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 IV
WATER SUPPLY SYSTEM FEASIBILITY STUDY

< Advance Version >

MARCH 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

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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
DIP	Ductile Iron Pipe
DMA	District Metered Area
E/N	Exchange of Notes
EC	Electric Conductivity
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
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
MOECF	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

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 = 101.1 JPY

1 Kyat = 0.114 JPY

1 UAD = 885 Kyat

(as of June 2013)

CHAPTER 1. SUMMARY OF MASTER PLAN AND PROJECT FOR FEASIBILITY STUDY

1.1 Summary of Master Plan

1.1.1 Study Area

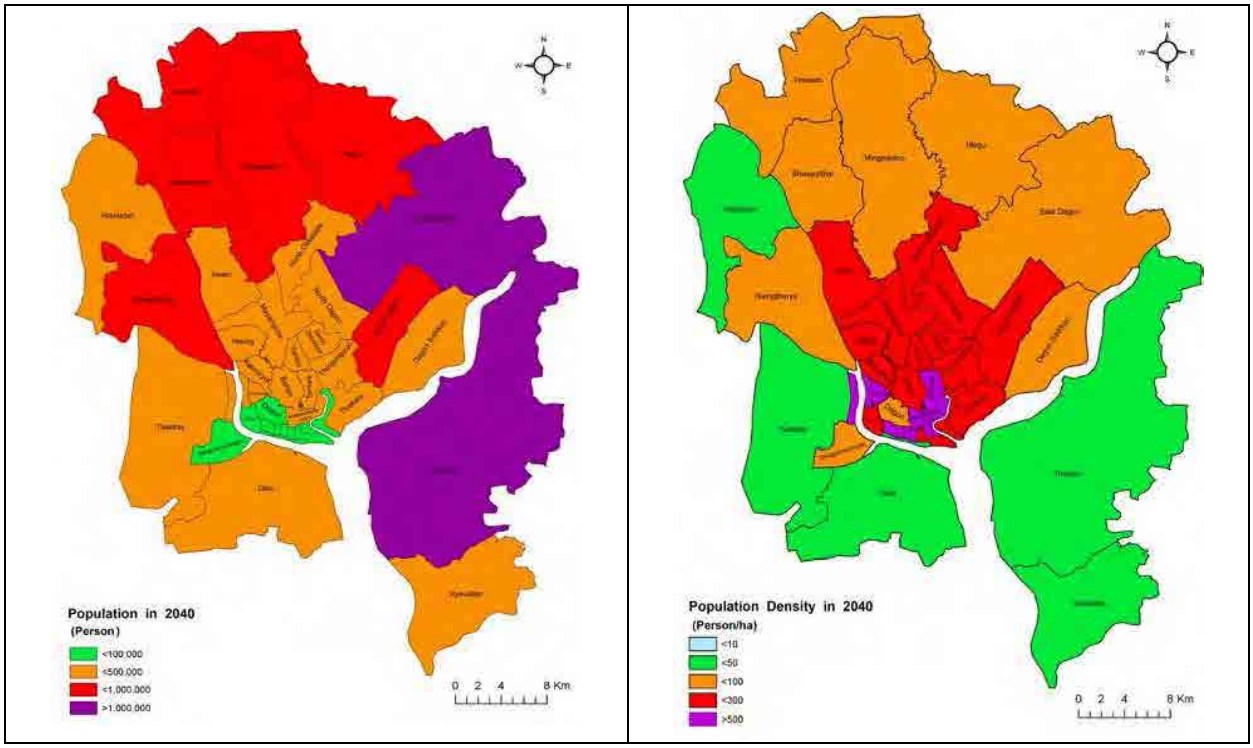
The study area is Greater Yangon with about 1,500 km^2 area, covering YCDC area (784 km^2, 33 townships) and parts of adjoining 6 townships (Kyauktan, Thanlyin, Hlegu, Hmawbi, Htantabin and Twantay).

1.1.2 Target Year

Target year for master plan has been set as 2040; same as that of the Project for the strategic urban development plan of the greater Yangon while that for feasibility study is set as 2025.

1.1.3 Planned Population and Its Distribution

Population in the greater Yangon has been estimated to increase from 5.57 million in 2011 to 11.73 million in 2040 by JICA Urban Plan Study, 2012. The increased population of 6.16 million between the two years has been planned to allocate within the greater Yangon, taking into account of developable areas and land use.

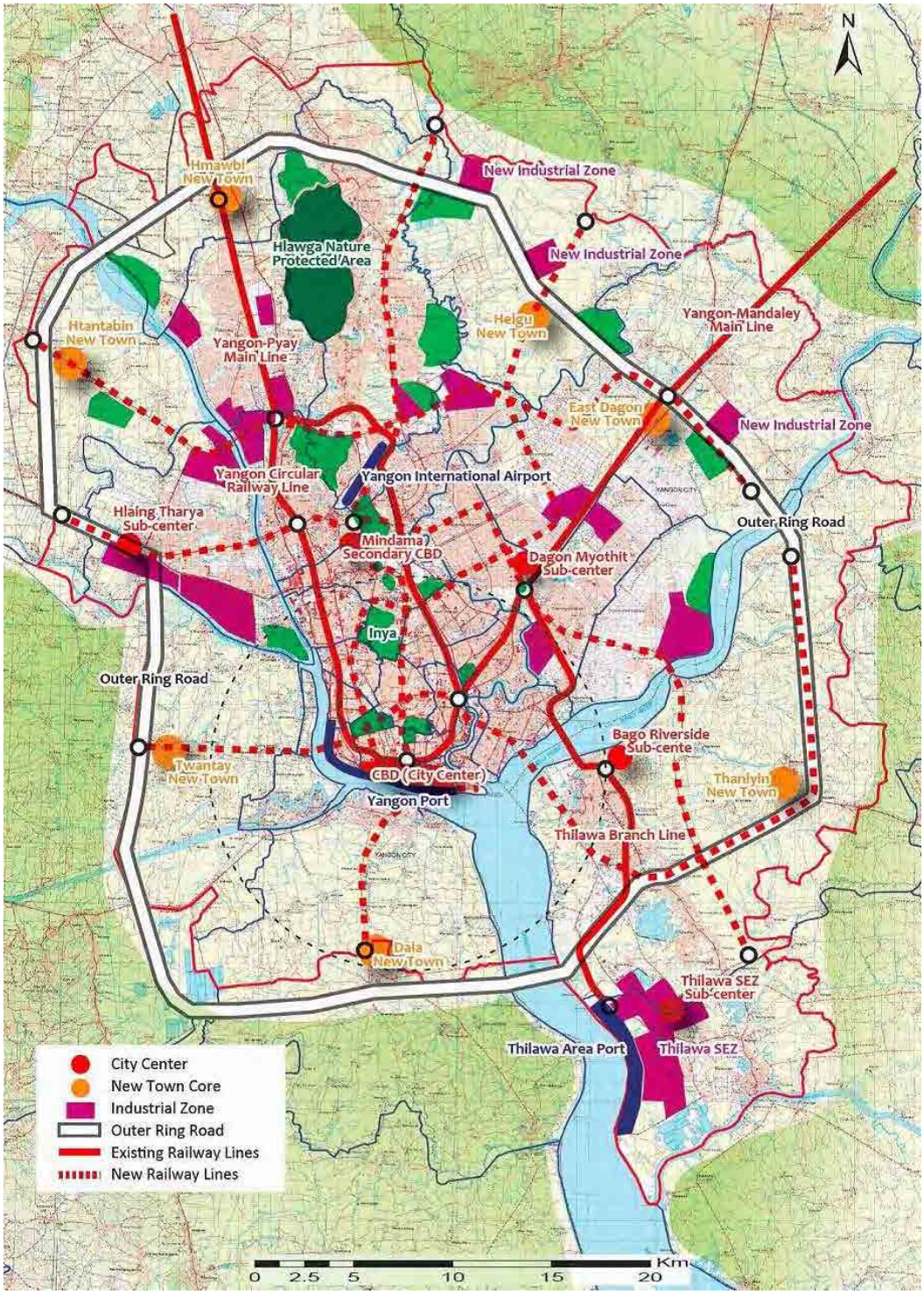


Source: JICA Urban Plan Study, 2012

Figure 1.1 Township-wise Estimated Population in 2040 (Left) and Population Density (Right)

1.1.4 Planned City Function and Land Use

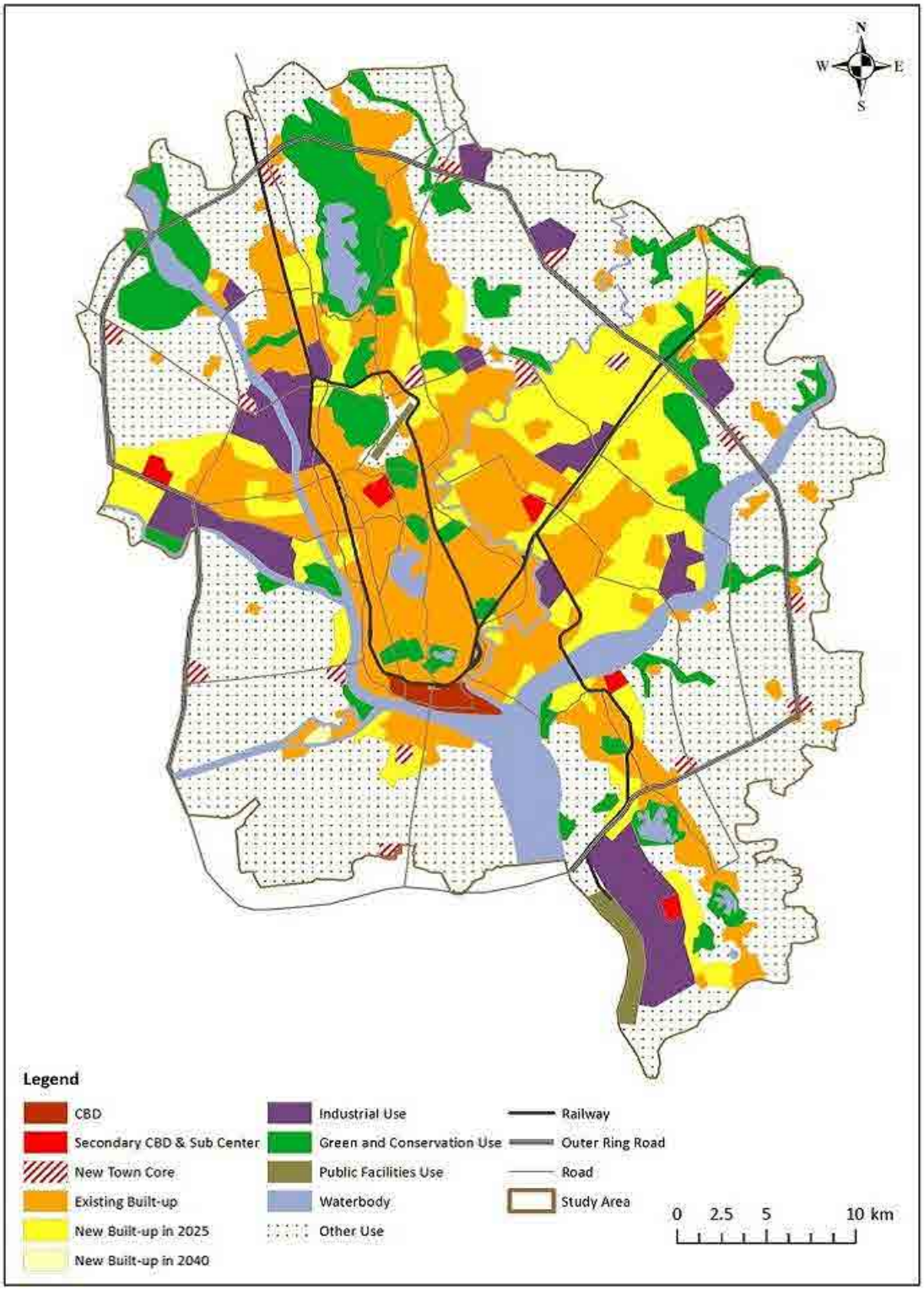
Greater Yangon has been proposed to have sub-centers and green islands system which will be at a distance of 10 to 15 km from the existing CBD or center.



