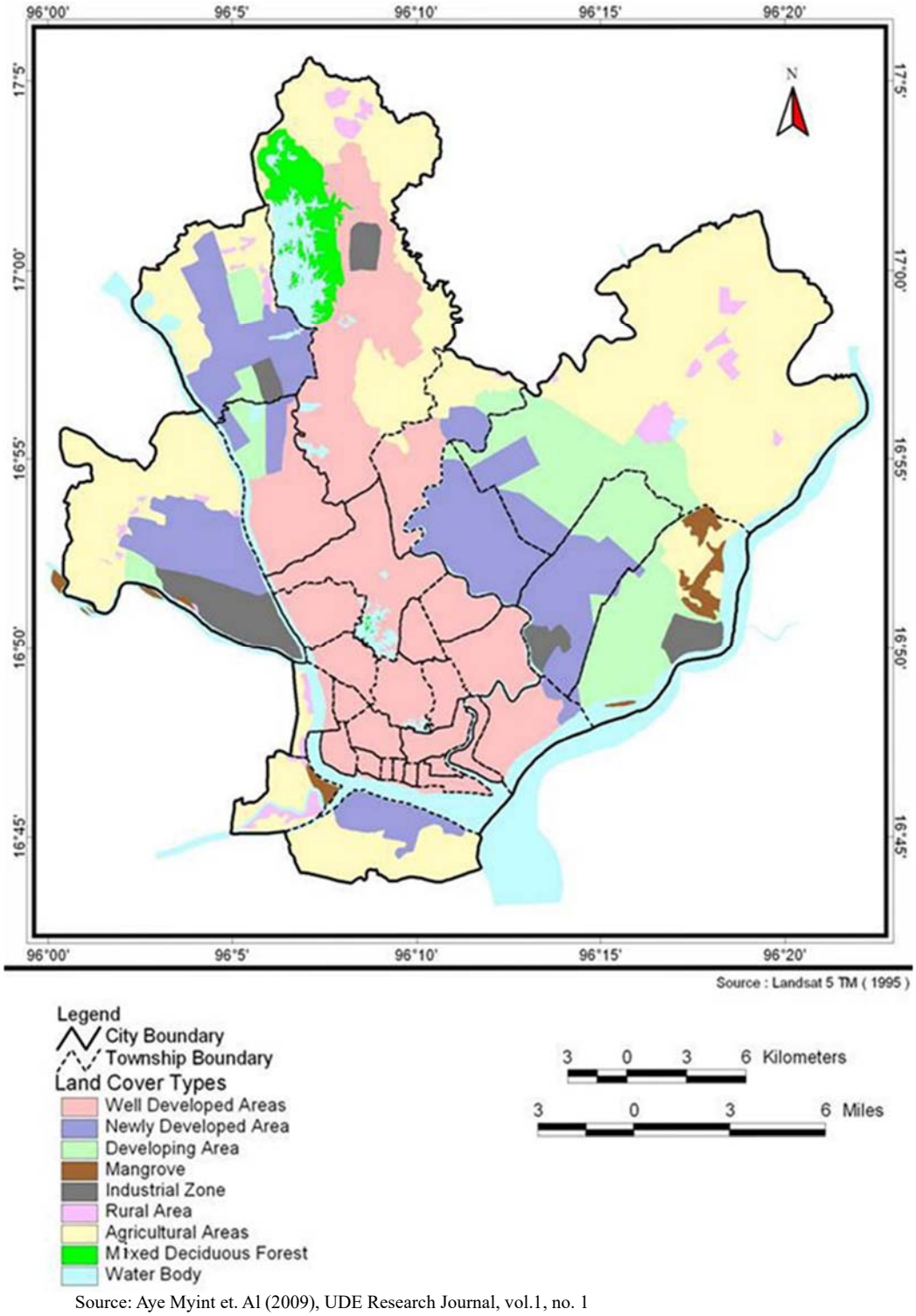
Yangon City is located in the eastern part of the Ayawady deltaic region of southern Myanmar. It is flanked by the Haling and Pan-Hlaing Rivers in the west and the Bago River in the east all flowing from north to south. According to the data available from 1872 to 2005, the areal extension of Yangon City is shown in Table 9.5.21.

Table 9.5.21 Successive Areal Expansion of Yangon City

Year	Area (Square Miles)
1872	11
1876	13
1891	22
1901	18
1921	33.38
1953	47.57
1965	63.54
1973	80.55
1983	133.64
1991	223.22
1995	262.08
2005	306.81

Source: Forest Department, MONREC

The spatial landscape of Yangon City consists of Well-developed residential area, Newly developed residential area, Developing residential area, Mangrove area, Industrial zone, Rural area, Agricultural area, Mixed deciduous forest and Water body as shown in Table 9.5.5.



Source: Aye Myint et. Al (2009), UDE Research Journal, vol.1, no. 1

Figure 9.5.5 Land Cover Map of Yangon City

9.5.3 Social Environment

(1) Demography

In Yangon City, there are a total of 33 Townships and seven (7) township groups, e.g., the Central Business District (CBD), Inner Urban Ring, South of CBD, Older Suburbs Zone, Outer Ring Zone, Northern Suburbs, and New Suburbs Zone. Moreover, there are six (6) townships in outskirt of

Yangon City such as Kyauktan, Thanlyin, Hlegu, Hmawbi, Htantabin, and Twantay.

The demographic data of the townships in the study area are described in Table 9.5.22.

Table 9.5.22 Demographic Data of Townships (2016-2017)

Townships	No. of Houses	No. of Household	Population			Area (km^2)	Population Density (per km^2)
			Male	Female	Total		
Dagon	828	4,575	12,108	13,103	25,211	5.05	4,992
Latha	2095	7,800	15,901	21,337	37,238	1.40	26,596
Lanmadaw	965	5,563	12,113	15,228	27,341	0.81	33,754
Pabedan	1087	5,356	14,318	16,115	30,433	0.73	41,689
Kyauktada	1240	6,078	30,10	14,805	27,815	0.73	38,103
Botahtaung	1242	7,937	18,774	21,133	39,907	2.45	16,289
Pazuntaung	1591	9,533	20,127	24,658	44,785	1.01	44,342

Source: Township profiles (2017), Township Administrative Department

(2) Economic Activities

Economic activities of each Township in the Study Area are summarized in Table 9.5.23 by showing main economic activities, private companies and domestic net production.

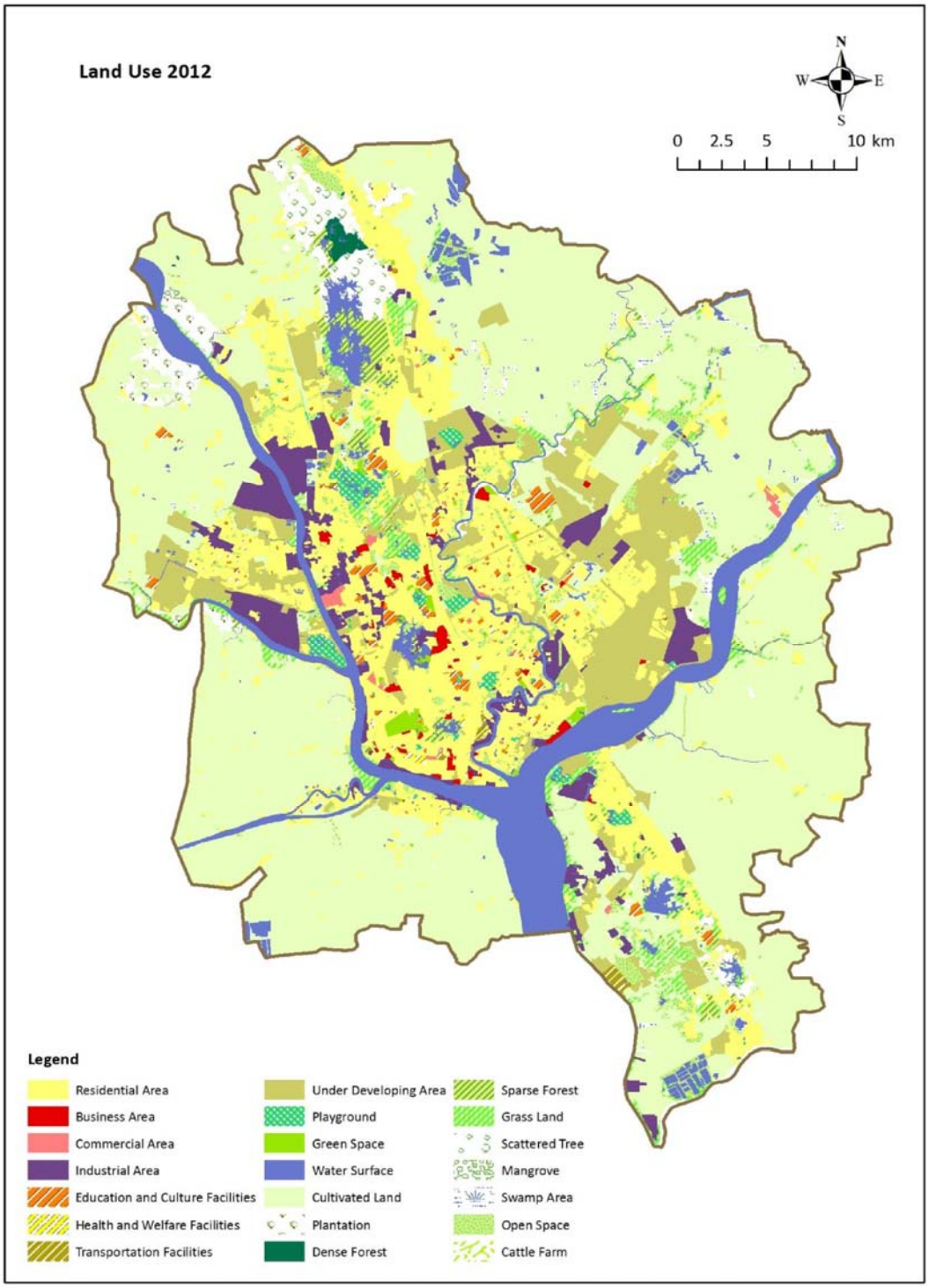
Table 9.5.23 Economic Activity by Township

