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

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR
THE IMPROVEMENT OF
WATER SUPPLY, SEWERAGE
AND DRAINAGE SYSTEM
IN YANGON CITY
IN
THE REPUBLIC OF THE UNION OF MYANMAR

VOLUME III

WATER SUPPLY SYSTEM MASTER PLAN

< Advance Version >

MARCH 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

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TOKYO SUIDO SERVICES CO., LTD.
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THE PROJECT FOR
THE IMPROVEMENT OF
WATER SUPPLY, SEWERAGE AND DRAINAGE SYSTEM
IN YANGON CITY

FINAL REPORT

MARCH 2014

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Abbreviation

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
DDA	Department of Development Affair
DEWS	Department of Engineering (Water Supply Sanitation)
DIP	Ductile Iron Pipe
DMA	District Metered Area
EC	Electrical Conductivity
E/N	Exchange of Notes
ECC	Environment Conservation Committee
F/S	Feasibility Study
FC	Foreign Currency
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
JICA-HIS	JICA Household Interview Survey
Kyat	Myanmar Kyat
LPCD (or Lpcd)	Liters 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 Liters
MLD	Million Liters per Day
MOAI	Ministry of Agriculture and Irrigation
MOECAF	Ministry of Environment Conservation and Forestry
MOF	Ministry of Forestry
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
PPP	Public–Private Partnership
PVC	Polyvinyl Chloride
R.	Reservoir
RC	Reinforced Concrete
S/R	Service Reservoir
SCADA	Supervisory Control And Data Acquisition
SCBD	South of CBD
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SS	Suspended Solids
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids
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	Waste Water Treatment Plant
YCDC	Yangon City Development Committee
YCDL	Yangon City Development Law

Abbreviation for the Relevant Studies

The Preparatory Study for Urban Development Programme in the Greater Yangon (JICA)	JICA Urban Plan Study, 2012
Household Interview Survey (JICA)	2012 JICA-HIS
Data Collection Survey on Water Resources Potential for Thilawa Special Economic Zone and Adjoining Areas (JICA)	JICA Thilawa Water Study
The Study on Improvement of Water Supply and Wastewater Treatment in Yangon (METI)	METI Water Supply and Sewerage Study
The Study on Improvement of Water Supply System in Yangon City	2002 JICA-M/P

Unit

1 Gallon (British Gallon) = 4.546 liter

1 Acre = 4,047 m^2

Foreign Exchange Rate

1 USD = 84.64 JPY (as of December 2012)

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Although the capital of Myanmar was moved to Naypyidaw in 2006, Yangon City is still the national center of economy, business and communication. Current population of Yangon City is approximately 5.1 million according to Yangon City Development Committee (YCDC). Water supply system in Yangon has a long history, the water supply services commenced in 1842. However, the service ratio is still as low as 38 %. Transmission and distribution pipes have not been rehabilitated properly resulting in large quantity of non-revenue water, i.e. 66 % of total daily supply of 520,000 m^3/day. Approximately, 90 % of water comes from reservoirs, and two thirds of them is distributed directly without any treatment. In addition, water treatment at the water treatment plant is insufficient. Approximately, 70 % of connections are equipped with water meter, which is higher compared to other developing countries, but water charge is rather low, approximately 8 Yen/m^3 for metered houses and 180 to 300 Yen/month for houses without meter. It cannot be said that sufficient financial sources is secured for operation and maintenance of water supply system. Regarding technical capability of the undertaking, YCDC's capability is evaluated to be high, since they have been making efforts to design water supply facilities and to manufacture pipes by themselves. On the other hand, there remains much room for improvement in operation and maintenance of water treatment plant and in management of water quality. In the 6 townships located outside boundary of YCDC administrative area, water supply system, if it exists, is managed by the Yangon regional government.

Sewerage system in Yangon was constructed in the downtown in 1880's, 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 2004 with a design capacity of 14,800 m^3/day. Currently sewerage service area is limited to 6 townships out of 33 townships. In the remaining 27 townships, wastewater is treated by on-site systems (septic tank etc.) and in such cases treatment efficiency is deemed to be low. Also, being located in monsoon region, Yangon City has suffered due to flooding in absence of appropriate wastewater collection networks. Under the circumstances mentioned above, efficient and timely development of water supply, sewerage and drainage systems in Yangon is the most urgent need to improve the level of services and living conditions.

Regarding water supply, JICA implemented a development study titled "The Study on Improvement of Water Supply System in Yangon City" in 2002, in which master plan was formulated and feasibility study was conducted to prepare development plan targeting year 2020. Estimation of future water demand, investigation of potential water resources, block distribution system, rehabilitation of pipe networks, construction of facilities such as new water treatment plant, transmission lines, and reservoirs, project cost estimation were included in the study. However, due to various reasons, most

of the projects proposed in the plan are yet to be implemented. Alternatively, measures to expand water supply coverage have been implemented to cope with the needs of development of new suburban areas; including 1 large water treatment plant for which raw water source is Ngamoeyeik reservoir and 4 small plants using ground water as sources of water. In addition, many service meters have been equipped.

After adoption of new liberal policies in Myanmar, JICA initiated discussion with the Yangon regional government on formulation of comprehensive development plan including water supply, sewerage, drainage, electricity, road, railways, ports, etc. and the minutes were concluded concerning "the project for the strategic urban development plan of the greater Yangon" on May 1st 2012. Further minutes were concluded concerning water supply, sewerage and drainage, one of the umbrella projects on May 22nd 2012.

As a result, the following related projects are under progress through the Japanese assistance;

- Project for the Strategic Urban Development Plan of the Greater Yangon (JICA)
- Study on Water Resource Potentialities for Thilawa SEZ and its environs" (JICA)
- "Study on the Improvement of Water Supply and Wastewater Treatment in Yangon City" (Ministry of Economy, Trade and Industry (METI), Japan)
- "Study on Development of Sewerage System in Myanmar, 2012" (Ministry of Land, Infrastructure, Transport and Tourism, Japan)
- In addition, advisor for water supply has been dispatched from Fukuoka city, Japan, funded by JICA

1.2 Objectives of the Study

The objectives of this study are formulation of development plan for water supply, sewerage and drainage in greater Yangon and selection of priority projects in order to contribute to economic development and to improvement of living environment of the Region.

1.3 Counterpart Organization

The main counterpart organization is Yangon City Development Committee (YCDC).

1.4 Study Area

The Study area is greater Yangon, covering YCDC area (33 townships) and parts of the surrounding 6 townships (Thanlyin, Kyauktan, Hmawbi, Hleagu, Htantapin and Twantay).

1.5 Target Year

Target year for master plan is set as 2040, same as that of the Project for the strategic urban development plan of the Greater Yangon, and that for feasibility study is set as 2025.

1.6 Study Schedule

This study started in August 2012 submitting Inception Report (IC/R). Then, a water vision and a master plan were prepared based on data of framework and household interview survey results obtained from "The Preparatory Study for Urban Development Programme in the Greater Yangon (JICA)" and interim report (IT/R) containing the water vision and the master plan (M/P) was submitted in March 2013. Furthermore, the revised interim report was submitted for disclosure to the public.

Of the project components in the master plan, priority projects were selected for a feasibility study (F/S) which started in February 2013. The feasibility study was completed in July 2013 and the contents were explained in the technology transfer seminar. Afterward, an additional survey was carried out according to change of the land for a service reservoir and the route of transmission pipeline to Thilawa SEZ, and the feasibility study was completed.

The draft final report (DF/R) containing Water Vision, Mater Plan and Feasibility Study was prepared and submitted in November 2013.

The final report (F/R) was prepared and finalized based on comments obtained from YCDC and submitted in March 2014.

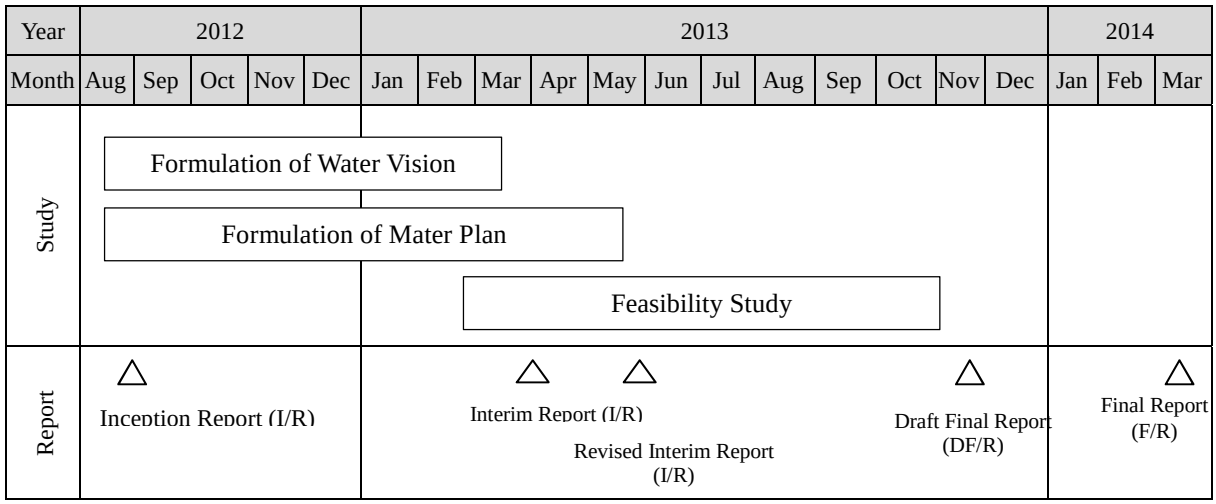


Figure 1.1 Study Schedule

CHAPTER 2 OUTLINE OF THE STUDY AREA

2.1 Socio-Economic Condition

2.1.1 Administrative Organization and Boundary of the Study Area

Administrative boundaries of YCDC has been gradually expanding, incorporating urbanizing townships in the peripheral area and, 33 townships are included in YCDC area as of 2012. In future, parts of other 6 townships in the Study Area might be incorporated with YCDC administrative area but at present it is under the administration of the Yangon Regional Government (see Figure 2.1). Thirty-three townships of YCDC are grouped into 7 categories, reflecting regional characteristics, according to the JICA urban development study (see Figure 2.2).

2.1.2 Present Land Use

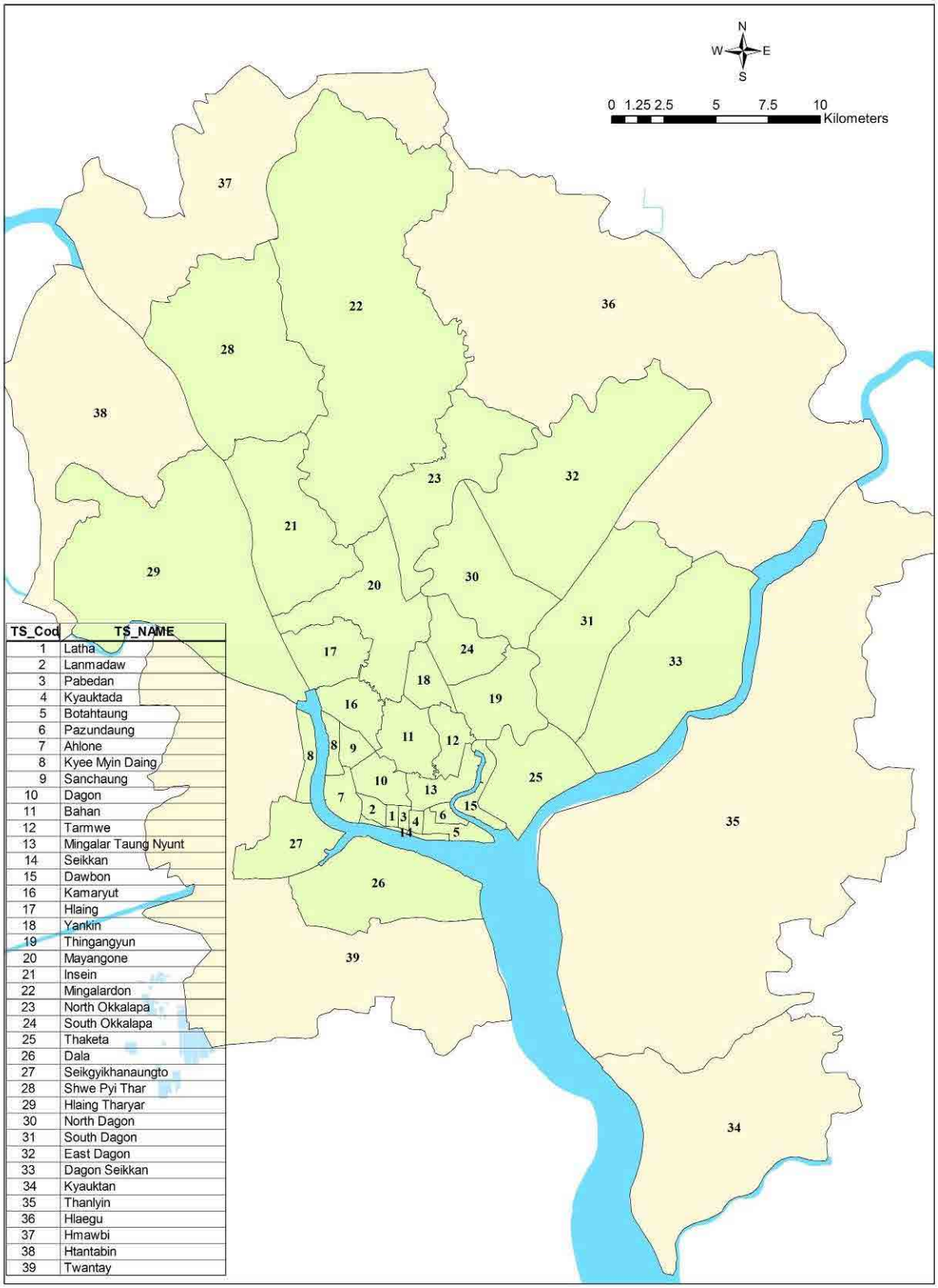
(1) Urbanization Trend

Present Yangon started its history from the current CBD (Central Business District) area, developed as a capital of lower Myanmar by the Britain in 1885. Urbanization expanded northward during 1950's to accommodate redevelopment of houses after devastation of houses and mitigation of developed slums and illegal settlements after the 2nd world war. New urban areas are township groups of Inner Urban Ring, Outer Ring Zone and Northern Suburbs. After 1959, older suburbs were developed in the low-lying area. Total population in the above zones having area of 126.54 mile^2 is 3.28 million in 2011. So population density is about 100 per hectare. The above area is situated along the egg-shaped central hills between the Hlaing River and the Ngamoeyeik (or Pazundaung) creek.

In late 1980's, egg-shaped hills area reached their saturation level in terms of population density (although this area still has potential of assimilating development according to the Japanese standard) and urbanization has shifted towards east and west crossing the above two rivers (creeks). They are called as "New suburbs". The population of new suburbs is estimated as 1.64 million in 2011 spread in an area of 174.02 mile^2 with population density of about 36 per hectare. Urbanization has not yet started in the south Yangon because of poor transportation access to the CBD.

(2) Present Land Use

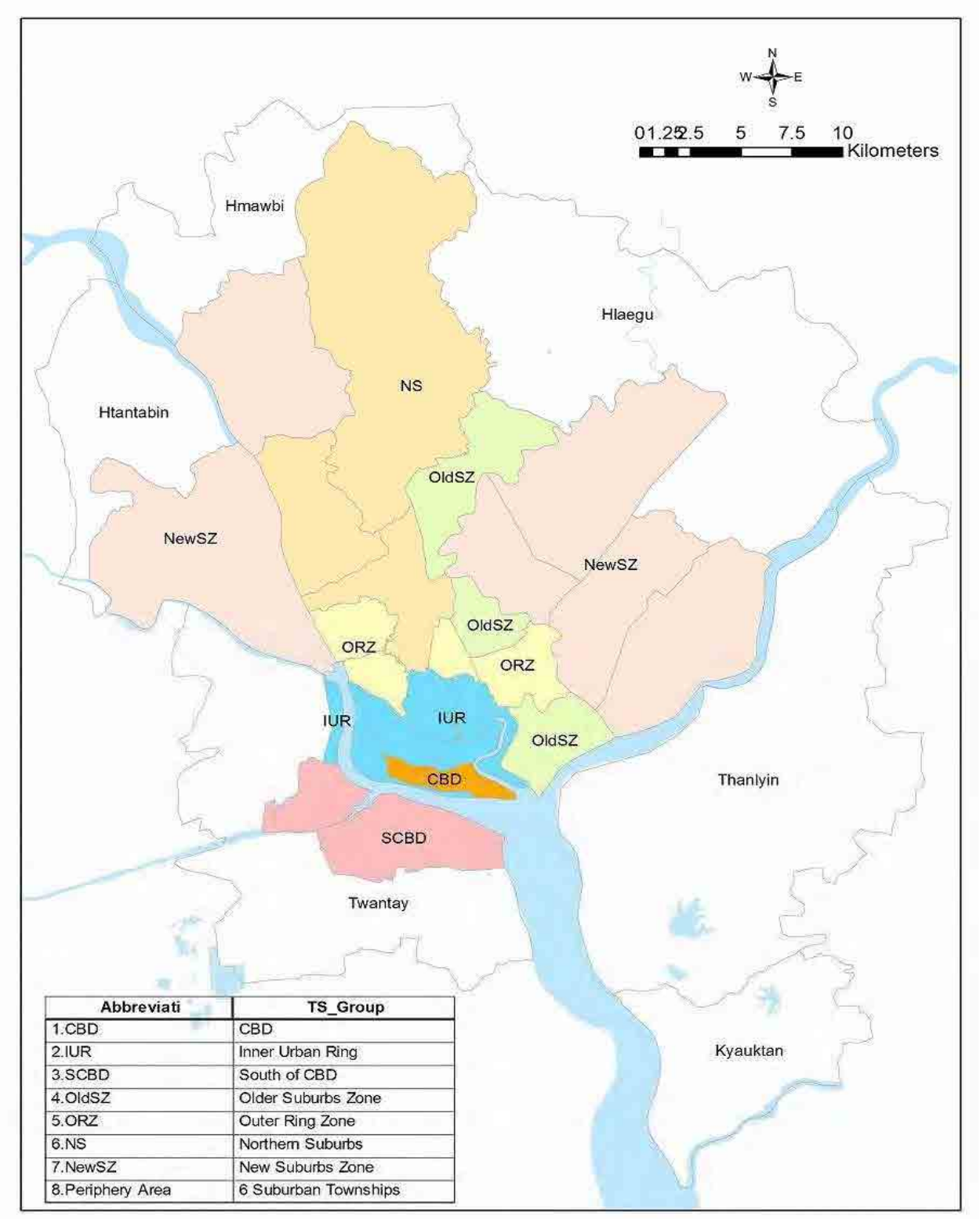
The land use pattern prevailing in the Study Area in 2012 was developed in the JICA urban development study based on the analysis of satellite imagery. Looking at the land use in 2012, YCDC area is already developed or undergoing development while most of the area outside YCDC boundary is agricultural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



TS_Cod	TS_NAME
1	Latha
2	Lanmadaw
3	Pabedan
4	Kyauktada
5	Botahtaung
6	Pazundaung
7	Ahlone
8	Kyee Myin Daing
9	Sanchaung
10	Dagon
11	Bahan
12	Tarmwe
13	Mingalar Taung Nyunt
14	Seikkan
15	Dawbon
16	Kamaryut
17	Hlaing
18	Yankin
19	Thingangyun
20	Mayangone
21	Insein
22	Mingalardon
23	North Okkalapa
24	South Okkalapa
25	Thaketa
26	Dala
27	Seikgyikhanaungto
28	Shwe Pyi Thar
29	Hlaing Tharyar
30	North Dagon
31	South Dagon
32	East Dagon
33	Dagon Seikkan
34	Kyauktan
35	Thanlyin
36	Hlaegu
37	Hmawbi
38	Htantabin
39	Twantay

Source: JICA Study Team

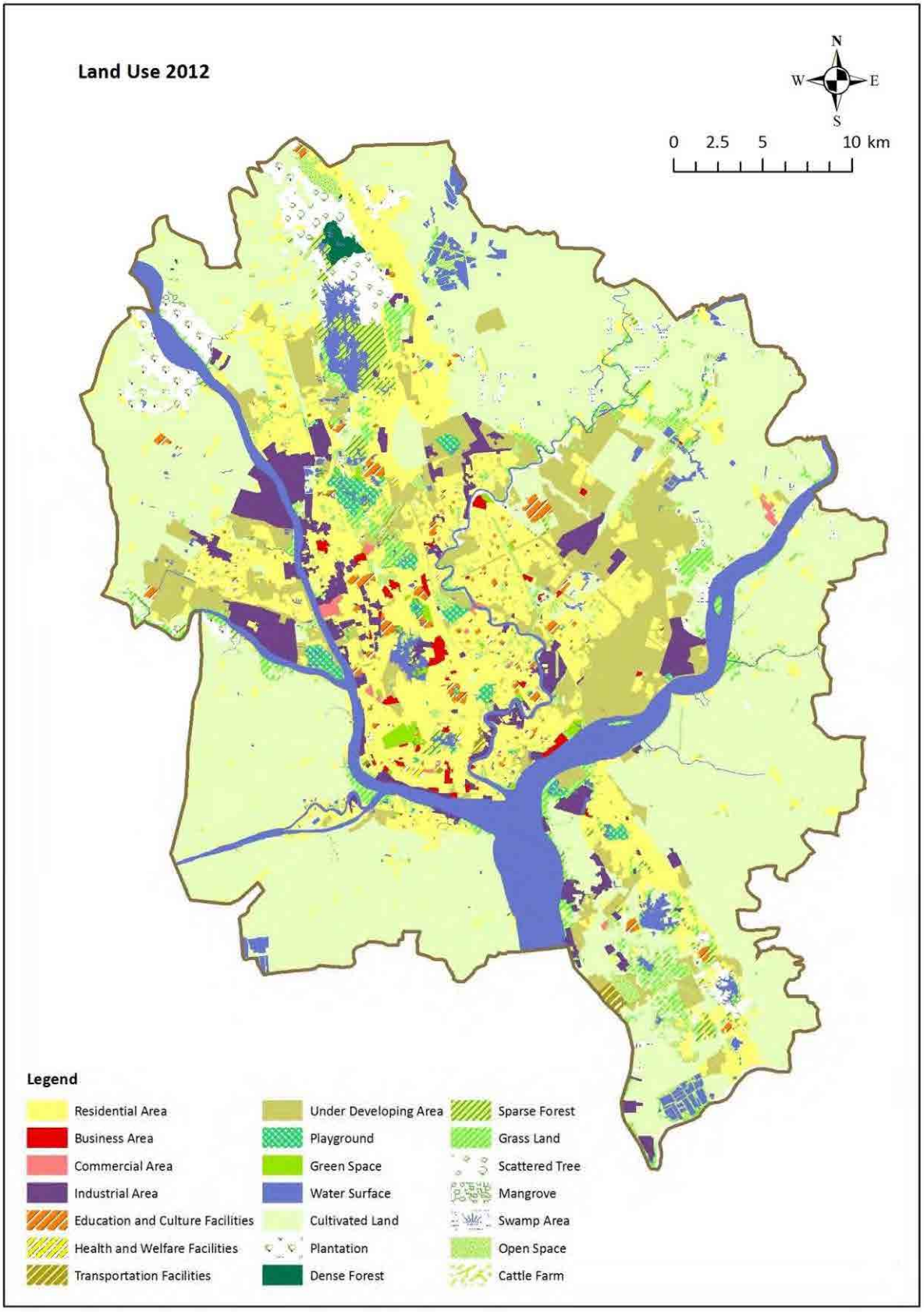
Figure 2.1 Study Area (33 Townships in Yangon City and the Part of Surrounding 6 Townships)



Abbreviati	TS_Group
1.CBD	CBD
2.IUR	Inner Urban Ring
3.SCBD	South of CBD
4.OldSZ	Older Suburbs Zone
5.ORZ	Outer Ring Zone
6.NS	Northern Suburbs
7.NewSZ	New Suburbs Zone
8.Periphery Area	6 Suburban Townships

Source: JICA Study Team

Figure 2.2 Grouping (33 Townships) and Surrounding Area of YCDC

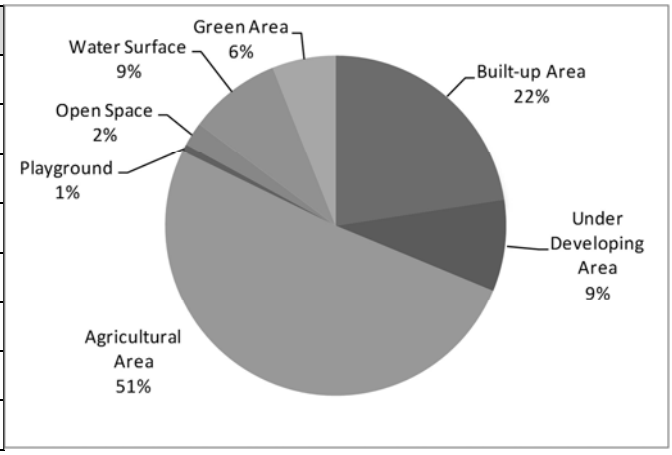


Source: JICA Urban Plan Study, 2012

Figure 2.3 Land Use in Greater Yangon (2012)

Table 2.1 The Composition of Land Use (2012)

Land Use	Are (sq.km)	%
Built-up Area	360.7	22%
Under Developing Area	139.7	9%
Agricultural Area	815.8	51%
Playground	11.5	1%
Open Space	36.4	2%
Water Surface	139.9	9%
Green Area	96.3	6%
Total	1,600.3	100%



Source: JICA Urban Plan Study, 2012

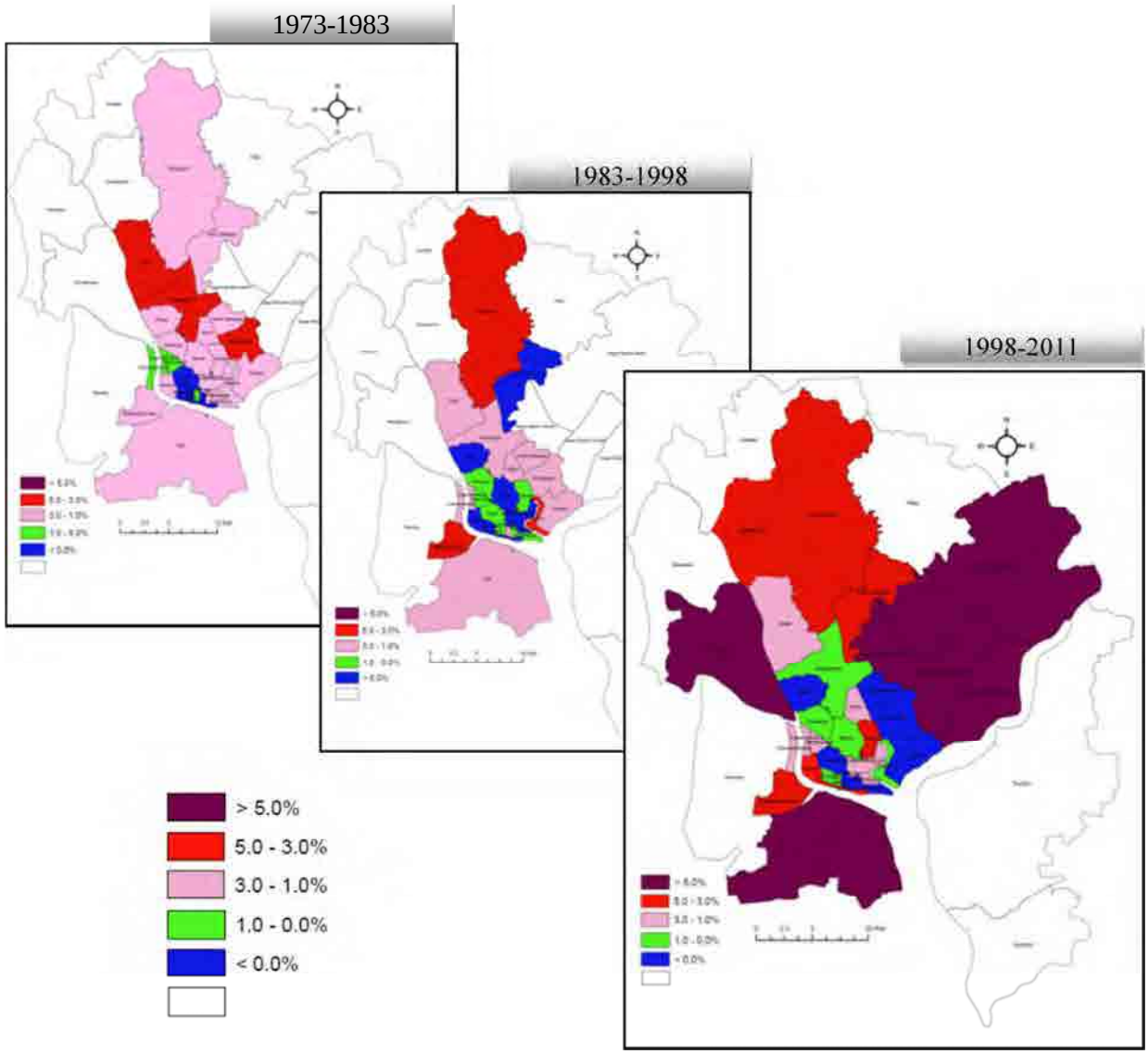
2.1.3 Population

Past populations together with the city area are shown in Table below. Population of 0.73 million in 1953 increased to 0.94 million (about 1 million) in 1963. Afterwards together with city area increase, population increased to 2 million in 1973, 3 million in 1993, 4 million in 2003 and 5.14 million in 2011. Average population growth rate has been about over 2%.

Table 2.2 Trend of Population in Yangon City

Year	Population (Mil.)	Average Population Growth (%)	Area (km^2)	Pop. Density (Person/km^2)	Remark
1953	0.73		123.3	5,925	
1963	0.94	2.5	164.2	5,725	
1973	2.01	7.9	221.4	9,077	Expansion of the City in 1965 and1973
1983	2.51	2.2	346.0	7,254	Expansion of 1983
1993	3.09	2.1	603.5	5,120	Expansion of 1991
2003	4.10	2.8	794.3	5,161	Expansion of 2003
2011	5.14	2.9	794.3	6,471	

Source: YCDC



Source: JICA Urban Plan Study, 2012

Figure 2.4 Trend of Population Growth by Township

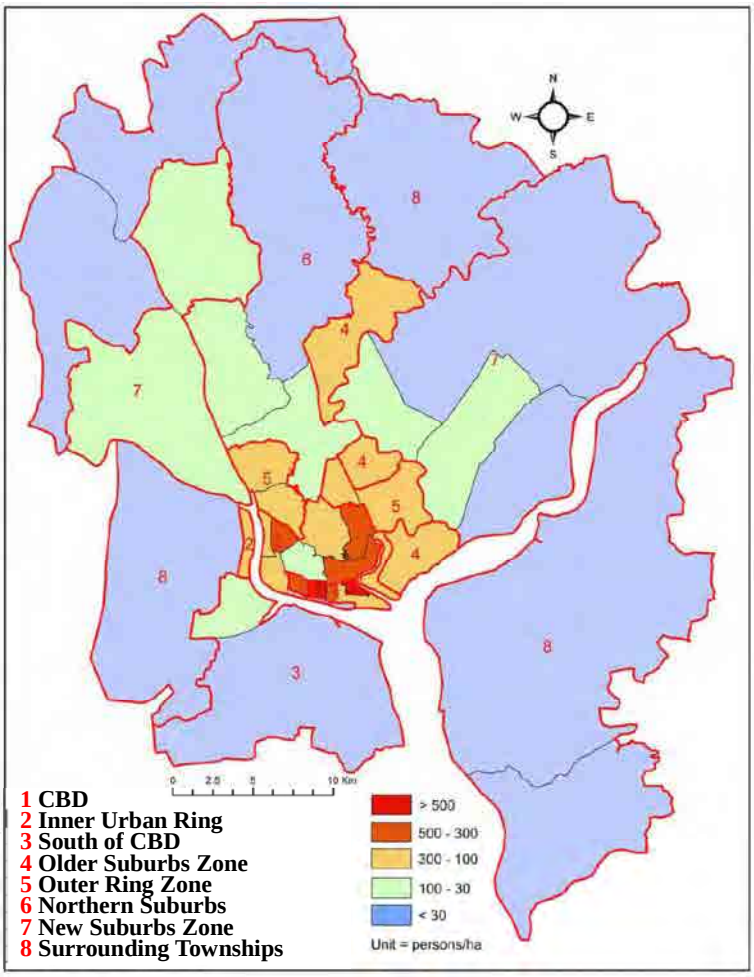
Urbanization rate in Myanmar is 29% in 2010, increased from 25% in 1983, which is lower than 50% of the average figure in the world. Henceforth, it is expected that urbanization will increase more rapidly in Myanmar.

Township-wise populations are shown in the Table below and township-wise population densities are shown in the Figure below. Population in the study area is 5.57 million consisting of 5.14 million in YCDC and 0.43 million in the peripheral area. Population density in the CBD zone is the highest, 365 persons per hectare and that in south of CBD is the lowest, 20 persons per hectare in YCDC. On the other hand, in the peripheral area, the population density is 6 persons per hectare. Population in the CBD has stopped growing recently while populations in the new suburbs and south of CBD have been growing at relatively higher rate of 4 to 15 % annually.

Table 2.3 Population, Population Growth and Population Density in Greater Yangon

No.	Township	TS Group	No. Ward	Area (m^2)	Population	Households No.	Pop. Growth (%)	Pop. Density (pop/ha)	Pop. Density by TS group (pop/ha)
				2011	2011	2011	1998-2011	2011	2011
1	Latha	CBD	10	604770.4	34125	5368	0.37%	564	
2	Lanmadaw	CBD	12	1310572	43137	7334	0.47%	329	
3	Pabedan	CBD	11	618984.4	37551	5366	-1.79%	607	
4	Kyauktada	CBD	9	701876.1	34797	6078	-1.80%	496	
5	Botahtaung	CBD	10	2601921.3	49134	8148	-0.53%	189	
6	Pazuntaung	CBD	9	1067498.3	53648	8258	2.61%	503	365
7	Ahlone	IUR	11	3380983.6	65510	9021	3.19%	194	
8	Kyeemyindaing	IUR	22	4570109.9	115841	20215	2.18%	253	
9	Sanchaung	IUR	18	2404655.5	105208	17242	2.25%	438	
10	Dagon	IUR	5	4894632.9	24492	3682	-3.70%	50	
11	Bahan	IUR	22	8474439.4	100695	16339	0.44%	119	
12	Tarmwe	IUR	20	4985869.1	191114	32505	3.10%	383	
13	Mingalar Taung Nyunt	IUR	20	4943031.6	155767	22732	2.73%	315	
14	Seikkan	IUR	3	1174224.5	2241	433	3.81%	19	
15	Dawbon	IUR	14	3111295	87284	13603	0.71%	281	224
16	Kamaryut	OR	10	6472492.7	87881	13663	0.45%	136	
17	Hlaing	OR	16	9820283	151014	25969	-0.81%	154	
18	Yankin	OR	16	4791565.1	125909	13921	1.25%	263	
19	Thingangyun	OR	39	13120302	231621	35335	-0.29%	177	174
20	Mayangone	NS	10	25834479	205403	33738	0.89%	80	
21	Insein	NS	21	31397616	311200	53324	2.00%	99	
22	Mingalardon	NS	32	127943855	288858	48896	4.12%	23	43
23	North Okkalapa	OldS	19	27755247	333484	57101	4.46%	120	
24	South Okkalapa	OldS	13	8217704.9	191388	33800	-1.07%	233	
25	Thaketa	OldS	19	13448713	253284	43076	-0.76%	188	157
26	Dala	SCBD	46	98400859	181087	31192	6.77%	18	
27	Seikgyikhanaungto	SCBD	9	12101872	38425	6804	3.18%	32	20
28	Shwe Pyi Thar	NewS	27	52706107	295993	38636	4.25%	56	
29	Hlaing Thar Yar	NewS	29	77614147	488768	73668	7.15%	63	
30	North Dagon	NewS	27	24177408	221200	36919	6.16%	91	
31	South Dagon	NewS	39	37506127	370403	58779	7.75%	99	
32	East Dagon	NewS	60	170871278	145505	22734	7.74%	9	
33	Dagon Seikkan	NewS	48	42035707	120161	21741	15.59%	29	41
			676	829060625	5142128	825620		62	
34	Kyauktan	PA	13	76120987	48473	40552	-	6	
35	Thanlyin	PA	36	254846226	181959	135772	-	7	
36	Hlaegu	PA	14	101003839	50793	37996	-	5	
37	Hmawbi	PA	18	84228570	83719	133977	-	10	
38	Htantapin	PA	18	81770250	40234	88888	-	5	
39	Twantay	PA	10	107864054	24936	135958	-	2	
	Periphery Total		109	705833925	430114	252477		6	6
Greater Yangon Total			785	1,534,890	5572242	825620		36	36

Source: JICA Urban Plan Study, 2012



Source: JICA Urban Plan Study, 2012

Figure 2.5 Population Density by Township Group (2011)

2.1.4 Economy

The industrial structure in Yangon Region (including whole 6 townships) is composed of processing and manufacturing sector (37%), trade sector (25%) and service sector (24%) in 2010/11. Agriculture, livestock, and fishery sectors accounted for only 8% of the total production value. Yangon is commercial and industrial city.

Table 2.4 Industrial Structure (GDB Base)

	Commercial	Service	Construction	Electricity	Manufacture	Energy Mining	Agriculture, Forestry and Fisheries
Ratio (%)	25	24	5	19	37	0	8

Source: JICA Urban Plan Study, 2012

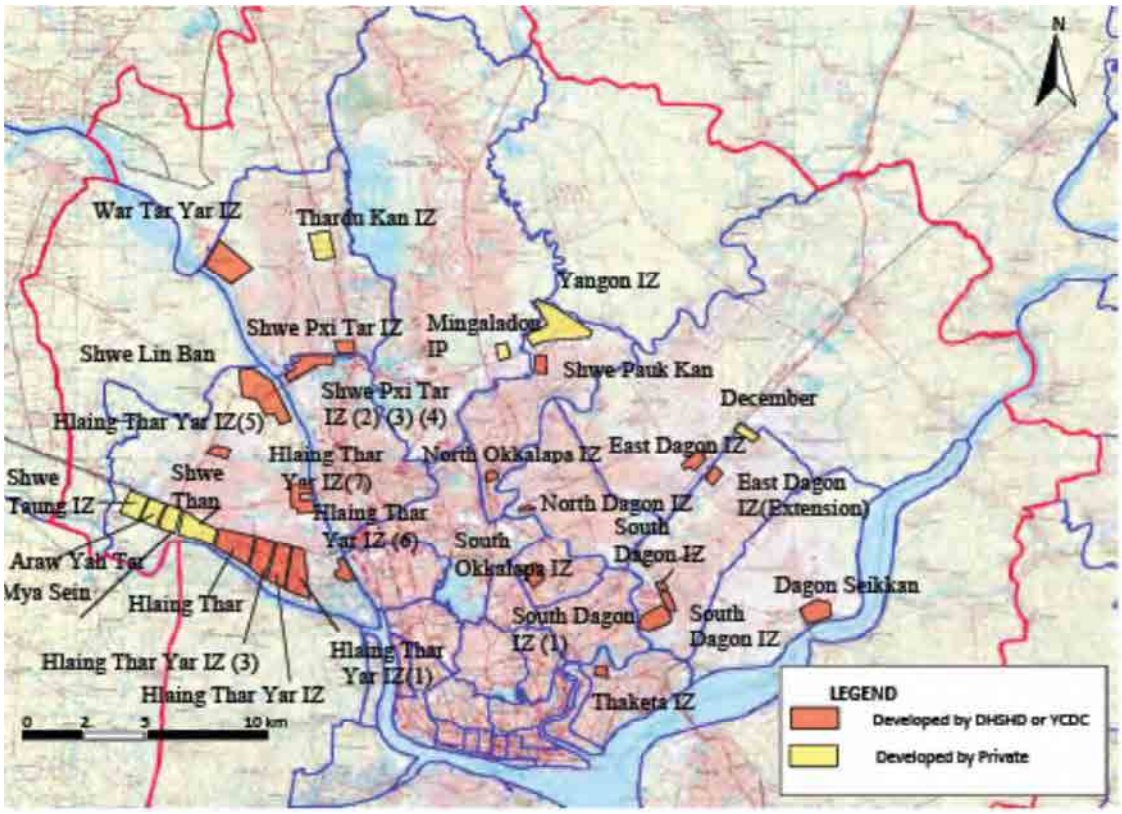
According to the data from Yangon regional office of Planning Department, Ministry of National Planning and Economic Development, there were a total of 15,089 factories or workshops in Yangon

Region in 2010/11. In the 39 townships of the Study Area, there were 13,582 factories or workshops. By zone, New Suburbs Zone is the most industrialized zone with 3,685 factories or workshops (27% of the 39 townships), followed by Inner Urban Ring Zone with 2,543 factories or workshops (19%), Older Suburbs Zone with 1,749 factories or workshops (13%), and Northern Suburbs Zone with 1,428 factories or workshops (11%). The area outside Yangon City has 1,679 factories or workshops (12%) but only a part of these factories or workshops are located in the Study Area.

There are 25 industrial zones in different stages of development with a total land area of 6,665 ha. They are mostly developed by Department of Human Settlement and Housing Development of Ministry of Construction in 1990's.

Existing condition of infrastructural facilities are investigated under the Yangon urban development study. According to the interim results, 80 % of establishments have backup power generation system to be used in case of frequent breaks of electricity supply. By establishments group, 100% modern commerce sector has backup power generation system while 84% of manufacturing sector has it.

As for water source, 55% traditional market sector and 54% services sector rely on water supply from YCDC. Among the manufacturing sector users, only 17% rely on YCDC water supply while 75% gets water from tube wells. Reliance on tube wells as a source of water is also high in case of other sectors; 45% of service sector and about 30% of traditional market and modern commerce sectors depend on tube wells for water.



Source: JICA Urban Plan Study, 2012

Figure 2.6 Locations of Industrial Zones

2.1.5 Health Status

The life expectancy in urban cities of Myanmar was 62.1 years for male and 66.2 years for female in 2003, but it has risen to 65.5 and 70.7 years respectively in 2009 (Statistical Yearbook 2010). According to WHO, in 2009 the median life expectancy for male and female of world was 69 and 75, and for south-east Asian countries, the corresponding values were 64 and 67 respectively. The life expectancy of Myanmar is little lower than the world median but higher among south-east Asian countries. The table below shows the birth rate, death rate, infant mortality rate, maternal mortality rate and under 5 mortality rate of Yangon Region from 2002 to 2011.

Table 2.5 Birth and Mortality Rate of Yangon Region

Sr. No	Impact Indicators	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	World median 2010
1	Crude Birth Rate (per 1,000 Population)	19.06	18.61	18.73	16.46	16.15	15.83	15.22	15.22	15.51	15.79	19.9
2	Crude Death Rate (per 1,000 Population)	8.11	7.72	7.97	7.72	7.76	8.01	8.09	7.35	7.24	6.76	8.2*
3	Infant Mortality Rate (per 1,000 live Births)	43.97	38.24	36.56	33.53	35.84	32.56	25.51	22.96	16.67	16.27	18
4	Maternal Mortality Rate (per 1,000 live Births)	0.39	0.52	1.22	1.30	0.93	1.15	0.86	0.94	1.07	1.05	0.66
5	Under 5 Mortality Rate (per 1,000 live Births)	57.27	51.04	47.10	45.18	45.11	45.13	33.80	28.76	22.15	21.78	20

Source: Yangon Regional Health Department, Ministry of Health, WHO for world median
* Data for 2009

The world median of each indicator is shown in the above table and the data reflects that in Yangon Region, the crude birth and death rate, and infant mortality rate are lower than corresponding figures for world but maternal and under five mortality rate is higher than the world.

The table below shows the number of cases and deaths of epidemic diseases in Yangon region from 2007 to 2011.

Table 2.6 No. of Cases and Deaths by Epidemic Diseases

Diseases	2007		2008		2009		2010		2011	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Cholera	4	-	49	0	191	7	22	1	37	0
DHF (Dengue Haemorrhagic Fever)	4,759	54	3,604	31	3,333	38	3,162	21	552	4
Plague	0	0	0	0	0	0	0	0	0	0

Source: Yangon Regional Health Department, Ministry of Health

The world median number of cases of cholera in 2010 is 951 and plague in 2011 is 0. For the cholera, the situation of Yangon Region is better compared to the world.

The table below shows the number of cases and deaths by the disease including water-borne diseases.

Table 2.7 No. of Case and Death by the Diseases

Sr. No	Name Of Disease	2007		2008		2009		2010		2011	
		Cases	Death	Cases	Death	Cases	Death	Cases	Death	Cases	Death
1	Diarrhea	17,344	7	17,462	9	13,166	10	11,851	2	10,969	4
2	Dysentery	8,507	0	9,489	-	6,135	0	6,361	0	4,436	0
3	Food Poisoning	244	7	259	3	435	7	255	0	395	0
4	Typhoid & Para Typhoid	103	1	71	1	55	0	98	0	47	0
5	Other Tetanus	2	1	3	1	6	1	4	0	5	0
6	Meningitis/ Encephalitis	32	5	24	2	1	4	9	4	10	2
7	ARI (Acute Respiratory Infections)	23,664	59	21,579	37	3	32	17,008	20	17,568	16
8	Viral Hepatitis	188	6	251	1	14	4	271	3	205	2
9	Rabies	17	17	14	14	10	8	8	8	8	8
10	Malaria	5,155	36	5,741	26	4,605	27	4,374	16	2,226	3
11	Snake Bite	486	62	446	57	401	45	479	45	569	64

Source: Yangon Regional Health Department, Ministry of Health

2.2 Natural Condition

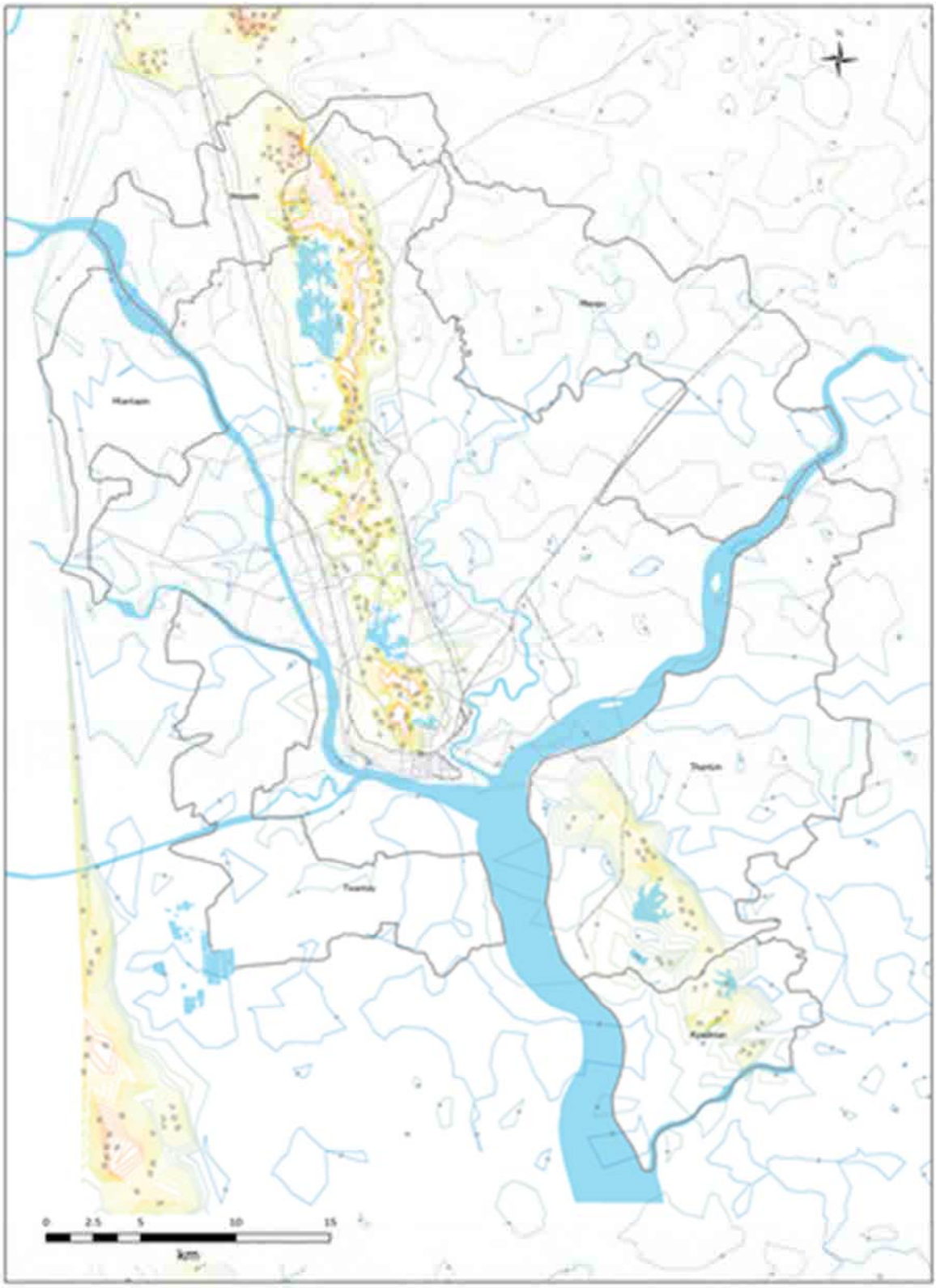
2.2.1 Topography

The study area is situated 34 km inland from the mouth of the Yangon River which traverses parts of the Ayeyarwadi delta.

Area in the center has lowland hills commonly known as the faulty zone ponds with artificial dam namely Kandawgyi Lake, Inya Lake, Hlawga R., Gyobyu R. and Phugyi R. which used to be or are main sources of YCDC water supply system. The three service reservoirs are also on the hills. This long and narrow spur of Pegu Yomas in the central area runs almost in N-S direction with an average height of 30m (100ft) and slopes gradually into flat plains towards east and west.

The relief of the City varies from flat plains to lowland hills in the central part as shown in Figure 2.7.

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 are almost occupied by paddy fields with elevation between about 3m (10ft) to 6m (20ft) above mean sea level.



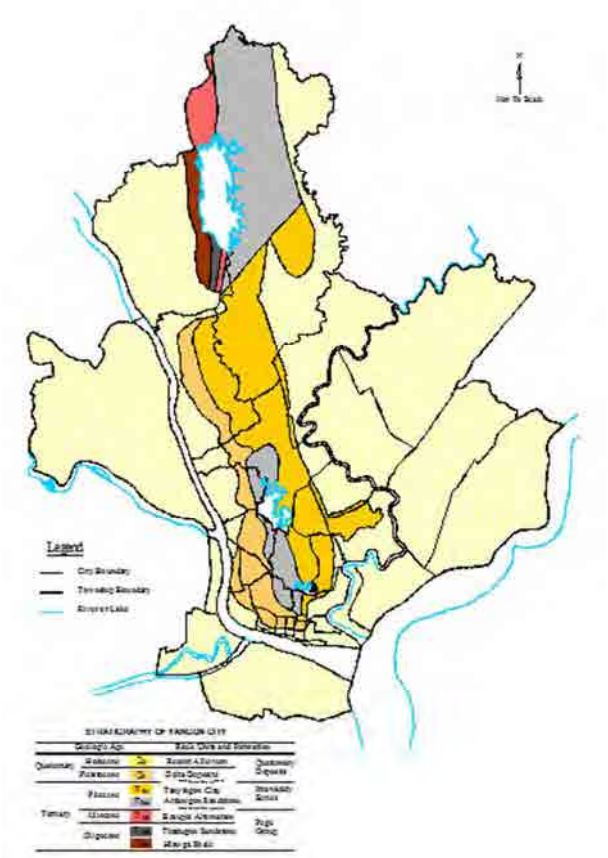
Source: JICA Study Team

Figure 2.7 Topography in Yangon Region

2.2.2 Geology

The geological structure of the city is attributed to moderate lowland hills. The rock formations in the city are classified into three main series/groups based on the geological ages. In terms of geological ages these are (from older to younger); (1) the Miocene and Older Systems-Pegu Group, (2) the Pliocene Series-Irrawaddy Series and (3) Pleisto-Holocene System-Quaternary Deposits, respectively.

Delta sediments consist of sands and gravels, remarkably free from clayey materials and lies upon the eroded surface of Irrawaddy Series. Recent alluvium consists of gravels, clay, silt and laterite. These deposits are widely distributed surrounding the main City area.



Source: 2002 JICA-M/P

Figure 2.8 Geology in Yangon City

2.2.3 Meteorology

(1) Climate

Yangon has a tropical monsoon climate which consists of three seasons as listed below. It has an annual rainfall of 2700 mm, annual evaporation of 1347 mm average temperature of 27.4 ^{o}C, maximum mean temperature of 33 ^{o}C, and minimum mean temperature of 21.8 ^{o}C.

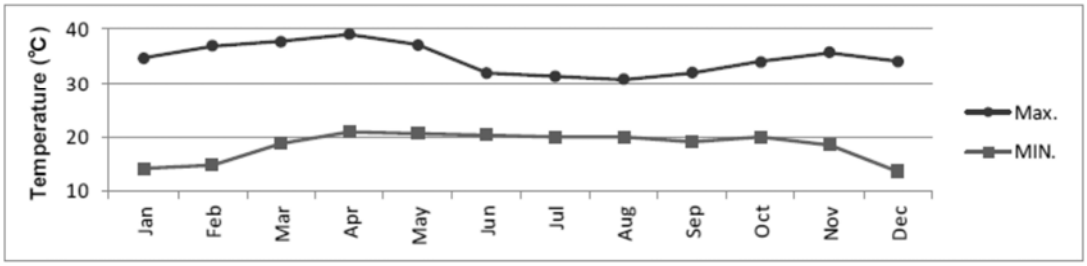
Summer season: March–mid May

Rainy season: mid May–October

Dry season: October–February

(2) Temperature

Figure 2.9 shows the mean maximum and minimum temperature in Yangon City (1991-2008). The difference between the monthly maximum and monthly minimum temperatures is more than 20 ^{o}C from December through February and around 10 ^{o}C from June through August.

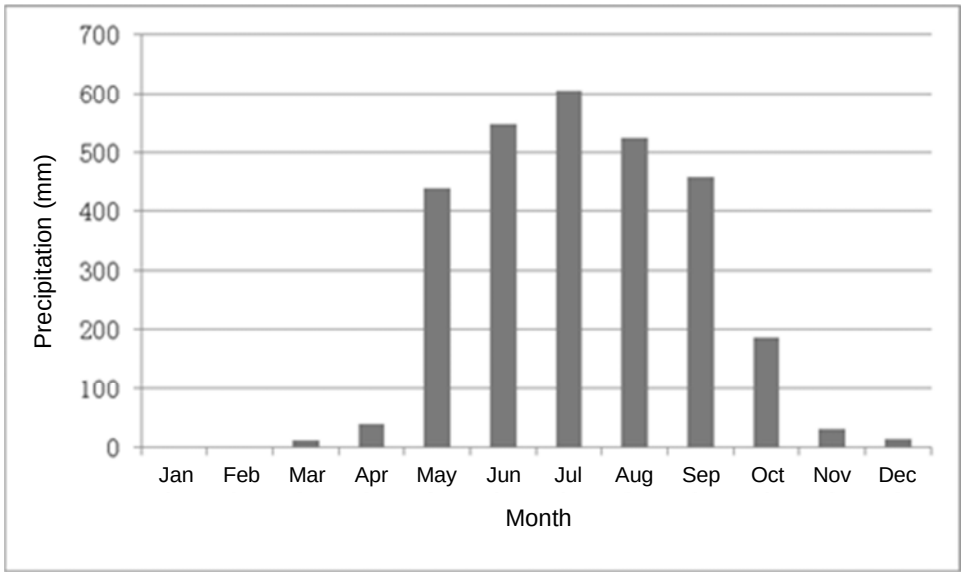


Source: JICA Study Team

Figure 2.9 Mean Maximum and Minimum Temperature in Yangon City (1991-2008)

(3) Rainfall

Figure 2.10 shows the mean monthly rainfall from 2001 to 2010 observed in Yangon (Kaba-Aye). From the graph, the annual mean rainfall is 2,700 mm. About 95% of the total rainfall throughout the year occurs during the rainy season period from May to October.



Source: JICA Study Team

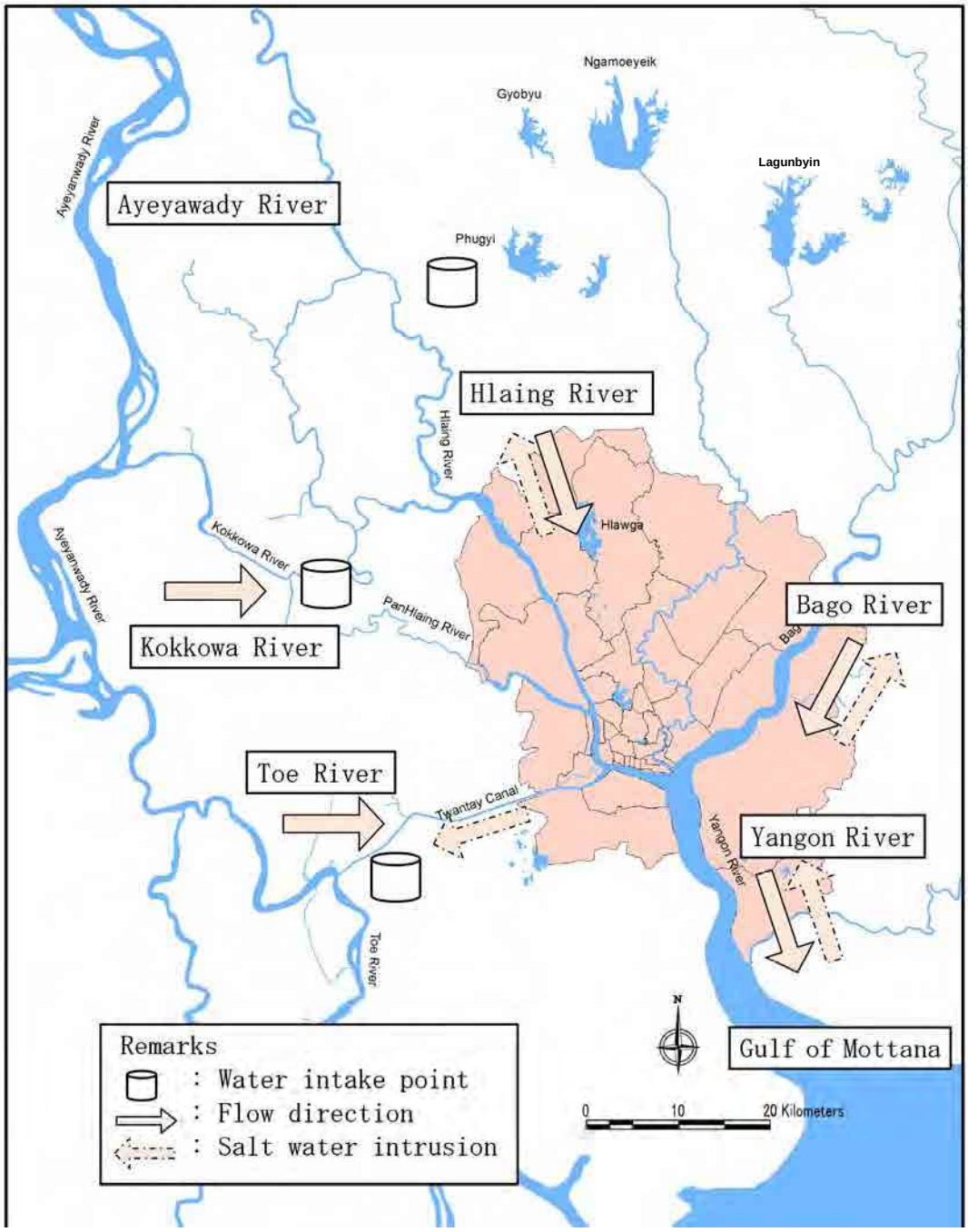
Figure 2.10 Mean Monthly Rainfall (Yangon: Kaba-Aye, 1991-2008)

2.2.4 Hydrology

(1) Rivers

Figure 2.11 shows a map which contains the rivers surrounding Yangon City. Yangon City lies at the confluence of the Bago River and the Hlaing River. The two rivers meet at the confluence of the Yangon River, which is connected to the Gulf of Mottama. The Pan Hlaing River and Twan Tay Canal, which converge and flow downstream the Yangon River, as well as the Kokkowa River which connects with the Hlaing River, all obtain its water from the Ayeyarwaddy River. These rivers are candidate water sources for the expansion of Yangon City's water demand expected to increase in the future. The Pazuntaung Creek flows through the eastern part of the city CBD. The river upstream of

this is called the Ngamoeyeik, where a Ngamoeyeik Reservoir has been built as part of the water source in YCDC. There are no river flow discharge data except of the Bago River and the Hlaing River in the available report. Therefore, the estimated river flow discharge by water level observations is described later.



Source: JICA Study Team

Figure 2.11 Map Showing the Rivers Surrounding Yangon

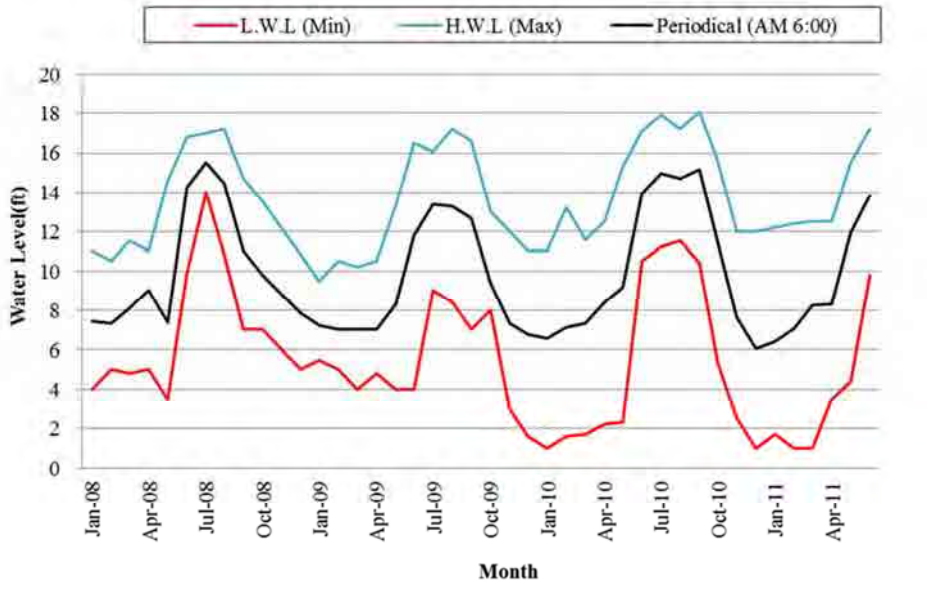
1) Hlaing River and Bago River

The periodical flow rate measurement for the Hlaing and Bago Rivers is carried out by Ministry of Agriculture and Irrigation (MOAI). The flow analysis of these rivers was made in the Study on Improvement of Water Supply System in Yangon City (2002 JICA-M/P) in 2002. The result of monthly river flow fluctuation at Khamonseik monitoring station in the Hlaing River shows that the smallest flow is about 20 m^3/s in January to April and the largest flow is 1,851 m^3/s in August and the difference amount to about 100 times. Likewise, the smallest flow is 2 to 3 m^3/s in January to April and the largest flow is 242 m^3/s in August in the Bago River.

The intake point for water supply in the Hlaing River was set at Gwedanshe with 8,290 km^2 of the catchment area, which may be not affected by salt intrusion from the sea. The analysis shows that the lowest flow rate that is occurred once and twice in 11 years is 4.3 m^3/s and 11.4 m^3/s at Gwedanshe. Likewise, the lowest flow rate that is occurred seven times in 11 years is 1.3 m^3/s. With is the small flow, the intake of river water for water supply from the Bago River is not possible.

2) Kokkowa River

The periodical flow level measurement for the Kokkowa River is carried out at the Pan Tai village in Pan Taing district by MOAI. The following figure shows the fluctuation of the water level of the monthly highest and lowest minimum and at fixed time during January in 2008 and July in 2011.The highest and lowest levels are 14.0 ft (about 4.2 m in July 2008) and 1.9 ft (about 0.3 m in February and March 2011), respectively.

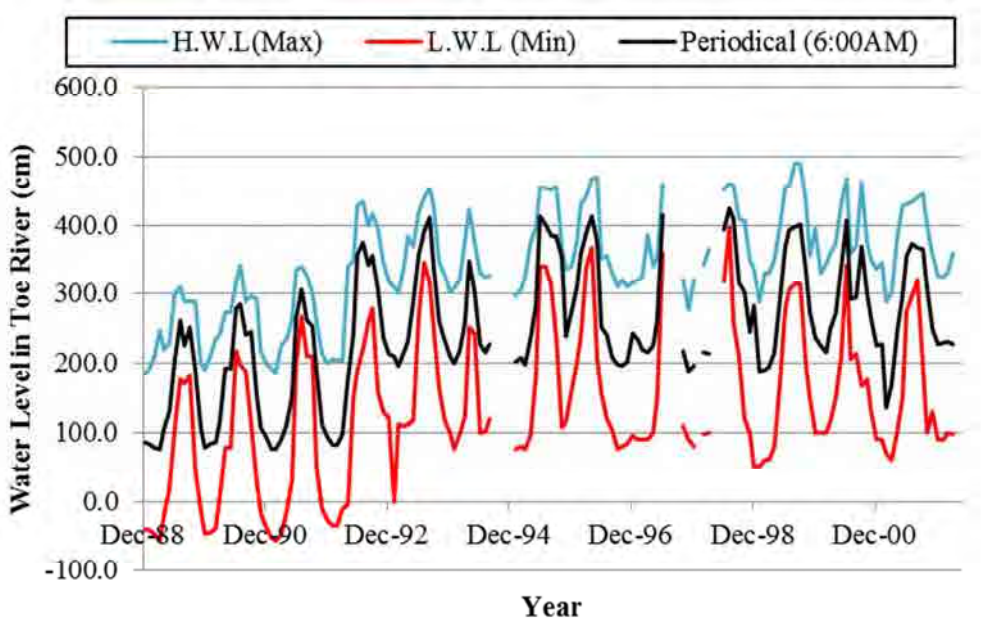


Source: Prepared by JICA study team based on the data of MOAI

Figure 2.12 Fluctuation of Monthly Flow Level at Pan Taing of the Kokkowa River (2008 to 2011)

3) Toe River

The river flow level at the Pann Hlaing monitoring station of the Toe River was monitored during January in 1989 and April in 2002 with data gap. The following figure shows monthly highest and lowest level and flow level at fixed time with 3.0 m to 4.5 m of the annual fluctuation of flow level.

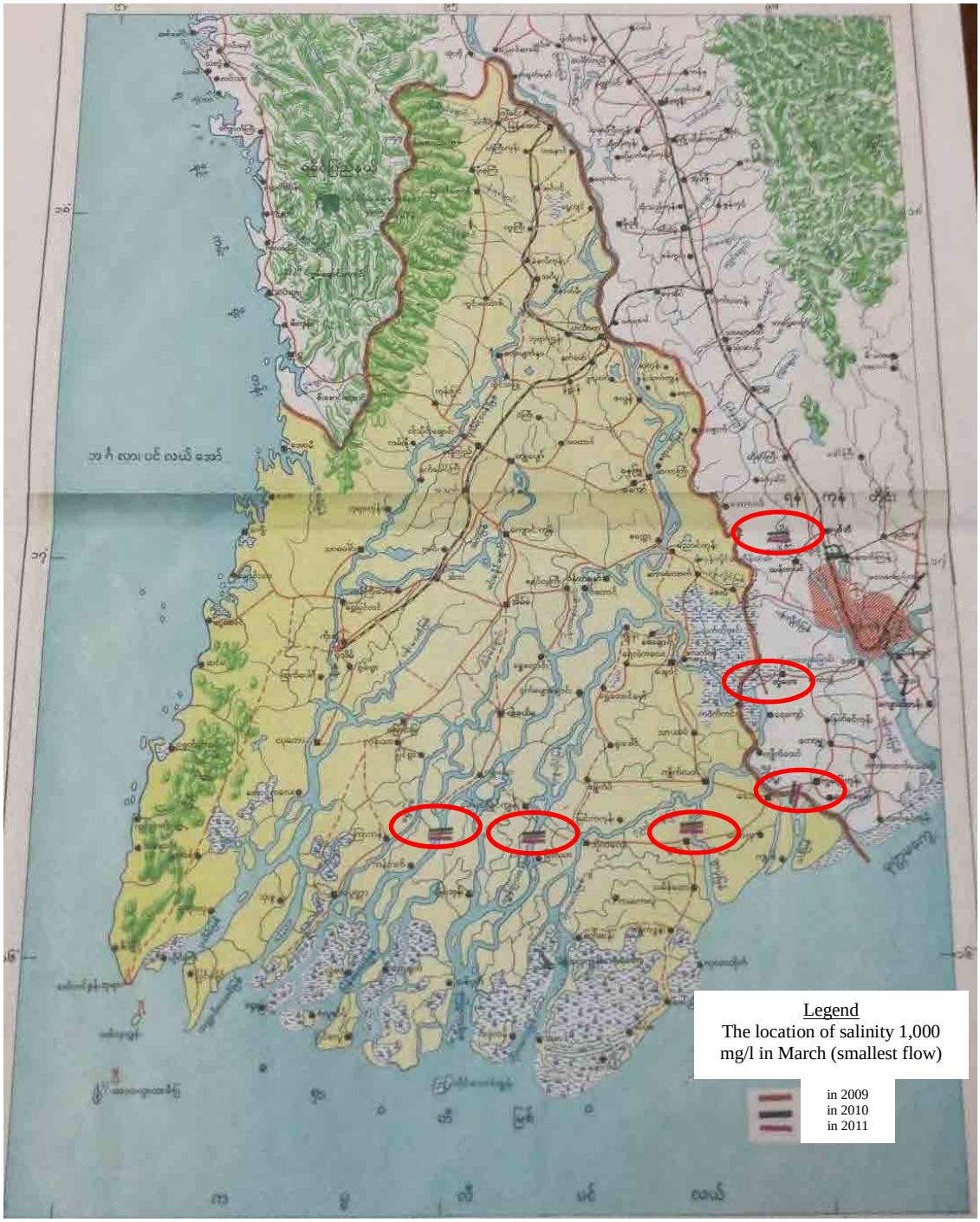


Source: Prepared by JICA study team based on the data of MOAI

Figure 2.13 Fluctuation of Monthly Flow Level at Pann Hlaing of the Toe River (1989 to 2002)

4) Salinity intrusion

The rivers mentioned are all tidal rivers. During dry season periods when the river flow is low, salt water intrusion occurs. Therefore, it is necessary to consider salt water intrusion when developing potential water source. As salt water intrusion is possible in the area of performance around Yangon, Figure 2.14 shows the salinity position having 1000 ppm concentration (circled in red) from 2009 to 2011.



Source: MOAI

Figure 2.14 Salt Water Intrusion in the Rivers Surrounding Yangon City

Table 2.8 shows available tidal information taken from the Myanmar Port Authority (MPA). From the Table, it shows that tidal observations have not been carried out since several years ago. The information is based on past observation records at Yangon Port (Sule Pagoda Wharf) and river mouth of Yangon River (Elephant point). In Yangon Port, 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 2.8 Tidal Information in Yangon Port

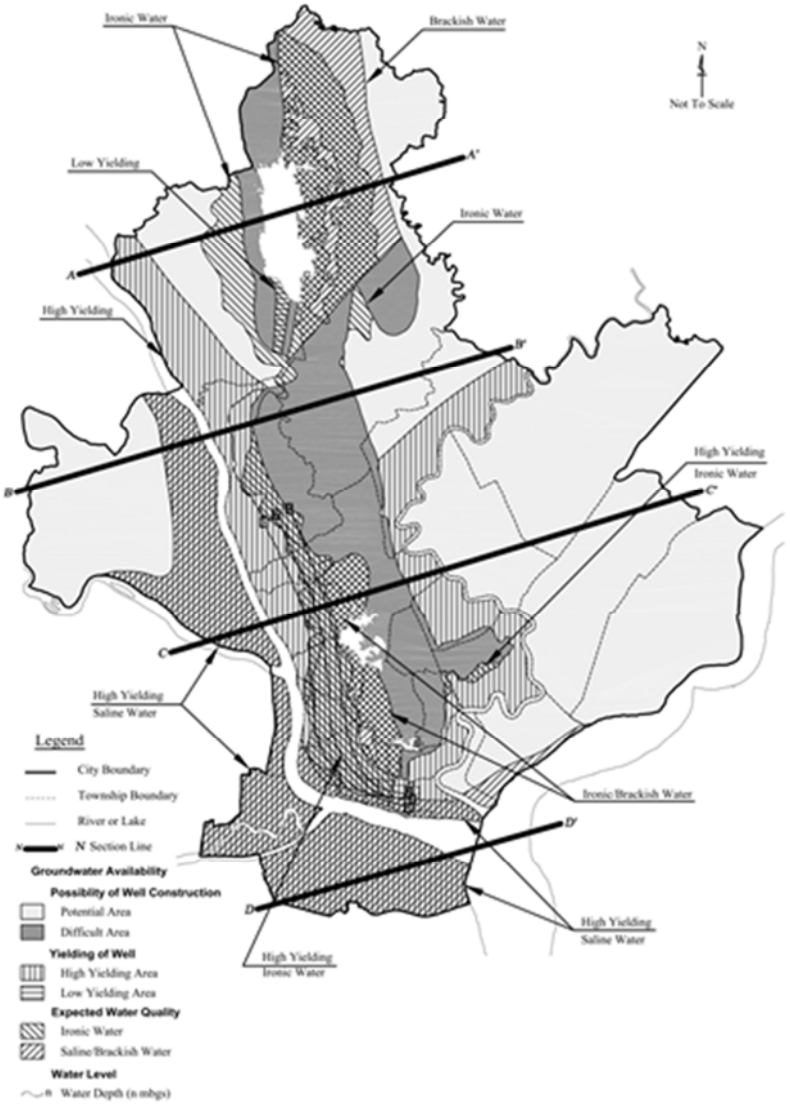
Items	Tidal Height (m)	Observed Dates
Highest High Water Level (HHWL)	+6.74	September 1899
Mean Water Level (MWL)	+3.121	Up to 1936
Lowest Low Water Level at Bo Aung Kyaw Street Wharf	-0.24	December 1902
Indian Spring Low Water Mark	+0.338	-

Source: MPA

(2) Hydrogeology

From the study on groundwater potential (refer to Figure below) in 2002 JICA-M/P, the followings are concluded;

- Groundwater potential is low in the central hilly areas.
- Iron contents might be high in groundwater in areas adjacent to hilly areas.
- Groundwater potential is high in the remaining low land areas.
- Groundwater potential is very high along the rivers.
- Salinity might be high in groundwater in CBD area.



Source: 2002 JICA-M/P

Figure 2.15 Groundwater Potential in Yangon City

2.3 Administrative Organization on Water, Sewerage and Drainage

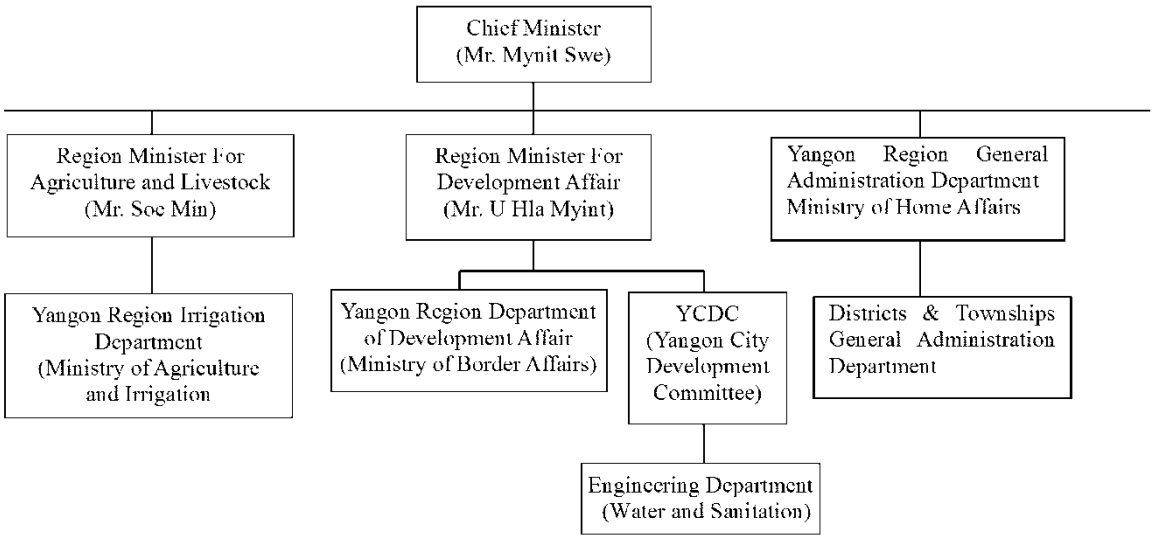
2.3.1 Yangon Region

Construction and operation/maintenance of irrigation canals and drainages are clearly defined in the Constitution as duties of the central and regional governments while the responsible agencies for construction of water supply, sewerage and urban drainage facilities is not explicitly defined under the Constitution. However, collection of water tax is defined as the regional government's responsibility. Department of Development Affairs in the regional government assumes the role of providing water supply systems. However, as a result of restructuring of the organizations in July 2012, responsible organization for water supply system has been transferred to the Department of Rural Development Affairs of the Ministry of Border Affairs. Then in 2013, the Department of Rural Development Affairs is transferred to Ministry of Livestock, Fisheries, and Rural Development from Ministry of Border

Affairs. So it is not clear to us whether the regional government still assumes water supply sector in Yangon region.