Source: JICA Urban Plan Study, 2012

Figure 1.2 Planned City Center/ Town Core and Main Infrastructure for 2040

Urbanization has been taking place in agricultural lands and "under developing" lands. These lands have been planned as developable lands for housing etc. Planned land use for 2025 is shown below.



Source: JICA Urban Plan Study, 2012

Figure 1.3 Planned Land Use for 2025

1.2 Service Level Targets for 2025

1.2.1 Service Level Targets and Implementation Policy

(1) Service Level Targets

Service level targets for the Greater Yangon and YCDC area are shown in the following table.

Table 1.1 Service Level Targets

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

Source: JICA Study Team

(2) Implementation Policy to Achieve Service Level Targets

Water supply facilities have been planned in the master plan so as to solve various issues YCDC has been facing with and to achieve the service level targets.

Table 1.2 Implementation Policy to Achieve Service Level Targets (Master Plan)

Item	New Facilities	Existing Facilities
1. Increase of Coverage Rate (35% to 69%)	・Development of water supply facilities to meet increasing water demand ・Development of river water sources with treatment plant (water allocation from the existing Lagunbyin reservoir, new development of Kokkowa river and Toe river) ・Development of transmission facilities	・Abandonment of groundwater use and reserve it as a back-up source
2. 24 hours Water Supply with Adequate Pressure	・Separation of distribution facilities from transmission facilities ・Creation of 10 distribution zones ・Creation of DMA within distribution zone ・Creation of water distribution Management center with SCADA ・Improvement of transmission facilities ・Modernization of facilities	・Separation of distribution facilities from transmission facilities ・Rehabilitation of the Kokine and Central service reservoirs in Zone 1 ・Pump replacement to meet the proposed plan ・Demolishing of the existing Yegu pump station ・Improvement of the transmission facilities
3. Safe Water Supply	・Disinfection facilities in Hlawga pumping station ・Disinfection facilities either in the treatment plant or service reservoirs ・Creation of water quality monitoring center	・Rehabilitation of Gyobyu treatment plant ・Rehabilitation of Nyaunghnapin treatment plant

Item	New Facilities	Existing Facilities
Leakage Reduction (50% to 10%)	・Creation of DMA within distribution zones ・Meter Installation for all connections	・Development of DMA with use of SCADA ・Pipe replacement and new pipe for DMA

Source: JICA Study Team

(3) Adequate Supply Pressure and Duration

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 1.3 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 two-story buildings
Supply Hours	(0-24 hours) Average 8 hours	24 hours	2025	A continuous, 24 hours supply is a must for optimum performance of any water supply system.

Source: JICA Study Team

(4) Water Quality Improvement

YCDC water is rarely used for drinking purposes and customers do not believe in YCDC water quality, according to JICA-HIS in 2012. The biggest dissatisfaction item of customers is water quality; mainly high turbidity and unhygienic water. Therefore, water quality improvement to the level of drinkable water at an earlier stage will increase customers' confidence in YCDC water supply services. YCDC already has intention for quality improvement.

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

Table 1.4 Water Quality Improvement Target

Item	Present Level	Target Level	Target Year
Water Quality	Not Drinkable	Drinkable, Target water quality parameters are shown separately	2018

Source: JICA Study Team

Table 1.5 Target Water Quality Parameters

Parameters	Purpose	Allowable Value	Reference
pH	Items relating to the comfortableness of water quality (Odor, Taste, Color)	7.0 – 8.5	Myanmar Highest desirable level
Taste		Foul smell and taste are not detected	Water quality standard for drinking water, Japan
Odor		Foul smell and taste are not detected	
Color		5 unit	Myanmar Highest desirable level
Turbidity		5 NTU or less	Myanmar Highest desirable level
Fecal coliforms	Biological safety of tap water	Not to be detected	Water quality standard for drinking water, Japan
Residual chlorine		To be detected	See *Note 1*
Zinc (Zn)	Items relating to the comfortableness of water quality (Odor, Taste, Color)	< 1.0mg/L	Water quality standard for drinking water, Japan (*Note 2*)
Aluminum (Al)		< 0.2mg/L	
Iron (Fe)		< 0.3mg/L	
Copper (Cu)		< 1.0mg/L	
Manganese (Mn)		< 0.05mg/L	
Hardness		< 100 mg/L	Myanmar Highest desirable level
Chloride ion		< 200mg/L	Myanmar Highest desirable level
Sulfide		< 200mg/L	Myanmar Highest desirable level

Note 1: During the initial phase of water quality management and chlorination, the initial goal is that residual chlorine is detected from all samples. However, concentration of residual chlorine will be revised in future (e.g. revised to 0.1mg/L). In addition, the target value at outlet of water treatment plant shall be set.

Note2: During the initial phase of water quality management, Zn, Al, Fe, Cu and Mn are measured using simple test kit (e.g. HACH test kit).

Source: JICA Study Team

1.2.2 Served Population

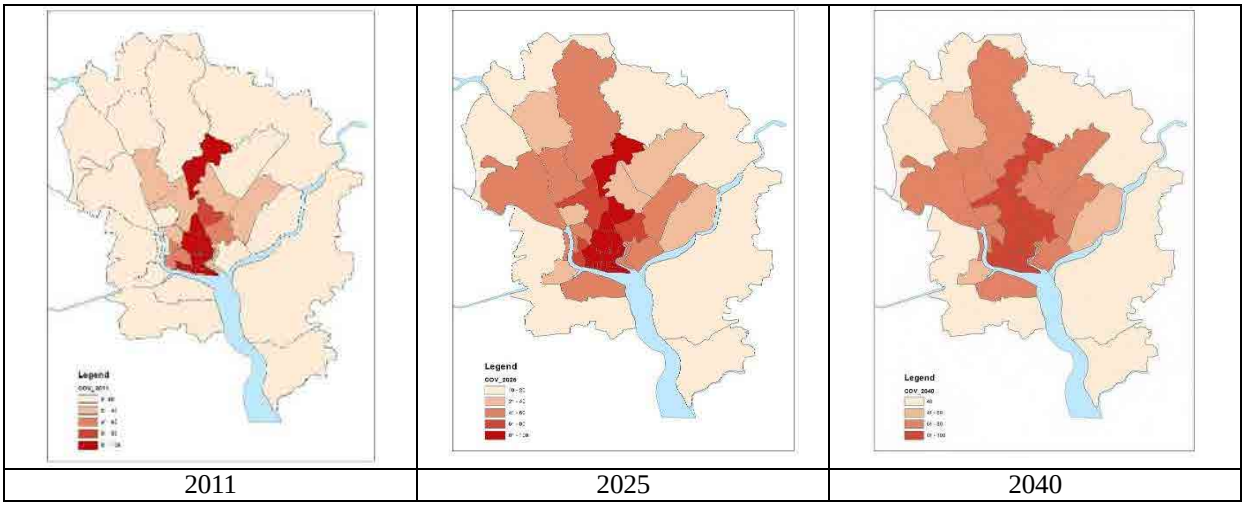
(1) Service Coverage Rate

Service coverage rates have been set for every township considering the present large differences of the service coverage rate among the townships. The planned overall service coverage rate for YCDC and the greater Yangon in 2025 are 58% and 49%, respectively.

Table 1.6 Service Coverage Rate

Area	2011	2018	2020	**2025**	2040
YCDC	37	48	52	**58**	80
Peripheral 6 townships	0	0	0	**10**	40
Greater Yangon	34	41	44	**49**	69

Source: JICA Study Team



2011	2025	2040

Source: JICA Study Team

Figure 1.4 Township-Wise Service Coverage Rate

Table 1.7 Water Service Coverage Rate by Township in Greater Yangon

(%)

No.	Area	Township	2011	2018	2020	**2025**	2040
1	1.CBD	Latha	93	100	100	**100**	100
2	1.CBD	Lanmadaw	86	97	100	**100**	100
3	1.CBD	Pabedan	94	100	100	**100**	100
4	1.CBD	Kyauktada	96	100	100	**100**	100
5	1.CBD	Botahtaung	92	100	100	**100**	100
6	1.CBD	Pazuntaung	99	100	100	**100**	100
7	2.IUR	Ahlone	47	59	62	**70**	100
8	2.IUR	Kyeemyindaing	17	34	40	**50**	80
9	2.IUR	Sanchaung	43	56	60	**70**	100
10	2.IUR	Dagon	59	75	80	**90**	100
11	2.IUR	Bahan	82	96	100	**100**	100
12	2.IUR	Tarmwe	88	97	100	**100**	100
13	2.IUR	Mingalar Taung Nyunt	96	100	100	**100**	100
14	2.IUR	Seikkan	60	75	80	**90**	100
15	2.IUR	Dawbon	26	37	40	**50**	80
16	5.ORZ	Kamaryut	24	36	40	**50**	80
17	5.ORZ	Hlaing	18	29	32	**40**	70
18	5.ORZ	Yankin	85	96	100	**100**	100
19	5.ORZ	Thingangyun	50	60	63	**70**	100
20	6.NS	Mayangone	39	55	59	**70**	100
21	6.NS	Insein	26	38	40	**50**	80
22	6.NS	Mingalardon	16	31	35	**45**	75
23	4.OldSZ	North Okkalapa	84	96	100	**100**	100
24	4.OldSZ	South Okkalapa	66	77	80	**90**	100
25	4.OldSZ	Thaketa	14	30	35	**45**	75
26	3.SCBD	Dala	5	28	40	**50**	80
27	3.SCBD	Seikgyikhanaungto	-	-	20	**30**	60
28	7.NewSZ	Shwe Pyi Thar	7	10	20	**30**	60
29	7.NewSZ	Hlaing Tharyar	2	26	33	**50**	80
30	7.NewSZ	North Dagon	26	33	35	**40**	70
31	7.NewSZ	South Dagon	28	37	39	**45**	75
32	7.NewSZ	East Dagon	20	30	33	**40**	70
33	7.NewSZ	Dagon Seikkan	-	15	19	**30**	60
SB1	1.CBD	CBD	93	99	100	**100**	100
SB2	2.IUR	Inner Urban Ring	63	74	77	**81**	95
SB3	3.SCBD	South of CBD	4	24	37	**47**	77
SB4	4.OldSZ	Older Suburbs Zone	57	70	74	**80**	92

No.	Area	Township	2011	2018	2020	**2025**	2040
SB5	5.ORZ	Outer Ring Zone	45	56	59	**65**	89
SB6	6.NS	Northern Suburbs	26	39	42	**52**	81
SB7	7.NewSZ	New Suburbs Zone	13	26	31	**41**	70
T-1		Total (YCDC)	37	48	52	**58**	80
Periphery Areas(6 suburban Townships)							
34	PA	Kyauktan				**10**	40
35	PA	Thanlyin				**10**	40
36	PA	Hlaegu				**10**	40
37	PA	Hmawbi				**10**	40
38	PA	Htantapin				**10**	40
39	PA	Twantay				**10**	40
T-2		Peripheral 6 township		0	0	**10**	40
		Total	34	41	44	**49**	69

Source: JICA Study Team

(2) Population Estimation

Future population for the water supply master plan has been adopted the same as estimated in JICA Urban Plan Study, 2012, which was conducted starting in August 2012 in parallel with this study.

Major population increase has been notably allocated not in the present urbanized area but in newly developing areas, “new suburbs zone” and peripheral 6 townships. The predicted future population is shown in the table below.

Table 1.8 Estimated Population

Area	Present	Year			
	2011	2018	2020	**2025**	2040
YCDC	5,142,128	5,743,669	5,936,343	**6,463,609**	8,519,527
Peripheral 6 townships	430,114	925,343	1,083,966	**1,518,047**	3,210,619
Greater Yangon	5,572,242	6,669,012	7,020,309	**7,981,656**	11,730,146

Source: JICA Urban Plan Study, 2012

(3) Served Population

Served population has been set as shown in the following table which was derived using the above coverage rate and township population. The served population will be 3.8 million in 2025 in YCDC area, an increase of 1.8 million compared to the current population, while it will be 3.9 million, an increase of 2 million in case of Greater Yangon.