Township	Description
Dagon	・ Main economic activities are export-import, hotel and tourism and other sale services. ・ There are about 37 private companies in Dagon Township. ・ Domestic net production (2016-2017) of the township is 70,649.5 million kyats and the net production and value of services is 3.7 million kyat/person.
Latha	・ Main economic activity is sale services especially in gold and jewellery and hotel and tourism service is minor. ・ There are about 48 private companies in Latha Township. ・ Domestic net production (2016-2017) of the township is 140,652.3 million kyats and the net production and value of services is 6.6 million kyat/person.
Lanmadaw	・ Main economic activity is sale services especially in gold and jewellery. ・ There are about 118 private companies in Lamadaw Township. ・ Domestic net production (2016-2017) of the township is 130,220.9 million kyats and the net production and value of services is 2.9 million kyat/person.
Pabedan	・ Main economic activity is sale services especially in gold and jewellery, chemical, electric products. Hotel and tourism, and printing services are secondary. ・ There are about 4 private companies in Pabedan Township. ・ Domestic net production (2016-2017) of the township is 145,989.1 million kyats and the net production and value of services is 4.8 million kyat/person.
Kyauktada	・ Main economic activities are sale services especially in electric and electronic products and media production while hotel and tourism, and printing services are secondary. ・ There are about 6 private companies in Kyauktada Township. ・ Domestic net production (2016-2017) of the township is 577,605.3 million kyats and the net production and value of services is 23.6 million kyat/person.
Botahtaung	・ Main economic activities are inland water transportation, cargo handling services, etc. ・ There are about 112 private companies in Botahtaung Township. ・ Domestic net production (2016-2017) of the township is 100,782.1 million kyats and the net production and value of services is 2.8 million kyat/person.
Pazuntaung	・ Main economic activities are fisheries, jetty service, cargo handling services, etc. ・ There are about 33 private companies in Pazundaung Township. ・ Domestic net production (2016-2017) of the township is 115,647.6 million kyats and the net production and value of services is 2.3 million kyat/person.

Source: Township profiles (2017), Township Administrative Department

(3) Land Use

A land use map of Yangon was developed in 2012 based on the satellite imagery in the JICA Project for the Strategic Urban Development Plan of the Greater Yangon as shown in Figure 9.5.6.



Source: Project for the Strategic Urban Development Plan of the Greater Yangon, Final Report I, April 2013, JICA

Figure 9.5.6 Land Use Map of Yangon Region

Looking at the map, YCDC Region is already developed or undergoing development while most of the area outside YCDC boundary is agricultural land except parts of Thanlyin and Kyauktan where are situated on the hilly areas seemingly extending from the central hills of Yangon.

(4) Transportation

Figure 9.5.7 shows road and railway networks in Yangon City.

Source: Final Report of a Strategic Urban Development Plan of Greater Yangon, 2013, JICA

Figure 9.5.7 Road and Railway Network of Yangon City

- There are five modes of transport: bus, stated-owned circular railway, riverine craft, taxi and private automobile.
- The bus dominates the traffic in the city, whereas the usage of train is limited as a preferred transportation due to its inconvenience.
- Bus trips account for almost 80% of all public transport trips, with the remaining 20% distributed to use of railway, water transport and taxi.
- Table 9.5.24 shows an estimation of growth of traffic volume in two main roads in Yangon City.

Table 9.5.24 Estimation of Growth of Traffic Volume (PCU/Hour)

Name of Road	Traffic Peak	2012	2020	2025	2030
Lower Pazundaung Road	Morning Peak	2,105	3,111	3,970	5,067
	Evening Peak	2,114	3,167	4,042	5,159
Shwe Dagon Pagoda Road	Morning Peak	2,569	3,796	4,845	6,183
	Evening Peak	2,645	3,907	4,987	6,365

Note: Traffic volume in each year was calculated based on the traffic counting results by YCDC in 2004 with 5.0% annual growth ratio.
PCU; Passenger Car Unit
Source: Final Report of A Strategic Urban Development Plan of Greater Yangon, 2013, JICA

(5) Infrastructure and Public Facility

Infrastructures and public facilities of the townships in the study area are shown in Table 9.5.25.

Table 9.5.25 Infrastructure and Public Facilities in the Study Area

Facilities	Dagon	Latha	Lanmadaw	Pabedan	Kyauk tada	Botahtaung	Pazun taung
Cinema	1	-	-	5	-	-	-
Park	6	-	-	-	1	1	1
Market	2	3	3	4	1	2	3
Shopping Mall	-	-	-	1	-	-	-
Bank	6	28	16	24	30	20	13
University/Collage	-	2	1	-	-	1	1
School	10	9	6	6	7	13	16
Pagoda/Stupa	6	3	-	-	2	-	5
Monastery	45	66	-	1	-	5	29
Church	5	5	3	3	3	5	2
Mosque	2	4	1	11	8	10	1
Hindu Temple	-	-	1	7	2	7	8
Chinese Temple	-	5	3	1	-	-	-

Source: Township Profiles (2017), Township Administrative Departments

- Sources of water for drinking and other use of residents are municipal pipe water and tube well.
- Electricity is supplied from state-owned power plants.
- In the study area, sewerage pipes with ejector system are mainly used in most of the wards while septic tanks are also utilized in some wards where municipal sewerage pipe does not exist.
- In addition, distribution of health facilities by type in Yangon Region is shown in Table 9.5.26.

Table 9.5.26 Distribution of Health Facilities in Yangon Region (2012)

No.	Type of Health Facilities	Number
1	Specialist Hospitals	9
2	General Hospitals	15
3	District Hospital	1
4	Township Hospitals	20
5	Station Hospitals	28
6	Primary Urban Health Centers	28
7	Secondary Urban Health Centers	22
8	Rural Health Centers (Main)	77
9	Rural Health Centers (Sub)	402
10	Maternity and Child Health Centers	15
11	School Health Centers	12
12	Community Nutrition Centers	25
13	Indigenous Medicine Centers	43
14	Diseases Campaigns	4
15	Private Clinics and Hospitals	2,887

Source: Health Profile, Department of Public Health, Yangon Region, 2012

In the study area, there are three (3) Central Level Hospitals in Latha, Lanmadaw and Dagon Townships respectively, while 200-Beded Hospital and School Health Center in Botahtaung Township.

(6) Cultural Heritage

There are hundreds of historical and religious monuments in Yangon City such as pagodas, temples, churches, mosques, and British colonial-era buildings built between the 19th and 20th centuries.

For the conservation of historical buildings, the Protection and Preservation of Cultural Heritage Regions Law was enacted in 1998 by the Ministry of Culture. The Yangon City Heritage Building

List for Conservation was issued in 1996 by YCDC. 189 buildings constructed before 1930 are listed as historical buildings and are being maintained since 1996.

- The locations and classifications of the listed buildings are shown in Table 9.5.27.

Table 9.5.27 Listed Heritage Buildings in Yangon City

No.	Township	Admin / Institution	Social Bldg	Commercial Bldg	Residential	Religious Buildings						Total	Ratio
						Christian	Buddhism	Hindu	Muslim	Chinese	others		
1	Latha		2					1	1	3		7	3.7%
2	Lanmadaw	2	3			1			1			7	3.7%
3	Pabedan	6	2	1		2	1	5	5		1	23	12.2%
4	Kyauktada	33		1		2	1		2			39	20.6%
5	Botahtaung	3	3			2	1					9	4.8%
6	Pazundaung					1	1	1	1			4	2.1%
7	Ahlone		1									1	0.5%
8	Kyee Myin Daing						1		1		1	3	1.6%
9	Sanchaung	1	2			2	5		1	1		12	6.3%
10	Dagon	2	5		1	3	6					17	9.0%
11	Bahan	2			2		3			5		12	6.3%
12	Tarmwe					1			2			3	1.6%
13	Mingalar Taung Nyunt			1		3		3	2			9	4.8%
14	Kamaryut		17			1	1					19	10.1%
15	Hlaing							1				1	0.5%
16	Yankin						1	3				4	2.1%
17	Thingangyun					1	2					3	1.6%
18	Mayangone						3					3	1.6%
19	Insein	3	3			1						7	3.7%
20	Mingalardon		1			2	2					5	2.6%
21	North Okkalapa						1					1	0.5%
Total		**52**	**39**	**3**	**3**	**22**	**29**	**14**	**16**	**9**	**2**	**189**	100%
		27.5%	20.6%	1.6%	1.6%	11.6%	15.3%	7.4%	8.5%	4.8%	1.1%	100%	

Notes: Administrative and Institutional Building: Offices, Medical Centers, etc. Social Buildings: Schools, hospitals, etc. Commercial Buildings: Hotels, Markets, etc.
Source: Project for the Strategic Urban Development Plan of the Greater Yangon, Final Report, April 2013, JICA

(7) Public Health

Table 9.5.28 shows morbidity in Yangon Region in 2013.