Among the 6 peripheral townships, there exist small-sized water supply systems in Thanlyin and Kyauktan townships. In addition, there is one small-sized water supply system for Thilawa Special Economic Zone (SEZ). There is no sewerage system in 6 peripheral townships.

YCDC act clearly defines that YCDC has responsibility of construction and operation/maintenance of water supply and sewerage systems.



Source: JICA Study Team

Figure 2.16 Water-Related Organization in Yangon Regional Government

2.3.2 Yangon City Development Committee

(1) Yangon City Development Committee

YCDC was established based on the "City of Yangon Development Act" aiming to foster development project in Yangon city independently. The law defined that YCDC is authorized to implement their own project by using their own funding resources. However, YCDC is not appropriately able to exercise their authority under current procedure, for instance, 1) YCDC needs to apply for permissions for implementation of projects to the central government, and 2) the funding sources of YCDC's activity are incorporated into the national budgetary system.

YCDC is responsible for water, sewerage and sanitation projects in 33 townships out of 45 townships of Yangon division. The law defines the role and the responsibility to establish policies, and to manage

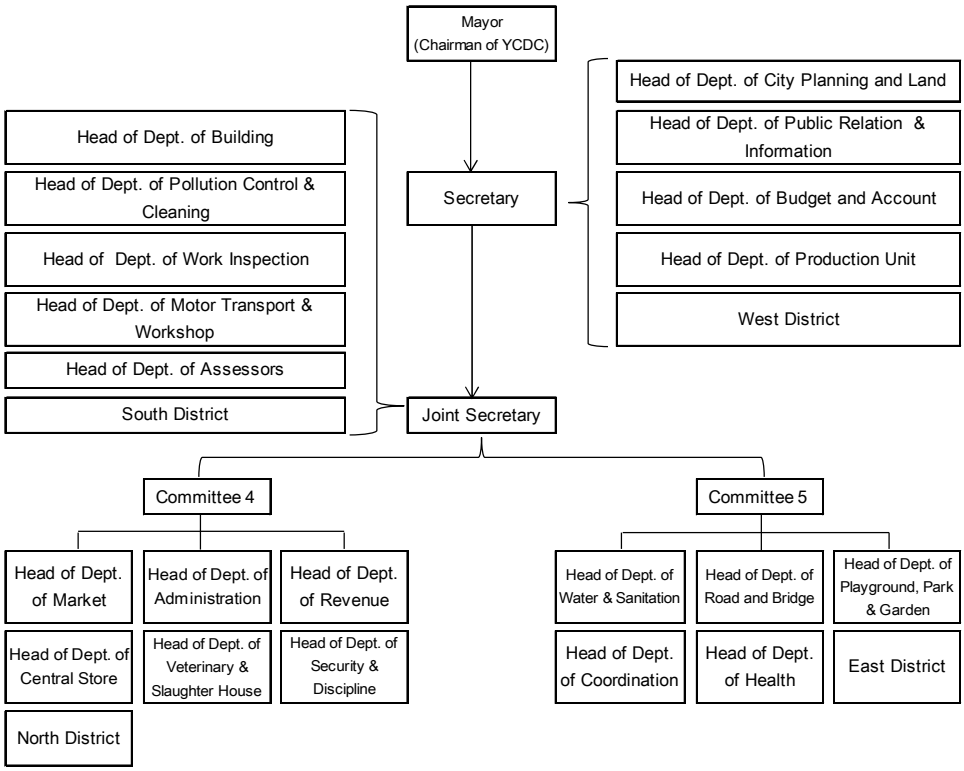
and implement them.

YCDC is headed by the mayor, and supported by the secretary and the joint-secretary under the mayor. The committee members consist of mayor, secretary, joint-secretary, and other 2 members (committee 4 and 5). 20 departments in YCDC belong to these committees.

Department of Engineering (Water Supply and Sanitation) (DEWS) is a central section to encompass water, sewerage and sanitation services in Yangon city. Water supply projects in 6 townships located out of Yangon city is handled by Department of Development Affairs (DDA), a part of regional government.

Meanwhile, storm water and drainage projects are under the responsibility of Department of Road and Bridge, water resource management for water supply, and water quality test and monitoring of quality test results are conducted by Department of Health and water quality monitoring section in Department of Engineering (Water Supply and Sanitation) respectively.

An organogram of overall YCDC is shown as follows.



Source：YCDC

Figure 2.17 Overall YCDC Organogram

(2) Department of Engineering (Water Supply and Sanitation)

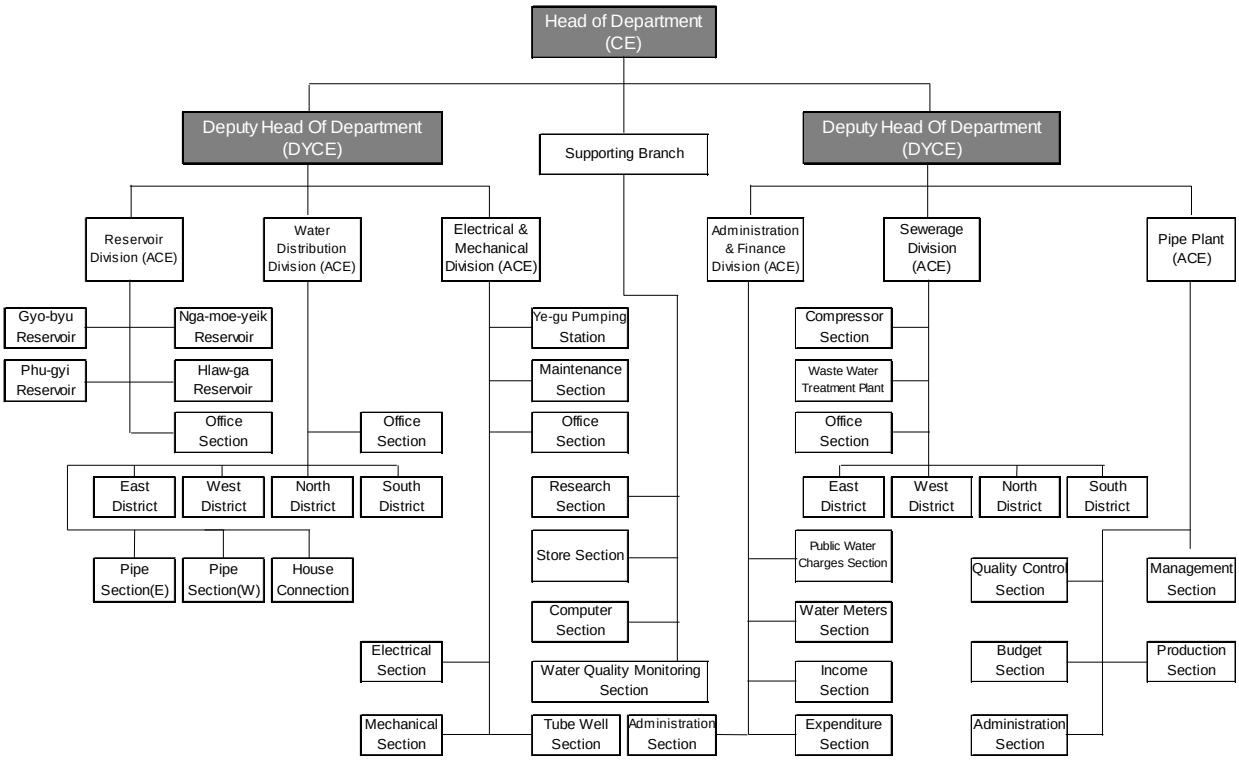
Engineering Department (Water Supply and Sanitation) consists of 6 divisions under the Head of Department and Deputy Head of Department : 1) Reservoir Division, 2) Water Distribution Division, 3) Electrical & Mechanical Division, 4) Finance & Administration Division, 5) Sewerage Division, 6) Pipe Plant Division.

Administrative support division including research section, store section, computer section, and water quality monitoring section is also organized. Total number of staff members is 2,171 as of January 2013.

The department is headed by Chief Engineer (CE), supported by two Deputy Chief Engineers (DYCE). In general Assistant Chief Engineers are allocated to the head of each division, and other officers such as Executive Engineers and Assistant Engineer (AE) exist. Those officers having a certain qualification, educational background, experiences take the central role of the organization.

Employment types are categorized into the following 5 types: (1) Officer, (2) Permanent, (3) Flat, (4) Daily Wages, (5) Work Authority. Most of engineers are allocated as officers. Employees of (1) – (3) who work on full-time basis share 59% of the total staff-members and the rest approximately 40% of the employees are contract-based employees on irregular-basis.

An organogram of DEWWS is shown as follows



Source：YCDC

Figure 2.18 YCDC DEWS Organogram

The role of each division and section of DEWS are shown below.

Table 2.9 Roles of Main Divisions/Sections of DEWS

Name of Division/ Section	Main Roles
Reservoir 485 employees (130 employees)	• Operation and management of the following four reservoirs and manufacturing and management of bottled water: - Gyobyu: Reservoir and pump station - Phugyi: Reservoir and pump station - Hlawga: Reservoir and pump station - Ngamoeyeik: Reservoir - Nyaunghnapin: WTP and P/S
Water Distribution Division 1,060 employees	• City of Yangon, including four districts of East, West, South, and North 32 township offices and the Head Office in the YCDC building - Receipt of applications for water supply construction/connection works - Collection of water charges - Repair of water leakage - Receipt of complaints from citizens
Electrical & Mechanical Division 86 employees	• Purification of ground water in South Dagon and Thaephyu and maintenance of water distribution facilities
Finance & Administrative Division	• Management of revenue in terms of water charges and expenditure and payment of wages - Collection of charges (US$) from government organizations and management of

Name of Division/ Section	Main Roles
215 employees	funds from foreign investors - Collection of water charges - Payment of wages to employees of Engineering Department (Water & Sanitation) - Management of revenue in the form of water charges and expenditure
Sewage Division 198 employees	• Maintenance and operation of sewer system in eight townships in the City of Yangon - Maintenance and management of public sewage pipes - Operation and management of sewage treatment plant - Operation and management of high pressure water distribution/discharge system (ejector station) - Operation and management of compressor station
Pipe Plant 136 employees	• Management of factory of pre-stressed concrete pipes - Manufacture and sale of concrete pipes of 16", 24", and 36" sizes (Sale route: Engineering Department (Water & Sanitation) of YCDC and Ministry of Agriculture and Irrigation)
Supporting Branch 13 employees	• Office that is directly controlled by the head of Engineering Department (Water & Sanitation) and supports operations of the above six divisions. - Cost analysis and drafting - Management of electronic data on pipe network, etc. - Water quality control - Storage of materials
Water Quality Monitoring Section	• Water quality monitoring for water supply service, particularly at the point of reservoir and water treatment plant. A laboratory for quality test is not owned. Water quality tests on 10 parameters are outsourced to the laboratory of Department of Health every month. The section monitors and manages the results of sampling test.

Source: Prepared by JICA study team based on the information of YCDC

(3) Department of Health

Department of Health was restructured and established in 1990. Main activity is prevention and control of infectious diseases. The details are: (1) Health education, (2) Disease Surveillance, (3) Prevention and Control measures, (4) Training, (5) Outbreak responses. Department of Health owns one laboratory for water quality test established by YCDC's funding sources in 1998. The Department has 225 employees, and approximately 15 employees out of them are working in the laboratory.

The laboratory conducts water quality tests of samples supplied by DEWWS and private sectors such as restaurants and factories etc., and on average in a month about 30-50 samples are analyzed. 17 parameters of WHO water quality standards can be tested in the laboratory.

Department of Health mentioned that the existing capacity of laboratory is likely not sufficient to handle quality test due to lack of human resource and financial budget if the number of samples increase in future.

2.3.3 Related Organizations

(1) Ministry of Agriculture and Irrigation (MOAI)

MOAI is restructured in 1996, renamed from Ministry of Agriculture to MOAI. It is mainly responsible for irrigation and agriculture development including water resource management. Under the acknowledgement that to secure irrigation water is crucial to enhance agricultural production, the activities of MOAI has focused on construction of new reservoirs and dams, rehabilitation for the reserved water amount, efficient utilization of groundwater, and so on. The Ministry has implemented projects mainly with the purposes such as storm water management, hydropower development, irrigation, dam construction, and water supply for township.

The rights of many water resource surrounding Yangon city, such as Ngamoeyeik dam and Lagunbyin dam, that are /or expected to be water resources of YCDC, are owned by MOAI. Current situation is that YCDC partially receives these water resources from MOAI and supply the treated water.

The main roles of irrigation department are O&M of irrigation project, and construction of irrigation facilities etc. Hydrological branch is responsible for monitoring of river stream flow and river level, and managing the monitored data. While, the activities of Water Resource Utilization Department (WRUD) focus on groundwater development by using machinery equipment like pump and supply water not only for irrigation but also for domestic purpose as a part of the project.

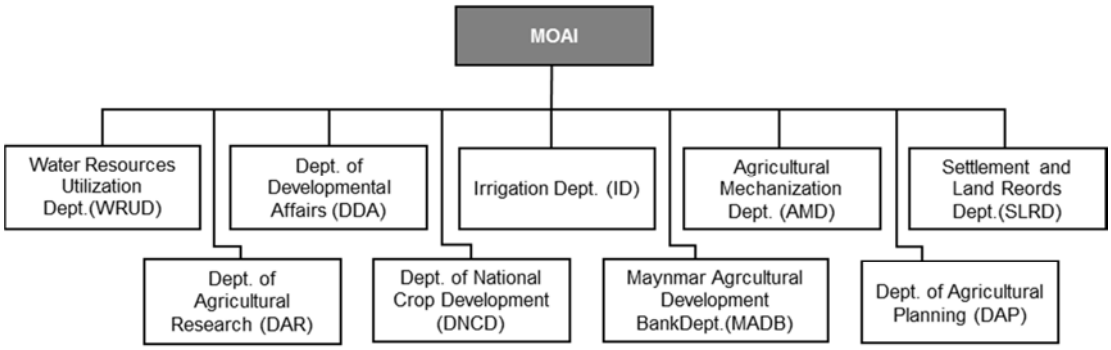
Activities of main departments of MOAI are shown below.

Table 2.10 Main Department Activities of MOAI

Department		Main Activities
Irrigation Department (ID)	Activity :	O&M of Irrigation project using surface water resources, new project for construction, research, design, and implementation. O&M of large scale facilities such as main dams, weirs, and main canals.
	Section :	(1) Head office, (2) Research Division, (3) Operation and Maintenance Division, (4) Mechanical Division, (5) Construction Division
	No. of Employees :	20,367 persons
Water Resource Utilization Department (WRUD)	Activity :	Irrigation and rural development by groundwater and river sources using pumping machines, Development and promotion of sprinkler
	Section :	(1) Planning Division, (2) Groundwater Division, (3) Pump Division, (4) Gravity Flow and Civil Work Division, (5) Production and Procurement Division, (6) Administration Division
	No. of Employees :	1,778 persons

Source: Prepared by JICA study team based on the information of MOAI

An organogram of MOAI is shown as follows.



Source: Prepared by JICA study team based on the information of MOAI

Figure 2.19 MOAI Organogram

2.4 Legal System on Water, Sewerage and Drainage

2.4.1 Legal System in Myanmar

Myanmar was treated as a state of British India until 1932 and its legal system was based on the Burma Code, which derived from the English law. However some amendatory laws have been prepared progressively after transition of civilian government, because some of the constitution is not in use under current environment.

The new Constitution of the Republic of the Union of Myanmar came into force in January 2011 and consists of 15 Chapters and 457 Articles. The constitution adopts a multi-party democracy under the presidential system and declares formal commitment to justice, freedom, equality, and the maintenance and development of peace and prosperity for the people. However, it also states that the military can play a leading role in politics.

It includes many notable provisions related to the protection of citizens' rights, such as those barring the nationalization of private companies and guaranteeing freedom of business and employment.
In addition, it establishes a system whereby the military can resume power in the state of emergency.

2.4.2 Laws Related to Water and Sewerage in the City of Yangon

(1) City of Yangon Development Law

"Chapter III Duties and Responsibilities of the Committee" of "the City of Yangon Development Law" clearly stipulates the businesses supervised by the YCDC including:

- Carrying out works for water supply;
- Construction of reservoirs and pipelines and maintenance thereof;

- Carrying out works for sanitation; and
- Carrying out works for public health.

On the other hand, Article 9 of Chapter IV "Powers of the Committee" sets forth the following provision that serves as grounds for exercise of autonomy by the YCDC:

- Demarcation and re-demarcation of the territorial limit;
- Right to operate works independently with funds owned by the Committee;
- Right to use foreign currency for development works; and
- Right to carry out works contributing to city development by making contacts with local and foreign organizations and with local and foreign individuals.

However, this study considers that most of Article 9 has lost its substance. The business activities of YCDC shall be voluntarily performed pursuant to the City of Yangon Development Law; however, the YCDC currently prepares plans and estimates for each business and applies to the provincial government for permission. Particularly with respect to the budget necessary for the performance of a business, YCDC actually seems to be forced to perform the business based on the permission of the provincial government under the budgetary system of the federal government as of April 2011.
Amendment and development of the legal system is considered to be urgently required in light of future prospects, including consistency between the City of Yangon Development Law and the relevant legal system.

(2) Rules on Water Supply and Sanitation (Notification No.6/99)

The YCDC established the Rules on Water Supply and Sanitation, conferred by Section 33(a) of the "The City of Yangon Development Law", with the approval of the Chairperson of the State Peace and Development Council. The Rules for water and sanitation are proclaimed by the Notification No.6/99.
In the Rules, the YCDC's role and the responsibilities on water and sanitation are described. Main relevant chapter and clause are shown below.

Rules on Water Supply, conferred by Section 33 in "The City of Yangon Development Law"
（Notification No.6/99）

CHAPTER II　WATERWORKS

3. The Committee shall manage to distribute sufficient drinking water to the inhabitants within the city limits.
4. The Committee may carry out the following works within the city and outside:-
    a) For the purpose of water distribution in the city, the Committee may build and establish necessary water tanks, artesian or tube- wells, pipelines or water works.
    For the purpose of water distribution, the Committee may purchase or lease land, equipment and machinery from its owners.
5. The Committee may acquire water resources, and carry out water works, by means of contract, auction or by tender, under prescribed rules.
11. The Committee:-
    a) Shall permit only licensed plumbers to work on water connections for the consumer.
    b) May check and examine any plumber who is carrying out water connection works.
12. The Committee may enter any premises, with the accompaniment of two ward elders, to inspect water works.
15. The owner of the building or the consumer shall protect the water pipes and appliances, attached thereto. If any damage occurs, he shall repair, as instructed.
16. Whoever is desirous to do the following, shall apply to the Committee for permission.
    a) To make direct water connection, from the Committee's main water pipeline, into his own premises.
    b) To make extensions from the Committee's water pipeline.
    c) To get more water, by pumping from the Committee's water pipeline, by means of electricity or other power or energy, or by manual methods.
    To replace the original water and sanitary materials, with better ones or make extensions.
21. Before the Committee confirms and prescribes the national drinking water standard, it shall use the drinking water standard of the World Health Organization, as prescribed from time to time.
22. The Committee may:-
    a) Collect charges for water consumption from the consumers.
    b) Sell water at a certain price.

（Source：YCDC DEWWS）

Rules on Sanitation, conferred by Section 33 in "The City of Yangon Development Law" (Notification No.6/1999)

24. The Committee may do the following, in or outside the city, in consultation with the government departments and organization respectively.
    a) Manage and operate sewage system and sanitary work.
    b) Purchase or lease buildings, lands, or machinery, for the purpose of operating sewage system.
    Give permission to others, to operate sewage system, with prescribed terms and conditions.
25. The Committee may:-
    a) Give permission to the owner or the occupier, to construct his own sewerage system, after proper scrutinization.
    b) Manage and determine the sewerage system of the building, where more than 250 people are residing or the building, which is determined by the Committee, as a residential premise, in which a large number of people are occupying.
    Where there is no sewerage system, the Committee may determine only the treated sewage, to be disposed of in the specified canals, rivers, creeks, lakes, ponds, or tanks, indirectly.
    Determine the standard of the treated sewage.

    e) Allow whoever is desirous to dispose of treated sewage under sub-rule (c) to apply to the Committee. If the Committee considers it to be in conformity with the prescribed standards and conditions, permission may be given.
    Allow the sewage from the building to be disposed of, in the sewerage system of the Committee, on payment of service charges.
26. The Committee may collect prescribed fees or charges, from the owner, or occupier, of the building, situated within or outside the city, for the disposal of sewage.
28. The Committee may determine what sewerage system, and sewer pipe lines are to be used in different regions of the city.
32. The Committee may direct the owner or the occupier of the building to reconstruct, repair or change and amend the cesspool or cesspit or sewerage system, if it is not in conformity with the prescribed standards and conditions.

(Source : YCDC DEWWS)

2.4.3 Comparison of Legal and Institutional System between Myanmar and Japan

Comparison of current legal and institutional system related to water supply and sewerage service between Myanmar and Japan is shown below. City water supply systems are limited to large urban cities such as Yangon and Mandalay so that the central government's role is limited to only budget allocation with no water related laws, regulations and technical guidance.

Japan	Myanmar
Local Public Enterprise Act The purpose is to set forth the organization and financial affairs of companies owned by local government (water utility, industrial water utility, electricity utility, and gas utility) and the treatment of employees engaged in such businesses, other fundamental management standards, and special provisions on procedures related to management of such companies, thereby contributing to the development of local autonomy. The principle is to always stress the economic nature of the company and enhance public welfare, which is the original purpose of the enterprise overall.	**No applicable law** ◆ To secure capital for water supply, review is required on the water utility as independent companies.
Ordinance for Enforcement of the Local Public Enterprise Act	**No applicable law**
Order for Enforcement of the Local Public Enterprise Act Stipulates detailed rules for implementation of the Local Public Enterprise Act.	**No applicable law**
Waterworks Act The purpose is to construct and properly manage water supply systems, develop them in a planned manner, protect and develop the water utility, and thereby supply abundant and inexpensive water and contribute to the improvement of public hygiene and the environment. The Act stipulates, depending on the type of water utilities and population supplied, definitions of water utility, small water utility, water wholesale, private water supply, and private water supply facilities, as well as requirements for a permit to operate each water utility.	**No applicable law** ◆ Consideration should be given to definition of waterworks, water utility and business, and responsibility of the establisher of water supply facility.
Chapter 1 General Provisions Article 1 Purpose of this Act Article 4 Water Quality Standards Article 5 Facility Standards Chapter 2 Water Utility Section 1 Permit, etc. for Business Article 6 Permit for Business and Management Body Article 8 Standards for Permit Article 12 Supervision of Construction Work by Engineer Article 13 Notification before Commencement of Supply and Inspection"	◆ Preparation of Myanmar's water quality standards is in progress. WHO standards are currently applied to the national standards. ◆ Similar law: Yangon City Development Law (YCDL)
Section 2 Inspection Article 14 Rules on Supply Article 15 Obligation to Supply Water Article 16 Structure and Materials of Water Supply Equipment Article 16-2 Work on Water Supply Equipment Article 17 Inspection of Water Supply Equipment	◆ Similar law: Rules for YCDL, Notification No.6/1999 ◆ Similar law: Rules for YCDL, Notification No.6/1999 ◆ Similar law: Rules for YCDL, Notification No.6/1999

Japan	Myanmar
Article 19 Technical Administrator of Waterworks Article 20 Water Quality Inspection	◆ Similar law: Rules for YCDL, Notification No.6/1999
Section 3 Designated Plumbing Contractor	◆ Similar law: Rules for YCDL, Notification No.6/1999
Article 25-2 Application for Designation Article 25-3 Standards of Designation Article 25-4 Designated Water Supply Installation Chief Engineer	◆ Similar law: Rules for YCDL, Notification No.6/1999
Chapter 3 Water Wholesale Article 26 Permit for Business Article 20 Standards for Permit	
Chapter 4 Private Water Supply Chapter 4-2 Private Water Supply Facilities Article 34-3 Obligation to Inspect	◆ When hotels and other large buildings install water supply facilities using their own water source (well), it is necessary to mandate the selection and allocation of engineers to monitor the independent water supply facility.
Order for Enforcement of the Waterworks Act	**No applicable law**
Ordinance for Enforcement of the Waterworks Act	**No applicable law**
Water Supply Ordinance of Municipal City Section 2 "Operations" of Chapter 2 of the Waterworks Act, which states that the water supplier must stipulate the water supply rules on charges, payment of the cost of water supply installation and other conditions of supply. Each city sets forth the detailed rules necessary at the time of water supply for persons in need of water supply in the relevant area.	**Similar law: Rules for YCDL, Notification No.6/1999** ◆ In order to supply safe water to citizens, consideration should be given to water charges and to construction method, rules on inspection and construction standards for contractors.
Sewerage Act The purpose is to set forth basic policies on the development of public and city sewer systems, matters concerning allocation, structure, and performance of fundamental facilities, and quality standards for discharged water, and thereby contribute to public hygiene and maintain the quality of public water.	**No applicable law** ◆ Urgent consideration should be given to definition of sewer business and the business operator, basic concept of sewer, rules on the maintenance of public sewer, establishment of preventing facilities for treatment obstacles, and rules on quality of sewage, etc.
Order for Enforcement of the Sewerage Act	**No applicable law**
Sewerage Ordinance of Each City With respect to drainage facilities connected with public sewers, each city sets forth definitions of terms, methods of connection with drainage facilities, designation of the contractor performing works on drainage facilities, rules on engineers performing work on drainage facilities, and collection of sewer charges paid for the volume of sewage.	**No applicable law** ◆ It is necessary to develop laws concerning the collection of sewer charges from drainage facilities established by citizens under the principle that the person who benefited must pay, notification associated with the installation of drainage facilities, method of treatment depending on classification of water such as

Japan	Myanmar
	rain, household wastewater, and sewage, and actual drainage facilities in the city center and the place of discharge.

Source: JICA Study Team

2.4.4 Public Private Participation (PPP) and Private Finance Initiative (PFI) Related Laws

(1) Development of Legal System for Implementation of PPP Business

In Myanmar, the PPP business sector will become more energized by the participation of private companies in the improvement of water and sewerage systems and the development of infrastructure directly affecting the people's livelihoods, but for the moment it seems that only temporary measures can be taken in response to the occurrence of problems, despite the existence of the Partnership Act of 1914.

In addition to the recent global financial crisis, the stability and reliability of the country's business environment does not measure up to other developing countries in Asia, and it is necessary to develop the economic and legal environment; this is especially so in regard to areas such as guarantees when foreign capital is provided and provision of support so as to enable international investors and financial institutions to finance long-term business as soon as possible.

Against this background, Myanmar revised the Foreign Investment Law in November 2012, assuming future investment from foreign countries. Further improvement is expected with respect to the situation of the Myanmar Investment Commission (MIC) that may considerably affect the foreign capital investment rate and the transparency of the decision-making process.

It is recognized that PPP in water and sewerage sector generate merits in the aspects of efficiency and profitability. Meanwhile, some challenges and failures of PPP projects are gradually emerged. The World Bank reported that there are no outstanding differences between private water supply service and public water supply service in the viewpoint of efficiency, in their review on PPP in water sector in the Asia region.

It is natural that private entities pursuit efficiency and profitability in their business in certain extent, it is pointed out from past lessons learnt that the original purpose which provides safe water to citizens with reasonable price is obscured if their activities exceed the level. Sufficient management capability to control such private provider's behavior is required for public side.

International Monetary Fund (IMF) suggested requisites for succeeding PPP in developing countries, as shown below for reference.

- Project management capability of public side is sufficiently matured
- Regulatory and institutional environment on PPP is sufficiently developed
- Financial market for making funding sources is matured
- Beneficiary-pay environment is matured and widely penetrated
- Sufficient water resources for project exist

(2) Trend of PPP

1) PPP Trend in Water and Sewerage Sector in East and Southeast Asia, South Asia Regions

Only one PPP projects as a management contract has been implemented in water and sewerage sector in low income countries according to the PPAIF database, so the number of projects is very limited. Meanwhile, PPP projects in water sewerage sector in low-middle developing countries account for 33 projects. It can be seen that the number of PPP projects increase as the income level of countries goes up. Particularly, concession types of contract such as Build, Rehabilitation, Operate, Transfer (BROT) and Build, Operate, Transfer (BOT) are relatively dominant cases.

Main results of water and sewerage PPP projects in East Asia and Southeast Asia, and South Asia is shown in the following Table.

Table 2.11 Contractual Types for PPP and Matrix Table

Income level/ Region	Management Contract	Lease Contract	Concession Contract			BOT, BOO Concession		Asset Sales	Total
			BROT	ROT	RLT	BOT	BOO		
Low income countries									*1*
East/ Southeast Asia									0
South Asia	1								1
Low and Middle income countries									*33*
East/ Southeast Asia		1	10	3		5	1		20
South Asia	5		2	1	1	4			13
Total	6	1	12	4	1	9	1	0	34

Source：World Bank PPAIF Database
[Note] BROT –- Build, Rehabilitate, Operate and Transfer, ROT -- Rehabilitate, Operate and Transfer
RLT -- Rehabilitate, Lease and Transfer, BOT -- Build, Operate and Transfer
BOO -- Build, Own and Operate

2) Overall Trend of PPP Projects

In Myanmar, PPP projects can be seen in energy and transportation sectors; however the number of projects is limited and have low tone in overall. According to PPIAF database operated by the world bank, the first PPP project was launched in energy sector in 1995, 5 PPP projects up to 2012 accounted for 1,325 US$ were held. New construction projects such as BOT type contracts share all. Recently, one notification of the New Hanthawaddy airport development project for bidding was publicized by

the central government.

Possibility of financing using the PPP framework and project implementation is expected to increase in general under the severe financial and budgetary circumstance of the central government in Myanmar. While, currently regulatory and institutional arrangement for PPP in Myanmar is not sufficiently established, thereby the attractive project merits and contents of the project contract could be crucial factors for private sector side. In addition, it is necessary for public sector to make regulatory and institutional environment mature through experiences learnt from trial and error of PPP projects.

2.5 Budgetary System for Water Supply, Sewerage and Drainage

2.5.1 Budgetary Situation on Water Supply, Sewerage and Drainage

All revenue income collected is credited to the account of regional government and the central government. All revenue income including waterworks sales used to be incorporated into the account of YCDC, however that system has been transformed to the current system since October 2011.

After YCDC prepares and applies the budget estimates for a new fiscal year, the actual expenditure against the approved amount is paid to YCDC through the regional government. Thus it seems to be a structural challenge for YCDC that YCDC has a very limited authority to determine how the revenue income is used flexibly.

2.5.2 Budgetary Situation of the Regional Government

The fiscal account for the period 1st April to 31st March is settled every year. Although the detail information on budgetary situation of the regional government is not yet obtained, it is confirmed by the JICA Study team for Strategic Urban Development Plan that the Yangon Region Government received an allocation of more than Kyat 15.6 billion from the Union Government to cover expenses in the second half of the 2011-2012 fiscal years under the Yangon Region Government and is thought to be running in deficits. Financial deficit situation of approximately 5 billion Kyat is reported. 20 out of 25 departments working under the Yangon Region Government were thought to be running in deficits.

2.5.3 Budgetary Situation of YCDC

(1) Budgetary Situation of YCDC and the Trend

The revenue income of YCDC is largely relied on the property tax consisting of general tax and environmental tax etc. The main financial source of the property tax is particularly the income from condominium, hotel, market, golf club, vehicle tax.

Meanwhile, 20 departments of YCDC including water and sanitation department are not authorized to determine by themselves how revenue income is used. Also they have no authority to decide the capital expenditure such as construction investment, it is necessary to get the approval from the executive committee.

(2) Budget Allocation of YCDC and Income Flow

The budgetary flow of YCDC from application to approval can be listed as follows: (1) 20 departments prepare budget estimates and submit to the mayor, (2) The Yangon city mayor submits the proposal application to the chief minister of the regional government. The chief minister of the regional government discussed with the regional offices of the Ministry of Finance and Revenue. A negotiation between the Yangon city mayor, 7 committee members, the department of budget and revenue is held, and the budget is determined and approved.

Revenue collection of water tariff is shown as follows: (1) In case of cash collection, water tariff is collected every day by meter readers and recorded in the record book by township officers, (2) then, the cash is transmitted to the account of the department of budget and accounting and is incorporated into the general account of the YCDC revenue, (3) the collected cash is transmitted to the account of the regional government, (4) in case of bank remittance, a remittance procedure of the collected amount is taken from township offices to YCDC, and from YCDC to the regional government.

2.6 Existing Environmental Framework

2.6.1 Policy, Laws and Regulations Related to Environmental and Social Considerations

Before the establishment of the Law on Environment Conservation Law in April 2012, the country did not have a law, administrative organization and environmental standards concerning to environmental protection. Laws on environment protection have been established independently in each industrial sector and these laws were regarded to have functions of environmental protection law. However, these laws have been established separately and independently in each sector, they are not enough to control environmental impacts taking whole picture of the impacts into consideration.

The recent formation of the Ministry of Environmental Conservation and Forestry demonstrates the government's commitment to improving the planning and management of natural resources and the environment. The 2012 Environment Conservation Law provides the legal basis for implementing a range of enhanced environmental management measures. Now drafting corresponding regulations to enact the Law including EIA law and pollution control standards such as air emission and water effluent is in progress.

The policies and major environment related laws are described below.

(1) National Environment Policy 1994

The Government of Myanmar adopted National Environment Policy in 1994 to establish sound environmental policies in the utilization of water, land, forests, mineral, marine resources and other natural resources in order to conserve the environment and prevent its degradation.

- "The wealth of a nation is its people, its cultural heritage, its environment and its natural resources. The objective of Myanmar's environment policy is aimed at achieving harmony and balance between these through the integration of environmental considerations into the development process to enhance the quality of the life of all its citizens. Every nation has the sovereign right to utilize its natural resources in accordance with its environmental policies; but great care must be taken not to exceed its jurisdiction or infringe upon the interest of other nations. It is the responsibility of the State and every citizen to preserve its natural resources in the interest of present and future generations. Environmental protection should always be the primary objective in seeking development".

(2) Myanmar Agenda 21

The development of the environmental policy was followed by the "Myanmar Agenda 21" in 1997, which follows a UN framework for a multi-pronged approach to sustainable development. Myanmar Agenda 21 calls for integrated management of natural resource and provides a blueprint for achieving sustainable development. Myanmar Agenda 21 seeks to achieve four main objectives:

- To provide a forum and context for the debate on sustainable development and the articulation of a collective vision for the future,
- To provide a framework for negotiation, mediation and consensus building in the country to achieve development with due regard to the environment, to focus the entire country on a common set of priority issues,
- To provide a strategy and implementation plans for the changing and strengthening of values, knowledge, technologies and institutions with respect to environmental protection and development, and
- To provide the impetus and the framework for the development of organizational capacities and institutions required for sustainable development.

Myanmar Agenda 21 contains programs and activities that will promote environmental protection and prevent environmental degradation. These programs are social, economic, institutional and infrastructural strengthening programs as well as environmental protection and conservation programs that will put the country onto the sustainable development path.

(3) Constitution of the Republic of the Union of Myanmar (2008)

New Constitution of the Republic of the Union of Myanmar 2008 was ratified. Under the Constitution, "The Union shall protect and conserve the natural environment" (Chapter 1, Article 45). The Assembly of Union shall have the right to enact laws for the entire or any part of the Union related to matters pertaining to protection of the environment (Chapter 4, Article 96). In addition, every citizen has the duty to assist the Union in carrying out the preservation and safeguarding of cultural heritage, and environmental conservation. Regarding the land, 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 the Union shall permit citizens right of private property, right of inheritance, right of private initiative and patent in accord with the law (Chapter 1, Article 37).

(4) National Sustainable Development Strategy (NSDS) 2009

The National Sustainable Development Strategy (NSDS) is part of a broader program of the UN Sustainable Development Commission set up after the World Summit on Sustainable Development in 2002. There are three goals in NSDS including sustainable management of natural resources, integrated economic development and sustainable social development. Specific strategies are outlined under each goal. To achieve the goal of sustainable management of natural resources, strategies for forest resource management, sustainable energy production and consumption, biodiversity conservation, sustainable freshwater resources management, sustainable management of land resources, sustainable management for mineral resource utilization and others are proposed. As the NSDS was officially accepted by the Ministry of Planning, it is a guiding document for government ministries, departments and local authorities and international and local NGOs for sustainable development.

(5) Environment Conservation Law 2012

Environment Conservation Law of Union of Myanmar was promulgated on 30th March 2012. The objectives of this Law are as follows:

- For implementation of Myanmar National Environment Policy,
- Adoption of basic principles and give guidelines so as to formulate systematic integration of environment conservation tasks for continuous development program,
- To develop good and clean environment for the benefit of present and future generations and conservation of nature and cultural heritage,

- To reveal and discover ecological systems which are starting to fall under oblivion,
- To take measures for prevention of decrease and loss of natural resources and making use of them beneficially and continuously,
- For implementation of propagating environment conservation consciousness and attracting more cooperation of the public, imperative education and teaching programs to be adopted,
- To increase international and country wide cooperation in environment conservation tasks,
- For achieving cooperation among government departments, international organizations, Non-governmental Organizations and private individuals.

This Law stipulates the establishment and roles of Environment Conservation Committee (ECC) and Ministry of Environment Conservation and Forestry (MOECAF). See more detail in chapter below. In this Law, descriptions related to system of environmental impact assessment (EIA) for development projects and strategic environmental assessment (SEA) is not included.

(6) Laws regarding Land

This British era act, Land Acquisition Act 1894 is still referred to at present due to the lack of any new legislation on the theme. The Act empowers the state to acquire land where it is needed for any public purpose. The Act provides for the relevant procedures, including the required notice to be given, procedures for objections to acquisition, the method of valuation of land, the process for taking possession of land, court processes and appeals, procedures for the temporary occupation of land and the acquisition of land for corporations. There are several laws related to the land, however it is not clear which law is still effective.

- The Land and Revenue Act (1879)
- The Transfer of Property Act (1882)
- The Rangoon Development Trust Act (1922)
- The Transfer of Immovable Property Restriction Act (1987)
- The Law Amending the Transfer of Immovable Property Restriction Act (2005)
- Procedures conferring the Right to Cultivate Land / The Right to Utilize Land (1991)

The classification of land type is made in the Guidance Note on Land Issues Myanmar published by UN-HABITAT and UNHCR.

- Freehold Land
- Grand Land
- Agricultural Land
- Garden Land
- Grazing Land
- Cultivable Land, Fallow Land and Waste Land
- Forest Land

- Town Land
- Village Land
- Cantonments
- Monastery

The Farmland Law (No. 11/2012) is enacted in 2012 and the definitions about farmland, farmer and right to use the farmland are established. The contents cover the procedures to obtain the permission to use the farmland, right of the person who has the right to use the farmland, terms and conditions to be complied by the person who has the right to use the farmland, action for the failure to comply terms and conditions, settlement of dispute on the right to use the farmland and appeal, duties and powers of the administrative body of the farmland. In the case of the land confiscation for interests of the State or the public interests, it is stipulated that the compensation will be paid to the person who has the ownership right to use the farmland but no detail is provided about the compensation policy or compensation calculation method. Based on the Farmland Law, the Farmland Rules is enacted on 31 August 2012 and the detail procedures from the application of the right to use to approval, and transfer / inheritance are described.

(7) Other related laws

There are several other environmental related laws in Myanmar.

- Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law, 1994
- Protection and the Preservation of Cultural Heritage Region Law, 1998
- The Conservation of Water Resources and Rivers Law 2006
- Forestry Law 1992
- Public Health Law

2.6.2 Administrative Framework on Environmental and Social Considerations

(1) National Commission for Environmental Affairs (NCEA)

In 1990, NCEA was established to advise the government on environmental policy, to act as a focal point and as a coordinating body for environmental affairs and to promote environmentally sound and sustainable development. Until 2005, the Minister of Foreign Affairs was the chair of NCEA which was a strong indication that the Myanmar Government created the NCEA merely as a tool to win international approval. In 2005, the NCEA was transferred under the Ministry of Forestry. The NCEA's main mission is to ensure sustainable use of environmental resources and to promote environmentally sound practices in industry and other economic activities, objectives and mandates.

The roles and function of NCEA are not defined in the Environment Conservation Law 2012 which is recently enacted and the functions of NCEA seem to be taken over by MOECAF and NCEA might be dissolved.

(2) Environment Conservation Committee (ECC)

The Environment Conservation Law enumerates that the Union Government shall organize Environment Conservation Committee (ECC), assigning Union Minister for the Ministry of Union as the Chairman of the Committee which shall constitute suitable members. ECC shall hold the following authoritative rights:

- Make educative organizing activities and movements on environmental conservation,
- Give advice on making required amendments in school lessons on environmental conservation after making coordination with concerned governmental departments,
- Receive donation funds, cash support, materials and technical assistance and administer these funds, materials and technologies for applying in environmental tasks,
- Give appropriate advice on environmental conservation to concerned government departments and organization and exhort them in implementing the task,
- Request proposals and advice on promoting environmental conservation from concerned governmental department and organizations,
- Forbid concerned government departments and organizations that could damage the environment and if necessary, submit the matter to the Union Government requesting its attitude and policy on the condition,
- Adopt Myanmar National Environment Policies and other related policies in conservation of environment with the approval of the Union government.

(3) Ministry of Environment Conservation and Forestry (MOECAF)

In the Environment Conservation Law 2012, the obligations and authoritative right of MOECAF are stipulated. The ministry has a broad responsibility:

- To implement the policies on environment conservation,
- To plan the environmental management both at the national and regional level,
- To plan, implement and monitor environmental conservation and promotion, and to prevent, control and reduce environmental pollution,
- To pave the way for sustainable development.

In order to do this, the Ministry has the power to create “guidelines for environmental administration, conservation and promotion in different sectors which include ozone layer protection, the conservation of biodiversity, marine coastal conservation, the effort to reduce and balance global warming and climate change, the fight against the increase of desert and waste management”. In particular, the Ministry can:

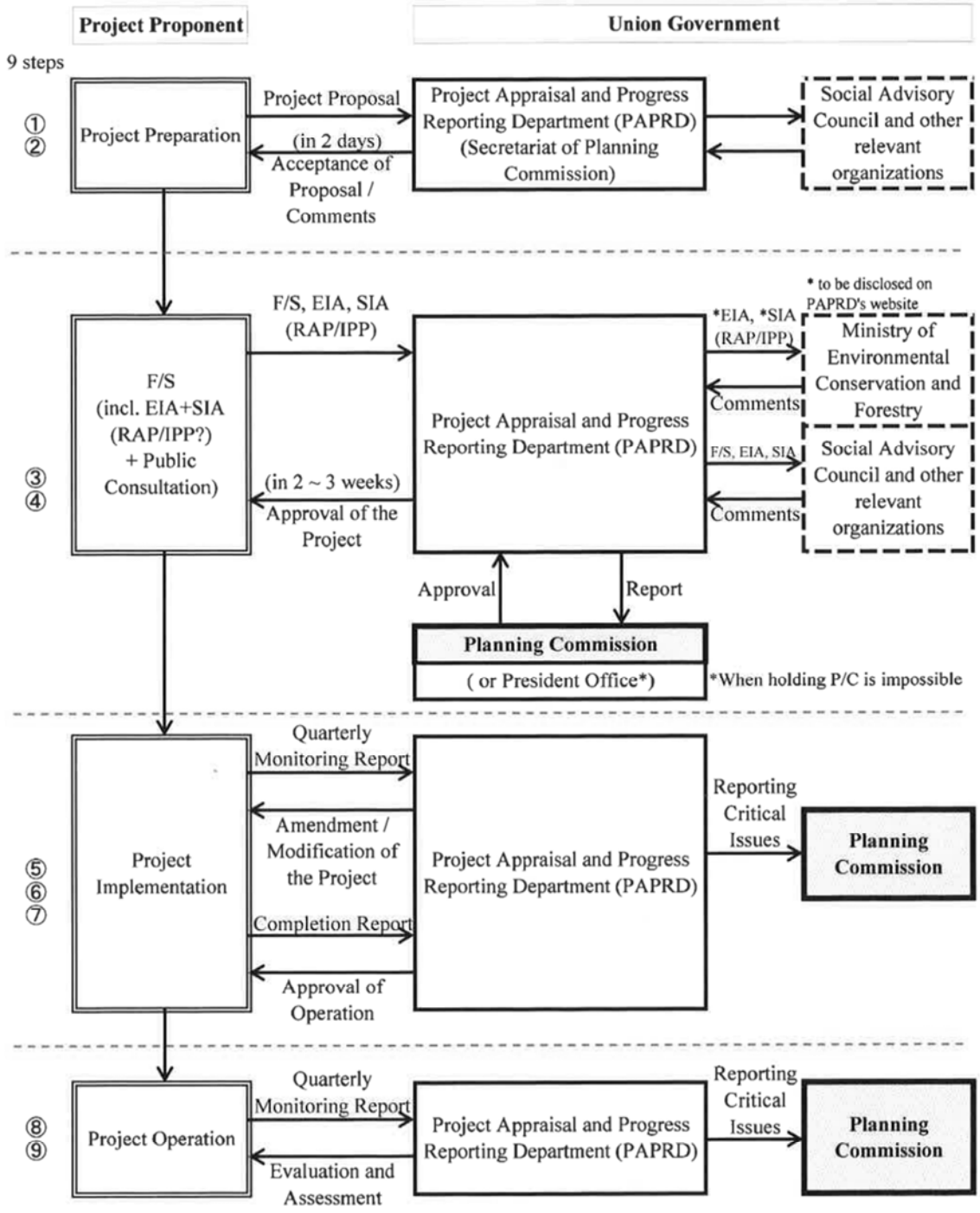
- Set the rules for how much and what type of pollution is allowed, and what businesses and individuals have to do to reduce pollution,
- Set up a system to assess the environmental and social impacts of projects (both those carried out by the government and those done by the private sector),

- Set up a system to monitor pollution from agriculture, industry and mining,
- Decide which types of projects require permission to operate,
- Decide whether to grant the permission to individual projects,
- Require companies to pay for environmental conservation projects to make up for the damage caused by the companies,
- Oversee the system for judging and punishing environmental damage, and
- Negotiate regional and international environmental agreement.

The Ministry, the Committee and the national government share responsibilities for taking action when there is a natural disaster, including warning people about natural disasters.

2.6.3 Process of Environmental and Social Considerations

Based on the information obtained from JICA, the process of environmental and social considerations will be as follows.



Source: JICA

Figure 2.20 Process of Environmental and Social Considerations

It seems that the responsible organization will be Project Appraisal and Progress Reporting Department (PAPRD) under the Ministry of National Planning and Economic Development, and the MOECAF will issue the comments on EIA (SIA) reports. EIA and SIA are expected to be implemented in the F/S stage and the public consultation will be required during or after the F/S.

2.6.4 International Commitments

Myanmar has signed 31 international treaties related to the environment. It is unclear however, how the contents of those treaties have been incorporated into domestic law.

Table 2.12 International and Regional Treaties Concerning the Environment

No.	Name
1	Plant Protection Agreement for the Southeast Asia and Pacific Region
2	Treaty Banning Nuclear Weapons Test in the Atmosphere in Outer Space and Under Water
3	Outer Space Treaty: Treaty on Principles Governing the Activities of States in the Exploitation and Use of Outer Space including the Moon and Other Celestial Bodies
4	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 (Seabed Treaty)
5	Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological and Toxin Weapons, and their Destruction
6	Vienna Convention for the Protection of the Ozone Layer
7	Montreal Protocol on Substances that Deplete the Ozone Layer
8	MARPOL: International Convention for the Prevention of Pollution from Ships
9	MAPROL: International Convention for the Prevention of Pollution from Ships as amended 1978
10	Agreement on the Networks of Aquaculture Centers in Asia and the Pacific Region
11	London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer
12	United Nations Framework Convention on Climate Change (UNFCCC)
13	Treaty on the Non-Proliferation of Nuclear Weapons
14	ICAO: ANNEX 16 Annex to the Convention on International Civil Aviation Environmental Protection Vol. I, II, Aircraft Noise
15	United Nations Convention to Combat Desertification
16	Vienna Convention for the Protection of Ozone Layer
17	Montreal Protocol on Substances that Deplete the Ozone Layer
18	London Amendment to the Montreal Protocol
19	Convention concerning the Protection of the World Cultural and Natural Heritage
20	Convention on Biological Diversity (CBD)
21	United Nations Convention on the Law of the Sea
22	International Tropical Timber Agreement (ITTA)
23	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
24	ASEAN Agreement on the Conservation of Nature and Natural Resources
25	Catagena Protocol on Biosafety
26	ASEAN Agreement on Transboundary Haze Pollution
27	Kyoto Protocol to the United Nations Framework Convention on Climate Change
28	Convention on the Prohibition of the Development, Production, and Stockpiling and Use of Chemical Weapons and on their Destruction
29	Stockholm Convention on Persistent Organic Pollutants
30	Ramsar Convention on Wetlands
31	Copenhagen Amendment to Montreal Protocol on Substances that deplete the Ozone Layer

Source: Burma's Environment, The Burma Environmental Working Group (BEWG)

2.6.5 Environmental Quality

Based on the Environment Conservation Law 2012, the new environmental quality are under preparation by MOECAF. The environmental quality will include:

- Surface water quality such as rivers, stream, canal, water spring, lake, pond marshy place, dam
- Water quality at sea coast lines and delta areas
- Underground water quality
- Ambient air quality
- Noise and vibration
- Fume emissions
- Liquid discharge quality
- Solid waste
- Other environment quality specifications prescribed by the Union of Government

If environment quality standards prescribed by government department concerned or by government organization are more stringent than that of MOECAF, they shall be applied as it is and if those standards are less stringent than that of MOECAF then the MOECAF standards shall be in force.
The present Myanmar's drinking water quality is presented in the Section 3.5.

2.6.6 Environmental and Social Considerations for the Project

As mentioned in the above section, the system of environmental impact assessment is under preparation. Thus till the regulations related to EIA will be enacted, JICA's Guidelines for Environmental and Social Considerations (April 2010) (hereinafter referred as "JICA Guidelines") is applied to the Project.

According to JICA Guidelines, the IEE-level environmental and social considerations studies including analysis of alternatives including "without project" situations should be implemented in the full-scale study stage (Master Plan Study). In addition, it is said that JICA applies a Strategic Environmental Assessment (SEA) when conducting Master Plan Studies. Thus, in the Project, IEE-level environmental and social considerations which introduce the concept of SEA shall be implemented.

CHAPTER 3 EXISTING WATER SUPPLY CONDITIONS

3.1 Outline of Water Supply Conditions

3.1.1 Classification of Existing Water Supply

Water supply is largely classified into two systems; YCDC water supply system and Non-YCDC water supply system.

(1) YCDC Water Supply System

This system gets raw water mostly from reservoirs, supplemented by tube wells. Some raw water is treated and some is not treated. Then water is distributed through pipes to customers. The service area is extended to parts of 30 townships out of 33 townships in YCDC area. Section 3.4 deals with YCDC water in detail.

(2) Non-YCDC Water Supply System

In the areas not-served by YCDC and in peripheral 6 townships, people get water by various means; including tube wells, rain water storage, streams, ponds, neighbors' piped water supply system/tube wells, bottled water, water vendors, public tube wells, public taps. There are small-sized public water supply systems in Thanlyin and Kyauktan townships and Thilawa SEZ, all located outside of YCDC service area.

3.1.2 Major Water Source

(1) Survey target and Questionnaire

The household interview survey in the Project for the Strategic Urban Development Plan of the Greater Yangon (2012 JICA-HIS) was implemented in the thirty-nine (39) townships. The sample number is 1 % of each township's households, 10,000 households in total. The questionnaires include issues related to water and are listed as follows.

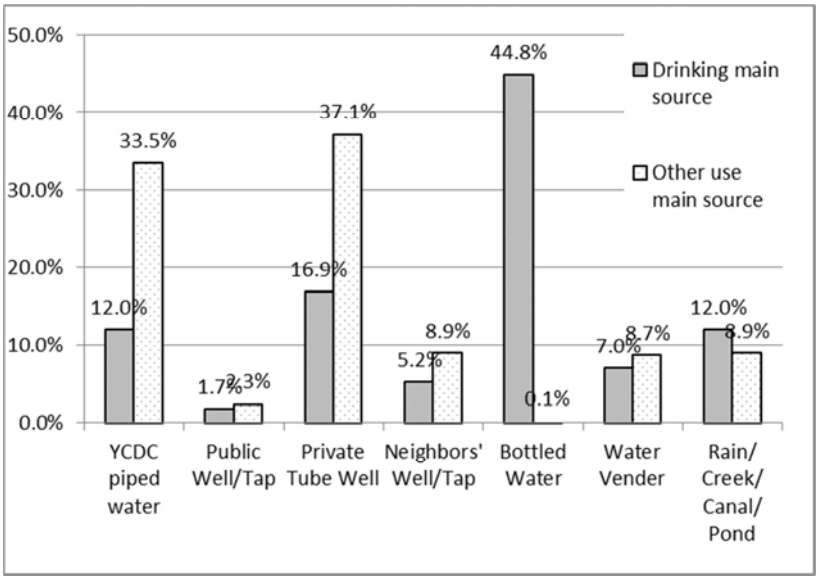
- Water source
- Access to water and consumption
- Evaluation of existing service level
- Water-borne diseases

The results thus obtained are described below.

(2) Whole samples

The water source for various uses other than drinking purpose is private tube well (37 %), followed by YCDC piped water (34 %) and neighbor's well/tap (free of charge) (9 %) as shown in the Figure below. This 34 % of YCDC piped water is equivalent to the coverage of water supply system. The main sources of drinking water are, however, bottled water (45 %) followed by private tube well (17 %) and YCDC piped water (12 %).

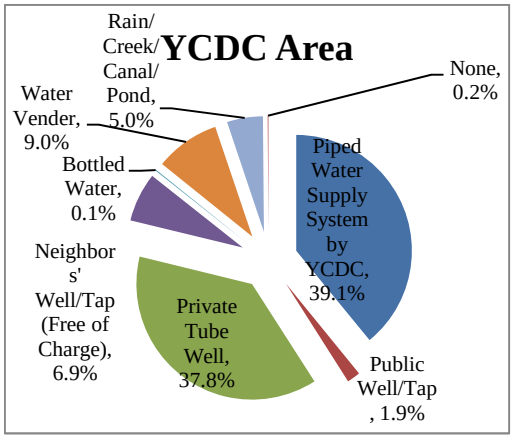
This tells that almost every household have access to water sources in Yangon. Access rate to improved or safe water is 83 % in the whole country (93 % in urban areas and 78 % in rural areas) according to the Joint Monitoring Programme. The access rate to safe water in urban areas can be regarded as almost equal to that in Yangon because Yangon is the largest city, which is much larger than the second city of Mandalay. However, access rate to water in Yangon does not necessarily represent access rate to safe water. So, the access rate to safe water defined by the Joint Monitoring Programme might not be correct.



Source: 2012 JICA-HIS

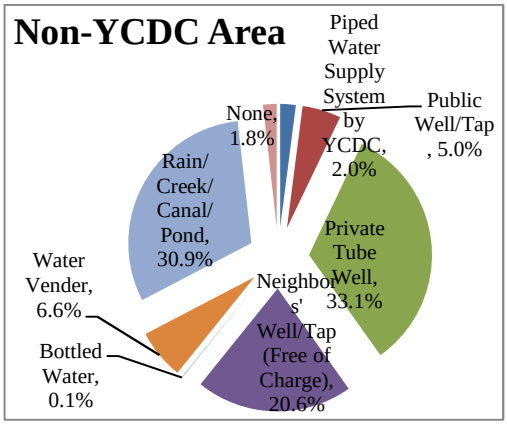
Figure 3.1 Water Source by Use (All Samples)

The figure below shows the main water source by YCDC area and non-YCDC area. In the YCDC area (33 townships), the water is supplied by YCDC piped water (39 %), private tube well (38 %), water vender (9 %), and rain/creek/canal/pond (5 %). In the non-YCDC area (6 townships), the main water source is private tube well (33 %), rain/creek/canal/pond (31 %) and neighbor's private tube well (21 %).



Source: 2012 JICA-HIS

Figure 3.2 Main Water Source in YCDC Area



Source: 2012 JICA-HIS

Figure 3.3 Main Water Source in Non-YCDC Area

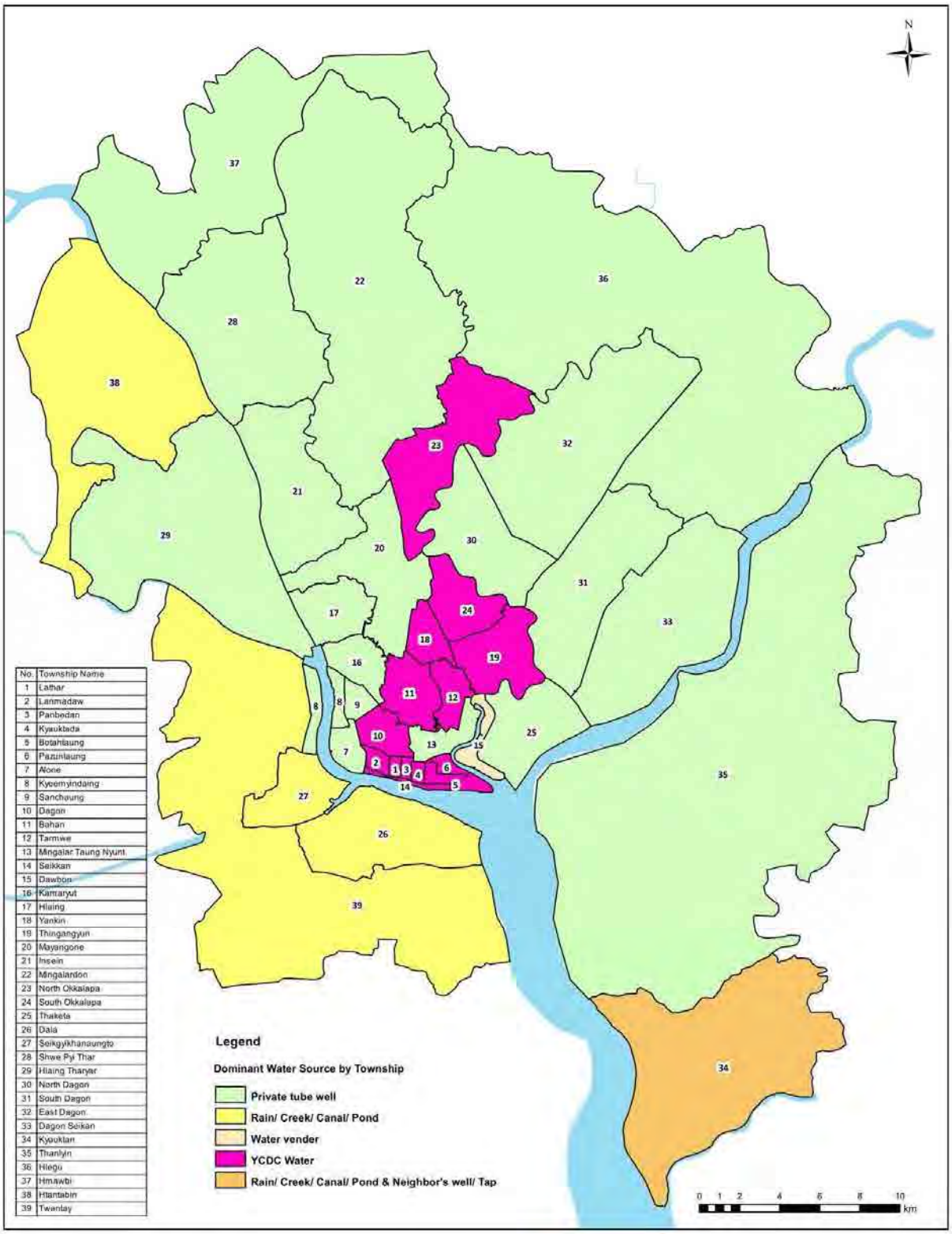
The Table below shows the percentage of water sources for various uses by township and Figure below shows the major water source by township. The number of townships where tube wells are the largest water source is 18 while 15 townships have YCDC water supply system as their main source of water. Only in 5 townships, the most popular means of getting water is from rain/creek/canal/pond.

In CBD area, almost 90 % depends on YCDC piped water. In the Inner Urban Ring located in the north of CBD, there are the townships where 90 % depends on YCDC piped water and the percentage of private tube well is high in some townships. In the Ahlone and Sanchaung in the Inner Urban Ring, the distribution pipeline is installed by YCDC but due to the water unavailability, people depend on tube wells. In Dawbon, the percentage of water vender is quite high (35 %). Outer Ring is in the same situation as Inner Urban Ring, despite the YCDC distribution pipeline is installed; people depend on tube wells due to the water unavailability. In other areas, the installation of distribution pipeline is limited, the percentage of tube well, water vender and rain/creek/canal is increased. For example, in Northern Suburb, people depend on tube well and water vender in South of CBD. In the New Suburbs, the most dominant water source is tube well followed by YCDC piped water and water vender. Outside of YCDC, the tube well is the dominant water source but the percentage of rain/creek/river is also high.

Table 3.1 Water Source by Township

No.	Township	YCDC Piped Water	Public Well/Tap	Private Tube Well	Neighbors' Well/Tap (Free of Charge)	Bottled Water	Water Vender	Rain/ Creek/ Canal/ Pond	None	No Answer	Total
Central Business District											
1	Latha	93%	3%	3%	0%	0%	1%	0%	0%	0%	100%
2	Lanmadaw	86%	3%	6%	2%	1%	1%	0%	0%	0%	100%
3	Pabedan	94%	0%	6%	0%	0%	0%	0%	0%	0%	100%
4	Kyauktada	96%	0%	4%	0%	0%	0%	0%	0%	0%	100%
5	Botahtaung	92%	2%	2%	0%	0%	3%	1%	0%	0%	100%
6	Pazuntaung	99%	0%	0%	0%	0%	1%	0%	0%	0%	100%
Inner Urban Ring											
7	Ahlone	47%	2%	48%	2%	0%	0%	0%	0%	0%	100%
8	Kyeemyindaing	17%	2%	46%	9%	0%	8%	17%	0%	0%	100%
9	Sanchaung	43%	1%	52%	4%	0%	0%	0%	0%	0%	100%
10	Dagon	59%	15%	23%	3%	0%	0%	0%	0%	0%	100%
11	Bahan	82%	1%	12%	2%	1%	2%	0%	0%	0%	100%
12	Tarmwe	88%	0%	11%	0%	0%	1%	0%	0%	0%	100%
13	Mingalar Taung Nyunt	96%	2%	1%	1%	0%	0%	0%	0%	0%	100%
14	Seikkan	60%	20%	20%	0%	0%	0%	0%	0%	0%	100%
15	Dawbon	26%	1%	31%	4%	0%	35%	3%	0%	0%	100%
Outer Ring Zone											
16	Kamaryut	24%	1%	69%	5%	0%	0%	0%	0%	0%	100%
17	Hlaing	18%	0%	72%	8%	0%	1%	0%	0%	0%	100%
18	Yankin	85%	1%	11%	2%	0%	0%	0%	1%	0%	100%
19	Thingangyun	50%	3%	31%	4%	1%	10%	0%	0%	0%	100%
Northern Suburbs											
20	Mayangone	39%	1%	49%	6%	0%	5%	0%	0%	0%	100%
21	Insein	26%	2%	61%	6%	0%	4%	0%	0%	0%	100%
22	Mingalardon	16%	5%	51%	20%	0%	7%	0%	0%	0%	100%
Older Suburbs											
23	North Okkalapa	84%	1%	9%	4%	0%	2%	0%	0%	0%	100%
24	South Okkalapa	66%	3%	21%	3%	0%	5%	1%	0%	0%	100%
25	Thaketa	14%	1%	44%	5%	0%	35%	1%	0%	0%	100%
South of CBD											
26	Dala	5%	0%	3%	2%	0%	20%	71%	0%	0%	100%
27	Seik gyi Khan Naung To	0%	0%	1%	0%	0%	22%	76%	0%	0%	100%
New Suburbs											
28	Shwe Pyi Thar	7%	3%	75%	12%	0%	2%	1%	0%	0%	100%
29	Hlaing Thar Yar	2%	1%	69%	23%	0%	3%	2%	0%	0%	100%
30	North Dagon	26%	1%	45%	5%	0%	21%	3%	0%	0%	100%
31	South Dagon	28%	2%	38%	5%	0%	20%	5%	1%	0%	100%
32	East Dagon	20%	1%	45%	5%	0%	21%	8%	0%	0%	100%
33	Dagon Seikkan	11%	4%	42%	5%	0%	25%	14%	0%	0%	100%
Outside of YCDC											
34	Kyauktan	13%	11%	13%	29%	0%	6%	29%	0%	0%	100%
35	Thanlyin	0%	6%	29%	22%	0%	14%	23%	5%	0%	100%
36	Hlaegu	1%	2%	43%	11%	0%	0%	44%	0%	0%	100%
37	Hmawbi	1%	6%	61%	30%	0%	1%	2%	0%	0%	100%
38	Htantapin	0%	0%	38%	17%	0%	5%	39%	1%	0%	100%
39	Twantay	0%	0%	1%	1%	0%	5%	93%	0%	0%	100%

Source: 2012 JICA-HIS



Source: Prepared by JICA Study Team based on the results of 2012 JICA-HIS

Figure 3.4 Main Water Source by Township

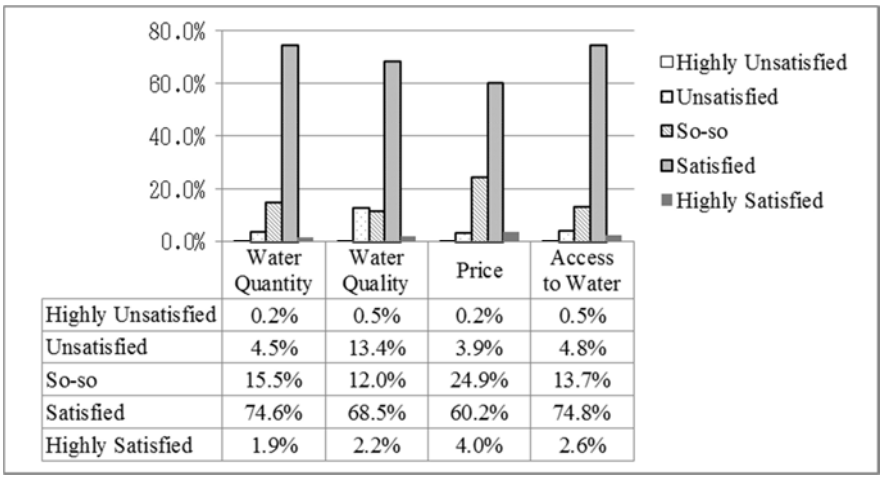
3.1.3 Satisfaction and Dissatisfaction of Water Supply Services

According to the Household Survey, the degree of satisfaction of Non-YCDC households water supply tends to be higher than that of YCDC water supply household. This mainly attributes to the incapability of YCDC that cannot supply adequate amount of safe drinking water to the customers continuously due to limited amount of water source and inadequate capacity of water supply facilities.

Non-YCDC households have higher satisfaction rate but in reality the ratio of use of rain /creek /canal /pond as drinking water is higher. These are not considered as satisfied water supply method. Tube wells are also susceptible to pollution in urban area and this source is not necessarily considered as safe water. According to the 2002 JICA-M/P, there are several tube wells which exceed the drinking water quality standards of Myanmar in Iron, Manganese, TDS, Color, and Turbidity. In addition, 26.5 % of the Non-YCDC households use bottled water for drinking water, which indicates they do not satisfy their main water supply and they satisfy their water supply at the lower level.

(1) Non-YCDC Water Supply System

Households that expressed dissatisfaction are only about 5% in terms of water amount, price and access to water. However, dissatisfaction level is relatively high among households, about 13%, in terms of water quality, especially about color and taste.



	Water Quantity	Water Quality	Price	Access to Water
Highly Unsatisfied	0.2%	0.5%	0.2%	0.5%
Unsatisfied	4.5%	13.4%	3.9%	4.8%
So-so	15.5%	12.0%	24.9%	13.7%
Satisfied	74.6%	68.5%	60.2%	74.8%
Highly Satisfied	1.9%	2.2%	4.0%	2.6%

Source: 2012 JICA-HIS

Figure 3.5 Satisfaction or Dissatisfaction

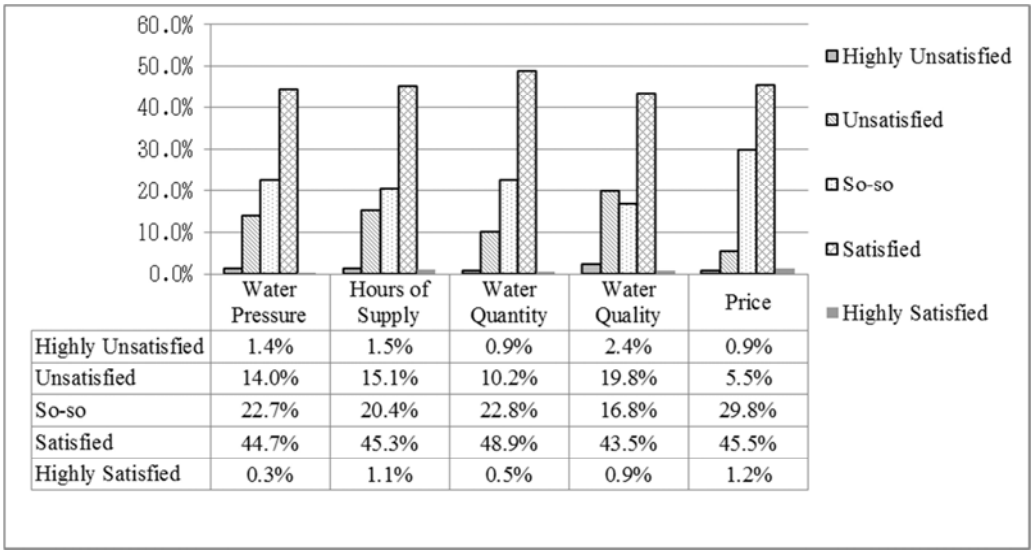
Table 3.2 Dissatisfaction Items for Water Quality

Color	Turbidity	Odor	Taste	Unsanitary
28.1%	13.6%	15.5%	26.6%	16.2%

Source: 2012 JICA-HIS

(2) YCDC Water Supply System

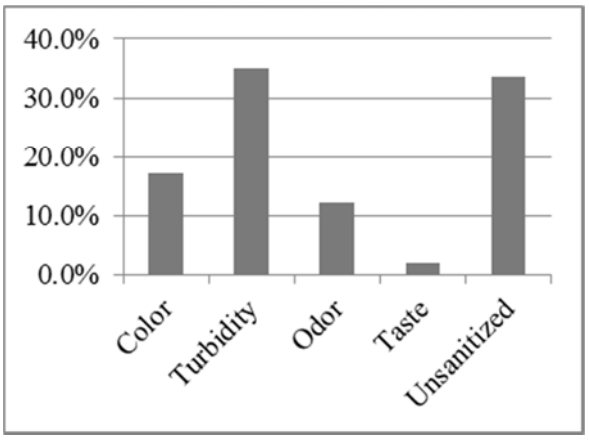
According to 2012 JICA-HIS, more than 40 % households are reported to be satisfied with pressure, supply hours, supply amount, water quality and price of YCDC water supply system and more than 60 % are satisfied with YCDC water supply condition if so-so level is included. Dissatisfaction level is relatively high in terms of water quality. Out of the dissatisfied households, 34.5 % is not happy with turbidity and 33.2 % is not happy with unhygienic condition.



	Water Pressure	Hours of Supply	Water Quantity	Water Quality	Price
Highly Unsatisfied	1.4%	1.5%	0.9%	2.4%	0.9%
Unsatisfied	14.0%	15.1%	10.2%	19.8%	5.5%
So-so	22.7%	20.4%	22.8%	16.8%	29.8%
Satisfied	44.7%	45.3%	48.9%	43.5%	45.5%
Highly Satisfied	0.3%	1.1%	0.5%	0.9%	1.2%

Source: 2012 JICA-HIS

Figure 3.6 Satisfaction Level with YCDC Water Supply System



Source: 2012 JICA-HIS

Figure 3.7 Unsatisfied Water Quality Items (YCDC Water)

(3) By Township

People's satisfaction of water supply services (including YCDC piped water and others) are summarized in the Table below. The mark "×" indicates more than 20 % of respondents answered unsatisfied and "Δ" means 10 % answered unsatisfied.

From the results, it is observed that the dissatisfaction is not high related to the non-YCDC water services, instead, the dissatisfaction in terms of water quality is high in almost all townships but low in terms of price.

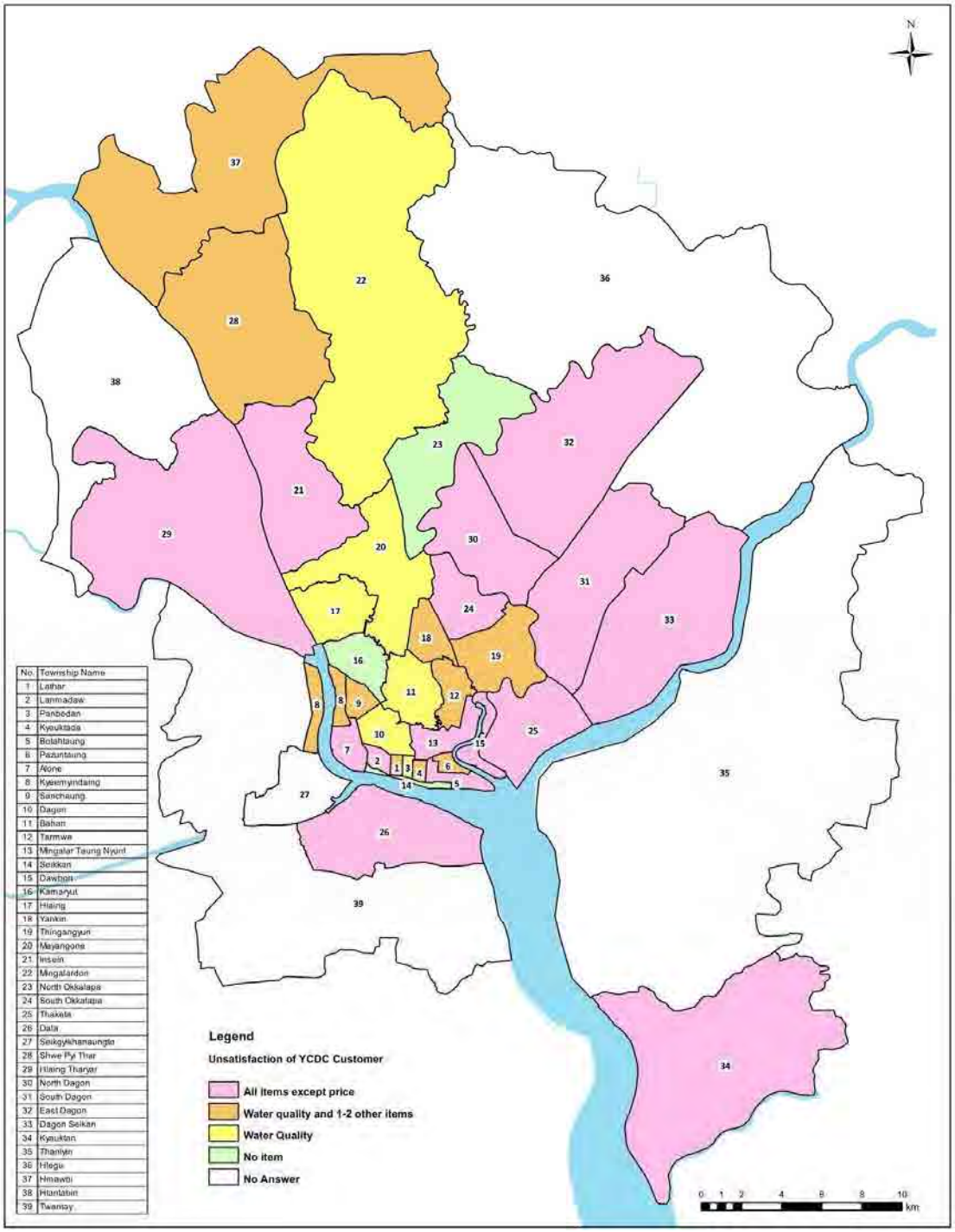
For YCDC piped water, in the old towns (CBD, Inner Urban Ring, Outer ring, Northern Suburbs, Older Suburbs) the satisfaction is relatively high.