Table 1.9 Population and Water Served Population

Area	Population	2011	2018	2020	**2025**	2040
YCDC	Served	1,920,471	2,742,337	3,061,819	**3,764,310**	6,810,338
	Total	5,142,128	5,743,669	5,936,343	**6,463,609**	8,519,527
Greater Yangon	Served	1,920,471	2,742,337	3,061,819	**3,916,114**	8,094,586
	Total	5,572,242	6,669,012	7,020,309	**7,981,656**	11,730,146

Source: JICA Study Team

Table 1.10 Water Served Population by Township in Greater Yangon

(Persons)

No.	Area	Township	2011	2018	2020	**2025**	2040
1	1.CBD	Latha	31,736	34,125	34,125	**34,125**	34,125
2	1.CBD	Lanmadaw	37,098	41,843	43,137	**43,137**	43,137
3	1.CBD	Pabedan	35,298	37,551	37,551	**37,551**	37,551
4	1.CBD	Kyauktada	33,405	34,797	34,797	**34,797**	34,797
5	1.CBD	Botahtaung	45,203	49,134	49,134	**49,134**	49,134
6	1.CBD	Pazuntaung	53,112	54,182	54,353	**54,822**	56,647
7	2.IUR	Ahlone	30,790	38,966	41,054	**46,679**	68,509
8	2.IUR	Kyeemyindaing	19,693	41,384	49,440	**64,375**	119,068
9	2.IUR	Sanchaung	45,239	59,216	63,548	**74,467**	108,207
10	2.IUR	Dagon	14,450	21,574	24,108	**30,493**	48,488
11	2.IUR	Bahan	82,570	98,206	102,811	**104,216**	109,693
12	2.IUR	Tarmwe	168,180	186,417	192,525	**193,461**	197,113
13	2.IUR	Mingalar Taung Nyunt	149,536	157,370	157,883	**159,288**	164,765
14	2.IUR	Seikkan	1,345	1,681	1,793	**2,017**	2,241
15	2.IUR	Dawbon	22,694	32,493	35,196	**44,229**	72,227
16	5.ORZ	Kamaryut	21,091	32,599	36,563	**46,875**	82,303
17	5.ORZ	Hlaing	27,183	44,414	49,227	**62,283**	114,108
18	5.ORZ	Yankin	107,023	120,873	125,909	**125,909**	125,909
19	5.ORZ	Thingangyun	115,811	140,255	147,699	**165,421**	243,619
20	6.NS	Mayangone	80,107	119,142	129,927	**161,034**	268,392
21	6.NS	Insein	80,912	122,722	130,687	**168,510**	301,751
22	6.NS	Mingalardon	46,217	123,662	151,955	**238,779**	680,061
23	4.OldSZ	North Okkalapa	280,127	335,530	354,644	**368,692**	423,468
24	4.OldSZ	South Okkalapa	126,316	148,191	154,239	**174,362**	197,387
25	4.OldSZ	Thaketa	35,460	77,428	90,871	**118,731**	210,209
26	3.SCBD	Dala	9,054	66,111	101,495	**150,984**	392,026
27	3.SCBD	Seikgyikhanaungto	0	0	9,378	**15,752**	44,651
28	7.NewSZ	Shwe Pyi Thar	20,720	33,499	69,497	**114,500**	308,972
29	7.NewSZ	Hlaing Tharyar	9,775	138,608	180,613	**293,089**	590,179
30	7.NewSZ	North Dagon	57,512	76,874	82,851	**98,808**	201,032
31	7.NewSZ	South Dagon	103,713	148,909	160,962	**198,369**	412,778
32	7.NewSZ	East Dagon	29,101	99,104	128,553	**220,629**	828,324
33	7.NewSZ	Dagon Seikkan	0	25,477	35,294	**68,792**	239,467
SB1	1.CBD	CBD	235,852	251,632	253,097	**253,566**	255,391
SB2	2.IUR	Inner Urban Ring	534,497	637,307	668,358	**719,225**	890,311
SB3	3.SCBD	South of CBD	9,054	66,111	110,873	**166,736**	436,677
SB4	4.OldSZ	Older Suburbs Zone	441,903	561,149	599,754	**661,785**	831,064
SB5	5.ORZ	Outer Ring Zone	271,108	338,141	359,398	**400,488**	565,939
SB6	6.NS	Northern Suburbs	207,236	365,526	412,569	**568,323**	1,250,204
SB7	7.NewSZ	New Suburbs Zone	234,039	522,471	657,770	**994,187**	2,580,752
T-1		Total (Yangon City)	1,920,471	2,742,337	3,061,819	**3,764,310**	6,810,338
Periphery Areas (6 suburban Townships)							
			2011	2018	2020	**2025**	2040
34	PA	Kyauktan	0	0	0	**8,955**	61,382
35	PA	Thanlyin	0	0	0	**59,742**	497,508
36	PA	Hlaegu	0	0	0	**23,974**	213,483
37	PA	Hmawbi	0	0	0	**26,680**	220,654
38	PA	Htantapin	0	0	0	**17,989**	158,868
39	PA	Twantay	0	0	0	**14,464**	132,353
T-2		Peripheral 6 townships	0	0	0	**151,804**	1,284,248
		Total	1,920,471	2,742,337	3,061,819	**3,916,114**	8,094,586

Source: JICA Study Team

1.2.3 Water Demand Estimation

(1) Domestic Per Capita Consumption

Target domestic per capita consumption by are and by township has been set as below.

Table 1.11 Target of Domestic Per Capita Domestic Consumption (LPCD)

	2011 (Present)	**2025**	2040
Yangon City	100	**150**	200
Yangon City – Suburbs	60	**100**	150
Peripheral 6 townships	-	**100**	150

Source: JICA Study Team

Table 1.12 Target of Domestic Per Capita Consumption by Township (LPCD)

No.	Area	Township	2011	2018	2020	**2025**	2040
1	1.CBD	Latha	109	125	132	**150**	200
2	1.CBD	Lanmadaw	109	125	132	**150**	200
3	1.CBD	Pabedan	110	125	132	**150**	200
4	1.CBD	Kyauktada	109	125	132	**150**	200
5	1.CBD	Botahtaung	92	125	132	**150**	200
6	1.CBD	Pazuntaung	72	125	132	**150**	200
7	2.IUR	Ahlone	154	127	134	**150**	200
8	2.IUR	Kyeemyindaing	85	127	134	**150**	200
9	2.IUR	Sanchaung	131	127	134	**150**	200
10	2.IUR	Dagon	136	127	134	**150**	200
11	2.IUR	Bahan	137	127	134	**150**	200
12	2.IUR	Tarmwe	109	127	134	**150**	200
13	2.IUR	Mingalar Taung Nyunt	72	127	134	**150**	200
14	2.IUR	Seikkan	-	127	134	**150**	200
15	2.IUR	Dawbon	43	127	134	**150**	200
16	5.ORZ	Kamaryut	165	124	131	**150**	200
17	5.ORZ	Hlaing	102	124	131	**150**	200
18	5.ORZ	Yankin	139	124	131	**150**	200
19	5.ORZ	Thingangyun	63	124	131	**150**	200
20	6.NS	Mayangone	149	144	146	**150**	200
21	6.NS	Insein	142	144	146	**150**	200
22	6.NS	Mingalardon	115	144	146	**150**	200
23	4.OldSZ	North Okkalapa	77	117	126	**150**	200
24	4.OldSZ	South Okkalapa	78	117	126	**150**	200
25	4.OldSZ	Thaketa	45	117	126	**150**	200
26	3.SCBD	Dala	27	70	79	**100**	150
27	3.SCBD	Seikgyikhanaungto	-	70	79	**100**	150
28	7.NewSZ	Shwe Pyi Thar	145	82	87	**100**	150
29	7.NewSZ	Hlaing Tharyar	95	82	87	**100**	150
30	7.NewSZ	North Dagon	63	82	87	**100**	150
31	7.NewSZ	South Dagon	55	82	87	**100**	150
32	7.NewSZ	East Dagon	41	82	87	**100**	150
33	7.NewSZ	Dagon Seikkan	-	82	87	**100**	150
			2011	2018	2020	**2025**	2040
SB1	1.CBD	CBD	99	125	132	**150**	200
SB2	2.IUR	Inner Urban Ring	104	127	134	**150**	200
SB3	3.SCBD	South of CBD	40	70	79	**100**	150
SB4	4.OldSZ	Older Suburbs Zone	84	117	126	**150**	200
SB5	5.ORZ	Outer Ring Zone	98	124	131	**150**	200

No.	Area	Township	2011	2018	2020	**2025**	2040
SB6	6.NS	Northern Suburbs	138	144	146	**150**	200
SB7	7.NewSZ	New Suburbs Zone	64	82	87	**100**	150
T-1		Total (Yangon City)	95	117	121	**135**	178
Periphery Areas (6 suburban Townships)							
34	PA	Kyauktan				**100**	150
35	PA	Thanlyin				**100**	150
36	PA	Hlaegu				**100**	150
37	PA	Hmawbi				**100**	150
38	PA	Htantapin				**100**	150
39	PA	Twantay				**100**	150
T-2		Total				**100**	150
		Grand Total		117	121	**133**	173

Source: JICA Study Team

(2) Non-domestic Per Capita Consumption

Ratio of domestic and non-domestic uses is 60:40 in Yangon. Ratios in the neighboring cities range from 30 to 50 % depending on cities' character and existence of individual water supply. It is reasonable to apply present non-domestic use ratio of 40 % for the future as well.

(3) Non-Revenue Water Rate

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

(4) Leakage Rate

Present leakage rate has been estimated as 50%. Leakage reduction requires continuous efforts and strong support from management side with investment costs of replacement of old pipes, etc. YCDC has set ambitious leakage level target of 10% in 2040. Target levels of leakage and non-revenue water are shown below by 5 years interval. Non-revenue water rate and leakage rate for 2025 will be 35% and 25%, respectively.

Table 1.13 Non-Revenue Water Rate and Leakage Rate

Item	2013	2018	2020	**2025**	2040
Non-revenue Water Rate (%)	66	51	46	**35**	15
Leakage Rate (%)	50	37	33	**25**	10

Source: JICA Study Team

(5) Peak Factor

Peak factor is the ratio of daily maximum demand and daily average demand and used for decision on design of the treatment and transmission facilities. The fluctuation of total monthly consumption is calculated as 1.09 in 2010 using YCDC metered consumption records. Therefore, the coefficient of this factor is set at 1.1.

(6) Water Demand Estimation

Water demand has been estimated as shown below.