Table 9.5.28 Single Leading Cases of Morbidity in Yangon Region (2013)

Sr. No.	ICD-10 Code	Causes	Male		Female		Total		Average duration of stay
			No.	%	No.	%	No.	%	
1	O80	Single spontaneous delivery	0	0.0	26777	13.7	26777	7.6	4.9
2	S09	Other and unspecified injuries of head	11010	7.0	4319	2.2	15329	4.3	4.1
3	O82	Single delivery by caesarean section	0	0.0	11478	5.9	11478	3.3	8.1
4	A09	Diarrhoea and gastroenteritis of presumed infectious origin	5946	3.8	4944	2.5	10890	3.1	4.2
5	H26	Other cataract	3899	2.5	6016	3.1	9915	2.8	3.2
6	A91	Dengue haemorrhagic fever	5114	3.2	4740	2.4	9854	2.8	4.5
7	B34	Viral infection of unspecified site	4706	3.0	4259	2.2	8965	2.5	4.4
8	F10	Mental and behavioural disorders due to use of alcohol	7223	4.6	195	0.1	7418	2.1	13.7
9	K29	Gastritis and duodenitis	3363	2.1	4027	2.1	7390	2.1	4.5
10	O06	Unspecified abortion	0	0.0	6715	3.4	6715	1.9	3.9
11	P59	Neonatal jaundice from other and unspecified causes	3373	2.1	2930	1.5	6303	1.8	4.7
12	J18	Pneumonia, organism unspecified	2753	1.7	2256	1.2	5009	1.4	5.7
13	A16	Respiratory tuberculosis, not confirmed bacteriologically or histologically	3226	2.0	1740	0.9	4966	1.4	9.5
14	K35	Acute appendicitis	1878	1.2	2339	1.2	4217	1.2	6.3
15	F39	Unspecified mood [affective] disorder	2662	1.7	1488	0.8	4150	1.2	30.6
	...	All other causes	102733	65.1	110617	56.8	213350	60.5	10.4
		Total	157886	100	194840	100	352726	100	7.2

Source: Annual Hospital Statistics Report, Ministry of Health (2013)

Table 9.5.29 summarizes mortality in Yangon Region in 2013. The mortality caused by HIV shows 809 cases equivalent to 6.6% of the total mortality.

Table 9.5.29 Single Leading Cases of Mortality in Yangon Region (2013)

Sr. No.	ICD-10 Code	Causes	Male		Female		Total		Average duration of stay
			No.	%	No.	%	No.	%	
1	B20	Human immunodeficiency virus [HIV] disease resulting in infectious and parasitic diseases	543	7.2	266	5.8	809	6.6	11.6
2	S09	Other and unspecified injuries of head	599	7.9	143	3.1	742	6.1	4.6
3	A41	Other septicaemia	321	4.2	271	5.9	592	4.9	5.8
4	A16	Respiratory tuberculosis, not confirmed bacteriologically or histologically	324	4.3	152	3.3	476	3.9	7.4
5	I61	Intracerebral haemorrhage	309	4.1	163	3.5	472	3.9	4.2
6	P07	Disorders related to short gestation and low birth weight, not elsewhere classified	228	3.0	169	3.7	397	3.3	7.0
7	K74	Fibrosis and cirrhosis of liver	289	3.8	67	1.5	356	2.9	6.4
8	I64	Stroke, not specified as haemorrhage or infarction	201	2.7	119	2.6	320	2.6	5.6
9	I50	Heart failure	149	2.0	157	3.4	306	2.5	6.5
10	I21	Acute myocardial infarction	151	2.0	125	2.7	276	2.3	3.1
11	N18	Chronic renal failure	130	1.7	131	2.8	261	2.1	8.7
12	R57	Shock, not elsewhere classified	115	1.5	93	2.0	208	1.7	3.6
13	C34	Malignant neoplasm of bronchus and lung	127	1.7	72	1.6	199	1.6	18.0
14	J18	Pneumonia, organism unspecified	112	1.5	87	1.9	199	1.6	3.9
15	C22	Malignant neoplasm of liver and intrahepatic bile ducts	144	1.9	42	0.9	186	1.5	9.3
	...	All other Causes	3816	50.5	2552	55.4	6368	52.3	7.8
		Total	7558	100.0	4609	100.0	12167	100.0	7.4

Source: Annual Hospital Statistics Report, Ministry of Health (2013)

(8) Risk

1) Flood

Floods in Greater Yangon can be classified into the following three types of

- River flooding.
- Localized inundations due to cloudburst (possibly due to climate change, heat island phenomenon) in combination with loss of infiltration rate by reclaimed and paved ground surface, underserved drainage infrastructure in urban areas, and decrepit dams, dykes and levees in rural areas.
- Floods due to cyclone and storm surge.

Past major flood events during 1997-2007 are described in "Hazard Profile of Myanmar", but there are only a few of the flood events in and around Greater Yangon as shown in Table 9.5.30.

Table 9.5.30 Past Major Flood in Greater Yangon (1997-2007)

Location	Date	Affected households	Affected population	Deaths	Remark
Kayan Township	7th June 1997	1,189	5,878	0	North part of the region
Hta/16 Ward, Shwe Pyi Thar Township	8th Sep 2002	886	4,541	0	Along the Hlaing River left bank within Greater Yangon

Source: Hazard Profile of Myanmar, Jul. 2009

2) Cyclone

Cyclones originating in the Bay of Bengal and head westward for India and then turn eastward to approach Bangladesh and Myanmar. Severe cyclones tend to occur during either the pre-monsoon season from April to May or the post-monsoon season from October to November.

- According to "Hazard Profile of Myanmar (2009)", 1,248 cyclones (tropical storms) formed

in the Bay of Bengal from 1887 to 2005, of which 80 storms (6.4% of the total) hit the Myanmar coast.

- From 1947 to 2008, 12 cyclones caused severe damage in Myanmar mainly due to the accompanying storm surge, and the maximum death or missing toll was 138,373 caused by Cyclone Nargis in May 2008.
- Cyclone Nargis also hit Greater Yangon and flood water spread on several Townships around Yangon City. Most of the inundated area during Cyclone Nargis are Dala, Twantay, Htantabin and Hlegu Townships.

3) Traffic Accident

Table 9.5.31 and Table 9.5.32 show the traffic accidents and the category from 2008 to 2012 in Yangon area respectively.

Table 9.5.31 Traffic Accident of Townships in Yangon (2008-2012)

Township	Cases					Died					Hurt				
	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
North Okkala	28	44	36	37	32	2	10	5	5	4	37	70	55	53	35
South Okkala	21	37	23	33	11	2	10	3	4	1	42	48	31	40	8
Thingungune	30	27	25	47	32	6	5	3	8	8	42	71	44	99	47
Yankin	24	7	13	27	17	4	1	-	2	2	32	6	29	34	13
South Dagon	27	32	27	54	32	8	6	10	13	11	49	61	47	51	59
Dagon Harbor	10	16	13	26	15	2	7	4	8	6	22	95	12	42	20
North Dagon	17	17	14	20	7	3	5	-	6	2	27	34	22	23	7
East Dagon	9	8	9	25	11	3	1	3	11	3	15	29	10	54	11
Pazundaung	8	1	6	11	4	3	-	1	2	1	5	-	4	8	3
Mingalartaungnyunt	29	30	18	30	20	4	5	4	2	3	41	68	32	37	21
Tarmwe	26	20	23	45	16	3	4	1	2	1	24	22	24	40	14
Tharkayta	19	28	38	46	22	4	4	6	9	4	52	62	67	50	35
Dawpone	10	13	18	19	9	3	1	6	2	1	26	26	25	25	16
Botahtaung	8	24	13	23	2	1	4	1	2	-	8	79	14	47	7
Mayangone	53	70	51	78	42	8	19	7	11	9	104	128	75	139	56
Hlaing	27	44	37	61	41	6	8	12	15	9	38	94	56	85	74
Kamaryut	24	40	20	44	26	4	6	6	1	4	63	42	43	72	46
Bahan	31	50	39	70	36	8	7	6	11	5	60	67	65	106	51
Sanchaung	18	5	12	24	10	1	1	-	2	-	34	3	21	47	8
Kyimyindine	24	25	30	24	5	6	5	8	5	1	40	26	32	25	4
Ahlone	14	22	24	21	10	5	1	3	1	4	35	49	30	20	6
Dagon	11	22	16	24	9	1	-	2	1	-	26	22	25	41	5
Lanmadaw	17	19	16	19	9	5	3	2	6	-	19	26	34	21	7
Latha	7	12	4	13	7	1	1	-	-	3	11	15	3	12	4
Panbedan	8	5	5	12	2	-	-	-	1	1	7	6	7	9	1
Kyauktada	19	12	10	12	5	3	1	-	-	-	25	42	20	21	5
Seikkan	1	1	2	3	1	6	-	1	2	-	1	-	-	-	-
Insein	36	62	54	88	50	21	16	15	13	12	48	91	74	138	114
Mingalardon	52	88	103	104	73	5	34	31	31	34	135	203	212	206	189
Shwepyithar	14	19	23	23	15	25	7	9	3	7	35	27	22	46	12
Hlaing Tharyar	46	64	73	106	49	-	34	26	29	16	82	107	116	239	78
Total	668	864	795	1169	620	153	206	175	208	152	1185	1619	1251	1830	956

Source: YCDC (2013)

Table 9.5.32 Category of Traffic Accident in Yangon (2008-2012)

Category	Cases					Died					Hurt				
	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
Careless driving	393	411	432	601	282	90	87	78	101	53	828	895	771	895	382
Over speed	19	72	32	126	69	4	13	12	24	27	46	322	129	469	285
Passenger's careless	25	23	21	32	18	7	7	8	6	11	19	17	15	28	8
Across road	127	218	181	238	137	34	63	46	56	34	113	186	150	195	117
Slow vehicle	26	41	33	44	18	7	13	12	9	6	27	44	28	45	16
Driver's no expert	4	4	5	8	1	-	-	1	-	-	18	11	6	6	-
No license	41	70	68	100	84	8	19	15	11	18	57	95	87	162	109
Car breaking down	21	18	20	14	9	2	1	3	1	3	60	43	56	18	27
Drunk driving	10	5	-	4	-	-	-	-	-	-	12	3	-	2	-
Waether condition	1	1	3	1	2	-	-	-	-	-	5	3	9	10	12
Rough roads	1	1	-	1	-	1	3	-	-	-	-	-	-	-	-
Total	668	864	795	1169	620	153	206	175	208	152	1185	1619	1251	1830	956

Source: YCDC (2013)

- The casualties were about 150 to 200 per year during five (5) years (2008-2012).
- The traffic accidents are categorized broadly into 11. Of these categorises careless driving was the most prominent cause of the high percentage of casualty or death toll.