The townships where dissatisfaction is high in all items (water pressure, supply hour, water quantity and water quality) except price can be divided into three groups. The first group is New Suburbs Zone excluding Shwe Pyi Thar, having the large area. The second group is old townships located in the lower and along the Ngamoeyeik Creek, such as Dawbon, Mingalar Taung Nyunt in Inner Urban Ring and Thaketa in Older Suburbs Zone. The third group is Dala located in the south of Yangon River and Kyauktan.

Table 3.3 Satisfaction and Dissatisfaction to Water Supply Services by Township

	YCDC and Township piped water supply					Non-YCDC and non-Township piped water supply			
Township	Water pressure	Hours of supply	Water quantity	Water quality	Price	Water quantity	Water quality	Price	Access to water
CBD									
Latha	△	△		×			△		△
Lanmadaw	△	△	△	×			△		
Pabedan				△		△	×	×	×
Kyauktada	△			△		×	×	×	×
Botahtaung	△	△	△	×		△	×		
Pazuntaung	△	△		×		×		×	×
Inner Urban Ring									
Alone	△	△	△	×					
Kyeemyindaing		△		△		△	×		△
Sanchaung		△		×					
Dagon				△					
Bahan				△					
Tarmwe	△	△		×					
Mingalar Taung Nyunt	×	×	△	×	△				
Seikkan									
Dawbon	×	×	×	×					
Outer Ring Zone									
Kamaryut									
Hlaing				△					
Yankin	△	△		×					
Thingangyun	△	△		×			△		
Northern Suburbs									
Mayangone				△					
Insein	△	×	△	×					
Mingalardon				△					
Older Suburbs Zone									
North Okkalapa									
South Okkalapa	×	×	△	×			△		
Thaketa	×	×	×	×	△		△	△	
South of CBD									
Dala	×	×	×	×		△	△		△
Seikgyikhanaungto	-	-	-	-	-	×	△		△
New Suburbs Zone									
Shwe Pyi Thar				×	△		×		
Hlaing Thar Yar	×	×	×	×	△		×		
North Dagon	×	×	×	×			△		
South Dagon	×	×	×	×			△	△	△
East Dagon	×	×	×	×			△		
Dagon Seikan	×	×	×	×	△		×		△
Outside of YCDC Area									
Kyauktan	×	×	×	×	×				
Thanlyin	-	-	-	-	-				
Hlaegu	-	-	-		-				
Hmawbi		×		×					
Htantapin	-	-	-		-				△
Twantay	-	-	-	-	-				△

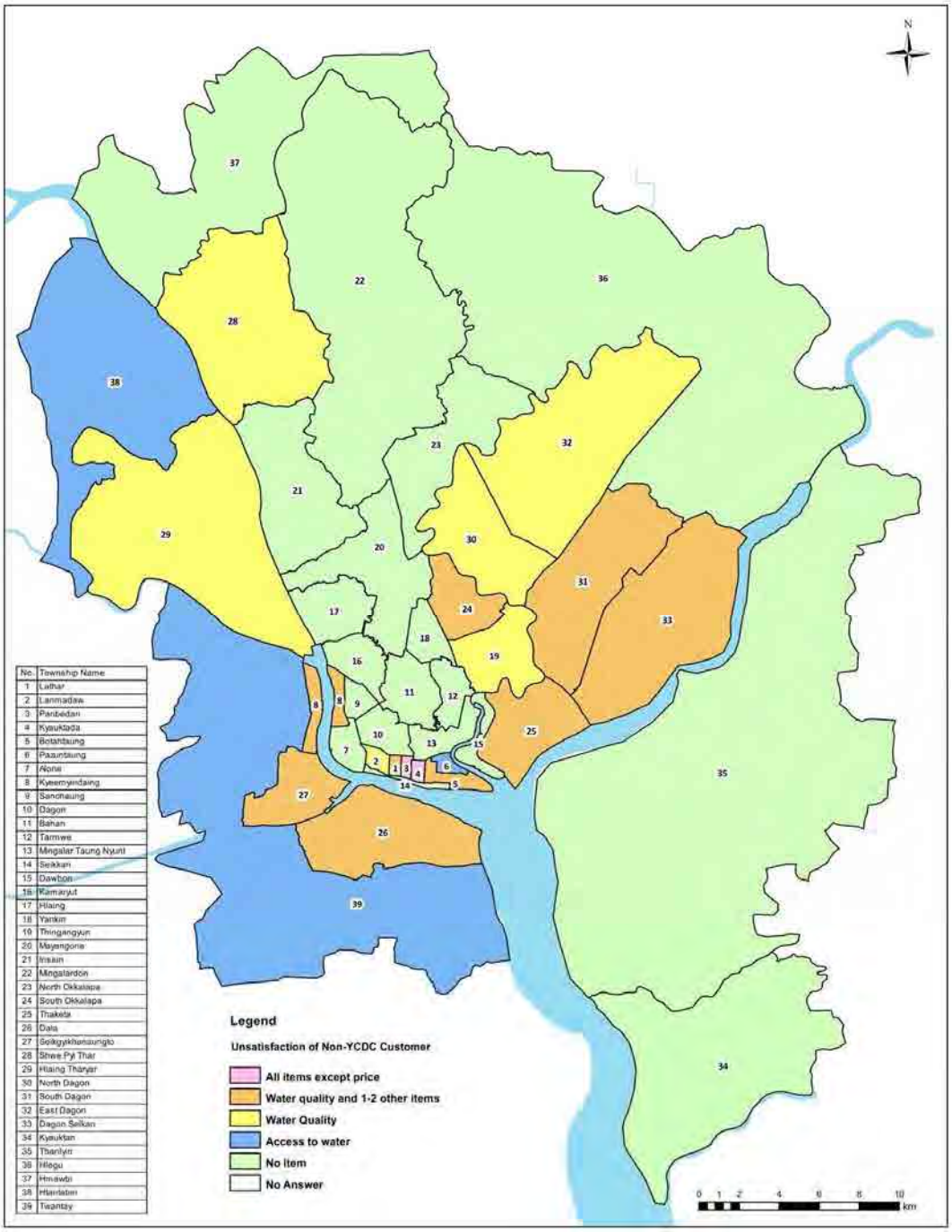
Note： × & △ indicates more than 20 % and 10% respondents are unsatisfied with items such as pressure, water quality.
Source: 2012 JICA-HIS



Note: YCDC piped water is not supplied to Kyaukutan (No. 34 in the figure) and Hmawbi (No. 37 in the figure), but the figure shows the results of respondents' answer.

Source: Prepared by JICA Study Team based on the results of 2012 JICA-HIS

Figure 3.8 Map of Satisfaction Level with YCDC Water Supply System

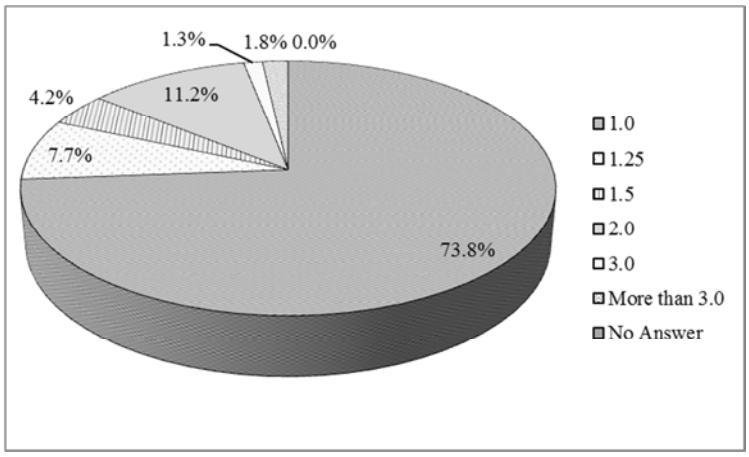


Source: Prepared by JICA Study Team based on the results of 2012 JICA-HIS

Figure 3.9 Satisfaction Level with Non-YCDC Water Supply System

3.1.4 Desirable Water Amount

The question how many times of water they want to consume more comparing to the current consumption (100 lpcd) was asked to all respondents, and 74 % answered satisfaction with the current consumption, followed by two times (11 %).



Source: 2012 JICA-HIS

Figure 3.10 Desirable Water Amount

3.1.5 Water-Borne Diseases

1.4 % of the respondents' household members suffered from the diarrhea, and other diseases such as dysentery, Cholera and typhoid are low (0.1 ~ 0.6 %). The number of infection in the past one year is one time (50.6 %) and 2-5 times (45.6 %).

Table 3.4 Rate of Water-Borne Diseases

Diarrhea	Dysentery	Cholera	Infectious Hepatitis	Typhoid or Paratyphoid	Malaria	Dengue Fever	Others
1.4%	0.6%	0.1%	0.1%	0.1%	0.1%	0.4%	0.4%

Source: 2012 JICA-HIS

3.1.6 Expenditure for Water

The average expenditure for drinking water is 5,600 Kyat per month, and 4,400 Kyat for other use. Some respondents answered high expenditure (such as 150,000 and 270,000 Kyat), so that it seems the average is raised. The median shows the 1,200 Kyat for drinking water and 700 Kyat for other use. It is estimated that the general public spends 1, 900 Kyat per month for water supply.

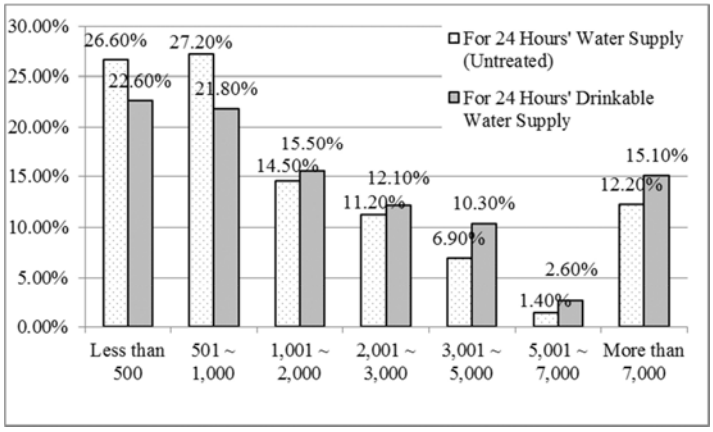
Table 3.5 Satisfaction and Dissatisfaction to Water Supply Services

	Average	Median	Maximum	Minimum
For drinking	5,636	1,100200	150,000	0
For other use	4,477	700	270,000	0

2012 JICA-HIS

3.1.7 Willingness to Pay for Water Supply Services

The question on their willingness to pay for drinkable water supply services for 24 hours was asked to all respondents. For untreated water supply, 54 % answered less than 1,000 Kyat per month, and for drinkable water supply, 44 % answered less than 1,000 Kyat per month.



Source: 2012 JICA-HIS

Figure 3.11 Willingness to Pay for Better Water Supply Services

The average willingness to pay (WTP) amount was calculated by using the medium value in each range, because the questionnaire format from which selection can be made included seven ranges. The WTP amount was 2,436 Kyat/hh/month. The monthly average water consumption volume per household was also estimated from the HIS results amounting to 13.9 m^3/hh/month (see section 3.4.3). Thereby the average WTP per cubic meter is estimated as 175 Kyat/ m^3. If this amount is compared to 88 Kyat of current tariff rate for domestic use, the current tariff level is lower than the WTP amount/m^3, by almost half.

Meanwhile, if focusing on the relationship between WTP and monthly household income, the monthly median household income amounted for 175,000 Kyat/hh/month. Thus, the WTP amount per month is equivalent to 1.4% of the monthly average household income, so that it is less than 4% of the income which is considered as a typical benchmark parameter. It can be thought that the current tariff rate level is set up as relatively low.

For reference, the affordability to pay (ATP) is 500 Kyat/m^3 calculated by using the aforementioned monthly average water consumption per household, if assumed that the level of ATP is 4% of monthly average household income.

3.2 Existing Water Supply System (Non-YCDC)

3.2.1 Public Water Supply

There are two public water supply systems in Thanlyin and Kyauktan TSs, managed by respective township committee. Main features of these systems are shown in Table below.

Table 3.6 Features of Thanlyin and Kyauktan Water Supply Systems

Item	Thanlyin TS	Kyauktan TS
Water Source	Tube Well	Tube Well
Number of Systems	3 Systems, 1.6km pipe	1 System
Number of Connection	97 (Individual), 3 (Public Tap)	1,436
Population in 2011	204,486	123,565
Service Coverage	0.2% (assuming 5 numbers per connection)	6% (assuming 5 numbers per connection)
Service Reservoir	3 Elevated Tanks	15 Communal Tanks
Water Tariff	1000 kyat/month	2,500 kyat/month

Source: JICA Urban Plan Study, 2012

In addition, there are two water supply systems for specific purposes of Thilawa SEZ(Special Economic Zone)and Thilawa port. Main features of these systems are shown in Table below.

Table 3.7 Features of Water Supply Systems in Thilawa Industrial Zone

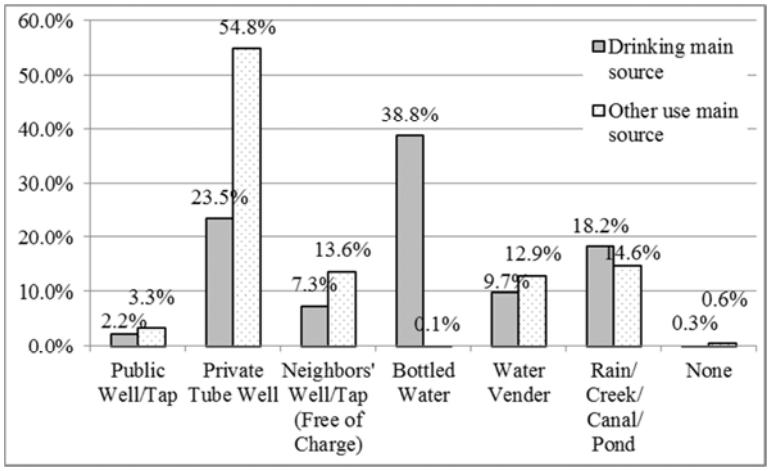
Items	Industrial Zone	Thilawa Port
Water Source	Bantwekone Reservoir (in Kyauktan TS)	Thilawa Reservoir (in Thanlyin TS)
Intake	3 Submersible Pump	2 Submersible Pump
Distribution System	Gravity system using ground reservoir, pump and elevated tank	Gravity system using ground reservoir, pump and elevated tank
Water Tariff	300 kyat/m^3	0.8 US \$/m^3
Management	Ministry of Industry	Ministry of Construction

Source: JICA Urban Plan Study, 2012

3.2.2 Individual Water Supply

(1) Water Source

People in non-YCDC area get water for drinking purposes mainly from bottled water (38.8%), tube wells (23.5%) and rain water/streams/ponds (18.2%). For non-drinking purposes, water used is mainly from tube wells constituting 54.8% and rain water/streams/ponds (14.6 %) while other means such as from neighborhood and, water vendor constitute about 13% each.



Source: 2012 JICA-HIS

Figure 3.12 Water Source in Non-YCDC Water Connections

Based on the definition of Improved and Unimproved Source of Drinking Water in WHO-UNICEF Joint Monitoring Program, water vender and rain/creek/canal/pond are classified as unimproved water source or unsafe water. The ratio of unsafe water is 27.9 %. In addition, bottled water is also considered as unimproved drinking water source on case by case. If this is included in unsafe water, the ratio of unsafe water totals 66.8 %

(2) Access to Water Source in Non-YCDC Water

Survey has been made to understand the situation of access to water, frequency of access to water and types of containers used. The responses indicate that in terms of time taken to fetch water, a large number of households (about 74%) take no time, followed by about 18% who spend less than 5 minutes, and 5% spend less than 10 minutes, reflecting closeness in terms of location of the water source, such as tube wells, neighbors' water, etc. In terms of frequency of access, 10% of households get water more than 10 times a day.

Table 3.8 Access to Water Source (minutes)

0	Less than 5	6～10	11～15	16～20	21～30	More than 30	No response
74.0%	17.5%	5.2%	1.3%	1.1%	0.0%	0.3%	0.6%

Source: 2012 JICA-HIS

Table 3.9 Frequency of Access to Water Source (times per day)

0	1	2～3	4～5	6～7	8～9	More than 10	No response
70.0 %	3.7%	6.9 %	3.4%	3.3%	2.1%	10.0%	0.4%

Source: 2012 JICA-HIS

Table 3.10 Containers

Bucket	Water bag	Polybottle	Piped Supply	Others	No response
27.1%	0.1%	2.0%	67.8%	2.5%	0.5%

Source: 2012 JICA-HIS

(3) Consumed Water Amount

About 48% of households use 51～100gallon (230～454 liter) per day per household, followed by 27% with less than 50 gallon and 18% with 101～200 gallon. Average amount is estimated as 97 gallon (441 liter), representing median value as each bracket.

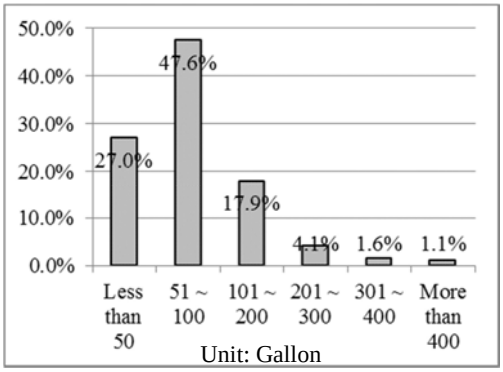


Figure 3.13 Per Household Water Consumption

3.3 Water Supply Service Conditions (YCDC)

3.3.1 Water Service Coverage

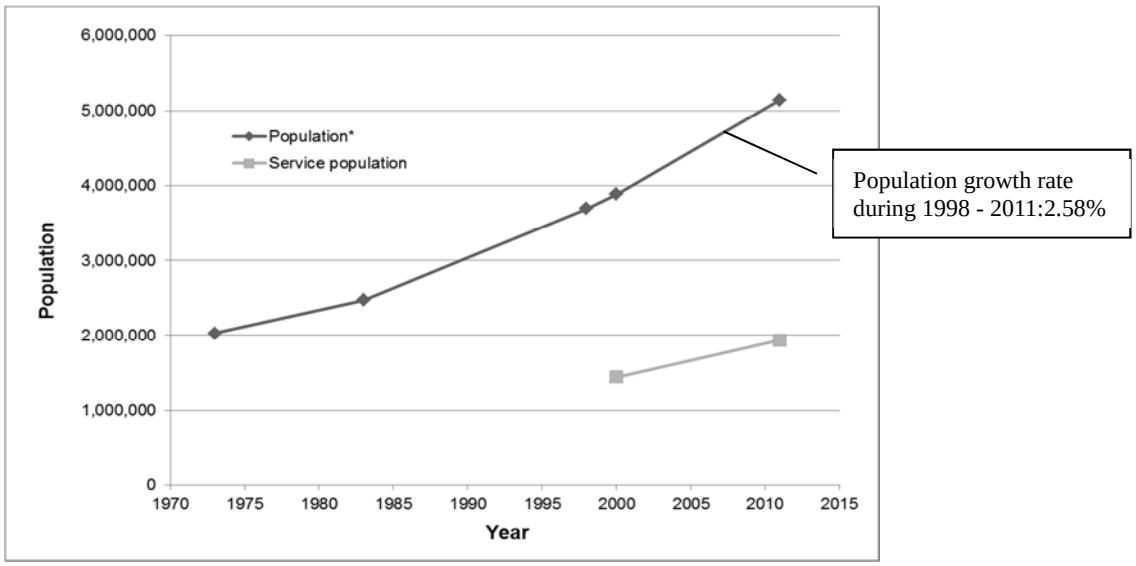
Percentages of population getting water from the YCDC water supply system is 39% in YCDC area and 34 % in the Study Area (according to 2012 JICA-HIS). Water service coverage rate has increased slightly from 37 % in 2000 (according to 2002 JICA-M/P)

The population of Yangon city increased by 1,250,000 between 1998 and 2011 with the corresponding growth rate of 2.58%. During the period of 11 years, the water supply service population increased by 480,000 (1,920,000 – 1,440,000). This indicates that the service population increased by 45,000 per year.

Table 3.11 Water Service Coverage in 2012

Number of Household in YCDC Area	Number of Water Connection	Water Service Coverage (%)	
		Estimate from the YCDC record	Result of 2012 JICA-HIS
825,620	187,827	23%	39%

Source: JICA Study Team

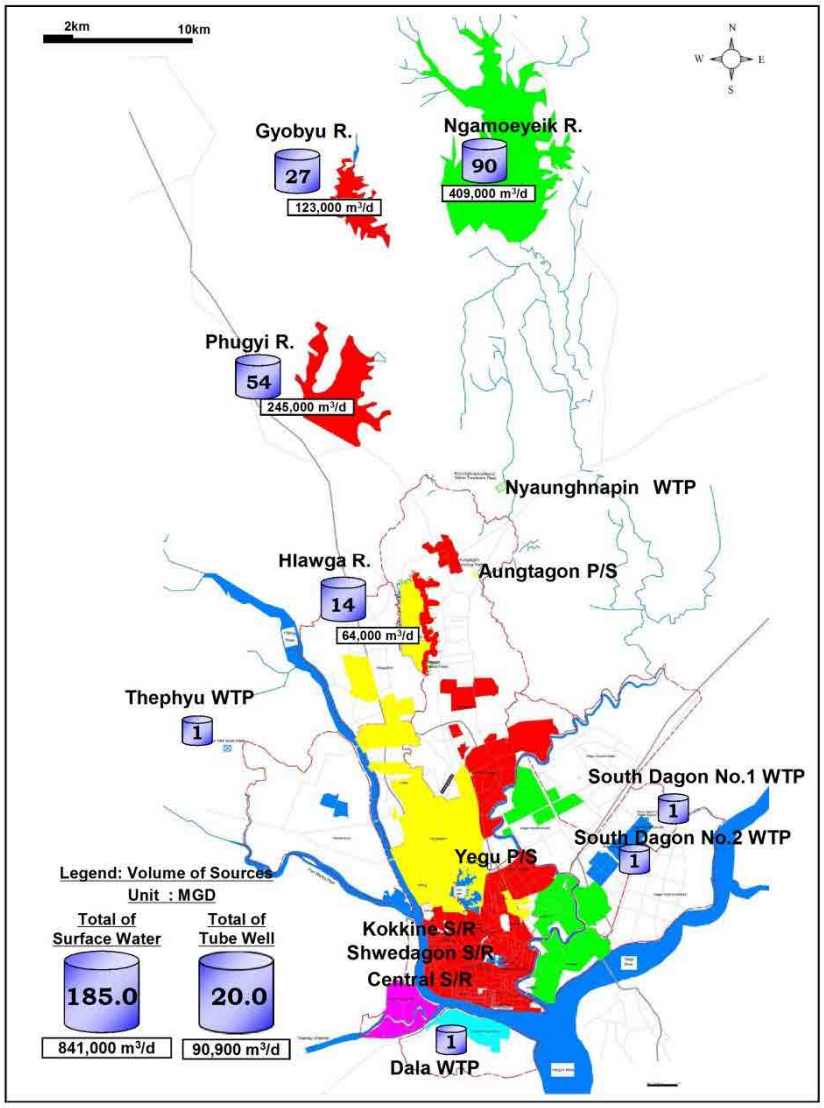


Source: JICA Study Team

Figure 3.14 Increase of Total Population and Water Supply Service Population in Yangon City

3.3.2 Water Source and Water Service Area

Figure below shows water service areas and corresponding sources from which water is received.



Source: JICA Study Team
Note: Details of water sources are shown in the Table 3.24.

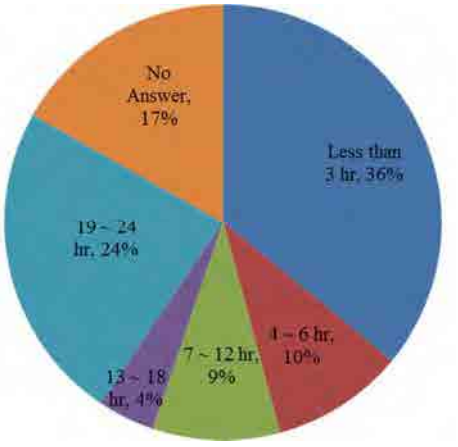
Figure 3.15 Service Area and Water Source

3.3.3 Service Condition

(1) Service Hours

2012 JICA-HIS investigated supply hours and amount. Households with less than 3 hours water supply constitute the largest share of 36 % while those with water supply duration between 19 and 24 hours are 24 %, indicating very wide difference.

Figure below shows service areas and service hours corresponding to the area for 2010. The service area

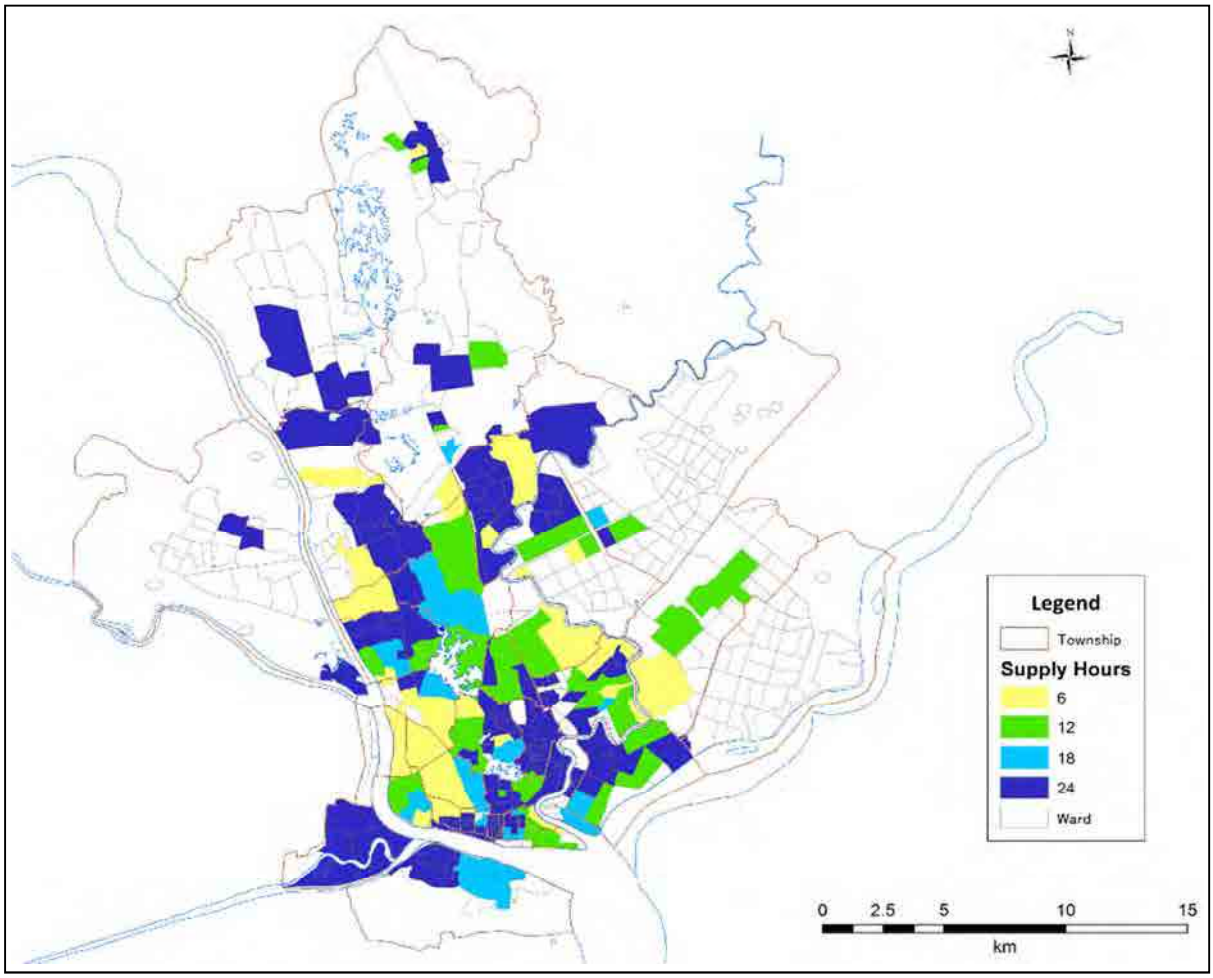


Source: 2012 JICA-HIS

Figure 3.16 Service Hours (YCDC Piped Supply)

covers most of the CBD, Inner Ring Zone, Outer Ring Zone and Older Suburb; and a small part of New Suburbs. The service hours varies widely between 24 hours and 6 hours a day depending on areas. It implies that hydraulically favorable areas such as those located near to water source and main pipes, low areas, etc., get water continuously while unfavorable areas including areas located far away from water source and main pipes, hilly areas at high altitude get water only when there is surplus water such as in night time, etc.

Average supply duration is estimated as 9.1 hours per day.

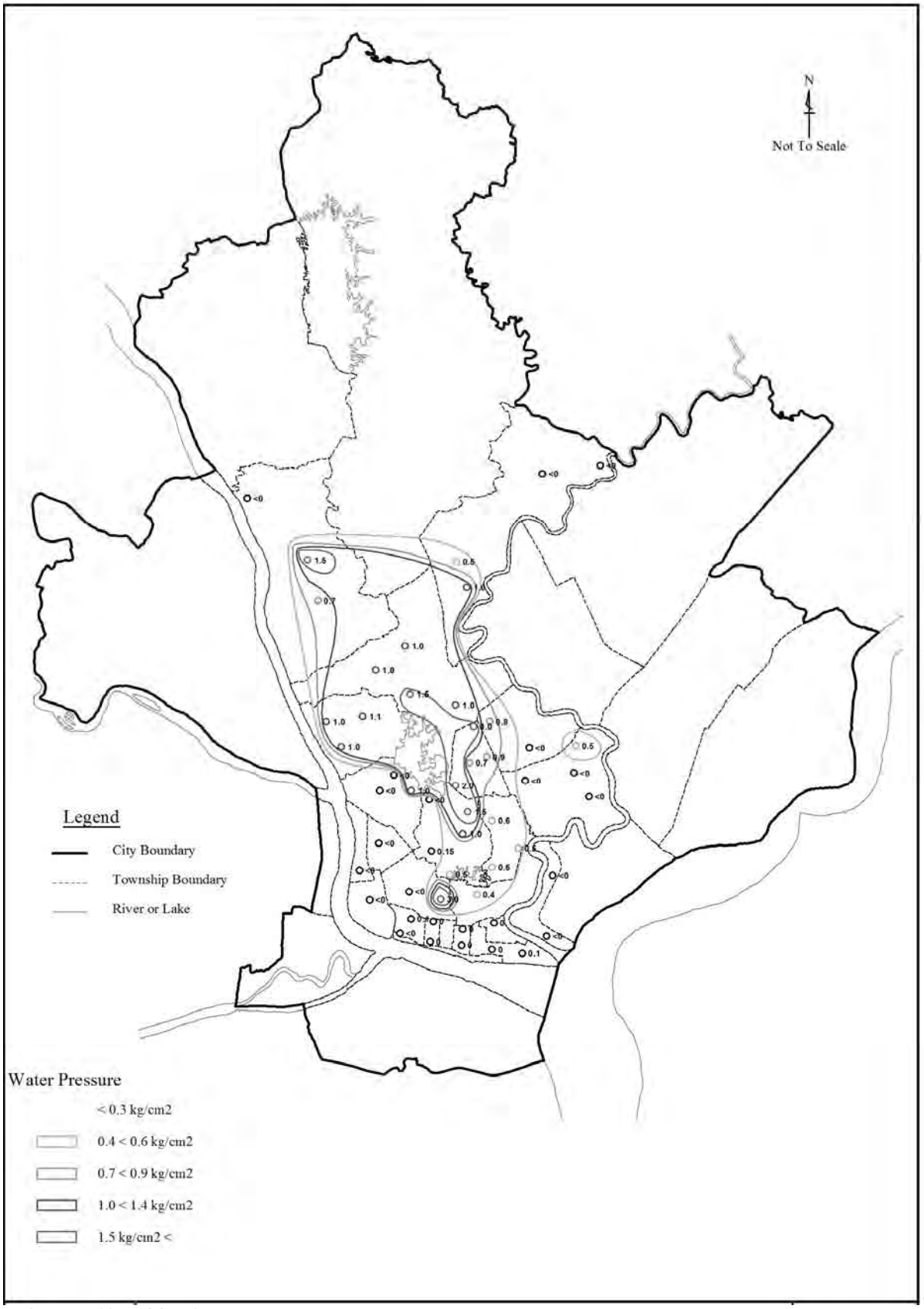


Source: YCDC
Remark: The water supply except for the piped water is also included.

Figure 3.17 Water Supply Hour in YCDC Area

(2) Water Pressure

Water pressures were measured in 2002 JICA-M/P. The result is reproduced here because the situations are almost the same. Townships with relatively high pressures are Bahan, Hlaing, Insein, Mayangone, Tarmwe and Yankin. Townships in the downtown had booster pumps and tanks to cope with low pressures.



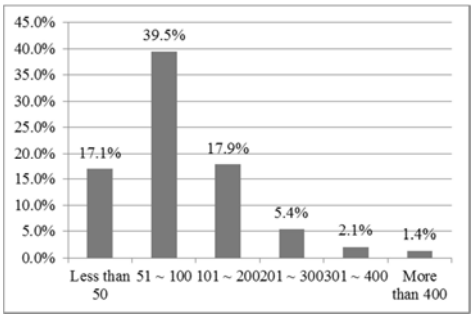
Source: 2002 JICA-M/P

Figure 3.18 Estimated Water Pressure Contour in 2001

(3) Consumed Amount

Concerning domestic water consumption amount according to 2012 JICA-HIS, households with 51 to 100 gallons (230 to 454 liters) per day are the largest, 40 %, those with 101 to 200 gallons (459 to 909 liters) are 18 % and those with less than 50 gallons are 17 %. Average per household consumption is calculated as 102 gallons and average per capita consumption is 24 gallons (110 liters) assuming 4.3 persons per household.

On the other hand, per capita domestic consumption is 94 liters per day according to the YCDC data. It is high, 138 liters in northern suburbs (Mayangone, Insein, Mingalardon Townships) where service condition (water pressure and supply hours) is good due to these locations being near to water sources.



Source: 2012 JICA-HIS

Figure 3.19 Domestic Water Consumption (YCDC System)

Areas with low water consumption are south of CBD (Dala、Seikgyikhanaungto) where supply amount is not sufficient. Other areas with low consumption exist in New Suburbs zone (North Dagon, South Dagon, and East Dagon).

Table 3.12 Per Capita Consumption by Area (LPCD)

Area	Domestic	Commercial	Total
CBD	99	38	137
Inner Urban Ring (IUR)	104	26	131
South of CBD (SCBD)	27	6	33
Older Suburbs Zone (OSZ)	74	10	84
Outer Ring Zone (ORZ)	98	13	111
Northern Suburbs (NS)	138	56	194
New Suburbs Zone (NSZ)	64	31	94
Yangon City	94	26	121

Source: JICA Study Team

(4) Water for Drinking

According to 2012 JICA-HIS, only a few households drink YCDC water directly. More than half households drink YCDC water after treatment such as filtering and boiling. About 60 % use bottled water for drinking purposes.

Table 3.13 Treatment for Drinking Water

Boiling	Filtering	Boiling and Filtering	Bottled Water Purchase	No Treatment	Purification Device
5.0%	23.5%	8.2	59.8%	0.5%	2.9%

Source: 2012 JICA-HIS

(5) Water Tariff System and Water Meter

According to 2012 JICA-HIS, households that pay tariff based on volumetric consumption constitute 53% and those with fixed tariff are 31%. Households that responded having water meter installed are 63%, out of which 6% responded that water meter is not in operation.

Table 3.14 Water Tariff System and Water Meter (YCDC Water)

Water Tariff			Meter					
Fixed	Volumetric	No Response		Existing			no	No Response
				Working				
				Yes	No	No Response		
30.6%	52.6%	16.8%	62.7%	93.9%	5.9%	0.2 %	20.6%	16.7%

Source: 2012 JICA-HIS

3.3.4 Water Use Category

Number of connections in 2011 for various water use categories is shown in Table below. Out of the 205 thousands connections, 90 % is for domestic, 6.7 % is for commerce and 0.6 % is for department. Connections for religious facilities are not counted in the above Figures. Meters are installed in case of about 70% connections.

Table 3.15 Number of Connections by Water Use Category in 2011

	Domestic	Commerce	Department	Foreign (FE)	Total
Number					
Number of Connection	187,827	13,684	1,168	2,841	205,520
1) Metered Connection	132,890	10,959	360	337	144,546
2) Fixed Charge Connection	54,937	2,725	808	2,504	60,974
Percentage					
Total	91.4	6.7	0.6	1.4	100
1) Metered Connection	64.7	5.3	0.2	0.2	70.4
2) Fixed Charge Connection	26.7	1.3	0.4	1.2	29.6

Source: JICA Study Team

Water consumption is estimated from the metered amounts; average water consumption calculated from the metered connections is applied to un-metered connections. Total water consumption is calculated as 187,500 m^3/day (41 MGD), out of which 60 % is for domestic use and 40 % is for non-domestic use.

Table 3.16 Water Consumption by Water Use Category in 2011

Category	Domestic	Commerce	Department	Foreign (FE)	Total
Annual Consumption (m^3)	40,747,238	11,305,420	15,732,895	650,224	68,435,777
Average Daily Consumption (m^3)	111,636	30,974	43,104	1,782	187,496
Average Daily Consumption (MGD)	25	7	10	0	41
Percentage	60	17	23	1	100

Source: JICA Study Team

Table below shows connection numbers in 2000 (2002 JICA-M/P) and increase in figures in 2011 compared to 2000. Number of connection increased by 93,205 while number of metered connections increased by 118,894 from only 25,652 in 2000.

Table 3.17 Number of Connections by Water Use Category in 2000 and Increased Number from 2000 to 2011

	Domestic	Commerce	Department	Foreign (FE)	Total
Connection in 2000					
Number of Connection	104,632	6,411	1,272		112,315
1) Metered Connection	22,612	2,939	101		25,652
2) Fixed Charge Connection	82,020	3,472	1,171		86,663
Increase in Number during 2000-2011					
Number of Connection	83,195	7,273	(104)	2,841	93,205
1) Metered Connection	110,278	8,020	259	337	118,894
2) Fixed Charge Connection	(27,083)	(747)	(363)	2,504	(25,689)

Note: Refer Figure 3.57 for the data of the year 2011
Source: JICA Study Team

3.3.5 Supplied Quantity and Non-Revenue Water Quantity

(1) Supplied Quantity

Accurate estimation of supplied water is rather difficult due to non-existence of source meters and absence of water meters for a large number of customers. Nevertheless, YCDC estimates supplied quantity as 123 MGD in 2011, about 75 % of the total water available at source.

Table 3.18 Supplied Quantity from YCDC Water in 2011

Source	Supplied Quantity	
	MGD	1,000 m^3/day
Water Source Quantity		
Reservoirs	140	636
Tube Wells (625 pumps)	20	91
Total	160	727
Supplied Quantity		
From Gyobyu Reservoir (24 hours continuous supply)	16.8	76
From Hlawga and Phugyi Reservoirs (24 hours continuous supply)	56.1	255
From Nyaunghnapin water treatment plant(Ngamoeyeik Reservoir)	30.4	138
Tube Wells	20	91
Total	123.3	561

Source: YCDC

Supplied amount is shown in Table below, which was measured in 2001 using portable flow meters (2002 JICA-M/P).

Table 3.19 Supplied Quantity from YCDC Water in 2011 (2) Using Measured Data in 2001

Source	Supplied Quantity		Distribution Means	Data Source
	MGD	m^3/day		
From Gyobyu Reservoir	27	121,330	Gravity	Measured in 2001
From Hlawga No 1	9	42,047	Pump No 4	Measured in 2001
From Hlawga No 2	41	187,439	Pump No 1 and No 4	Measured in 2001
From Nyaunghnapin WTP	30	136,380	2 pumps	Estimated in 2012
Tube Wells	8	36,368		Refer below
Total	115	523,564		

Source: JICA Study Team

Table 3.20 Supplied Quantity from Tube Wells

Number of Tube Wells	Total Capacity	Number of Working Tube Wells	Estimated Working Capacity	Actual Supplied Quantity assuming 14 hours operation per day
645	19.901	414	12.8 MGD	7.5=(8MGD)

Source: JICA Study Team

Supplied quantity is estimated at around 120 MGD from the above two estimates, which are similar, 115 and 123 MGD, about 72 to 77 % of the total capacity.

(2) Non Revenue Water Quantity

1) Leakage Rate

Leakage quantity is difficult to estimate due to lack of accurate supplied and consumed quantities. However, leakage is believed to be very high because a) many large-scale leakages are frequently observed everywhere in the city and b) most of the pipes were laid more than 50 years ago.

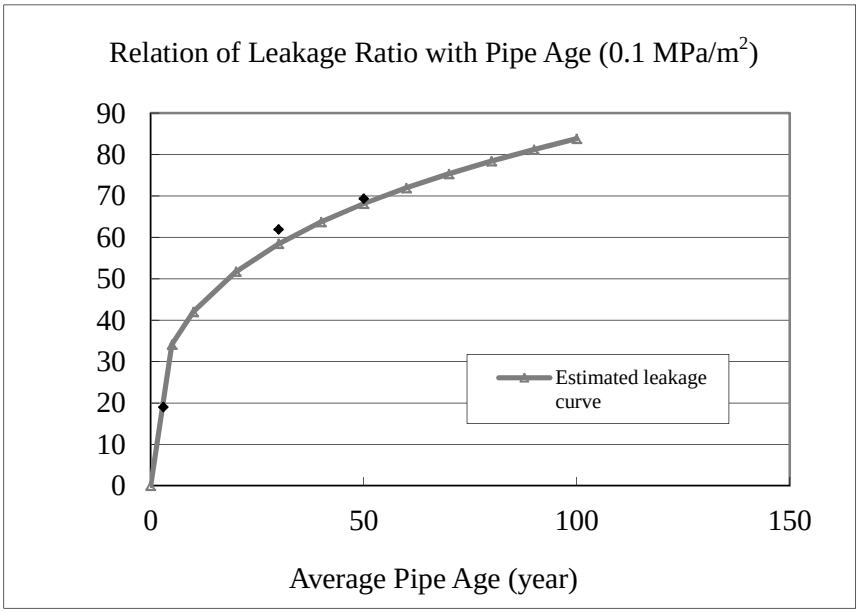
Leakage was measured for three pilot areas in 2002 JICA-M/P and result obtained is as shown below.

Table 3.21 Leakage Rate in the Pilot Areas (2002)

Pilot Area	Water Pressure (kgf/cm^2)	Leakage Rate (%)	Pipe Age (years)
Insein	0.7	13.3	3
Yankin	0.95	58.8	30
Tarmwe	0.3	20.8	50

Source: 2002 JICA-M/P

Leakage rate is known to be linked with pressure and pipe age. Firstly, measured leakage ratios were converted as those of observed 1.0 kgf/cm^2 (0.1 MPa). Then, graph shown below was developed, indicating leakage rate vs. pipe age.



Source: 2002 JICA-M/P

Figure 3.20 Relation of Leakage Ratio with Pipe Age (0.1 MPa)

Average pipes age is 50 years based on YCDC pipe age data so that leakage ratio is broadly estimated as 65 % when pressure is 0.1 MPa. Average water pressures are again broadly estimated as 0.07～0.08 MPa using the measured data in 2001. Considering this pressure, average leakage rate in 2012 can be said as 50%.

2) Non Revenue Water Rate

Previously revenue water quantity was estimated as 41 MGD while supplied quantity was estimated as 120 MGD. So non-revenue water is calculated as 79 MGD or 66 % as shown below.

Water balance in case of Yangon is shown below.

Table 3.22 Water Balance by IWA Definition (Referred to IWA)

System Input Volume 120 MGD 100% (Accurate data is not available due to the lack of bulk meters and house meters)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Billed amount (Metered)	Metered	26 MGD	41 MGD (Est.) 34%	Revenue Water
			Billed Unmetered Consumption	Billed amount (Unmetered)	Estimation	15 MGD		
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Unbilled amount (Metered)	Unknown	19 MGD	79 MGD (Est.) 66%	Non-Revenue Water
			Unbilled Unmetered Consumption	Free of Charge、YCDC business	Unknown			
	Water Losses	Commercial Losses	Unauthorized Consumption	Illegal extraction, others、	Unknown			
			Customer Meter Inaccuracies and Data Handling Errors	Customer Meter Inaccuracies and Data Handling Errors				
		Physical Losses	Leakage on Transmission and Distribution Mains	Volumes lost through leaks from transmission and distribution pipeline	50% (Est.)	60 MGD		
			Leakage and Overflows from the Utilities Storage Tanks	Volumes lost through leaks from mains, service reservoirs				
			Leakage on Service Connections up to the Customer Meter	Volumes lost through leaks from service pipeline upstream,				

Source: JICA Study Team

High non-revenue seemingly results from the followings;

Leakage due to old pipes

Overflow from Yegu P/S when power supply is off due to non-closure of inlet valves

Free water to Religious Facilities

Customer meter malfunction

Unpaid customer

Illegal connection

3.4 Existing Water Supply System (YCDC)

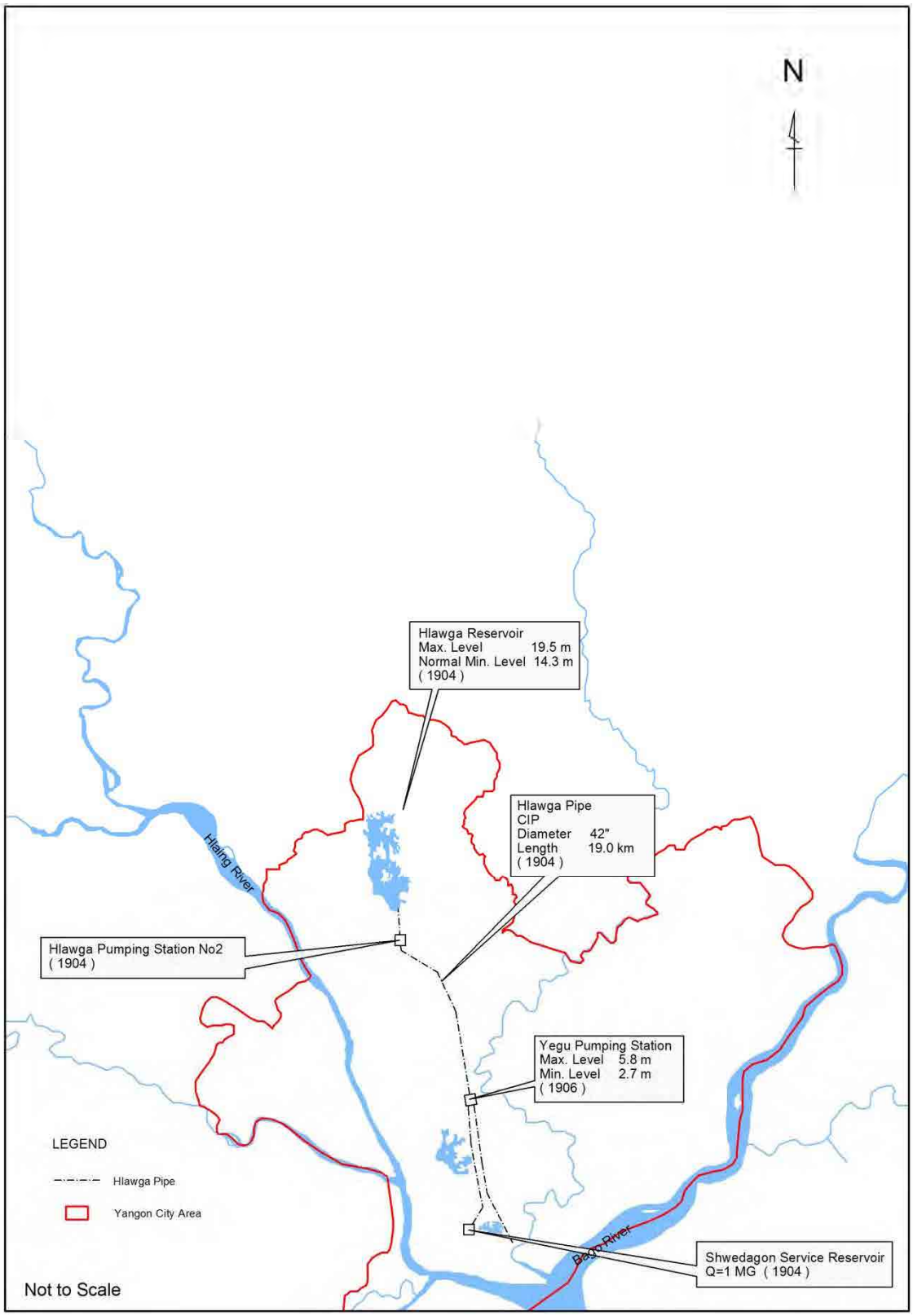
3.4.1 History of Water Supply System Development

In 1842, waterworks in Yangon city which has history of 170 years started supplying water to served area of 0.04 miles^2 (Approximately 10ha) by thirty (30) shallow wells. Since waterworks started supplying water, the waterworks reached to the present condition through several expansions. The history of main developments is shown below and outline of the existing water supply system is shown in the Figures 3.21 to 3.24.

Table 3.23 History of Main Development of Waterworks

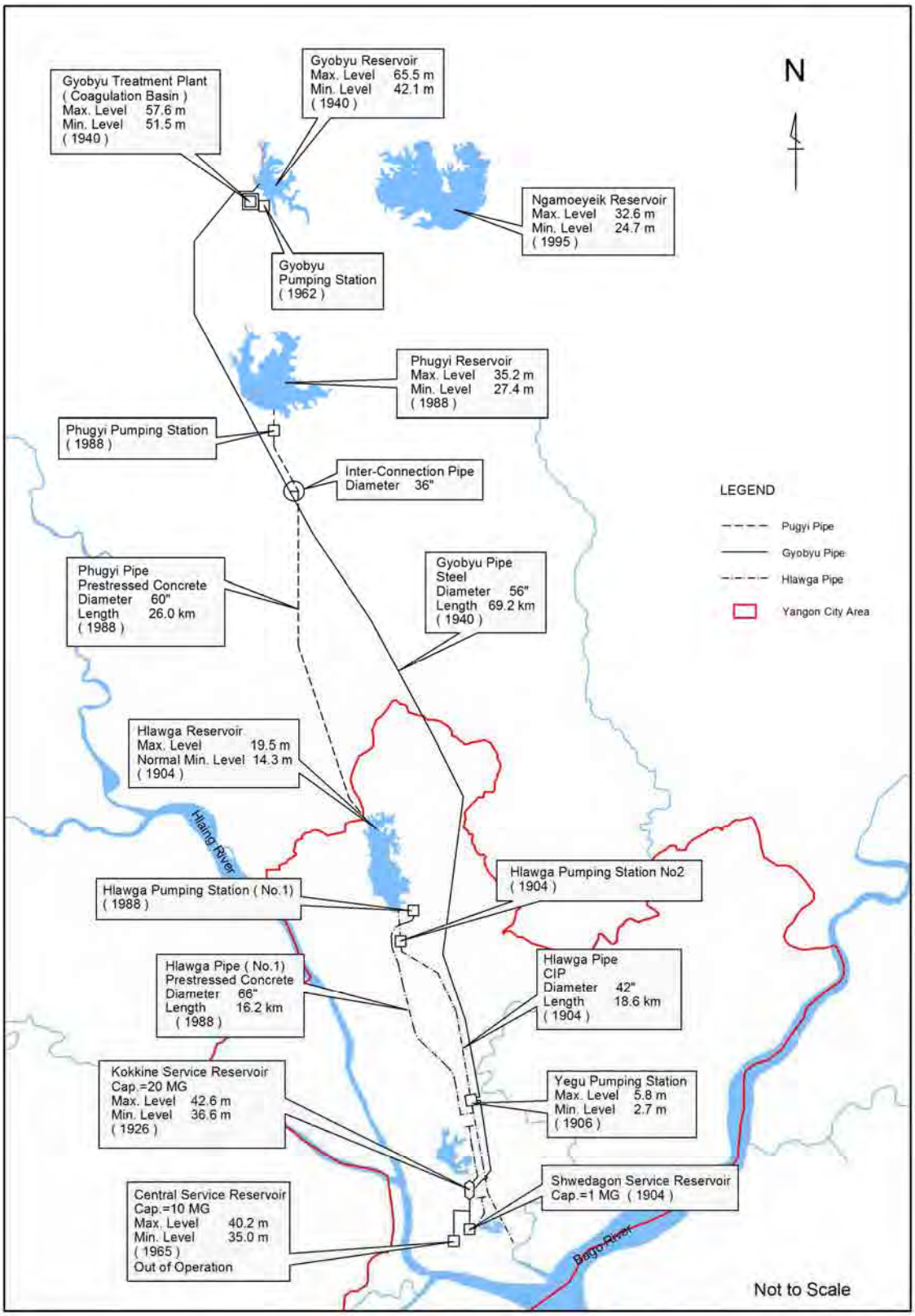
Year	Development History
1879	Commencement of water supply to the size of 35,000 people from the water source of Kandawgyi lake
1884	Implementation of water supply to the city from Inya lake
1894	Construction of Shwedagon S/R (4,540 m^3)
1904	Population served was increased to 65,000 by completion of Hlawga project (Term-1: completion in 1904, term-2: completion in 1921-24) and Shutdown of intake from Kandawgyi lake and Inya lake.
1906	Construction of Yegu P/S and started transmission of water to Shwedagon S/R and water supply to the whole Yangon city.
1925	Construction of Kokine S/R This reservoir was connected to Shwedagon S/R and supplied water to western and eastern area in addition to existing served area in the city.
1940	The capacity of water supply met with the increased demand by completion of Gyobyu R. project.
1965	Construction of Central S/R Accident of water leakage occurred at the time of waterproofing test in 1967. This reservoir has not been used since 1967.
1989	Completion of a part of Phugyi R. project (1973-89) Commencement of water transmission to Hlawga reservoir
1992	Completion of transmission pipe with diameter of 1,650 mm in Phugyi R. project The water supply amount in Yangon city from Gyobyu, Hlawga, Phugyi and deep wells managed by YCDC increased to 385,900 m^3/day.
2000	Commencement of water supply with amount of 4,500 m^3/day to Dala TS by completion of Yangonpauk WTP.
2005	Commencement of water supply to nine (9) townships in eastern and southern area by completion of term-1 of the project on Nyaunghnapin WTP with capacity of 204,500 m^3/day which has water intake in Ngamoeyeik R.
2009	Commencement of water supply of 9,000 m^3/day to South Dagon TS by completion of South Dagon WTP project (Completion of No. 1 water treatment plant in 2008 and No. 2 in 2009) Commencement of water supply of 4,500 m^3/day to industrial complexes and surrounding residence in Hlaing Thar Yar TS by completion of Thaephyu WTP
2012	Scheduled completion of term-2 with capacity of 204,500 m^3/day which is under construction on the project on Nyaunghnapin WTP and plan to supply water to same area as term-1

Source: YCDC



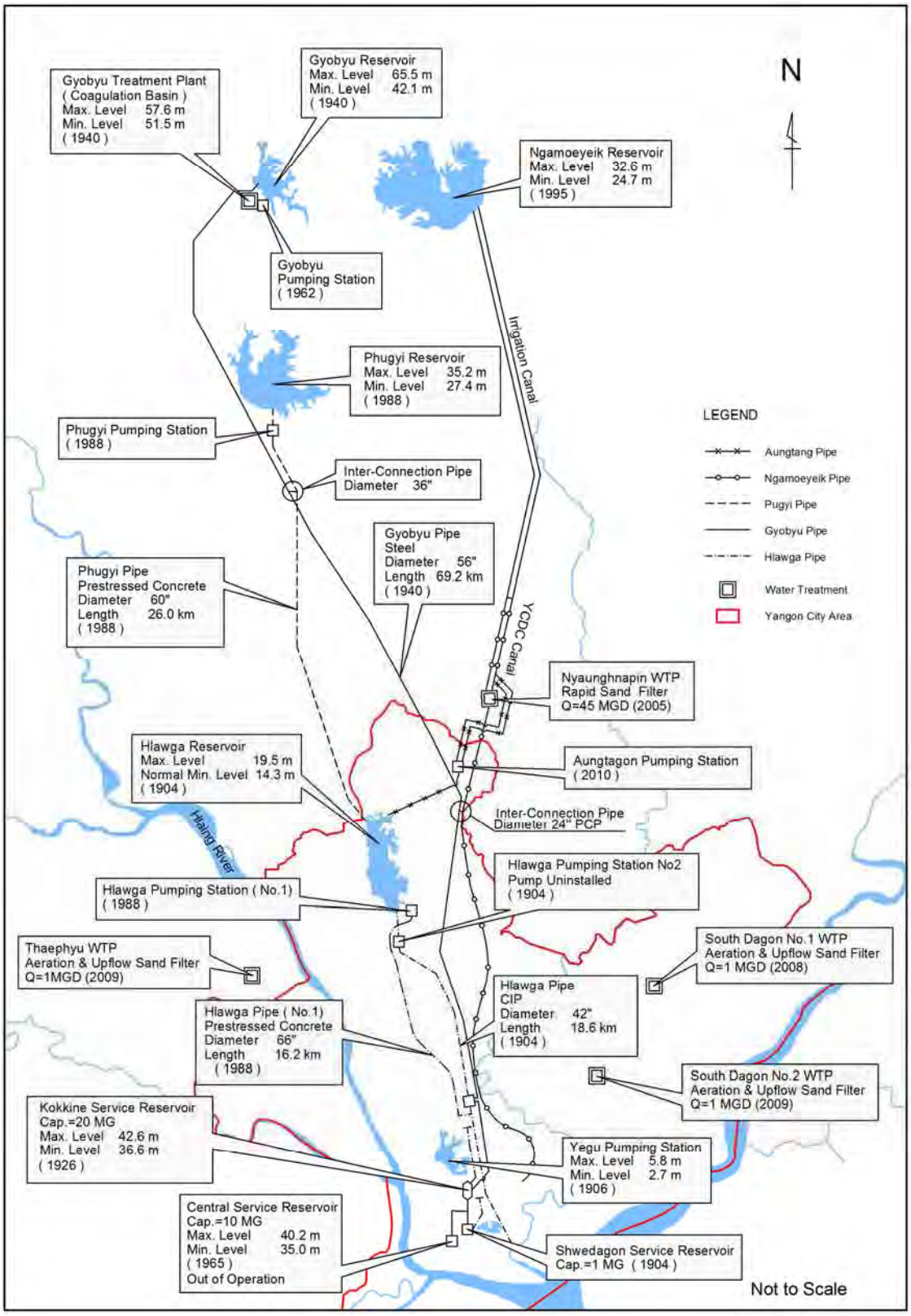
Source: JICA Study Team

Figure 3.21 Water Supply System (1906)



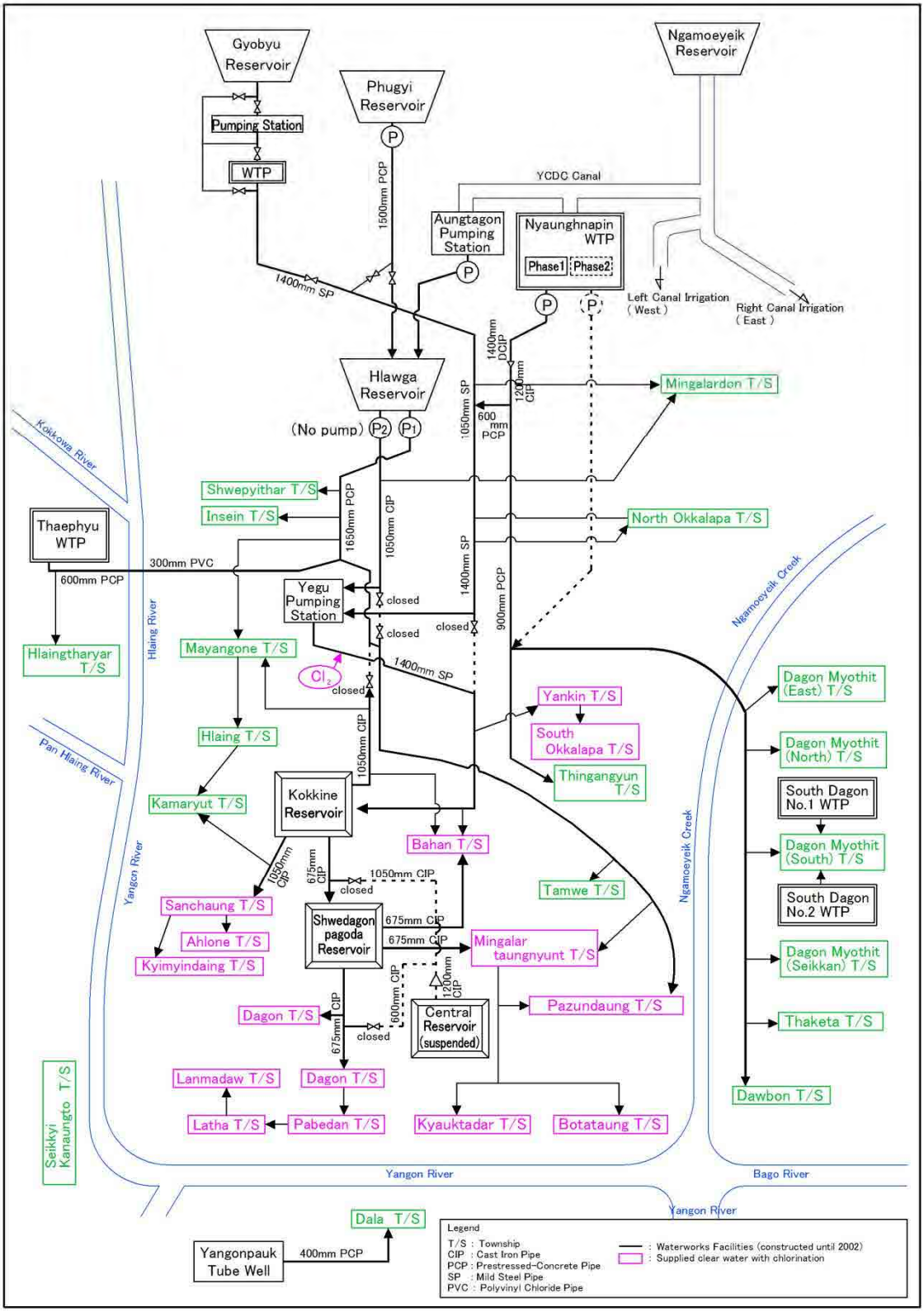
Source: JICA Study Team

Figure 3.22 Water Supply System (2002)



Source: JICA Study Team

Figure 3.23 Water Supply System (2011)



Source: JICA Study Team

Figure 3.24 Detailed Drawing of Water Supply System (2012)

3.4.2 Water Supply Sources

Table 3.24 shows the list of current water supply sources based on data from the 2012 Yangon City Development Conceptual Plan. Current water supply sources are classified as surface water source stored in reservoirs, tube wells from groundwater, and others. The current water capacity is at 933,000 m^3/day (205 MGD) including 205,000 m^3/day (45 MGD) capacity generated by the second stage of Ngamoeyeik to start operation in 2013.

Table 3.24 List of Current Water Sources for Water Supply in Yangon City

Name	Water Supply Capacity		Remark
	m^3/day	MGD	
Gyobyu R. (Surface water)	123,000	27	YCDC
Phugyi R. (Surface water)	245,000	54	YCDC
Hlawga R. (Surface water)	64,000	14	YCDC
Ngamoeyeik (Surface water: First stage)	205,000	45	MOAI
Ngamoeyeik (Surface water: Second stage)	205,000	45	Operated by MOAI from 2013
Tube Well (Underground)	73,000	16	The source quantity is equivalent to 24 hour pumping and includes wells out of order.
Others (Treatment Plant for ground water sources)	18,000	4	The source quantity is equivalent to 24 hour pumping
Total	933,000	205	

Source: JICA Study Team

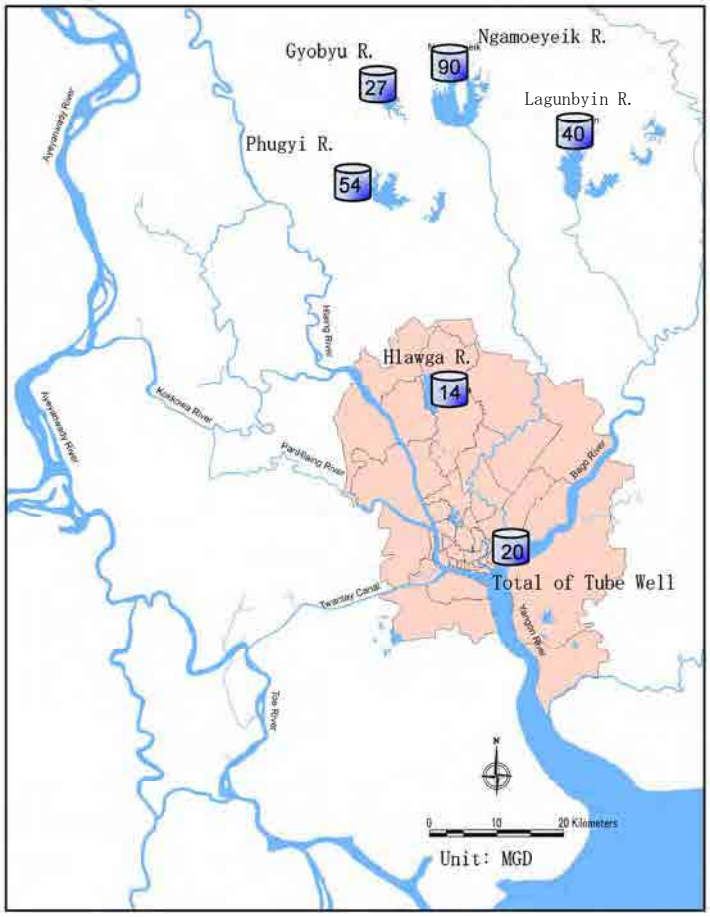
(1) Surface Water (Reservoir)

The present surface water sources are mainly reservoirs (except for wells) of Gyobyu, Phugyi, and Hlawga). These water supply reservoirs are operated and managed by YCDC. Ngamoeyeik Reservoir has been constructed and managed by MOAI. Figure 3.25 shows the map of current water supply sources around Yangon City and their water amount.

Table 3.25 List of Surface Water Reservoirs and Their Salient Features

No	Items	Gyobyu (YCDC)	Phugyi (YCDC)	Hlawga (YCDC)	Ngamoeyeik (MOAI)
1	Duration of Construction	1937-1940	1973-1992	1900-1904	1992-2013
2	Location	Tyeikkyi Township	Myawbi Township	Mingalardon Township	Hlaegu Township
3	Catchment Area	33.41 km²	70.63 km²	27.2 km²	414.4 km²
4	Water Surface Area	7.25 km²	17.63 km²	11.4 km²	44.52 km²
5	Effective Capacity	38 x 10^6 m³	91 x 10^6 m³	48.2 x 10^6 m³	20.7 x 10^7 m³
6	Total Capacity	75 x 10^6 m³	10.4 x 10^7 m³	54.5 x 10^6 m³	22.2 x 10^7 m³
7	High Water Level	66 m	36 m	19 m	32.6 m
8	Low Water Level	42 m	27 m	14.3 m	24.7 m
9	Top of Spill well	66 m	35 m	19 m	33.5 m
10	First Intake Level	61 m	27 m	17 m	27.4 m
11	Second Intake Level	55 m	22.5 m	15 m	22 m
12	Third Intake Level	42 m	-	13 m	-
13	Water Supply Capacity	123,000 m³/day	245,000 m³/day	63,600 m³/day	409,000 m³/day

Source: Ministry of Agriculture and Irrigation (MOAI)



Source: JICA Study Team

Figure 3.25 Current Water Supply Sources Around Yangon City and Water Amount

(2) Groundwater

1) YCDC tube wells

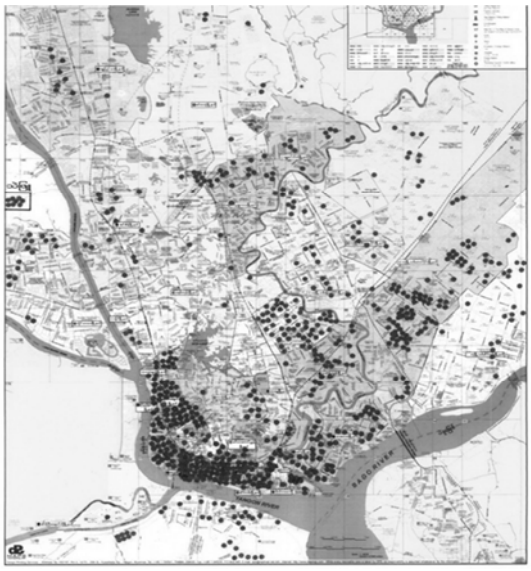
YCDC has 645 tube well pumps with maximum yield amount of 20 MGD. Of these pumps, 414 pumps are in order. Assuming yielding capacity of 12.8 MGD and 14 hours operation, YCDC is supplying about 7.5 MGD water through these tube wells.

Table 3.26 YCDC Tube Wells

Number	Diameter of Tube Well						Total	Yielding Amount	Estimated Yielding Amount
	2"	4"	6"	8"	10"	12"		MGD	MGD
Total Pump	142	139	111	191	44	18	645	19.901	
Pump in Order	2	71	101	191	36	12	414	12.8	8

Source：JICA Study Team Estimate

YCDC tube wells are mostly concentrated in the CBD area and a few of these wells are in the central hilly areas as shown in Figure below.



Source: YCDC

Figure 3.26 Location of YCDC Tube Wells

2) Estimation of Groundwater Balance

Groundwater balance in Yangon is estimated and description is made here. Conditions are defined for the estimation using the 2012 JICA Household Survey data and is listed below.

Population using groundwater wells is 3,000,000.

Per capita water consumption is 63 liters on average.

Ratio of domestic use and non-domestic use is 60: 40. (from records of YCDC water consumption)

Amount of groundwater abstraction by YCDC is 8 MGD.

Groundwater development potential is 83 MGD. (from 2002 JICA water master plan)

YCDC and the private houses/establishments are using a total of 79 MGD of groundwater, which is almost approaching the groundwater development potential of 83 MGD. If additional groundwater would be used in future to meet the increasing water demand, this will lead to exceeding the total groundwater potential. Eventually, lowering of groundwater table is expected and further resulting into land subsidence.

Table 3.27 Groundwater Balance in Yangon (MGD)

Groundwater Potential	Abstracted Amount		Balance
	YCDC	Private	
83	8	71	4

Source：JICA Study Team
Note: Groundwater potential was estimated in 2002 JICA-M/P

3.4.3 Existing Facilities (Intake Towers, Intake Pumping Stations, Conveyance Pipeline)

The major intake towers and intake P/Ss which are available currently are composed of Gyobyu intake tower constructed in 1939, Gyobyu intake P/S in 1962, Hlawga P/S in 1980, Phugyi intake tower and Phugyi intake P/S in 1988, and Aungtagon P/S in 2011.

Type of major intake pumps and transmission/ distribution pumps is double suction volute, which has high efficiency and generally used at the water works all over the world. Horizontal type of pump is used in almost all pumping stations, except Hlawga pumping station where the pump is vertical shaft type. Easy O and M works are expected because series of equipment is not many. Surge tank and check valve with counter weight/ or hydraulic are installed due to flat and long transmitted pipe line in the pumping stations.

Major equipment list, problems, and issues are shown in the following section.

(1) Gyobyu intake tower and pumping station

The capacity of this reservoir is 123,000 m^3/day (27 MGD). It was constructed in 1940 and is located at about 64 kilometers (40miles) north side from Yangon. Raw water taken by intake pipe is transmitted to Yegu pumping station through transmission steel pipe with diameter of 1400 mm, and distributed to downtown by booster pumps. In order to handle high turbidity time to time, the coagulation sedimentation facility is placed in the downstream of reservoir.

Current problems and issues are listed below.

- Raw water quality is not so bad, but occasionally blue-green algae occur in the reservoir.
- All pump facilities have become older.
- Pumps in Gyobyu reservoir have not been operated since May 2011, and water generally has been transmitted by gravity.
- Absence of water level gauges, water flow meters and pressure gauges which are required for pump operation.
- Transmission pipeline between Gyobyu reservoir and Yegu pump station was installed in 1940 and is very old cast iron pipe. Air valves and its maintenance valves installed in the pipeline are not able to open and close.

Table 3.28 Major Equipment in the Existing Gyobyu Intake Tower (1939)

Item name	Specification	Number (D: duty, S: standby)	Remarks
Screen	Coarse screen, opening 100 mm	3	
Intake valve	Manual butterfly valve Dia. 1,400 mm	6	Made in British, intake from each water level

Source：YCDC

Table 3.29 Major Equipment in the Existing Gyobyu Pumping Station (1962)

Item name	Specification	Number (D: duty, S: standby)	Remarks
Intake pump	Horizontal double suction volute 3310 m^3/ hr x 13.7 m x 184 kW	2D + 1S	Made in France
Maintenance valve	Manual sluice valve Dia. 1,400 mm	1	Made in British, in 1939
Maintenance valve	Manual sluice valve Dia. 1,400 mm	2	
Maintenance valve	Manual sluice valve Dia. 600 mm	6	
Check valve	Swing type, Dia. 600 mm	3	

Source：YCDC

(2) Phugyi intake tower and pumping station

The capacity of this reservoir is 245,000 m^3/day (54 MGD), and it was constructed in 1992. Raw water taken by intake pipe is transmitted to Hlawga reservoir through transmission concrete pipe having diameter of 1500 mm.

Current problems and issues are shown as the following.

- All pump facilities have become older.
- Absence of water level gauges, water flow meters and pressure gauges which are required for pump operation.

Table 3.30 Major Equipment in the Existing Phugyi Intake Tower (1988)

Item name	Specification	Number (D: duty, S: standby)	Remarks
Screen	Coarse screen, opening 50 mm	3	
Intake valve	Motorized butterfly valve Dia.1500mm	3	Made in British, intake from each water level

Source：YCDC

Table 3.31 List of Major Equipment in the Existing Phugyi Pumping Station (1988)

Item name	Specification	Number (D: duty, S: standby)	Remarks
Maintenance valve	Motorized butterfly valve	5	
Maintenance valve	Motorized butterfly valve Dia. 900 mm	6	
Intake pump	Horizontal double suction volute 5160 m^3/ hr x 24 m x 450 kW	2D + 1S	Made in Japan
Check valve	Hydraulic type, Dia. 900 mm	3	
Drain pump 1	1.5kW	1	
Drain pump 2	Diesel engine	1	
Flow meter	Venturi type	1	
Pressure meter	-	1	Need calibration

Source：YCDC

(3) Hlawga reservoir and pumping station

The capacity of this reservoir is 63,600 m^3/day (14 MGD), and it was constructed in 1906. Capacity of pumping station is 309,000 m^3/day, which is capable of handling 245,000m^3/day from Phugyi reservoir and 64,000 m^3/day from Hlawga itself. Raw water is transmitted and distributed by No. 1 and No. 2 pumping station.

Current problems and issues are listed as the following.

- All pump facilities have become older.
- Water level gauges, water flow meters and pressure gauges, which are required for pump operation, are not available.
- All transmission pumps in Hlawga No.2 have been dismantled, and water is transmitted by gravity flow at present.
- Due to occurrence of drought in 2010, Aungtagon pumping station is constructed for recovery of water level of Hlawga reservoir. Currently, surplus water from Ngamoeyeik reservoir is also transmitted to Hlawga reservoir by pumps.
- Water leakage sometimes occurs from concrete pipe of diameter 1650 mm in Hlawga No. 1.

No.1 pumping station

The number of distribution pumps with the capacity of 4,980 m^3/hr is two, and pumps are regularly operated. The maximum distribution capacity is 239,000 m^3/day and this capacity is almost equal to the capacity of Phugyi reservoir (245,000 m^3/day). Raw water taken by intake gate doesn't go through Yegu pumping station, but is directly distributed to northeast area and east area through the distribution pipe (concrete pipe) having diameter of 1650 mm from this pump station.