Table 1.14 Water Demand Estimation

(1) For Greater Yangon

Item	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
Peak Factor	---	1.09	**1.10**	1.10
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

(2) For Yangon City

Item	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
Peak Factor	---	1.09	**1.10**	1.10
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

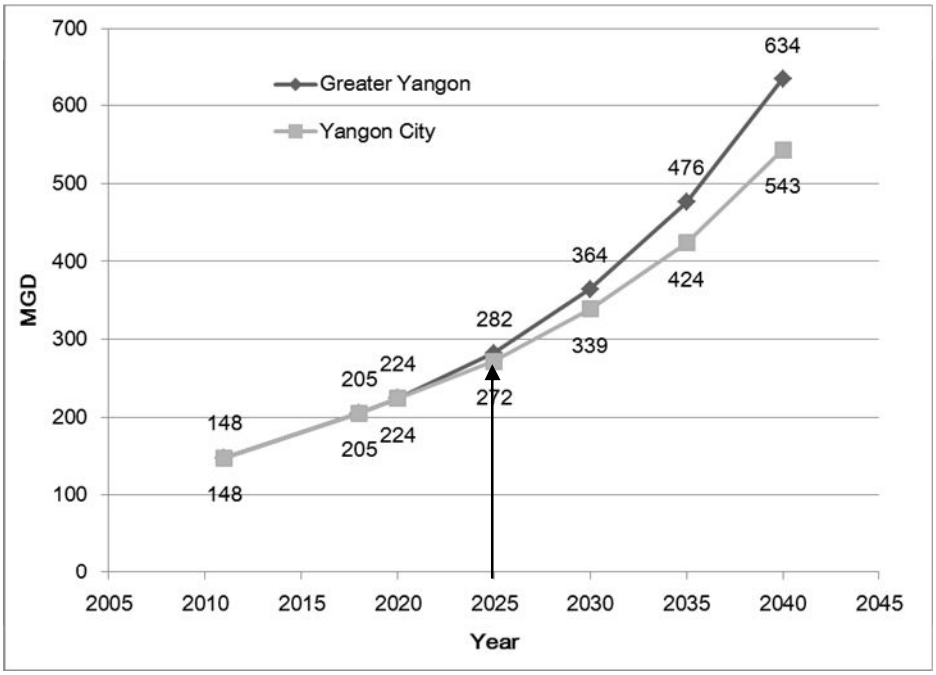
(3) Daily Average Water Demand

Area	2011	2018	2020	**2025**	2040
m^3/day					
Yangon City	611,952	846,778	924,969	**1,125,773**	2,242,961
Periphery Areas	0	0	0	**38923**	377718
Greater Yangon	611,952	846,778	924,969	**1,164,696**	2,620,679
MGD					
Yangon City	135	186	203	**248**	493
Periphery Areas	0	0	0	**9**	83
Greater Yangon	135	186	203	**256**	576

(4) Daily Maximum Water Demand

Area	2011	2018	2020	**2025**	2040
m^3/day					
Yangon City	673,148	931,459	1,017,467	**1,238,351**	2,467,258
Periphery Areas	0	0	0	**42,816**	415,491
Greater Yangon	673,148	931,459	1,017,467	**1,281,167**	2,882,749
MGD					
Yangon City	148	205	224	**272**	543
Periphery Areas	0	0	0	**9**	91
Greater Yangon	148	205	224	**282**	634

Source: JICA Study Team



Source: JICA Study Team

Figure 1.5 Daily Maximum Water Demand for Greater Yangon and Yangon City

1.3 Water Supply Plan

(1) Main Features in 2011 (Present)

Present (2011) main features on water supply are shown below by the proposed 10 distribution zones.

Table 1.15 Main Features by the Proposed 10 Zones in 2011

(Present)

Item/Zone	1	2	3	4	5	6	7	8	9	10	Total
Population	875,783	722,995	735,821	654,538	433,389	116,006	366,705	490,564	488,768	257,560	5,142,129
	17.0%	14.1%	14.3%	12.7%	8.4%	2.3%	7.1%	9.5%	9.5%	5.0%	100%
Served Population	624,785	305,282	347,719	365,799	42,703	18,561	86,613	103,713	9,775	15,522	1,920,472
	32.5%	15.9%	18.1%	19.0%	2.2%	1.0%	4.5%	5.4%	0.5%	0.8%	100%
Served Rate	71.3%	42.2%	47.3%	55.9%	9.9%	16.0%	23.6%	21.1%	2.0%	6.0%	-
Connection Number	74,977	35,782	33,325	33,497	3,958	2,286	10,489	6,760	1,400	2,340	204,814
Daily Maximum Demand m^3/d, MGD	237,049	90,800	148,720	123,579	20,284	7,826	17,658	20,915	3,406	2,911	673,148
	52	20	33	27	4	2	4	5	1	1	149

Source: JICA Study Team

(2) Main Features in 2025

Main features on water supply for 2025 with 2040 are given in the following tables, and the proposed 10 distribution zones are shown in Figure 1.6.

Table 1.16 Main Features by Distribution Zone in Yangon City

(1) Served Population

(Unit: Person)

No.	Distribution Zone Name	2011	2018	2020	**2025**	2040
1	Central area	624,785	717,303	741,643	**783,630**	925,906
2	Tamwe, Taketa	305,282	397,280	425,992	**481,550**	682,901
3	Hlaing	347,719	445,558	473,374	**544,231**	749,649
4	Mayangone	365,799	471,539	502,625	**563,363**	798,760
5	Mingaladon, Shwe Pyi Thar	42,703	92,319	141,775	**228,076**	632,444
6	North side	18,561	49,663	61,025	**95,894**	273,113
7	East side 1	86,613	175,978	211,404	**319,437**	1,029,356
8	East side 2	103,713	174,386	196,256	**267,161**	652,245
9	West side	9,775	138,608	180,613	**293,089**	590,179
10	South side	15,522	79,704	127,112	**187,880**	475,785
T-1	Total (Yangon City)	1,920,471	2,742,337	3,061,819	**3,764,310**	6,810,338

(2) Daily Maximum Demand

(Unit: m^3/day)

No.	Distribution Zone Name	2011	2018	2020	**2025**	2040
1	Central area	237,049	263,483	270,389	**287,331**	377,223
2	Tamwe, Taketa	90,800	143,313	152,960	**176,568**	278,222
3	Hlaing	148,720	164,800	172,962	**199,548**	305,411
4	Mayangone	123,579	171,233	181,391	**206,567**	325,421
5	Mingaladon,Shwe Pyi Thar	20,284	32,642	45,419	**69,632**	226,193
6	North side	7,826	20,811	24,380	**35,161**	111,268
7	East side 1	17,658	41,996	50,326	**78,085**	314,526
8	East side 2	20,915	41,616	46,723	**65,307**	199,298
9	West side	3,406	33,075	42,996	**71,644**	180,333
10	South side	2,911	18,491	29,921	**48,508**	149,363
T-1	Total (Yangon City)	673,148	931,459	1,017,467	**1,238,351**	2,467,258

(3) Daily Maximum Demand

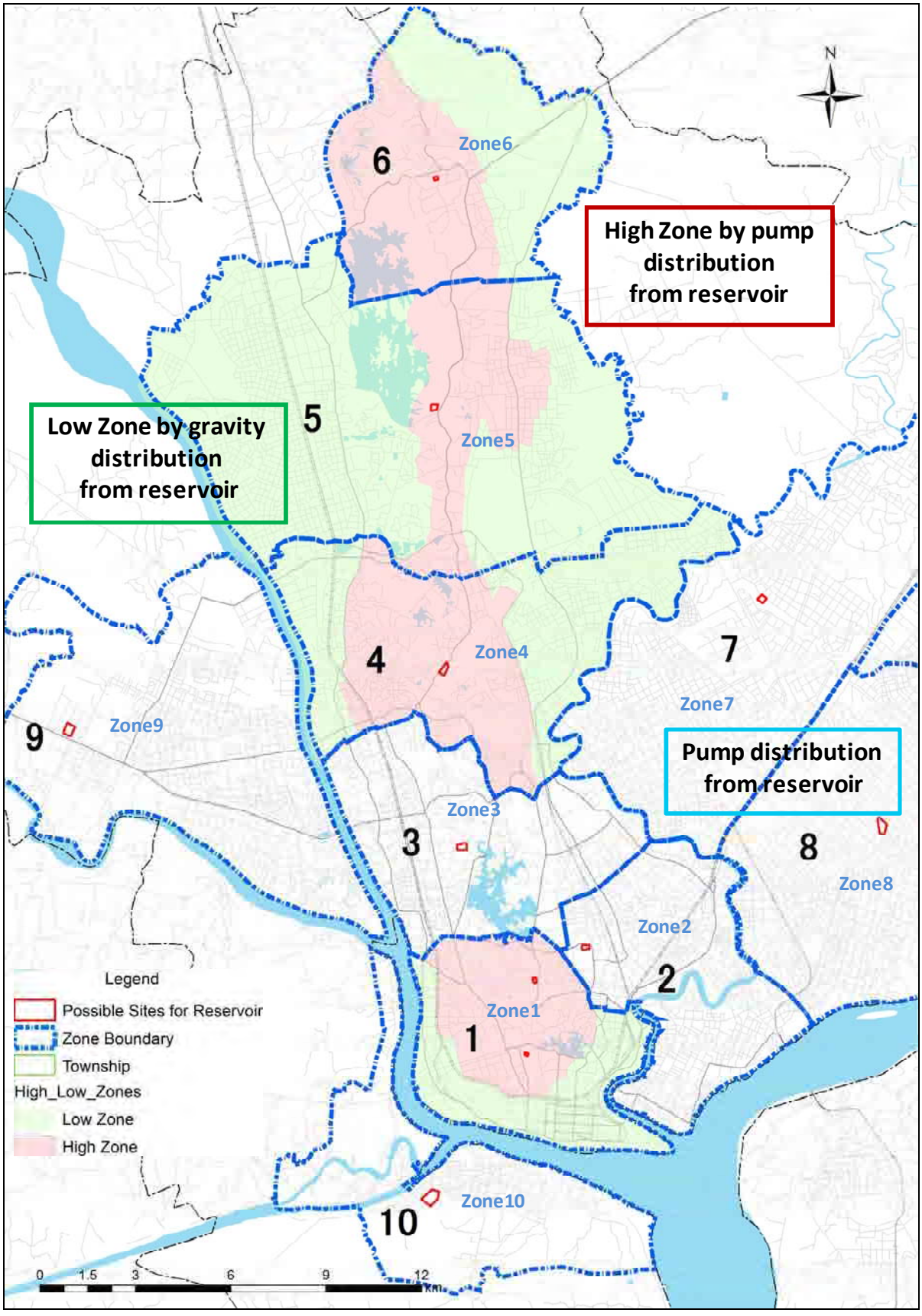
(Unit: MGD)

No.	Distribution Zone Name	2011	2018	2020	**2025**	2040
1	Central area	52	58	59	**63**	83
2	Tamwe, Taketa	20	32	34	**39**	61
3	Hlaing	33	36	38	**44**	67
4	Mayangone	27	38	40	**45**	72
5	Mingaladon,Shwe Pyi Thar	4	7	10	**15**	50
6	North side	2	5	5	**8**	24
7	East side 1	4	9	11	**17**	69
8	East side 2	5	9	10	**14**	44
9	West side	1	7	9	**16**	40
10	South side	1	4	7	**11**	33
T-1	Total (Yangon City)	148	205	224	**272**	543

Note: In addition, 10 MGD demand is envisaged for Thilawa SEZ
Source: JICA Study Team