9.6 EIA Procedure to be done by YCDC

9.6.1 Budgetary Request for EIA Procedure

As specified in Section 9.3.6, an EIA procedure for getting an ECC (Environmental Compliance Certificate) from ECD of MONREC for the proposed project is required to be done by YCDC as the proponent in accordance with the EIA Notification (2015).

YCDC has initiated necessary arrangements on a budgetary request of 50 million Kyat in the next fiscal year for carrying out the EIA procedure. (See Appendix 19).

- In 2017, the Government of Myanmar to change the fiscal year. Consequently, 2018-2019 fiscal year will start from October 2018 and end at September 2019.
- Therefore, the budget for the EIA procedure to be started after conclusion of this feasibility study will be allocated in 2019-2020 fiscal year from October 2019 to September 2020.

9.6.2 Implementation Method for the EIA Procedure

The proposed project is subject to the full-scale EIA procedure starting from the screening process, and then the procurement of a local consultant licensed by MONREC as specified in Section 9.3.6 and summarized in Table 9.3.4.

Table 9.6.1 shows implementation methods in carrying out the EIA procedure for the proposed project.

Table 9.6.1 Implementation Methods for the EIA Procedure

Method	Description
Utilization of the JICA Study Results	The results of the environmental and social considerations in this Study shall be reflected in the EIA investigation for the Project during the detailed design stage.
Supervision of EIA procedure in Consulting Services	A local consultant licensed by MONREC shall implement the EIA procedure for the Project under the supervision by a consultant team to be employed by YCDC. An EIA investigation (which is conducted in the EIA procedure) results shall be reflected appropriately in the implementation and operation of the Project.
Assignment of International/National Experts	Two international experts and two national experts in environmental impact assessment and social impact assessment shall be assigned as the members of the consultant team and shall take charge of the supervision of the EIA procedure.
Counterparts (C/Ps) from EDWS/YCDC	YCDC shall assign two C/Ps from EDWS staff to take charge of the supervision of the EIA investigation in collaboration with the consultant's experts, who shall also organize a technical cooperation program for capacity development of the EDWS staff through on-the-job training (OJT) relating to the subjects of environmental and social considerations, EIA, environmental management plan (EMP), and environmental monitoring plan (EMoP).

Source: JICA Study Team

9.6.3 Draft Schedule for EIA Procedure and Issuance of ECC

A draft schedule for the EIA procedure and issuance of ECC for the Project can be depicted as shown in Table 9.6.2 by considering the following points.

- Budget allocation for the EIA procedure is expected in October 2019.
- Required time frame in the EIA Procedure is regulated by the EIA Notification 2015 (See Table 9.3.5).

- The entire period of one year is required for the EIA procedure which includes screening, selection of a local consultant, scoping, EIA investigation (study), stakeholder meetings, pubic consultations, and issuance of environmental permission.
- The EIA procedure for the Project is required to be completed before preparation of bidding documents.
- An environmental permission (ECC in terms of EIA Notification (2015)) for the Project shall be issued before bidding.

Table 9.6.2 Draft Schedule for EIA and ECC for the Project

Action	2018	2019	2020	2021
JICA Study	▬▬▬▬▬▬▬▬			
Budget for EIA Procedure	▲ Request	▲ EIA Budget Allocation		
EIA Investigation and Issuance of ECC		▪▪▪▪▪▪▪▪ Preparation for EIA	▬▬▬▬ EIA Investigation ▲ ECC	
Loan Agreement (L/A)	▲▲ FF & AP Missions	▲ L/A		
Consultant Procurement, D/D and BID		▬▬▬▬▬▬▬▬	▲ BID ▬▬▬▬	
Construction				▬▬▬▬

Note: ECC; Environmental Compliance Certificate, FF; Fact Finding, AP; Appraisal, D/D; Detailed Design, BID: Bidding
Source: JICA Study Team

9.7 Land Acquisition and Resettlement

9.7.1 Legal Framework on Land Acquisition and Resettlement of Myanmar

(1) Relevant Laws and Regulations

Relevant laws and regulations related to land tenure, land use, land acquisition, compensation of assets and losses in Myanmar are summarized in Table 9.7.1.

Table 9.7.1 Relevant Laws and Regulations on Land Acquisition and Resettlement

Law and Regulation	Description
Land Acquisition Act No. 1/1894	· The Act is still the legal basis for land acquisition including consideration for calculating a suitable amount of compensation is to be made as quick as possible for affected person when the land is acquired by the government. · Government has authority to acquire the land under this Act not only for public purpose but also for business reasons for the companies at that time.
Land Nationalization Act 1953	· Repealed by the Farmland Law 2012, determines nationalization of farmlands and procedures for conversion of farmlands to other purposes (La Na 39).
Forest Law 8/92	· The law includes the classification of type of land belonging to Forestry Department. · The law supports conservation, sustainable forestry and socio-economic benefits. · In addition, the law decentralizes forest management to some degree and encourages the private sector and community participation in forest management
Union Government Notification No. 39/2011	· On the application of right to use land owned by government, government departments, organization, citizens.
Myanmar Special Economic Zone Law, 2011	· The developer shall bear the expenses of transferring and compensation of houses, buildings, farms and gardens, orchards/ fields, plantation on land permitted by the Central Body if these are required to be transferred
Farmland Law 11/2012	· The law introduces right to use the land to farmers through land use certificate and acquiring the farmland for other purpose
Farmland Rules 62/2012	· The Rules details the eligibility of farmer or organization for the process of acquiring land use certificate, the role and responsibility of farm land committee in various level and the application process of land use certificate. · And regulating the requirement of indemnity and compensation to the affected person when it comes to the case of confiscating farms in the interests of nation.
Vacant, Fallow & Virgin Lands Management Law 10/2012	· Stipulation of claiming unused land to usable in form of agriculture, livestock, mining & government allowable other purpose.
Vacant, Fallow & Virgin Lands Management Rules 1/2012	· The Rules introduces the process of application and approval of the unused land for various purposes;
National Land Use Policy 2016	· The most updated guidance notes on land acquisition, but no procedures or laws have been defined.

Source: Government of Myanmar and JICA Study Team

(2) Overview of Legal System on Land Acquisition and Resettlement of Myanmar

Even though relevant laws and regulations in Myanmar listed in Table 9.7.1, currently there is no law comprehensively stipulating land acquisition and resettlement regulations in Myanmar. However, the Article No. 7 of the EIA Notification (2015) stipulates as follows (See Table 9.3.6).

- Article 7; EIA Procedure does not address specific matters in relation to resettlement. Projects involving resettlement shall additionally comply with separate procedures issued by responsible ministries, and in the absence of such procedures all such Projects shall adhere to international best practice on Involuntary Resettlement."

Therefore, the Project will also need to be consistent with international lender's safeguards policies, specifically the IFC Performance Standards (PS) and the JICA Guidelines.

In addition, the JICA guidelines, which is consistent with safeguard policies by World Bank (OP4.12 Annex A Resettlement Plan), will be referred.

(3) Steps of Farm Land to use for Public Purpose

In order to acquire farm land to use for public purpose, two main steps are required as follows.

- First: the project owner has to get approval from a Land Record Department at relevant township for conversion of land from agricultural land to other purposes.

- Second: the project owner has to set compensation price in consulting with a compensation committee organized by General Administration Department (GAD) at relevant Township.

9.7.2 JICA Policies on Involuntary Resentment

The following shows "the JICA policies on involuntary resettlement"

The key principle of JICA policies on involuntary resettlement is summarized below.

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.
II. When, after such an examination, avoidance is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected.
III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.
IV. Compensation must be based on the full replacement cost* as much as possible.
V. Compensation and other kinds of assistance must be provided prior to displacement.
VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.
VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.
VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.
IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principle based on World Bank OP 4.12 is as follows.

X. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.
XI. Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.
XII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.
XIII. Provide support for the transition period (between displacement and livelihood restoration.
XIV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.
XV. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.

In addition to the above core principles on the JICA policy, it also laid emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc.

* Description of "replacement cost" is as follows.

Land	Agricultural Land	The pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes.
	Land in Urban Areas	The pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes.
Structure	Houses and Other Structures	The market cost of the materials to build a replacement structure with an area and quality similar or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees, plus the cost of any registration and transfer taxes.

Source: JICA Guidelines

9.7.3 Comparison between the JICA Guidelines and the Laws on Land Acquisition and Resettlement of Myanmar

Based on the recognition above, a comparison between the JICA Guidelines and the laws and regulations on land acquisition and resettlement of Myanmar were made as shown in Table 9.7.2.