Table 3.32 Major Equipment in the Existing Hlawga Pumping Station (1980)

Item name	Specification	Number (D: duty, S: standby)	Remarks
Inlet gate	Manual sluice gate	5	One is broken, much leakage.
Maintenance valve	Motorized butterfly valve Dia. 750 mm	8	One is under repair.
Intake pump	Vertical double suction volute 4980m^3/ hr x 54 m x 1000 kW(VFD)	2D + 2S	Made in Japan
Check valve	Hydraulic type, Dia. 750 mm	4	
Flow meter	Venturi type	1	
Pressure meter	-	1	Broken
Surge tank system	Steel tank, Compressor 15 kW	2	Made in Japan (compressor)

Source：YCDC

No.2 pumping station

This pump station is being shut down now. The transmission water amount is the remaining water after deduction of distribution amount from No. 1 pump station (same as capacity of 64,000 m^3/day in Hlawga reservoir). Raw water taken from intake tower is transmitted to Yegu pumping station through transmission pipe (cast iron pipe with diameter of 1,050 mm) by gravity flow.

(4) Ngamoeyeik reservoir

This reservoir was constructed by MOAI in 1995, and is located at upstream of Pazundaung creek where Ngamoeyeik creek and Mahoe creek meet about 48 kilometers (30 miles) north of Yangon city. Raw water from intake tower of Ngamoeyeik reservoir is transmitted to Nyaunghnapin WTP through irrigation canal. The capacity of this reservoir at the existing phase-1 is 204,500 m^3/day (45 MGD).

Table 3.33 Major Equipment in the Existing Ngamoeyeik Intake Tower (1995)

Item name	Specification	Number (D: duty, S: standby)	Remarks
Screen	Coarse screen	1	
Intake Valve	Manual butterfly valve Dia. 1,500mm	2	For the lake bottom and medium water level, Made in Japan,

Source：YCDC

Current problems and issues are listed below

- Although Ngamoeyeik creek which MOAI has is covered with sand/mud and the canal should be dredged, implementation work will be difficult during operation of WTP.

(5) Aungtagon Pumping Station (P/S)

Aungtagon P/S was constructed in 2010, where reserve water from Ngamoeyeik reservoir is stored temporarily, and water is transmitted to Hlawga reservoir in case of emergency in order to recover water level in Hlawga reservoir. Grit chamber (raw water reservoir), P/S including 3 pumps, power receiving facilities including transformer are constructed. Problems and issues in particular are not found now.

Table 3.34 Major Equipment in the Existing Aungtagon Pumping Station (2011)

Item name	Specification	Number(D: duty, S: standby)	Remarks
Inlet gate	Manual sluice gate	5	
Intake pump	Horizontal double suction volute 3780m^3/ hr x 40 m x 500 kW	2D + 1S	Made in China
Maintenance valve	Manual butterfly valve Dia. 700 mm	6	
Check valve	Counter weight type Dia. 700 mm	3	
Surge tank system	Steel tank, Compressor 7.5 kW	1	

Source：YCDC

3.4.4 Water Treatment Plant (WTP)

These are six WTPs in the existing water supply systems. It includes Gyobyu WTP with a capacity of about 123,000 m^3/day along with Gyobyu intake pumping station, Thaephyu and Yangonpauk WTPs with capacity of about 4,500 m^3/d established by YCDC in the west suburb in 2000, Nyaunghnapin WTP having capacity of about 204,500 m^3/day constructed by YCDC in the north east in 2005, South Dagon No. 1 in 2008 and 2 WTP in 2009 with capacity of about 4.500 m^3/day each. In 2013, expanded Nyaunghnapin WTP project having capacity of about 204,500 m^3/d (45 MGD) in phase II will be completed by YCDC.

In the oldest Gyobyu WTP, water is treated by sedimentation process without coagulant, whereas in Nyaunghnapin WTP, water is treated by flocculation, sedimentation, and filtration process. At WTPs, which uses groundwater as raw water, aerated cascade and filtration process for Fe removal is applied for water treatment. Currently, chlorination system is not used in any of the WTPs, chlorine is injected in only Yegu booster P/S.

Table 3.35 Design Condition of WTP

Item	Gyobyu	Nyaunghnapin (First stage)	Yangonpauk	South Dagon No.1	South Dagon No.2	Thaephyu
Design flow	123,000m^3/d	204,500m^3/d	4,500m^3/d	4,500m^3/d	4,500m^3/d	4,500m^3/d
Water source	Gyobyu reservoir	YCDC canal from Ngamoeyeik reservoir	Tube well (3 wells)	Tube well (9 wells)	Tube well (10 wells)	Tube well (6 wells)
Treatment process	Flocculation and Sedimentation	Flocculation, Sedimentation, and Filtration	Aeration and Up flow Filtration	Aeration and Up flow Filtration	Aeration and Up flow Filtration	Aeration and Up flow Filtration
Coagulant	-	Aluminum sulfate	-	-	-	-
Chlorine dosing	-	-	-	-	-	-
Construction year	1940	2005	2000	2008	2009	2000
Distribution area	Distribution to Mingalardon township, and transmission to Yegu pumping station	Transmission to Yegu pumping station partially, and distribution to 9 townships of Yangon east area	Dala	South Dagon	Dagon South	Hlaing Thar Yar
Remarks		Expanded 204,500 m^3/d flow as second stage is under construction.				

Source：YCDC

(1) Gyobyu WTP

The oldest Gyobyu WTP is composed of flocculation and sedimentation tanks, but currently raw water is treated without coagulation and chlorination since quality of water in source seems to be good. Treated water which is passed through 1 mm mesh screen is transmitted to Yegu booster pumping station. Over aged chemical facility including alum and chlorine have been dismantled. However, generation of algae and high turbidity occur rarely.

Problems and issues related to this WTP are listed below.

- Chlorination facility is not available.
- Installation of alum and chlorine injection facility is recommendable since it has been dismantled due to deteriorated equipment.
- Insufficiency of coagulation and sedimentation function due to damage of agitator baffle in flocculation basin.
- It is difficult for pumps to operate automatically because of non-availability of water level gauges, water flow meters and pressure gauges, timers.

List of major equipment at this WTP is presented in Table below.

Table 3.36 Major Equipment in the Existing Gyobyu WTP (1962)

Item name	Specification	Number(D: duty, S: standby)	Remarks
Inlet valve	Manual sluice gate	10	
Drain gate	Manual steel sluice gate	2	
Inlet gate for sedimentation basin	Manual steel sluice gate	8	
De-sludge valve	Manual steel sluice gate	4	
Outlet gate from sedimentation basin	Manual steel sluice gate	4	
Fine screen	Automatic drum type, Opening 1mm mesh	4	

Source：YCDC

(2) Nyaunghnapin WTP

Nyaunghnapin conventional WTP is the first and largest plant as of now which is designed and constructed by YCDC. Therefore, they are considered as the most important facilities with capacity of about 204,500 m^3/ d (45 MGD). Water from Ngamoeyeik reservoir is transmitted to Nyaunghnapin reservoir through irrigation open canal. Treatment process used in this WTP is conventional flocculation, sedimentation, and rapid filtration system.

Regarding treated water quality, turbidity of treated water quality is about 5 NTU against turbidity of about 45 NTU of raw water. However, treated water is not adapted for drinking since total coliforms of more than 16 MPN/mL and fecal coliforms are detected both in the treated water and raw water.

Biological test data of Nyaunghnapin WTP Raw water and Treated water

Test date: Dry season (11 September, 2012) and Rainy season (11 March, 2013)

- Raw water: Total coliforms: Detected, Fecal coliforms: Detected
- Treated water: Total coliforms: Detected, Fecal coliforms: Detected

Reference

Drinking water quality standard (Japan)

Coliforms (including Fecal coliforms): Not Detected

WHO Guideline for drinking water quality (4th)

Total coliforms and Fecal coliforms are not detected in 100ml sample

Regarding coagulant, flake type of aluminum sulfate imported from China have been used, but it has already changed to liquid type imported from Malaysia for reducing toughness of operator works. One veteran engineer for jar test is working in WTP, and coagulation seems to be well.

Treated water is distributed to the 9 townships of central and south east area of town, extreme length of transmission/ distribution pipes is 38.8 km long.

Construction of expanded WTP with capacity of about 204,500 m^3/day (45MGD) will be completed in 2013 by YCDC. After completion, total treatment capacity of 409,000 m^3/day (90MGD) will be available.

1) Nyaunghnapin phase I WTP

Total four distribution pumps including one standby with capacity of 204,500 m^3/day are regularly operated. Treated water is directly distributed to the central and east area of Yangon city through the distribution pipe (cast iron and concrete pipe) with diameter of 1,650 mm to 400 mm from this pump station.

2) Nyaunghnapin phase II WTP

WTP and distribution pipes are under construction with same capacity as in phase I. On completion, treated water from this WTP will be distributed to the east area of Yangon city directly through the distribution pipe (HDPE pipe) with diameter of 1,200 mm to 400 mm by distribution pumps.

Problems and issues related to this WTP are as follows.

(Raw Water Conveyance)

(Water quality)

- Chlorination facility is not available.
- Comparing with reservoir, high turbidity and high risk of contamination by agricultural chemical due to transmission of water by open channel.
- Poor level of Jar test is carried out manually since YCDC do not have adequate instrument for jar test.

(WTP facility)

- Water level difference between flocculation basin and sedimentation basin is large. It results into destruction of the formed flocs when water flows from flocculation basin to sedimentation basin. However, the situation has improved during the ongoing phase II.
- Algae are grown and adhere to the wall of sedimentation basin, filtration basin and clear water tank. It is necessary to provide adequate pre-chlorination and intermediate chlorination facilities.
- In the dual filtration basin , flow meters and pressure gauges for feed and backwash water are not installed and appropriate control of water flow and water pressure cannot be carried out. It results in damage of filter, carryover of filtration media.
- Repair/or replacement of gates related to rapid sand filters is needed, since it is impossible in case of many gates to stop inflow/ outflow.
- Repair of surface wash pipes are needed.
- Poor back washing condition of filters due to shortage of capacity of back wash drainage valve. Realignment of wash system is needed soon.
- Generation of mud ball due to insufficient washing of filtration basin.
- Contamination due to non-slab on open channel from filtration and clear water tank is a matter of concern.

(Transmission/ distribution facility)

- Frequent damage of pumps probably due to operation outside the rated pump specification.
- Inadequacy of procurement of accessories and maintenance service.
- Blowout of ground water in transmission/ distribution pump house due to the problem of foundation work.
- Pumps have submerged because of above mentioned reason.
- Damages of pumps and valves due to large impact of water hammer by high frequency of power interruption.
- Shortage in capacity of surge tank and absence of standby compressor for preventing water hammer.

(Electrical and instrumental facility)

- Basically, absence of equipment for automatic operation mode such as pressure meter, flow meter, level meter, timer.

- Electrical power failure occurs at frequency of over 150 times per year (total 128 hours per year).
- Intake water and transmission/ distribution flow are not able to be measured or recorded due to absence of flow meters and pressure gauges.

Table 3.37 Major Equipment in the Existing Nyaunghnapin WTP (2005)

Item name	Specification	Number (D: duty, S: standby)	Remarks
Coarse Screen	Opening 100mm mesh	4	
Intake pump	Horizontal double suction volute 2841 m^3/ hr x 10 m x 110 kW	3D + 1S	Made in China
Filter inlet gate	Manual sluice gate, 450 mm W x 450 mm H	28	Made in Myanmar, much leakage.
Surface wash valve	Manual butterfly valve, dia. 150 mm	56	
Backwash valve	Manual butterfly valve, dia. 300 mm	56	
Filter outlet gate	Manual sluice gate, 600 mm W x 600 mm H	28	Made in Myanmar, much leakage.
Reservoir outlet gate	Manual sluice gate, 1,050mm W x 1,050 mm H	4	Made in Myanmar
Suction valve	Manual butterfly valve, dia. 500mm	4	
Distribution pump	Horizontal double suction volute 2,850 m^3/ hr x 72 m x 800 kW	3D + 1S	Made in China, one unit is under repair.
Check valve	Counter weight type, dia.400mm (PN16)	3D + 1S	Replaced from China made to Myanmar made.
Discharge valve	Manual butterfly valve, dia. 400mm	3D + 1S	
Compressor	50-100m^3/ min x 70m x 11kW	1	Made in China, no existence of standby
Surge tank	Steel tank 65m^3	2	Shortage of capacity
Backwash pump	Horizontal single suction volute 792m^3/ hr x 25m x 90kW	1 D + 1 S	Proposed for backwash, made in Singapore in 2012.
PAC storage tank	FRP tank、14m^3	4	Proposed in 2012
PAC supply pump	-	1 D + 1 S	Made in Turkey in 2012.
PAC injection pump	120 L/ hr x 40 m x 0.13 kW	2(1)	Made in Germany in 2012

Source：YCDC

(3) Groundwater WTP

With regard to WTPs with capacity of about 5,000 m^3/day each, they are composed of tube wells for intake, aerated cascade tanks, filtration tanks for Fe removal, and pump houses basically. In South Dagon No.1 and 2, raw water from tube wells is treated by aerated cascade and filtration process, and treated water is transmitted directly to the distribution area by distribution pumps. In Yangonpauk WTP, water from tube wells is reserved and transmitted to Dala area directly by distribution pumps because water quality is good. In Thaephyu WTP, aeration cascade and filtration facility for Fe removal are installed, but they are not used due to same reason as in case of Yangonpauk. Therefore, water is transmitted to Hlaing Thar Yar area directly. All facilities do not have chlorination system.

Problems and issues are shown as the following.

- No existence of chlorination facility.
- No existence of intake flow meter of tube wells, distribution flow meter, and pressure gauge for transmission pipe.

Table 3.38 Major Equipment in the Existing Yangonpauk WTP (2000)

Item name	Specification	Number(D: duty, S: standby)	Remarks
Tube well	Dia.300 mm x 0.75m^3/min x 7.5kW	3	
Tube well	Dia.250 mm x 0.75m^3/min x 7.5kW	4	
Tube well	Dia.200mm x 0.75m^3/min x 7. 5kW	1	
Reservoir	Civil structure 450m^3	1	2000
Reservoir	Civil structure 450 m^3	1	2012
Distribution pump	Horizontal single volute pump 160 m^3/ hr x 32 m x 22 kW	1 D	Made in Singapore, in 2000.
Distribution pump	Horizontal single volute pump 115 m^3/ hr x 40 m x 22 kW	1 D	Made in Germany, replaced in 2009.
Distribution pump	Horizontal single volute pump 120 m^3/ hr x 37 kW	1 S	Older
Distribution pump	Horizontal single volute pump —	1 S	Made in Myanmar, dismantled due to broken.

Source：YCDC

Table 3.39 Major Equipment in the Existing South Dagon No. 1 WTP (2008)

Item name	Specification	Number(D: duty, S: standby)	Remarks
Tube well	Dia.250 mm x 0.45m^3/min x 7.5kW	4	
Tube well	Dia.200 mm x 0.45m^3/min x 7.5kW	4	
Aeration cascade	Civil structure	8	
Filter	Civil structure	8	
Reservoir	Civil structure	1	
Distribution pump	Horizontal single volute pump 160 m^3/ hr x 32 m x 22 kW	1 D + 2 S	Made in China
Distribution pump	Horizontal single volute pump 114 m^3/ hr x 32 m x 18.5 kW	2 D + 1 S	Made in Singapore

Source：YCDC

Table 3.40 Major Equipment in the Existing South Dagon No. 2 WTP (2009)

Item name	Specification	Number(D: duty, S: standby)	Remarks
Tube well	Dia.250 mm x 0.6 m^3/ min x 7.5kW	10	
Aeration cascade	Civil structure	6	
Filter	Civil structure	6	
Reservoir	Civil structure	1	
Distribution pump	Horizontal single volute pump 160 m^3/ hr x 32 m x 22 kW	1	Made in China
Distribution pump	Horizontal single volute pump 160 m^3/ hr x 32 m x 22 kW	1 D + 2 S	Made in Singapore

Source：YCDC

Table 3.41 Major Equipment in the Existing Thaephyu WTP (2000)

Item name	Specification	Number(D: duty, S: standby)	Remarks
Tube well	Dia.300 mm x 0.75m^3/min x 7.5kW	1	
Tube well	Dia.250 mmx 0.75m^3/min x 7.5kW	3	
Tube well	Dia.200 mmx 0.75m^3/min x 7.5kW	2	
Aeration cascade	Civil structure	6	
Filter	Civil structure	6	
Reservoir	Civil structure	1	
Distribution pump	Horizontal single volute pump 115 m^3/ hr x 40 m x 22 kW	2 D + 1 S	Made in Germany, replaced in 2009.
Distribution pump	Horizontal single volute pump 156-186 m^3/ hr x 32-44 m x 45 kW	1 S	Made in Japan, replaced in 2009.
Distribution pump	Horizontal single volute pump —	1	Made in Myanmar, dismantled due to broken.

Source：YCDC

3.4.5 Transmission Pumping Station

Currently, Yegu booster P/S is operated as one of major transmission/ distribution facility. This is because almost all water coming from upstream meets at Yegu and is only disinfected here. Yegu P/S is composed of No. 1 old booster station installed in 1990 and No. 2 new booster station installed in 2007.

Pumps with total capacity of 187,000 m^3/day are regularly operated handling Gyobyu reservoir water amounting 123,000 m^3/day and Hlawga No. 2 P/S with 64,000 m^3/day of water from Hlawga reservoir. Water is distributed to the 3 townships (Yankin, South Okkalapa and Bahan) directly after boosting transmission pressure and chlorination, and is also transmitted to Kokine reservoir.

No. 2 booster station is constructed since enough transmission head is not secured by only No. 1 booster station, and pumps in No. 1 station is not able to transmit water to Kokine S/R. Normally only 2 duty booster pumps in No. 2 station are operated. However, in case when suction water level of tank decreases, 1 pump in No. 2 station and 2 pumps in No. 1 station are operated.

Problems and issues related to transmission pumping station are listed below.

- Water level gauge in suction tank, water flow meter and water pressure gauge for transmission/ distribution which are required for pump operation, and chlorine dosing meter and residual chlorine meter are not installed.
- Absence of standby electro chlorinator and standby supplementary equipment such as chemical pumps, though chlorination is only implemented in the Yegu booster P/S. Further, membrane including electro chlorinator is not being maintained adequately such as chemical cleaning.
- Implementation of chlorine demand test and confirmation of the necessary specification of

chlorine facilities are recommendable since chlorine dosing rate depend on the condition of water quality and water temperature.

Table 3.42 Major Equipment in the Existing Yegu old Booster Pumping Station (1990)

Item name	Specification	Number (D: duty, S: standby)	Remarks
Maintenance valve	Manual butterfly valve	14	
Booster pump	Horizontal double suction volute $1982m^3$/ hr x 44 m x 275 kW	2D + 5S	Five are under repair, Made in France
Check valve	Swing type	7	

Source：YCDC

Table 3.43 Major Equipment in the Existing Yegu New Booster Pumping Station (2007)

Item name	Specification	Number (D: duty, S: standby)	Remarks
Inlet valve	Manual sluice valve	3	
Maintenance valve	Manual butterfly valve	8	
Booster pump	Horizontal double suction volute $3800m^3$/ hr x 47 m x 710 kW	1D + 3S	Made in China
Check valve	Swing type	4	
Electro chlorinator	1 – 2 ppm (Cl2)	1	Made in Thailand, 2006, Standby does not exist
Chlorine injection pump	580L/hr x 70m x 0.37kW	3(1)	Made in Germany
Acid solution mixer	1.1kW	1	Standby does not exist
Acid injection pump	0.25kW	1	Under repair, no existence of standby
Brine solution mixer	0.25kW	1	Standby does not exist
Brine injection pump	0.09kW	1	Standby does not exist
Softener	-	2	

Source：YCDC

3.4.6 Service Reservoir (S/R)

S/R has a regulating function for stable water supply. The existing S/Rs are located at three (3) places downstream of Yegu P/S, such as Kokine, Shwedagon and Central. However, Central S/R has been out of operation for 58 years since the water leakage was found in 1967 during hydraulic test after completion of construction.

Currently, Kokine and Shwedagon S/R have function to supply water to southern townships including neighborhood and old town. The outline of each S/R is described below.

Table 3.44 Outline of Service Reservoir

Name	Component
Kokine S/R	Structure: Underground type, RC Capacity: 90,920 m^3 Water level: HWL +42.7 m, LWL +36.6 m, Depth 6.1 m Inlet pipe: φ1,400 mm Steel pipe (Transmission from Yegu P/S) Outlet pipe: Transmission pipe of φ1050 mm for Shwedagon S/R, φ1,050 mm cast iron pipe for northern townships and φ1,050 mm cast iron pipe for east-south township
Shwedagon S/R	Structure: Underground type, RC Capacity: 4,546 m^3 Effective water level: +36.0 m, LWL +35.1 m, current water level: approx. 0.9 m Inlet pipe: φ1,050 mm cast iron pipe (Transmission from Kokine S/R, φ1,050 mm cast iron pipe is branched and transmitted to Central S/R) Outlet pipe: Distribution to downtown by three (3) pipes with φ675 mm cast iron
Central S/R (Out of operation)	Structure: Underground type, RC Capacity: 45,460 m^3 Water level: LWL +38.1 m, LWL +32.0 m, depth 6.1 m Inlet pipe: φ1050 mm cast iron pipe (This pipe is branched from the transmission pipe between Kokine to Shwedagon S/R and connected to Central S/R. Inlet pipe is used both as inlet and outlet, and type is φ1200 mm cast iron pipe)

Source：YCDC

The detention time of each S/R compared to daily maximum supply water of 148 MGD (673,000m^3/day) in 2011 is mentioned below. At least 8 hours of detention time is required for stable water supply.

Service reservoir	Capacity	Detention time
Kokine	90,920m^3(20MG)	3.2hrs
Shwedagon	4,546m^3(1MG)	0.2hrs
Total	95,466m^3(21MG)	3.4hrs

The detention time mentioned above is insufficient from the view point of stable water supply. Short detention time cannot respond to the peak time requirements of water uses such as in morning or evening, therefore short supply duration areas exist in the city. Capacity of two (2) S/Rs being operated has not been utilized effectively since sediment has accumulated at the bottoms due to untreated water.

The problems and issues related to S/R are listed below.

- Detention time of S/Rs is short.
- Since Central S/R has not been operated for 58 years, it needs to be rebuilt.
- Kokine S/R and Shwedagon S/R were constructed in 1925 and 1904 respectively. Both of them are aged facilities.
- Shwedagon S/R has a large water supply area compared to its small capacity. Therefore, the transmitted water is being directly distributed.

- Turbidity in S/R is high, and the bottom of S/R is covered with the sediment, S/R need to be cleaned periodically.
- Water level gauge in S/R, water flow meters at inlet/ outlet pipe and residual chlorine meter need to be installed, and it needs to carry out proper distribution management by regular monitoring.

3.4.7 Distribution Pipeline and House Connection

(1) Distribution pipeline

In water supply networks, there are pipelines that are more than 100 year old and/or pipelines choked by scaling, and such pipelines do not have enough flow capacity. Also, the distribution network have been expanded year by year due to population growth in the city and development activities, thus, new and old pipe are mixed.

On the other hand, Development of land and housing and construction of distribution pipelines has been carried out by the Housing Department. However, maintenance of pipeline including repairing leakages, etc., is carried out by YCDC, not by the Department. Distribution pipelines assets were officially transferred to YCDC in April, 2012. After the transaction, YCDC is now trying to grasp the condition of pipelines.

The distribution block has not been formed since the service area has expanded without any distribution network planning, and appropriate distribution management with respect to water quality and water pressure is not being implemented.

The length of distribution pipe owned by YCDC is shown in the following table, total length is estimated to be 1455 km. The lengths that are identified, after being transferred from Housing Department, is included in the table.

Cast iron pipes have been widely used since old times, consisting of about 80% of the total length. The cast iron pipes without internal and external coatings are susceptible to corrosion, resulting in great chances of leakage. Recently, PVC pipe which has resistance to corrosion has started to use for particularly small-sized diameter pipe.

Table 3.45 Length of YCDC Pipe

Diameter	Length (m)	Diameter	Length (m)	Diameter	Length (m)
25	1,694	350	0	1000	0
40	3,314	375	1,750	1050	28,744
50	144,408	400	4,097	1100	0
75	127,824	425	4,084	1200	25,252
100	279,198	450	5,064	1300	0
125	1,304	500	0	1350	0
150	386,186	600	103,407	1400	72,376
200	43,005	675	16,134	1500	26,252
225	23,054	700	0	1600	0
250	12,044	750	5,901	1650	19,407
275	2,823	800	0		
300	104,542	900	13,790		
				Total	1,455,651m

Source: YCDC
Note: The table does not include all pipes which were transferred from the Housing department.

Average pipe age of YCDC is shown in the following table. Since distribution pipe age transferred from Housing Department is unclear, average pipe age is estimated to be 63 years based on the pipeline data of 2002 M/P.

Table 3.46 Estimation of Average Pipe Age which YCDC Owns

Aged pipe (year)	Length (m)	Length x pipe age (my)	Average pipe age
95	281,080	26,702,607	
70	105,572	7,390,068	
45	184,639	8,308,744	
20	146,469	2,929,373	
Total	717,760	45,330,791	63years

Source: The data of 2002 M/P is re-calculated as the present time.
Notes: Since Sources differ, the above-mentioned Table is 1,456 km in length and upper Table are 718 km in length.

Current problems and issues are listed below

- Current, average pipe age is estimated to be 63 years.
- Old pipelines don't have enough flow capacity due to scaling of pipes.
- Pipes are not replaced, but it is extended year by year, and old and new pipes have been mixed.
- Distribution pipelines assets owned by Housing Department were officially transferred to YCDC in April, 2012. YCDC is now trying to grasp the conditions of pipelines since the transaction.
- The distribution block has not been formed since the served area has expanded without any distribution network plans foreseeing the future, and appropriate distribution management regarding water quality and water pressure is not being implemented.

(2) Booster pump

In many poor supply areas, the water supply pressure is low, and 150 booster pumps for maintaining pressure are installed in distribution network. The number and capacity of booster pump owned by YCDC, in each township, is shown in the following table. Since a large number of booster pump exists in the distribution network, O&M is troublesome.

Table 3.47 Number and Capacity of Booster Pump in Each Township

Township of Pump List

No	Township	1.5 KW(2HP)	2 KW	2.25 KW	3.7 KW	3.75 KW	5.2 KW	5.6 KW(7½HP)	7.5 KW(10HP)	11 KW	11.2 KW	11.25 KW	11.5 KW	12 KW(16HP)	12.68 KW	13.43 KW(18HP)	15 KW	16.41 KW(22HP)	17 KW	17.5 KW	18.75 KW	22 KW	22.5 KW	30 KW	37 KW	45 KW	56.25 KW			Total	Remarks
	East District																														
1	North Okkalapa	–	–	–	–	–	–	–	–	–	–		2	–	–	–	–	–	–	1		4	–	–	–	4	4			**15**	
2	South Okkalapa	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			**1**	
3	Thingangyun	–	–	1	–	–	–	–	9	–	–		–	–	–	–	1	–	–	–	1		2	–	–	–	–			**14**	
4	South Dagon	–	–	–	–	2	–	–	15	–	–	3	–	–	–	–	–	–	–	–	3		7	–	–	–	–			**30**	
5	North Dagon	–	–	–	–	–	–	–	8	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–			**9**	
6	East Dagon	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–			**5**	
7	Shwepaukan	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–			**3**	
	Total	**–**	**–**	**1**	**–**	**2**	**–**	**–**	**37**	**–**	**–**	**4**	**2**	**–**	**–**	**–**	**5**	**–**	**–**	**1**	**4**	**4**	**9**	**–**	**–**	**4**	**4**			**77**	

No	Township	1.5 KW(2HP)	2 KW	2.25 KW	3.7 KW	3.75 KW	5.2 KW	5.6 KW(7½HP)	7.5 KW(10HP)	11 KW	11.2 KW	11.25 KW	11.5 KW	12 KW(16HP)	12.68 KW	13.43 KW(18HP)	15 KW	16.41 KW(22HP)	17 KW	17.5 KW	18.75 KW	22 KW	22.5 KW	30 KW	37 KW	45 KW	56.25 KW			Total	Remarks
	West District																														
1	Bahan	1	–	–	3	–	1	5	1	–	1	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–			**14**	
	Total	**1**	**–**	**–**	**3**	**–**	**1**	**5**	**1**	**–**	**1**	**–**	**–**	**–**	**2**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**			**14**	

Township of Pump List

No	Township	1.5 KW(2HP)	2 KW	2.25 KW	3.7 KW	3.75 KW	5.2 KW	5.6 KW(7½HP)	7.5 KW(10HP)	11 KW	11.2 KW	11.25 KW	11.5 KW	12 KW(16HP)	12.68 KW	13.43 KW(18HP)	15 KW	16.41 KW(22HP)	17 KW	17.5 KW	18.75 KW	22 KW	22.5 KW	30 KW	37 KW	45 KW	56.25 KW			Total	Remarks
	South District																														
1	Tharkata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	3	–	–	2	–	–	–	–	–			**6**	
2	Mingalar Taung Nyunt	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			**2**	
3	Pazuntaung	4	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–			**5**	
4	Dala	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	3	–	1	2	–	–			**8**	
5	Seikkyikhanaungto	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–			**2**	
	Total	**4**	**–**	**–**	**–**	**–**	**–**	**1**	**1**	**2**	**–**	**–**	**–**	**1**	**–**	**1**	**1**	**1**	**3**	**–**	**–**	**5**	**–**	**1**	**2**	**–**	**–**			**23**	

No	Township	1.5 KW(2HP)	2 KW	2.25 KW	3.7 KW	3.75 KW	5.2 KW	5.6 KW(7½HP)	7.5 KW(10HP)	11 KW	11.2 KW	11.25 KW	11.5 KW	12 KW(16HP)	12.68 KW	13.43 KW(18HP)	15 KW	16.41 KW(22HP)	17 KW	17.5 KW	18.75 KW	22 KW	22.5 KW	30 KW	37 KW	45 KW	56.25 KW			Total	Remarks
	North District																														
1	Mayangone	–	1	–	–	–	–	2	1	1	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–			**8**	
2	Insein	–	–	–	–	–	–	–	4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			**6**	
3	Mingalardon	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			**4**	
4	Hlaingtharyar	–	–	–	–	7	–	–	4	1	–	–	–	–	–	–	–	–	–	–	–	3	–	2	–	1	–			**18**	
	Total	**–**	**1**	**–**	**4**	**7**	**–**	**2**	**9**	**4**	**–**	**–**	**–**	**–**	**–**	**–**	**3**	**–**	**–**	**–**	**–**	**3**	**–**	**2**	**–**	**1**	**–**			**36**	

Source: YCDC

(3) House connection

Currently, a customer pays the expense of house connection and the qualified technicians of YCDC carry out the connection works.

House connections are randomly installed, and water supply is stopped in large area in case of leakage or replacement works because of insufficient number of valves installed in the networks. Each high flat has a pump set to pump out water from distribution pipe. Sometimes water on the surface of the ground or wastewater in the ground infiltrates into water supply pipelines and accidently pumped up when leakage occurs.

The material of house connection pipes is mainly galvanized iron and it is frequently corroded, leading to water leaks. Currently, the replacement to polyvinyl chloride (PVC) pipe has been implemented; however, the water leakage from PVC occurs frequently due to illegal connection and inferior workmanship. Main problems are listed as follows.

- There are many areas with short-duration water supply.
- Supplied water amount is not sufficient due to leakage and lack of appropriate supply management.
- There are few district valves.
- Supplied water is not disinfected.
- Turbidity of water in taps and S/R is high, according to the result of water quality test, general bacteria and coliform was detected.
- The contaminated water has possibility to mix in the distribution pipeline through breakage due to many cases of water leakage and illegal connections.
- Private shallow wells and deep wells are used outside the service area; however, water from private shallow wells is contaminated.

3.5 Operation & Maintenance

3.5.1 Water Source to Water Treatment Plants

(1) Water Source

The YCDC staff is carrying out O&M of Gyobyu, Phugyi and Hlawga Reservoir which are owned by YCDC. Although intake pumps are installed in Phugyi and Hlawga reservoir, when the water level of reservoir is high, these pumps do not operate and water is transmitted through gravity flow.

An intake tower built for Nyaunghnapin Phase 3 only exists in Ngamoeyeik reservoir which is under the ownership of MOAI, and YCDC staff is carrying out O&M of the tower. However, facilities are not in operation since Phase 3 has not been started yet, and stagnated water in the tower periphery is discharged to nearby river.

(2) Conveyance pipe

There exists two main conveyance pipelines. One line links Gyobyu reservoir and Yegu P/S in the city through SP of dia. 1400mm (56"). Other line links Phugyi reservoir and Hlawga Reservoir and is characterized by PCP dia. 1500mm (60"). PCP has more water leakage from joints, and leakage point is repaired by YCDC each time it occurs. In addition, a short section pipeline links Auntagon P/S and Hlawga reservoir. Furthermore, an irrigation canal of MOAI is used for transmitting water from Ngamoeyeik reservoir to Nyaunghnapin WTP.

(3) Water treatment plant (WTP)

YCDC owns two large-sized WTPs which filter surface water of Gyobyu and Nyaunghnapin, and has four small WTPs which supply groundwater. These WTPs are operated by YCDC, however the chemicals (flocculating agent and disinfectant) are not injected appropriately. The turbidity standard of Myanmar is set to 20 degree compared to 5 degree which is the turbidity standard of WHO. When raw water has high turbidity, it is assumed that the turbidity of supplied water from WTP reaches the standard level. As a result, treated water containing many inorganic substances may cause muddy sedimentation in S/R. Since accumulated mud through distribution pipe network causes trouble in water meter, WTPs should supply as clean water as possible.

In addition, since chlorine equipment is not installed in any of WTPs, water without disinfection is supplied to the city and has a problem from the viewpoint of safety and hygiene.

(4) Operation and maintenance of equipment

YCDC staffs have experience of maintaining facility by themselves for over one hundred years, mechanical staffs solve most of the equipment problems in case when equipment is out of order. Over fifty years have passed in case of the oldest major pumps operation, and the oldest valves have been used for over seventy years, and it is possible for YCDC staffs to repair major equipment of water treatment facility such as gates, cranes, motors, and pipes.

YCDC purchased pumps from famous venders of country such as Britain, Germany, France and Japan, which have high quality and reliability. That is reason why pumps can be used for long time after repair works. However, YCDC staff is uncomfortable recently since imported pumps from Singapore and China are sometimes broken. Single suction volute pumps which are manufactured in Myanmar have been selected for the small pumping stations, but almost all these pumps have been replaced after several years due to serious damage.

Equipment have been in operation for about 30 years to over 50 years with adequate repair works by YCDC, but there is high possibility of complete breakdown of such equipment since they are in operation over their design life period. Therefore, YCDC should prepare list of equipment needing

maintenance soon and arrange for maintenance, preventive repair and arrangement of maintenance manual is needed before equipment is broken seriously.

Problems and issues are listed below.

- Equipment has a possibility to be out of order soon, since it has been in operation for about 30 years to over 50 years with repair works. Further, rated flow and pressure head have a possibility to decrease since efficiency is lower than original design.
- There is possibility of ground/ or sump well water inflow into pump house due to inadequate construction works. Therefore, installation of drain pit and additional standby drain pump and enhancement of rated capacity are recommendable. Also, fundamental countermeasure considering rehabilitation of building is necessary.

3.5.2 Mechanical and Electrical Equipment

Total fifty (50) staffs including mechanical engineers and mechanical technicians are working in mechanical and electrical department of YCDC. Four mechanical engineers for management are working in head office, one manager and several technicians for each PS and WTP are working.

Operation of major pumps is done only manually. Due to lack of flow meters, pressure meters, and level meters except in case of a few pumping stations, it is very difficult to control system.

Problems and issues are as follows.

- It is difficult to control pumps since flow meters and pressure meters are not installed except at few pumping stations. Meters of Hlawga and Phugyi pumping stations need to be calibrated. Transmission flow is calculated manually by rated flow from specification, number of pumps operated and duration of operation.
- Clogging of pumps and intrusion of some floating debris to transmitted pipe may be considered, since screen of adequate opening is not installed at suction side. Further, it is impossible for operator to check and clean screen since it is located much under water level.

Many of problems on electrical equipment arise from the deterioration and/or the fault, same as in case of the pumps. Details are as follows;

- Electrical equipment with high failure risk due to exceeding the lifetime
- Continuous use of damaged cables due to non-availability of spare cable
- Insulation deterioration risk due to water leakage in pump house
- Electrical shock hazard for workers due to puddle of water

Apart from the problem in electrical equipment itself, many of power supply cables in pump houses and water supply stations are easily accessible. Therefore, workers have a high risk of accidentally coming in contact with the power cables and be injured by electrical shock under such condition.

Cable re-routing to avoid easy access and/or laying the cable in conduit are recommended in addition to education on safety practices for workers.

3.5.3 Disinfection

All WTPs do not have any chlorination equipment. Only Yegu P/S is equipped with chlorination dosing equipment. However, even at this P/S chlorination is carried out only once in a week or two weeks (operation time is 6:00 to 14:00), because capacity is not sufficient to handle water supply amount due to the lack of equipment ability. Thus, the safety of supply water has not been secured.

The amount of water supply from Yegu P/S is 187,000 m^3/day of Gyobyu and Hlawga reservoir, and this amount is estimated to be about 25% of the total supply. In other words, 75% of supplied water does not go under any disinfection process.

In the old disinfection system, bleaching powder was dissolved and injected. The present system of chlorination is the electro chlorinator system (generated from NaCl solution by electrolysis on site) with low chemicals cost. However, this system has many accessories and is not recommended from the viewpoint of difficult maintenance/control of membrane and risk of explosion in absence of suitable maintenance. Liquid Sodium-hypochlorite system used by existing WWTP is suitable for future disinfection from the viewpoint of safety.

Problems and issues related to disinfection are listed below.

- Only Yegu P/S, which is supplying water to the central city, has chlorination equipment.
- Electro chlorinator does not have spare machine.
- There is lack of maintenance staff having knowledge and experience of technique such as replacement of membrane.

3.5.4 Transmission and Distribution System

YCDC assigns staff of water supply and sanitation department in the branch office in each township and conducts O&M of distribution facilities, installation and management of house connection, water meter reading and water tariff collection. The branch office deals with small scale water leakage; however, large scale water leakage is handled by YCDC head office. In the service area distributed from YCDC's tube wells, the staff of branch office has been implementing patchwork distribution management (valve control and well operation).
In existing O&M system mentioned above, the budget is insufficient and it can be said that appropriate O&M is not being carried out.

The issues regarding O&M are summarized below.

- Due to shortage of budget, replacement of facility and efficient/effective non-revenue water control has not been carried out.
- Electrical and mechanical equipment that have already crossed their defined operation life, are still being operated.
- Transmission and distribution water amount has not been monitored and efficient operation management is not implemented.
- Water quality test is carried out regularly, however the countermeasure based on result thus obtained is not implemented.

3.5.5 Service Pipe and Water Meter

Size of the connection pipes to houses and establishments is generally 20 mm in diameter. In the existing situation, these pipes are usually not laid under the roads but laid along inside of drains, to reduce cost of digging/filling of roads. Such practice is unsanitary; because there is high probability of wastewater in drain and/or sewer infiltrating into service pipes through loose joints. Maintaining proper water pressure to avoid wastewater infiltration into the water supply service pipes is the first step to be taken. In addition, it is also necessary to define regulations and standards on pipe size, structure and material of water supply service facilities, etc., suitable for the situations in Yangon, either by YCDC or the central government, and accordingly to monitor the installation of such facilities.

Total number of applications for service pipes connections amounts to about 10,000 in a year. Applications are handled, starting from township offices, district offices, and YCDC. Inspections of the constructed service pipes are seemingly not performed. Therefore, inspections of the constructed pipes in terms of pressure, structure, alignment, etc., need to be encouraged. This will enable reducing leakage and water supply getting polluted due to infiltration of wastewater into water supply pipes.
Water Quality Management of Water Works

3.6 Water Quality Management

3.6.1 Actual Status of Water Quality Management

(1) Actual status of Water quality standard and Water quality monitoring

Following table shows existing drinking water quality standards of Myanmar (published in 1990), Proposed drinking water quality standard (Draft, 2011) and WHO Guideline for drinking water quality.

Many of these items are mentioned as “Acceptability aspects of drinking water” in WHO guideline, because health concern of these items is considered to be low. However, these are important items to

maintain essential quality of drinking water.

Table 3.48 Drinking Water Quality of Myanmar

No.	Item	Unit	Standard in Myanmar		WHO Guideline for drinking water quality (4th edition)
			Existing	Proposed in 2011	
1	pH		6.5～9.2	6.5～8.5	Note
2	Turbidity	NTU	20	5	Note
3	Color	Pt-unit	5～50	15	Note
4	Aluminium (Al)	mg/l	0.2	0.2	Note
5	Arsenic (As)	mg/l	0.05	0.05	0.01
6	Calcium (Ca)	mg/l	75～200	100	Note
7	Chloride (Cl)	mg/l	200～600	250	Note
8	Copper (Cu)	mg/l	1.0	2.0	2.0
9	Cyanide (CN)	mg/l	0.05	0.07	Note
10	Hardness	mg/l	500	500	Note
11	Iron (Fe)	mg/l	0.5～1.5	1	Note
12	Manganese (Mn)	mg/l	0.3	0.3(0.1)	Note
13	Lead (Pb)	mg/l	0.05	0.01	0.01
14	Magnesium (Mg)	mg/l	30～150	500	Note
15	Nitrate (NO_3)	mg/l	10 (as N)	50	50
16	Sulfate	mg/l	400	250	Note
17	Total dissolved solids	mg/l	1000	1000	Note
18	Zinc (Zn)	mg/l	5～15	3	Note
19	Total Coliforms	CFU/100ml	0	0	Must not be detectable in any 100 mL sample
20	Fecal Coliforms	CFU/100ml	0	0	Must not be detectable in any 100 mL sample

Note: Guideline value for human health is not decided.
Source: METI report
*Guideline value considering human health is not decided. However, these items are described as "Acceptability aspects of drinking water". Number in ( ) is an acceptable level described in WHO Guideline for drinking water quality.
** Total coliform and E. Coli is described as biological indicator for drinking water safety, however, guideline value is not shown.

The Health Department of YCDC implements monthly water quality monitoring. Monitoring is done at 4 S/R (Ngamoeyeik S/R, Gyobyu S/R, Hlawga S/R and Phugyi S/R), Nyaunghnapin WTP and Aungtagon raw water P/S, (near Nyaunghnapin WTP, raw water is transmitted to Hlawga R.). Analyzed parameters are shown in table below. These analysis items can be measured using colorimetric method, titrimetric and gravimetric method. For reference, description on WHO Guideline for drinking water quality and Japanese drinking water quality standard are shown in the Table.

Table 3.49 Analysis Item and Standard Value for Waterworks

Parameter	Myanmar		WHO GL for drinking water quality (4th Edition)	Drinking water standard, (Japan)
	Highest Desirable level	Maximum Permissible level		
Appearance	2)	2)	3)	2)
Odor	2)	2)	3)	Not detect
Color (Pt, Co scale)	5 Unit	50 Unit	3)	< 5 degree
Turbidity (Silica scale unit) 4)	5 NTU	25 NTU	3)	< 2 degree (Kaolin standard solution)
pH	7.0 – 8.5	6.5 – 9.2	3)	5.8 – 8.6
Total Solid	500 mg/l	1500 mg/l	3)	500 mg/l as TDS
Total hardness (as $CaCO_3$)	100 mg/l	500 mg/l	3)	300 mg/l
Total alkalinity (as $CaCO_3$)	5)	5)	3)	2)
Calcium: Ca	75 mg/l	200 mg/l	3)	300mg/l (as Hardness)
Magnesium: Mg	30 mg/l	150 mg/l	3)	300mg/l (as Hardness)
Chloride: Cl	200 mg/l	600 mg/l	3)	200 mg/l (as Chloride ion)
Sulphate: SO_4	200 mg/l	400 mg/l	3)	2)
Total Iron: Fe	0.3 mg/l	1.0 mg/l	3)	2)
Lead: Pb	0.05 mg/l	0.05 mg/l	0.01 mg/l	0.01 mg/l

Source: JICA Study Team

1) Analysis item and regulation value of Myanmar is derived from actual water quality test record of YCDC. In 2011, new water quality standard is drafted.
2) Standard value is not decided
3) "Not decided" means that the guideline value for human health is not decided in WHO Guideline.
4) Water test record describes "Turbidity (Silica scale unit)". This description can be understood that Myanmar uses kaolin standard for turbidity analysis (same as in Japan). However, Myanmar's standard value uses NTU (nephelometric turbidity unit).
5) Value is not described.

Analysis item in Myanmar drinking water standard means basic nature of drinking water (color, odor, taste). That is to say, monitoring of these items is minimum requirement to maintain drinking water quality.

For these items, guideline value for human health is not decided in WHO Guideline for drinking water quality (Except Lead (Pb)).

For Lead (Pb), WHO decides guideline value of 0.01 mg/L. Current Myanmar desirable / permissible value is 0.05mg/L, however, drafted (new) Myanmar standard proposes the same value as in case of WHO guideline (0.01 mg/L).

On the contrary, analysis item in Myanmar is similar to Japanese drinking water quality standard. However, actual Myanmar drinking water quality monitoring doesn't include Residual chlorine and Total coliform (or Fecal coliforms). These items are important indicator to maintain safe drinking water.

Supply of safe drinking water is essential role of water supply system. Therefore, it is important to implement water quality monitoring including Residual chlorine and Total coliform (or Fecal coliforms) to maintain safe drinking water supply.

3.6.2 Water Quality Investigation

(1) Outline of investigation

Water quality investigation was implemented to understand the actual water quality of waterworks system including water source, WTP, S/R, P/S and water supply tap. Pesticide analysis of river water (3 samples) and raw water (1 sample) is included in this investigation.

The investigation in rainy season was done in October, 2012, and for dry season sampling was done in March, 2013. Also, salinity water invasion survey on Kokkowa River and Toe River was held in dry season (March, 2013).

(2) Water quality of water source (Reservoir and River)

Sampling in rainy season was done at Ngamoeyeik R., Gyobyu R. and Hlawga R. (near water intake tower) and Kokkowa River and Hlaing River (planned site of water intake facility). Also, sampling in dry season was done at Ngamoeyeik R., Gyobyu R. Hlawga R. and Lagunbyin R. (near water intake tower) and Kokkowa River and Toe River (planned site of water intake facility, Hlaing R. was cancelled). Summary of water quality investigation is listed as follows;

- Water quality of 3 reservoirs (Ngamoeyeik R., Gyobyu R. and Hlawga R.) was adequate as a water source. Therefore, conventional water treatment method (e.g. coagulation, sedimentation, sand filtration and Cl disinfection) will be able to satisfy the drinking water quality standard of Myanmar. Detail of assessment of Kokkowa River and Toe River is discussed in "(6) Summary of salinity water invasion survey".
- Ngamoeyeik Creek had high level of Turbidity and color. However, water quality of these rivers was judged as adequate as water source. Same as in case of other rivers (Kokkowa River and Toe River), conventional water treatment method will be applied to obtain satisfactory quality level of drinking water.

Pesticide analysis

Pesticide analysis of Nyaunghnapin WTP raw water and river water samples (Rainy season: Kokkowa River and Hlaing River, Dry season: Kokkowa River, Toe River and Ngamoeyeik Creek) was done. Pesticide analysis was carried out in Japan.

Analysis result is shown in following Table. Pesticide is not detected in the samples of both rainy season and dry season.

Table 3.50 Result of Pesticide Analysis

(Unit: mg/l)

Pesticide	WS-4 Nyaunghnapin WTP (Raw water)	WS-5 Kokkowa River	WS-16 Toe River	WS-17 Ngamoeyeik Creek	WS-6 Hlaing River
Season	Rainy, Dry	Rainy, Dry	Dry	Dry	Rainy
Fenitrothion (MEP)	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Isofenphos	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Methidathion (DMTP)	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004
α-Endosulfan	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
β-Endosulfan	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Source: JICA Study Team

(3) Water quality of water works facility (WTP, P/S and S/R)

Sampling was done at Nyaunghnapin WTP, Thaephyu WTP and South Dagon No. 2 WTP, Yegu P/S and Kokine S/R. Among these WTP, Nyaunghnapin WTP uses surface water, Thaephyu WTP and South Dagon No. 2 WTP uses groundwater.

Among the water works facilities of YCDC, only Yegu P/S has chlorine feeding facility (i.e. chlorine disinfected water is distributed only in Yegu P/S service area).

Summary of water quality investigation is as follows;

Rainy season

- In rainy season, total coliforms were isolated in samples collected from treated water of all WTP (Nyaunghnapin WTP, Thaephyu WTP and South Dagon No.2WTP). Moreover, fecal coliforms were isolated from treated water of Nyaunghnapin WTP and South Dagon No.2 WTP.
- Yegu P/S has a chlorine feeding facility. However, total coliforms and fecal coliforms were also detected in Yegu P/S sample in rainy season.

Dry season

- In dry season, total coliforms and fecal coliforms were isolated in samples collected from treated water of all WTP (Nyaunghnapin WTP, Thaephyu WTP and South Dagon No.2WTP).
- Total coliforms and fecal coliforms were detected also from Yegu P/S and Kokine S/R.

- Therefore, all water works facilities were polluted by total coliforms and fecal coliforms.

Table 3.51 Satisfaction Level of Water Quality (Waterworks Facility) (Rainy Season)

Items	pH	Turbidity	Color	Arsenic (As)	Calcium (Ca)	Chloride (Cl^-)	Copper (Cu)	Cyanide (CN)	Hardness	Iron (Fe)	Manganese (Mn)	Lead (Pb)	Nitrate (NO_3)	Sulfate	TDS	Zinc (Zn)	Total coliforms	Fecal coliforms
Nyaunghnapin WTP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x
Thaephyu WTP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-
South Dagon No.2 WTP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x
Yegu pump station	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x
Kokine Service Reservoir	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x

- : Drinking water quality standards are satisfied.
x : Drinking water quality standards are not satisfied.

Source: JICA study team

Table 3.52 Satisfaction Level of Water Quality (Waterworks Facility) (Dry Season)

Items	pH	Turbidity	Color	Aluminum (Al)	Arsenic (As)	Calcium (Ca)	Chloride (Cl^-)	Copper (Cu)	Cyanide (CN)	Hardness	Iron (Fe)	Manganese (Mn)	Lead (Pb)	Nitrate (NO_3)	Sulfate	TDS	Zinc (Zn)	Total coliforms	Fecal coliforms
Nyaunghnapin WTP	-	-	-	-			-		-	-	-			-	-	-		x	x
Thaephyu WTP	-	-	-	-			-		-	-	-			-	-	-		x	x
South Dagon No.2 WTP	-	-	-	-			-		-	-	-			-	-	-		x	x
Yegu pump station	-	x	-	-			-		-	-	-			-	-	-		x	x
Kokine Service Reservoir	-	x	-	-			-		-	-	-			-	-	-		x	x

Note: Analysis data of As, Mn, Pb, Cu, Zn are not reported as of May 9.

- : Drinking water quality standards are satisfied.
x : Drinking water quality standards are not satisfied.

Source: JICA study team

(4) Water quality of water supply tap

Water quality of water supply tap of Dagon T/S (Tap A) and Thingangyun T/S (Tap B) were surveyed. Tap water of Dagon T/S is chlorinated in Yegu P/S. Chlorinated water is transmitted to Kokine S/R and Shwedagon S/R, and distributed to Dagon T/S.

Tap water of Thingangyun T/S is distributed directly from Nyaunghnapin WTP without chlorination.

<u>Rainy season</u>

- pH (measured value: 6.3), total coliforms and fecal coliforms of supplied water in Tap A did not satisfy Myanmar drinking water quality standard.
- Turbidity (measured value: 26 NTU), total coliforms and fecal coliforms of supplied water in Tap B did not satisfy Myanmar drinking water quality standard.

Dry season

- Turbidity (measured value: 33 NTU), total coliforms and fecal coliforms of supplied water in Tap A did not satisfy Myanmar drinking water quality standard.
- Turbidity (measured value: 10 NTU), total coliforms and fecal coliforms of supplied water in Tap B did not satisfy Myanmar drinking water quality standard.

Table 3.53 Satisfaction Level of Water Quality (Water Supply Tap) (Rainy Season)

Items	pH	Turbidity	Color	Arsenic (As)	Chloride (Cl)	Copper (Cu)	Cyanide (CN)	Hardness	Iron (Fe)	Manganese (Mn)	Lead (Pb)	Nitrate (NO_3)	Sulfate	TDS	Zinc (Zn)	Total coliforms	Fecal coliforms
Water Tap (A)	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x
Water Tap (B)	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x

- : Drinking water quality standards are satisfied.
x : Drinking water quality standards are not satisfied.

Source: JICA study team

Table 3.54 Satisfaction Level of Water Quality (Water Supply Tap) (Dry Season)

Items	pH	Turbidity	Color	Arsenic (As)	Chloride (Cl)	Copper (Cu)	Cyanide (CN)	Hardness	Iron (Fe)	Manganese (Mn)	Lead (Pb)	Nitrate (NO_3)	Sulfate	TDS	Zinc (Zn)	Total coliforms	Fecal coliforms
Water Tap (A)	-	x	-	-	-	-	-	-	-	-	-	-	-	-		x	x
Water Tap (B)	-	x	-	-	-	-	-	-	-	-	-	-	-	-		x	x

- : Drinking water quality standards are satisfied.
x : Drinking water quality standards are not satisfied.

Source: JICA study team

Through these surveys of waterworks facilities and service tap, total coliforms and fecal coliforms were detected. From these observations, it is pointed out that the enhancement of chlorination and satisfaction of sanitation requirement is a pressing issue for YCDC waterworks.

(5) Water quality of water supply tap (Part 2)

Additional water supply tap survey was done in Yegu P/S water supply system to understand the effect of chlorination in Yegu P/S. Main analytical item is Residual chlorine, Total coliforms and Fecal coliforms. Summary of analytical data is as follows;

Table 3.55 Water Quality of Water Supply Tap (1)

(Yegu P/S→Yankin T/S)

Sampling point	pH	EC (μS/cm)	Turbidity (NTU)	Free chlorine (mg/l)	Total coliforms	Fecal coliforms
Yegu P/S	7.39	80	4.64	0.21	Detected	Detected
Yankin T/S	7.27	90	9.63	0.17	Detected	Detected

Source: JICA study team

Table 3.56 Water Quality of Water Supply Tap (2)

(Yegu P/S→Kokine S/R→Dagon T/S→Pabedan T/S→LathaT/S→Lanmadaw T/S)

Sampling point	pH	EC (μS/cm)	Turbidity (NTU)	Free chlorine (mg/l)	Total coliforms	Fecal coliforms
Yegu P/S	7.39	80	4.64	0.21	Detected	Detected
Kokine S/R	7.45	80	4.12	0.21	Detected	Detected
Dagon T/S	7.34	90	7.07	0.25	Detected	Detected
Pabedan T/S	7.36	50	1.85	0.11	Detected	Detected
Latha T/S	6.25	130	1.24	0.10	Detected	Detected
Lanmadaw T/S	6.40	110	1.28	0.04	Detected	Detected

Source: JICA study team

Table 3.57 Water Quality of Water Supply Tap (3)

(Yegu P/S→Kokine S/R→SanchaungT/S→Ahlone T/S)

Sampling point	pH	EC (μS/cm)	Turbidity (NTU)	Free chlorine (mg/l)	Total coliforms	Fecal coliforms
Yegu P/S	7.00	80	2.83	0.18	Detected	Detected
Kokine S/R	6.86	90	0.88	0.22	Detected	Detected
Dagon T/S	7.43	90	2.95	0.14	Detected	Detected
Pabedan T/S	5.25	40	0.09	0.00	Detected	Detected

Source: JICA study team

Table 3.58 Water Quality of Water Supply Tap (4)

(Yegu P/S→Kokine S/R→Sanchaung T/S→Kyimyindain T/S)

Sampling point	pH	EC (μS/cm)	Turbidity (NTU)	Free chlorine (mg/l)	Total coliforms	Fecal coliforms
Yegu P/S	7.00	80	2.83	0.18	Detected	Detected
Kokine S/R	6.86	90	0.88	0.22	Detected	Detected
Dagon T/S	7.43	90	2.95	0.14	Detected	Detected
Pabedan T/S	6.94	80	2.10	0.14	Detected	Detected

Source: JICA study team

- Total coliforms and Fecal coliforms were detected in all samples. Therefore, it is said that the chlorination in Yegu P/S is not effective.
- Increasing of EC and decreasing of free chlorine was measured between Yegu P/S to Yankin T/S. The reason of this is assumed that there is interfusion of pollutant (e.g. interfusion of wastewater) in water distribution system.
- Also, Increasing of EC and decreasing of free chlorine was measured in Pabedan T/S, Latha T/S and Lanmadaw T/S. The reason of this is assumed that there is interfusion of pollutant (e.g. interfusion of wastewater) in water distribution system of Dagon T/S, Pabedan T/S, Latha T/S and Lanmadaw T/S.
- Decreasing of pH, EC, Turbidity and Free chlorine was measured between Sanchaung T/S and Ahlone T/S. Reason of this change of water quality is not clear. However, considering the low pH value, tap water of Ahlone T/S is not suitable for drinking.
- Therefore, it is pointed out that tap water quality distributed from Yegu P/S have a serious problem about water quality and sanitation because of inadequate chlorination and wastewater infusion to water distribution system.

(6) Summary of salinity water invasion survey

Salinity water invasion survey of Toe River and Kokkowa River was implemented to understand the extent of impact of saline water intrusion. These surveys were done in the high tide and low tide period in March 2013.

Survey point of Toe River was decided in the water intake facility construction site and its upstream / downstream and Twantay Canal. Kokkowa River survey point was decided in the water intake facility construction site and it's upstream / downstream.

The parameter analyzed included water temperature, pH, EC, TDS and Chloride. For TDS and Chloride, assessment criterion was decided based on the description of WHO Guidelines for Drinking-water Quality 4th edition (see Reference).

- TDS: < 500 mg/L (0.5g/L = 0.5 ppt)
- Chloride: < 250mg/L

Summary of this survey is as follows;

- In Toe River, influence of saline water intrusion was observed. High concentration of Chloride (200 – 250mg/L) was detected near water intake facility construction site. On the other hand, in the upstream of Toe River / Twantay Canal diversion point, both TDS and Chloride satisfied assessment criterion.

- In Kokkowa River, samples of all points, i.e. near water intake facility construction site and upstream / downstream of water intake facility construction site satisfied assessment criterion.

Therefore, water quality of Kokkowa River water intake facility construction site meets assessment criterion (TDS < 500mg/L, Chloride < 250mg/L), and satisfies water quality as a source of drinking water.

On the contrary, water quality of Toe River water intake facility construction site didn't satisfy assessment criterion, because 250mg/L of Chloride was detected near construction site.

However, water quality upstream of Toe River / Twantay Canal diversion point satisfied assessment criterion.

From these observations, it is said that the water intake facility construction site of Toe River have to be reconsidered in the upstream area of Toe River / Twantay Canal diversion point

Reference

Description about TDS and Chloride for water source in WHO drinking water safety guideline, 4th edition.

TDS

The palatability of water with a total dissolved solids (TDS) level of less than about 600 mg/L is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances.

Chloride

High concentrations of chloride give a salty taste to water and beverages. Taste thresholds for the chloride anion depend on the associated cation, and are in the range of 200–300 mg/L for sodium, potassium and calcium chloride. Concentrations in excess of 250 mg/L are increasingly likely to be detected by taste, but some consumers may become accustomed to low levels of chloride-induced taste.

3.7 Financial Condition and Water Charge Collection System

3.7.1 Managerial Situation of Waterworks

The water and sanitation department of YCDC is responsible for water supply and sewerage services in Yangon city and control financial balance with reporting to finance department of YCDC every month. In the aspect of budgetary management, YCDC has limitation with respect to the following points: (1) the accounting system of water supply and sewerage is incorporated into the general account without independence, (2) the YCDC budget is also incorporated into the national budgetary system of the central government. Therefore, financial autonomy has not yet been applied to current YCDC system.

(1) Operating Revenue Income of DEWWS

The operating income during 2011/2012 accounted for 4.71 billion Kyat indicating a steady annual growth of 2-6%. 90-95% of income is shared by water sales every year. Other income such as connection fee, rental fees for shop and tenant, and license fee for plumber shares only few percentage of the total.

Operating income of water supply and sanitation department and the trend is shown in the following Table.

Table 3.59 Operating Income of Water Supply and Sanitation Department and the Trend

Account items	2007-2008		2008-2009		2009-2010		2010-2011		2011-2012	
	million Kyat	(%)	million Kyat	(%)	million Kyat	(%)	million Kyat	(%)	million Kyat	(%)
Water Charge	3,966.3	89.5	4,065.8	91.7	4,185.9	94.4	4,345.8	95.1	4,382.3	93.1
Departmental Water Charges	1,236.5	27.9	1,171.1	26.4	1,117.5	25.2	1,094.8	24.0	1,081.9	23.0
Public Water Charges	2,729.8	61.6	2,894.7	65.3	3,068.4	69.2	3,251.0	71.1	3,300.4	70.1
Water Connection	198.6	4.5	148.3	3.3	122.3	2.8	139.2	3.0	185.7	3.9
Sales of Water Meters	88.9	2.0	43.2	1.0	38.9	0.9	26.5	0.6	16.2	0.3
Rental of Shops and Sites	33.5	0.8	34.7	0.8	33.5	0.8	35.3	0.8	44.3	0.9
Plumber Licenses Fees	0.7	0.0	0.8	0.0	0.7	0.0	0.6	0.0	1.3	0.0
Other Revenue	20.2	0.5	26.7	0.6	52.1	1.2	23.4	0.5	79.1	1.7
Total	**4,308.2**	100	**4,319.5**	100	**4,433.4**	100	**4,570.9**	100	**4,709.0**	100

Source: YCDC DEWS

(2) Operating expenditure of DEWS

Operating expenditure of DEWS during recent 5 years is shown in the following Table.

The operating expenditure of DEWS for the period 2011-2012 totaled about 4.47 billion Kyat, which

has increased by more than 30% in the recent 3 years. Expenditure mainly consists of material costs/ labor and service costs amounting about 71%, personnel costs amounting 17% and maintenance and repair costs sharing about 12%. The largest costs within the material costs/ labor and service costs is electricity costs amounting 41%, followed by material costs amounting 18%.

The sum of labor costs and personnel costs contribute approximately 25% of the total expenditure, which is not at dominant level in comparison to the average level of other developing countries.

Table 3.60 Operating Expenditure of DEWS

Cost Items	2007-2008		2008-2009		2009-2010		2010-2011		2011-2012	
	million Kyat	(%)	million Kyat	(%)	million Kyat	(%)	million Kyat	(%)	million Kyat	(%)
Salary & Cost	**516.2**	**15.3**	**500.1**	**14.9**	**547.1**	**16.3**	**725.2**	**19.7**	**740.8**	**16.6**
Salary	516.2	15.3	500.1	14.9	547.1	16.3	725.2	19.7	740.8	16.6
Travelling Allowance	0.2	0.0	0.2	0.0						
Local Traveling	0.2	0.0	0.2	0.0						
Material Cost, Labor Charge and Service	**2,100.5**	**62.4**	**2,792.8**	**83.0**	**2,586.8**	**76.8**	**2,602.0**	**70.7**	**3,190.5**	**71.4**
Labor Charges	174.7	5.2	221.9	6.6	288.1	8.6	401.2	10.9	393.2	8.8
Rental & Production Fees	0.1	0.0	0.1	0.0	0.1	0.0	0.2	0.0	0.5	0.0
Transportation	5.4	0.2	2.0	0.1	6.5	0.2	3.8	0.1	5.5	0.1
Office utensil	0.9	0.0	1.1	0.0	0.7	0.0	2.1	0.1	2.0	0.0
Petrol & Lubricant	94.4	2.8	76.9	2.3	55.8	1.7	119.2	3.2	99.6	2.2
Stamp & Telecommunication	2.9	0.1	2.7	0.1	7.5	0.2	1.0	0.0	2.4	0.1
Electricity Charges	1,271.0	37.8	1,618.1	48.1	1,730.3	51.4	1,404.0	38.1	1,832.3	41.0
Periodical									0.1	0.0
Uniform	0.0								0.1	0.0
Operating Material	527.3	15.7	829.1	24.6	454.9	13.5	627.2	17.0	800.0	17.9
Printing & Publishing	23.8	0.7	41.1	1.2	42.2	1.3	43.3	1.2	54.0	1.2
Advertising										
Maintenance & Repair	**128.6**	**3.8**	**217.7**	**6.5**	**232.4**	**6.9**	**355.0**	**9.6**	**536.2**	**12.0**
Materials & Tools	63.5	1.9	71.3	2.1	94.2	2.8	210.0	5.7	141.1	3.2
Buildings	0.2	0.0	3.2	0.1	7.0	0.2	7.1	0.2	32.1	0.7
Road	0.0	0.0	0.9	0.0	0.0	0.0			4.8	0.1
Transporting Machine	34.2	1.0	30.2	0.9	19.2	0.6	7.6	0.2	18.7	0.4
Motor Vehicles & Equipment									4.5	0.1
Miscellaneous	30.8	0.9	112.0	3.3	112.0	3.3	130.3	3.5	335.0	7.5
Entertainment Charges									0.2	0.0
Total	**2,745.5**	100	**3,510.8**	100	**3,366.3**	100	**3,682.1**	100	**4,467.7**	100

Source: YCDC DEWS

(3) Current Account Balance of DEWS and the Trend

Current account balance considering operating revenue and operating expenditure for water supply and sewerage service for FY2011/2012 is a surplus of 240 million Kyat. The revenue from water services has been in excess during the recent 5 years, however the surplus amount has been gradually decreasing. Revenue income met approximately 10 % growth during 5 years, in contrast to 60 % growth of revenue expenditure. Under the circumstance that rapid growth of revenue income cannot be expected, financial balance of operating income and operating expenditure may not be balanced if the expenditure continues increasing at this pace.

Meanwhile, financial balance of operating income and operating expenditure appear to be not balanced at the first glance, the capital expenditure is not accounted in this calculation.

(4) Capital Expenditure of DEWS

Capital expenditure such as construction investment costs was financed by internal financial sources of YCDC until September 2011, however the budget has been allocated from special account of the central government since October 2011. The budget for FY2011/12 totaled about 4.47 billion Kyat comprising approximately 97 % for water supply sector and approximately 3 % for sewerage sector. The investment is dominantly allocated to water supply sector.

The budget amount has increased more than 2.3 times during the recent 5 years, the investment in the development of Ngamoeyeik-Hlawga has been increasing.

The trend of capital expenditure during recent 5 years is shown in the following Table.

Table 3.61 Capital Expenditure of DEWS

Account items	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
	million Kyat	million Kyat	million Kyat	million Kyat	million Kyat
Extension of Water Supply Pipes	**1.8**	**6.0**	**50.9**	**171.3**	**49.7**
Water Supply	**517.1**	**944.7**	**508.6**	**3235.0**	**3737.2**
Ngamoeyeik-Hlawga	431.5	718.4	99.9	1596.7	2962.7
Water Supply from Ngamoeyeik Chaung					195.0
Water Supply for New Township	1.7	1.6	28.9	30.4	40.9
Lakes and Tube Wells	79.7	224.7	379.7	709.8	262.5
Hlawga-Yangon	4.3			898.2	276.0
To Sufficient Water Supply for Downtown	**1486.5**	**1102.1**	**1708.5**	**736.1**	**790.1**
To Sufficient Water Supply for Downtown	1328.5	1010.2	1038.6	558.3	483.9
Water Service for Upgrading					18.6
Production of Water Pipes	158.0	91.9	669.9	177.8	287.7
Sewerage	**2.8**	**5.0**	**7.3**	**11.2**	**138.0**
Waste Water Treatment Plant	**1.2**	**6.7**	**1.0**	**3.5**	**15.7**
Total	**2009.4**	**2064.5**	**2276.3**	**4157.1**	**4730.8**

Source: YCDC DEWS

3.7.2 Tariff Structure and Customer Type

(1) Tariff Collection Policy

The YCDC directive describes that water tariffs on water supply service be basically charged to all customers except customers such as monastery.

In existing practices, the frequency of meter reading and issuing of water bill varies with customer types. For metered customers, meter reading and billing is carried out every month for domestic, and commercial and industries type of customer, once a year for governmental institutions and houses, and quarterly for foreign exchange customers. For flat rate customers, billing is conducted quarterly for domestic, and commercial and industries, and once a year for governmental institutions and houses, and also quarterly for foreign exchange customers.

(2) Current Tariff Structure and Tariff System

YCDC has applied 2 types of tariff structure, namely metered rate system and flat rate system by customer types. Flat rate system defines monthly water tariff by customer types. Uniform metered rate system which has a constant or universal tariff rate within metered rate systems has been in practice. Current tariff rates have been adopted since April 2012.

Customers are mainly categorized into the following five types: governmental offices and houses, public and private institutions including domestic, foreign-financed hotel, foreign-financed industry and factory, rental house and building for foreigners. Either metered rate or flat rate has been applied even within the same customer type depending on the situation of meter installation. For foreign-financed customers or offices and buildings targeting foreigners, water tariff is collected in US dollars, and the rate level is set up at relatively higher than that of general customers such as domestic, departmental and commercial, etc.

In terms of metered rates, the tariff rates are 55 Kyat/ m^3 for governmental offices and houses, 88 Kyat/m^3 for domestic, and 110 Kyat for commercial. It could be said that the difference between tariff rates is relatively small. Flat rate system has a little bit complicated structure, because the standard for tariff setting seems to be not clear in case of some customers. The tariff rate for governmental institutions and factory/ workshops is determined based on the consideration of connection diameter and water consumption situation and the tariff rate for commercial customers is decided depending on the occupancy space of the customers. In case of foreign-financed hotels, the tariff rate per customer is fixed and the different amount may be charged depending on the number of customer's stay nights in the target one month.

If unit rate for domestic customer between flat rate and metered rate is compared, the tariff rate in case of metered customer is approximately 9.0 yen/ m^3 and flat rate is 184 yen/ month for general house and apartment. If we calculate monthly tariff by using this metered rate and the average consumption volume of 17.8 m^3/month, the monthly charge is approximately 87% of 184 yen/month of flat rate, hence, relatively smaller than the flat rate. To summarize, the rate level remain at very low level, it could be an outstanding feature that the preferential tariff rate is given to governmental institutions and houses, which is lower than the domestic rates.
Tariff rates applied from April 2012 are shown in the following Table.

Table 3.62 Tariff Rates in Use (As of January 2013)

Category		Metered Rate	Flat Rate
General		(Kyat/ m^3)	(Kyat/ month)
Government institution	Departmental, Officers & Staff housing	55	Depending upon water usage and connection diameter
	Factories, Workshops	77	
Domestic	- Individual house and apartment	88	3,000
	- High rise building, separate compound, residence	88	1,800
Commercial & industry	- Construction	110	309.6 /m^2
	- Commercial	110	
Foreign Exchange (FE)		(US$/ m^3)	(US$)
FE	- Hotel, Motel, Inn. (invested in foreign currency)	0.88	0.5 /customer/night
	- Industries, Workshops, Marts and Condominiums	0.88	Depending upon water usage and connection diameter
	- Rent of Household (Residence, Apartment, etc.)	0.44	25 /month

Source: YCDC DEWS

(3) Revision of Water Tariff and the Transition

Transition of tariff rates during 12 years, after 2001, is shown in the following Figure.

It is observed that tariff rates for domestic has been revised at least more than once, however tariff rates for foreign customers has not been revised since 2001.

Type	Customer		2001	2002	2005	2006	2012	unit	increase ratio
Metered	General	Household		13.2			88	Kyat/ m^3	6.7
		Commercial Commercial		20		77	110	Kyat/ m^3	5.5
		Commercial Construction		13.2		77	110	Kyat/ m^3	8.3
		Department Building		3.3	55		55	Kyat/ m^3	16.7
		Department Factory		3.3	77		77	Kyat/ m^3	23.3
	FE	Household	0.44				0.44	US$/ m^3	1.0
		Commercial	0.88				0.88	US$/ m^3	1.0
		Hotel, motel, inn etc.	0.88				0.88	US$/ m^3	1.0
Flat	General	Household Ordinary	120		1,125		1,875	Kyat/ month	15.6
		Household High class			1,875		3,000	Kyat/ month	25.0
		Commercial	135			1,575-57,068	2,250-81,525	Kyat/ month	
		Department Building Department Factory	20 K						
	FE	Household	25				25	US$/ month	1.0
		Commercial	35-1,440				35-1,440	US$/ month	
		Hotel, motel, inn etc.	0.5				0.5	US$/ guest/day	1.0
		Construction	83.6 or 9,720 k/floor		155.0	217.0	309.6	Kyat/sq-m	3.7

Source: YCDC DEWS

Figure 3.27 Revision of Water Tariff and the Transition

(4) Customer Type and Number of Connection

The total number of connection is 248,570 as of January 2013. The majority of total is shared by domestic with approximately 91.6%, followed by commercial and industry sharing 7.8%, and governmental institutions sharing 0.4% of the total customers. Metered customer is 76% of the total customers. For various customer types the ratio of customers that are metered varies, it is 75 % for domestic, 84 % for commercial and industry, 31 % for governmental office and house, therefore metering in commercial and industry customer meets progress and that in governmental customers is relatively lagging behind.

The number of customer during recent three years indicates a steady annual growth of about 5%. Annual growth rates by customer type are 8.5% for domestic, 7.4% for commercial and industry, -0.4% for governmental institution and houses. The growth rate of domestic customer is remarkable.

The composition of number of connections and the trend are shown in the following Table.

Table 3.63 Composition of Number of Connections and the Trend

Category		2009/10	2010/11	2011/12
Domestic/ Commercial & Industries				
Metered	Domestic	118,907	125,381	139,670
	Domestic (Non-settled)	18,415	26,510	32,772
	Commercial & Industries	10,447	10,431	12,349
	Commercial & Industries (Non-settled)	2,846	3,699	3,932
Flat	Domestic	61,520	58,369	55,282
	Commercial & Industries	3,612	3,310	3,091
Government & Departmental				
Metered		370	374	366
Flat		905	855	808
Foreign Exchange (FE)				
Metered	Domestic	85	86	91
	Commercial & Industries	78	79	83
Flat	Domestic	121	127	111
	Commercial & Industries	18	18	15
Total		217,324	229,239	248,570

Source: YCDC DEWS

Note: Numbers of connections does not match with those mentioned in the previous section (3.3.4).

3.8 Relevant Plans and Projects

The followings other projects, which are relevant to this Project, have been currently implemented.

(1) Studies and Projects implemented by Japanese side

1) The Preparatory Study for Urban Development Programme in the Greater Yangon (JICA)
2) Data Collection Survey on Water Resources Potential for Thilawa Special Economic Zone and Adjoining Areas (JICA)
3) Water Supply Management Advisor (JICA)
4) The Study on Improvement of Water Supply and Wastewater Treatment in Yangon, Myanmar (METI: Ministry of Economy, Trade and Industry). This study mainly aims to select the urgent individual project; however, Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City mainly aims to establish the entire plan regarding water supply system, sewerage system and drainage system.
5) The Study on Development of Sewerage System, Myanmar (Ministry of Land, Infrastructure, Transport and Tourism (MLITT), FY2012)
6) The Preparatory Survey on the Project for Urgent Improvement of Water Supply System for Yangon City (JICA, FY2013)
7) Project for Urgent Improvement of Water Supply System for Yangon City (JICA, FY2013)

Myanmar government requested Japanese side to implement the grant assistance for the project for the rehabilitation of pump station in Nyaunghnapin water treatment plant phase I and replacement of distribution pipes in the pilot area of Yankin Township which were selected as No. 6 of the Project mentioned above. Responding to this request, the project is under implementation by grant assistance starting from February 2013.

Regarding the replacement of the aged pipes in the pilot area, it aims to understand the rate of non-revenue water by establishment of DMA (District Metered Area). The establishment of DMA is proposed in this project and is to implement Non-Revenue Water Control and equal water supply.

(2) Projects being implemented by other countries

The status of the projects implemented by other countries or other development partners is shown below. The MOU of F/S for construction of water treatment plant in front of Kokkowa River located in western side of Yangon city was concluded in November 2012 between YCDC and Chinese private companies. Furthermore, the MOU of M/P and F/S for water supply to industrial areas in east and west side of Yangon city including Thilawa SEZ and 4 locations in Dagon area was concluded among

YCDC, K-Water from Korea and Shwe Town Development Company in November 2012.