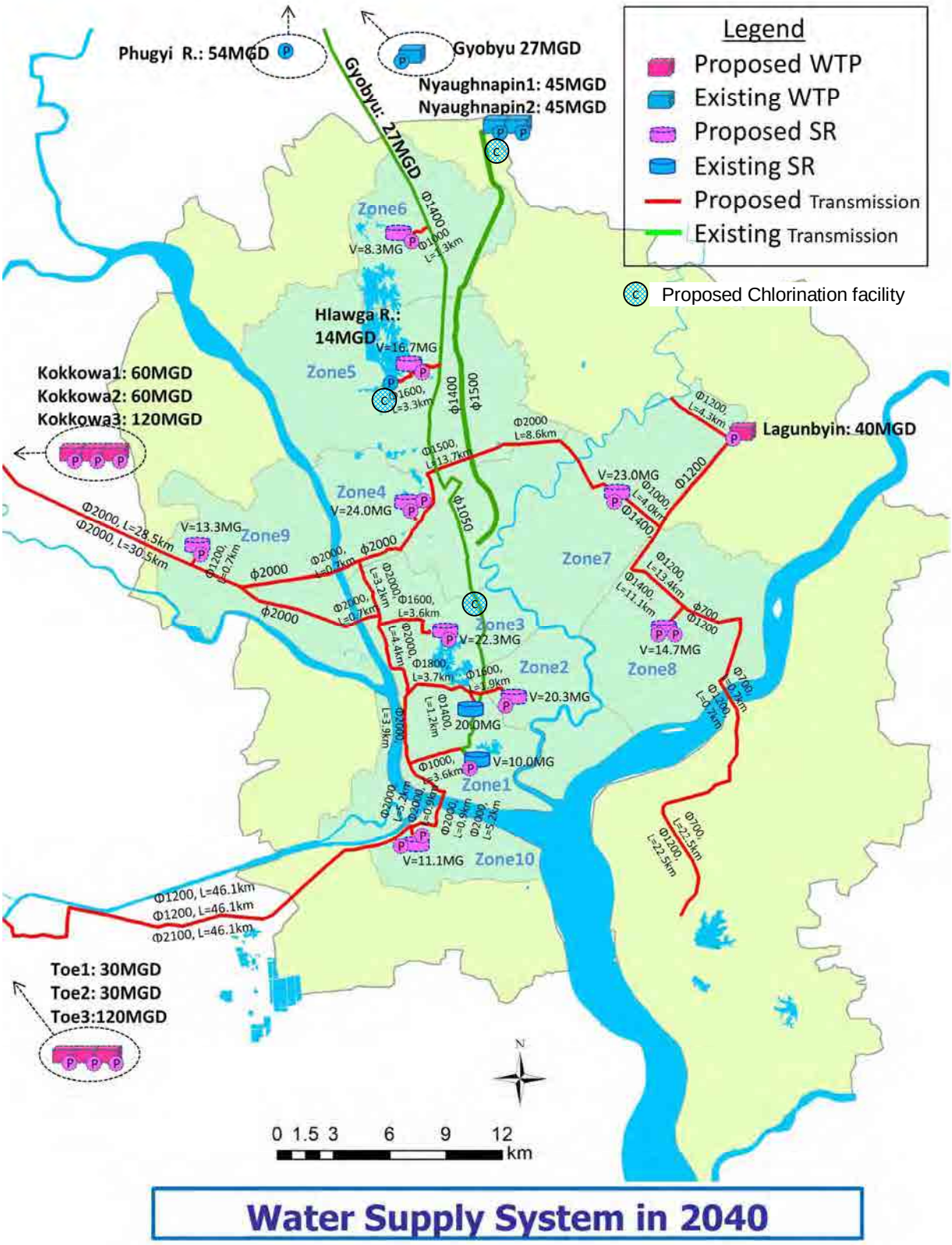
(3) Water Supply Facility Plan

Water supply facilities are planned to meet Yangon city's demand of 272 MGD for 2025 and 543 MGD for 2040. Planned main facilities (water treatment plant, transmission pipes and service reservoirs) in 2040 are shown in Figure 1.7.



Source: JICA Study Team

Figure 1.6 Proposed 10 Distribution Zones



Source: JICA Study Team

Figure 1.7 Main Water Supply Facilities (2040)

1.4 Projects for Feasibility Study (Target Year 2025)

The following three projects are selected as the priority projects for feasibility study. The locations of the priority projects are shown in following figure in proposed major water supply facilities in 2025.

(1) Development of Lagunbyin Water Supply System

This system intends to increase water coverage rate for the eastern Yangon and to supply water to the Thilawa SEZ. Water source will be the existing Lagunbyin Reservoir, operated and maintained by the irrigation department. All facilities except the reservoir and canals need to be constructed.

- Water will be supplied to East Dagon, North Dagon, South Dagon and Dagon Seikkan (the proposed Zone 7 and Zone 8) and Thilawa SEZ (Special Economic Zone).
- The water amount allocated by the irrigation department will be 30 MGD for Zone 7 and Zone 8 and 10 MGD for Thilawa SEZ.

(2) Modernization of Water Supply System in Zone 1

Zone 1 is selected because it is the oldest town with high population density, includes CBD, and contains old and dilapidated facilities. Modernization will ensure continuous water supply and reduce leakage.

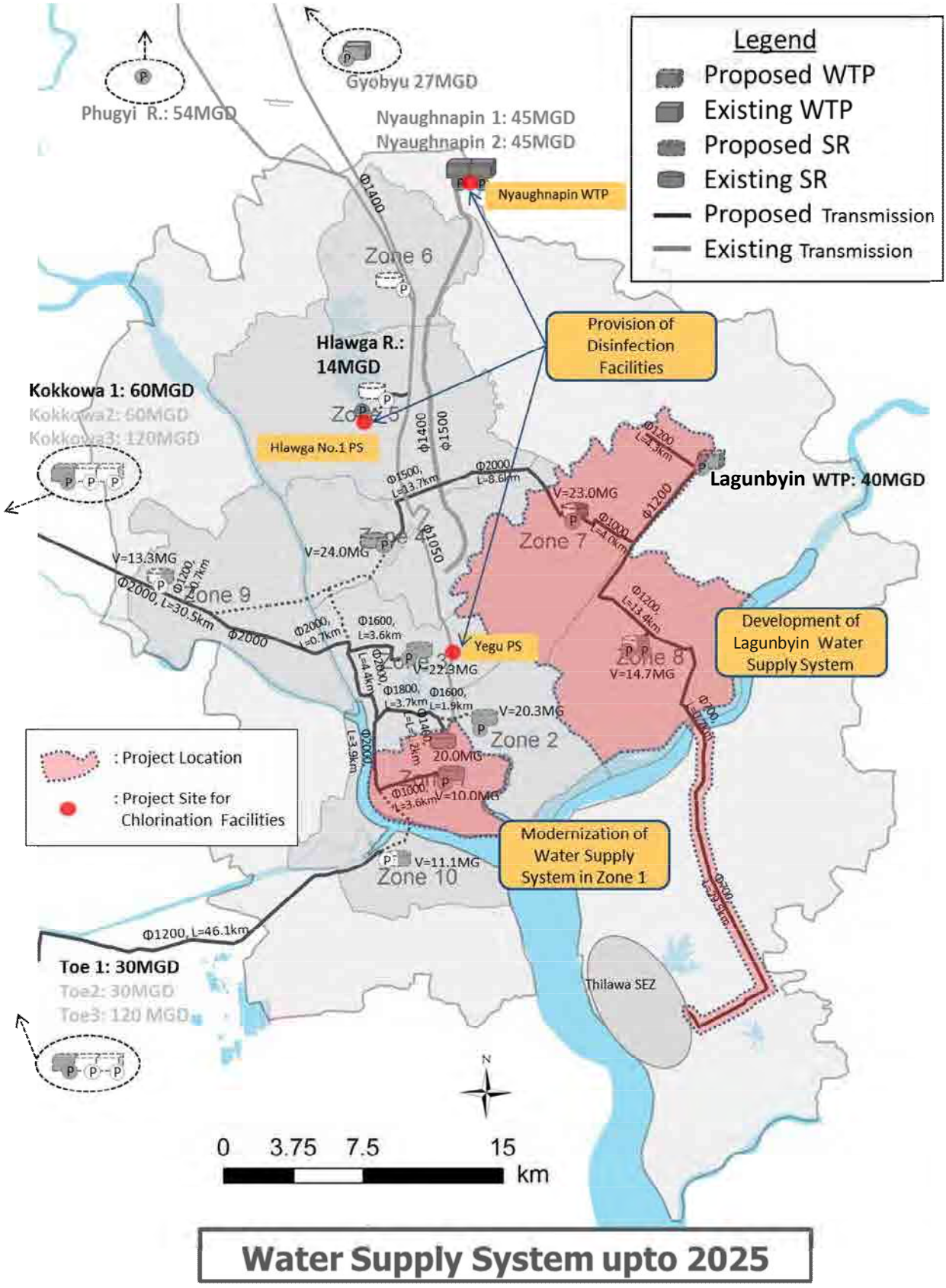
(3) Provision of Disinfection Facilities

This is selected to ensure that YCDC' water is drinkable in the entire service area of YCDC water supply.

(4) Capacity Development

YCDC needs to enhance its capacity to ensure its water supply management as stated in the Master Plan. Among the required fields to enhance its capacity, the following three fields are studied in the Feasibility Study;

- Business Management of Waterworks
- Water Quality Management
- Non-revenue Water (NRW) Management



Source: JICA Study Team

Figure 1.8 Main Water Supply Facilities (2025) - Scope of Feasibility Study

CHAPTER 2. DEVELOPMENT OF THE LAGUNBYIN WATER SUPPLY SYSTEM

2.1 Planned Target Area

2.1.1 Served Area

(1) Characteristics of the Served Area

Lagunbyin water supply system will cover 4 townships of East Dagon, North Dagon, South Dagon and Dagon Seikkan, located in the east of Yangon city. These 4 townships have been developed as industrial and residential areas. According to the JICA Urban Plan Study, 2012, population has been expected to grow significantly in these townships. The Dagon Bridge, as a part of the outer ring road was constructed on the Bago River, connecting with the Thanlyin area. This bridge together with the Yangon - Thanlyin Bridge, constructed in 1993 will accelerate goods transportation further from the industrial areas to the Thilawa Port.

As a result, water demand in this area is expected to increase dramatically. Water supply to this area has not been adequate, resulting in low service coverage rate and development of the water supply facilities is needed in this area. The Lagunbyin water supply system is planned to cover this area and Thilawa SEZ with a capacity of 40 MGD. In this area, Zone 7 and Zone 8 have been proposed in the master plan. Current characteristics of Zone 7 and Zone 8 are shown below.

Table 2.1 Characteristics of Zone 7 and Zone 8 in 2011

	Zone 7	Zone 8
Township	East Dagon, North Dagon	South Dagon, Dagon Seikkan
Population (person)	366,705	490,564
Served Population (person)	86,613	103,713
Coverage Rate	23.6 %	21.1 %
Number of Connections	10,489	6,760
Daily Maximum Demand	17,658 m^3/day	20,915 m^3/day
	3.9 MGD	4.6 MGD

Source: JICA Study Team

(2) Zone 7

Zone 7 covers East Dagon and North Dagon townships. These two townships started their development in 1989 as planned satellite towns and the developments were slow due to the lack of basic infrastructures until the 2000's.

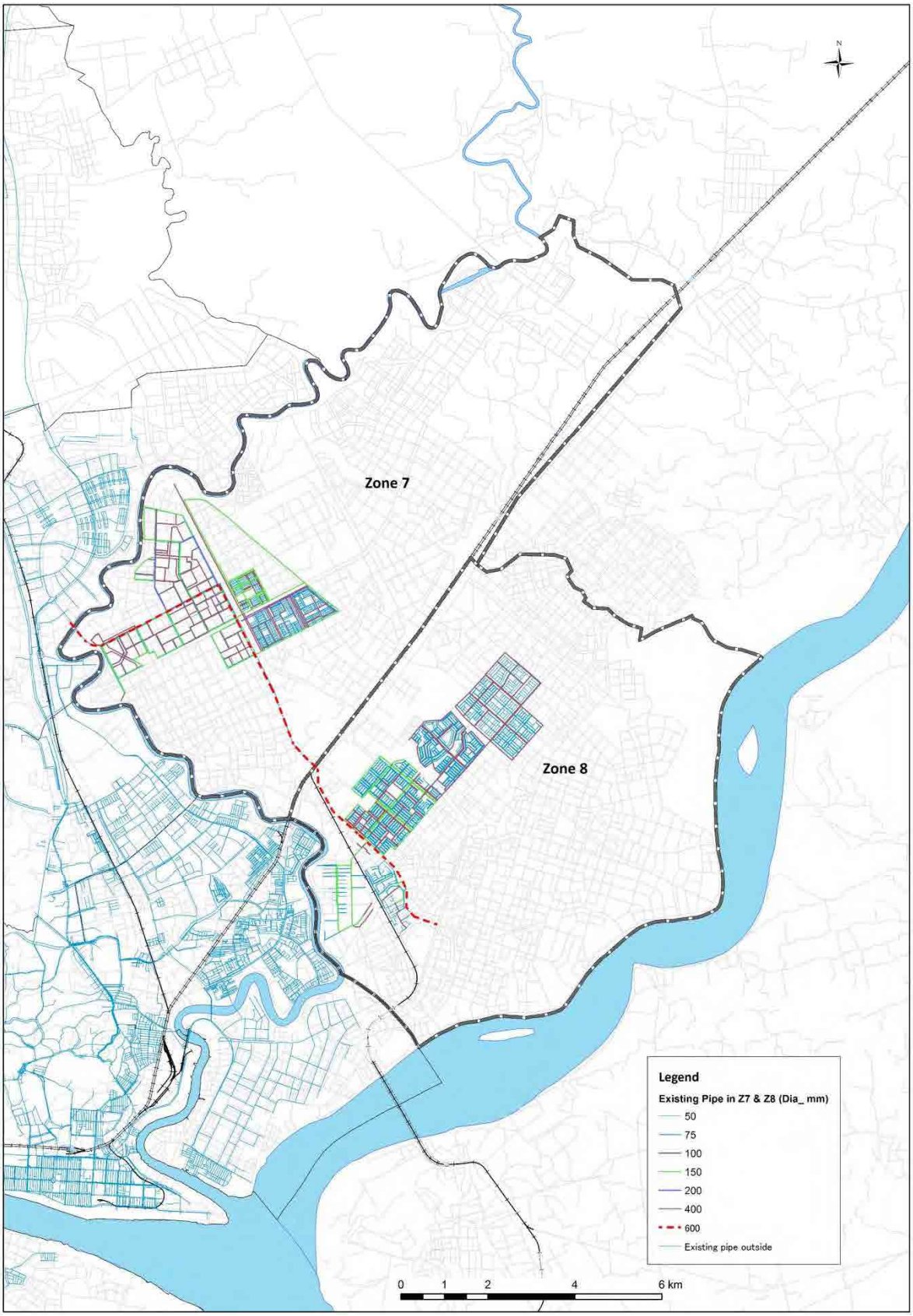
North Dagon T/S has high residential areas like Dagon Yeik Mon Garden City while Dagon University and Yangon Institute of Economics occupy a considerable area in East Dagon. East Dagon

also functions as a transportation center; from Togyaunggalay terminal station trains depart for Bago, Mandalay, etc. Many buses connecting to various areas also depart from here.