Table 9.7.2 Comparison between the JICA Guidelines and the Laws on Land Acquisition and Resettlement of Myanmar

No.	JICA Guidelines (GL)	Laws of Myanmar	Gap between JICA GL and Laws of Myanmar
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	No relevant laws other than Art. 7 of EIA Notification (2015).	There is no regulation which mentions or requests to avoid or minimize involuntary resettlement and loss of livelihood means in Myanmar. However, following the Article 7 of the EIA Notification (2015), it can be considered there may have no gap.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	Compensation or indemnity is provided for farmland acquisition for the interest of the State or public. (Farmland Law (2012) Art. 26, Farmland Rules (2012) Art. 64)	There is no difference.
3	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	Damages to standing crops/trees, lands, movable/immovable properties, transfer cost, economic activities are requested to compensate. (Land Acquisition Act (1894) Art. 23, Farmland Rules (2012) Art. 67)	There is no stipulation of improving or at least restoring living standard, income opportunities and production levels to pre-project levels in the Myanmar legal framework
4	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	Land: Market-value compensation (Land Acquisition Act (1894) Art.9, 23 (1) and 23(2)) Crops: Compensation at three times of the value calculated based on the average production of crops in the current market price of that area is provided. (Farmland Rules (2012) Art. 67)	Land: Partial gap since the act lacks standard methodology in determining compensation, though it requires considering the market value. Additionally, there would be a gap between the market value and full replacement cost. Crops: There is no significant difference.
5	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	When compensation is not paid on or before land acquisition, compensation amount awarded with interest rate must be paid.	There is no clear indication about timing of compensation payment in the Myanmar legal framework.
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	Not applicable	There is no regulation which mentions or requests to avoid or minimize involuntary resettlement and loss of livelihood means.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL)	Not applicable	There is no regulation requesting to organize consultations with PAPs.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	Not applicable	There is no regulation requesting to organize consultations with PAPs
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Not applicable	There is no regulation requesting participation of PAPs into planning, implementation and monitoring of resettlement action plans.
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	1) Notice of compensation amount to PAPs directly: appeal to the court within six weeks from the date of compensation award 2) Notice of compensation amount to representatives of PAPs: i) within six weeks of receipt of compensation notice, or ii) within six months from the from the date of compensation award, whichever period shall be first expiring (Land Acquisition Act (1894) Art. 18)	The procedure of grievance in the Myanmar context is direct settlement at the court, which is not necessarily easy or accessible to PAPs.
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12 Para.6)	A notification of land acquisition or public purposes is published in the Gazette, which is also published at the convenient place in the concerned municipality. (Land Acquisition Act (1894) Article 4)	There is no specific description of identifying affected people as early as possible in the national law.
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	Occupiers/stakeholders of lands to be acquired are explained about acquisition and claims to compensations. (Land Acquisition Act (1894) Article 9)	Detail procedures as well as eligibility criteria are not clearly defined. Also, there is no specific indication about displaced persons without titles.
13	Preference should be given to land-based resettlement strategies for displaced persons	Not Applicable	There is no regulation stipulating to give land-based resettlement strategies.

No.	JICA Guidelines (GL)	Laws of Myanmar	Gap between JICA GL and Laws of Myanmar
	whose livelihoods are land-based. (WB OP4.12 Para.11)		
14	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	Not Applicable	There is no regulation stipulating to provide support for the transition period.
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	Not Applicable	There is no regulation stipulating to provide particular attention to the vulnerable groups.
16	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	Not Applicable	There is no regulation stipulating to prepare resettlement plan.

Note: PAH: Project Affected Household, PAP: Project Affected People, RAP: Resettlement Action Plan, ARAP: Abbreviated Resentment Plan
Source: - Framework of Resettlement Works for the 2000ha Development Area of Thilawa SEZ, Feb 2016, Thilawa SEZ Management Committee
- EIA Notification (2015), - JICA Guidelines (GL), - WB Safe Gard Policy, - JICA Study Team

9.8 Adaptation to Climate Change

This project is expected to reduce the deterioration of the public health environment etc. during heavy rains and floods assumed as the influence of the climate change by improving wastewater at the time of rain through improvement of sewer system facilities. Therefore, the Project will contribute to the climate change adaptation through improvement of sewer system facilities.

CHAPTER 10 FINANCIAL AND ECONOMIC ANALYSIS

10.1 Financing Scheme of the Project

The project is executed by YCDC and its initial investment cost is financed by the Japan International Cooperation Agency Official Development Assistance (JICA ODA) loan (eligible portion) and the Yangon City Development Committee (YCDC) own fund (non-eligible portion). The JICA loan is lent to the Ministry of Planning and Finance (MoPF) based on the Loan Agreement (L/A), and then on-lent to YCDC. The previous on-lending agreement between MoPF and YCDC (for the Greater Yangon Water Supply Improvement project) states that the interest rate and repayment schedule are the same as the L/A, and YCDC will pay it back to MoPF in the local currency. This project expects the same terms and conditions regarding the subsidiary loan agreement.

10.2 Financial Situation of YCDC

YCDC has wide range of responsibilities and has the ability to raise its own revenue through tax collection, fees, license, and property development. Under YCDC, there are 20 departments[1], and the fiscal deficit of a department has been covered by a surplus of other departments. Although its budget is a part of Yangon Region Government (YRG), YCDC does not regularly receive subsidy from YRG nor from the union government.

10.2.1 Financial status of Water and Sanitation

Table 10.2.1 shows the cash inflow and outflow of the department.

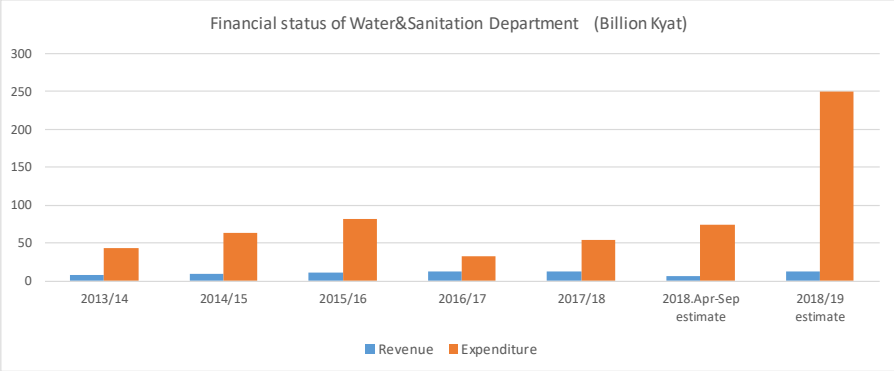
[1] It will be reorganized under the new YCDC law which was approved in June 2018

Table 10.2.1 Revenue and Expenditure of the Water and Sanitation Department

Water & Sanitation Department Fiscal Status (Unit: million Kyat)	Actual 2013/14	Actual 2014/15	Actual 2015/16	Actual 2016/17	Actual 2017/18	Interim period Estimaetd 2018.Apr-Sep	Estimated 2018/19
I. Revenue	**7,599**	**9,288**	**11,753**	**12,104**	**13,323**	**5,961**	**12,519**
1. Water Tariff Revenue	7,084	8,515	10,193	10,908	12,102	5,350	11,419
(1) Government	1,111	1,608	1,697	1,620	1,677	500	1600
(2) Public	5,973	6,906	8,497	9,288	10,425	4850	9818.7
2. House Connection Fees	218	296	536	416	456	282	450
3. Water Meter Sales	130	280	732	549	580	261	519
4. Others	167	197	292	232	186	68	131
II. Operational Expenditure	**-9,377**	**-13,624**	**-16,496**	**-18,153**	**-18,143**	**-10,864**	**-22,439**
1. Salary and allowance	-1,512	-1,729	-2,233	-2,186	-2,146	-1,144	-2,287
2. Materials and service expenses	-5,631	-9,552	-11,474	-13,006	-13,110	-7,989	-15,975
(1) Labor expenses	-951	-1,055	-1,192	-1,407	-1,448	-797	-1,602
(2) Transportation	-27	-28	-30	-11	-16	-15	-20
(3) Fuel and lubricant	-121	-72	-45	-33	-50	-50	-100
(4) Electricity	-2,865	-6,374	-8,964	-10,111	-9,838	-5,400	-10,800
(5) Equipment	-1,603	-1,943	-1,192	-1,381	-1,688	-1,672	-3,339
(6) Others	-63	-80	-50	-63	-69	-55	-114
3. Maintenance expenses	-2,234	-2,343	-2,789	-2,961	-2,886	-1,731	-4,178
(1) Machinery and accessories	-240	-290	-143	-150	-237	-220	-451
(2) Buildings	-340	-340	-337	-314	-200	-185	-524
(3) Roads	-59	-60	-95	-147	-86	-150	-550
(4) Vehicles	-20	-18	-19	-19	-25	-25	-50
(5) Watercrafts	-10	-9	-3	-3	-3	-3	-3
(6) Others	-1,566	-1,626	-2,192	-2,328	-2,335	-1,149	-2,600
Operational Margin	**-1,779**	**-4,336**	**-4,743**	**-6,049**	**-4,820**	**-4,902**	**-9,920**
(% to Revenue)	-23%	-47%	-40%	-50%	-36%	-82%	-79%
III. Capital Expenditure	**-34,402**	**-49,362**	**-65,461**	**-14,920**	**-36,733**	**-63,943**	**-226,942**
1. Expansion of piping	-190	-2,243	-5,146	-1,277	-3,626	-718	-5,198
2. Water supply projects	-32,153	-38,860	-56,055	-11,863	-29,375	-60,741	-211,236
(1) Ngamoeyeik-Hlawga	-13,299	-11,571	-31,766	-3,987		-4,603	-8,595
Ngamoeyeik-Hlawga (YCDC)	-12,665	-9,185	-19,227	-2,814			
Ngamoeyeik-Hlawga (ODA Grant)	-634	-2,385	-12,539	-1,172			
(2) Lagunbyin	-12,834	-22,328	-15,913	-6,580	-26,404	-46,436	-98,518
Lagunbyin (YCDC)	-12,834	-22,328	-13,098	-3,554	-4,741	-5,011	-20,925
Lagunbyin (ODA Loan)	0	0	-2,815	-3,026	-21,663	-41,425	-77,593
(3) Greater Yangon Water Supply	-3,350	-930	-282	-204	-202	-1,677	-4,445
(4) Reservoirs and tube wells	-2,556	-3,527	-5,231	-821	-2,629	-2,515	-2,990
(5) Hlawga-Yangon	-115	-5	-80	0	0	0	0
(6) Kokkowa	0	-498	-2,783	-271	-140	-5,510	-96,688
3. Sanitation works	-167	-241	-208	-55	-389	-352	-3,693
4. Water supply facility expansion	-1,843	-7,950	-4,013	-1,725	-3,344	-2,132	-6,815
(1) Water supply facility expansion (Downtown)	-732	-4,922	-2,990	-510	-3,344	-2,132	-6,815
(2) Myo Daw purified water production	-784	-3,028	-1,024	-1,215	0	0	0
(3) Pipe production factory	-327	0	0	0	0	0	0
5. Sewerage treatment plant	-49	-69	-39	0	0	0	0
Total Revenue	**7,599**	**9,288**	**11,753**	**12,104**	**13,323**	**5,961**	**12,519**
Total Expenditure	**-43,779**	**-62,986**	**-81,957**	**-33,073**	**-54,876**	**-74,807**	**-249,381**
IV. Surplus (Deficit)	**-36,181**	**-53,698**	**-70,205**	**-20,969**	**-41,553**	**-68,845**	**-236,862**