Table 3.64 Detail of the Projects Implemented by Other Development Partners for which MOU has been Concluded with YCDC

Name of MOU and Date concluded	Implementation organizations or Contractors	Detail
Water Supply Project, November, 2012	Chengdu Longxiang Investment Industrial Co., Ltd China Construction International Corporation Co., Ltd	F/S of water supply to Hlaing Thayar township, west of Yangon, with intake facilities at Kokkowa River
Water Supply to Hlaing Thayar, west of Yangon and Central Yangon, MOU being processed as of January, 2013	SK, Korea	
Development of Water Supply in East & West Suburb Area of Yangon City, November, 2012	Shwe Taung Development Company Limited (STD) and Korean Water Resource Corporation (K-Water)	MOU of M/P and F/S for water supply to northwestern part of Yangon, industrial areas in east and west of Yangon city and Thanlyin SEZ.

Source: JICA Study Team

CHAPTER 4 ISSUES/PROBLEMS OF WATER SUPPLY SYSTEM AND IMPROVEMENT TARGETS

Following the description of the water supply system in Yangon, issue and problems being faced by Yangon water is explained, and then improvement targets are set in this Chapter.

4.1 Major Issues of Water Supply System

4.1.1 Technical (Including O&M) Issues

(1) Low water coverage

YCDC has gradually extended its service areas with the expansion of Yangon City, development of satellite towns and new towns. Practically all these areas are anticipated to fall within the water supply served area in 2013 (but excluding New Suburbs and Mingalardon township forming the northern part of the old city). With the completion of the second phase of the project in the eastern part making the Ngamoeyeik reservoir planned for completion in 2013 as the water source, the service area is expected to expand significantly. On the other hand, water is being supplied from the Hlawga Lake and wells in the western part such as Insein, and the service area is restricted.

As shown in Table 3.1 earlier, the served population ratio by township tends to be high for old city areas and tends to be low for new residential areas. Causes of the low served population ratio include less development of distribution network, existing private wells that are already provided or the short period of water supplied from the water supply system.

(2) High non-revenue water rate

The non-revenue water rate at approximately 60% is extremely high. The daily average water consumption is slightly above 100 liters, and this figure may be slightly above 200 liters in certain townships. These figures are considered to be generally adequate at this stage. The domestic consumption is considered not to have any effect on the number of hours of water supply. For instance, although the water supply period of a certain township is only six hours, the consumption amount is slightly greater than 200 liters. Here, the supplied water is often stored in water tanks on roofs using private pumps.

Although the quantity of water for commercial and industrial use is generally considered to be about two-thirds the quantity of water for household use, Yangon is characterized by high water consumption in government and public offices, particularly in military establishments. In addition to the water consumption in these government and public offices, the water consumption in religious facilities like pagodas has not been metered, and such locations are factors contributing to the high non-revenue water rate.

YCDC is aware of the need for reducing non-revenue water, and has been promoting the installation of meters particularly at locations where new connections are being given. The meter installation rate, which was about 30% in 2001, has increased to more than 70% in 2011.

On the other hand, the cheap water tariff seems to have hindered incentives for saving water. One of the topics henceforth is to introduce a progressive tariff rate system and promote incentives for saving water after giving due consideration to low-income population.

Reducing non-revenue water has the effect of deferring development of water resources. Measures for non-revenue water include replacement of old pipes, strict enforcement of proper pipe laying work, measures such as introduction of DMA and SCADA, campaigns for customers on the importance of water savings, and so on.

(3) Poor water quality

In addition to the coagulation-sedimentation process of the surface water of resources such as the Gyobyu reservoir and the Ngamoeyeik reservoir, iron removal is being carried out on comparatively large-scale groundwater resources. On the other hand, water from the Hlawga and Phugyi reservoirs is being distributed without treatment. Chlorination facility is provided only at the Yegu booster pumping station, which relays water partly from the Hlawga and Phugyi reservoirs.

Dissatisfaction with respect to water quality was high even according to the questionnaire implemented during the Master Plan Study in 2002, and the household survey carried out by JICA in 2012.

(4) Ageing of facilities

Priority was given to investments for ensuring water resources and laying transmission pipelines to meet the expansion of service areas and the growth in demand; therefore, service reservoirs were not constructed, and practically none of the existing pipelines were renewed. The result is that old pipelines that were laid more than 100 years ago in the central business district (CBD), and more than 50 years ago in the old city areas still exist. Pipes are cast-iron pipes mainly used at that time. These pipes are likely to corrode easily due to the large amounts of rust and scales that deposit on the internal surface. The insides of the pipes are presumed to be covered with sand and sludge due to the negative pressure generated within. The reduction in the cross section of the pipe is likely to create poor water flow and low water pressures. The result is that the consumer generally installs a water pump independently, and since the distribution pipeline sucks in water, negative pressure is further created, thereby forming a vicious circle. Large diameter transmission pipelines are made of concrete pipes which are liable to leak easily. Consequently, it is essential to renew aged pipes.

(5) Inappropriate layout of facilities

When the Yangon water supply system was installed, water was supplied to the old city areas especially to the CBD; so the water sources used were the two reservoirs in the hilly area in the northern part (Hlawga and Gyobyu). The plan for this system included installation of two service reservoirs at the hilly southern end near the CBD with a relay pumping station installed at one location. Reality however is that the water supply system of Yangon after the Second World War until today has been hard pressed to meet the increasing water demand and the increase in service areas with the growth of satellite towns and construction of new towns. The Ministry of Construction has constructed infrastructure such as water supply facilities in satellite towns and new towns, and has transferred control to the YCDC.

In the beginning, pumps were installed in the existing Gyobyu reservoir in 1962 for use as a water source. Later, the Phugyi reservoir was constructed in 1988. All these reservoirs were under the direct control of YCDC. The subsequent water sources had to depend on the water distributed from the Ngamoeyeik reservoir (completed in 1995) under the Ministry of Agriculture and Irrigation since there were no appropriate areas for new reservoirs. Water was led from the Ngamoeyeik reservoir and used in the irrigation canal under the jurisdiction of the Ministry of Agriculture and Irrigation instead of dedicated pipelines previously used in the reservoir. Although the volume of water in the water source increased, new service reservoirs were not provided, and the consumers were serviced directly using pumps. Furthermore, while water treatment plants were provided at the Gyobyu reservoir and the Ngamoeyeik reservoir and water was being treated, no water was treated at the Hlawga reservoir and the Phugyi reservoir. Thus the irrationality of the entire system became the focus of attention.

Consequently, facilities should be rationally located in a planned manner, ensuring that they will satisfy the demand in the future. The additional required volume of water source 30 years later in 2040 is about 400 MGD. This is about twice the volume of the existing water source of 205 MGD (including the second stage of Nyaunghnapin). Thus, the volume of water sources should be rationally distributed in the service areas.

(6) Operation and maintenance of facilities

- Database on Facilities
  YCDC is rated highly in terms of its ability to carry out repairs and rehabilitation. However, YCDC does not maintain facility logbooks. Although there is some CAD data of important structures and distribution pipelines, important drawings are retained on paper only in each department.
- Operation and Maintenance of Facilities
  As mentioned above, since facility logbooks especially lists of machinery and equipment do not exist, properly conceived repair plans cannot be formulated, and repairs of machinery

and equipment, or replenishment of spare parts and so on, are not implemented systematically. For this reason, budgets to account for repairs and rehabilitation are not adequately allotted to the Operation and Maintenance Department. As a result, emergency response cannot be adopted when an accident or breakdown occurs, and it takes considerable time to resolve various issues. Furthermore, repair frequency has increased due to the introduction of low quality equipment with low reliability; therefore, increase in the repair and rehabilitation cost henceforth together with the degradation of machinery and equipment, is a cause for concern.

- Database on Tariff Collection
  There are customer lists and water tariff table on paper so that access to these data is rather limited. Computerization of these data is required for disclosure of data to every concerned staffs.

4.1.2 Organization and Institutional Issues

Issues related to organizational aspects of the Department of Engineering (Water Supply and Sanitation), YCDC to be resolved aiming for efficient and effective water supply business in the future are as below.

(1) Need for a department in charge of planning

Currently, policies, plans, strategies and business plans that constitute systems for water supply and sewerage systems of the future do not exist. Departments for formulating such policies, plans, and so on, do not exist as well. YCDC, which is responsible for the water supply and sewerage business of a large city such as Yangon, has a social responsibility, and needs to set clear business targets over the short, medium and long terms, share them with the employees, and systematically improve its business services. However, it has not adopted and implemented such a system as of this stage.

Amongst the activities related to planning of the said department, estimation and application for the annual budget is one of its few activities. It seems that the approach to the overall business activity of the organization is a makeshift solution. Planning and monitoring activities are indispensable to set clear directions and goals for the organization and to work positively toward these goals.

(2) Need for a department in charge of monitoring

As aforementioned, if the DEWWS starts their works according to their plan established, it is necessarily crucial to check and monitor on whether their works is along with their plan or not. Also, as mentioned later, performance indicators (PIs) could be an effective tool for the entity to manage their waterworks and sewerage works. For that, thus it is functionally essential to monitor their performance regularly.

(3) Unclear distribution of work and concentrated official authority

Roles and duties and professional jobs for every department are defined but those of other general staff have not been defined. By clearly defining the duties of staff members, issues to be tackled become clear, and encouragement in having a sense of responsibility, self-consciousness and self-reliance may be anticipated in every employee.

On the other hand, official authority seems to be concentrated in the hands of some of professionals, such as Chief Engineer (CE), Deputy Chief Engineer (DYCE), Assistant Chief Engineer (ACE), and so on, and it takes considerable time to pass judgments. Since water supply and sewerage works are public service works, an organization needs to be established that can respond quickly as a service provider in a bureaucracy.

(4) Lack of operation and management according to performance indicators (PIs)

It is widely recognized that performance indicators (PIs) enable the performance level of an existing entity to be grasped quantitatively and reflected in business operations, and that a performance indicator is an effective tool for the water supply and sewerage works. Performance indicators enable comparison of water supply and sewerage works of neighboring countries as well and comparisons with the facilities in the past. They can be utilized for making future plans and strategies, and for setting targets as well. Such an approach to business operations and management by benchmarking has not yet commenced in the Department of Engineering (Water Supply and Sanitation).

(5) Raising awareness of customer services

Chances to interact with customers are comparatively frequent in township offices; therefore, there is awareness that this is a service industry offering services to customers. On the other hand, the awareness that water supply and sewerage works is a public service industry for townspeople is rather weak among the Head Office employees.

Public relations magazines, posters, pamphlets, and so on, that raise customer awareness toward water supply and sewerage works are also interactive tools for interacting with customers, but such items have not been prepared and distributed. Publicity activities should preferably be strengthened since this is a business for interacting with society.

(6) Poor water quality testing system

Water supply and sewage treatment plants owned by YCDC presently conduct water quality inspections for regulating chemicals used in water treatment; however, instruments or equipment for inspection do not exist, and inspections are performed manually. For this reason, accuracy has been observed to be low. There are no record books to record the results, and records are not maintained.

Monthly water quality inspections are entrusted to outside agency (to the Department of Health, YCDC). Since the organization is the same (YCDC), the inspection itself is free of charge and is performed by the inspection laboratory. However, this inspection laboratory is meant for conducting water quality inspections of public health, food and food service industries. When the Department of Engineering (Water Supply and Sanitation), requests inspections additional to the monthly inspections, it becomes difficult to respond flexibly and on priority because of the limited equipment and personnel and because the service is free, according to reports from the Department of Health. For this reason, a system that can monitor water quality regularly needs to be established.

(7) Human resources development

Some employees have received training, thanks to donor assistance, but employees in the engineering, finance, accounting, and general affairs sections have received practically no training. Opportunities to enhance specialization and reflect it in work are limited. There is no department to plan the development of human resources so as to continually improve the ability of employees, and there is no budget specially allocated to training. Recognizing that human resource is the No. 1 resource supporting the organization, the Department of Engineering (Water Supply and Sanitation) should re-recognize its importance and develop human resources.

On the other hand, YCDC has a qualification system incorporating technical qualification tests for piping technicians and plumbers, and such qualifications are mandatory for carrying out water supply equipment work. Development of human resources in the department should be continued while making use of such a system.

4.1.3 Institutional Issues

There exists “YCDL” and the “Rules for YCDL” relevant to water supply, however it is thought to be insufficient in the Myanmar national laws and regulations related to water supply issues. This legal system must be reviewed and improved in the future. The various issues are listed below.

(1) Definition of water supply works and definition of the parent organization must be given, or definition of responsibility of entity installing the water supply equipment must be studied.

(2) From the viewpoint of ensuring resources of project cost related to water supply, study on implementing autonomous corporate accounting of the water supply works is necessary.

(3) Studies are in progress toward formulating national water quality standards. WHO standards are being followed presently, but water quality standards need to be formulated quickly.

(4) Studies on work implementation methods considering the urban environment, inspection requirements, and work standards for working personnel are necessary with the aim of supplying stable supply of safe water to the townspeople.

(5) Study on work standards for construction and installation as an indication at certain level are necessary with the aim of supplying stable supply of safe water to the townspeople.

(6) Study on inspection rules including inspection method and inspection items for the construction and installation works implemented by the contractors are necessary.

(7) Water supply

Systems complementing water supply technology are thought to be insufficient, and water supply is not being used effectively. Provision of adequate technologies from technological aspects will become necessary henceforth. The necessary systems identified from site reconnaissance are as given below.

- Standards for Installation of Service Connections

  The diameter of service pipes in buildings should be about 20 mm, however there is no standards clearly mentioned. It is necessary to make standards for determining the diameter of connections (technical standards appropriate for the actual situation of the City of Yangon) and also standards for structures and materials for the use and installation of connections in consideration of hydrostatic pressure resistance and durability (standards on water supply facilities to be set forth by the state or province).
- Standards for Water Meter

  Under the current system, these meters are purchased and installed by users, and the water meters are used without inspection after installation or renewal, meaning that there may be anomalies in their performance and malfunction due to age-related deterioration.

  In the future, it is necessary to standardize the performance of meters and the mechanical duration, and to aim at the creation of a fair meter-reading system, including installation of meters by the YCDC, early realization of installation at all facilities and a full meter-rate system, amendment of the appropriate rate, and the speedy completion of a customer database for collection of water usage charges, as well as discussing the introduction of a sewer rate system.
- Standards for Installation of Individual Storage Tank

  In the City of Yangon, 24-hour water distribution is not performed in most areas and water pressure in the distribution pipeline is low, at a maximum of 0.15 MPa. Most facilities have a storage tank installed, but almost no tanks have equipment to stop water flow at the full level installed (ball tap, etc.) and actually water overflowing from the overflow pipe is lost until the pump stops. In the future, it is necessary for YCDC to confirm the number of storage

tanks and to establish the standards that mandate installation of equipment to stop water overflow.

- Standards for Installation of Individual Pump Facilities

  In the City of Yangon, currently most water supply facilities have a pump installed to raise water to a storage tank. Therefore water supply system seems to rely on pumping up from distribution pipe line rather than supplying by water pressure. As a result, differences in pump' capacity between neighboring water supply facilities may cause negative differential water pressure. In future, it is desirable to gradually switch to a water supply system not using pump equipment in areas where water pressure in distribution pipelines is secured in each water supply facility.

  In Japan, the Order for Enforcement of the Waterworks Act prohibits direct connection with a pump that may affect water pressure in distribution pipes. No pump other than an inverter-controlled booster pump unit used for pressured water service systems (water pressure in distribution pipes and discharge pressure are controlled automatically) is permitted.

- Inspection of Installation Works for Service Pipe

  Current inspection of installation works for service pipe checks only water flow through the pipeline inside the building, not installation status of the pipeline outside. It is necessary to ensure water pressure in distribution pipes for stable supply to the water supply facilities and to make standards for determining the diameter of pipes at water supply facilities (technical standards appropriate for the actual situation of the City of Yangon) and also standards for structures and materials for the use and installation of water supply facilities in consideration of hydrostatic pressure resistance and durability (standards on water supply facilities to be set forth by the state or province).

- YCDC's Qualification System for Engineers

  In the City of Yangon, persons who have passed engineering qualification examinations held by the YCDC are qualified as engineers performing design and construction of water and sewer systems. Persons taking the examination are required to have completed the necessary course at the Yangon Institute of Technology, the Government Technical Institute, or the technical universities in any state.

  The qualification is classified into the following categories, and at the time of application for construction, it is necessary to fill in the name and qualification number of the qualified person:

  a) Working Plumber (without qualification)
  b) Master Plumber (official qualification requiring at least 3 years' experience)
  c) Plumber Engineer (official qualification requiring completion of university course and at least 3-year experience)

  The term of validity of the qualification is one year and an engineer's certificate of it is also

issued. The YCDC does not permit foreigners to take the engineering qualification examination nor does it accept any technical qualifications held by foreigners as valid, except for qualifications approved by the YCDC.

4.1.4 Financial and Management Issues

Issues related to financial and management aspects in the Department of Engineering (Water Supply and Sanitation), YCDC to be resolved so as to aim for efficient and effective water supply business in the future are as below.

(1) Budget with little freedom

The accounting system for water supply and sewerage works are included in the general accounting system of YCDC and is not an independent system. The YCDC budget itself is included in the national budget of the central government after October 2011, and is not a self-supporting accounting system. Consequently, YCDC has very little freedom in deciding the use of revenues by itself; this is a basic structural issue.

(2) Need for introducing corporate accounting system

As mentioned above, the accounting system for water supply and sewerage works is not an independent system, and corporate accounting is not being implemented. For correctly grasping the management status and the status of assets in the future, introduction of corporate accounting by double-entry bookkeeping is recommended. The Department of Engineering (Water Supply and Sanitation) is currently preparing financial statements only for current account and capital expenses of the water supply and sewerage works for reporting to the YCDC.

(3) Generally cheap water tariff

The water tariff presently is restricted to a low level generally. Although the income from water tariff currently covers the management, operation and maintenance costs, it does not include depreciation of the facilities at all. Although there are restrictions such as the inability to use one's own financial resources freely in the present budgetary system, in the future, the management, operation and maintenance expenses and depreciation expenses must be reflected in the water tariff when proper maintenance, operation and management have been performed. Studies are necessary on revising the tariff from the aspects of strengthening the financial base by properly charging the consumers.

(4) Revision of the tariff system

Two tariff systems, namely the fixed rate system and the meter rate system are being used together. It is difficult to work on the consumers to create awareness for saving water in case of the fixed rate system, and the water consumption also tends to be large. The tariff for government organizations and

parties related to the government is slightly lower than that for general households; thus, this tariff needs to be reconsidered. Even in case of the fixed rate system, the actual tariff varies depending on the customer; standards are ambiguous.

On the other hand, the existing meter-rate system is a uniform volumetric tariff rate system where the cost per m^3 is consistent. However, since consumers lack the awareness for saving water, the progressive volumetric tariff rate system should also be studied.

(5) Computerization of limited services

Although a part of the customer data management has been converted to database in the Computer Section, customers for which the fixed rate tariff system is applicable, customers for which foreigners' tariff system is applicable, and customers in government organizations, are managed using hand-written customer ledgers and account books since the past. Generally, other work such as financial and accounting work is also performed based on handwritten documents, and computers are limited to use in only a small part of the work, therefore the efficiency is poor.

4.1.5 Issues and Improvement of Non-YCDC Water

There are many issues particularly with respect to water quality in the non-YCDC water according to 2012 JICA-HIS. These issues are summarized below together with improvement measures. Extension of YCDC water supply system to non-YCDC water supply area will solve many of the issues. Pace of YCDC water supply system needs to accelerate further. In addition, YCDC needs to supply water with quality that is drinkable.

Table 4.1 Issue and Improvement Measures for Non-YCDC Water

Water Source	Issue	Improvement Measures
Private Tube Well (Up to 200 ft.)	● Containing iron and chlorine,, difficult to remove them by individuals ● Chances of contamination due to closeness to wastewater discharging point, particularly for shallow wells (up to 60 ft.) ● Poor Maintenance by individual ● High chances of depletion of ground water and land subsidence if abstraction quantity increases due to population increase	● Awareness campaign together with Health department on water contamination, water quality monitoring for the existing well users. ● Conversion of tube wells to YCDC water supply system with drinkable water quality.
Public Well/Tap	● Inconvenience of fetching water. ● Public well/tap is not necessarily hygienic.	● Number of public well/tap is decreasing due to YCDC policy to convert them into piped supply system.
Neighbors' Well/Tap	● Same as above	● Same as above
Bottled Water	● No problem	● Purchase of bottled water will decrease when YCDC provides drinkable water and gets credibility among customers.
Water Vender	● Management of water quality is	● Extension of YCDC water supply

Water Source	Issue	Improvement Measures
	necessary. Difficulty in obtaining sufficient amount of water.	system.
Rain/ Creek/ Canal/ Pond	● Unhygienic water	● Extension of YCDC water supply system.

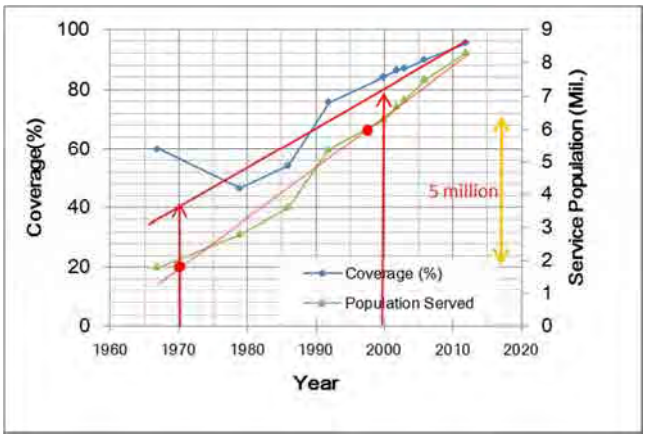
Source: JICA Study Team

4.2 Case Study on Similar Cities in the Neighboring Countries

Improvement targets are usually decided forecasting future economic development based on the past development records. This is not true in Yangon region because drastic economic improvement is expected attributed to the recent policy changes in Myanmar. Master plan for the water supply system should meet the needs of such changes. So, development trends in neighboring cities are studied, where drastic economic initiatives have been experienced. Section 4.2 deals with this trend of development, followed by setting targets for water supply services in Yangon region.

(1) Bangkok

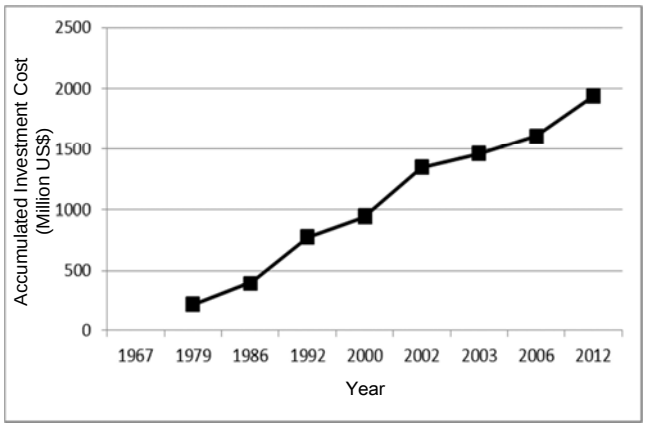
Bangkok is the nearest city that has experienced drastic economic development. The condition of water supply services after 1960's till now in Bangkok is studied. Figure shows water supply coverage ratio and population after 1960's. Water service coverage rate was 40% and population was about 2 million in 1970. Water service coverage in Yangon is about 40 %. After 30 years in 2000, water service coverage rate in Bangkok improved to 80 % with 7 million water-served populations. Coverage rate improved by 40 % and served population increased by 5 million.



Source: JICA Study Team

Figure 4.1 Water Service Coverage Rate and Population

Investment costs during such period for water supply system are shown in Figure. Investment costs totaled to 2,000 million US $ from 1980 to 2012, about 60 million US$ per year on average. Investment cost is 300 US$ in nominal terms for the increased service population of about 6.5 million.

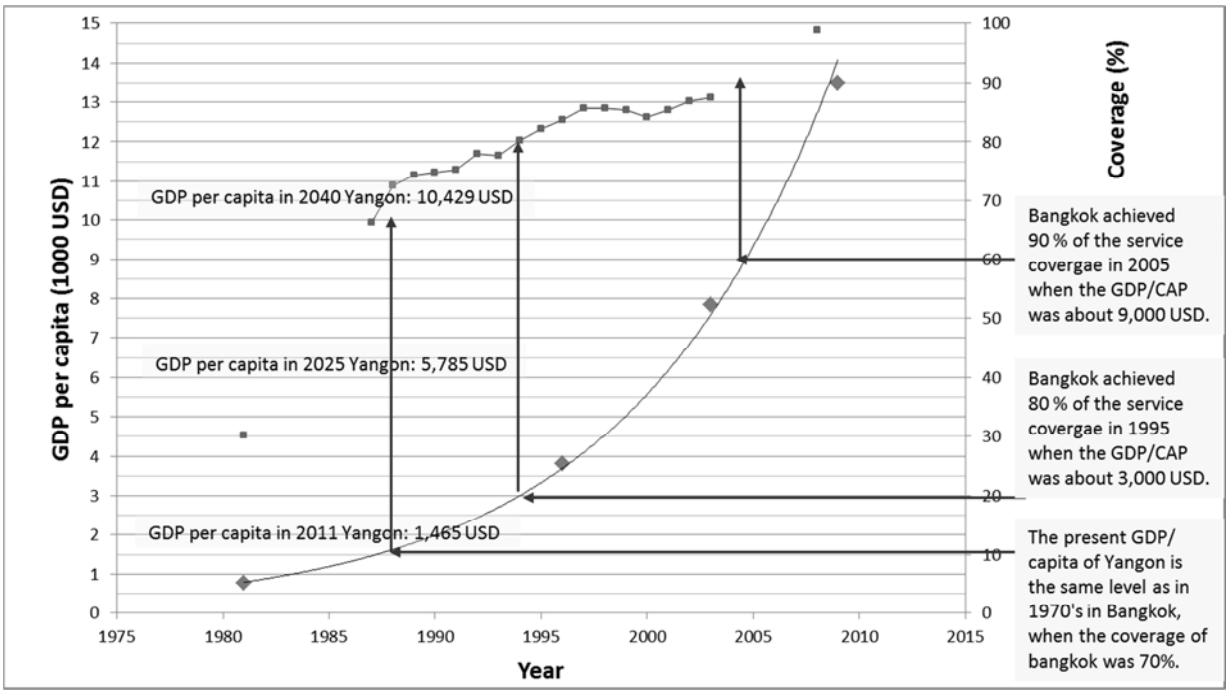


Source: JICA Study Team

Figure 4.2 Accumulated Investment Cost for Water Supply System in Bangkok (Nominal Terms)

Water supply coverage rate in Yangon could be 80% in 2040 if the investment continues with the same pace.

Water supply coverage rate and per capita GDP are shown together in Figure below. The rate exceeds 80% when per capita GDP was 3,000 US$ in Bangkok. When GDP in Bangkok was 1,465 US$, which is the current level of GDP in Yangon, the water supply coverage rate was 70% in Bangkok. However, corresponding rate is 40% in Yangon. This is probably due to lack of investment in the past while Bangkok obtained funds for investment largely from external agencies in the form of soft loans. In this master plan, required fund for investment is assumed to be available. Financial analysis is presented in this master plan.



Source: JICA Study Team

Figure 4.3 Water Supply Coverage Rate vs. Per Capita GDP

(2) Other Cities

Service levels in YCDC system and other Southeast Asian cities are compared using Performance Indicators. Ho Chi Min city and Singapore is in the same scale in terms of population. Singapore is much improved in respect of water supply services; coverage rate is 100% and non-revenue water rate is only 4%. Ho Chi Min city is also better than Yangon in terms of water supply services.

Characteristics of water service level in YCDC are as follows;

i. Coverage ratio is low.
ii. Per capita consumption is low.
iii. Non-revenue water ratio is high.
iv. Water price is low.

How low service levels mentioned in “i” to “iii” could be improved at least to the current levels in the Southeast Asian cities is a challenging issue for YCDC. During the improvement period, how water tariff can be modified and collected is also a matter of concern for YCDC. This is because the costs will surely increase to cover increased costs on treatment and conveyance from the remote-distance river water source and to cover replacement costs of the old facilities, particularly pipes.

Operating cost coverage ratio is +1.19, good ratio. However, to maintain positive ratio considering the expected increasing capital expenditure as well as O&M expenditure to achieve better service level, revision in tariff will be inevitable.

Table 4.2 Water Service Level in YCDC and Southeastern Cities

PIs /Unit	Utility / City / Country	YCDC	Metropolitan Waterworks Authority	Ho Chi Minh City Water Supply Company	Singapore Public Utility Board	Davao City Water District	JWSRB	Phnom Penh Water Supply Authority	Syarikat Bekalan Air Selangor Sdn Bhd	Nampapa Nakhone Luang
		Yangon	Bangkok	HCMC	Singapore	Davao	Jog Jakarta	Phonon Penh	Kuala Lumpur	Vientiane
		Myanmar	Thailand	Vietnam	Singapore	Philippine	Indonesia	Cambodia	Malaysia	Lao PDR
1. Population	1,000	5,142	7,958	5,976	4,737	4,468	8,700	1,519	1,493	799
2. Water coverage	%	35	93	84	100	59	62	80	100	50
3. Sewerage coverage	%	5	54	N/A	100	N/A	3	N/A	N/A	N/A
4. Total water consumption	L/person/day	95	169	147	262	164		172	379	296
5. Non Revenue Water	%	66	29	41	4	25	50	6	35	28
6. Average Revenue W&WW	US$/$m^3$ water sold	0.05	0.45	0.27	N/A	0.34	0.70	0.28	0.45	0.12
7. Operational Cost W&WW	US$/$m^3$ water sold	0.04	0.31	0.24	N/A	0.23	0.15	0.12	0.55	0.28
8. Collection Ratio	%	N/A	N/A	N/A	N/A	92	95	N/A	N/A	N/A
9. Operating Cost Coverage	Ratio	1.19	1.46	1.13	N/A	1.46	1.50	2.36	0.82	0.43
Statistical year		2012	2009	2009	2008	2009	2007	2007	2007	2007

[Note]

- Myanmar: YCDC, Performance indicators (PIs) are calculated based on data obtained by JICA Study team.
- Thailand: MWA, PIs are obtained/ or calculated based on the "Annual Report 2009" of MWA.
- Indonesia: JWSRB, PIs are obtained from JWSRB, Palijya, Aetra homepage http://www.jakartawater.org/, http://www.aetra.co.id, http://www.palyja.co.id/, PIs 6-7 refers to only Aetra performance.
- Information on PIs - 1 of other water utilities are obtained from UN DESA population division, and City population, http://www.mongabay.com/igapo/Southeast_Asia.htm
- Information on PIs 2-8 of other water utilities are obtained from IBNET Database, http://www.ib-net.org/production/?action=utility

Source: JICA Study Team

4.3 Service Level Targets

4.3.1 Overall Service Level Target

Overall service level targets are set as shown below.

Table 4.3 Overall Service Level Target

Item	By Area		Unit	2011 (Present)	Year 2018	**Year 2025**	Year 2040
Service Coverage rate	YCDC		%	37	48	**58**	80
	Region			34	41	**49**	69
Served Population	YCDC		Million	1.92	2.74	**3.76**	6.81
	Region			1.92	2.74	**3.92**	8.09
Per Capita Consumption	Domestic	YCDC	LPCD	95	117	**135**	178
		Region		95	117	**133**	173
	Non-domestic			40% of total consumption			
Water Pressure			MPa	0.075	-	More than 0.15Mpa	
Supply Duration			Hour	8 on average	-	24	
Water Quality Improvement			-	Not drinkable	Drinkable		

Note: The coverage of YCDC and Region are estimated as 39% and 34 %, respectively based on 2012 JICA-HIS.
Source: JICA Study Team

4.3.2 Supply Pressure and Hours

There are large differences in supply hour and water pressure in the YCDC area. Lack of numbers and volumes of the service reservoirs, direct tapping from the transmission facilities, insufficient capacity of the pipes, etc., are the main causes. About 150 small-sized booster pumps are installed to improve water pressure and supply hour. This is effective only for the limited areas.

To rectify these problems and to aim at equitable distribution, the following targets are set;

Table 4.4 Target of Water Pressure and Supply Hour

Item	Present Level	Target Level	Target Year	Remarks
Water Pressure	0-0.15 MPa (average 0.075)	0.15 MPa	2025	Direct supply to two-story houses, Indirect supply with use of tanks and pumps to above three-story buildings
Supply Hours	(0-24 hours) Average 8 hours	24 hours	2025	With water pressure improvement, supply hours should be continuous, 24 hour

Source: JICA Study Team

4.3.3 Water Quality Improvement

YCDC water is not used for drinking purposes and, customers do not rely on YCDC water quality according to JICA-HIS in 2012. The items of water quality in which customers are dissatisfied are mainly high turbidity and unhygienic. Therefore, water quality improvement to the level of drinkable water at the earlier stage will increase customers' confidence in YCDC water supply services. YCDC has already intention for quality improvement.

For the improvement of drinking water quality, at first, periodical water quality monitoring is necessary. On that basis of the result of monitoring, establishment of operation and management scheme of water treatment and distribution facility is necessary.

Table 4.5 Water Quality Improvement Target

Item	Target
Present Level	Not Drinkable
Target Level	Drinkable Water, the target water quality level is shown table below.
Target Year	2018

Source: JICA Study Team

Table 4.6 Water Quality Target Value

Parameter	Maximum Allowable Value
pH	7.0 – 8.5
Taste	Foul smell and taste are not detected
Odor	Foul smell and taste are not detected
Color	5 degree
Turbidity	5 NTU
Standard plate count	< 100CFU/mL
Total coliform	Not detected
Residual chlorine	> 0.1 mg/L (at individual water tap or inlet of storage tank)*1
Zinc (Zn)	< 1.0mg/L
Aluminum (Al)	< 0.2mg/L
Iron (Fe)	< 0.3mg/L
Copper (Cu)	< 1.0mg/L
Manganese (Mn)	< 0.05mg/L
Hardness	< 100 mg/L
Chloride ion	< 200mg/L
Sulfide	< 200mg/L

Note: *1: > 0.0 mg/L (to be detected) as provisional value
Source: JICA Study Team

Establishment of drinking water quality management scheme based on these water quality items is priority for YCDC. However, investigative research of measures against water quality accident (e.g. spillover of pesticide or other harmful matter into water source) should be considered as the task for future.

4.3.4 Service Coverage Rate

Service coverage rate is calculated as 23% in 2012 based on connection numbers of YCDC customers data. It was 35% according to 2002 JICA-M/P. Customers data does not include free-water customers, illegal connections, etc. On the other hand, service coverage rate is estimated as 39% according to JICA-HIS in 2012.The Study Team considers the data obtained through interview more reliable and slightly different Figure of 38% is adopted as current rate. Coverage rate for 2011 is enumerated in Table 4.3.

Different improved rates of service coverage are set as shown below reflecting the present level to be realistic. Using this criterion, the rates are firstly set for each township. Then, referring to this set value, YCDC has decided the rates for each township as shown in Figure 4.4.

In the Study, peripheral townships are assumed to be incorporated into YCDC administrative areas in 2025 so that these townships are assumed as YCDC water supply coverage area. However, their development level and population density will catch up YCDC level. So, their water service coverage rate is set as 40% for 2040, starting from 2025.

Table 4.7 Criterion of Increase of Service Coverage Rate for Yangon

(%)

2011 (Present)	2018	2020	**2025**	2030	2035	2040	Note
91-100	100	100	**100**	100	100	100	YCDC Area
81-90	95	100	**100**	100	100	100	
71-80	80	90	**100**	100	100	100	
61-70	70	80	**90**	100	100	100	
51-60	60	70	**80**	90	100	100	
41-50	50	60	**70**	80	90	100	
21-40	30	40	**50**	60	70	80	
0-20	10	20	**30**	40	50	60	
0	0	0	**10**	20	30	40	Peripheral townships

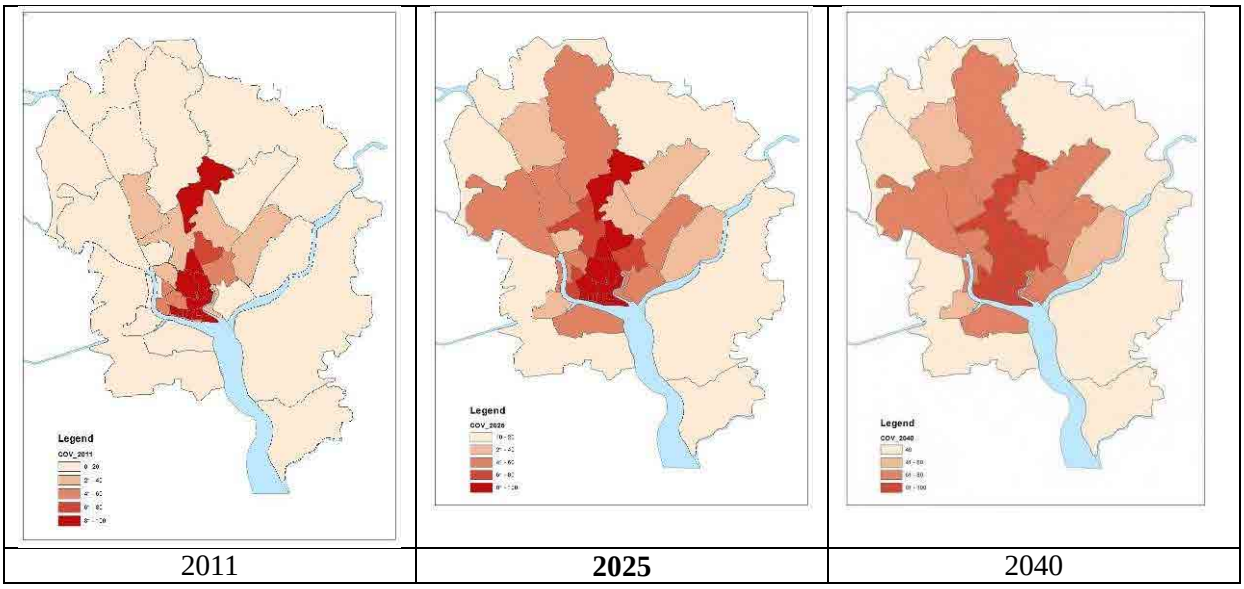
Source: JICA Study Team

Overall service coverage rates in 2040 are 80% for YCDC and 40% for peripheral 6 townships.

Table 4.8 Target of Water Supply Coverage

Area	2011	2018	2020	**2025**	2030	2035	2040
Yangon City (YCDC)	37	48	52	**58**	65	72	80
Peripheral 6 Townships	0	0	0	**10**	20	30	40
Greater Yangon	34	41	44	**49**	55	62	69

Source: JICA Study Team



2011 | **2025** | 2040

Source: JICA Study Team

Figure 4.4 Water Service Coverage Rate

Table 4.9 Water Service Coverage Rate by Township in Greater Yangon

(%)

Code	Township Group	Township	2011	2018	2020	**2025**	2030	2035	2040
1	1.CBD	Latha	93	100	100	**100**	100	100	100
2	1.CBD	Lanmadaw	86	97	100	**100**	100	100	100
3	1.CBD	Pabedan	94	100	100	**100**	100	100	100
4	1.CBD	Kyauktada	96	100	100	**100**	100	100	100
5	1.CBD	Botahtaung	92	100	100	**100**	100	100	100
6	1.CBD	Pazuntaung	99	100	100	**100**	100	100	100
7	2.IUR	Ahlone	47	59	62	**70**	80	90	100
8	2.IUR	Kyeemyindaing	17	34	40	**50**	60	70	80
9	2.IUR	Sanchaung	43	56	60	**70**	80	90	100
10	2.IUR	Dagon	59	75	80	**90**	100	100	100
11	2.IUR	Bahan	82	96	100	**100**	100	100	100
12	2.IUR	Tarmwe	88	97	100	**100**	100	100	100
13	2.IUR	Mingalar Taung Nyunt	96	100	100	**100**	100	100	100
14	2.IUR	Seikkan	60	75	80	**90**	100	100	100
15	2.IUR	Dawbon	26	37	40	**50**	60	70	80
16	5.ORZ	Kamaryut	24	36	40	**50**	60	70	80
17	5.ORZ	Hlaing	18	29	32	**40**	50	60	70
18	5.ORZ	Yankin	85	96	100	**100**	100	100	100
19	5.ORZ	Thingangyun	50	60	63	**70**	80	90	100
20	6.NS	Mayangone	39	55	59	**70**	80	90	100
21	6.NS	Insein	26	38	40	**50**	60	70	80
22	6.NS	Mingalardon	16	31	35	**45**	55	65	75
23	4.OldSZ	North Okkalapa	84	96	100	**100**	100	100	100
24	4.OldSZ	South Okkalapa	66	77	80	**90**	100	100	100
25	4.OldSZ	Thaketa	14	30	35	**45**	55	65	75
26	3.SCBD	Dala	5	28	40	**50**	60	70	80
27	3.SCBD	Seikgyikhanaungto	0	0	20	**30**	40	50	60
28	7.NewSZ	Shwe Pyi Thar	7	10	20	**30**	40	50	60
29	7.NewSZ	Hlaing Thar Yar	2	26	33	**50**	60	70	80
30	7.NewSZ	North Dagon	26	33	35	**40**	50	60	70
31	7.NewSZ	South Dagon	28	37	39	**45**	55	65	75
32	7.NewSZ	East Dagon	20	30	33	**40**	50	60	70
33	7.NewSZ	Dagon Seikkan	0	15	19	**30**	40	50	60
SB1	1.CBD	CBD	93	99	100	**100**	100	100	100
SB2	2.IUR	Inner Urban Ring	63	74	77	**81**	86	91	95
SB3	3.SCBD	South of CBD	4	24	37	**47**	57	67	77
SB4	4.OldSZ	Older Suburbs Zone	57	70	74	**80**	86	89	92
SB5	5.ORZ	Outer Ring Zone	45	56	59	**65**	73	81	89
SB6	6.NS	Northern Suburbs	26	39	42	**52**	61	71	81
SB7	7.NewSZ	New Suburbs Zone	13	26	31	**41**	51	60	70
T-1		Total (Yangon City)	37	48	52	**58**	65	72	80
Periphery Areas (6 suburban Townships)									
34	PA	Kyauktan				**10**	20	30	40
35	PA	Thanlyin				**10**	20	30	40
36	PA	Hlaegu				**10**	20	30	40
37	PA	Hmawbi				**10**	20	30	40
38	PA	Htantapin				**10**	20	30	40
39	PA	Twantay				**10**	20	30	40
T-2		6 suburban TSs		0	0	**10**	20	30	40
		Grand Total	34	41	44	**49**	55	62	69

Source: JICA Study Team

4.3.5 Population Estimation

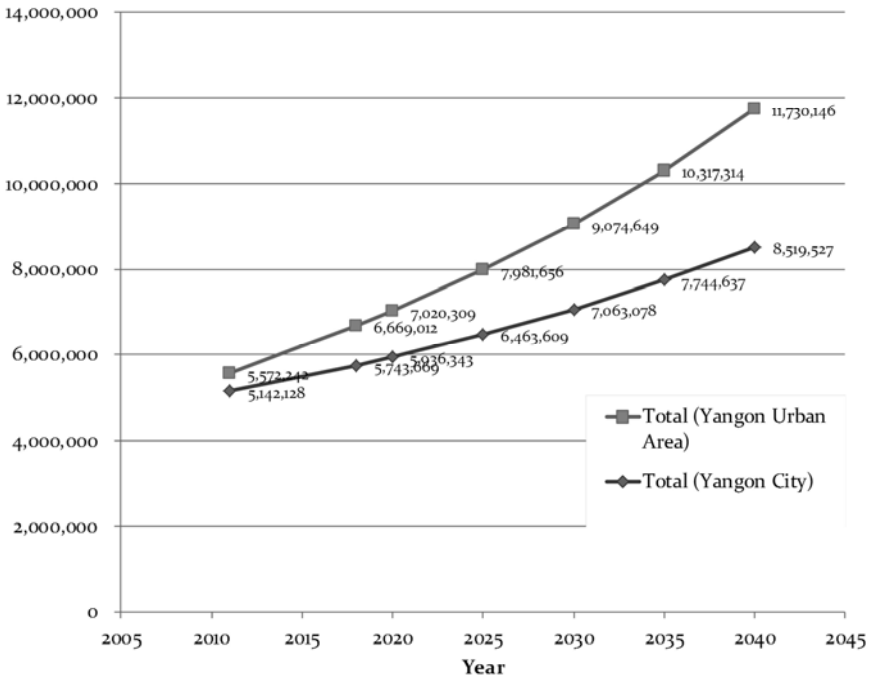
Future population for the water supply master plan is employed same as estimated in JICA Urban Plan Study, 2012, which is conducted starting August 2012 in parallel with this study. Population increase is notably allocated not in the present urbanized area but newly developing areas, "new suburbs zone" and peripheral 6 townships. The future population is shown in the Table and Figure below.

Table 4.10 Future Population in Greater Yangon

(persons)

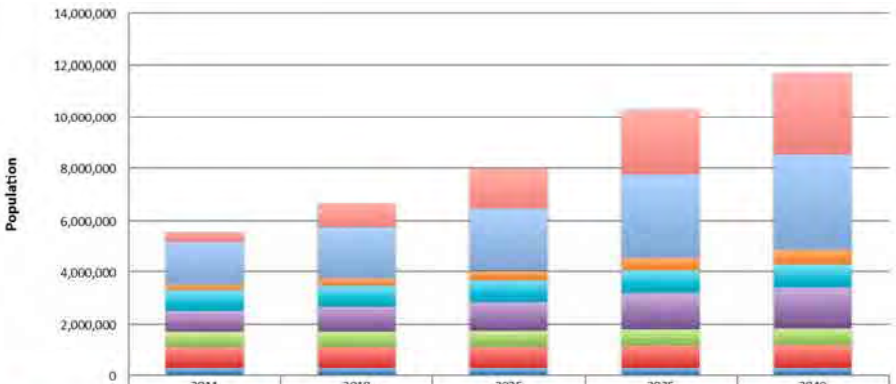
Area	Current	Projected					
	2011	2018	2020	**2025**	2030	2035	2040
Yangon City	5,142,128	5,743,669	5,936,343	**6,463,609**	7,063,078	7,744,637	8,519,527
Periphery areas	430,114	925,343	1,083,966	**1,518,047**	2,011,571	2,572,677	3,210,619
Greater Yangon	5,572,242	6,669,012	7,020,309	**7,981,656**	9,074,649	10,317,314	11,730,146

Source: JICA Urban Plan Study, 2012



JICA Urban Plan Study, 2012

Figure 4.5 Future Population in Greater Yangon (Persons)



	2011	2018	2025	2035	2040
Periphery Area	430,114	925,343	1,518,047	2,572,677	3,210,619
New Suburbs	1,642,030	2,003,702	2,436,562	3,206,771	3,672,669
South of CBD	219,512	280,948	354,477	485,310	564,451
Older Suburbs	778,156	800,059	826,274	872,919	901,134
Northern Suburbs	805,461	938,484	1,097,689	1,380,971	1,552,328
Outer Ring	596,425	603,370	611,682	626,472	635,418
Inner Urban Ring	848,152	864,179	883,360	917,491	938,136
CBD	252,392	252,926	253,566	254,703	255,391

Source: JICA Study Team

Figure 4.6 Future Population by Township Group

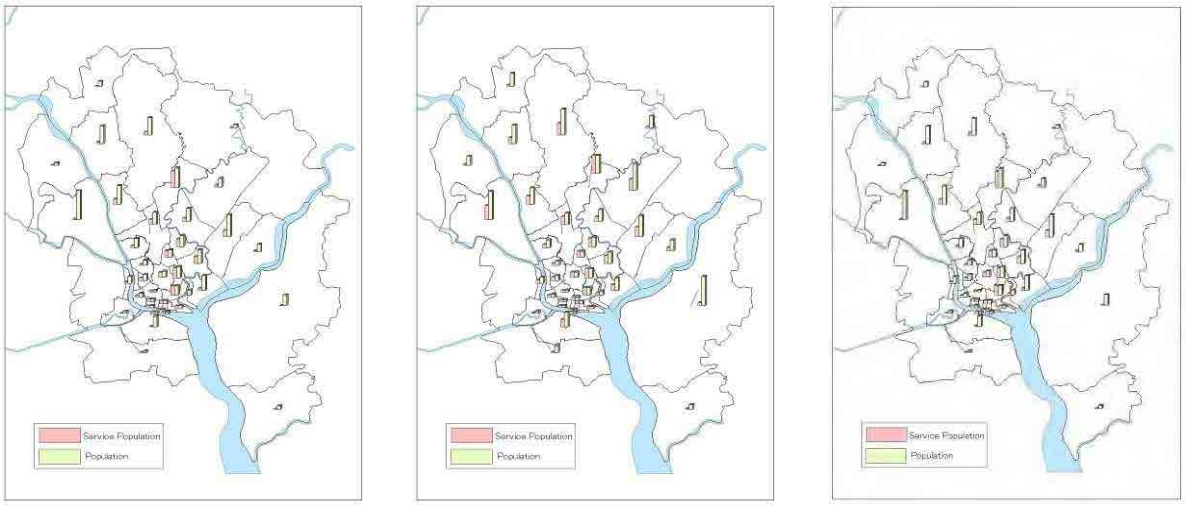
4.3.6 Served Population

Served population is set as enumerated in Table below using the above coverage rate and township population, which are explained in Chapter 5. Served population will be 6.8 million in 2040 in YCDC area, an increase of 4 million compared to the current population while it will be 8.1 million, an increase of 5 million in case of Greater Yangon.

Table 4.11 Population and Water Served Population

Area	Category	2011	2018	2020	**2025**	2030	2035	2040
Yangon City	Service pop	1,920,471	2,742,337	3,061,819	**3,764,310**	4,617,069	5,614,139	6,810,338
	Total pop	5,142,128	5,743,669	5,936,343	**6,463,609**	7,063,078	7,744,637	8,519,527
Greater Yangon	Service pop	1,920,471	2,742,337	3,061,819	**3,916,114**	5,019,383	6,385,941	8,094,586
	Total pop	5,572,242	6,669,012	7,020,309	**7,981,656**	9,074,649	10,317,314	11,730,146

Note; Population is explained in Chapter 5.
Source: JICA Study Team



2011 2025 2040

Source: JICA Study Team

Figure 4.7 Population and Served Population by Township

Table 4.12 Water Served Population by Township in Greater Yangon

(Persons)

Code	Area	Township	2011	2018	2020	**2025**	2030	2035	2040
1	1.CBD	Latha	31,736	34,125	34,125	**34,125**	34,125	34,125	34,125
2	1.CBD	Lanmadaw	37,098	41,843	43,137	**43,137**	43,137	43,137	43,137
3	1.CBD	Pabedan	35,298	37,551	37,551	**37,551**	37,551	37,551	37,551
4	1.CBD	Kyauktada	33,405	34,797	34,797	**34,797**	34,797	34,797	34,797
5	1.CBD	Botahtaung	45,203	49,134	49,134	**49,134**	49,134	49,134	49,134
6	1.CBD	Pazuntaung	53,112	54,182	54,353	**54,822**	55,354	55,959	56,647
7	2.IUR	Ahlone	30,790	38,966	41,054	**46,679**	53,773	61,039	68,509
8	2.IUR	Kyeemyindaing	19,693	41,384	49,440	**64,375**	80,764	98,886	119,068
9	2.IUR	Sanchaung	45,239	59,216	63,548	**74,467**	85,531	96,767	108,207
10	2.IUR	Dagon	14,450	21,574	24,108	**30,493**	38,140	42,982	48,488
11	2.IUR	Bahan	82,570	98,206	102,811	**104,216**	105,813	107,629	109,693
12	2.IUR	Tarmwe	168,180	186,417	192,525	**193,461**	194,526	195,737	197,113
13	2.IUR	Mingalar Taung Nyunt	149,536	157,370	157,883	**159,288**	160,885	162,701	164,765
14	2.IUR	Seikkan	1,345	1,681	1,793	**2,017**	2,241	2,241	2,241
15	2.IUR	Dawbon	22,694	32,493	35,196	**44,229**	53,394	62,717	72,227
16	5.ORZ	Kamaryut	21,091	32,599	36,563	**46,875**	57,847	69,606	82,303
17	5.ORZ	Hlaing	27,183	44,414	49,227	**62,283**	78,919	96,155	114,108
18	5.ORZ	Yankin	107,023	120,873	125,909	**125,909**	125,909	125,909	125,909
19	5.ORZ	Thingangyun	115,811	140,255	147,699	**165,421**	190,756	216,780	243,619
20	6.NS	Mayangone	80,107	119,142	129,927	**161,034**	192,983	228,546	268,392
21	6.NS	Insein	80,912	122,722	130,687	**168,510**	209,239	253,434	301,751
22	6.NS	Mingalardon	46,217	123,662	151,955	**238,779**	352,161	497,239	680,061
23	4.OldSZ	North Okkalapa	280,127	335,530	354,644	**368,692**	384,664	402,823	423,468
24	4.OldSZ	South Okkalapa	126,316	148,191	154,239	**174,362**	194,800	196,011	197,387
25	4.OldSZ	Thaketa	35,460	77,428	90,871	**118,731**	147,751	178,156	210,209
26	3.SCBD	Dala	9,054	66,111	101,495	**150,984**	214,083	293,405	392,026
27	3.SCBD	Seikgyikhanaungto	0	0	9,378	**15,752**	23,559	33,080	44,651
28	7.NewSZ	Shwe Pyi Thar	20,720	33,499	69,497	**114,500**	168,212	232,358	308,972
29	7.NewSZ	Hlaing Thar Yar	9,775	138,608	180,613	**293,089**	378,219	476,423	590,179
30	7.NewSZ	North Dagon	57,512	76,874	82,851	**98,808**	129,366	163,229	201,032

Code	Area	Township	2011	2018	2020	**2025**	2030	2035	2040
31	7.NewSZ	South Dagon	103,713	148,909	160,962	**198,369**	260,019	330,902	412,778
32	7.NewSZ	East Dagon	29,101	99,104	128,553	**220,629**	367,890	567,126	828,324
33	7.NewSZ	Dagon Seikkan	0	25,477	35,294	**68,792**	111,527	167,555	239,467
SB1	1.CBD	CBD	235,852	251,632	253,097	**253,566**	254,098	254,703	255,391
SB2	2.IUR	Inner Urban Ring	534,497	637,307	668,358	**719,225**	775,067	830,699	890,311
SB3	3.SCBD	South of CBD	9,054	66,111	110,873	**166,736**	237,642	326,485	436,677
SB4	4.OldSZ	Older Suburbs Zone	441,903	561,149	599,754	**661,785**	727,215	776,990	831,064
SB5	5.ORZ	Outer Ring Zone	271,108	338,141	359,398	**400,488**	453,431	508,450	565,939
SB6	6.NS	Northern Suburbs	207,236	365,526	412,569	**568,323**	754,383	979,219	1,250,204
SB7	7.NewSZ	New Suburbs Zone	234,039	522,471	657,770	**994,187**	1,415,233	1,937,593	2,580,752
T-1		Total (Yangon City)	1,920,471	2,742,337	3,061,819	**3,764,310**	4,617,069	5,614,139	6,810,338

Periphery Areas(6 suburban Townships)

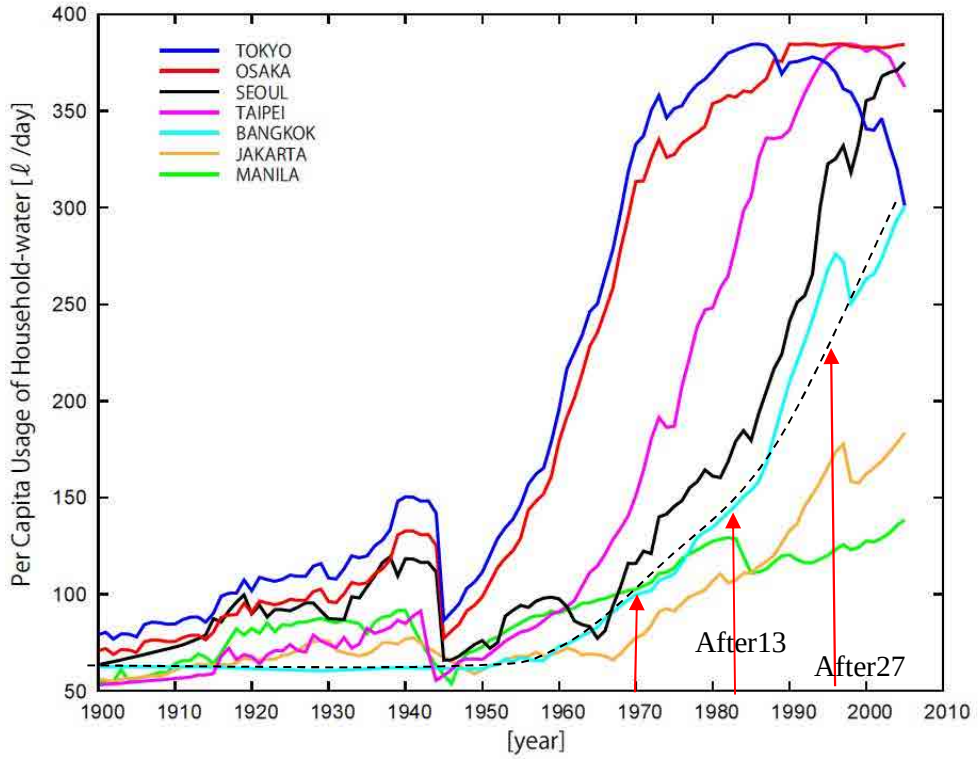
			2011	2018	2020	**2025**	2030	2035	2040
34	PA	Kyauktan	0	0	0	**8,955**	21,637	38,810	61,382
35	PA	Thanlyin	0	0	0	**59,742**	157,176	300,046	497,508
36	PA	Hlaegu	0	0	0	**23,974**	65,092	126,873	213,483
37	PA	Hmawbi	0	0	0	**26,680**	69,971	133,284	220,654
38	PA	Htantapin	0	0	0	**17,989**	48,649	94,583	158,868
39	PA	Twantay	0	0	0	**14,464**	39,789	78,206	132,353
T-2		6 suburban TSs	0	0	0	**151,804**	402,314	771,802	1,284,248
		Grand Total	1,920,471	2,742,337	3,061,819	**3,916,114**	5,019,383	6,385,941	8,094,586

Source: JICA Study Team

4.3.7 Unit Water Consumption

(1) Domestic

Unit consumption tends to increase with economic development and stops increasing when economic development matures due to satisfaction of water consumption and introduction of water management policy. Figure below shows unit consumption variation with time in the Asian cities. Unit consumptions are stable in Japan, Korea and Taiwan and it decreases in Tokyo. They are increasing in developing cities and the figure in Bangkok reached to the level of developed cities. Unit consumption in Yangon is set referring to those in Bangkok. Current unit consumption of 100 liters in Yangon is same as the level of Bangkok was in 1970. After 1970, unit consumption in Bangkok continued increasing and reached 230 liters in 1995 in 27 years' duration when per capita GDP was 5,000 US$.



Source: Research Institute for Humanity and Nature

Figure 4.8 Unit Consumption Change with Time in Asian Cities

Unit consumption will increase drastically in Yangon, however, it is set as not so high considering introduction of water management policy including water saving campaigns. Referring to unit consumptions in Bangkok and Jakarta, 200 liters are applied to urban areas and 150 liters for suburban areas for 2040. Unit consumption is set as 150 liters in 2025 referring to those of Bangkok 13 years after 1970.

Unit domestic consumption in the peripheral townships should be lower than in YCDC and is set as 150 liters in 2040 and 100 liters in 2025.

Table 4.13 Unit Domestic Consumption Target (LPCD)

Items	2011 (present)	**2025**	2040
Urban Yangon	100	**150**	200
Suburban Yangon	60	**100**	150
Peripheral Yangon	-	**100**	150

Source: JICA Study Team

Target of unit consumption rate by township in Greater Yangon is shown in Table 4.15.

(2) Non-domestic

Ratio of domestic use and non-domestic is 60:40 in Yangon. Ratios in the neighboring cities range

from 30 to 50 % depending on cities' salient features and existence of individual water supply. It is reasonable to apply present non-domestic use ratio of 40 % for the future.

Table 4.14 Ratio of Domestic Use and Non-Domestic Use in the Neighboring Cities

Items	Ho Chi Minh	Jakarta	Kuala Lumpur	Manila	Osaka	Seoul	Shanghai	Bangkok
Year	2001	2001	2001	2001	2001	2001	2001	2009
Domestic water use	73	59	53	61	54	71	64	52
Non-domestic water use	27	41	47	39	46	29	36	48

Source: Water in Asian Cities, Utilities' Performance and Civil Society Views, ADB 2004

Table 4.15 Target of Unit Domestic Consumption Rate by Township in Greater Yangon (Liters per capita per day (LPCD))

Code	Area	Township	2011	2018	2020	**2025**	2030	2035	2040
1	1.CBD	Latha	109	125	132	**150**	167	183	200
2	1.CBD	Lanmadaw	109	125	132	**150**	167	183	200
3	1.CBD	Pabedan	110	125	132	**150**	167	183	200
4	1.CBD	Kyauktada	109	125	132	**150**	167	183	200
5	1.CBD	Botahtaung	92	125	132	**150**	167	183	200
6	1.CBD	Pazuntaung	72	125	132	**150**	167	183	200
7	2.IUR	Ahlone	154	127	134	**150**	167	183	200
8	2.IUR	Kyeemyindaing	85	127	134	**150**	167	183	200
9	2.IUR	Sanchaung	131	127	134	**150**	167	183	200
10	2.IUR	Dagon	136	127	134	**150**	167	183	200
11	2.IUR	Bahan	137	127	134	**150**	167	183	200
12	2.IUR	Tarmwe	109	127	134	**150**	167	183	200
13	2.IUR	Mingalar Taung Nyunt	72	127	134	**150**	167	183	200
14	2.IUR	Seikkan	-	127	134	**150**	167	183	200
15	2.IUR	Dawbon	43	127	134	**150**	167	183	200
16	5.ORZ	Kamaryut	165	124	131	**150**	167	183	200
17	5.ORZ	Hlaing	102	124	131	**150**	167	183	200
18	5.ORZ	Yankin	139	124	131	**150**	167	183	200
19	5.ORZ	Thingangyun	63	124	131	**150**	167	183	200
20	6.NS	Mayangone	149	144	146	**150**	167	183	200
21	6.NS	Insein	142	144	146	**150**	167	183	200
22	6.NS	Mingalardon	115	144	146	**150**	167	183	200
23	4.OldSZ	North Okkalapa	77	117	126	**150**	167	183	200
24	4.OldSZ	South Okkalapa	78	117	126	**150**	167	183	200
25	4.OldSZ	Thaketa	45	117	126	**150**	167	183	200
26	3.SCBD	Dala	27	70	79	**100**	117	133	150
27	3.SCBD	Seikgyikhanaungto	-	70	79	**100**	117	133	150
28	7.NewSZ	Shwe Pyi Thar	145	82	87	**100**	117	133	150
29	7.NewSZ	Hlaing Thar Yar	95	82	87	**100**	117	133	150
30	7.NewSZ	North Dagon	63	82	87	**100**	117	133	150
31	7.NewSZ	South Dagon	55	82	87	**100**	117	133	150
32	7.NewSZ	East Dagon	41	82	87	**100**	117	133	150
33	7.NewSZ	Dagon Seikkan	-	82	87	**100**	117	133	150
Code	Area	Area	2011	2018	2020	**2025**	2030	2035	2040
SB1	1.CBD	CBD	99	125	132	**150**	167	183	200
SB2	2.IUR	Inner Urban Ring	104	127	134	**150**	167	183	200
SB3	3.SCBD	South of CBD	40	70	79	**100**	117	133	150
SB4	4.OldSZ	Older Suburbs Zone	84	117	126	**150**	167	183	200
SB5	5.ORZ	Outer Ring Zone	98	124	131	**150**	167	183	200
SB6	6.NS	Northern Suburbs	138	144	146	**150**	167	183	200
SB7	7.NewSZ	New Suburbs Zone	64	82	87	**100**	117	133	150
T-1		Yangon City Average	95	117	121	**135**	149	163	178

Periphery Areas(6 suburban Townships)

Code	Area	Area	2011	2018	2020	**2025**	2030	2035	2040
34	PA	Kyauktan				**100**	117	133	150
34	PA	Kyauktan				**100**	117	133	150
35	PA	Thanlyin				**100**	117	133	150
36	PA	Hlaegu				**100**	117	133	150
37	PA	Hmawbi				**100**	117	133	150
38	PA	Htantapin				**100**	117	133	150
39	PA	Twantay				**100**	117	133	150
T-2		6 suburban TSs				**100**	117	133	150
		Grand Total		117	121	**133**	147	159	173

Source: JICA Study Team

4.3.8 Non-Revenue Water Rate

Non-revenue water rates in the cities of the southeastern Asian countries are shown in Table below. The condition in Ho Chi Min city is the worst, 41% and Singapore is the best, 4%. Bangkok shows 28% while still-developing Phnom Penh and Vientiane show less than 10%. Non-revenue water rate does not relate to GDP level and it can be reduced with efforts and budgets of the water supply organizations towards it.

Table 4.16 Non-Revenue Water Rate in Cities of Southeastern Countries

(%)

HCMC	Singapore	Davao	jog Jakarta	Phnom Penh	Kuala Lumpur	Vientiane	Bangkok
Vietnam	Singapore	Philippines	Indonesia	Cambodia	Malaysia	Lao PDR	Thailand
41	4	25	17	6	35	9	28

Source: IBNET etc.

Present non-revenue water rate is estimated as 66% in Yangon. YCDC has intention to reduce it and the target level is set as 15% by 2040.

4.3.9 Leakage Rate

Present leakage rate is estimated as 50%. Leakage reduction requires continuous efforts and strong support from management side with investment costs for replacement of old pipes, etc. YCDC has set ambitious leakage level as 10% in 2040. Target levels of leakage with non-revenue water are shown in the Figure on right by 5 years interval.

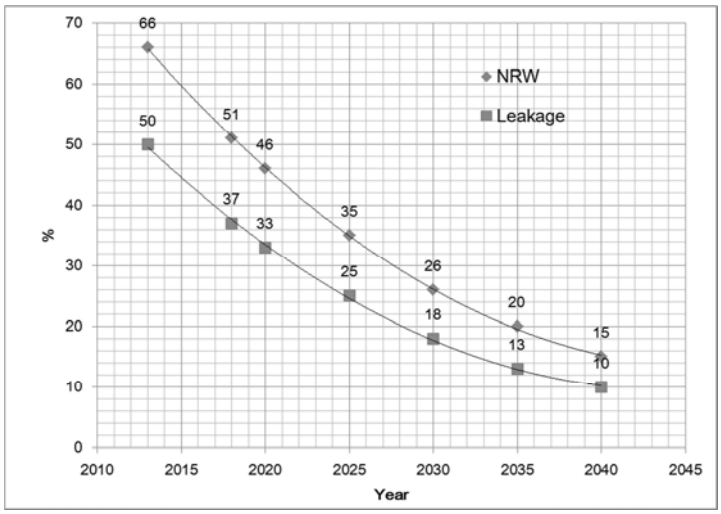


Figure 4.9 Target Level of Leakage and Non-Revenue Water

Table 4.17 Target Level of Non-Revenue Water Rate and Leakage Rate

Items	2013	2018	2020	**2025**	2030	2035	2040
Non-revenue Water Rate (%)	66	51	46	**35**	26	20	15
Leakage Rate (%)	50	37	33	**25**	18	13	10

Source: JICA Study Team

4.3.10 Peak Factor

Peak factor is the ratio of daily maximum demand and daily average demand and used for decision on design of the treatment facilities. Variations of total monthly consumption are calculated as 1.05 in 2009 and 2011 using YCDC metered consumption records. The coefficient in Bangkok is about 1.1.

The planned service coverage of piped water supply is 69 % in 2040. Even in 2040, water supply facilities and the amount of water supply are not enough for entire population and many of the population still cannot have access to the safe piped water supply. Therefore, at first, the target will be to meet the daily average water demand. In addition, the excessive investment in water supply facilities over the capability of YCDC must be avoided. For these reasons, the planned daily maximum water demand coefficient shall be as low as possible. Referring to the past values of YCDC, Bangkok, and the large cities in Japan (see below), the coefficient is set at 1.1.

Table 4.18 Coefficient of Daily Maximum Water Supply Amount in 2011

City	Service population	Daily average water supply amount	Daily maximum water supply amount	Coefficient
Tokyo	12,858,221	4,200,700	4,699,600	1.12
Sapporo	1,913,686	525,000	589,410	1.12
Yokohama	3,706,454	1,179,400	1,294,100	1.10
Nagoya	2,388,943	782,200	895,563	1.14
Osaka	2,679,701	1,210,100	1,347,900	1.11
Fukuoka	1,437,004	399,800	434,055	1.09

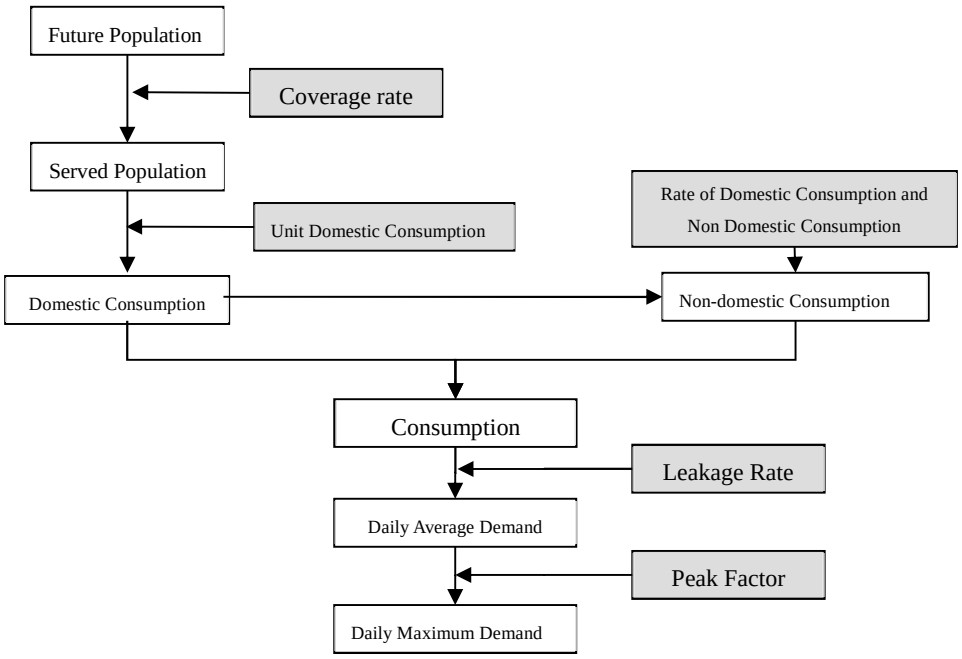
Source: JICA Study Team

CHAPTER 5 WATER DEMAND AND SOURCE BALANCE

5.1 Water Demand Estimation

5.1.1 Estimation Method

Water demand estimation process is shown in Figure below. Various parameters such as target values of water coverage rate, unit domestic consumption, rate of domestic use and non-domestic use and leakage rate are already decided in the preceding Chapter. Remaining parameter of peak factor is set here.



Source: JICA Study Team

Figure 5.1 Water Demand Estimation Process

5.1.2 Water Demand Estimate

The results of calculation of water demand based on the estimation flowchart are given in the table below.

Table 5.1 Water Demand in Greater Yangon

Items	Year	2011	**2025**	2040
Population	person	5,572,242	**7,981,656**	11,730,146
Served Population	Person	1,920,471	**3,916,114**	8,094,586
Water Coverage Rate	%	34	**49**	69
Unit Consumption	lpcd	95	**133**	173
Leakage Rate	%	50	**25**	10
Daily Average Water Demand	m^3/day	611,952	**1,164,696**	2,620,679
Daily Maximum Water Demand	m^3/day	673,148	**1,281,167**	2,882,749
Daily Average Water Demand	MGD	135	**256**	577
Daily Maximum Water Demand	MGD	148	**282**	634

Source: JICA Study Team

Table 5.2 Water Demand in Yangon City

Items	Year	2011	**2025**	2040
Population	person	5,142,128	**6,463,609**	8,519,527
Served Population	Person	1,920,471	**3,764,310**	6,810,338
Water Coverage Rate	%	37	**58**	80
Unit Consumption	lpcd	95	**135**	178
Leakage Rate	%	50	**25**	10
Daily Average Water Demand	m^3/day	611,952	**1,125,773**	2,242,961
Daily Maximum Water Demand	m^3/day	673,148	**1,238,351**	2,467,258
Daily Average Water Demand	MGD	135	**248**	493
Daily Maximum Water Demand	MGD	148	**272**	543

Source: JICA Study Team

Water demand is estimated as shown below. Daily maximum demands are 543 MGD for YCDC and 634 MGD for greater Yangon, both in 2040.

Table 5.3 Daily Average Water Demand in Yangon

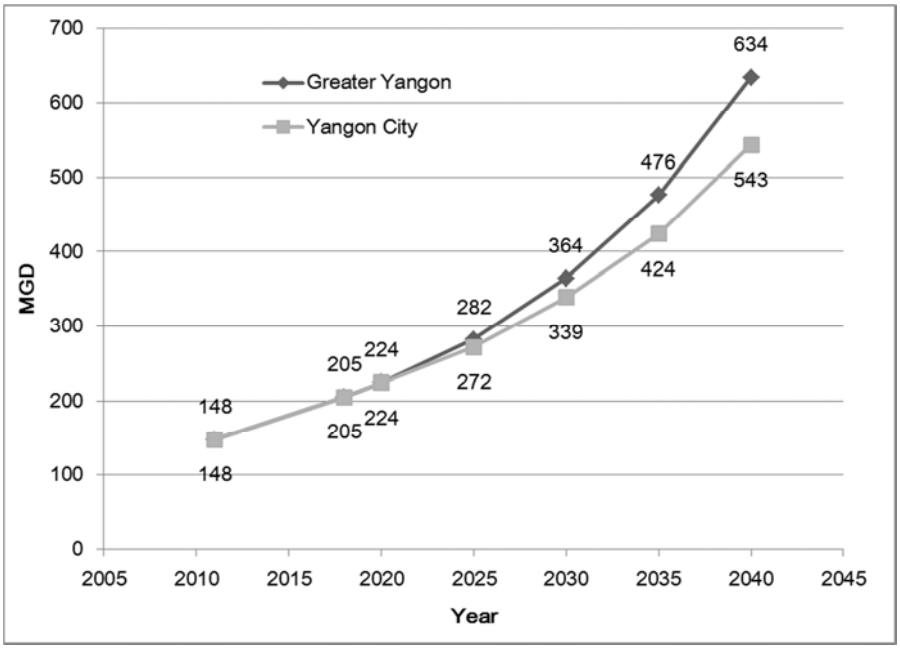
Area	2011	2018	2020	**2025**	2030	2035	2040
m^3/day							
Yangon City	611,952	846,778	924,969	**1,125,773**	1,399,201	1,751,309	2,242,961
Periphery Areas	0	0	0	**38,923**	106,018	213,855	377,718
Greater Yangon	611,952	846,778	924,969	**1,164,696**	1,505,219	1,965,164	2,620,679
MGD							
Yangon City	135	186	203	**248**	308	385	493
Periphery Areas	0	0	0	**9**	23	47	83
Greater Yangon	135	186	203	**256**	331	432	576

Source: JICA Study Team

Table 5.4 Daily Maximum Water Demand

Area	2011	2018	2020	**2025**	2030	2035	2040
m^3/day							
Yangon City	673,148	931,459	1,017,467	**1,238,351**	1,539,121	1,926,442	2,467,258
Periphery Areas	0	0	0	**42,816**	116,619	235,240	415,491
Greater Yangon	673,148	931,459	1,017,467	**1,281,167**	1,655,740	2,161,682	2,882,749
MGD							
Yangon City	148	205	224	**272**	339	424	543
Periphery Areas	0	0	0	**9**	26	52	91
Greater Yangon	148	205	224	**282**	364	476	634

Source: JICA Study Team



Source: JICA Study Team

Figure 5.2 Daily Maximum Demand in Yangon

5.2 Water Sources

5.2.1 Reservoir Water

The existing surface water reservoirs supplied to Yangon City consists of the Gyobyu, Phugyi, and Hlawga reservoirs which are operated by YCDC. The Ngamoeyeik Reservoir (first and second phase) are managed by MOAI.

At first, the third phase of the Ngamoeyeik Reservoir was one of the candidate water sources for this study. However, this idea was terminated at the end of 2012. Instead, the water right of the Lagunbyin Reservoir with capacity of 40 MGD, out of which 10 MGD shall be allocated to Thilawa SEZ, has been approved to YCDC and is considered as a water source. Table 5.5 shows the list of water sources (reservoir). The total capacity of the existing water reservoirs is 215 MGD.