This area is low-lying area so that water needs to be distributed by pumping. In the master plan, service reservoirs have been proposed to be located in the center of each zone in order to achieve fairly equal water pressure within the zones.

(3) Zone 8

South Dagon and Dagon Seikkan are covered in Zone 8. Population was only 10 thousand until this area started development as industrial and satellite towns in 1990's. National Youth Resource Development Degree College and "City of Industry Dagon Seikkan" occupy large portion of this zone. This is also low-lying area and water is to be distributed by pumping. Similarly, service reservoir has been proposed in the center of this zone.



Source: JICA Study Team

Figure 2.1 Existing Water Supply System (Location and Existing Pipe Network) in Zone7 and 8

2.1.2 Planning Parameters for Target Year 2025

Planning parameters are shown below.

Table 2.2 Planning Parameters for Zone 7 and Zone 8

(1) Estimated Population

(unit: person)

Zone	2011	2018	2020	2022	**2025**	2040
7	366,705	563,301	626,271	695,199	**798,592**	1,470,510
8	490,564	572,301	598,481	627,139	**670,126**	949,480
Total	857,269	1,135,602	1,224,752	1,322,338	**1,468,718**	2,419,990

(2) Served Population

(unit: person)

Zone	2011	2018	2020	2022	**2025**	2040
7	86,613	175,978	211,404	254,617	**319,437**	1,029,356
8	103,713	174,386	196,256	224,618	**267,161**	652,245
Total	190,326	350,364	407,660	479,235	**586,598**	1,681,601

(3) Coverage Rate

(unit: %)

Zone	2011	2018	2020	2022	**2025**	2040
7	23.6	31.2	33.8	36.6	**40.0**	70.0
8	21.1	30.5	32.8	35.8	**39.9**	68.7
Total	22.2	30.9	33.3	36.2	**39.9**	69.5

(4) Number of Connections

(unit: number)

Zone	2011*	2018	2020	2022	**2025**	2040
7	10,489	27,933	33,556	40,415	**50,704**	163,390
8	6,760	27,680	31,152	35,654	**42,407**	103,531
Total	17,249	55,613	64,708	76,069	**93,111**	266,921

Note: * YCDC record, number of connections is calculated as estimated served population divided by 6.3 persons per household.

Source: JICA Study Team

2.1.3 Water Demand

Daily maximum water demand is shown below. Daily maximum water demand of the Zone 7 and Zone 8 is 31 MGD in the target year 2025. This demand is coincidentally almost the same amount as allocated water amount of 30 MGD. The facilities are planned for 40 MGD including 10 MGD for Thilawa SEZ.

Table 2.3 Daily Maximum Water Demand

Zone	2011	2018	2020	2022	**2025**	2040
m^3/day						
7	17,658	41,996	50,326	61,430	**78,085**	314,526
8	20,915	41,616	46,723	54,157	**65,307**	199,298
Thilawa	0	2,760	9,200	15,600	**25,300**	42,000
Total	38,573	86,372	106,249	131,187	**168,692**	555,824
MGD						
7	3.9	9.2	11.1	13.5	**17.2**	69
8	4.6	9.2	10.3	11.9	**14.4**	44
Thilawa	0.0	0.6	2.0	3.4	**5.6**	9.2
Total	8.5	19.0	23.4	28.8	**37.2**	122.2

Source: JICA Study Team

2.2 Planning Parameters

2.2.1 Planning Parameters for Zone 7 and Zone 8

Supply planning parameters for Zone 7 and Zone 8 are shown below. The parameters in the target year 2025 are used for facilities planning except number of connections which will be used for replacement of service pipes. The planned pipe network is also shown below.

Table 2.4 Planning Parameters for Zone 7 and Zone 8

(1) Planning Parameters for Zone 7

	2011	2018	2020	2022	**2025**	2040
Population (person)	366,705	563,301	626,271	695,199	**798,592**	1,470,510
Served Population (person)	86,613	175,978	211,404	254,617	**319,437**	1,029,356
Number of connections	10,489	27,933	33,556	40,415	**50,704**	163,390
Coverage rate	23.6 %	31.2	33.8	36.6	**40.0**	70.0
Leakage rate	50 %	37.0	33.0	29.4	**25.0**	10
Per Capita Consumption	56 Lpcd	82	87	94	**100**	150
Daily Average Demand	16,052 m^3/day	38,178	45,751	55,845	**70,986**	285,933
	4 MGD	8.4	10.1	12.3	**15.6**	63
Peak Factor	1.09	1.10	1.10	1.10	**1.10**	1.10
Daily Maximum Demand	17,658 m^3/d	41,996	50,326	61,430	**78,085**	314,526
	4 MGD	9.2	11.1	13.5	**17.2**	69
Number of DMA (Nos.)	0	29	29	29	**29**	29

(2) Planning Parameters for Zone 8

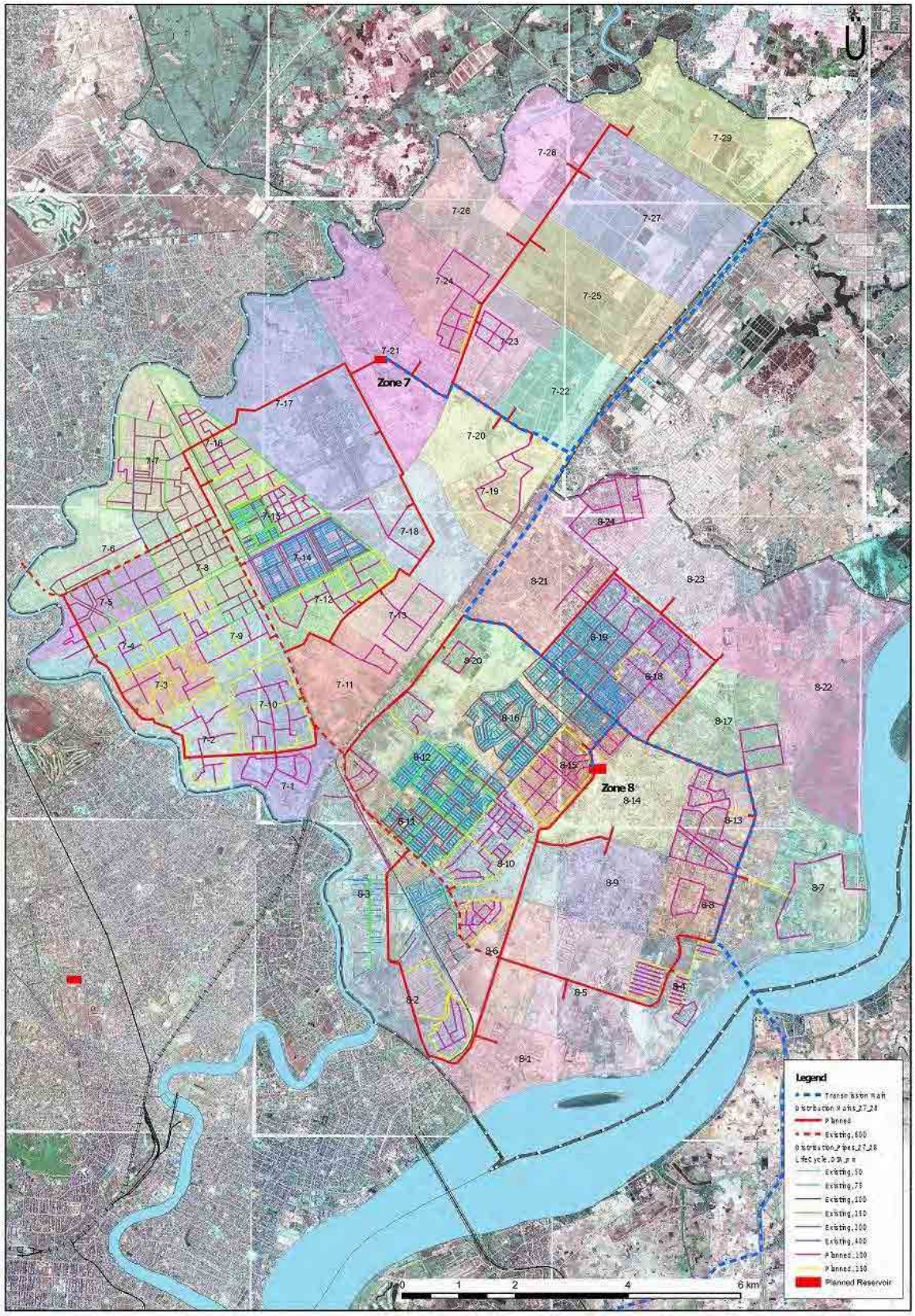
	2011	2018	2020	2022	**2025**	2040
Population (person)	490,564	572,301	598,481	627,139	**670,126**	949,480
Served Population (person)	103,713	174,386	196,256	224,618	**267,161**	652,245
Number of connections	6,760	27,680	31,152	35,654	**42,407**	103,531
Coverage rate	21.1 %	30.5	32.8	35.8	**39.9**	68.7

	2011	2018	2020	2022	**2025**	2040
Leakage rate	50.0 %	37.0	33.0	29.4	**25.0**	10
Per Capita Consumption	49 L/day	82	87	94	**100**	150
Daily Average Demand	19,014 m^3/day	37,832	42,475	49,233	**59,370**	181,180
	4.2 MGD	8.3	9.3	10.8	**13.1**	40
Peak Factor	1.09	1.10	1.10	1.10	**1.10**	1.10
Daily Maximum Demand	20,915 m^3/day	41,616	46,723	54,157	**65,307**	199,298
	4.6 MGD	9.2	10.3	11.9	**14.4**	44
Number of DMA (Nos.)	0	24	24	24	**24**	24

(3) Planning Parameters for Zone 7 and Zone 8

	2011	2018	2020	2022	**2025**	2040
Population (person)	857,269	1,135,602	1,224,752	1,322,338	**1,468,718**	2,419,990
Served Population (person)	190,326	350,364	407,660	479,235	**586,598**	1,681,601
Number of connections	17,249	55,613	64,708	76,069	**93,111**	266,921
Coverage rate	22.2 %	30.9	33.3	36.2	**39.9**	69.5
Leakage rate	50 %	37	33	29	**25**	10
Per Capita Consumption	52 Lpcd	82	87	93	**100**	150
Daily Average Demand	35,066 m^3/day	76,010	88,226	105,078	**130,356**	467,113
	8 MGD	16.7	19.4	23.1	**28.7**	103
Peak Factor	1.09	1.10	1.10	1.10	**1.10**	1.10
Daily Maximum Demand	38,573 m^3/d	83,612	97,049	115,587	**143,392**	513,824
	9 MGD	18.4	21.3	25.4	**31.5**	113
Number of DMA (Nos.)	0	53	53	53	**53**	53

Note; DMA : Destruct Metered Area
Source: JICA Study Team



Source: JICA Study Team

Figure 2.2 Transmission Pipe and Distribution Pipe Network for Zone 7 and Zone 8 in 2025

2.2.2 Planning Parameters for Thilawa SEZ

The supply amount of 42,000m^3/day (9.2MGD) for Thilawa SEZ has been decided in the "Thilawa scheme" and water demand for Thilawa SEZ Class A is planned as shown in table below.