Source: JICA Study Team based on Water and Sanitation Department
Note: In 2018, fiscal year calendar of Myanmar has been changed to October-September, from April to March. Government sets April to September 2018 as interim period.

About 90% of the revenue comes from the water tariff, and the rest comes from house connection fees and water meter sales. The only revenue from the sewerage service is the one-time permit grant fee of septic tanks, which is negligible. The operational expenditure alone exceeds the total revenue where the electricity bill being the largest portion. As the two ODA loan projects (Greater Yangon Water Supply Improvement Projects) proceed, deficit of the department is expected to be larger (Figure 10.2.1). Water tariff increase and introduction of wastewater tariff are critical steps to improve the status and will be discussed later in this chapter.

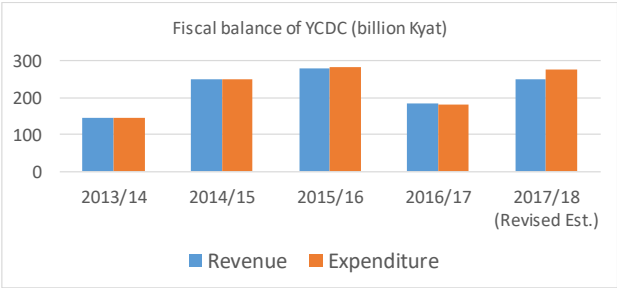


Source: JICA Study Team based on Water and Sanitation Department

Figure 10.2.1 Fiscal Balance of Water Supply and Sanitation Department

10.2.2 Financial status of YCDC

Figure 10.2.2 below shows YCDC's fiscal scale and balance. The city has been keeping its balance by adjusting its capital expenditure to revenue fluctuation, except for 2015/16 when the union government decided to raise the officials' salaries and YCDC made a deficit, which was later covered by the union government.



Source: JICA Study Team based on YCDC

Figure 10.2.2 Fiscal Scale and Balance of YCDC

Looking into the breakdown (Table 10.2.2), current revenue keeps surplus over operational expenditure throughout 2013/14 to 2017/18. Capital revenue is deeply affected by the real estate market: 70-80% of which comes from the Engineering Department (building) plus the City Planning and Land Administration Department through land lease and housing activities. Therefore, capital revenue dropped in 2016/17 due to the government's introduction of relevant regulations and following the market stagnation. Capital expenditure grows rapidly from 2013/14 to 2015/16, majority of which is spent on roads and bridges (40%), water and sanitation (31%), and building (17%) projects. Then it was cut by 61% in 2016/15 to make balance with decreasing revenue, but quickly increased next year, and 48% of it was spent on water and sanitation projects.

Table 10.2.2 YCDC Revenue and Expenditure

	YCDC revenue and expenditure		Actual 2012/13	Actual 2013/14	Actual 2014/15	Actual 2015/16	Actual 2016/17	Revised Est. 2017/18
I.	**Revenue**		**103,167**	**145,768**	**252,179**	**279,359**	**184,888**	**250,579**
		(Growth %)		*41%*	*73%*	*11%*	*-34%*	*36%*
	1.	Current revenue	95,311	92,180	134,232	141,795	140,821	145,146
	2.	Capital revenue	7,856	52,953	115,562	122,210	39,870	46,516
	3.	Foreign Grant		634	2,385	12,539	1,172	0
	4.	Loan				2,815	3,026	58,917
II.	**Expenditure**		**100,198**	**145,727**	**252,141**	**284,826**	**181,761**	**278,563**
	1.	Current expenditure	48,273	50,410	67,693	79,779	101,337	103,370
	2.	Capital expenditure	51,926	95,317	184,448	205,047	80,424	175,192
III.	**Surplus (Deficit)**		**2,969**	**41**	**38**	**(5,467)**	**3,127**	**(27,984)**

Source: JICA Study Team based on YCDC

CHAPTER 11 ORGANIZATION DEVELOPMENT AND INSTITUTIONAL ARRANGEMENT

11.1 Outline of Capacity Development

For smooth introduction of the new sewerage system by the Project, the JICA Study Team proposed the organization development and institutional arrangement detailed in Chapter 11.

11.2 Required Capacity Development

11.2.1 Organization Development

The implementation of the Project includes “detailed design”, “tender assistance”, and “construction”, which includes the selection of the consultant and contractor for implementation. The Yangon City Development Committee (YCDC) shall provide a project management unit and selection committee for management of the implementation procedures.

11.2.2 Capacity Development for Project Implementation

For the implementation of a large-scale project, a management unit should be established to carry out the management work of the project implementation. The project management unit should work with all stakeholders such as relevant government organizations, consultants, contractors, service population, etc., during the detailed design and construction supervision stages. For the Project, the project management unit (PMU) is proposed as shown in Figure 11.2.1. The PMU shall be established before the commencement of the consulting service for the project.

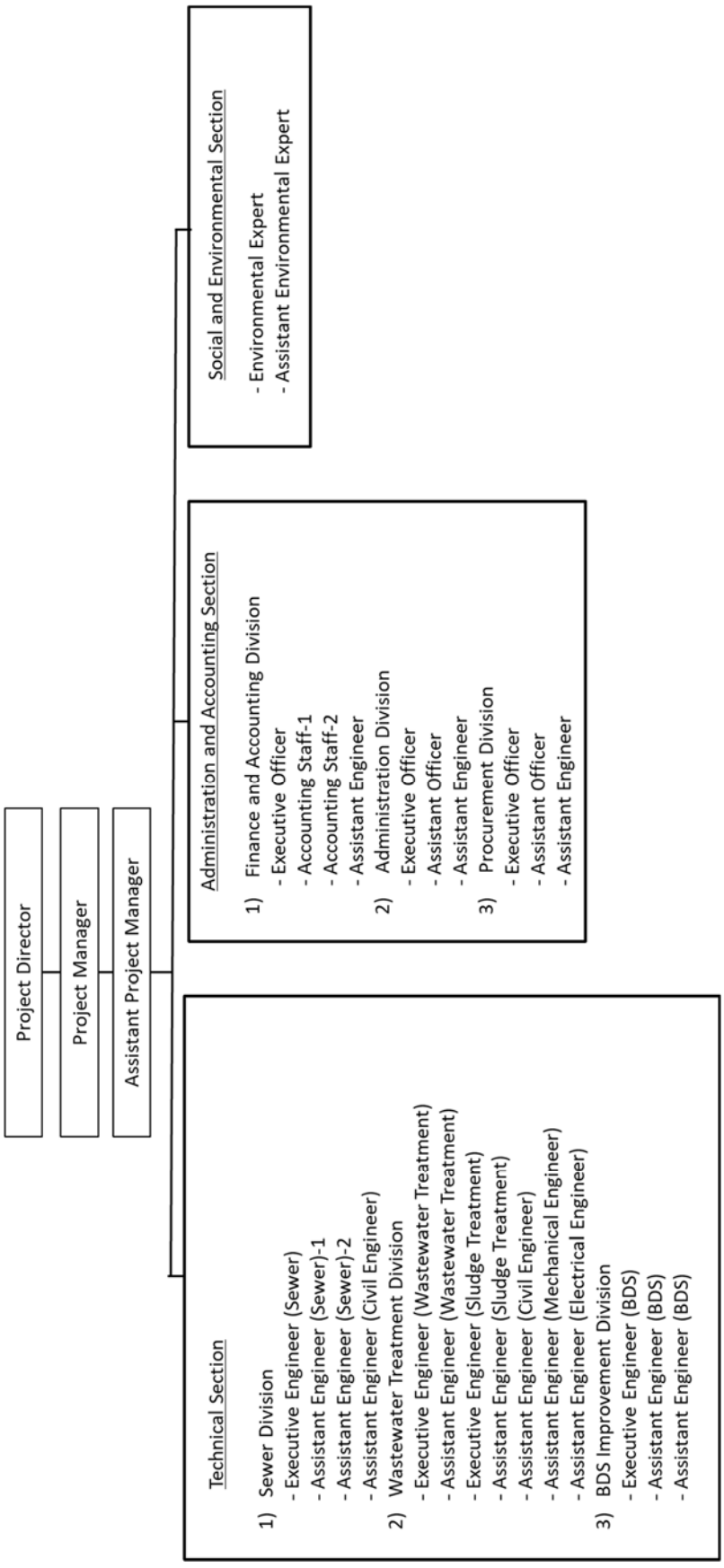
As for the selection of the consultant and contractor working for the Project, a “selection committee” will be established. The secretary of the YCDC will be the head of the committee.