Table 5.5 List of Water Sources (Reservoirs)

Name	Water Source Capacity		Remark
	m^3/day	MGD	
Gyobyu R. (Surface water)	123,000	27	
Phugyi R. (Surface water)	245,000	54	
Hlawga R. (Surface water)	64,000	14	
Ngamoeyeik (Surface water: First Phase)	205,000	45	
Ngamoeyeik (Surface water: Second Phase)	205,000	45	Second Phase WTP will be commissioned in 2013
Lagunbyin Reservoir (Surface water)	135,400	30	Decision on Jan 2013, for YCDC use.
Total	977,400	215	If Thilawa SEZ (10 MGD) is added, it will be 225 MGD.

Source: JICA Study Team

5.2.2 Groundwater

About 8 MGD groundwater is used for YCDC water supply system, which is 5% of total water sources of 160 MGD. Groundwater generally contains iron in Yangon. Iron removal plants of 1 MGD capacity exist in the suburban areas, east, west and south. Water taken from other large number (414) of small-scale tube wells is supplemented to distribution pipes. Maintaining tube wells requires large number of staffs.

About 79 MGD groundwater both by YCDC and individuals was estimated to be abstracted out of the estimated safe yield amount of 83 MGD (2002 JICA-M/P). If groundwater abstraction increases with population and demand increases, lowering of water Table will take place and eventually land subsidence might occur.

Bangkok has already experienced the above phenomenon with significant impacts like sea water intrusion into ground water aquifer and land subsidence. Land subsidence has resulted in frequent inundations.

Accordingly, groundwater abstraction need to be gradually reduced and kept only as back-up facilities as surface water will be developed in the future. In the master plan, ground water is not utilized after 2025 by shifting towards the use of river water resources as shown in the following Table.

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Table 5.6 Groundwater Source (MGD)

	2011	2020	**2025**	2030	2040
Intake volume (MGD)	8	8	**0**	0	0
Intake volume (m^3/day)	36,000	36,000	**0**	0	0

Source: JICA Study Team

5.2.3 River Water

(1) Transition to Development of River Water Source

The maximum water demand per day in Yangon Region in 2025 and 2040 are 273 MGD and 634 MGD, respectively. On the other hand, planned water source is 225 MGD (including Thilawa SEZ) by the reservoir only. Therefore, development of potential water source from river is required to meet the water demand in 2025 and 2040.

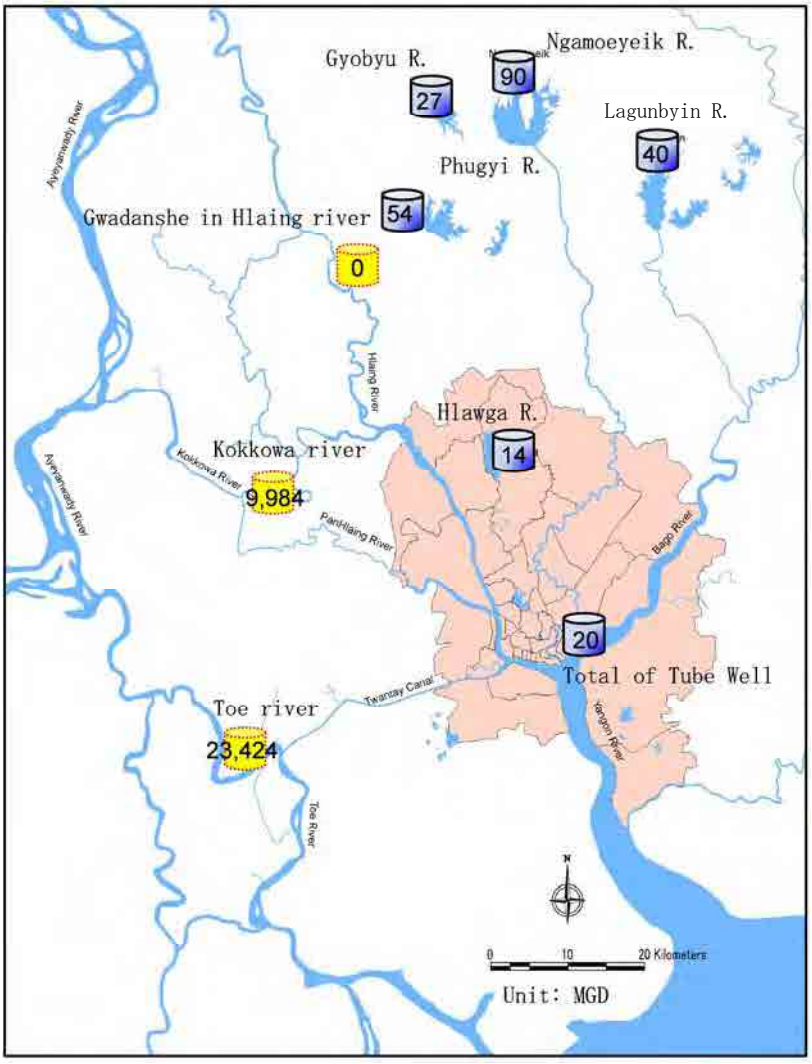
(2) Selection of Rivers for Development

In the JICA 2002 survey, the Bago River was observed to have low available water flow (1 m^3/s). Therefore, the Bago River was not selected as future water source. In the 2012 study, the Hlaing River has minimum water flow of 11 m^3/s and irrigation will use 4.7 m^3/s. If river maintenance flow is considered the available water is minimal. Therefore, the Hlaing River is also omitted from the list of

future water source.

(3) Estimation of Water Flow of Rivers

The potential river source will be Kokkowa and Toe Rivers, which are branches of the Irrawaddy. The characteristic of these sources are that long distance water conveyance is required to send water to Yangon city and water has high turbidity in rainy season compared to conventional reservoir source. The proposed intake points in both rivers are shown in the figure below.



Source: JICA Study Team

Figure 5.3 Proposed Intake Points of Rivers

Table 5.7 shows the development of potential water sources in river sections. The possibility of water intake from the surrounding rivers is presented as follows; a) Hlaing River 0 MGD, b) Kokkowa 9,984 MGD, and c) Toe River 23,424 MGD, although the accuracy of this estimate is not very high. Appendix B includes the detail process of potential water sources in river sections.

It was confirmed that MOAI monitors water levels in both rivers but not water discharge. In order to convert these water level data to flow discharge, the JICA Study Team requested MOAI to measure flow rate and cross section of the rivers. MOAI implemented these measurements in Kokkowa River in November 2012 and March in 2013, and Toe River in December 2012 and March 2013. Based on these data obtained, the JICA Study Team estimated the minimum discharge of the rivers. The details are shown in Appendix B. With consideration of irrigation and river maintenance use, the minimum river flow is about 10,000 MGD and 23,000 MGD for Kokkowa river and Toe river, respectively. These flows are much more than the future water demand in 2040 (643 MGD).

Table 5.7 Development of Potential Water Sources (River Section)

Unit: m^3/s

River	Minimum River Flow Discharge	Irrigation use	Maintenance use	Potential Water Resource	
				m^3/s	MGD
Hlaing River	11.4	2.3 (Pump) 4.7 (MOAI plan)	4.4	0	0
Kokkowa River	1,045	12.0	525	520	9,984
Toe River	2,448	0	1,228	1,220	23,424

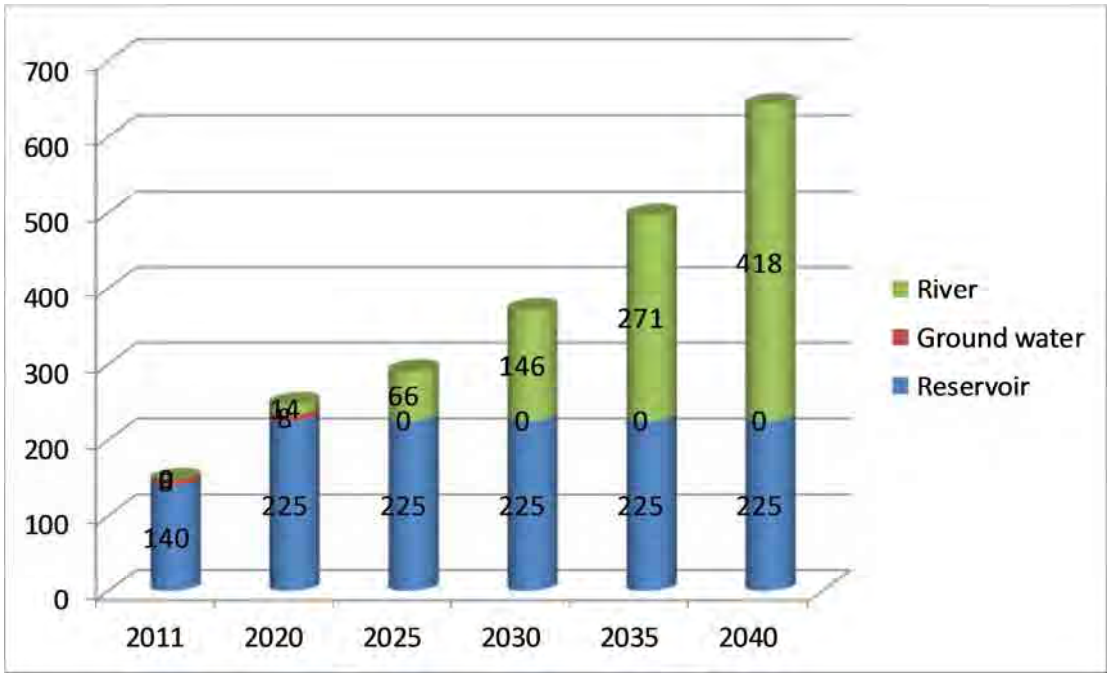
Note: (Pump) Irrigation pump station is installed near the proposed intake points. The number is pump capacity.
(MOAl plan) MOAl has a plan for irrigation. The number is planned required flow rate for irrigation plan.
Source: JICA Study Team

(4) Salt Concentration in Rivers

Both the rivers have potential of salt intrusion from the sea. To use these rivers as source of drinking water, salt concentration need to be checked. The salt concentration measurement survey was carried out on the assumed day when salt intrusion gets severest. The assumed day is around the day of the spring tide in March 2013, when it is dry season and rain has not yet started at the upstream of the rivers. The details of the survey are given in the Appendix C. The result shows that salt concentration in Kokkowa river is less than the guideline of WHO but the concentration in Twantay canal and at the downstream of branch part of Twantay canal in Toe river is slightly higher than that of Kokkowa river and close to the guideline. It is assumed that the salt intrusion comes from Twantay canal to Toe river. The second survey was conducted to check the influence of salt intrusion at the upstream of the branch point of Twantay canal in Toe river. As a result, no salt influence is found in the upstream part in Toe river so that it is understood that salt influence does not reach to the upstream and water intake is not affected by salt if water is taken from the upstream of the Twantay canal in Toe river. It is recommended that continuous monitoring of salt concentration be made for further confirmation.

5.2.4 Staged Water Source Development

The development of water source by source type was planned by 5 year interval up to 2040 and is illustrated below.



Source: JICA Study Team

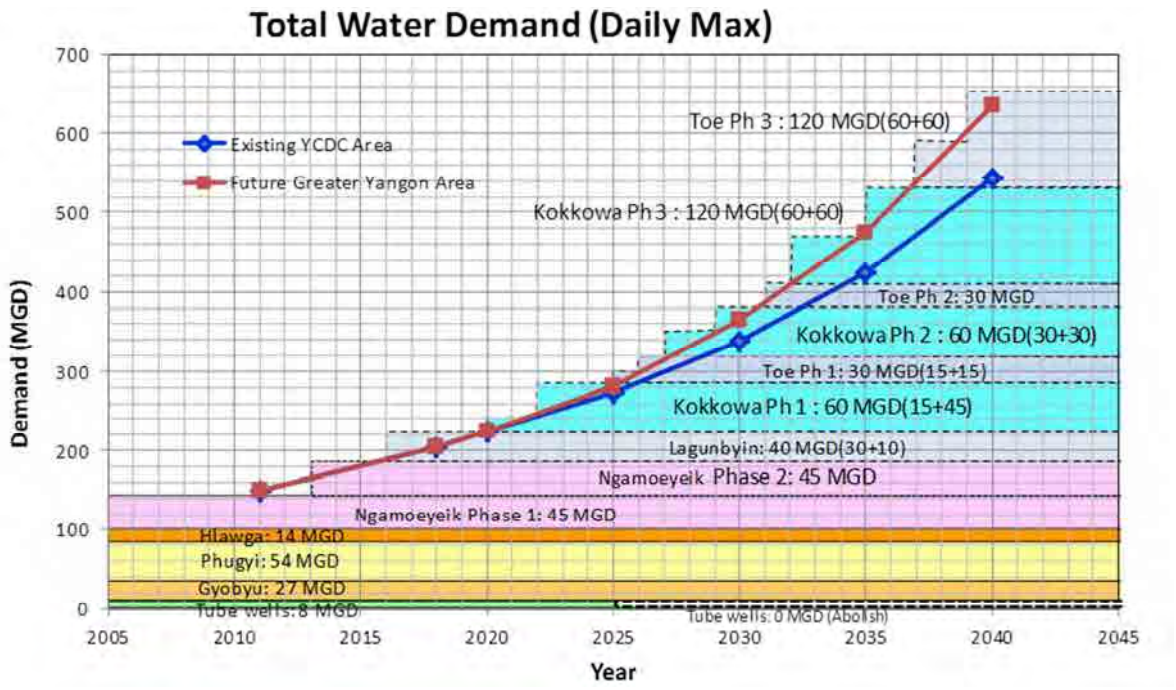
Figure 5.4 Water Sources for Greater Yangon

Water sources are proposed to be developed in stages according to increasing demand. Both Kokkowa source and Toe source are planned to be developed in three-stages as shown in Table 5.8 and Figure 5.5. Treatment plants and transmission systems are to be developed accordingly. As shown in the figure, it can be read that stage of treatment plan will be divided into 2 construction phases. .

Table 5.8 Staged Water Source Development

Water Source	Commissioning Year	2011	2018	2020	**2025**	2030	2035	2040
Groundwater								
Tube well	Existing	8	8	8	**0**	0	0	0
Reservoirs								
Gyobyu	Existing	27	27	27	**27**	27	27	27
Phugyi	Existing	54	54	54	**54**	54	54	54
Hlawga	Existing	14	14	14	**14**	14	14	14
Ngamoeyeik 1	Existing	45	45	45	**45**	45	45	45
Ngamoeyeik 2	2013	0	45	45	**45**	45	45	45
Lagunbyin	2016	0	40	40	**40**	40	40	40
Sub-total		140	225	225	**225**	225	225	225
Rivers								
Kokkowa	2020,2022,2027,2029,2032,2035	0	0	15	**60**	120	240	240
Toe	2025,2026,2031,2037,2039	0	0	0	**15**	30	60	180
Sub-total		0	0	15	**75**	150	240	420
Total		148	233	248	**300**	375	540	645
Total Demand		148	205	224	**282**	364	476	634

Source: JICA Study Team



Source: JICA Study Team

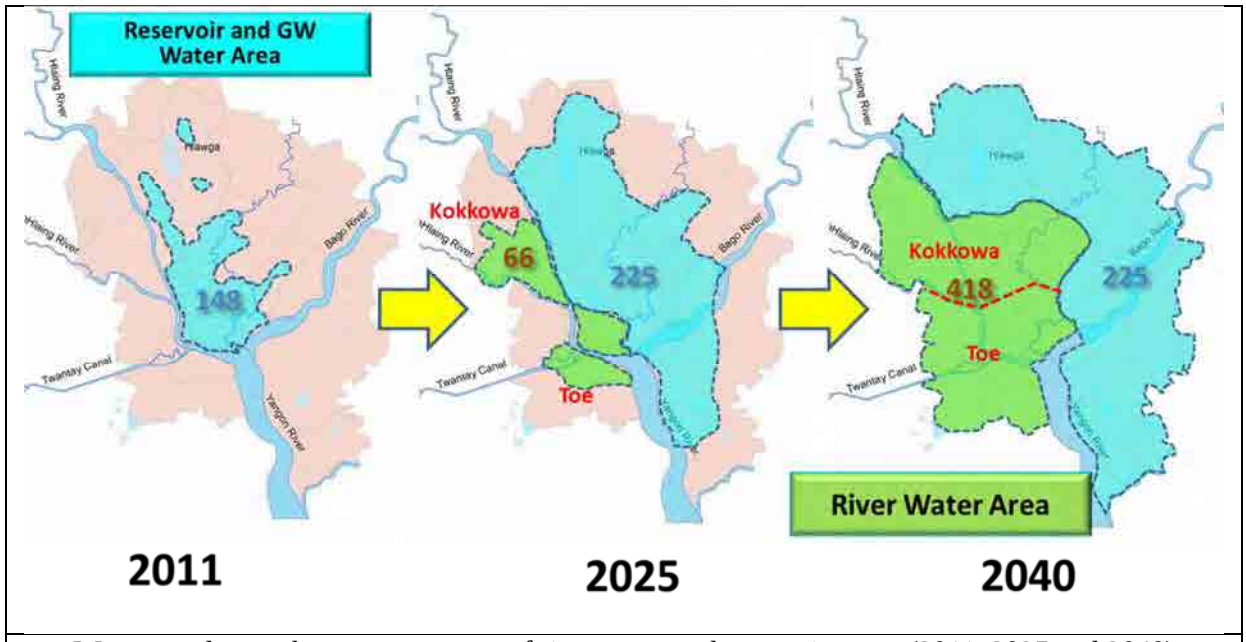
Figure 5.5 Staged Water Source Development

5.3 Water Balance

The areal water balance is estimated based on the conditions below.

- Water demand is as estimated above.
- The water source capacity of reservoir will be 225 MGD in 2025 and will not increase anymore.
- After full development of reservoir source, source development will shift to river.
- After the shift to river source, inefficient use of groundwater will be reduced and abolished.
- Thilawa SEZ water demand will be 9 MGD after 2018.
- The daily maximum water demand of Yangon city and Yangon urban area in 2040 will be 543 MGD and 634 MGD including Thilawa SEZ water demand.

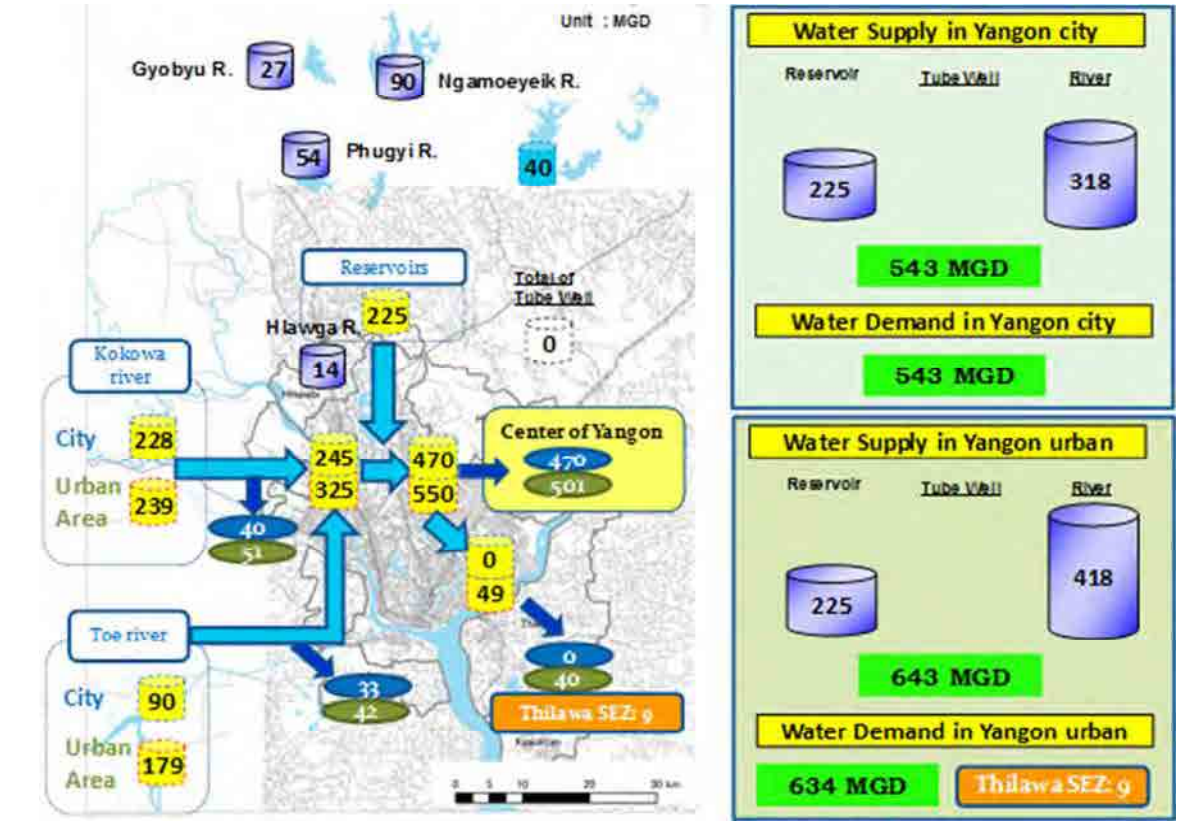
Water supply area by water resource and water balance in 2025 and 2040 are shown below.



Water supply area by water resource of river water and reservoir water (2011, 2025 and 2040)

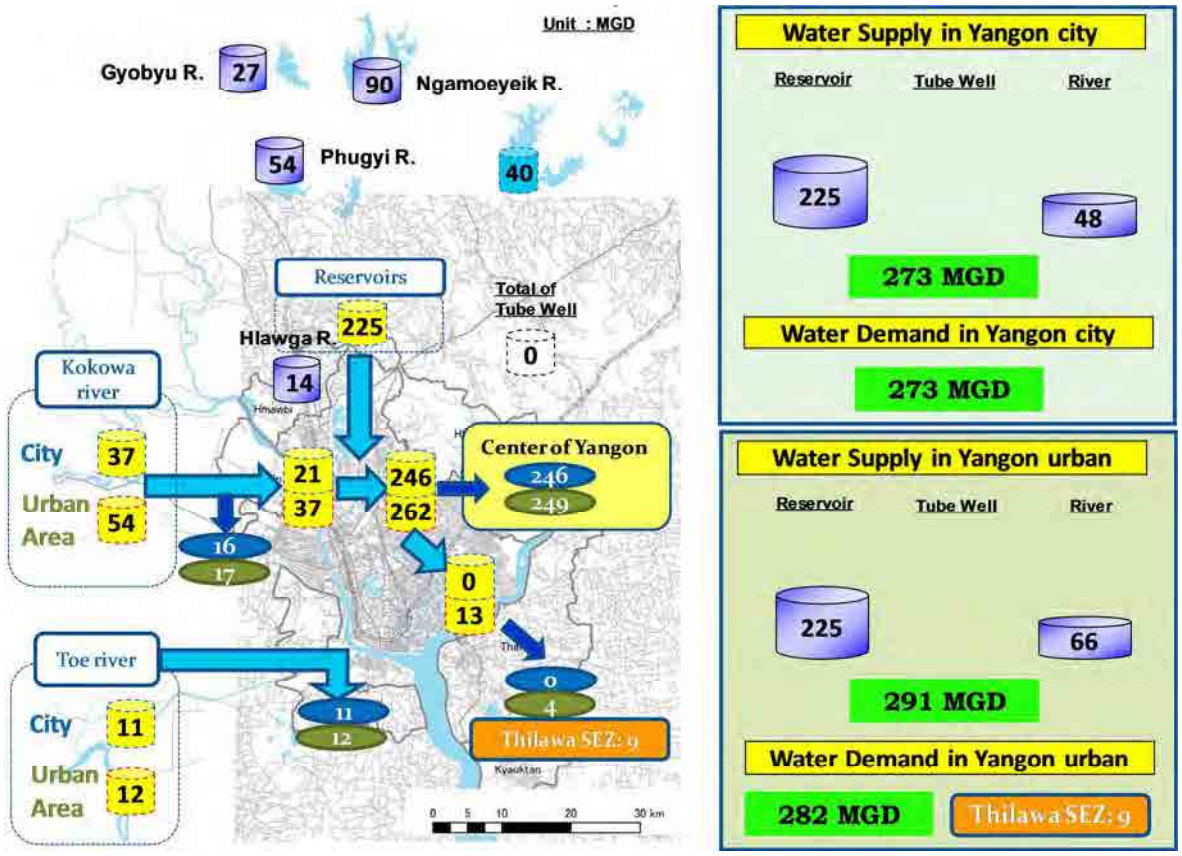
Source: JICA Study Team

Figure 5.6 Water Supply Area for Each Water Resource



Source: JICA Study Team

Figure 5.7 Water Balance in Greater Yangon (2040)



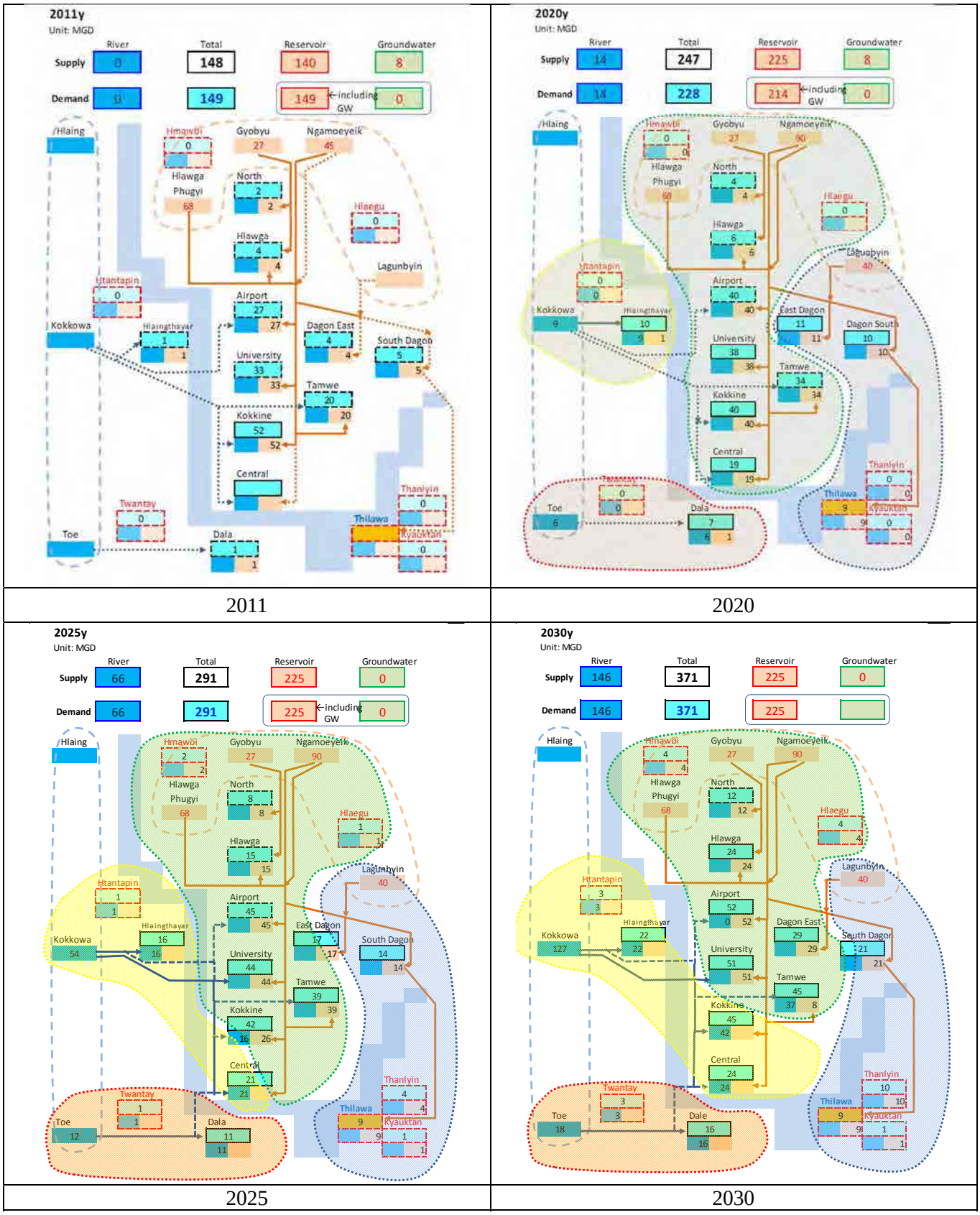
Source: JICA Study Team

Figure 5.8 Water Balance in Greater Yangon (2025)

5.4 Transmission System Linking Treatment Plant with Water Distribution Zone

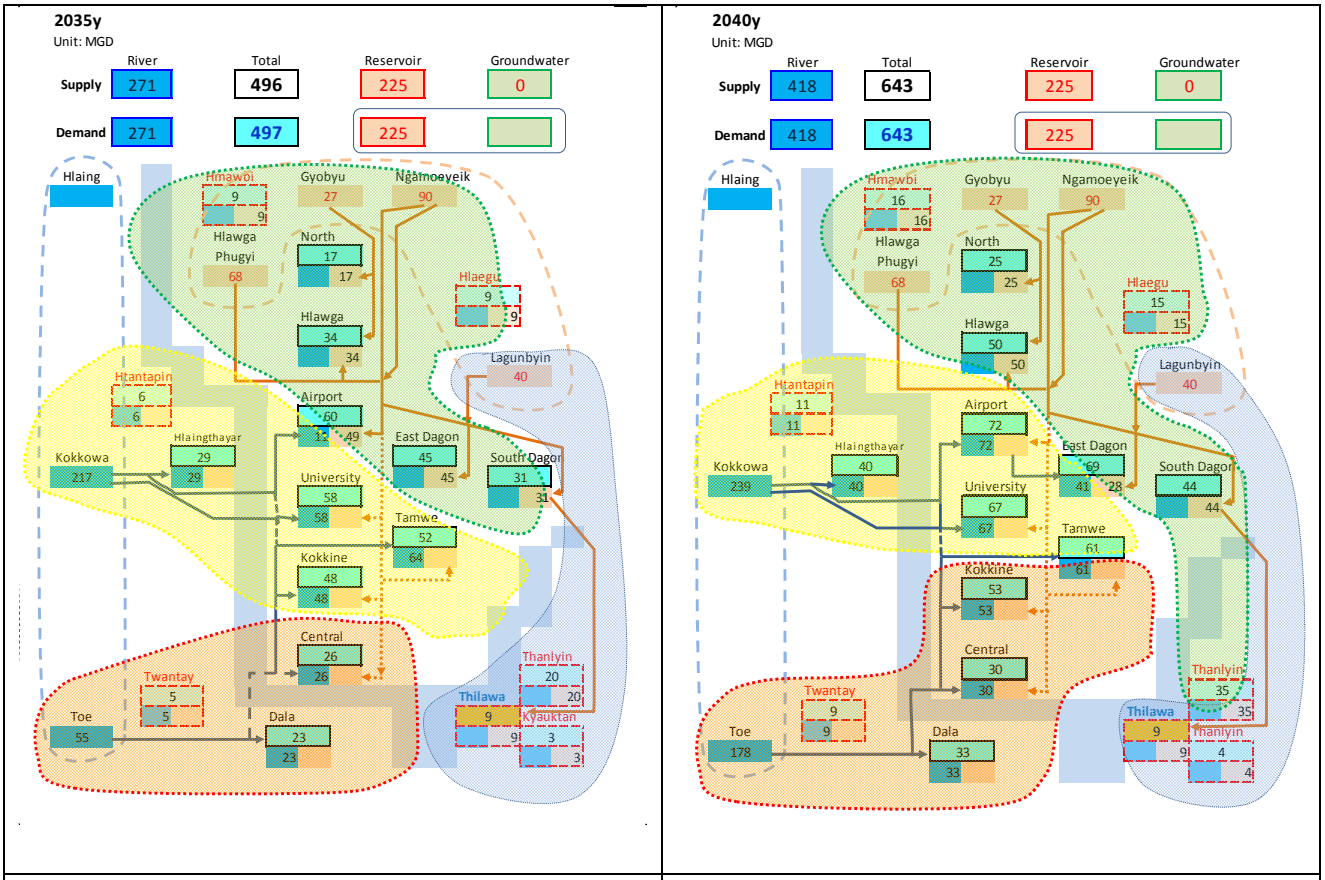
Water supply plans with an interval of every five years to each distribution zone are shown in Figure 5.9-5.10. As main facilities of water supply system, the plan route of transmission line which links WTP to service reservoir (S/R) in 2040 is shown in Figure 5.11. These routes are selected through route survey by YCDC staff and Study Team based on the location of existing facilities and proposed WTP.

The facilities which will be built by 2040 are illustrated in Figure 5.11 and the proposed facilities to be constructed by 2025 are shown in Figure 5.12. Transmission facilities of Figure 5.11-5.12 are fitted to water supply plans of Figure 5.9-5.10, and are planned accordingly.



Source: JICA Study Team

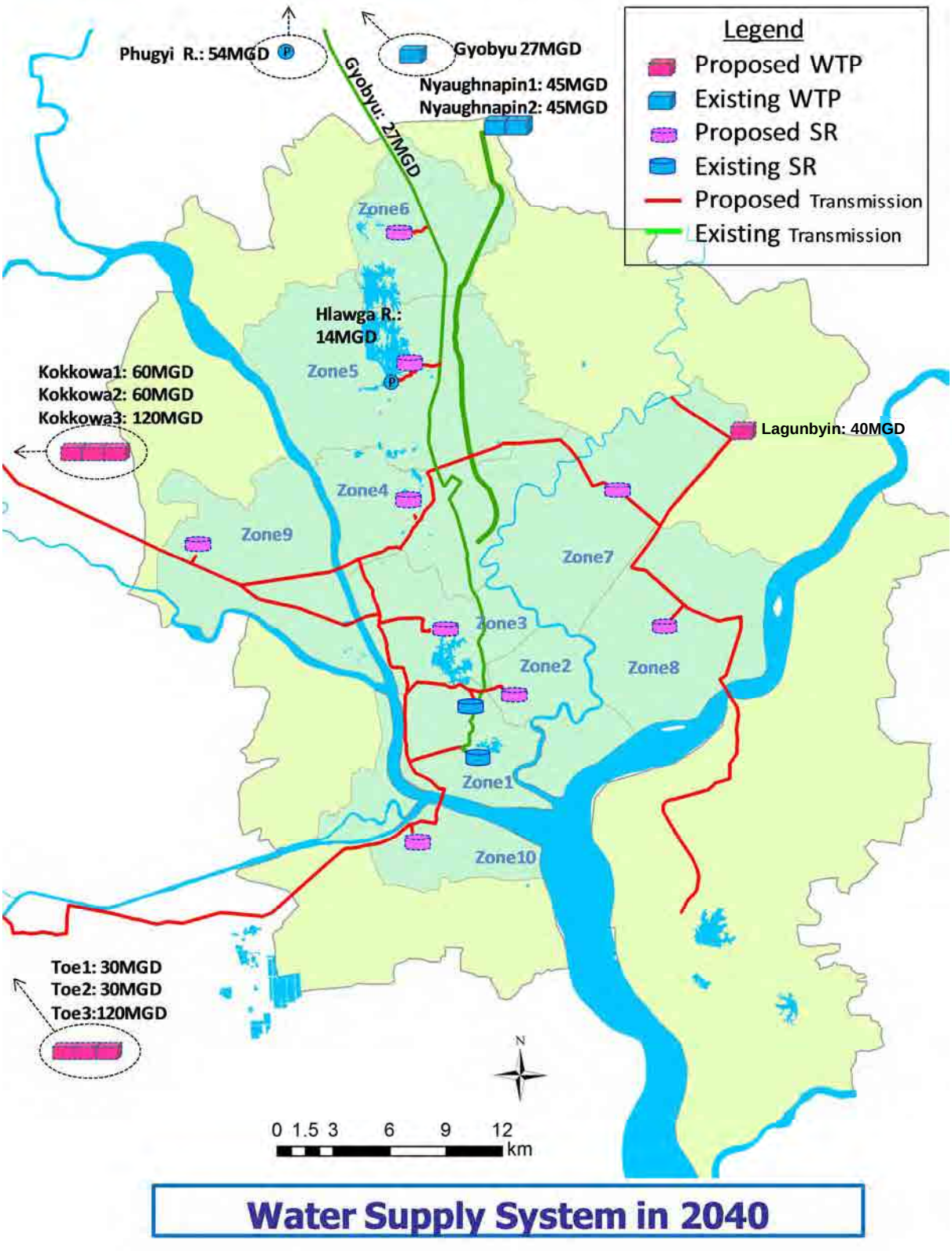
Figure 5.9 Plan for Transmission System (2011- 2030)



2035	2040

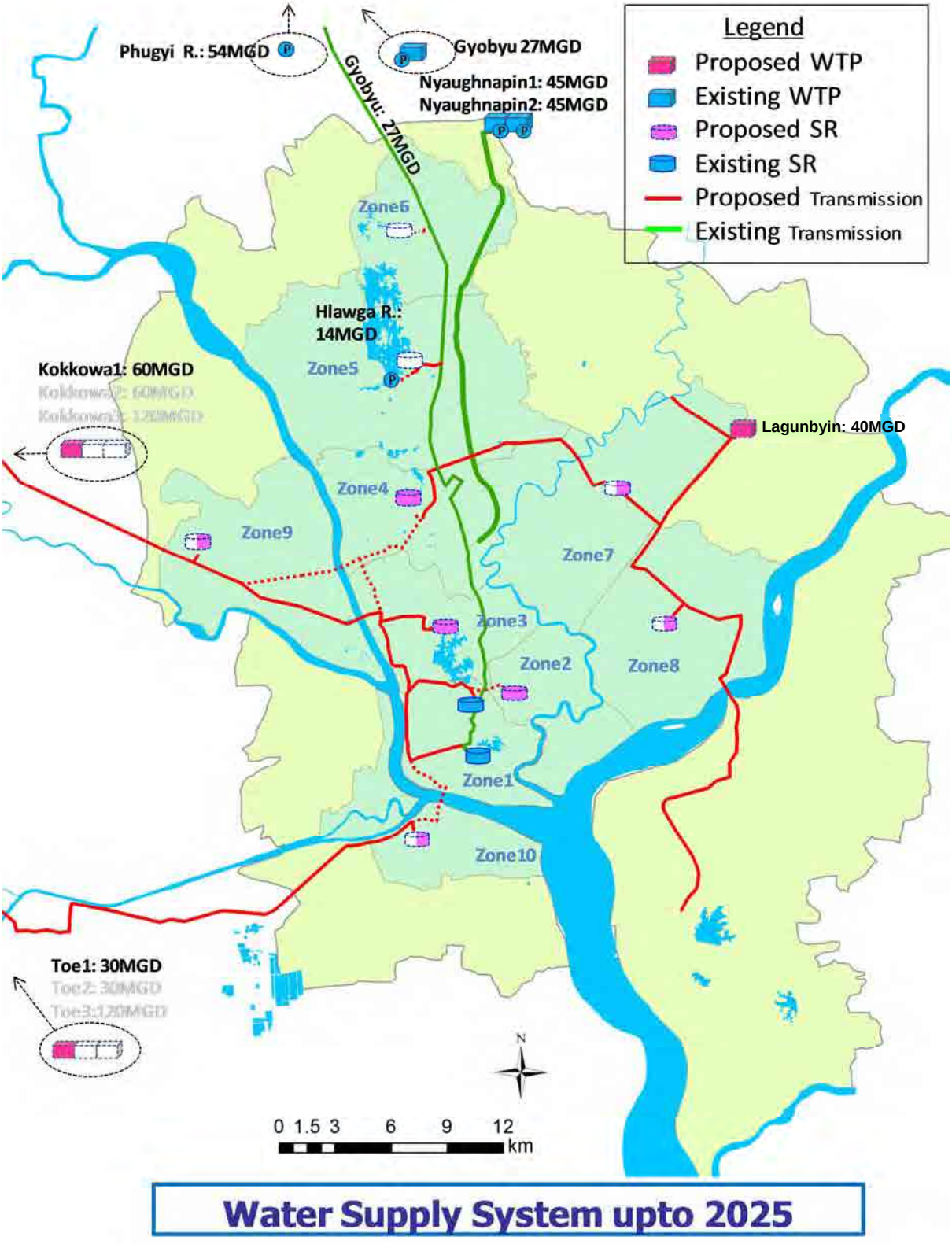
Source: JICA Study Team

Figure 5.10 Plan for Transmission System (2035 - 2040)



Source: JICA Study Team

Figure 5.11 Main Facilities (WTPs, Transmission Lines, S/Rs) and Distribution Zones in 2040



Source: JICA Study Team

Figure 5.12 Main Facilities (WTPs, Transmission Lines, S/Rs) and Distribution Zones in 2025

CHAPTER 6 WATER SUPPLY PLAN

6.1 Planning Policy and Condition

6.1.1 Policy of Water Supply Plan

(1) Target Area

Target areas are greater Yangon (YCDC 33 Township and part of surrounding 6 Townships including Thilawa SEZ). Water sources and transmission facilities are developed for the greater Yangon. However, YCDC can supply water only to YCDC area and cannot supply to the surrounding 6 townships. Therefore, when facilities are constructed to cover the surrounding townships, consensus should be reached between the regional government and YCDC.

On the other hand, distribution facilities are developed only for YCDC area. There are many alternatives of planning the distribution facilities for the surrounding 6 townships. For example, creation of independent distribution zone in each township, each township area are merged into the neighboring distribution zone, creation of one distribution zone in each township (both included part in the Study Area and excluded part). These alternatives need to be analyzed before the facilities are planned and constructed. In any case, water sources are planned in this Study. Independent transmission facilities or combined transmission facilities of YCDC and the surrounding townships are also decided.

(2) Policy of Improvement of Water Supply

In order to solve the problems in water supply facilities of YCDC and achieve improvement in water supply services, the water supply facilities are planned based on the policies mentioned below.

Table 6.1 Policies to Achieve the Improvement Target of Water Supply Condition

Target items	New Facilities	Existing Facilities
1. Increase of the water service coverage (from 35% to 69%)	・ New development of river surface water and new construction of water treatment plant (Water resource from reservoir: Lagunbyin R., Water resource from river: Kokkowa river and Toe river)	・ Abandon the use of groundwater intake (Maintain it as backup water resource)
2. Achievement of 24hrs water supply with appropriate water pressure	・ Rationalization of transmission and distribution facilities including division of transmission and distribution function ・ Improvement of transmission and distribution capacity ・ Establishment of distribution facilities in 10 DMAs	・ Rationalization of transmission and distribution facilities including division of transmission and distribution function ・ Enhancement of transmission and distribution capacity ・ Rehabilitation of the existing Central S/R and the existing Kokine S/R ・ Replacement of the existing pumps due to rationalization of distribution

Target items	New Facilities	Existing Facilities
		・ Abolishment of the existing Yegu booster P/S
3. Provision of the treated water with chlorination	・ Installation of chlorination equipment in Hlawga ・ Chlorination in new service reservoir ・ Establishment of water quality control center	・ Rehabilitation of Gyobyu WTP ・ Rehabilitation of Nyaunghnapin WTP
4. Reduction of Leakage Ratio (from 50% to 10%)	・ Establishment of DMA in the served area ・ Installation of water meter in all household ・ Establishment of distribution management center	・ Establishment of DMA, Utilization of SCADA ・ Scheduled replacement of the aged pipes in accordance with the establishment of DMA

Source: JICA Study Team

6.1.2 Design Criteria

Design criteria in the water supply plan are shown below.

Table 6.2 Design Criteria of Water Supply Plan

Water Demand	Design daily maximum demand
Intake Facilities	
Design Intake Flow	1.10 x Design daily maximum demand
Water treatment plant	
Design Intake Flow	1.05 x Design daily maximum demand
Water Treatment Process	Coagulation >> Sedimentation >> Rapid Sand Filtration >> Purification >> Transmission
Wastewater Treatment Process	Sludge Drying and Reuse
Transmission main Line	Design daily maximum demand
Distribution Network	
Capacity of Service reservoir	Design daily maximum demand /3; 8hrs of Detention time
Distribution system	High Zone: Pumped Distribution
	Low Zone: Gravity flow Distribution
Hourly Factor	1.5 x Design daily maximum demand
District Metered Area (DMA)	About 4,200 connections
Distribution Network Calculation	Hazen-Williams' equation, C-factor = 110 (New pipe), 90 (Existing pipe)

Source: JICA Study Team

6.1.3 Planning Policy of Water Treatment Plant

(1) Location of Water Treatment Plant and Planned Water Supply Amount

The existing WTPs are Gyobyu and Nyaunghnapin. In these WTPs, rehabilitation works which include the replacement of equipment and addition of chlorination equipment are considered. In Hlawga reservoir (and Phugyi R., the water from Phugyi R. is transmitted to Hlawga R.), there is no WTP; however, only chlorination equipment is installed since turbidity of raw water is low and stable.

Turbidity of raw water was 22 NTU (Rainy season, October, 2012) and 11 NTU (Dry season, March, 2013).

The new WTP for reservoir is Lagunbyin. Lagunbyin creek (Irrigation canal) outflows from Lagunbyin R. and joins together with Ngamoeyeik creek in the midstream. In the downstream of the junction, there is boundary of Yangon city and this location is assumed as intake point. The construction of intake canal from creek and securement of the land for WTP are included in the plan of construction of new WTP.

As mentioned in the Chapter 5, the water resources of surface water are Kokkowa River and Toe River. In order to prepare the plan of construction of WTP, the raw water is taken from River, the area of WTP is located near the intake facility. For the selection of the site, the priorities are given from the view point of environmental and social considerations; (i) state land / YCDC land, (ii) private land but not in use for any purpose, (iii) private land without the houses. The policy to avoid the involuntary resettlement and loss of livelihood as much as possible is followed.

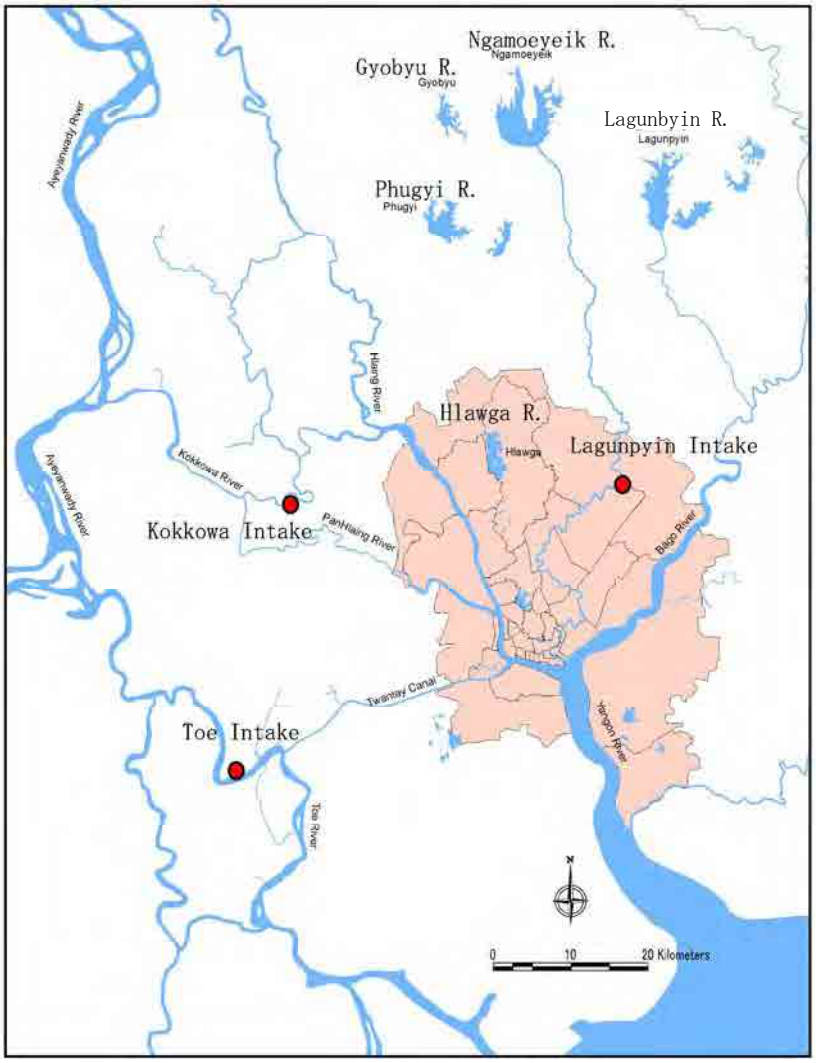
Currently, electricity is not supplied to the planned WTP site, and the power supply line to nearby transformation equipment will be needed.

The following Table summarizes the WTP construction plan.

Table 6.3 Planned Capacity of WTP

Categories	Name	Capacity (MGD)	Capacity (m^3/day)	Required land area (ha)	Note
Existing	Gyobyu	27	123,000	Existing	Rehabilitation of the existing WTP and installation of chlorination equipment
	Hlawga + Phugyi	68	309,000	Existing	Installation of chlorination equipment
	Nyaunghnapin	90	410,000	Existing	Rehabilitation of the existing equipment and installation of chlorination equipment
New	Lagunbyin	40	182,000	21	Series of Reservoir water
	Kokkowa	240	1,091,000	125	Series of River surface water
	Toe	180	818,000	94	Series of River surface water
Total		645	2,933,000	240	

Source: JICA Study Team



Source: JICA Study Team

Figure 6.1 Location of Intake Point and WTP

(2) Intake Site and Water Right

Intake sites are selected where required amount of water can be withdrawn and salinity concentration is below water quality standard. Further, intake sites are selected as the nearest sites to Yangon for relatively lower costs of transmission facilities and nearby areas to main transportation routes for ease of construction. Water quantities in every river are sufficient considering the water demand so that water can be taken from any site. The intake points are selected after consultation with YCDC to the nearest points to the major roads. Their salinity levels measured in November or December 2012 were below the standard. Further, salinity levels were measured in March 2013 when they are considered the highest in a year. After the survey, intake points in Toe river has been selected as the points that does not affect salt intrusion while intake point in Kokkowa river is fixed as original proposed point.

Water right issues are not seemingly a serious one because of abundance of flow volume except for constructed reservoirs. The MOAI do not have an authority of water right issues. It says that Ministry of inland transportation might have the authority. The Study Team thinks that abstracted water volume

is decided considering maintenance flow for inland transportation etc., so that it does not affect inland transportation.

Table 6.4 Planned Intake Points

Items	Description	Kokkowa River	Toe River
Water Quantity	Required quantity	Any Point	Any Point
Water Quality, particularly salinity	Low Salinity below the Standard	Proposed point by YCDC	The upstream of branch part of Twantay canal
Distance to Yangon	Near is better	Feasible	Feasible
Ease of Construction	Near to Roads	Near to Roads	Near to Roads
Land Use	Public land is the best, followed by agricultural land	Agricultural Land	Agricultural Land

Source: JICA Study Team

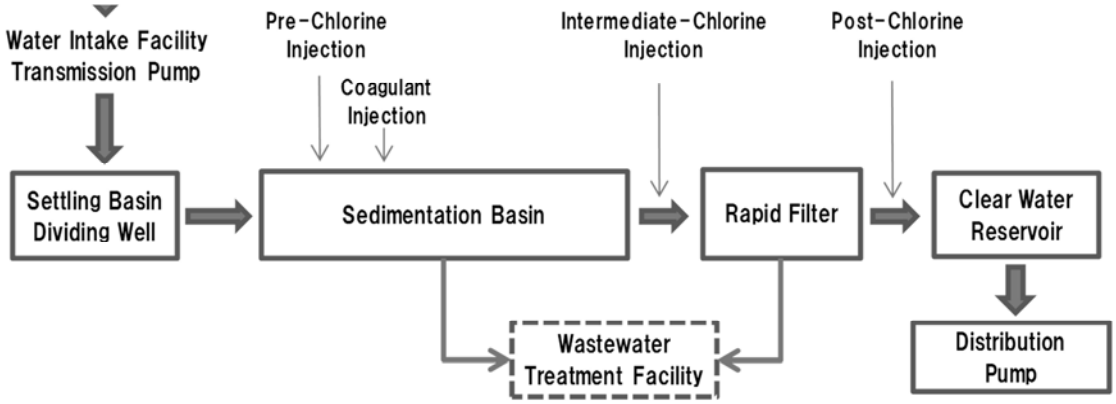
(3) Water Treatment Process

The technologies of water treatment consists of the methods for removal of insoluble matter such as turbidity, algae and bacteria, and the methods for removal of soluble matter such as odor, taste, color, organic matter, disinfection by-product and inorganic matter.

According to the result of water quality test, agricultural chemical was not indicated and it is not required to adopt any special treatment process and the method of “coagulation, sedimentation and rapid sand filtration” which is most popular treatment process for surface water, is adopted in the plan. There is no special equipment in the above mentioned system, and YCDC has the ability to repair WTP equipment.

Since chemical dosing rate of coagulant and pH control chemical shall be determined by Jar-test, the same method of the existing Nyaunghnapin WTP (PAC of foreign products is used as coagulation chemical) is adopted. In the implementation stage, water quality test (including Jar-test) shall be carried out and the selection of coagulant, setting of dosing rate and examination of necessity of pH control shall be studied.

Since the raw water from river become highly turbid in the rainy season and it causes a negative effect on sedimentation and filtration process, a pre-settling basin is proposed to be placed at the intake point which will enable reduction of turbidity and reduce the consumption of coagulation chemical.

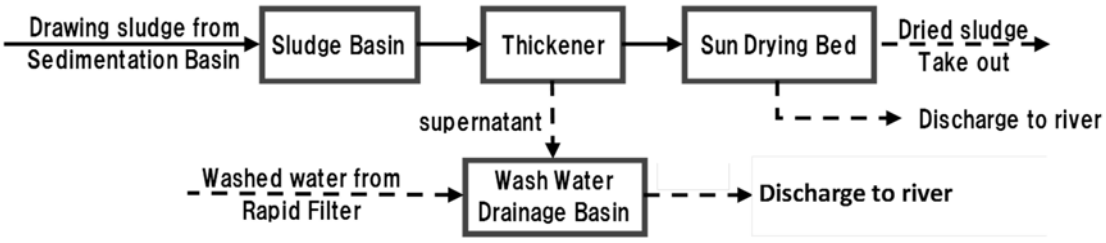


Source: JICA Study Team

Figure 6.2 Water Treatment Process Flow

(4) Treatment of Sludge and Back-washed Water

The treatment method of drainage water is determined by study of raw water quality, quantity and quality of drainage water, aspect of sludge, disposal method of sludge, difficulty level of O&M and construction cost, etc. The treatment facility for discharged water consists of drainage basin, sludge basin and thickener, etc. and solar drying bed and mechanical dewatering equipment are planned to be added at later stage. The surrounding area of the proposed site for WTP using river water is far from city center and the surrounding area of the proposed site of Lagunbyin WTP is agricultural land, hence it is assumed that the land acquisition will not be very difficult. Therefore, as the dewatering method, the drying bed method which needs large area and has advantages of economic efficiency and energy saving is adopted.



Source: JICA Study Team

Figure 6.3 Drainage Water Treatment Flow (Tentative)

(5) Chlorination equipment

The chlorination equipment is planned to be installed in all WTPs from the viewpoint of achieving safe drinking water after treatment. For disinfection, use of liquid sodium hypochlorite (foreign products is used in WWTP) is adopted.

(6) Electricity Supply

Electricity will be supplied from the nearby high-voltage transmission lines to the sites and, transformers will be installed.

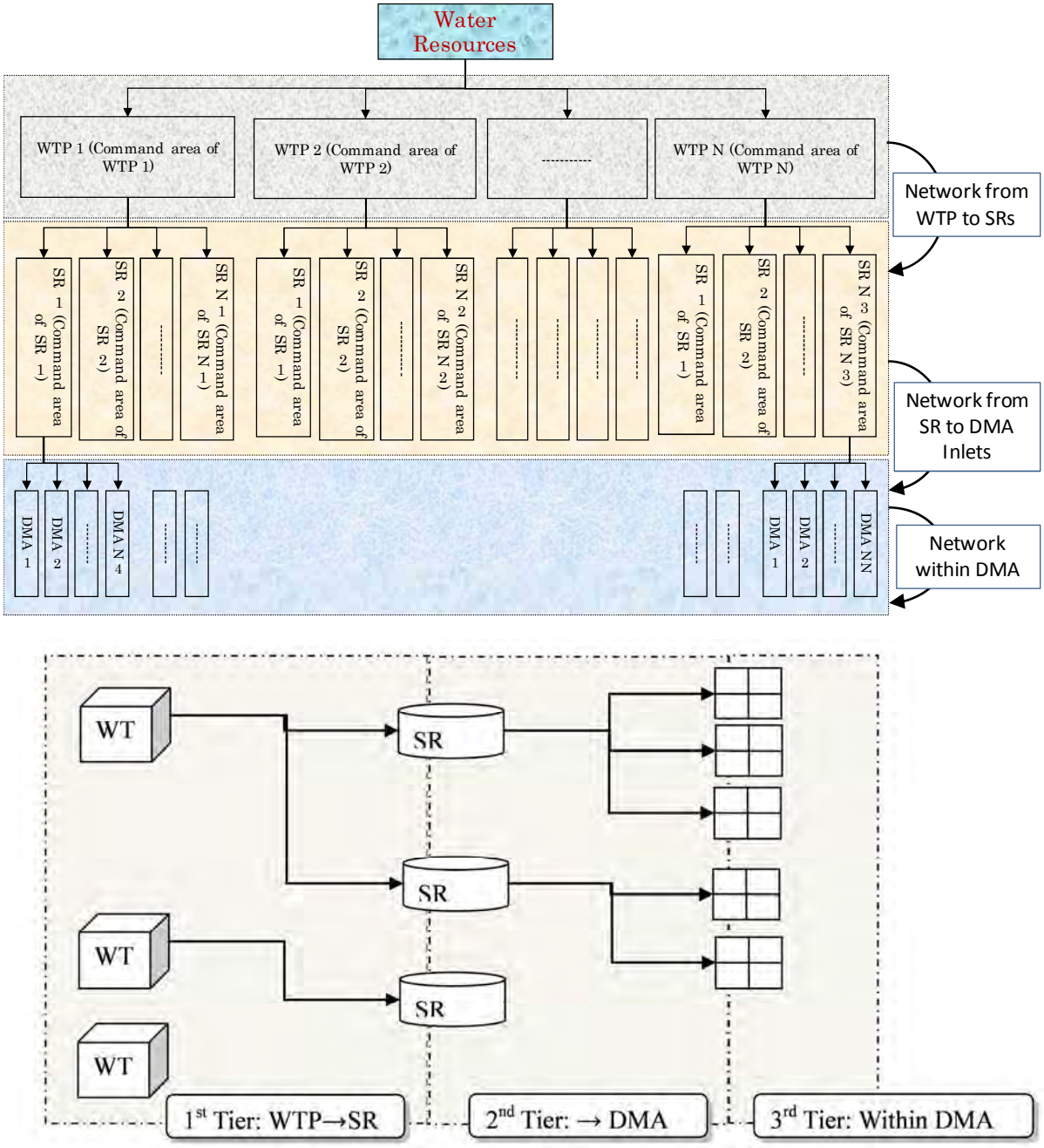
6.1.4 Policy of Transmission and Distribution Plan

(1) Introduction of 3-tier Water Distribution System

The water supply method to city center is currently direct distribution system except in south of the city. The transmission and distribution water amount from WTP and Reservoir is certain fixed volume. Therefore, in the peak time of water demand, water is consumed in the areas near WTP or Reservoir. and shortage of water occurs in remote places or high altitude areas.

In order to implement equal water supply and non-revenue water control, the 3-tier water distribution system which consists of transmission from WTP to S/R, transmission from S/R to District Metering Area (DMA) and distribution within DMA to house connection is proposed. The conceptual diagram is shown below. The isolation between transmission and distribution function is planned by this 3-tier water distribution system. Water supply to households from transmission pipes which connect between WTP and S/R is abolished and distribution is implemented from distribution branch pipes in DMA. Transmission pipes (from WTP to S/R) and distribution main pipes (from S/R or distribution P/S to DMA) are set as the specialized pipes.

Since the distribution zones are set up in whole city and S/R for each zone is constructed, the water supply system corresponds to time fluctuation of water demand. Furthermore, DMA is set up by dividing distribution zones, thus, it is possible to monitor and control the transmission water amount to each distribution zone and water flow to DMA in distribution zone. Equal water supply and appropriate water pressure are secured by monitoring and control of water flow between steps. Distribution management center is established by SCADA which is a tool of monitoring and control of these items.



Source: JICA Study Team

Figure 6.4 Conceptual Diagram of 3-Tier Water Distribution System

(2) Creation of Distribution Zone

Whole city is divided into several distribution zones with consideration to topographic condition and water demand. In each distribution zone, S/R is constructed and enough capacity to meet the peak water demand is secured, it is possible to supply the required amount of water in the peak time of demand and it finally aims to achieve 24 hours water supply. If 24 hours water supply is actualized, people will be able to remove private wells, private pumps and roof tanks and it prevents intrusion of contaminants due to negative pressure in the pipes, thus, it is possible to achieve safe water supply. In order to secure water supply pressure in distribution zones, the water supply to low altitude area is

done through gravity flow and distribution is done by pumping up to high altitude area.

(3) Setting up of DMA

Inside distribution zone, the area is segmented into several blocks of appropriate scale and DMAs are set up. The inlet pipe to DMA is only one in principle and water pressure and inlet water amount are monitored and controlled, and then, equal water supply is planned. Another purpose of DMA is Non-Revenue Water Control. It is easy to calculate non-revenue water by comparison between inlet water amount to DMA and water consumption in DMA. Commencement of Non-Revenue Water Control from DMA that has high ratio of non-revenue water is effective method. The appropriate size of DMA is about thousands connections. The DMAs are set up depending on the pipelines condition and road condition.

(4) Location of the Main Facilities (Transmission) with Consideration of Demand Trend

The water demand of 291 MGD (including Thilawa) in 2025 will be satisfied with production capacity which is strengthened to 300 MGD by construction of Lagunbyin WTP (40MGD) and Kokkowa phase I (60MGD). On the other hand, water demand in 2040 is 643 MGD and it is 2.2 times of year 2025. This water demand would not be satisfied with water from reservoirs only. In the water resource plan, it is planned to supply water to the city by development of river water of Ayeyarwadi River which is located in the west of Yangon city and it has enough water resources. Along with this water supply, the water supply areas will be shifted from whole of the city to north-east of the city and it means that the water supply area is expanded from Westside.

Therefore, the following projects are required to meet the increased water demand in transmission plan (Refer to the section of “Water Utility Plan”) from 2025 to 2040.

- Addition of transmission pumps
- Stepwise expansion of transmission pipeline
- Extension work of S/R
- Shift of inlet pipe in S/R
- Addition of distribution pumps

To implement the stepwise investment, the structure of new S/R is designed as multi-system.

6.2 Proposed Distribution Zone

In this section, a distribution zone which is the 2nd tier of the Three-Tier Distribution/ Allocation System is proposed. Transmission lines (the 1st Tier) from WTPs to distribution zones are planned after the creation. Transmission facilities of the 1st Tier are proposed in next paragraph.

(1) Main considerations for zoning system creation

A zoning system is introduced to the existing system based on following conditions.

< Conditions >

Water demand conditions;

The maximum water demand distributed to all existing ward in 2040,

Water pressure conditions;

The minimum residual pressure is 15m, (Japanese standard is applied),

Administrative boundaries;

Road boundaries and township boundaries etc.,

Proposed zone boundaries;

A zone boundary is proposed such that water demand is mostly divided into equal size, and the proposed site of S/R is located at center of the zone,

Proposed gravity flow area boundaries;

A gravity flow area is proposed considering the ground level and minimum distribution pressure as 15m.

(2) Proposed Distribution Zones and Proposed Sites for Service Reservoir

Proposed sites for S/R and proposed distribution zones are listed in Table 6.5. The details of each Zone are shown in Appendix E. These locations are proposed considering the contour line in Yangon, satellite view, and site survey. In addition, service population and design daily maximum demand in each zone are enumerated in Table 6.6 to Table 6.9.

(3) Progress of Land Acquisition of Proposed Sites for Service Reservoir

YCDC has been negotiating with landowners in order to acquire proposed sites for S/R. As results, several lands were not acquired by YCDC, and have been changed into the nearby substitute land. The details of each Zone are shown in Appendix E.

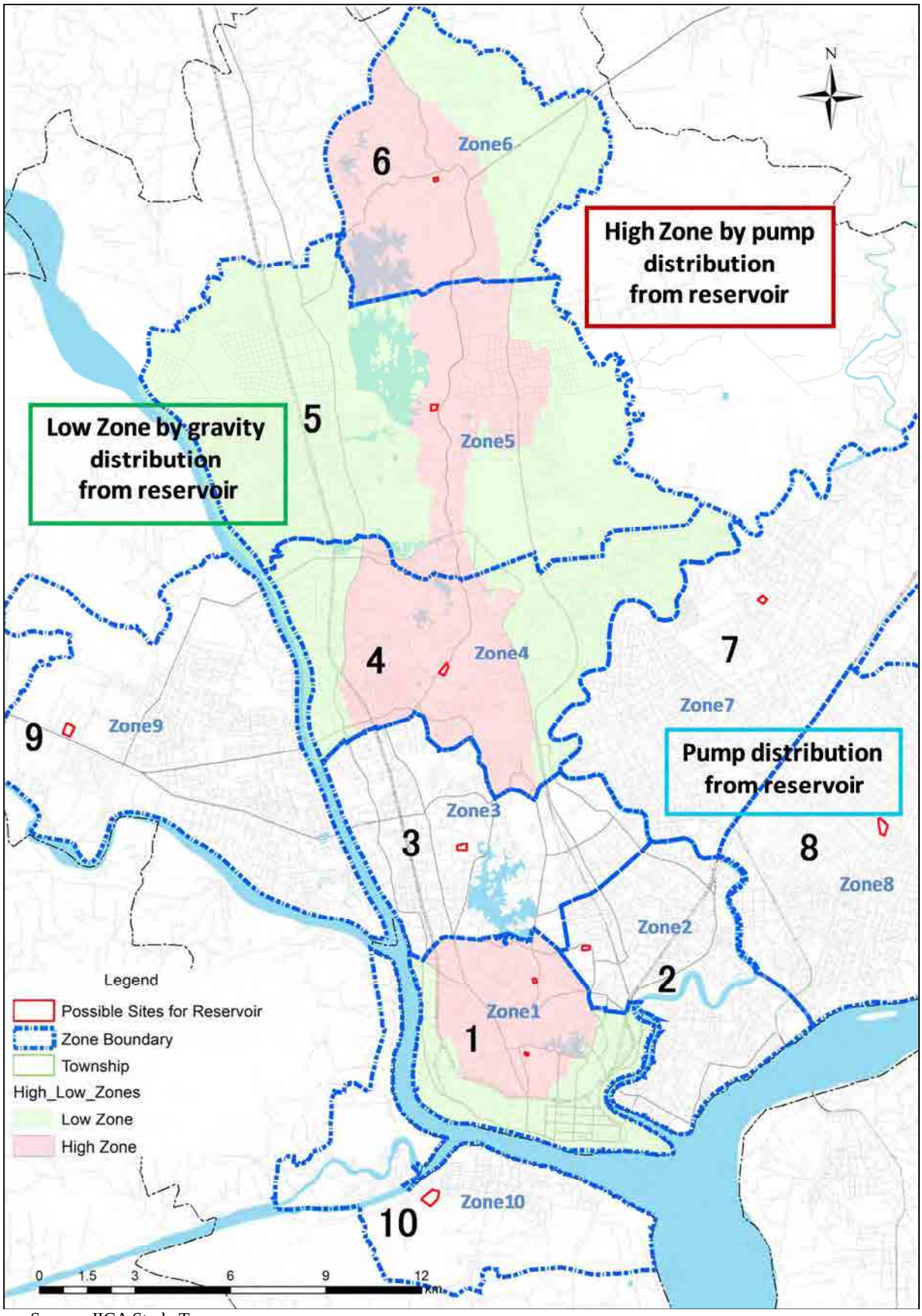
(4) Separation of High sub-Zones and Low sub-Zones

In order to secure the water supply pressure in distribution zones, low zones are supplied by gravity flow and high zones are supplied by pumps in some distribution zones. The outline of high zones (Pump distribution) and low zones (gravity flow) are shown in the following Table and the following Figure.

Table 6.5 Outline of Proposed High Zones and Low Zones

Zone	Name of Zone	TS and TS Group's name to supply	Location of S/R	Water Demand in 2040 (MGD)		
				Pump distribution	Gravity flow distribution	Total
1	Central area	CBD, IUR	Kokine	0	53	83
			Central	30	0	
2	Tarmwe, Thaketa	Tarmwe, Thingangyun, Thaketa	Kyaikkasan Playground area	61	0	61
3	Hlaing	Mayangon ,Yankin, Hlaing	Near Yangon University Hlaing Campus	67	0	67
4	Mayangon	(s) Mingaladon, North Okkalapa, (S) Insein	Near Airport	22	50	72
5	Mingaladon, Shwe Pyi Thar	(C) Mingaladon, (N) Insein, Shwe Pyi Thar	Near Survey Dept Benchmark	12	38	50
6	North side	(N) Mingaladon	Hlawga Road Side near Htauk Kyant	10	15	25
7	East side 1	East Dagon, North Dagon	East Dagon	69	0	69
8	East side 2	South Dagon, Dagon Seikkan	South Dagon	44	0	44
9	West side	Hlaing Thar Yar	Hlaing Thar Yar	40	0	40
10	South side	Dala, Seikgykhananungto, (W) Kyeemyindaing	Dala	33	0	33
			Total	388	156	544

Source: JICA Study Team



Source: JICA Study Team

Figure 6.5 Proposed Zones with High Sub-Zones for Pump Distribution and Low Sub-Zones for Gravity Flow Distribution

Table 6.6 Proposed Distribution Zones and Proposed Sites for Service Reservoir

Zone number	Name of Distribution Zone (tentative name)	Supply Area (TS and TS Group's name)	Area of zone (km^2)	Location of S/R	Ground level at Site (m)	Total Area Required (m^2)	Water Demand in 2040 (MGD)
1	Central area	CBD, IUR	38.41	Kokine	22	Existing	83
				Central	30	Existing	
2	Tarmwe、Thaketa	Tarmwe, Thingangyun, Thaketa	35.06	Kyaikkasan Playground area	8	22,200	61
3	Hlaing	Mayangon ,Yankin, Hlaing	54.16	Near Yangon University Hlaing Campus	17	24,200	67
4	Mayangon	(s)Mingaladon, North Okkalapa, (S)Insein	67.16	Near Airport	29	27,600	72
5	Mingaladon, Shwe Pyi Thar	(C)Mingaladon, (N)Insein, Shwe Pyi Thar	120.89	Near Survey Dept Benchmark	35	18,400	50
6	North side	(N)Mingaladon	53.84	Hlawga Road Side near Htauk Kyant	40	10,000	25
7	East side 1	East Dagon, North Dagon	82.62	East Dagon	5	24,800	69
8	East side 2	South Dagon, Dagon Seikkan	88.19	South Dagon	5	16,400	44
9	West side	Hlaing Thar Yar	81.54	Hlaing Thar Yar	5	15,100	40
10	South side	Dala, Seik gyi Kha Nanung To, (W)Kyeemyindaing	43.40	Dala	5	18,400	33
	Total		665.27			177,100	544

Source: JICA study team

Table 6.7 Service Population in Each Zone

(Unit: person)

Zone number	Name of distribution zone (tentative name)	2011	2018	2020	**2025**	2030	2035	2040
1	Central area	624,785	717,303	741,643	**783,630**	830,269	876,319	925,906
2	Tarmwe、Thaketa	305,282	397,280	425,992	**481,550**	546,142	613,114	682,901
3	Hlaing	347,719	445,558	473,374	**544,231**	620,602	682,324	749,649
4	Mayangon	365,799	471,539	502,625	**563,363**	631,720	709,621	798,760
5	Mingaladon, Shwe Pyi Thar	42,703	92,319	141,775	**228,076**	335,718	468,870	632,444
6	North side	18,561	49,663	61,025	**95,894**	141,428	199,691	273,113
7	East side 1	86,613	175,978	211,404	**319,437**	497,256	730,355	1,029,356
8	East side 2	103,713	174,386	196,256	**267,161**	371,546	498,457	652,245
9	West side	9,775	138,608	180,613	**293,089**	378,219	476,423	590,179
10	South side	15,522	79,704	127,112	**187,880**	264,169	358,964	475,785
T-1	Total (Yangon City)	1,920,471	2,742,337	3,061,819	**3,764,310**	4,617,069	5,614,139	6,810,338
Periphery Areas(6 suburban Townships)								
	Kyauktan	0	0	0	**8,955**	21,637	38,810	61,382
	Thanlyin	0	0	0	**59,742**	157,176	300,046	497,508
	Hlaegu	0	0	0	**23,974**	65,092	126,873	213,483
	Hmawbi	0	0	0	**26,680**	69,971	133,284	220,654
	Htantapin	0	0	0	**17,989**	48,649	94,583	158,868
	Twantay	0	0	0	**14,464**	39,789	78,206	132,353
T-2	6 suburban TSs	0	0	0	**151,804**	402,314	771,802	1,284,248
	Grand Total	1,920,471	2,742,337	3,061,819	**3,916,114**	5,019,383	6,385,941	8,094,586

Source: JICA study team

Table 6.8 Daily Maximum Demand in Each Zone

(Unit: m^3/day)

Zone number	Name of distribution zone (tentative name)	2011	2018	2020	**2025**	2030	2035	2040
1	Central area	237,049	263,483	270,389	**287,331**	310,003	337,935	377,223
2	Tarmwe, Thaketa	90,800	143,313	152,960	**176,568**	203,914	236,437	278,222
3	Hlaing	148,720	164,800	172,962	**199,548**	231,716	263,125	305,411
4	Mayangon	123,579	171,233	181,391	**206,567**	235,868	273,654	325,421
5	Mingaladon, Shwe Pyi Thar	20,284	32,642	45,419	**69,632**	106,544	156,330	226,193
6	North side	7,826	20,811	24,380	**35,161**	52,805	77,008	111,268
7	East side 1	17,658	41,996	50,326	**78,085**	130,076	204,696	314,526
8	East side 2	20,915	41,616	46,723	**65,307**	97,190	139,702	199,298
9	West side	3,406	33,075	42,996	**71,644**	98,937	133,526	180,333
10	South side	2,911	18,491	29,921	**48,508**	72,068	104,029	149,363
T-1	Total (Yangon City)	673,148	931,459	1,017,467	**1,238,351**	1,539,121	1,926,442	2,467,258
Periphery Areas(6 suburban Townships)								
	Kyauktan	0	0	0	**2,527**	6,273	11,829	19,858
	Thanlyin	0	0	0	**16,850**	45,561	91,452	160,959
	Hlaegu	0	0	0	**6,761**	18,868	38,669	69,067
	Hmawbi	0	0	0	**7,526**	20,283	40,624	71,388
	Htantapin	0	0	0	**5,073**	14,102	28,830	51,399
	Twantay	0	0	0	**4,079**	11,532	23,836	42,820
T-2	6 suburban TSs	0	0	0	**42,816**	116,619	235,240	415,491
	Grand Total	673,148	931,459	1,017,467	**1,281,167**	1,655,740	2,161,682	2,882,749

Table 6.9 Daily Maximum Demand in Each Zone

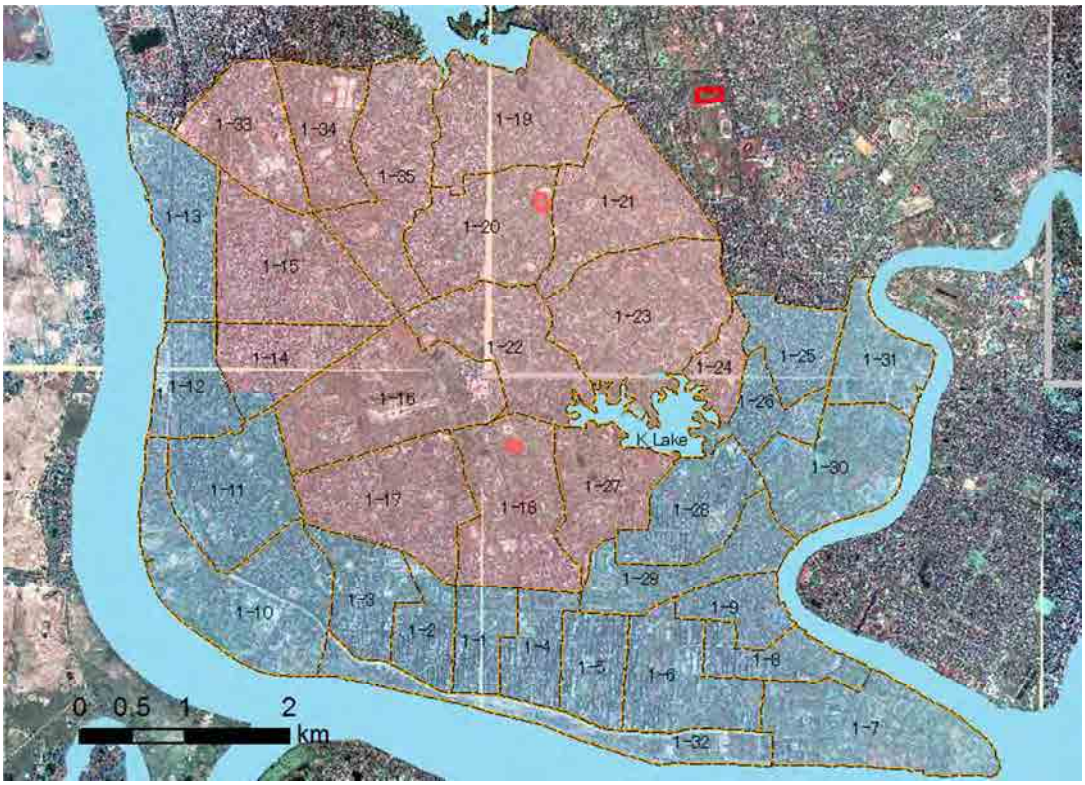
(Unit: MGD)

Zone number	Name of distribution zone (tentative name)	2011	2018	2020	**2025**	2030	2035	2040
1	Central area	52	58	59	**63**	68	74	83
2	Tarmwe, Thaketa	20	32	34	**39**	45	52	61
3	Hlaing	33	36	38	**44**	51	58	67
4	Mayangon	27	38	40	**45**	52	60	72
5	Mingaladon, Shwe Pyi Thar	4	7	10	**15**	23	34	50
6	North side	2	5	5	**8**	12	17	24
7	East side 1	4	9	11	**17**	29	45	69
8	East side 2	5	9	10	**14**	21	31	44
9	West side	1	7	9	**16**	22	29	40
10	South side	1	4	7	**11**	16	23	33
T-1	Total (Yangon City)	148	205	224	**272**	339	424	543
Periphery Areas(6 suburban Townships)								
	Kyauktan	0	0	0	**1**	1	3	4
	Thanlyin	0	0	0	**4**	10	20	35
	Hlaegu	0	0	0	**1**	4	9	15
	Hmawbi	0	0	0	**2**	4	9	16
	Htantapin	0	0	0	**1**	3	6	11
	Twantay	0	0	0	**1**	3	5	9
T-2	6 suburban TSs	0	0	0	**9**	26	52	91
	Grand Total	148	205	224	**282**	364	476	634

Note: The water demand of Thilawa SEZ is not included.
Source: JICA Study Team

(5) Proposed DMAs

As an example, a DMA plan in Zone 1 is shown in the following Figure. DMAs in central part are divided into high zone (red), and DMAs in the peripheral part of lowlands are divided into low zone (blue) in Zone 1.