Table 2.5 Water Demand for Thilawa SEZ Class A

	Unit	2018	2020	2022	**2025**	2040
Daily Maximum Demand	m^3/d	2,760	9,200	15,600	**25,300**	42,000
	MGD	0.61	2.1	3.4	**5.6**	9.2

Source: Thilawa SEZ

The southwest area of Zamani Reservoir was selected as the water supply point by a request of Thilawa SEZ. Then, two alternative routes as follows and following figure were selected by the Study Team to connect pipeline from Zone 8 to this point.

- Alternative route 1: Western route, pipeline passes through Thanlyin town
- Alternative route 2: Eastern route, pipeline divert the town

The route 1 has undulated topography and requires railway crossings for installation of pipeline but the route 2 is almost flat. The road rehabilitation work is planned along the route 1 when pipeline will be installed. Considering the topography, road barrier, and other construction work, Alternative route 2 was selected as the pipeline route to Thilawa SEZ as shown in figure below.

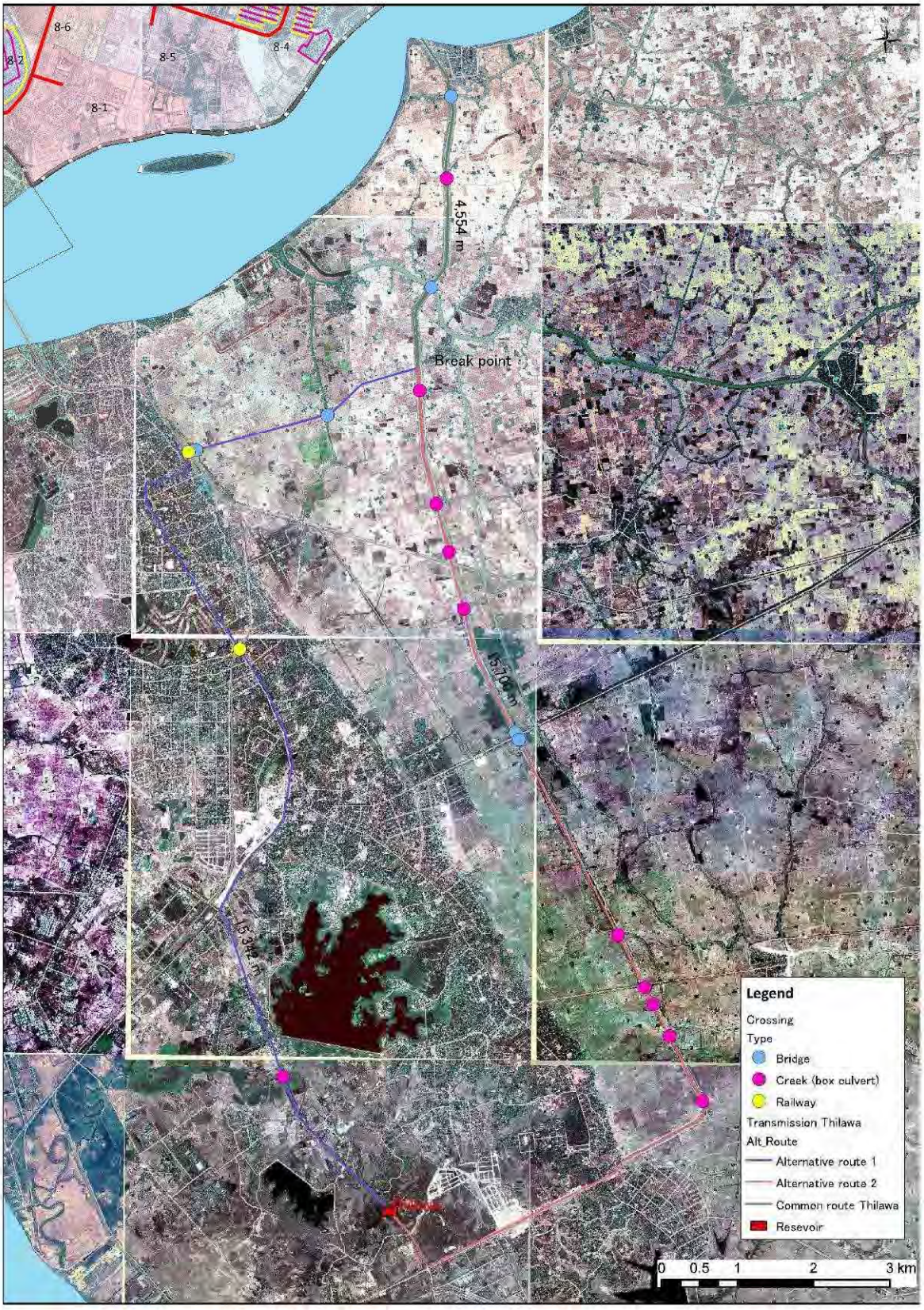
2.2.3 Water Demand for Lagunbyin Water Supply System

Water demand estimation for Lagunbyin water supply system is shown in table below. The water source for Lagunbyin water supply system is 40 MGD including 30MGD for YCDC and 10 MGD for Thilawa SEZ. Therefore, the capacity of Lagunbyin water treatment plant is planned at 40MGD (181,800 m^3/day).

Table 2.6 Water Demand Estimation for Lagunbyin Water Supply System

	Unit	2011	2018	2020	2022	**2025**	2040
Daily Average Demand	m^3/day	35,526	78,770	97,426	120,678	**155,656**	509,113
	MGD	7.7	17.3	21.5	26.5	**34.3**	112
Daily Maximum Demand	m^3/day	39,033	86,372	106,249	131,187	**168,692**	555,824
	MGD	8.5	19.0	23.5	28.8	**37.2**	122

Source: JICA Study Team



Source: JICA Study Team

Figure 2.3 Transmission Pipe Route for Thilawa SEZ

2.3 Facility Planning

2.3.1 Planning Conditions

(1) Water Source and Water Treatment Site

The source of water supply system of Lagunbyin Reservoir (Lagunbyin Water Supply System) is Lagunbyin Reservoir which is managed by Ministry of Agriculture and Irrigation (MOAI). Total source of 40 MGD is ensured for treatment plant, including 30 MGD for YCDC and 10 MGD for Thilawa SEZ. The site of water treatment plant is located in the side of the junction of Route No. 2 and Route No. 7, and is in the east of Yangon near Ngamoeyeik Creek at Sitpingtan.

(2) Facility Planning and Planning Parameters

The facilities are planned for 40 MGD, the daily maximum demand. Although allocated water amount is 40 MGD, intake amount and treated amount are designed exceeding slightly 40 MGD for operational loss amount within the treatment plant. Transmission facilities will be designed for daily maximum demand of 40 MGD while distribution facilities will be designed for 1.5 times of 40 MGD considering diurnal fluctuation of demand.

Table 2.7 Parameters for Facility Planning

Item	Amount	Note	Remarks
Daily Maximum Demand	181,800 m^3/day	40MGD	
Intake flow	200,000 m^3/day	40MGD x110%	Japanese design guideline
Treated flow	190,900 m^3/day	40MGD x105%	Loss within plant
Transmitted flow	181,800 m^3/day	40MGD	For transmission facilities
Distributed flow	11,360 m^3/ hr	40MGD ÷ 24 hours x 1.5	For distribution facilities

Source: JICA Study Team

(3) Water Quality

1) Drinking Water Quality Standard

The target treated water quality is set considering that water should be drinkable and decided as shown below considering standards in Myanmar and WHO.

Table 2.8 Target Water Quality after Treatment

Parameters	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 (1 NTU for target turbidity of treated water in WTP)
Standard plate count	< 100CFU/mL
Fecal coliforms	Not to be detected
Residual chlorine	To be detected (at service tap by direct supply and before storage tank of customer)

Parameters	Allowable Value
	The residual chlorine at the exit of WTP shall be set separately, considering the travel time to the end of the service area.
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

Source: JICA Study Team

2) Raw Water Quality

Water quality was measured by JICA Study Team at several locations. The sampling points and quality results are shown below. Raw water from Lagunbyin Reservoir is allocated for the Lagunbyin water supply system; however, as is clear from the sampling points map, water from the Lagunbyin Reservoir is merged with the Ngamoeyeik creek. Therefore, raw water quality for Nyaunghnapin water treatment plant is referred although this plant uses only Ngamoeyeik Reservoir. As a result, planning parameters of water quality is set below.

Table 2.9 Raw Water Turbidity for Facility Planning (NTU)

Season	Measured Range near Ma-So	Turbidity in Nyaunghnapin Water Treatment Plant	Planning Raw Water Turbidity
Dry	26-48	60-70 NTU	20-70 NTU
Rainy	28-154	100-500 NTU, average 200-250 NTU	20-250 NTU

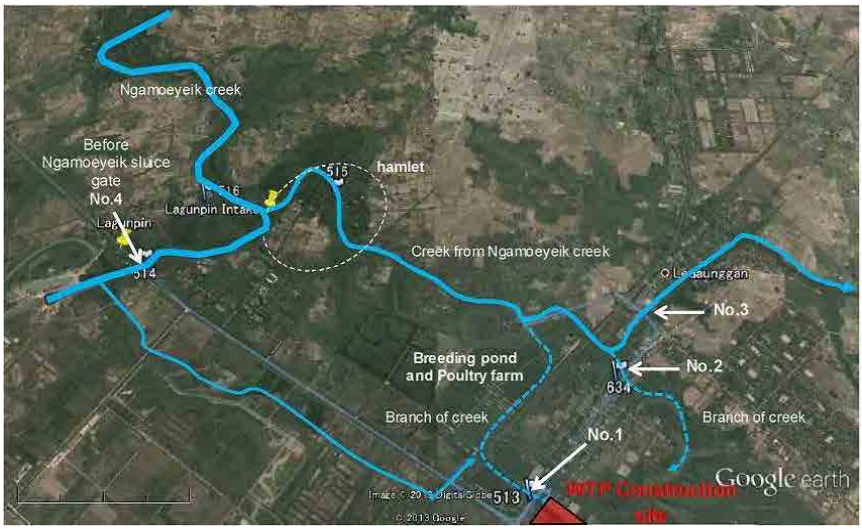
Note: Turbidity is measured as degree. Conversion rate is NTU*0.8 = 1 degree.
Source: JICA Study Team

Table 2.10 Water Quality Near Ma-So (Lagunbyin) Water Treatment Plant

Item	Channel Near Lagunbyin WTP site (Sampling point: No. 1)		Small river near Ledaungan (1) (Sampling point: No. 2)		Small river near Ledaungan (2) (S. point: No. 3)
	2013Jul.3	2013Jun.25	2013 Jul.3	2013 Jun.28	2013 Jul. 3
pH	6.72	6.57	6.49	6.44	6.43
EC (μS/cm)	110	100	160	120	80
Turbidity (NTU)	124	104	154	22	70
Color (Deg)	700	500	910	305	470
TDS (mg/L)	50	40	80	60	40
BOD (mg/L)	--	--	--	4	--

Item	Ngamoeyeik Sluice gate (Canal mainstream) (Sampling point: No. 4)				
	2013 Jul.3	2013Jun.28	2013Jun.25	2013Mar.	2012Sep.
pH	6.52	6.43	6.69	7.16	7.0
EC (μS/cm)	50	30	140	160	68
Turbidity (NTU)	28	52	38	48	--
Color (Deg)	270	305	250	15	--
TDS (mg/L)	20	20	60	--	--