YCDC has experience in management of the implementation of two ongoing water supply projects under the Japan International Cooperation Agency (JICA) loan scheme. However, the YCDC is still not so familiar with the implementation of a JICA loan project. It is recommended that one of the members of the PMU should be able to have an opportunity to attend a seminar/training including the contents shown in Table 11.2.1.

Table 11.2.1 Recommended Contents of the Seminar/ Training for PMU

Objective	Timing	Contents of the Training
PMU Member	At the beginning stage of the Project and as necessary	・Reporting and coordination with JICA and donors ・Discussion and negotiation with relevant agencies ・Obtaining necessary approval and permission ・Procedure for the selection of the consultant and the contractor ・Holding the public meeting for land acquisition and coordination for information disclosure ・Environmental monitoring ・Fund claiming to JICA ・Disbursement management ・Publication relation activity

Source: JICA Study Team



Source: JICA Study Team

Figure 11.2.1 Proposed Organization Chart of the Project Management Unit

11.2.3 Capacity Development for Operation and Maintenance

The Sanitation Division in the Water and Sanitation Department of the YCDC is responsible for the O&M of the sewerage system, including the existing wastewater treatment plant and sewer pipe network. The current organization chart of the Sanitation Division is shown in Figure 11.2.2.

After discussion with the Water and Sanitation Department, the JICA Study Team proposed the development of O&M organization, considering adoption of advanced technologies (MBR and Sludge Drying Process) and changing sewer pipe network, considering demolishment of ejection system and expansion of the network.

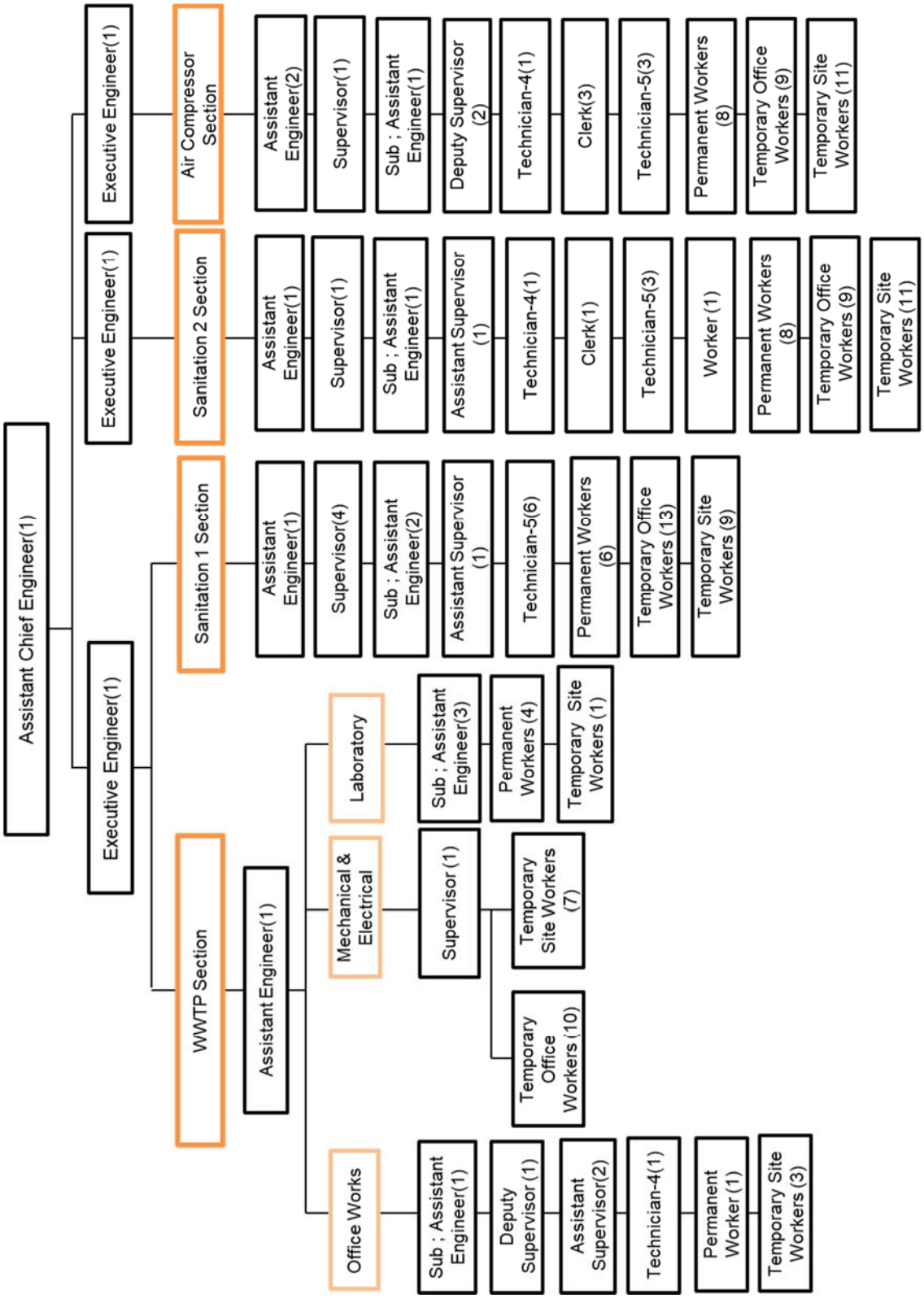
Table 11.2.2 shows the number of current and future staff of the Sanitation Division. The operation staff for the new wastewater treatment plant and new sewer pipe network in Dagon area will increase. On the other hand, the operation staff for the air compressor for the ejection system will be removed. Source: JICA Study Team based on the information from YCDC

Figure 11.2.3 shows the proposed organization chart of the Sanitation Division for O&M of the new sewerage system.

Table 11.2.2 Number of Staff for O&M in Sanitation Division (Current and Future)

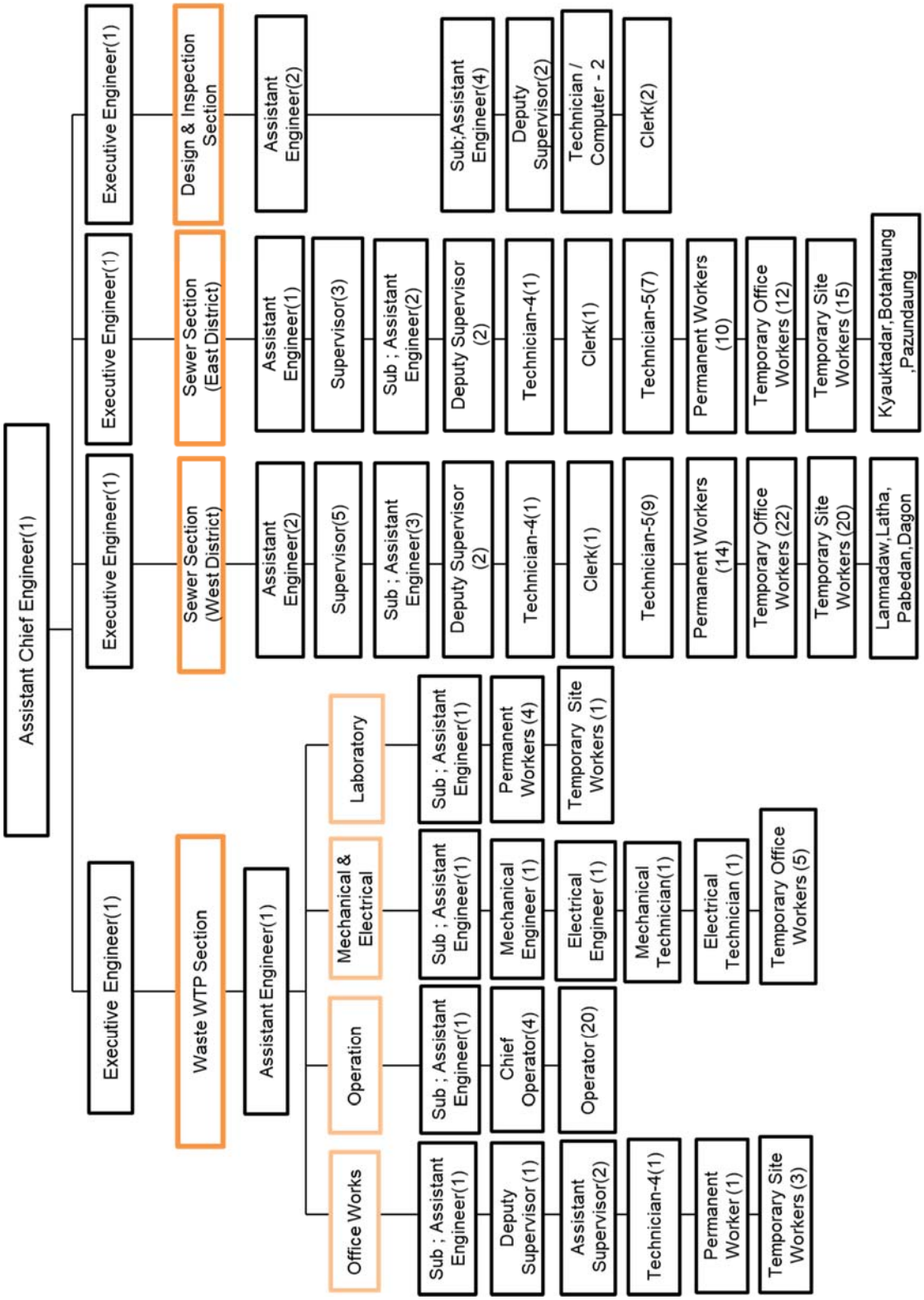
Position of Staff		Number of Staff		
		Current	Future	Balance
1) Management		**4**	**4**	**0**
2) Wastewater Treatment Plant	Office Works	10	10	0
	Operation	0	25	+25
	Mechanical and Electrical	18	15	-3
	Laboratory	8	8	0
	Subtotal	**36**	**58**	**+22**
3) Sewer Pipe Network	CDA Area (Sanitation-1 & 2)	80	78	-2
	Dagon Area	0	54	+54
	Air Compressor	25	0	-25
	Subtotal	**105**	**132**	**+27**
Total		**145**	**193**	**+48**