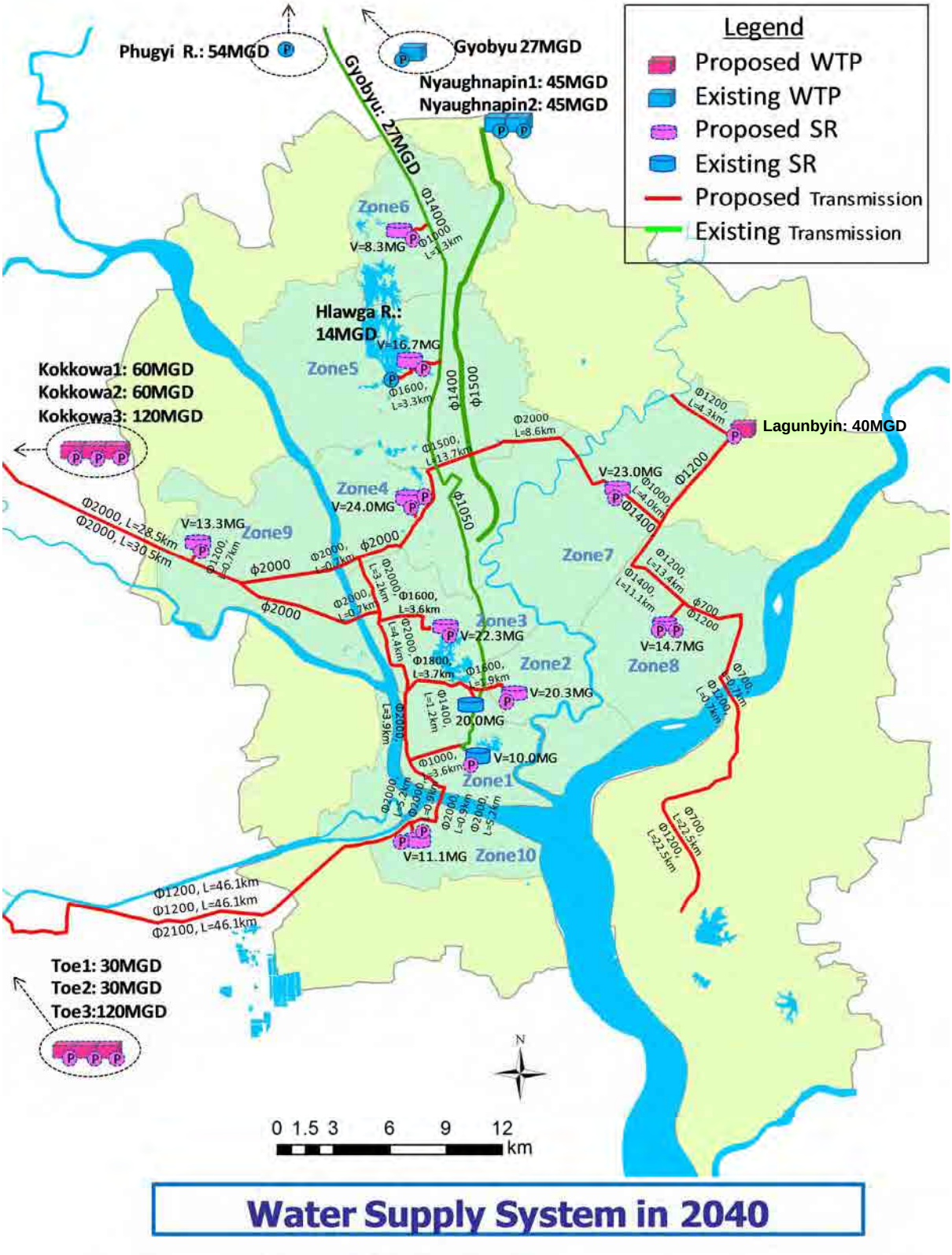
Source: JICA Study Team

Figure 6.6 District Metering Areas (DMAs) in Zone1

6.3 Water Supply Facility Plan

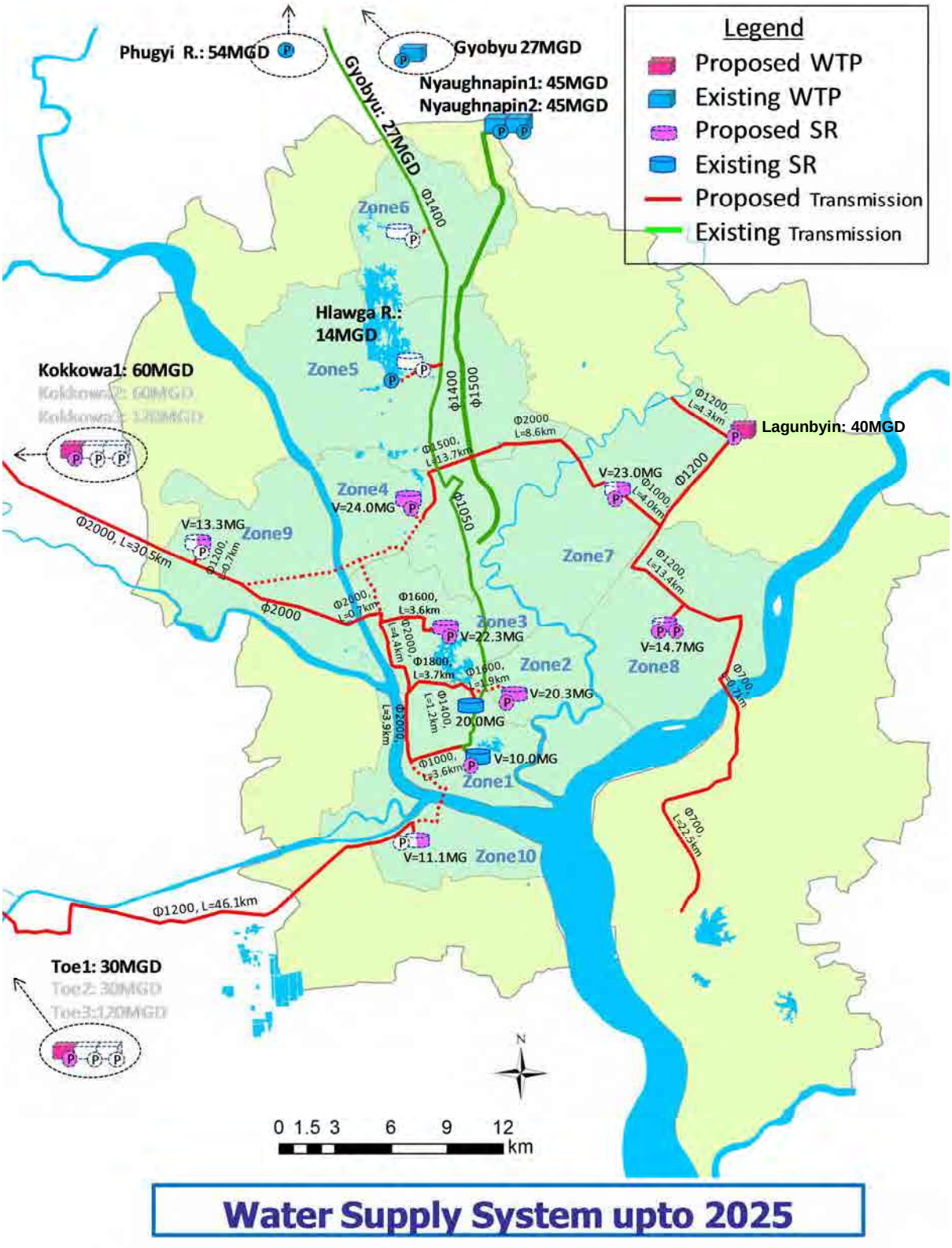
6.3.1 Overall Facility Plan

The water supply facilities planning targets water demand of 643MGD in Yangon Metropolitan. The main facilities planning in 2040 and 2025 are shown in the following Figures. The dotted line or white in the Figure shows the parts that are not implemented by 2025, and the new and improvement facilities by 2040 are presented in the following Tables. The basis of facilities planning is shown in Appendix D.



Source: JICA Study Team

Figure 6.7 Proposed Water Supply System in 2040



Source: JICA Study Team

Figure 6.8 Proposed Water Supply System up to 2025

6.3.2 Facilities for Augmentation of Water Source

(1) Intake pumping station

Name	Contents
Gyobyu	Renewal of existing pumps; 122,800 m^3/day (27MGD): Renewal of structures, M&E equipment 47.0 m^3/m×25m×280kw×3units (1 unit stand-by)
Phugyi	Renewal of existing pumps; 245,500 m^3/day (54MGD): Renewal of structures, M&E equipment 86.0 m^3/m×24m×450kw×3units (1 unit stand-by)
Lagunbyin	New 181,800 m^3/day (40MGD): 46.3 m^3/m×20m×350kw×4units (1 unit stand-by)
Nyaunghnapin Phase-1	Renewal of existing pumps;204,600 m^3/day (45MGD): M&E equipment 52.1 m^3/m×10m×110kw×4units (1 unit stand-by)
Nyaunghnapin Phase-2	Renewal of existing pumps;204,600 m^3/day (45MGD): M&E equipment 52.1 m^3/m×10m×110kw×4units (1 unit stand-by)
Kokkowa Phase-1	New 272,700 m^3/day (60MGD): 69.5 m^3/m×16m×280kw×4units (1 unit stand-by)
Kokkowa Phase-2	New 272,700 m^3/day (60MGD): 69.5 m^3/m×16m×280kw×4units (1 unit stand-by)
Kokkowa Phase-3	New 545,400 m^3/day (120MGD): 139.0 m^3/m×16m×500kw×4units (1 unit stand-by)
Toe Phase-1	New 136,400 m^3/day (30MGD): 52.1 m^3/m×16m×200kw×3units (1 unit stand-by)
Toe Phase-2	New 136,400 m^3/day (30MGD): 52.1 m^3/m×16m×200kw×3units (1 unit stand-by)
Toe Phase-3	New 545,400 m^3/day (120MGD): 139.0 m^3/m×16m×500kw×4units (1 unit stand-by)

(2) Water treatment plant

Name	Contents	Process	Capacity
Gyobyu	Improvement	Coagulated Sedimentation+ Disinfection	122,800 m^3/day (27MGD)
Hlawga	Improvement	+ Disinfection	309,100 m^3/day (68MGD)
Lagunbyin	New	Coagulated Sedimentation +Rapid sand filtration	181,800 m^3/day (40MGD)
Nyaunghnapin Phase-1	Improvement	Replacement of mechanical / electrical equipment + Disinfection	204,600 m^3/day (45MGD)
Nyaunghnapin Phase-2	Improvement	Ditto	204,600 m^3/day (45MGD)
Kokkowa Phase-1	New	Coagulated Sedimentation +Rapid sand filtration	272,700 m^3/day (60MGD)
Kokkowa Phase-2	New	Ditto	272,700 m^3/day (60MGD)
Kokkowa Phase-3	New	Ditto	545,400 m^3/day (120MGD)
Toe Phase-1	New	Ditto	136,400 m^3/day (30MGD)
Toe Phase-2	New	Ditto	136,400 m^3/day (30MGD)
Toe Phase-3	New	Ditto	545,400 m^3/day (120MGD)

Notes: The existing facilities are repaired for water quality improvement, and new facilities are established for increase in amount of water supply.

(3) Transmission pumping station

Addition of pump equipment at existing P/S, renewal of decrepit equipment, abolition, and transmission P/S to S/R of each zone are planned. After reconstruction of Central S/R and construction of Kokkowa Phase-1 P/S, direct delivery of water to be transmitted to Kokine and Central S/R can be achieved without going via Yegu, and then existing Yegu P/S can be abolished.

Name	Contents
Gyobyu P/S	New 122,800 m^3/day (27MGD): 42.7 m^3/m×47m×450kw×3units (1 unit stand-by)
Hlawga P/S	New 309,200 m^3/day (68MGD): 71.6 m^3/m×43m×800kw×4units (1 unit stand-by)
Hlawga No.1 P/S	This facility is abolished after construction of new Hlawga P/S.
Hlawga No.2 P/S	ditto
Yegu P/S	This facility is abolished after Kokkowa Phase-1 P/S to Zone 1
Lagunbyin P/S	New 181,800 m^3/day (40MGD): 42.1 m^3/m m×40m×570kw×4units (1unit stand-by)
Nyaunghnapin P/S	Renewal of existing pumps; 409,200 m^3/day (90MGD): Renewal of structures, M&E equipment 40.6 m^3/m×98m×800kw×8units (1 unit stand-by)
Kokkowa Phase-1P/S	New 272,200 m^3/day (60MGD): 37.9 m^3/m×86m×800kw×6units (1 unit stand-by)
Kokkowa Phase-2P/S	New 272,200 m^3/day (60MGD): 37.9 m^3/m×86m×800kw×6units (1 unit stand-by)
Kokkowa Phase-3P/S	New 545,400 m^3/day (120MGD): 37.9 m^3/m×86m×800kw×11units (1 unit stand-by)
Toe Phase-1P/S	New 136,400 m^3/day (30MGD): 31.6 m^3/m×97m×800kw×4units (1 unit stand-by)
Toe Phase-2P/S	New 136,400 m^3/day (30MGD): 31.6 m^3/m×97m×800kw×4units (1 unit stand-by)
Toe Phase-3P/S	New 545,400 m^3/day (120MGD): 47.4 m^3/m×71m×800kw×9units (1 unit stand-by)

When pump head from WTP to S/R is high, the following relay P/S is planned to be put side by side to S/R.

Name	Contents
Airport P/S	New 186,400m^3/day (41MGD): 64.8 m^3/m×33m×500kw×3units (1 unit stand-by)
Dala Transmission P/S Phase-1	New 309,100 m^3/day (68MGD): 43.0 m^3/m×71m×800kw×6units (1 unit stand-by)
Dala Transmission P/S Phase-2	New 309,100 m^3/day (68MGD): 43.0 m^3/m×71m×800kw×6units (1 unit stand-by)

In addition, water supply to Thilawa and Thanlyin TS is planned as follows.

Name	Contents
Thilawa Transmission	New 42,000 m^3/day (9.2MGD): 14.6 m^3/m×85m×280kw×3units (1 unit stand-by)
South Dagon Transmission Thanlyin, Kyauktan	New 177,300 m^3/day (39MGD): 41.1 m^3/m×77m×800kw×4units (1 unit stand-by)

(4) Transmission Line

Transmission Lines are planned to ten (10) Distribution Zones as follows. DIP will be used in case if pipe diameter is 600 mm or less, and SP will be used if pipe diameter is not less than 700 mm.

Facilities name (from)	Facilities name (to)	Diameter (mm)	Length (km)
Gyobyu	Zone No.6 North	1400	Existing pipe SP=41.5km is used
	Zone No.6 North	1000	1.3km
	Zone No.5 Hlawga	1400	Existing pipe SP=8.20km is used
Hlawga	Zone No.5 Hlawga	1600	3.3 km
Ngamoeyeik	Zone No.4 Airport	1500	13.7 km
	Zone No.4 + Zone No.7 +Zone No.8	1400+1500	Existing pipe DIP/ PE are used
	Zone No.4 + Zone No.7 +Zone No.8	2000	8.6 km
	Zone No.8 South Dagon	1500	11.1 km
Lagunbyin Creak	Lagunbyin WTP	1200	4.3km
Lagunbyin	Zone No.7 East Dagon	1200	13.4 km
	Zone No.8 South Dagon	1000	4.0 km
Kokkowa Phase-1	Zone No. 9 Hlaing Tharyar	1200	0.7 km
	Zone No.1	2000	30.5km
	Hiaing River crossing	2000	0.7 km
	Zone No.1	2000	4.4 km
	Zone No.1	2000	3.9 km
	Zone No.1 + Zone No.2	2000	3.7 km
	Zone No.1 Kokine S/R	1400	1.2 km
	Zone No.1 Central S/R	1000	3.6 km
Kokkowa Phase-2	Zone No.2 Tamwe	1600	1.9 km
	Zone No.3 University	1600	3.6 km
Kokkowa Phase-3	Zone No.3 + Zone No.4	2000	28.5 km
	Hiaing River crossing	2000	0.7 km
	Zone No.3 + Zone No.4	2000	3.2 km
	Zone No.4 Airport	2000	4.4 km
Toe Phase-1	Zone No.10 Dala	1200	46.1 km
ToePhase-2	Zone No.10 Dala	1200	46.1 km
Dala S/R Phase-1	Kokine S/R+Central S/R	2000	5.2 km
	Yangon River crossing	2000	0.9 km
Toe Phase-2	Zone No.10 Dala	2100	46.1 km
Dala S/R Phase-2	Kokine S/R+Central S/R	2000	5.2 km
	Yangon River crossing	2000	0.9 km
Total pipe length	---	---	301.2 km

Transmission Line to Thilawa and Thanlyin TS is planned as follows.

Facilities name (from)	Facilities name (to)	Diameter (mm)	Length (km)
Zone8	Thilawa	700	29.5km
	Bago River crossing	700	0.7km
Zone8	South Dagon Transmission Thanlyin, Kyauktan	1200	29.5km
	Bago River crossing	1200	0.7km
Total pipe length	---	---	60.4km

6.3.3 Facilities for Equitable Water Distribution and Reduction of Non-Revenue Water

(1) Service Reservoir and Distribution Pumping Station

S/Rs in ten (10) distribution zones are planned as follows. S/R is subdivided into "gravity flow distribution" and "pump distribution" depending on conditions of location. In addition, existing Central S/R has remained unused till present for remarkable water leakage. However, since reservoir is located on the high elevation and has effective hydraulic condition, it should be rebuilt after demolition.

Name	Distribution system	Capacity (m^3)	Required area (m^2)
Zone No. 1 Central	Pumping	45,000 (10MG)	Existing reconstruction
Zone No. 1 Kokine	Gravity flow	91,000 (20MG)	Existing
Zone No. 2 Tarmwe	Pumping	93,000 (20.3MG)	22,200
Zone No. 3 University	Pumping	102,000 (22.3MG)	24,200
Zone No. 4 Airport	Gravity flow Pumping Relay pump	117,000 (24.0MG)	27,600
Zone No. 5 Hlawga	Gravity flow Pumping	76,000 (16.7MG)	18,400
Zone No. 6 North	Gravity flow	38,000 (8.3MG)	10,000
	Pumping	---	---
Zone No. 7 East Dagon	Pumping	105,000 (23MG)	24,800
Zone No. 8 South Dagon	Pumping	69,000 (14.7MG)	16,400
Zone No. 9 Hlaing Thar Yar	Pumping	61,000 (13.3MG)	15,100
Zone No. 10 Dala	Pumping Relay pump	70,000 (11.0MG)	18,400
Total	---	865,000 (183.6MG)	177,100

Name	Contents
Zone No. 1 Central	New 136,400 m^3/day (30MGD): 26.0 m^3/m×42m×230kw×2units +88.6m^3/m×42m×800kw×3 units (1 unit stand-by)
Zone No. 2 Tarmwe	New 277,300 m^3/day (61MGD): 96.4 m^3/m×31m×800kw×4units (1 unit stand-by)
Zone No. 3 University	New 304,600 m^3/day (67MGD): 79.4 m^3/m×39m×800kw×5units (1 unit stand-by)
Zone No. 4 Airport	New 100,000 m^3/day (22MGD): 52.2 m^3/m×37m×800kw×3units (1 unit stand-by)
Zone No. 5 Hlawga	New 54,600 m^3/day (12MGD): 28.7 m^3/m×28m×280kw×3units (1 unit stand-by)

Name	Contents
Zone No. 6 North	New 45,500 m^3/day (10MGD): 23.7 m^3/m×40m×250kw×3units (1 unit stand-by)
Zone No. 7 East Dagon	New 313,700 m^3/day (69MGD): 30.7 m^3/m×32m×230kw×4units +88.6m^3/m×32m×800kw×4 units (1 unit stand-by)
Zone No. 8 South Dagon	New 200,000 m^3/day (44MGD): 28.1 m^3/m×35m×230kw×3units +76.2m^3/m×35m×630kw×3 units (1 unit stand-by)
Zone No. 9 Hlaing Thar Yar	New 181,800 m^3/day (40MGD): 94.8 m^3/m×37m×600kw×3units (1 unit stand-by)
Zone No. 10 Dala	New 150,000 m^3/day (33MGD): 78.2 m^3/m×34m×600kw×3units (1 unit stand-by)

(2) Distribution Pipe and creation of DMA

In order to restructure distribution pipe network, DMAs are proposed to be created for every zone and distribution main pipe from S/R to DMAs are to be laid newly.

No.	Estimated length of distribution main pipe (km)		Estimated DMA (No.)	Estimated length of distribution pipe (km)		Estimated house connection
	Replacement (km)	New (km)		Replacement (km)	New (km)	(1,000 connections)
Zone No. 1	62	4	35	198	0	147
Zone No. 2	59	34	26	185	148	108
Zone No. 3	48	68	28	158	156	119
Zone No. 4	38	80	30	94	330	127
Zone No. 5	17	196	24	96	479	100
Zone No. 6	4	47	10	8	43	43
Zone No. 7	8	147	39	60	493	163
Zone No. 8	5	163	25	33	569	104
Zone No. 9	13	109	22	24	412	94
Zone No. 10	5	39	18	9	149	76
Total	259	887	257	865	2,779	1,081
	1,146			3,644		

Notes: The length of distribution pipe is the sum total length of New and Replacement.

6.3.4 Other Facilities

(1) Operation and Maintenance

Following facilities are planned for improvement in O&M and monitoring. Yegu P/S is located at the center of city and is excellent in access. Therefore, construction of following facilities is proposed in the site after abolishing the existing facilities. The water supply management center has the function to collect and store data (flow, water pressure, operational information, etc.) of each facilities (WTP, DMA, etc.) transmitted from SCADA.

Name	Contents
Water quality management center	Management of laboratory and water quality information
Water supply management center with SCADA	Monitor/control facilities and DMAs, and collect/manage data, for example, water flow, pressure, etc.
Computer assisted Ledger System	Centralized control of customer data/facilities ledger

6.4 Rehabilitation Plan

6.4.1 Pumping Station (P/S)

Based on above mentioned facility planning list, Gyobyu P/S, Phugyi P/S, and Hlawga P/S are to be rehabilitated. The Yegu booster P/S at which only chlorination is carried out will be demolished, and it is suggested to reconstruct a central control center of distribution system and water quality management.

Horizontal double suction volute type of pump is recommended as major intake pumps and transmission/ distribution pumps, which is same as the existing pumps and also has high efficiency. Countermeasure such as surge tank system, check valves with counter weight or/ hydraulic for preventing water hammer should be considered. In addition, flow meters, pressure meters, motorized discharge valves should be considered to control water flow. Bar screen at intake P/S is necessary, too. Mechanical components that have already been used over their design life needs to be replaced.

Regarding electrical components, not only control panels for pumps but also circuit breaker panels, power cable, and other related necessary items are proposed to be replaced. In particular, power cable needs to be replaced urgently due to heavy damage.

Regarding instrumentation, circuit breaker panels equipped with communications interface to meet the requirements of automatic control and remote monitoring system will be introduced.

Replacement of facilities will be completed to meet the requirements due to change of the design condition of transmitted area.

Name	Existing Capacity	Renewal Capacity
Gyobyu P/S	Intake pump 47.0 m^3/m×25m×280kw×3units (Transmission/ Distribution is un-dissociating)	Transmission pump 47.0 m^3/m×25m×280kw×3units (1 unit stand-by)
Phugyi P/S	86.0 m^3/m×24m×450kw×3units (included stand-by)	86.0 m^3/m×24m×450kw×3units (1 unit stand-by)
Hlawga P/S	---	71.8 m^3/m×43m×800kw×4units (1 unit stand-by)
Hlawga No.1 P/S	83.0 m^3/m×54m×1000kw×4units	Proposed abolition

Name	Existing Capacity	Renewal Capacity
	(included stand-by)	
Hlawga No.2 P/S	Equipment were already removed	Proposed abolition
Nyaunghnapin Phase-1&2	(Phase-1) 47.5 m^3/m×72m×800kw×4units (1unit stand-by) (Phase-2) 47.5 m^3/m×72m×800kw×4units (1unit stand-by)	(Phase-1&2) 40.6 m^3/m×98m×800kw×8units (1 unit stand-by)
Aungtagon P/S	63.0 m^3/m×40m×500kw×3units (1unit stand-by)	Proposed abolition
Yegu P/S	33.0 m^3/m×44m×275kw×7units (included stand-by) 63.3 m^3/m×47m×710kw×4units (included stand-by)	Proposed abolition

Source: JICA Study Team

6.4.2 Water Treatment Plant (WTP)

Improvement of Gyobyu WTP and Hlawga P/S are planned as follows. Improvement of other mechanical and electrical components is included in above P/S.

Name	Existing Capacity	Renewal Capacity
Gyobyu	•Intake pump 47.0m^3/m×25m×280kw×3units (1unit stand-by)	•Improvement of baffle wall in sedimentation basin •Addition of coagulation equipment •Addition of coagulation equipment •Intake pump 47.0 m^3/m×25m×280kw×3units (1unit stand-by)
Hlawga		•Addition of disinfection equipment

Source: JICA Study Team

The improvement plan of Nyaunghnapin WTP is as follows.

Name	Existing Capacity	Renewal Capacity
Nyaunghnapin Phase 1		•Rehabilitation of inlet flow to sedimentation basin •Supplementation of sand in filtration basin •Addition of roof on clear water reservoir •Rehabilitation of coagulation equipment •Addition of disinfection equipment
Nyaunghnapin Phase 2		•Rehabilitation of coagulation equipment •Addition of disinfection equipment

Source: JICA Study Team

6.4.3 Service Reservoir (Rehabilitation)

The existing Central service reservoir needs to be demolished and newly constructed.

(1) Current Condition

The Central service reservoir is surrounded by houses and pagodas. The existing reservoir having capacity of 10 MG is half-buried covered by soils on top. It is RC-flat slab structure with no partition walls inside. It was constructed 40 to 50 years ago but it has not been used due to leakage. So, reservoir is structurally not safe with concrete-wall deteriorated and steels bars in walls visible from outside.

(2) New Construction of Service Reservoir

Distribution pumps will be constructed together with new service reservoir. It will have the following functions;

Increase of water storage volume to 8 hours

To cater to the needs of pumped supply zone in the proposed distribution zone 1

(3) Construction Policy

The following are conditions for new construction;

- High water level should be same as in case of Kokine service reservoir (two reservoirs in zone 1)
- Site of the Reservoir cannot be extended.
- Reservoir capacity is 10 MG.

Under the above conditions, the followings are considered for planning of the reservoir;

- Existing structure should be utilized, even though it is minimum scale, as much as possible.
- Reservoir is divided into 2 compartments for operation and maintenance purpose
- Guiding wall is planned to make the flow uniform to avoid stagnant flow.
- Drainage facilities are to be provided for de-silting of inside of reservoir.
- Construction methods are to be selected to cause minimum noise and vibration to nearby houses and pagodas,

Planned dimension, etc., of the Reservoirs in Zone 1 is shown below.

Service Reservoir Name	Current Situation	New or Rehabilitation
Central	•RC-made 10MG capacity •Not in use due to leakage	•RC-made 10MG capacity •Supplied to "High sub-zone by Pump" •Distribution Pump 109,100 m^3/day (24MGD): 26.0 m^3/m×35m×230kw×2 sets + 88.6 m^3/m×35m×800kw×3 sets (including 1 stand-by)
Kokine	•Supplied to :Shwedagon S/R, Kamayut, Sanchaung, Ahlone, Kyeemyindaing •RC-made 20MG capacity	•Supplied to "Low sub-zone by Gravity"
Shwedagon	•Supplied to :CBD, Bahan, Mingala Taung Nyunt •RC-made 1MG capacity	•To be demolished

Source; JICA Study Team

6.4.4 Distribution Pipes Renewal

The existing distribution pipes were laid 50 to 100 years ago. These pipes have not been replaced and are being used at present. Cast iron pipes are widely used, constituting about 70% of total length according to 2002 JICA-M/P. Other pipe materials in use are galvanized iron, reinforced concrete. These old pipes are generally prone to corrosion etc., resulting in high leakage ratio. Therefore, renewal of distribution and service pipes together with installation of meters is proposed to reduce leakage when distribution districts and district metered areas are created, i.e., reservoir and pumps are constructed.

New pipes are proposed to be laid in the new service areas to increase water supply coverage. Pipe lengths are estimated to be same as the length of roads.

CHAPTER 7 O&M AND CAPACITY DEVELOPMENT PLAN

7.1 O&M Plan

Items to be included in the operation and maintenance plan are as follows:

- Facility maintenance
- Facility operation
- Crisis management
- Water Management
- Non-revenue Water Reduction
- Water quality control

7.1.1 Facility Maintenance

Facility maintenance may be divided into “maintenance work” such as inspection, maintenance and repairs, and “functional improvement work” that includes diagnosis, renewals, and so on, for evaluating functions objectively and improving them. Generally, the life of a facility is extended by planned maintenance management of equipment, and the initial investment and the overall cost for operation and maintenance also decreases. Since YCDC has high skills in maintenance work, the latter is described in this section.

(1) Preparation of manuals and adhering to the manual

Manuals giving details of methods for inspection, maintenance and repair should be prepared so that anybody can use them to achieve adequate results. Manuals should be prepared, work should be implemented based on the manuals, and instructions in the manuals strictly adhered to. Periodic revisions of the manuals are also important. For each facility, the following items should be established in the manual:

- Patrol and inspection: Prepare patrol routes and list of items for visual inspection
- Breakdown: Record inspections and maintenance work
- Record values indicated by meters and inspection values noted using simple tools and measuring instruments
- Clearly indicate maintenance and inspection items, maintenance and inspection period, maintenance and inspection methods, judgment standards for abnormalities in the study table so that even a beginner can understand the content.
- Clearly specify routine patrols, adjustments, cleaning, oil filling, replacement of consumables, and so on.
- Establish a proper system for contacting persons in the event of an accident.

(2) Acquiring specialist knowledge and upgrading skills

Acquisition of specialist knowledge and upgrading skills for becoming familiar and possessing thorough knowledge of equipment specifications, properties, handling methods, and initial response to be adopted during an abnormality, are essential. Training and drills should be implemented.

(3) Appropriate maintenance and inspection

Appropriate stationing of personnel, tools for maintenance and inspection, supply of vehicles and spare parts, allocation of budget, and so on, are indispensable for implementing proper inspection and maintenance.

(4) Prevention of breakdowns and accidents

Spares should be kept for equipment that have a major effect during breakdown or breakdown location should be predicted beforehand, and replacement parts kept ready so as to prevent breakdowns or accidents.

(5) Collection of inspection data

Inspection data collected over a long period is extremely useful to understand the trends of breakdowns and accidents, the condition of deterioration of equipment structures and pipes. This data is also beneficial as reference for understanding the condition of equipment for operation and control, for preparing renewal plans and for implementing inspections. For this purpose, preparation of rules for collecting and processing data such as breakdown records and inspection and maintenance records, sharing of information and so on, are very important. The introduction of SCADA system for centralized management of these data has been proposed in this plan.

7.1.2 Operation and Management of Facilities

Operation and management of a facility has the aim of adequately demonstrating the functions of a facility through efficient operation and control of related equipment.

(1) Operation and management records

1) Records of day-to-day operation and management

Records are necessary for understanding the working state of a facility since water flow, water pressure, water quality, quantity of chemicals used, and amount of power consumed always vary.

2) Operation and management during an abnormality or an accident

During an abnormality such as water quality mishap or power failure, proper judgment must be made and prompt response adopted. By maintaining records of conditions during an abnormality, the records

can be used as reference when a similar instance occurs.

(2) Improving operation and management

1) Operation, control and maintenance management

Maintenance management (inspection and servicing) includes the following procedure: (1) Repair and correct abnormalities and breakdowns that occur during operation. (2) Diagnose the issues and causes of the degradation in functions that have been identified. (3) Revise operating and control methods, and the operating manuals, Impart training and drills to the operators before installing new equipment. Long-term ideal operation and control can be realized by accumulating such information.

2) Preparing and understanding the operation manual

The primary causes for problems during operation and management are: (1) Abnormality in facility; (2) Operational mistakes; (3) Mistakes in judgment. The manual should therefore clearly state the operating procedure at all times, judgment standards for equipment conditions during an abnormality or an accident (temperature, alarm, etc.), and correction measures (operation of equipment, how to stop equipment, how to reset alarms, etc.). It is equally important to make the operator understand these procedures thoroughly.

(3) Detecting abnormalities and adopting measures

An accident may be preceded by an event or change that accompanies it. These changes may sometimes be missed, so normal values and abnormal values of operation data should be stated in the manual. When an abnormality is detected, the causes must be studied immediately, and appropriate means must be adopted to prevent its recurrence. During normal usage, simulating accidents and implementing drills periodically is an effective measure.

7.1.3 Crisis Management

Risks to water supply systems include natural disasters such as drought and typhoon, water pollution, power failure, accident in facility, human injury, and subversive activity. Plans are being formulated, such as facility plans that include preventive measures to minimize damage due to such risks. These measures include intakes from multiple systems (development of Kokkowa and Toe), water utilization between water supply systems (Nyaunghnapin, Kokkowa, Toe, etc.), forming multiple systems of treatment and distribution facilities, fencing around water treatment plants, and installation of private power generating equipment as measure against power failure. Furthermore, measures also include introduction of water distribution blocks, distributed arrangement of infrastructure, and introduction of monitoring systems, which form part of a plan to minimize risks for the entire Yangon City water supply system.

Remaining risks that can be visualized are chlorine leakage, inflow of oily and toxic substances, and information leaks due to centralization of data terminals. Since new risks may appear as a city matures, measures need to be adopted from time to time.

7.1.4 Water Utilization

(1) Water volume and water pressure management

Water volume management refers to ensuring the availability of planned water volumes at every stage of the water supply system starting from intake, treatment, delivery, distribution and supply, and to operate and manage the facility so that the planned water volume is supplied in a stable manner. On the other hand, water pressure management refers to clearly identifying the relationships of pressures (water levels) among various systems and the pressure losses, and to adjust the water pressure and water level with the aim of ensuring terminal water pressure.

Important points for appropriate control are: (1) Compare the actually measured data on site and the control data obtained by automatic measurements periodically, and apply corrections as required; (2) To prevent wrong operations due to abnormal data, validate the data; (3) Calibrate the measuring instruments if necessary.

In the present plan: (1) Yangon City is divided into several blocks, and water transmitted to each block is controlled; (2) Each block is divided into several DMA, and the distribution amount to each DMA is controlled; (3) Flow meters and telemeters are installed at the intake points of the DMA. Activities in this plan include adjustment of control valves installed at the intake points of the DMA for adjusting the water volume and the water pressure. Other activities are operation and management of pumps in the water transmission and distribution facilities, adjusting the valve opening angle, and monitoring the telemeters.

Upgrading the performance of instrumentation for measuring water volume and water pressure and upgrading measurement technologies are essential for reducing leakage. In addition to leakage investigation, it is necessary to understand the supplied volume and the causes of leakage in each DMA.

(2) Overall management of water supply facilities

The plan includes installing a SCADA system in the intake plant, water treatment plant, service reservoir, and pumping station, and setting up a water distribution management center for centralized monitoring from one location in each facility. By establishing a SCADA system, the operating status of each facility can be grasped at all times, and optimum operation and management can be performed to suit the occasion. By setting up a distribution management center, information on water volume,

water pressure, water quality, water level, operating state of equipment, chemical dosage, and so on can be concentrated at one location, enabling speedy and correct commands to be issued. For this purpose, computers and software must be provided so that enormous volumes of data can be centrally managed, analyzed and controlled. Specialized personnel for such operations also need to be fostered.

7.1.5 Water Quality Control

(1) Maintaining water quality of water sources

Water quality status of water sources should be grasped normally, and efforts made to detect abnormal water quality at an early stage. Collection of information such as positions of facilities likely to become sources of water pollution (such as effluent from industries), discharge of drainage, and so on, at all times is very important. Particular attention should be paid to development activities in the upstream regions of intake points since the water supply system of Yangon City will change from water sources of the reservoir system to water sources of the river system in the future.

(2) Water quality control in water supply systems

The water quality control procedure is as shown in the Figure on the right. The Myanmar National Drinking Water Standards (Draft) has been prepared as control standards. Monitoring activities must be carried out quickly based on these standards. Residual chlorine concentration and coliform group, which are indices related to safety of water supply, are not being measured presently, therefore, establishing disinfection facility and monitoring the quality of water supply needs to be planned.

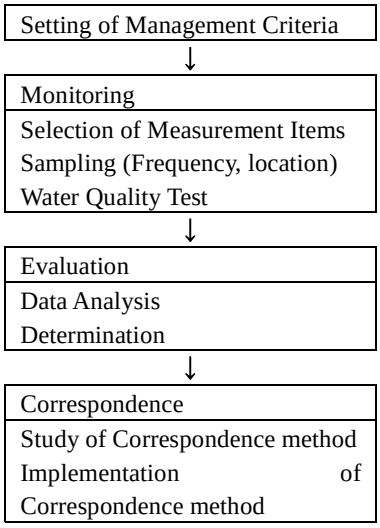


Figure 7.1 Procedure of Water Quality Management

1) Water quality control at the water distribution stage

Turbidity and residual chlorine concentration in the water supply system should be monitored at all times since these are indices indicating the safety of the supplied water. The SCADA system proposed in this plan is to be installed on the output side of the service reservoir and the input side of the DMA. Residual chlorine concentration meters will be installed in the pipelines, and automatically measured data will be transmitted to the central terminal in this system. Sampling will be carried out on the outflow side of the water treatment plant, the service reservoir, and at the terminal draw-off tap, and water quality inspection will be implemented.

2) Drinking water monitoring

Monitoring item is decided in accordance with following policy.

- Prevention of waterborne infectious disease
- Supply of clear and drinkable water

Considering the existing water quality monitoring in Myanmar, first of all, fundamental water quality item to maintain comfort and safety should be selected. Recommendable monitoring items are shown in Table below.

Table 7.1 Recommendable Item of Water Quality Monitoring

Monitoring item	Purpose of monitoring	Target value*	Example of analytical method
pH	Desirable items	7.0 – 8.5	pH meter
Taste		Foul smell and taste are not detected	Organoleptic test
Odor		Foul smell and taste are not detected	Organoleptic test
Color		5 degree	Color meter
Turbidity		5 NTU	Turbidimeter
Standard plate count	Maintain biological safety	< 100CFU/mL	Colony count
Total coliform		Not detected	Colony count
Residual chlorine		> 0.1 mg/L at individual tap or inlet of storage tank	Colorimetric analysis
Zinc (Zn)	Avoid coloring trouble	< 1.0mg/L	Atomic absorption spectrophotometry
Aluminium (Al)		< 0.2mg/L	
Iron (Fe)		< 0.3mg/L	
Copper (Cu)		< 1.0mg/L	
Manganese (Mn)		< 0.05mg/L	
Hardness	Taste and odor-causing substance Chloride ion indicates salt water intrusion	< 100 mg/L	Titration method
Chloride ion		< 200mg/L	Titration method
Sulfide		< 200mg/L	Titration method

*Target value is selected from Highest Desirable value in Myanmar and Japanese drinking water quality standard.

*1: > 0.0 mg/L (to be detected) as provisional value.

Source: JICA Study Team

First of all, above mentioned monitoring should be implemented in routine monitoring work.
Other monitoring item, e.g. heavy metal and organic halogen compound should be implemented after above mentioned monitoring is implemented without problem.

However, if there is any occurrence of water quality accident, monitoring of additional items should be implemented.

Possible monitoring item is as follows;

Table 7.2 Possible Monitoring Item

Monitoring item	Reason
Nitrate nitrogen Nitrite nitrogen	Cyanosis (Blue baby) Ground water pollution by black water
Fluorine (F)	Bone sclerosis Geological condition, Industrial wastewater
Cyanide (CN)	Harmful matter Mining wastewater, Industrial wastewater
Arsenic (As)	Harmful matter Geological condition, Mining wastewater, Industrial wastewater
Cadmium (Cd)	Itai-itai disease Mining wastewater, Industrial wastewater

Source: JICA Study Team

(3) Water source monitoring

Water source monitoring is implemented to maintain preferable water source quality. Monitoring item is selected based on the drinking water monitoring.

Table 7.3 Recommendable Item of Water Source Monitoring

Monitoring item	Purpose of monitoring
Standard plate count	Maintain biological safety Especially groundwater
Total coliform	
Chloride ion	Salt water intrusion
BOD	Organic pollution matter e.g. Influence of industrial wastewater
CODcr	
TS	
SS	

Source: JICA Study Team

If it is necessary (e.g. if accident occurs, or any health problem is caused, etc.), following item should also be included among monitored parameters.

- Nitrate nitrogen and Nitrite nitrogen
- Fluorine (F)
- Cyanide (CN)
- Arsenic (As)
- Cadmium (Cd)
- Heavy metal
- Pesticide
- Other organic compound

(4) Response during abnormal water quality

Speedy and correct response can be adopted by installing the SCADA system mentioned above when abnormal water quality occurs. Sampling and storage of water at appropriate times for studying the causes of abnormality are necessary and should be carried out by the water quality inspector or water

quality inspecting organization.

(5) Road map to safe water

YCDC has the goal to supply safe water by 2018. Improvement of water quality monitoring process to achieve this goal is proposed as follows;

Table 7.4 Road Map to Accomplish Safe Water Supply

No.	Improvement	2013	2014	2015	2016	2017	2018
1	Establishment of water quality monitoring system						
2	Commence monitoring (simplified check)						
3	Implementation of monitoring and up skilling						
4	Construction of chlorination facility						
5	Implementation of chlorination and up skilling						
6	Construction of analysis laboratory						
7	Training of water quality engineer						
8	Improvement of water quality (turbidity) through adequate O&M of WTP						
9	Accomplishment of water quality standard						

Source: JICA study team

7.1.6 Outsourcing

The project cost and the project scale are enormous, and achieving the objectives of the plan cannot be accomplished by YCDC on its own. For this reason, YCDC should aggressively outsource the work. For outsourcing work, safety of the water supply system should be ensured first and foremost, and the outsourced work, work procedures, reports, communication system, inspection standards and so on, must be clearly defined. YCDC should revise the legal system so that outsourcing can be promoted and should restructure the organization so that employees become familiar with the system.

7.2 Capacity Development Plan

Capacity development to be adopted on priority includes:

- Development of organization and systems
- Water quality control and operation and maintenance of water treatment plants
- Water distribution management and non-revenue water management
- Data management of facilities
- Management of customer data and water tariff collection data

7.2.1 Institutional and Organizational Development Plan

(1) Development of organization

The following policies that form the three pillars of an organization to be incorporated first, have been proposed under the framework of organizational development up to 2040 for building the foundation for strengthening the organization:

a) Clearly defining the policies of the Department of Engineering (Water Supply and Sanitation)
b) Reconstruction of the Department of Engineering (Water Supply and Sanitation) and township offices
c) Strengthening the organization of the Department of Engineering (Water Supply and Sanitation) and township office

The policies are as given below.

1) Policy 1: Clearly defining policies of the Department of Engineering (Water Supply and Sanitation)

a) Formulation of high level policies and plans for organization

Once an organization has policies to aim for that are not limited to water supply and sewerage works, it can start making plans, strategies, business plans and set comprehensive targets. It is extremely important to clearly define the high level policies of the Department of Engineering (Water Supply and Sanitation) and to establish the direction to proceed so as to make the water supply and sewerage works sustainable. The vision prepared in the Master Plan will become a part of the policies, and such high level policies and plans should be formulated in gradual stages henceforth.

b) Setting up the planning and monitoring section

Department (for example: planning and monitoring department) should be set up for preparing high level policies and plans, strategies, business plans and so on, and for continually monitoring and updating the same. The said department should be under the Chief Executive, may not be a large department, but it should overlook the entire organization including the roles and duties of existing sections from the management viewpoint, and should have the role of proposing improvements.

c) Utilizing performance indicators (PIs)

Performance indicators should be effectively utilized in the business operation of the Department of Engineering (Water Supply and Sanitation). Although performance indicators are not being used currently, they should be periodically reviewed, and the state of existing business operation and target achievement status should be always monitored. Such actions will clarify issues and improvement points to be undertaken and prove to be effective.

d) Setting goals for each department

Work goals and achievement standards should be clearly established in each department. Although the performance indicators mentioned above are not applicable to all departments, if

targets using performance indicators are used as far as possible, results will become visible.

2) Policy 2: Reconstruction of the Department of Engineering (Water Supply and Sanitation) and township offices

a) Services based on customer needs

Water supply service is a public service for the citizens. The organization should change to one that is aware of customers so that services are offered based on customer needs.

b) Change to an organization with business awareness

The Department of Engineering (Water Supply and Sanitation) is part of the regional government. It is important that this department changes to a provider with business awareness as part of its organizational culture rather than change to an administrative organization with technical specialization.

c) Clear division of work and delegation of authority

Division of work and delegation of responsibility should be clearly established in each department. Authority should be delegated to departments lower in the hierarchy. Self-awareness and self-reliance of employees should be encouraged more than ever before.

d) Creating the Customer Services/Public Relations Section

A section in charge of customer services and public relations should be set up in the township office to reinforce the functions of customer services. Customer satisfaction surveys should be planned and implemented periodically, and reflected from time to time in business operations so as to enhance the quality of services.

e) Reinforcing the functions of House Connections Section

The House Connections Section in the Water Distribution Division should be strengthened. According to YCDC, although the same section exists currently in the organization, it has no substance. The number of house connections is estimated to reach 1 million by 2040 according to the proposal in the Master Plan. Thus, the number of employees has to be increased substantially to monitor installations and meet the demand for piping work and installation of water meters. On the other hand, upgrading the skills of the employees through scheduled drills and training is also essential and indispensable.

f) Strengthening meter reading work

The number of meter reading staff should also be increased similarly in the township offices to cater to the increase in the number of house connections in the future. Outsourcing such work in the future may be considered, but as of this stage, it is difficult to find a company quickly to entrust such work to in the private sector within the country. Moreover, training personnel for such work would incur considerable time. However, outsourcing in the future must be seriously looked at, plans must be made from now onward for implementing the training and upgrading the skills of water meter reading staff.

g) Setting up a water quality control center

A water quality control center should be set up and a system formed such that water quality is monitored periodically at the facility's own laboratory. Presently, all work is outsourced, and inspection frequency is also small, at once a month. Henceforth, new water treatment plants will be constructed, and the water supply diffusion rate will increase necessitating the reinforcement of the monitoring system.

3) Policy 3: Strengthening the organization of the Department of Engineering (Water Supply and Sanitation) and township office

a) Formulating plans for human resource development

Plans should be formulated to develop human resources, and skills of personnel upgraded periodically and continuously. With the expansion in facilities, the efficiency and quality of the water supply and sewerage services need to be enhanced. For this purpose, human resources should be developed on priority and skills of the employees enhanced, recognizing that humans are the most important of all resources.

b) Building up the human resource management system

Human resources must be understood at all times and should be efficiently utilized and assigned properly by developing the human resource management system at the Head Office. In addition, evaluation standards must be set and information systems developed so as to evaluate the performance of the employees.

c) Making work more efficient by installing computers

Managing work by handwritten documents should be reduced as far as possible so as to aim for more efficient work. Use of computers should be encouraged in townships and in the Head Office. Hand-written customer ledgers and accounting books are being used since the past for customer management and water tariff collection in townships especially. Computerization of such information is essential. In case of surplus of human resources as a result of computerization, such human resources may be appropriately assigned throughout the organization supplementing the shortage and thereby strengthening the organization. For instance, transferring existing office staff is one measure to cope with the increase in demand for meter reading employees in township offices.

(2) Legal system

The legal system considered inadequate presently or in the future in the water supply and sewerage sector, its importance and urgency, is summarized in the Table below. Of the laws that need to be improved, a mark is affixed in the table especially to those that are urgent.

Table 7.5 Legal and Regulatory Framework Needed for Short- and Mid/ Long-Term (Water and Sewerage Sector)

[Period expected to be required ◎: within 1–3 years, ○: within 3–5 years]

Relevant Legal and Regulatory Framework	Present need	Future need	Evaluation for improvement	
			Importance	Emergency
(A-1) Water Supply Act	✔			◎
Chapter 1 General Provisions				
Article 4 Water Quality Standards	✔		◎	
Article 5 Facility Standards	✔		○	
Chapter 2 Water Utility				
Article 13 Notification before Commencement of Supply and Inspection			◎	
Section 2 Inspection				
Article 14 Rules on Supply				◎
Article 15 Obligation to Supply Water			◎	
Article 16 Structure and Materials of Water Supply Equipment	✔		○	
Article 17 Inspection of Water Supply Equipment			◎	
Article 19 Technical Administrator of Waterworks		✔	○	
Article 20 Water Quality Inspection	✔		○	
Section 3 Designated Plumbing Contractor	✔		○	
Chapter 3 Water Wholesale	✔		○	
Chapter 4 Private Water Supply	✔		○	
Chapter 4-2 Private Water Supply Facilities		✔	◎	
Article 34-3 Obligation to Inspect				
(A-3) Ordinance for Enforcement of the Water Supply Act	✔			◎
(B) Municipal Ordinance for Water Supply	✔			◎
(C) Industrial Water Supply Business Act		✔	○	

Source: JICA Study Team

Ordinances for the water supply and sewerage systems of Yangon City may be formulated based on the existing Yangon City Development Law and its enforcement rules. On the other hand, the formulation of the Waterworks Act, Sewerage Works Act, other enforcement rules, Local Autonomy Law, and the Industrial Waterworks Supply Business Act proposed in the same table form the legal system at the national level. During the study stage until now, adequate discussions have not been held on the improvements, feasibility, content, and process of laws between YCDC and the central government. Henceforth, there are plans for holding detailed discussions with associated organs.

The Figure below is attached as reference to the process chart for tentative improvement of the legal system.

Title	Ner- / Mid-Term (within 1-5 yrs)	Long Term (within 5-10 yrs)
1. Waterworks Act		
• Rules on supply		
• Water quality standards		
• Notification before Commencement of Supply and Inspection		
• Obligation to Supply Water		
• Inspection of Water Supply Equipment		
• Private Water Supply Facilities		
2. Ordinance for Enforcement of the Water Supply Act		
3. Municipal Ordinance for Water Supply		
4. Industrial Water Supply Business Act		

Source: JICA Study Team

Figure 7.2 A Preliminary Roadmap for Legal and Regulatory System for Short- and Mid/Long-Term (Water Sector)

7.2.2 Water Quality Monitoring and O&M of WTP

YCDC must establish water quality controls for supplying safe water, and strive for the proper operation and maintenance of new water treatment plants. Presently, the amount of disinfected tap water supplied to the city is at a very low level. YCDC has implemented operation and maintenance of the Nyaunghnapin water treatment plant, and has the experience of operating water treatment plants with coagulation-sedimentation process and rapid sand filtration process. However, these are water treatment plants designed and constructed by YCDC itself, and abnormalities such as losses from facilities such as outflow of anthracite from sand filters, equipment that have been installed without budget limitations and so on, have been reported. To supply safe, disinfected water by 2018, it is important to enhance the operation and maintenance level of the water treatment plant.

In water treatment plants, especially when large amounts of inorganic and organic substances are present in the filtered water, the chlorine injection quantity increases, chlorine is consumed in the service reservoirs and distribution pipelines, and safe water may not be supplied. Consequently, proper coagulating effect is necessary to implement these operations correctly. It is important to optimize and reduce the injected chlorine quantity by reducing turbidity in filtered water. To successfully complete these operations, it is very important to upgrade the technical level of the operator in respect of the seven broad categories listed below.

- Operation and management
- Water volume control
- Maintenance management
- Water quality control
- Disaster and accident measures

- Security
- Cleaning

Various operation and maintenance tasks are described below. Training, such as On-the-job (OJT) training is effective in improving operation and maintenance skills. In addition, technical cooperation projects and deputation of experts are also effective measures.

(1) Operation and management

1) Operation and management work
   - Understand the relationship of water treatment plant with other facilities because other water supply facilities are organically interconnected.
   - Prepare operation manuals.
   - Prepare daily, monthly and annual reports and make these reports public.

2) Operation and management of water treatment plants
   - Operate the plant such that treated water to suit the day-to-day distribution amount is produced.
   - Perform day-to-day operations on equipment to suit the treated water amount and the raw water quality.

3) Operation and management of chemical equipment
   - Manage all stages of work from the procurement of chemicals required for water and wastewater treatment processes to dosing of the same. More specifically, check quantity of chemicals stored, procure chemicals and perform quality control of the same. Next, operate the equipment for dosing chemicals and control the effects after dosing the chemicals.

4) Operation and management of wastewater treatment facilities and effective use of dehydrated sludge
   - Operate wastewater treatment facilities properly. More specifically, check the treated water quality and amount of treated water, and if necessary, perform day-to-day operations to suit the equipment. Effectively use the sludge drawn out from the sludge drying beds.

(2) Water volume control

1) Operation and management of treated water reservoirs and service reservoirs
   - Monitor the water level, inflow rate, outflow rate and water pressure in treated water reservoirs and service reservoirs.

2) Monitor other facilities.
   - Adopt immediate measures when alarm for turbidity, residual chlorine, water pressure or flow rate is activated.

3) Maintenance management
   - Maintenance management refers to inspection, repairs and improvements to facilities. It is required to manage various kinds of work smoothly by maintaining the initial performance and functions established in the design document through inspections of various equipment.

4) Inspection management of each facility
   - Prepare maintenance and inspection manual.
   - Periodically patrol and inspect the facility based on the prepared manual.
   - Perform repairs and improvements before equipment breakdown occurs or before functions deteriorate.

5) Inspection items of a facility are as given below.
   - Power substation: Perform periodic inspection and periodic repairs annually
   - Electrical equipment: Perform periodic inspection and periodic repairs annually
   - Monitoring control equipment: Perform periodic inspection and periodic repairs annually
   - Instrumentation equipment: Perform periodic inspection and periodic repairs annually
   - Premises generator: Perform periodic inspection and periodic repairs annually
   - Treated water reservoir and service reservoir: Perform cleaning once in 5 years. Also, perform cleaning when the occasion demands it.

(3) Water quality control

1) Measurement of raw water quality
   - For measurement of raw water, measure items necessary for water treatment (water temperature, turbidity and pH) at least once a day. Increase the frequency of inspection when it rains and the turbidity increases.

2) Measurement of treated water quality
   - Measure quality of treated water at least once a day (water temperature, turbidity, pH, residual chlorine concentration).
   - Measure the residual chlorine concentration continuously.

(4) Disaster and accident measures

- Formulate effective measures against disasters and accidents and implement them; mitigate the damage as far as possible.
- Respond immediately when an emergency situation arises.

1) Preparation of crisis management manual
   - Prepare the crisis management manual, and clearly indicate the responses to be taken during an emergency such as disaster or accident.

2) Build up an emergency response system
   - Plan for operational method in an emergency and implement it even if partial stoppage of functions occurs during a breakdown arising from a disaster or an accident. Ensure that a system is established that can quickly restore normal operation when a part of the functions of a water treatment facility or wastewater treatment facility is disabled during a breakdown.

(5) Response during an emergency
   - Respond according to the Crisis Management Manual in an emergency such as disaster or accident.
   - Prepare a report after adopting the response and record the report.

(6) Security
   - Adopt measures such as securely locking the entrances and exits so that no harm or damage occurs to the water supply facilities.

(7) Cleaning

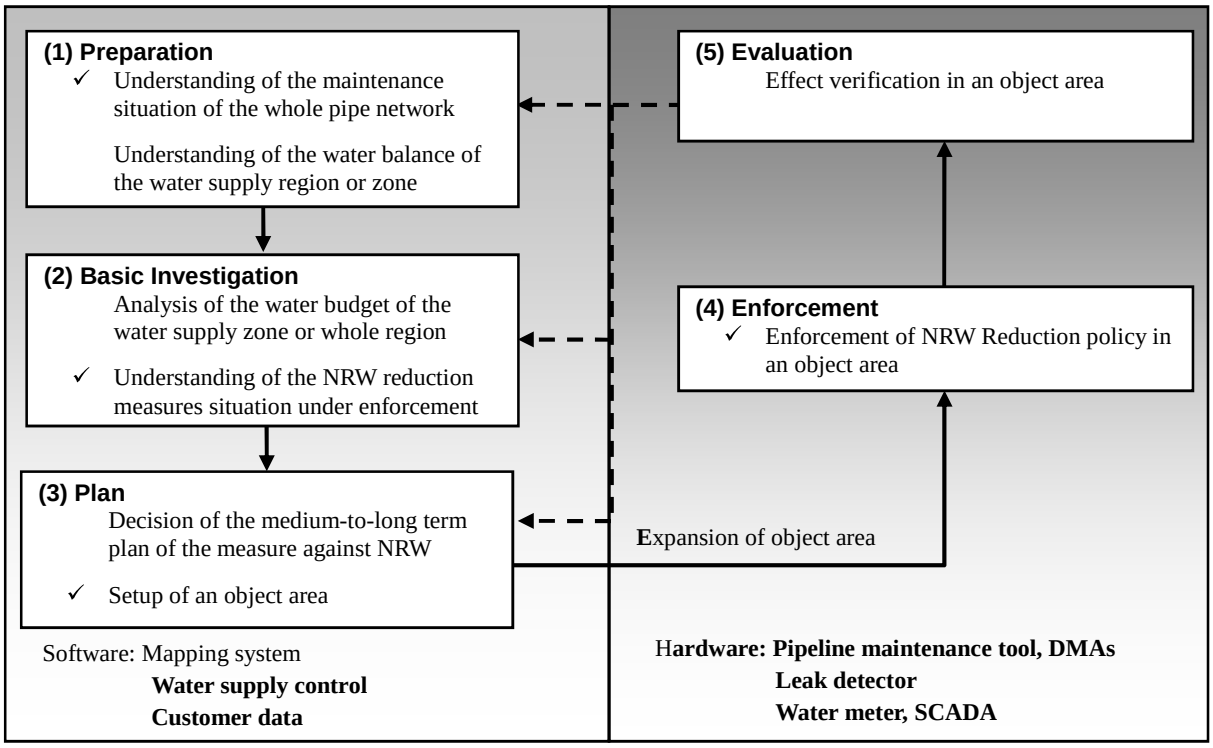
1) Cleaning buildings and civil structures
   - Clean buildings and civil structures.

2) Cleaning the exterior (landscape)
   - Collect fallen leaves and trash and dispose them off.

3) Controlling vegetation and removing weeds
   - Inspect and trim vegetation, and remove weeds.

7.2.3 Water Distribution Management and Non-Revenue Water Management

Water distribution management and non-revenue water management are one of the main subjects of this M/P. Much data analysis and continuous work is indispensable to presumption of NRW. In MP, DMA creation of water supply network is proposed as clear action. It is necessary to carry out proposed action for NRW reduction and leakage water.



Source: JICA study team

Figure 7.3 Flow of a NRW Reduction System

Following five steps are proposed for NRW reduction.

- Analysis of present state
- DMA creation from existing water supply network
- Establishment of NRW reduction plan
- Implementation of NRW reduction plan
- Strengthening of staff/organization

(1) Analysis of present state

YCDC does not have a special department of leakage water control and is not carrying out regular flow measurement. Therefore, exact amount of supply/consumption is not known, and the leakage rate in Yangon is uncertain.

1) Network condition
   - Pipe network is deteriorated (There are also pipe exceeding 100 years of use), and aged with over 50% of the network more than 60 years old
   - Cast Iron: approximately 80% of the network is cast iron
   - Joints: most joints are leak prone lead caulked joints
   - Lack of secondary mains and sections valves, etc.
   - Lot of leakage on service pipes
   - Network drawings are not exact
   - There are many pipes transferred from the housing department

2) Service level
   - Only 35% population is served in Yangon
   - Most areas have very low pressure (Even if high, the water head is about 15m)
   - Large areas have intermittent supplies
   - Valve operation limit supply to some areas
   - There is much poor supply area due to limitation of natural features/facilities

3) Water supply department operations
   - No department of leakage water, and no NRW reduction plan & activity
   - Shortage of the maintenance staff with abundant experience
   - Not invested for a long time because of the capital deficit
   - Repair teams under-equipped
   - Passive leakage control
   - Lack of regulation and or enforcement for consumers
   - Unclear metering plan

4) Flow measurement
   - No production or supply metering

5) Consumers
   - Problems with meter failures
   - Unaccounted for consumption from large connections

6) Present NRW(UFW) rate of Yangon is estimated at around 66%

(2) DMA creation from existing water supply network

It is not possible to do everything at once and immediately, so the approach will be to start small and expand progressively until the entire network is effectively covered. A general strategy is proposed

below, which will need to be adapted and modified to suit changing circumstances.

※A general Approach

The NRW reduction will need to focus on large users and high leakage areas first. In order to begin work efficiently, starting from continuous supply/high pressure area is advisable, and is divided as one DMA. Although great effort (installation of flow meter/isolation valve, network check, etc.) is needed as 1st step, the step should be started immediately.
Notes: In Yankin TS, A general Approach will be planned as a pilot project of Japanese Grant Aid.

(3) Establishment of NRW reduction plan

There are following three phases in a NRW reduction plan, and each activity is proposed as follows.

1) Phase 1: Preliminary
   - The setup for all activities
   - Training and practice of basic techniques and methods
   - Installation of equipment especially, inflow meters to DMA
   - Survey of pilot area sampling
   - Mapping of network
   - Establishment of NRW reduction unit/team
   - Work on trial pilot areas
   - Technical assistance and technology transfer for detailed planning and implementation Methods

2) Phase 2: Medium term
   - Establishing routing procedures
   - Monitoring of Non-revenue water
   - Progressively repeat and expand task to cover more and more of network
   - Continue and complete survey
   - Reduce and phase out technical assistance as NRW unit becomes self-sufficient
   - Prioritize and direct NRW reduction activities

3) Phase 3: Long term
   - Review NRW levels and control measure strategically
   - Modify and prepare a plan and revise objectives
   - Continue and repeat NRW reduction, prevention and monitoring
   - Continue expansion of area covered until completion
   - Development of a detailed level by data deepening

(4) Implementation of NRW reduction plan

Various activities are divided into three phases as above-mentioned plan. Each activity should be carried out based on the plan. Especially the important activities are as follows.

- Establishment and implementation of NRW reduction plan
- Physical loss activities (Leakage repair, DMA, etc.)
- Non-Physical loss activities (Un-detecting of meter, illegal connection, etc.)
- Measuring and prioritizing of NRW reduction activities
- Technical cooperation program

Phase 1 and phase 2 will be carried out continuously, and then phase 3 will be carried out. About three (3) years are appropriate to review an activity plan. For that reason, a review of the activity/plan which includes the following contents as the minimum should be repeated every three (3) years.

- Organizational aspects
- Rechecking data
- Pressure control
- Updating district and water metering
- Application of new techniques and technologies
- Renewal/calibration of metering and other equipment
- Updating and improving active leakage control
- Public relations
- New works and repairs

(5) Strengthening of staff/organization

In order to be effective over a sustained period, it is essential that adequate financial resources and budgets are available for NRW reduction. The followings are the five main aspects to be considered.

1) Organization

A separate, dedicated unit headed by a manager with sufficient authority and requisite autonomy is essential. The unit must be set up immediately on starting the programme and it should be considered as a permanent unit, not a time limited temporary one. It is considered that the functional enhancement of the house connection section of above-mentioned water supply department is effective.

2) Personnel to Staff the Team

The unit should be staffed with project manager of NRW reduction, three engineers to head PL controller, NPL controller, and data analysis & recording. The unit should be composed of two or more teams, and each team should have one GIS engineer, at least six technicians and one draftsman (a total of eight persons/ team).

3) Training and Skills Acquisition for the Staff

To start with, about three employees should be trained for a period of up to three months from a specialized training center in developed country that include theory of leakage control, practical experience in use of a wide variety of equipment, maintenance of and simple repairs of all equipment as its formal courses. In addition, the technical assistance consultants should provide on-the-job trainings.

4) Technical Assistance to the Organization

Since the NRW reduction is a long-term activity requiring sustained effort, need for appointing a competent, long-term consultant to assist the authority should be seriously considered. In the phase-1, a professional consultant should be provided, a detailed plan should be established with a unit, and various activities should be started based on a detailed plan. Technology transfer is gradually achieved through experience of OJT.

5) Material and Equipment Resources

Much equipment and material will be needed, but in the three main categories.

- Office-based drawing, data records, functional equipment and computer with GIS for staff
- Equipment and transport for fieldwork including specialist leak detection equipment
- Repair materials, tools and equipment of the type and quantity necessary to get repairs in a timely and effective manner

(6) Recommendations

The key recommendations and conclusions are:

- NRW is a big problem in Yangon and should be properly addresses
- NRW reduction efforts should be integrated with general water supply improvements
- A team should be set up and trained as soon as possible and assigned with the task of beginning to deal with the problem
- Similarly, repair teams should be set up trained and supplied with proper repair materials
- NRW reduction will require a long and sustained effort over many years
- Cost-benefit analysis will determine the level of NRW to be aimed for

7.2.4 Data Management for Facilities

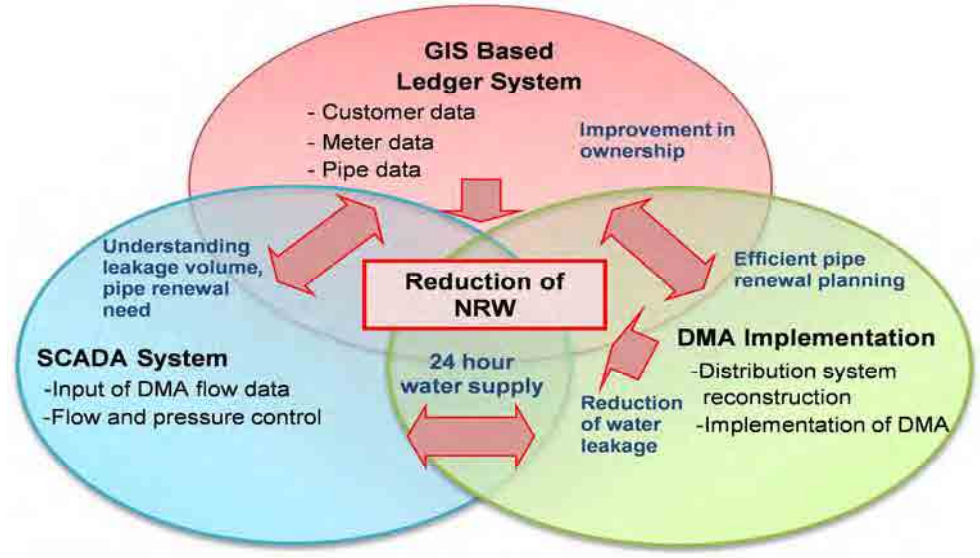
(1) Present condition and Improvement Proposal

YCDC is not preparing institution ledger. Although a part of water supply network is available in digital form by CAD, the valuable information about facilities, such as a design drawing, is maintained on paper basis in each office. In addition, although the charge collection system has a customer list and a charge collection list, similarly, these lists are maintained on paper basis only.

When information is needed, the data cannot be accessed easily. Therefore, institution ledger system equipped with facilities information and data on condition of facilities by GIS is proposed for future data management.

The feature of this system inputs facilities data (WTP, P/S, etc.) and customer data (distribution pipe, house connection, etc.) into the same system, and assists management/implementation of O&M and NRW reduction. The system serves as assistance for 24-hour water supply.

In the early stage, as customer research and parallel work, the existence of water meters and the functioning of equipment are identified, and RW is estimated. In the middle stage, service pipe and meter are replaced for the purpose of water leakage reduction, and DMAs are reconstructed from existing network. Furthermore, the real flow is measured by introduction of SCADA and the volume of RW is collected. Grasp of NRW-rate will be attained by analyzing such recorded amount of water carefully. By evaluating/ analyzing such a result and revising replacement plan/water leakage survey plan for next step, the management cycle of PDCA is formed and, probably, the effect of NRW reduction is expected further.



Source: JICA Study Team

Figure 7.4 Three Main Components Proposed for the Study and Their Role in Achieving the Defined Goals

(2) The process of data management

The data creation method, the function and maintenance management by Institution Ledger System with GIS is proposed below.

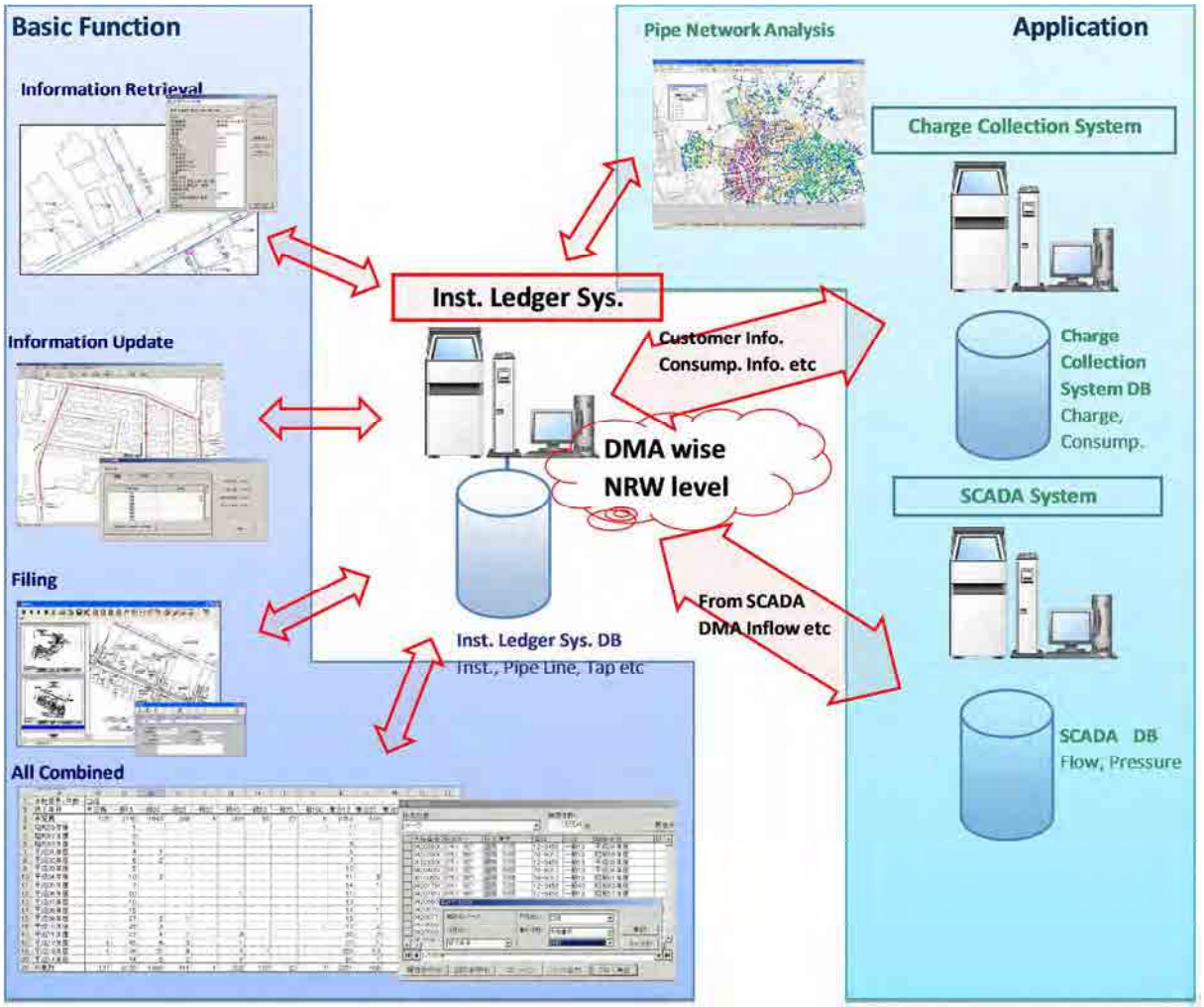
1) Data creation method

In order to build a system, the fundamental information on pipe diameter, material of pipe, year of installation, location of house connection, etc. needs to be collected, and exact information needs to be input at the same time the existing data are rechecked/ revised. In particular, survey of pipe location

may require not only an interview but a pipe locator or trial excavation. In addition, probably, all the house survey, Service pipe, and installation/replacement of water meter are needed in order to collect exact customer data.

2) Function

A screen of Institution Ledger System is formed from infrastructure information (property information, including the location of WTP, S/R, P/S, facilities capacity, volume, diameter of pipe, material of pipe, etc.) and pipeline information (property information, including transmission line, distribution pipe, service pipe, meter, etc.) in GIS. A customer information system by GIS combines various subsystems with these, and function is exhibited. An image of function of Institution Ledger System with GIS is shown in the following Figure.



Source: JICA Study Team

Figure 7.5 Image of the Functions of Institution Ledger System

(3) Maintenance management

Institution Ledger System has an interface for accessing the required information, and is operated in dispersed section. In each department, the authority of information (a range of access/updating, etc.) need to be regulated, and security needs to be established. YCDC will have to determine a setting position of these terminals, access right, etc. at the time of equipment introduction. In addition, even after equipment is introduced, it is necessary to carry out updating of data continuously. It is necessary to carry out update of the system under instruction of the skilled engineer of database organization, and a continuous budget is needed.

7.2.5 Management of Customers and Tariff Collection

Customers are receivers of water supply and sewerage services. The Department of Engineering (Water Supply and Sanitation), YCDC, supplies safe drinking water to customers and in return receives water tariff from the customers. Tariff can be collected correctly by appropriately managing customer information. Such management also helps to satisfactorily maintain the relationship with customers and to ensure stable income. The Department of Engineering (Water Supply and Sanitation), YCDC, should bear the points mentioned above in mind, and once again recognize the importance of managing customer data and tariff collection data.

The points below are proposed for enhancing the ability to manage customer data and water tariff data.

(1) Management of customer data and water tariff collection data in the Department of Engineering (Water Supply and Sanitation)

1) Creating database of customer data

A database management system using MS Visual Fox Pro has been used in the computer room with input of data of about 185,000 customers under the meter rate tariff system. In addition to customer data as input information, water meter readings are entered every month, invoice amounts are calculated, and invoices are issued. On the other hand, customers under the fixed rate system, customers to which foreigners' tariff applies, and customers in the government organization are managed since the past using hand-written customer ledgers and accounting books. Thus, considerable time is required for retrieving customer data, invoice and collection records, and for preparing overall statistics, and this makes the system inefficient. At the outset, databases using computers should be created for customers as well.