Source: JICA Study Team



Source: JICA Study Team based on the information from YCDC

Figure 11.2.2 Current Organization Chart of the Sanitation Division in YCDC



Source: JICA Study Team based on the information from YCDC

Figure 11.2.3 Proposed Organization Chart of the Sanitation Division in YCDC

11.3 Institutional Arrangement

11.3.1 House connection

The Project includes the construction of the wastewater treatment plant and the expansion of the sewer pipe networks. However, the house connections from the sewer pipe network are not included. The service population will be responsible for the house connection and bearing a part or all of O&M costs under the sewerage tariff to be established.

11.3.2 Operation and Maintenance

(1) Organization Development

For successful O&M of the new sewerage system, capacity development shall be proposed considering the following points:

- Development of an organization for the O&M of the new wastewater treatment plant using advanced technologies, such as Membrane Bioreactor (MBR) and Sludge Drying Process
- Change of the organization for the O&M of the new sewer pipe networks due to the demolishment of the existing ejector system and the expansion of the pipe networks

(2) Institutional Arrangement

A certain amount of budget for the O&M should be provided. However, the financial source for O&M has not been found. To prepare the budget for O&M, institutional arrangements such as sewerage tariff and government subsidy system are required.

11.3.3 Required Institutional Arrangement

For implementation of the Project and O&M of new sewerage system, the following institutional arrangements are required:

1) Establishment of a Law and Standard for Construction and Operation

Even if construction of the Project is completed, the sewerage system has not been completed. The service population is required to complete house connections to the sewer network on their own cost, under the Sewerage Law. The Sewerage Law requires to complete the sewerage system, hopefully before the commencement of the construction of the Project.

For suitable operation of the system, various standards and regulations are required such as effluent water quality standards of the public water body, regulation for emergency case, standard and regulation on discharging to the sewerage system, regulations on sludge disposal and reuse, regulation for setting the sewerage tariff and collection. These standards and regulations should be completed before the commencement of the operation.

2) Finding a Financial Source

After completion of the Project, a certain amount of annual budget will be required for operation and maintenance of the new sewerage system to be established by the Project. In addition, the repayment for the loan of the Project will also be required from 2028. However, an adequate financial source for the O&M and repayment have not been found yet.

The sewerage tariff and government subsidy are possible and essential financial sources. Before commencement of the operation of the new wastewater treatment plant in 2023, setting the sewerage tariff and governmental subsidy rules should be established for preparation of enough budget.

For smooth implementation of the above arrangement, a technical cooperation program may be required.

CHAPTER 12 CONCLUSIONS AND RECOMMENDATIONS

12.1 Conclusions of the Study

The three packages, CP-1: Sewer, CP-2: WWTP and CP-3: BDS sewer connection, have been proposed in this study.

As reported, there is an existing sewerage system established for a part of the target area. However, the existing system has serious problems and does not function properly. Firstly, the existing system collects only black water, and grey water is discharged to drains and finally to the river without any treatment. The ejector system which collects black water was constructed in 1888 and has been used until now with only occasional minor repairs. Procurement of spare parts is also difficult due to the obsolete system. The corrosion of the force main is very concerning, and the investigation for the whole existing sewer system is difficult.

Considering increased future wastewater, it is decided that the existing ejector system is to be abandoned, and a new sewer is to be constructed because the rehabilitation of the existing system is difficult from the technical and economical point of view.

On the other hand, the Membrane Bioreactor (MBR) process for wastewater treatment has been selected mainly because of the land limitation and the mechanical sludge drying process that has been adopted for minimizing the sludge volume from the WWTP. In the future, the YCDC will further study the possibility of installing incineration facilities in the area.

When the entire planned sewerage facilities are completed, all wastewater generated in the target area will be collected and treated. Thus, it would lead to the improvement of the citizen's living conditions and water quality in the public water receiving body.

12.2 Summary of Project Scope

The following project scope in Table 12.2.1 has been proposed and concluded throughout the study.

Table 12.2.1 Project Scope

	Work Item	Description
1	**Sewer (CP-1: ICB)**	**[Sewer (open-cut)]** 26,320 m (Central Business District (CBD): 13,113 m, Dagon: 13,207 m) Diameter: 200 mm - 450 mm **[Sewer (pipe-jacking)]** 26,319 m (Central Business District (CBD): 21,263 m, Dagon: 5,056 m) Diameter: 200 mm - 1,500 mm

		Vertical shaft: H = 4.00 m – 14.90 m, 210 Nos. **[Manhole]** 732 Nos.
2	**Wastewater Treatment Plant (WWTP) (CP-2: ICB)**	Capacity: 112,000 m^3/day (The 1st phase construction (the first three years of the construction period): 56,000 m^3/day. The 2nd phase construction (the last three years of the construction period): 56,000 m^3/day Wastewater Treatment Facility: Membrane Bioreactor (MBR) Influent Pumping Station: Q = 30 m^3/min x 6 Nos. (4: duty, 2: stand-by) Sludge Treatment Facility: Thickener, Dewatering machine, Mechanical Dryer (100 t/day x 2 Nos.) Administration Building: Administration Office, Operation Room (SCADA), Laboratory, PR Facility Electrical Room: (capacity) 4,000 KVA Effluent Pipeline (outlet): Diameter: 1,000 mm x 2 Nos., L = 20 m
3	**BDS Sewer Connection (CP-3: LCB)**	BDS sewer connection with chamber to collect graywater: 176 Nos. Pilot BDS sewer replacement: 6 Nos. Connection from ejector chamber to the main sewers: 40 Nos.

12.3 Operation Indicator and Effect Indicator

Operation and Effect Indicators for the project is shown in Appendix 21.

12.4 Required Additional Study in Detailed Design Stage

The following additional studies will be required during the detailed design stage:

12.4.1 Environmental Impact Assessment (EIA) Assistance

Further study on the environmental and social considerations is required for the assistance of the EIA which will be obtained by the YCDC.

12.4.2 Investigation of Sewage Sludge Characteristics

During the detailed design of the sludge treatment facilities, detailed investigation of the sewage sludge characteristics is required in order to fix the scale of the facilities.

12.4.3 Soil Investigation

Soil investigation along the alignment of the sewer will be required in order to select the pipe installation method. Especially, the type of pipe-jacking machine is determined through the result of the investigation.

12.5 Recommended Further Assistance

12.5.1 Technical Transfer

In order to operate the new sewerage facilities such as MBR, dewatering machine and sludge drying machine properly, special training for the YCDC staff by an operation specialist who is dispatched by the supplier will be necessary. Also, the daily operation and maintenance status of the WWTP are not recorded at present, therefore, it is an obstacle to establish an appropriate maintenance plan. This issue should be addressed by a specialist, accordingly.

In addition, the sewerage assets database should be introduced for planning of maintenance works and stock management for the future.

12.5.2 Capacity Development

As reported in Chapter 4 and Chapter 11, at present the development of wastewater treatment in Yangon City remains at an overall low level, therefore, the skills for sewerage works including operation and maintenance are at a low level too. Capacity development in the individual, organizational and societal level is required for improvement of wastewater treatment in new facilities.

Institutional development, development of legal and regulatory frameworks, social and environmental activities for local people aiming at enhancement of developing wastewater facilities should be considered a priority.

In order to appropriately operate new sewerage systems in the near future, cultivation of experienced trainers capable of giving guidance and acquisition of broader and deeper understanding and technology by the trainers are essential. From the long-term point of view, it is expected to nourish resource persons effectively, and it is required to ensure that they teach the knowledge and experiences that they obtained to the younger staff. Furthermore, it is necessary to develop an environment for individuals to improve their motivation for learning.

At the initial stage, a technical assistance project carried out by foreign experts who have enough knowledge and skills is necessary for the entire capacity development of the YCDC staff.

12.5.3 Formulation of a Master Plan for Sludge Treatment

YCDC is interested in the introduction of an incinerator for the generated sludge in the future. In connection to this, the generated sludge from the several locations of WWTPs that are to be developed in the future has to be disposed after a certain treatment. It is recommended to formulate a master plan for sludge treatment to grasp the sludge treatment policy as a long-term plan of Yangon City, including the scope of works such as projection of generated sludge volume, treatment method, disposal site, and reuse of the sludge.