2) Unification of departments in charge of customer data management

As mentioned above, the section in charge differs depending on the customer; therefore, the organization should be formed such that one section can perform centralized customer management

together with the creation of database of customer. Presently, the Computer Section is a part of the Service Support Center, and customers under the fixed rate tariff system, foreigners' tariff system, and customers of government organizations are treated separately according to the Public Water Tariff Section and Water Meter Section of the Financial Management Department. Unification of the sections and departments is recommended from the viewpoint of service efficiency and security of data.

3) Fulfillment and renewal of customer data

Claims from customers and records of measures adopted should be included in the customer database. Information related to customer care should also be input and managed through the database. If the database is checked, the response status and issues in the past, improvement measures and so on can be grasped, and elaborate customized measures for the customer can be adopted. It is equally important to renew from time to time such customer data, make it known to the employees, and to build up a close, coordinated system with the township offices.

(2) Management of customer data and water tariff collection data in the township offices

1) Creating database of customer and making services more efficient

Database of customer should be created similar to the case of the Department of Engineering (Water Supply and Sanitation). According to information from several townships, almost no computerization has permeated in the township offices, and pre-modern management is being performed. Among the series of services from customer management to data management of tariffs, about 16 formats (ledgers, records, reports) are entered manually and stored. Of these records, customer name, address, meter number, registration code and so on, are again entered in the same handwritten format. Thus, a lot of unnecessary work is being performed. The amount of work in the township office can be reduced significantly by introducing and increasing the use of databases.

2) More efficient water meter reading

Depending on the township, a team of two members perform water meter reading. In principle, meter reading by one person is proposed. Water meter reading and distribution of invoices, and sometimes tariff collection may also be included, but if staff members are trained in such work, a single person can adequately perform all these jobs. Sometimes two persons may be preferred when cash is being handled; however, such a system may be avoided if the township engineer performing the monitoring work is trained properly in monitoring skills. When the number of customer connections increase in the future, work efficiency for one-person system and two-person system will vary significantly. It is therefore recommended to shift to a one-person system right now by starting with the training of persons aiming for a one-person system.

3) Enhancing skills of employees considering outsourcing of water tariff collection

Considering outsourcing of water meter reading and tariff collection work in the future, it is recommended that the monitoring skills of the employees in the township offices be fostered. At this point of time, it is presumed that the environment is not ripe for outsourcing to the private sector; moreover, formation of database for customer management is not ready, so outsourcing at this stage may invite problems. However, outsourcing water tariff collection is an option for enhancing work efficiency in the future. For this reason, it is imperative that the monitoring skills and knowledge of database management of the employees be fostered through on-the-job (OJT) training from now onward.

CHAPTER 8 PROJECT IMPLEMENTATION AND COST ESTIMATION

8.1 Project Implementation Plan

The Table attached below shows the implementation plan of waterworks project. The target year of the development plan is 2040.

Table 8.1 Implementation Plan of Waterworks

Facilities	Phase 1													Phase 2													
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Water Treatment Plant																												
Gyobyu P/S																												
Hlawga P/S																												
Phugyi																												
Nyaunghnapin Phase I																												
Nyaunghnapin Phase II																												
Lagunpyin																												
Kokkowa Phase I																												
Kokkowa Phase II																												
Kokkowa Phase III																												
Toe Phase I																												
Toe Phase II																												
Toe Phase III																												
Formulation of DMA																												
Zone No. 1																												
Zone No. 2																												
Zone No. 3																												
Zone No. 4																												
Zone No. 5																												
Zone No. 6																												
Zone No. 7																												
Zone No. 8																												
Zone No. 9																												
Zone No. 10																												
Improvement of O&M																												
Water quality control center																												
Distribution control center																												
SCADA and ledger system																												

Source: JICA Study Team

8.2 Policy and Condition of Cost Estimation

- The price level and exchange rate are defined below.
  Price level: Average in December 2012
  Exchange rate: 1USD=84.64JPY

Considering the condition listed below, the construction cost is calculated.

- It is possible to procure civil and building material, labour and construction machine within the country and the procurement in local country is set as basic policy for project cost estimation.
- The mechanical and electrical equipment is basically procured from overseas including third country; such as European Union (EU) etc. The equipment will be procured with consideration of quality, performance, economic efficiency and O&M, etc.
- The local contractors have enough experiences and ability for normal civil engineering work. On the other hand, they are not experienced in the specialized project regarding water supply and sewerage. However, Japanese experts and foreign experts are staffed in implementation system of the Project and construction is conducted by the local contractor.
- The local contractors haven’t experienced the construction methods of pipe jacking and shield.

The unit cost of these construction methods is collected from Thailand where many contractors have relevant experiences.

- The installation unit cost of house connection is estimated by YCDC, based on the standard section drawings for pipe installation.
- The construction plan is established with the considerations of local natural condition (topographic aspects, geotechnical condition and meteorological condition) and legislation/custom.

8.3 Project Cost Estimation

8.3.1 Capital Cost

Non-disclosure Information

Table 8.2 Project Cost of Water Supply Project

Non-disclosure Information

8.3.2 Operation and Maintenance Cost

The required operation and maintenance cost for waterworks is shown below. In the field of waterworks, the annual total cost of operation and maintenance is approximately 12.8 Billion JPY per year and 78% of the total cost is calculated as chemical cost.

Table 8.3 Annual Operation and Maintenance Cost for Waterworks

Unit: Mil. JPY/Year

Category	Cost
Labor cost	51.7 (0.5)
Electricity cost	1,719.7 (17.0)
Spare parts cost	817.4 (8.1)
Chemical cost	9,936.7 (98.3)
Others	250.3 (2.5)
Total	12,775.8 (126.4)

Source: JICA Study Team, (): Mil. USD/Year

8.4 Staged Development of Water Supply Facilities

8.4.1 Staged Development

Water supply facilities are developed stage by stage as required. In this section, background of the staged development plan is described. Purposes of the planned facilities are firstly described followed by an idea for staged development.

(1) Purposes of the Planned Facilities

The facilities are planned for the following purposes;

- Increase in Supply Amount (Construction of Water Treatment Plant and Transmission System)
- Equitable Distribution and Non-revenue Water Reduction (Creation of Service District and DMA, two of the 3-tier distribution system)
- Water Quality Improvement (Water Treatment Plant with Disinfection Devices)
- Prolongation (Rehabilitation) of the Existing Facilities
- Data Management
- Coverage Ratio Increase

(2) Transmission Facilities

Water treatment plants are constructed according to the water demand. So transmission facilities are constructed to convey treated water to zones. Routes to zones are described in the section 5.4.

(3) Creation of Distribution District/DMA and Coverage Ratio Increase

Ten distribution districts with DMA are created which requires the followings;

- construction of distribution reservoir, distribution pump, distribution main pipes connecting reservoir/pump with DMA and distribution pipes within DMA,
- creation of DMA,
- replacement of old distribution pipes, services pipes and meters etc.
- water distribution/management center with SCADA system

Priority of distribution districts is given to the older areas where urbanization took place earlier. Pipes in the older areas were installed earlier and, they are supposed to be dilapidated and leakages are supposedly high. In the older areas, population density is high so that cost benefit ratio is expected to be high.

Water coverage increase is also an important target. Costs for this category is not earmarked separately, however, pipes costs are included in the cost of distribution district creation. Although creation of distribution district is started from the old areas, pipe costs of coverage increase occur in new developing areas. So some costs should be diverted from that of old areas to that of new areas.

(4) Water Quality Improvement and Rehabilitation of the Existing Facilities

Water from Hlawga and Phugyi reservoirs used to be clean and was distributed without treatment. However, probably deterioration of raw water quality has started annoying customers and bottled water has been used instead of water supply. Hence, the priority of the improvement of water quality is assumed high.

8.4.2 Cost Estimate by Stage

Refer to Appendix F for details.

CHAPTER 9 FINANCIAL PLAN

9.1 Financial Analysis

9.1.1 Financial Analysis Method

Financial analysis was implemented with the aim of confirming the financial adequacy of the project from the viewpoint of YCDC, the implementing organization. The Net Present Value (NPV) and the Benefit Cost ratio (B/C ratio) were calculated as indices of financial analysis and evaluation was performed. Financial analysis is based on a large number of pre-conditions. It should be noted carefully that when a change occurs in the pre-conditions, the results also may be changed.

9.1.2 Pre-Conditions of Financial Analysis

Financial analysis of the Master Plan was implemented based on the conditions and pre-requisites as below. The evaluation period for financial analysis was taken as 67 years from the start of the project in 2014 to 2080. A discount rate of 3% is used in the calculation of NPV and B/C.

(1) Start of project : 2014
(2) Project period : 2014-2080
(3) Discount rate : 3%
(4) Accounted-for water ratio : 33% (2013), 65% (2025) , 85% (2040)
(5) Water tariff : 4 simulation plans based on 88 kyats for domestic households
1 simulation plan based on 175 kyat as WTP for domestic households

9.1.3 Willingness to Pay (WTP)

The willingness to pay amount was estimated in order to assess whether the citizens are willing to accept the set water tariff rates against the rate level expected by them. For calculating both the items, the results of citizens' awareness study implemented by the household interview survey (2002 JICA-HIS) of JICA Urban Plan Study, 2012 were utilized.

The main points and results are shown in the Table below.

Table 9.1 Willingness to Pay and Monthly Average Consumption

Item	Method	Estimated Average Value
Monthly willingness to pay	Format from which selection can be made from seven ranges. The willingness to pay amount at the center of each range. Valid replies: 10,068	2,436 (kyats/m^3/household)
Monthly average water consumption (customer with house connection to YCDC's water service)	Format in which selection can be made from five ranks. The value of water consumption per household at the center of each rank. Valid replies: 2,836	13.9 (m^3/day/household)

Source Calculated based on results of 2012 JICA-HIS

9.1.4 Ability to Pay (ATP)

From the results of public awareness study by the Yangon City JICA Study Team (valid replies: 10,000), the average household income was estimated at 175,000 kyats/household/month).

On the other hand, international organizations such as the World Bank, OECD and WHO generally set a benchmark preferring approximately 3 to 5% of the household income as the water supply tariff for the residents. If the tariff is taken as 3% of the household income, the ability to pay may be estimated as 5,250 kyat/household/month.

The present unit price of water tariff for domestic household is 88 kyats/m^3. From the estimated average consumption of 13.9 m^3, the average monthly payable amount is estimated as 1,223 kyats/household/month. This amount is about 23% of the ability to pay (estimated value) of 5,250 kyat/household/month. Therefore, it is assumed that the existing water tariff rate is at an adequately payable level, and is also probably at a comparatively low level.

9.1.5 Financial Analysis

(1) Financial expenditure

The financial expenditure of the project consists of capital costs including initial construction cost and renewal and repair cost, and operation and maintenance cost.

1) Capital investment cost

The total amount of the capital investment costs including the initial construction costs of water supply systems, and renewal and repair costs planned for about 67 years from 2014 to 2080, which is the target period in the Master Plan, is [redacted] For the calculation, the infrastructure life is assumed 50 years for civil infrastructure, and 20 years and 15 years for electrical and mechanical

equipment of water treatment plant and of pumping house respectively. The predicted change in the initial construction cost, and renewal and repair cost of the water supply system in the period mentioned above is shown in the Figure below.

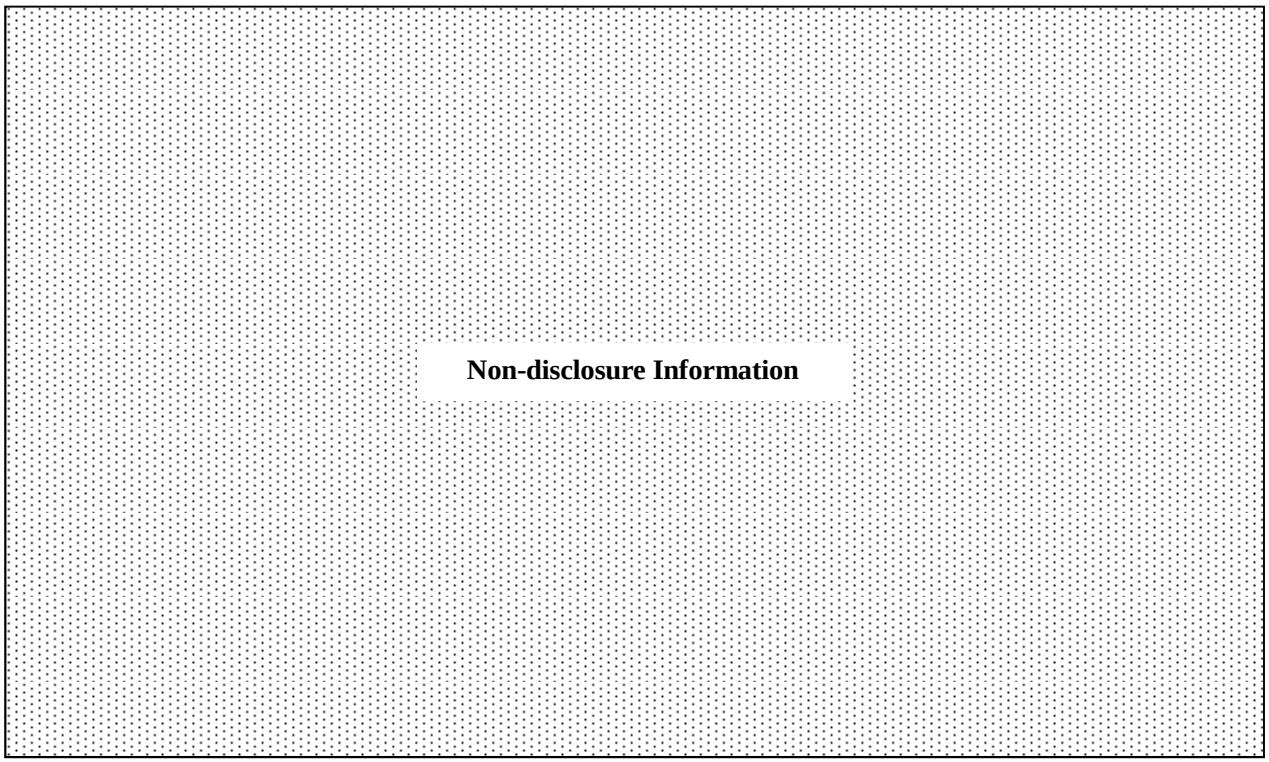


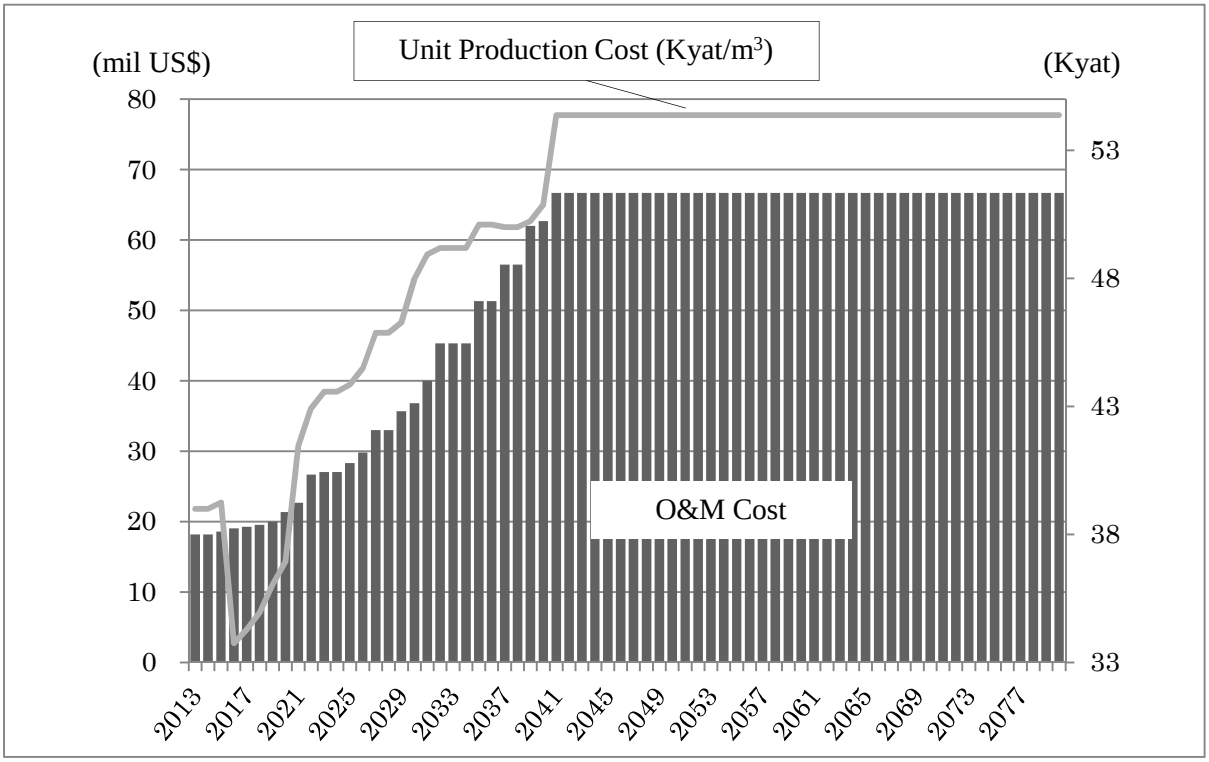
Figure 9.1 Predicting Changes in the Initial Construction Cost, and Renewal and Repair Cost

2) Operation and maintenance cost

The operation and maintenance cost consists of personnel cost, electrical cost, chemical cost, repair cost and administration cost. The composition ratio of operation and maintenance costs include 78% by chemical cost, 13% by electrical cost, 6% by repair cost, 2% other costs and only 0.4% by personnel cost. The annual operation and maintenance cost is estimated as 28.31 million US dollars in 2025 and 62.70 million US dollars in 2040. In addition, the estimated unit production cost only considering operation and maintenance cost ranges 34-54 kyat/ m^3.

It is estimated that annual volume of accounted for water is 107 million m^3, annual operation and maintenance cost is 3,682 million kyat and the unit production cost of supplied water per m^3 is at 34 kyats for reference information. This cost also includes the cost of sewerage services.

The Figure below gives the prediction of changes in the operation and maintenance cost of the water supply facilities in the future in the target period of the Master Plan.



Source: JICA Study Team

Figure 9.2 Predicting Changes in Operation and Maintenance Cost

3) Alternative plans for initial construction cost, and renewal and repair cost

The following five simulation plans were proposed by share ratio of government subsidies to initial construction cost in the financial simulation and calculations were made.

Table 9.2 Alternative Plans for Initial Construction Cost, and Renewal and Repair Cost

Alternative Plan	Share of initial construction cost		
	Borne by YCDC	Government subsidies (Central govt./State govt.)	JICA ODA Loan
Alternative Plan A: O&M cost recovery 100% subsidy for capital investment cost	0%	100%	–
Alternative Plan B: 60% subsidy for capital investment cost	40%	60%	–
Alternative Plan C: 40% subsidy for capital investment cost	60%	40%	–
Alternative Plan D: Full cost recovery (YCDC fund)	100%	0%	–
Alternative Plan E: Full cost recovery (JICA ODA Loan for initial construction cost 80%)	20%	-	80%

* JICA ODA loan conditions are: repayment period of 40 years, repayment grace period of 10 years, and interest rate of 0.55%.
Source: JICA Study Team

Alternative Plan A is a cost recovery plan for only the O&M cost of YCDC. The YCDC's budgetary system presently, in which the government budget covers the capital expenditure, seems to have a similar form. **Alternative D** – full cost recovery – is for the case when the entire expenditure including

initial construction cost, renewal and repair cost, and the operation and maintenance cost, is covered by the income of YCDC itself without depending on the assistance of the central government. **Alternative Plan B and C** are plans that visualize supplementing capital investment cost by subsidies from the government to the tune of 60% and 40% respectively. **Alternative Plan E** visualizes the case of full cost recovery using JICA ODA loans for 80% of the initial construction costs until 2040.

(2) Revenue

Revenue from the project proposed in the Master Plan is based on the water tariff recovered from customers. The predicted value of revenue water is multiplied by the water tariff to calculate the revenue. More specifically, the prediction of revenue water and the number of connections uses the prediction values prepared based on the data obtained from YCDC. The water tariff used is based on the unit metered rate of 88 kyats/m^3 for domestic households presently, and 175 kyats/m^3 for the estimated willingness-to-pay amount.

Simulations of revenue from water tariff are made assuming the three types shown in the Table below.

Table 9.3 Simulation Plans of Revenue Collection

Simulation Plan	Tariff Rate for Simulation
Simulation plan 1: Tariff rate increase 3%/year	Tariff unit rate for general households 88 kyats/m^3
Simulation plan 2: Tariff rate increase 4%/year	Tariff unit rate for general households 88 kyats/ m^3
Simulation plan 3: Tariff rate increase 5%/year	Tariff unit rate for general households 88 kyats/m^3
Simulation plan 4: Tariff rate increase 3%/year	Estimated value of willingness to pay 175 kyats/ m^3 [Willing to pay (kyat) ÷ average water consumption (m^3/HH/month)

* Willingness to pay is the amount each individual household user of YCDC is willing to pay for receiving 24 hours supply of safe water.

Source: JICA Study Team

(3) Financial simulation results

The following Table shows the summary of financial simulation results. The detail results is attached in Appendix G.

Financial simulation was carried out combining five alternative expenditure plans and four revenue calculation plans. The Net Present Value (NPV) and the Benefit-Cost ratio (B/C ratio) results are shown for a discount rate of 3%.

Table 9.4 Financial Simulation Results

		Revenue from tariff					
		Simulation Plan 1 3% annual increase from 88 kyat		**Simulation Plan 2** 4% annual increase from 88 kyat		**Simulation Plan 3** 5% annual increase from 88 kyat	
		NPV	BC	NPV	BC	NPV	BC
Financial expenditure	**Alternative Plan A**: O&M cost recovery		2.42		3.07		3.90
	Alternative Plan B: 60% support		1.09		1.39		1.76
	Alternative Plan C: 40% support		0.86		1.09		1.38
	Alternative Plan D: Full cost recovery (YCDC)		0.60		0.76		0.96
	Alternative Plan E: Full cost recovery (JICA ODA Loan)		0.79		1.00		1.27

* The shaded part shows values of NPV that are positive, or B/C values greater than 1.0.

Source: JICA Study Team

The NPV in the project evaluation period was positive and the B/C ratio was greater than 1.0 for ten cases shown by the shaded part.

1) Alternative Plan A and B

All calculation results of Alternative A-B indicates positive NPV and B/C ratio with more than 1.0. Even "Simulation B1" which is the case of the lowest rate increase ratio with 3% and of receiving 40% subsidy of capital investment cost shows positive NPV and preferable B/C with more than 1.0.

2) Alternative Plan C

Among Alternative Plan C, "C2" and "C3" are positive NPV and B/C ratio with more than 1.0. In case of "C1", the financial balance does not reach to full cost recovery level of the capital investment cost, however is sufficient for cost recovery of O&M costs having revenue amounted for more than 2 times of O&M costs.

3) Alternative Plan D

Alternative Plan D, which is the simulation of full cost recovery by only YCDC funding sources, does not show positive NPV and preferable B/C ratio with more than 1.0. Thus, every case is considered not to reach full cost recovery level. Meanwhile, cost recovery of O&M costs are presumably achieved.

4) Simulation Plan 4 (according to willingness to pay)

On the other hand, willingness to pay 175 kyats/m^3 mentioned earlier, will apply from the starting year, and was also used in the Simulation for the case of "Alternative Plan D" and "Simulation Plan 1" with

an annual percentage rate of 3%. In this case, the final cash inflow moved at a higher level than "Simulation Plan D1" even with the same tariff increase rate, and showed revenue in the order of about 1.9 times the operation and maintenance cost, positive NPV and 1.16 of B/C ratio. Thereby the annual cash inflow becomes positive. Points to be noted are: a sudden increase in the water tariff will adversely affect the lifestyle of the residents in practice, although the unit cost is used in the Simulation such that it becomes more than twice the existing cost from the starting year. Therefore, a stepwise revision is realistic and preferable, and the value shown here is only for reference.

The financial simulation result and the profit-loss prediction in "Simulation C2" are shown as follows. "Simulation C2" indicates the case of receiving 40% subsidy of capital investment cost and with 4% of tariff increase.

Table 9.5 Financial Simulation Results (C2)

Non-disclosure Information

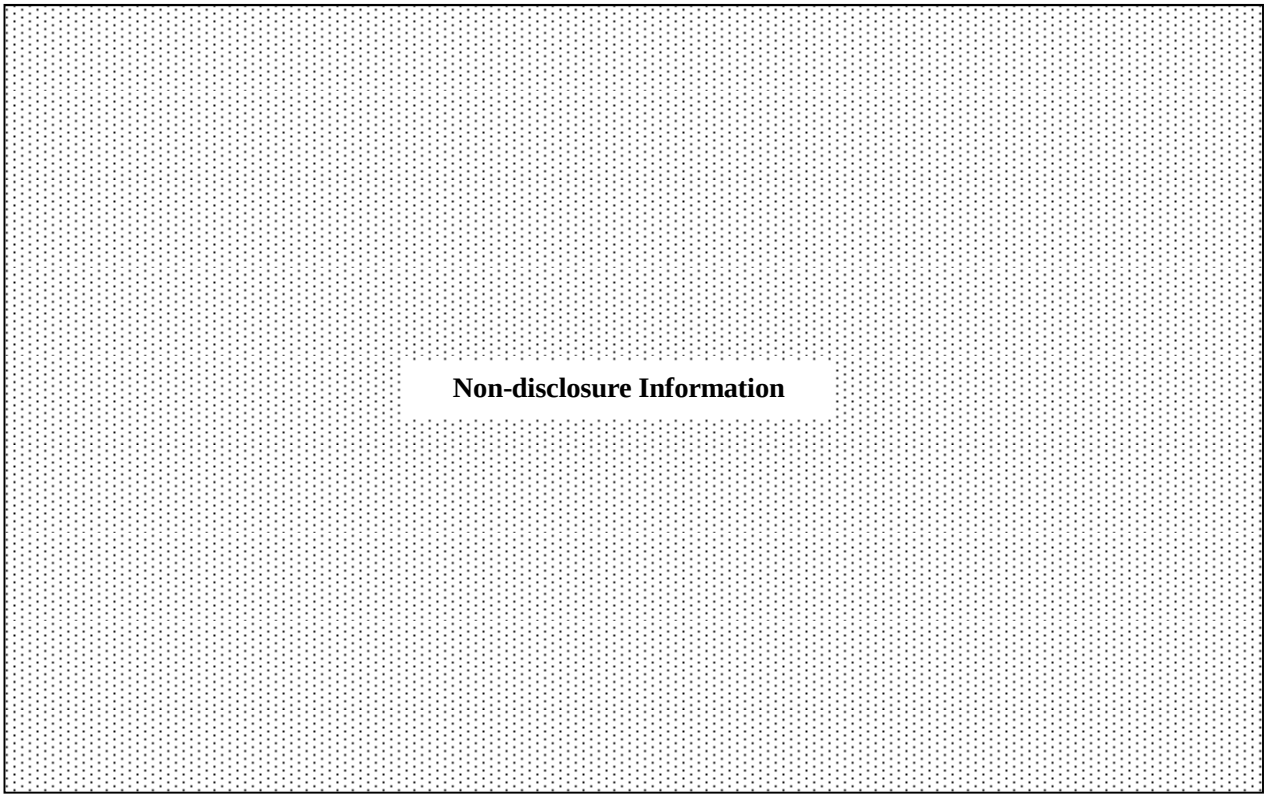


Figure 9.3 Profit and Loss Forecast Table (C2: Annual Rate Increase of 4%, Full Cost Recovery)

In the Simulation of Alternative Plans A-D, it is presumed that the initial construction cost is to be covered either by YCDC self-generated funds or by government subsidies. However, because of the fiscal austerity of Myanmar, it is probably not an easy task to procure the entire amount for investment. The initial construction cost that requires a substantial investment amount can be covered by development funds through external capital procurement, such as by ODA. Funds can also be repaid at the stage when the entire country is on a sound development path. Therefore, it has the advantage of utilizing ODA funds.

For instance, we compare “Simulation D3”, which is subsidy 0% of capital investment cost with tariff increase 5%/year, with “Simulation E3”, which uses ODA loan for 80% of initial construction cost with tariff increase 5%/year here. In the “Simulation D2”, the peak of accumulated deficit in 2038 amounted 3.3 billion US dollars. Meanwhile, the peak of accumulated deficit of “E3” in 2040 amounted 2.1 billion US dollars which is relatively lower than “D3” by extending investment by own sources , and the holistic trend of financial balance becomes leveling. Also, at maximum, 1.15 billion dollars per year of financing amounts will be saved by using ODA financing.

The financial simulation result and the profit-loss prediction in the simulation “D3” and “E3”are shown as follows.

Table 9.6 Financial Simulation Results (D3)

Non-disclosure Information

Table 9.7 Financial Simulation Results (E3)

Non-disclosure Information

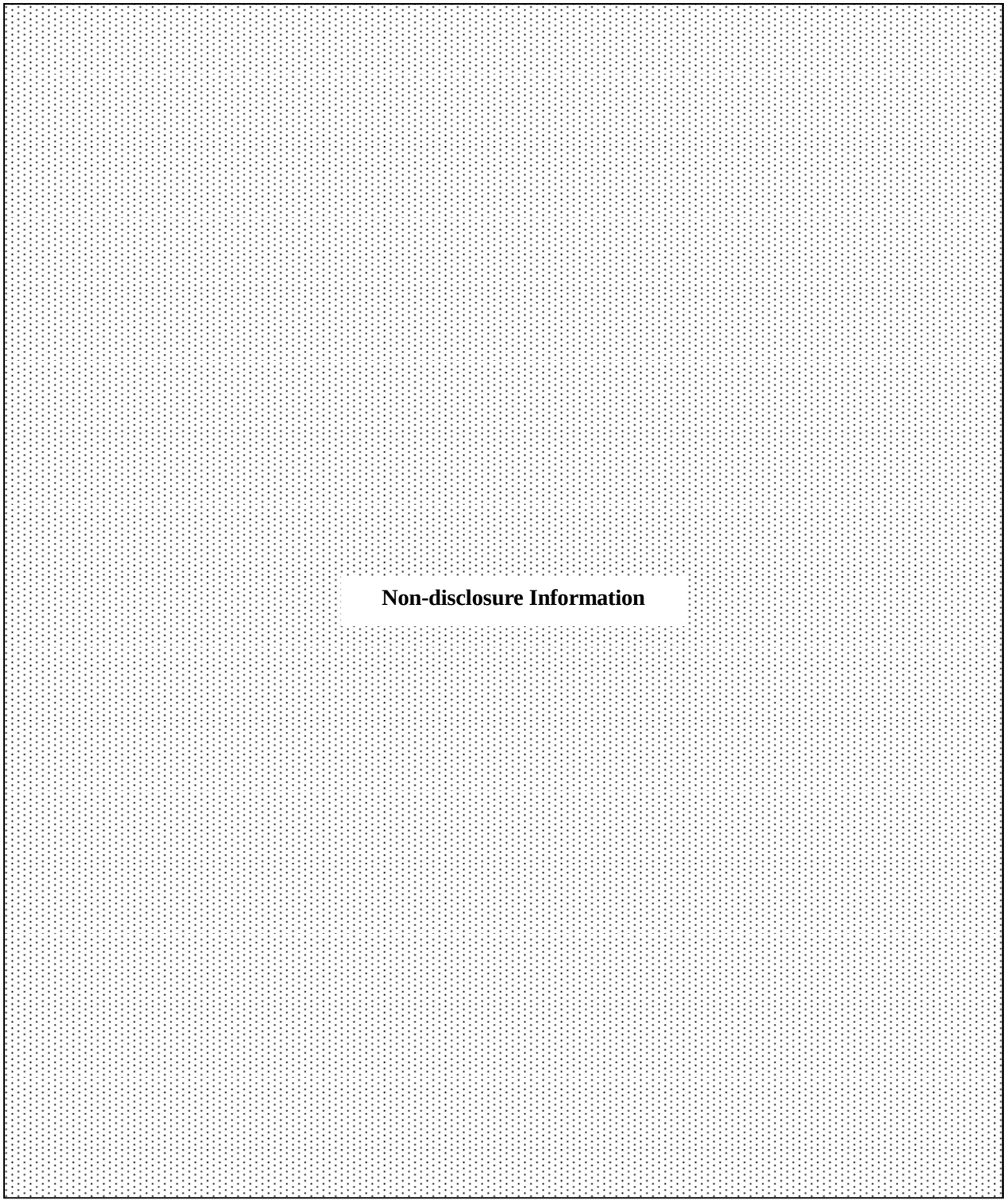


Figure 9.4 Profit and Loss Forecast Table D3 (Above) and E3 (Below)

9.1.6 Need for Revising Water Tariff in Relation to the Financial Plan

(1) Issues related to the existing water tariff system

The existing water tariff: (1) Should be limited to a generally low tariff level; (2) Fixed rate tariff should be used by about one-fifth of the customers as of old; (3) Tariff should be uniform volumetric tariff and not the progressive volumetric tariff. Consumer's awareness for saving water is also comparatively weak; and incentives do not work well. These are the issues related to the existing tariff system.

It is important to urge all customers to save water and optimize water use considering the social circumstances henceforth wherein water demand will increase. Particularly, awareness for water savings should be fostered among large-volume consumers, and equilibrium in water demand should be ensured. On the other hand, funds should be distributed more correctly than ever before for appropriate operation and maintenance, appropriately feeding chemicals such as coagulants and chlorine, strengthening the water quality control system, adopting measures to reduce water leaks, and so on, for enhancing the quality of the services. At the same time, funds for investment costs for the future should be internally accumulated and retained; this is important for sustained business management.

(2) Revision of tariff rate level and ability to pay

For sustained operation and maintenance of water supply facilities proposed in the Master Plan, YCDC should first set the average tariff greater than the annual increase rate of 3% estimated as the minimum level that can lead to recovery of operation and maintenance cost. However, care must be taken to set this level different from the price escalation.

For instance, if the household income is assumed to increase consistently at the rate of 3% annually, the average monthly household income will become 249,508 kyat/household/month in 2025 and 388,726 kyat/household/month in 2040. In such a case, if the water tariff is tentatively assumed to increase at the annual rate of 7%, and if on an average 20.0 m^3/month in 2025 and 26.0 m^3/month in 2040 are used per household, then the respective spending amounts will be 3,954 kyat in 2025 and 14,190 kyat in 2040. These figures correspond to 1.6% and 3.7% respectively of the average monthly household income. Making a broad assumption, this is generally within the scope of amount of affordability to pay, 4% of monthly household income.

Table 9.8 Average Spending for Water and Affordability to Pay

Item		**2025**	2040
(1)	Tariff rate (Kyat/m^3)*1	**198**	547
(2)	Household income (estimated) (Kyat/hh/month)	**249,508**	388,726
(3)	Household spending for water (estimated) (Kyat/m^3/hh/month)*2	**3,954**	14,190
(4)	(3)/(2) (%)	**1.6%**	3.7%

*1 Assumed tariff rate increase 4%/year、Price escalation 3%/year.
*2 Assumed average water consumption volume 20.0 m^3/month (2025), 26.0 m^3/month (2040)

(3) Transition to progressive tariff rate system

YCDC must prepare a tariff improvement plan ensuring the introduction of the progressive tariff rate system in the future, encourage consumer awareness on the need to save water, and set the tariff at the appropriate level from the viewpoint of financial management. Among consumers under the meter rate system of YCDC, the distribution of monthly average water consumption of general household shows that about 40% of the households account for less than 10 m^3/household/month. Considering these conditions, for instance, if the existing tariff level for consumers using less than 10 m^3 is kept as-is, and a progressive tariff rate is set in stages close to the level of willingness to pay for the remaining 60% of consumers using more than 10 m^3, the financial condition will improve, and the Simulation level according to the willingness to pay amount mentioned in the previous section will also assume a sense of reality.

Such a study on the details of the progressive tariff rate system is scheduled to be carried out through a feasibility study on priority projects while keeping in mind the internal assistance to sewerage business.

CHAPTER 10 STRATEGIC ENVIRONMENTAL ASSESSMENT

10.1 Necessity of Environmental and Social Considerations

The implementation of the project and operation of the constructed facilities by the project might provide the adverse impacts on the environment such as air, water, soil, ecosystem, flora, and fauna, as well as the social impacts including involuntary resettlement, land use, water right and so on. These impacts should be avoided, minimized or mitigated as much as possible. The environmental and social consideration is the process of identifying, predicting, evaluating and mitigating the environmental and social impacts of development projects prior to major decisions being taken and commitments made. The environmental and social considerations studies include baseline surveys, predicting and evaluating the adverse impacts and likely impacts that projects may have on the environment and on local society, and mitigation measures to avoid and minimize these impacts.

The environmental and social considerations have different level of the considerations. The level depends on the stages of the projects.

SEA (strategic environmental assessment) is systematic decision support process, aiming to ensure that environmental and possibly other sustainability aspects are considered effectively in policy, plan and program making. IEE (initial environmental examination) and EIA (environmental impact assessment) is applied to the projects to evaluate the environmental and social impact that projects are to have. Those studies include the analysis of alternative plans, the prediction and assessment of environmental impacts, and the preparation of mitigation measures and monitoring plans. IEE study is based on easily available information including existing data and simple field surveys and EIA study is based on the detailed field surveys.

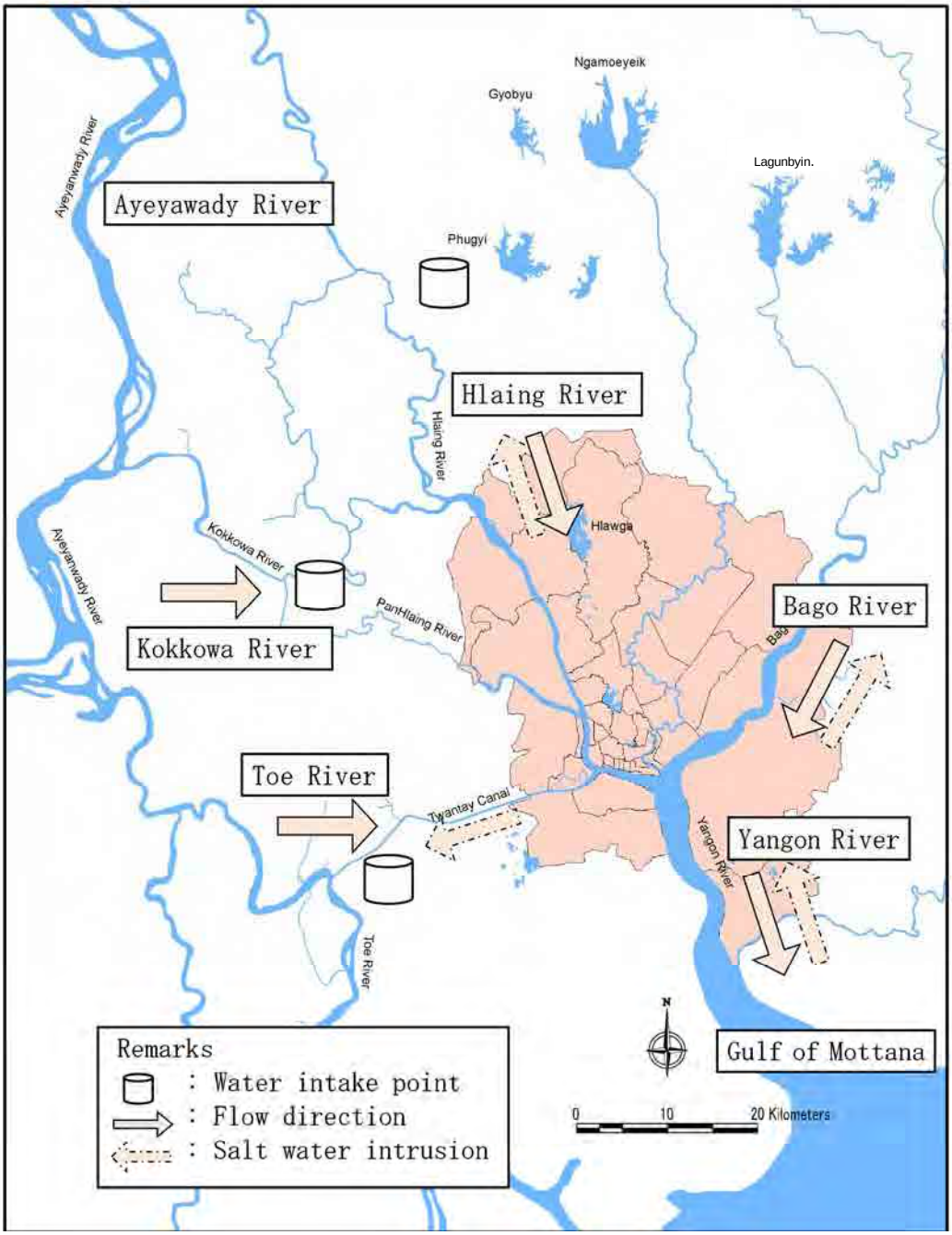
10.2 Environmental and Social Considerations in the Master Plan

As mentioned in the above section, the system of environmental impact assessment is under preparation. Thus till the regulations related to EIA will be enacted, JICA's Guidelines for Environmental and Social Considerations (April 2010) (hereinafter referred as "JICA Guidelines) is applied to the Project.

According to JICA Guidelines, the IEE-level environmental and social considerations studies including analysis of alternatives including "without project" situations should be implemented in the full-scale study stage (Master Plan Study). In addition, it is said that JICA applies a Strategic Environmental Assessment (SEA) when conducting Master Plan Studies. Thus, in the Project, IEE-level environmental and social considerations which introduce the concept of SEA shall be implemented.

10.3 Alternative in the Master Plan

The alternatives of water resources for 2040 are set as the alternative for master plan. The Figure below shows the location of the Toe, the Kokkowa and the Hlaing Rivers which are the potential water sources for 2040 water demand of Study area. The Toe and the Kokkowa Rivers are the tributaries of the Ayeyarwady River which flows along the western part of Yangon City.



Source: JICA Study Team

Figure 10.1 Location of Potential Water Source

The alternatives are set as below:

- Zero option: The current water sources are utilized by reducing the NRW (the new water intake from Lagunbyin R. 30 MGD/day will be included).
- Alternative 1: Kokkowa will be the new water source.
- Alternative 2: Kokkowa and Toe will be the new water sources.

The information about the two rivers is summarized below. The survey revealed that the Hlaing River considered as potential water source does not have enough capacity as water source.

Table 10.1 Outline of Characteristics of River Sources

River	Distance from YCDC boundary	Distance from YCDC center	Amount of available water resource(m^3/s)
Hlaing	30 km from north boundary	55 km	0
Kokkowa	15 km from Hlangthyar boundary	35 km	520
Toe	40 km from Dale	42 km	1,220

Source: JICA Study Team

10.4 Selection of Evaluation Items

The environmental and social items to be evaluated are set as shown below to conduct SEA.

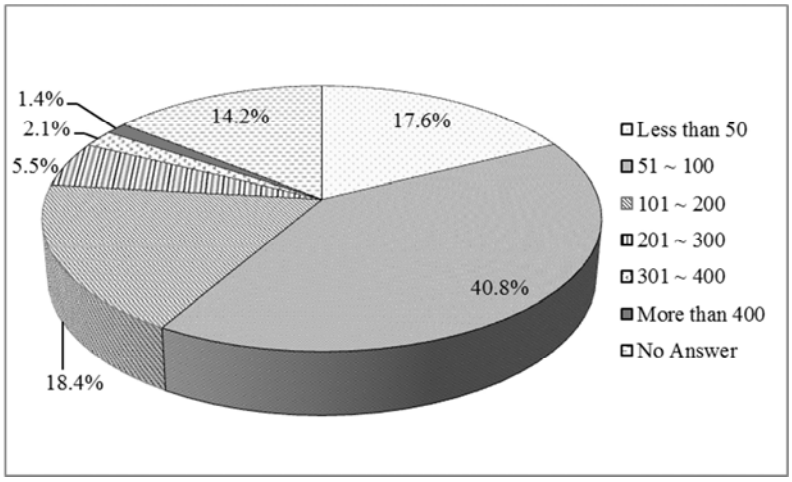
Items	Main Impacts
Water Use	● Water use to improve the citizen's basic human needs ● Impact to other water users by water intake
Land acquisition and involuntary resettlement	● Land is required for construction of intake facility, treatment plant and transmission / distribution pipelines ● Involuntary resettlement due to the land acquisition
Land Use and utilization of local resources	● Change of land use by land acquisition ● Impact to the local resources by water intake
Living and livelihood	● Impact on people's living and livelihood by the project ● Impact on water use of downstream
Indigenous, or ethnic people	● Impacts on the culture and lifestyle of ethnic minorities and indigenous peoples ● Impacts on the rights of ethnic minorities and indigenous peoples in relation to land and resources
Protected area / cultural heritage	● Impact to the protected area
Topography and Geology	● Impact on a large-scale alteration of the topographic features and geologic structures in the surrounding areas
Ecosystem	● Impact on downstream aquatic organisms, animals, plants, and ecosystems
Hydrological situation	● Impact on hydrologic changes of surface water and groundwater
Air pollution / noise and vibration	● Impact on air pollution, noise and vibration

Source: JICA Study Team

10.5 Baseline Data for Evaluation Items

10.5.1 Water Use

The household interview survey was conducted in the Project for the Strategic Urban Development Plan of the Greater Yangon and the present water use conditions of the citizens are identified.



Source: JICA Study Team

Figure 10.2 Water Use

58% of respondents answered that they consume 100 gallon / day in the family and considering the average household member as 4.3 persons, the amount of consumption per capita per day is around 100 liter. 74 % of the respondents are satisfied with the present consumption amount and 11 % prefer twice of the present amount.

10.5.2 Land Acquisition and Involuntary Resettlement

Around 240 ha of land will be needed to construct the new water intake and treatment plant to meet the future additional demand of 420 MGD. The proposed intake site is outside the jurisdiction of YCDC and used as agricultural land, so close coordination with MOAI will be required. According to YCDC, the request for land acquisition is submitted to the Ministry of Home Affair and after the approval, it is announced in the newspaper for one month and notice is sent to the land owners. The responsible department within YCDC is General Administration Department. The detail procedures of land acquisition will be studied during the feasibility study period. The land acquisition should be implemented to meet the requirements of JICA Guidelines and the Abbreviated Resettlement Action Plan shall be prepared during F/S stage. The affected assets by land acquisition should be compensated based on the replacement cost principle.

The present land use of the proposed intake locations is agriculture as shown in the Figure below.

JICA Study Team

Figure 10.3 Present Land Use of Proposed Intake Location (Left: Kokkowa, Right: Toe)

The proposed locations of intake point and treatment plant of Lagunbyin canal are shown in the figure below. YCDC owns the right to use the land of proposed location of treatment plant. The land was used by the Production Department of YCDC as pond but the right of use is already transferred to the Water and Sanitation Department for the purpose of construction of treatment plant. The water was drained from the middle of the pond and the land is dried up. The intake point is proposed at the location near the sluice gate for irrigation and the right to use the land belongs to the private.

JICA Study Team

Figure 10.4 Present Land Use of Proposed Intake Location

10.5.3 Land Use and Utilization of Local Resources

The land use is described in Section 10.5.2.

The river water of Kokkowa and Hlaing are used for the irrigation and relevant information is shown in the Table below.

Table 10.2 Irrigation Information of Kokkowa and Hlaing River

Name	Intake location	Volume of water intake (MGD)		Purpose	Area of irrigation (ha)
		Dry	Rainy		
Kokkowa River Pantaing (1) Sluice	Htantapin Township	10.12	-	Irrigation	542.3
Kokkowa River Pantaing (2) Sluice	Htantapin Township	52.85	-	Irrigation	2,832.9
Kokkowa River Khunnaaingtan sluice	Htantapin Township	47.98	-	Irrigation	2,571.4
Kokkowa River Chaungnyiako sluice	Htantapin Township	42.47	-	Irrigation	2,276.4
Hlaing River	Taikkyi Township	89.64	-	Irrigation	4,804.5

Source: Yangon Regional Office, Department of Irrigation, MOAI

10.5.4 Living and Livelihood

As the proposed sites for WTP and intake are now used for the agriculture, the impact on the living and livelihood of the user will be expected. 110 MGD/day of water of Kokkowa River is used for irrigation during the dry season. The amount of intake for irrigation is equivalent to 1.1 % of possible intake amount of 10,000 MGD/day and the 48 MGD/day is taken at the downstream of intake point of water supply. The amount of intake water for water supply is maximum 4.2 % (420 MGD/day and it will not affect the water use of downstream of water intake. The water of Toe River is not used for any purpose.

10.5.5 Indigenous, or Ethnic People

The ethnicity of Greater Yangon is shown in the table below. About 10 % of people are from the minority groups. There are no settlements near around the intake point so that the impact is not expected.

Table 10.3 Ethnicity

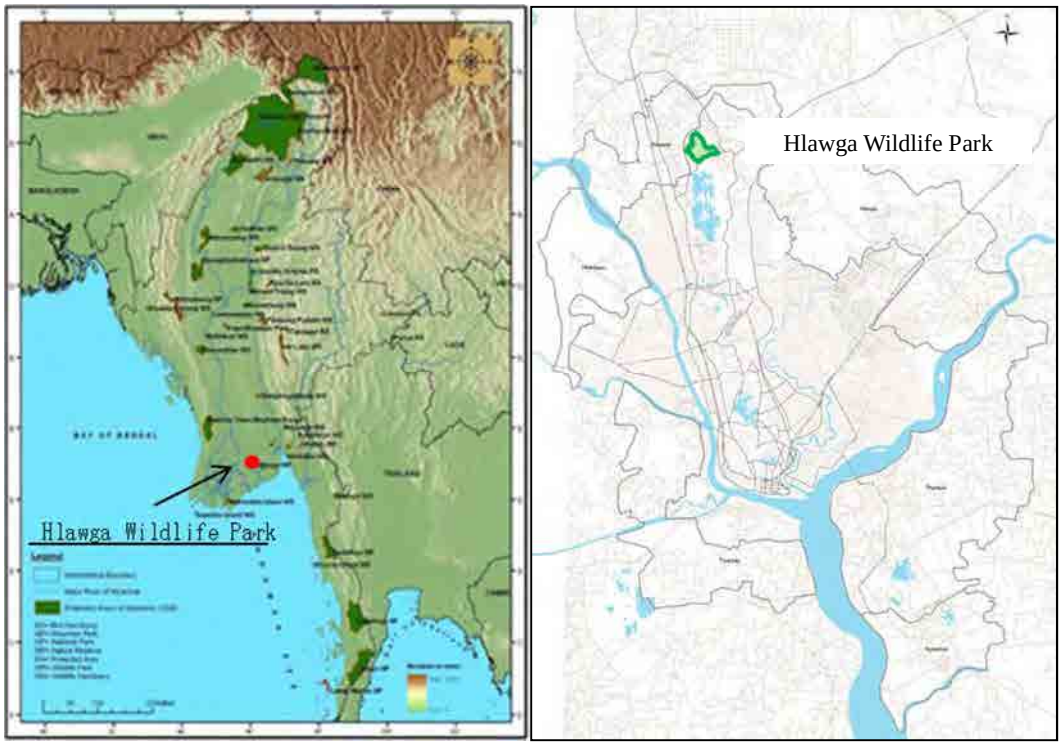
Kachin	Kayar	Karin	Chin	Myanmar	Mon	Rakhine	Shan	Others
0.2%	0.1%	2.1%	0.2%	88.1%	0.7%	1.7%	0.4%	6.5%

Source: 2012 JICA-HIS

10.5.6 Protected Area / Cultural Heritage

The protected areas of Myanmar (wildlife park, wildlife sanctuary, bird sanctuary, etc.) are shown in the Figure below. The protected area within the Study Area is Hlawga Wildlife Park. The Hlawga Wildlife Park is located 35 km north of Yangon and the area is 6.2 km^2 including a wildlife park (3.1 km^2), a mini-zoo (0.3km^2) and a buffer zone (2.7 km^2). The park was established in 1982 to establish an environmental education center near Yangon, to protect the forests and vegetative cover in the

catchment of Hlawga Lake, to establish a representative collection of Myanmar indigenous wildlife species of mammals, reptiles and birds, and kept under as near as possible natural conditions in such a way that they can be readily viewed by visitor.



Source: (Left) Fourth National Report to the United Nations Convention on Biological Diversity, Ministry of Forestry, 2009

Figure 10.5 Protected Area

189 buildings which were constructed before 1950 are registered as cultural heritage buildings by YCDC in 1996. Most of the heritage buildings are located in the southern part of the Yangon City and there are no heritage buildings near around the WTP and transmission route.

10.5.7 Topography and Geology

See Chapter 2.2.1 for topography and 2.2.2 for geology of this Report.

10.5.8 Ecosystem

The biodiversity inventory has not yet been completed in Myanmar, it is officially stated that there are 153 endangered species. In Greater Yangon, it is recorded that four kinds belongs to “Endangered” (No. 1 – 4 of table below) and one “Vulnerable” (No. 5 of table below) as shown in the Table below. The habitat of those species is the forest and the impact is not expected as no activities on forest are included in the Project.

Table 10.4 Endangered Animal Species and Plant

No.	Scientific name	Common name	Family	IUCN, 2011
1	Lissemys punctata 	Indian flap shell turtle	Trionychidae	Endangered (EN) 絶滅危惧IB類
2	Indotestudo elongate 	Yellow tortoise	Testudinidae	Endangered (EN) 絶滅危惧IB類
3	Python molurus divittatus 	Burmese Python	Boidae	Endangered (EN) 絶滅危惧IB類
4	Dipterocarpus alatus 	Kanyin-phyu	Dipterocarpaceae	Endangered (EN) 絶滅危惧IB類
5	Hopea Odorata 	Thin-Gan	Dipterocarpaceae	Vulnerable (VU) 絶滅危惧II類

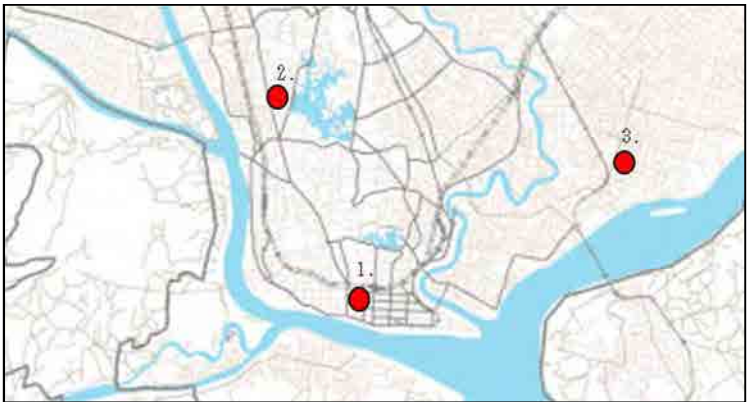
Source: JICA Urban Plan Study, 2012

10.5.9 Hydrological Situation

See Chapter “2.2.4 Hydrology” and “5.2.3 River Water” of this Report.

10.5.10Air Quality / Noise and Vibration

YCDC is not monitoring the air quality regularly. The existing data of air quality is the result of the measurements of April 2007 and January 2008 by NCEA. The air quality standards are not established yet in Myanmar. Comparing the WHO standards, the values of PM10 and TSP are higher than the standards.



Source: JICA Study Team

Figure 10.6 Measurement Locations

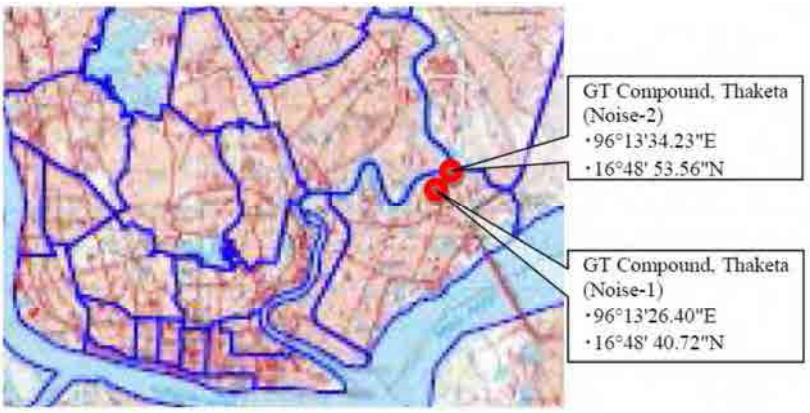
Table 10.5 Results of Air Quality

Site	Date	TSP (ug/m^3)	PM10 (ug/m^3)	SO2 (ug/m^3)	NO2 (ug/m^3)
1. Commercial site (Traders Hotel)	April, 2007	342.58	177.69	-	-
	Jan, 2008	143.21	71.75	-	-
2. Residential site (IBC)	April, 2007	168.61	68.59	1.14	23.22
	Jan, 2008	118.70	65.30	1.24	22.28
3. Surrounding site near to industrial zone (Forest Department Head Quarter)	April, 2007	127.37	66.95	0.37	28.36
	Jan, 2008	188.66	136.92	0.25	25.42
WHO (2005 updated)		100	50.00	20.00	40.00

Source: PCCD, YCDC

The standards for noise and vibration are not established yet in Myanmar and the measurement has not been conducted. The survey was implemented at two locations in Yangon City by the Project for the Strategic Urban Development Plan of the Greater Yangon shown in the figure below.

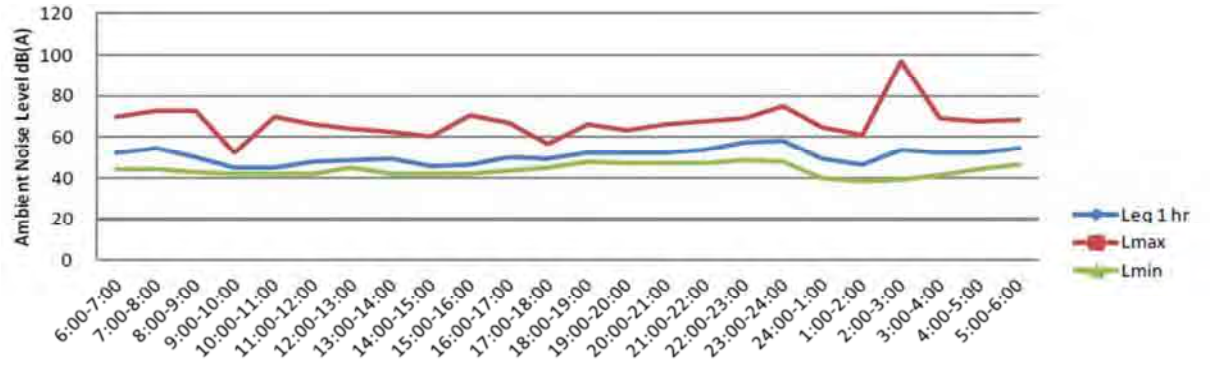
The equivalent sound level for one hour was 50 dB (A) and maximum was from 47.7 dB (A) to 96.8 dB (A).



Source: JICA Urban Plan Study, 2012

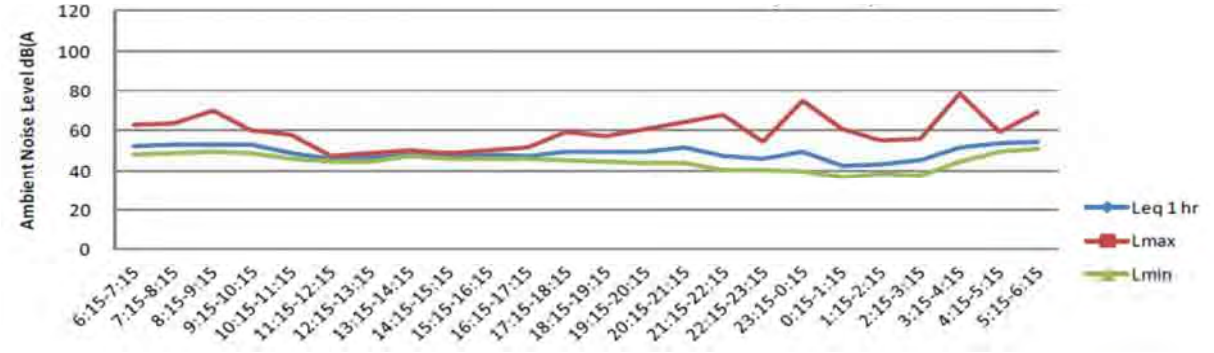
Figure 10.7 Location of Noise Measurement

The equivalent sound level for one hour varies from 49.25 dB(A) to 50.81 dB(A). At the measurement location 1, the maximum was from 52.4 dB(A) to 96.8 dB(A), and from 47.7 dB(A) to 78.3 dB(A) at location 2. The IFC daytime noise level is 55 dB(A) in the residential/educational area and 70 dB(A) in industrial and commercial area, so that the noise level in two measurement locations are under the IFC standards.



Source: JICA Urban Plan Study, 2012

Figure 10.8 Noise Level Observation at Thaketa(Noise 1)



Source: JICA Urban Plan Study, 2012

Figure 10.9 Noise Level Observation at Thaketa (Noise 2)

10.6 Analysis of Alternatives

The alternatives are analyzed from the view point of environmental and social, financial and technical aspects.

Table 10.6 Evaluation Matrix of Alternatives

Item		Zero Option	Alternative 1 (Kokkowa)	Alternative 2 (Kokkowa and Toe)
Environmental and social aspects	Land use and utilization of local resources	No intake of water from the rivers and reservoirs is planned so that it will not provide any impacts on land use or local resources. D	There are four sluice gates for agriculture in the Kokkowa River and 150 MGD/day of water is used in dry season (November – April). The area of irrigation is 8,223 ha. The amount of river water is enough for irrigation and water source and no impact on local resources is expected. The proposed intake location is used for agriculture purpose and there will be negative impact on land use. B-	The impact by water intake from Kokkowa River is same with Alternative 1. The water of Toe River is not utilized for agriculture so that the impact on land use and local resources are not expected. The proposed intake locations of Kokkowa and Toe are used for agriculture purpose and the impact will be expected on land use. B-
	Water use	The current ratio of NRW (66 %) and leakage (50%) will be reduced to 15 % and 10 % by 2040. The current water intake from groundwater (20 MGD/day) will not be used around 2026. The total demand of 643 MGD/day in 2040 cannot be met even if the amount of NRW and leakage will be decreased, and the water use for the citizens will be damaged. A-	The additional water demand by 2040 is 420 MGD/day and enough water is available in Kokkowa River. The residents have the positive impacts on water use. A+	No impact is expected. The total water demand by 2040 can be met by the new water intake and the residents have the positive impacts on water use. A+
	Land acquisition and involuntary resettlement	No impact is expected. D	The required land for construction of intake facility and treatment plant is 220 ha and land acquisition is necessary. There is no house in the proposed site but there are some huts to store the agriculture products and land is used for agriculture. B-	The required land for construction of intake facility and treatment plant at Kokkowa and Toe is 125 ha respectively and land acquisition is necessary. There is no house in the proposed site but there are some huts to store the agriculture products in Kokkowa and in both cases land is used for agriculture. B-
	Living and livelihood	As described in “water use”, the demand of water in future cannot be met, the water shortage can be expected and it will affect people’s living and livelihood. A-	The proposed sites of WTPs are currently used for agriculture and the impact is expected on users of the area. The impact on downstream flow by water intake for water supply is 4.2 % of total possible intake amount and the impact is not expected.	The proposed sites of WTPs are currently used for agriculture and the impact is expected on users of the area. The impact on downstream flow by water intake for water supply is 2.4 % of Kokkowa River and 0.7 % of Toe River of total possible intake amount and the impact is not expected.

Item		Zero Option	Alternative 1 (Kokkowa)	Alternative 2 (Kokkowa and Toe)
			A-	A-
	Indigenous, or ethnic people	No impact D	As there is no settlement of indigenous or ethnic people, the impact is not expected. D	As there is no settlement of indigenous or ethnic people, the impact is not expected. D
	Protected area / Cultural heritage	No impact D	No protected are near or around the proposed facilities. D	No protected are near or around the proposed facilities. D
	Topography and Geology	No impact D	The scale of facility is not large so that the impact on topography and geology is not expected. D	The scale of facility is not large so that the impact on topography and geology is not expected. D
	Ecosystem	No impact D	There is no protected species in the downstream of the river and the impact is not expected. D	There is no protected species in the downstream of the rivers and the impact is not expected. D
	Hydrological situation	No impact D	The water amount of possible intake from Kokkowa River is 11,000 MGD/day. The necessary intake for water supply is 420 MGD/day, equivalent to 4.2 % and the impact is not expected. D	The water amount of possible intake from 11,000 MGD/day in Kokkowa River and 23,000 MDG/day in Toe River. The necessary intake for water supply is 240 MGD/day of Kokkowa River and 180 MGD/day of Toe River, equivalent to 2.4 % and 0.7 % respectively and the impact is not expected. D
	Air pollution / noise and vibration	No impact. D	The noise and vibration may be expected near and around the intake and treatment facilities at Kokkowa. B-	The noise and vibration may be expected near and around the intake and treatment facilities at Kokkowa and Toe. B-
Financial aspect		No new investment is required. D	As water intake is from one location, the distance of transmission is shorter than other alternatives. B-	Intake from two locations and construction of four water pipe bridges will cost. A-

Item	Zero Option	Alternative 1 (Kokkowa)	Alternative 2 (Kokkowa and Toe)
Technical aspect	-	At one location, the pipeline should cross the river and water pipe bridge or pipe jacking method is necessary. No technical difficulty in this. More than half of the water demand depends on Kokkowa so the risk on citizen's life is high when any accident occurs. B-	At four locations, the pipeline should cross the river and water pipe bridge or pipe jacking method is necessary. No technical difficulty in this. As there are two water resources, the degree of dependence on water resource is lower than alternative 1 and the risk on citizen's life is also lower. B- / A+
Overall evaluation	The water demand of 2040 cannot be met, and the impact on citizen's life is very severe. **Not recommended**	64 % of the water demand depends on only Kokkowa River and the accidents such as deterioration of water quality of Kokkowa and breakage of transmission pipe occur, the negative impact on citizens' life is large. Land acquisition of agricultural land is necessary. **Not recommended**	Alternative 2 can satisfy the water demand of 2040 and if the accidents such as deterioration of water quality of river and breakage of transmission pipe occur, risk on citizen's water use can be dispersible. Land acquisition of agricultural land is necessary. **Highly Recommended**

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
D: No impact is expected.

10.7 Mitigation Measures

The mitigation measures are proposed for the identified optimal alternative.

(1) Land use and utilization of local resources

The management of the Kokkowa River is under MOAI and close coordination is required. By the hearing to MOAI, it is not clear which department is in charge of water right by present laws. MOECAF is preparing the laws and regulations about environment and the regulations about water management might be established. More information should be collected at the F/S stage.

(2) Water use

Close coordination with MOAI is also needed. It is important to provide safe and enough amount of water to the citizens as basic human needs, at the same time, the attention should be paid to the requirement of water for irrigation.

(3) Land acquisition and involuntary resettlement

The involuntary resettlement is not expected to occur. As the proposed site for intake and water treatment plan is used for agriculture, the required area should be minimized as much as possible during planning and design. The procedures of land acquisition should be studied as the site is outside of YCDC jurisdiction. In addition, the compensation policy and entitlement should be discussed with related organizations. If the land area would be required, the resettlement action plan or abbreviated resettlement plan should be prepared based on JICA Guidelines.

(4) Living and livelihood

By the land acquisition, the users who use the proposed WTP sites for agriculture will suffer from the loss of assets and it will provide impact on living and livelihood. YCDC has to take necessary measures such as compensation and restoration of livelihood based on JICA Guidelines.

(5) Air pollution / noise and vibration

As there are no standards for air quality, noise and vibration in Myanmar, the standards of other Agencies such as WHO or neighborhood countries should be considered to regulate the air pollution, noise and vibration during construction

10.8 Public Consultation

The information disclosure and transparency are important items in the process of SEA. The results of M/P and SEA were presented in the stakeholder meeting. The objectives of stakeholder meeting are as follows:

- To disclose and share the results of water supply, sewerage and drainage M/P and formulation process,
- To exchange the opinions with stakeholders

The stakeholder meeting was organized as follows.

Date and time: 10 April 2013 (Wed), 9:00-13:00
Venue: Traders Hotel
Agenda: 1) Opening Speech
2) Presentation
(i) Water Vision of Yangon City
(ii) Master Plan for Water Supply in Yangon City
(iii) Master Plan for Sewerage and Drainage in Yangon City
3) Questions and Answers
4) Closing Remarks

More than 140 stakeholders participated in the stakeholder meeting. The participants included representatives of the residents, the parliament members of Yangon Region who were elected by the direct election, professors and advisor, and private companies. The composition of participants is as follows.

Regional Government Departments: 5
Professors / Advisor: 7
Member of Parliament: 8
Expert and Retired Government Official: 4
Myanmar Company: 12
Media: 10-19
Japanese Companies: 23
JICA Myanmar: 5
EMBASSIEs: 4
YCDC: 78
JICA Study Team: 7

To obtain the broader opinion from the participants, the comment paper was distributed for free writing. The comments were read aloud and the answers were made by the presenter.
The main comments/suggestions are as follows. The detail is shown in the minutes in Appendix H.

- The immediate program will be seriously taken into considerations: replacement of pumps and aging pipe to control water leakage, replacement of pumps and sewerage (existing pipe), and provision of transmission mains from Ngomoyeik Reservoir to Nyaunghnapin water treatment

station (at present water is raked by open channel) to improve water quality (especially with turbidity and pesticides) and to reduce cost.

- To provide safe and clean water, the improvement of water supply system must be implemented as soon as possible.
- Can citizen pay the increased water tariff proposed by the Project?
- Special Economic Zone, Industrial Zones and urban areas need to share limited water resources. It is advisable that Yangon Water Vision should be part and parcel of the overall "Yangon City Development Plan".
- The decentralized wastewater treatment system known as DEWAS should be studied, which provides clean water for domestic use except for drinking.
- In the sewerage presentation, improvement of the existing system and zone is proposed as the highest prioritized project. I think that the improvement of existing septic tanks must also be done at first.
- For the development of legal system such as effluent standard from the factories to sewerage system, It is very helpful if the JICA study team can propose or show us the example of the standards or regulation laws of this kind since this kind of laws are currently being studied in the Union Government and some of them are expected to be promulgated next year.
- Myanmar Water Professionals are currently drafting the Myanmar Water Law. That needs JICA's support.
- If the Water Law is drafted with the support of JICA through the YCDC, the future implementation, monitoring and law enforcement activities would be more effective and efficient. Yangon City would also become pioneer in such systematic approach.

CHAPTER 11 SELECTION OF PRIORITY PROJECT FOR FEASIBILITY STUDY

A feasibility study will be conducted for priority projects with a target year of 2025 following the formation of the master plan. Out of the proposed project components in the M/P, priority projects are selected as high priority projects for a feasibility study. Further, the priority projects are selected for which Japanese ODA loan may be extended.

The projects proposed in the master plan have the following three purposes;

- Water source development together with treatment plant and transmission system to increase water supply coverage (Water sources development for water supply)
- Creation of distribution zone together with a) construction of service reservoir, distribution pump and distribution pipe, and b) DMA creation to make equitable water supply and NRW reduction (Modernization of distribution network)
- Installation of disinfection equipment to supply safe water (Installation of disinfection equipment)

The above measures are equally important and therefore a project each is selected from the three categories of purposes above.

(1) Water Source Development for Water Supply

Proposed new water sources are the Lagunbyin reservoir and Kokkowa River, both of which are required by 2025 for improved level of water supply services. Toe River development is excluded from the priority project since the water of Toe River will be mainly necessary after 2025, and the initial cost will be huge for two river development and the priority of Kokkowa River is high because the water of Kokkowa River will be distributed to the center of the Yangon City at first. Therefore, the issue on selection attributes to which of Lagunbyin reservoir or Kokkowa River has higher priority.

- Supply Area

It is true that either source is required to meet the water demand in Yangon. The next issue is the water supply areas from the sources. Lagunbyin with ultimate capacity of 40 MGD, of which 30 MGD for YCDC and 10 MGD for Thilawa SEZ are secured, will cover the eastern suburbs. The coverage rate of water supply is low in these eastern suburbs. A protest activity for water shortage was occurred in Yuzana area in these suburbs at the end of 2012. To tackle this event urgently, YCDC decided to implement development of water supply system for this area, of which water source is Lagunbyin reservoir.

Water source of Kokkowa River will firstly serve the western suburbs, also one of the water deficit areas and gradually extend to the central parts of Yangon. In 2025, Kokkowa water needs to supply

about 50 MGD to the central part. In this sense, Kokkowa River source will have higher priority. But F/S for Kokkowa is being carried out by Korean companies and also there is information that Chinese companies will carry out F/S for Kokkowa River source. Hence, JICA does not require implementing F/S for Kokkowa River source. However, it shall be confirmed whether water from this source is planned to be supplied to the central parts of Yangon in their plan, since a feasibility study for modernization of distribution network of Zone 1 located in the central parts will be implemented in this study, which is stated in the next section.

- Supply to Thilawa SEZ

If water supply to Thilawa SEZ is the highest priority and the facilities are to be constructed and operated by YCDC, the Lagunbyin system should have higher priority. Also the costs of this project is lower and construction period is shorter than those of the Kokkowa system

Conclusion

The outline of comparison of two sources is given in the table below. Considering the above discussion, Lagunbyin is selected as one of the priority project.

Table 11.1 Comparison of Water Sources Alternatives

Item	Lagunbyin reservoir	Kokkowa River
Capacity	40 MGD release is guaranteed by the Irrigation Department.	The required water source volume is 225 MGD in 2040 with staged development according to the demand increase.
Supply to Thilawa SEZ	10 MGD is guaranteed by the Irrigation Department.	None.
Supplied Area	East Dagon, North Dagon and South Dagon in the eastern suburbs and Thilawa SEZ.	Firstly to supply to Hlaing Thyar township in the western suburbs, then gradually extend to the Central city zones.
Water supply situation	Low coverage of water supply service. There is demonstration activity protesting water shortage at the end of 2012.	Low coverage of water supply service.
Current Development Status	5 MGD of WTP is planned to start operation in the beginning of 2015.	F/S is being carried out by Korea and completion is expected to be in June 2013.
Priority of YCDC	High to tackle the demonstration activity.	Not high although it is source of the Central part of YCDC.
Selected Priority Project	Yes	No

Source: JICA Study Team

(2) Modernization of Distribution Network

This component includes establishment of distribution zones in Yangon City and DMAs in zone, construction of service reservoirs, and replacement of aged network. This component is not meant for water source development or increase of supplied amount of water, but it is a very important project which reduces non-revenue water including leakage and achieves equitable and continuous water supply.

This component should be implemented by zone. Ten distribution zones are proposed in Yangon. Therefore, the priority shall be given by zone. The area with high non-revenue water including leakage will have higher priority. Among all zones in Yangon, water supply facilities were firstly developed in Zone 1 (including high density CBD, Inner Urban Rings etc.) and are oldest in Yangon. Therefore, Zone 1 is selected as the priority area for modernization of distribution network as effectiveness of non-revenue water reduction is the highest.

(3) Installation of Disinfection Equipment

Water quality is one of the most complained issues both in YCDC water supply area and Non-YCDC water supply area in the household interview survey. Therefore, installation of disinfection equipment is selected as a priority project.

(4) Implementation Priority of the Selected Priority Project

The first priority is given to the development of Lagunbyin water supply system. It is required to tackle water shortage in Yuzana area and water should be supplied to Thilawa SEZ by 2018.

Modernization of the distribution facilities in Zone 1 and provision of disinfection equipment in every treatment and source facility had better to be implemented earlier so as to reduce non-revenue water including leakage and achieve equitable, continuous and safe supply of water.

The cost of installation of disinfection equipment is rather less comparing other projects and it ensures safe water supply to almost entire Yangon City. Therefore, it is worth implementing as early as possible or same as the project of development of Lagunbyin water supply system.

The project of modernization of Zone 1 requires huge cost. It is advisable that this project shall be started for implementation when the Lagunbyin project is completing. The Kokkowa water supply system, although it is not selected for F/S, will supplement water to the Zone 1. In that sense, the Kokkowa system shall be completed at the same time of the modernization of Zone 1. However, based on the water balance in the city, development of the Kokkowa system can be deferred by a few years, around in 2022.

(5) Capacity Building Project

The needs of a wide range of capacity building activities for YCDC are identified in the previous sections, out of which the following higher priority capacity building projects will be studies in F/S stage. In the F/S, the scopes of these projects will be identified based on basic data collection.

- Introduction of business management to water and sanitation department of YCDC
- Water quality control
- Reduction of non-revenue water