Source: JICA Study Team



Source: JICA Study Team

Figure 2.4 Water Quality Sampling Points near Ma-So (Lagunbyin) Water Treatment Plant

Table 2.11 Water Quality in Ngamoeyeik Reservoir, Ngamoeyeik Creek and Nyaunghnapin WTP

Parameter	Unit	Ngamoeyeik Reservoir		Ngamoeyeik Creek	Nyaunghnapin WTP			
					Raw water		Treated water	
		Rainy season	Dry season	Dry season	Rainy season	Dry season	Rainy season	Dry season
Air Temperature	°C	32	32	36	29	41	29	36
Water Temperature	°C	29	31.5	32.5	29	31	29	31
pH	-	7.4	8.75	7.42	7	7.67	7.3	7.88
EC	µS/cm	137	90	110	77	80	71	70
Turbidity	NTU	5	18	48	88	26	3	6
Color	TCU	<5	<5	15	40	10	<5	<5
Ammonium Nitrogen	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Arsenic (As)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chloride (Cl^-)	mg/l	4	4	10	4	4	4	6
Copper (Cu)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total Cyanide (CN)	mg/l	0.07	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cyanide (CN) *	mg/l	N.D.	-	-	-	-	-	-
Cyanogen Chloride *	mg/l	N.D.	-	-	-	-	-	-
Fluoride (F)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Hardness (mg/l as $CaCO_3$)	mg/l	42	40	54	26	44	24	38
Iron (Fe)	mg/l	0.27	0.28	0.47	1.86	0.38	0.24	0.27
Manganese (Mn)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Lead (Pb)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Nitrate-nitrogen (as NO_3)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Nitrite-nitrogen (as NO_2)	mg/l	0.007	0.005	0.006	0.021	0.014	0.007	0.004
Selenium (Se)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sodium (Na^+)	mg/l	5.95	8.89	11.8	4.76	7.44	4.58	9.71
Sulfate (SO_4^{2-})	mg/l	16	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total Dissolved Solid (TDS)	mg/l	39	26	33	28	26	29	26
Zinc (Zn)	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total coliforms	-	Detected	Detected	Detected	Detected	Detected	Detected	Detected
Fecal coliforms	-	Detected	Detected	Detected	Detected	Detected	Detected	Detected

Source: JICA Study Team

(4) Planning Conditions of Water Treatment Plant

YCDC has started piling work for the facilities in proposed Lagunbyin WTP at Ma-So based on their own design when the JICA Study Team was carrying out the feasibility study for the WTP. Therefore, the facility planning was carried out under the following conditions

- The location, shape and excavation depth of proposed rapid sand filter shall be adjusted with those of sedimentation basin designed by YCDC.
- The location, shape and excavation depth of the proposed treated water reservoir shall be adjusted with those of treated water reservoir designed by YCDC.

(5) Design review for Lagunbyin WTP

YCDC is now under construction of Lagunbyin WTP with capacity of 40MGD by their own fund as stated in (4) above. YCDC and JICA have discussed about demarcation of construction of the water treatment plant since July, 2013 and have finally decided it in October, 2013. Regarding the water treatment plant, following will be constructed by YCDC own fund.

- Intake canal
- Pre-sedimentation pond with intake weir
- Water treatment plant except chlorination facility, transmission pumping house, SCADA and administration building

The remaining components including chlorination facilities, transmission pumping house, SCADA, administration building, and transmission and distribution system may be covered by Yen loan.

Simultaneously with this decision, YCDC intends to construct WTP based on the proposed design of JICA Study Team. To do this, YCDC requires technical support by JICA Study Team and requested a support to JICA. Upon this request, JICA Study Team has carried out a design review and modified the original JICA design since July, 2013 considering the technology available in Myanmar and YCDC's comments. The result of review work is attached in Appendix I.

(6) Selection of System of Facility

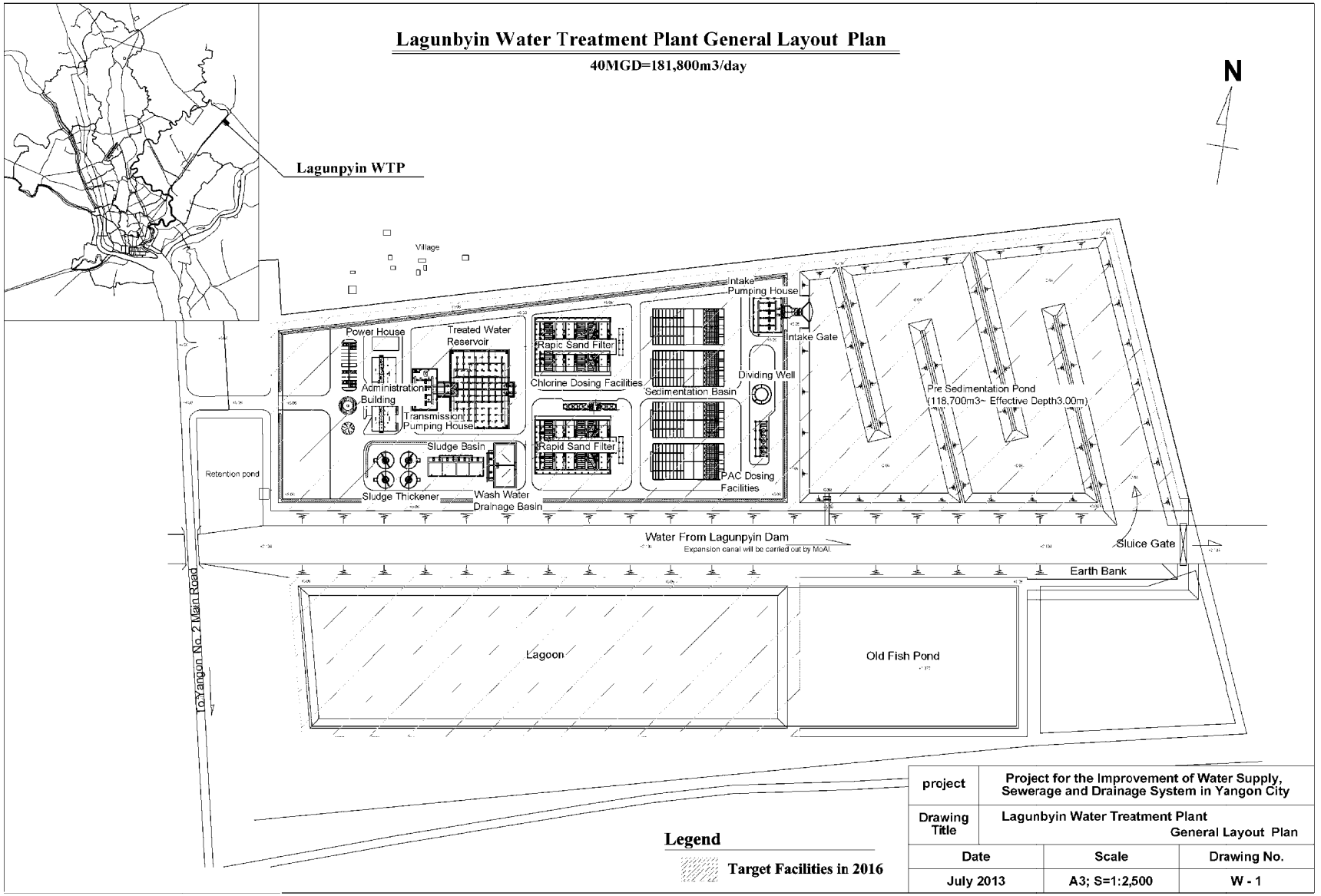
The system or type of equipment of facility is selected also considering operation and maintenance aspects. Equipment with many mechanical functions requires periodical rest of equipment for maintenance and replacement work. Such equipment must stop for a significant period of time when the spare parts are not ready at the time of a breakdown. Therefore, simple system such as mixture by gravity flow without electric power and maintenance-free shall be selected as much as possible.

(7) Capacity Calculation of Lagunbyin WTP

The result of capacity calculation of Lagunbyin WTP is attached in Appendix B.

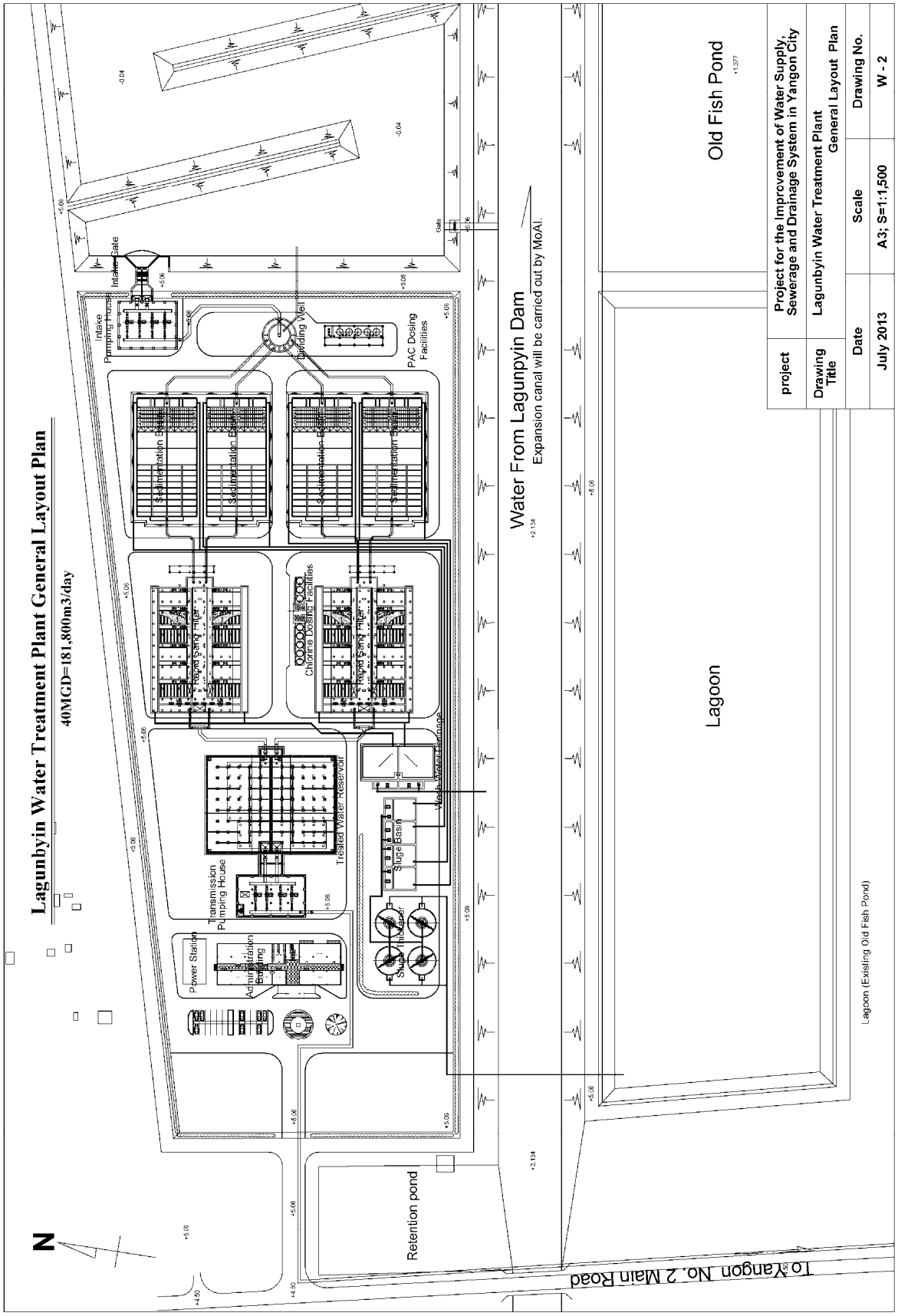
(8) General Layout Plan of Lagunbyin WTP

The general layout plan and water level profile of Lagunbyin WTP are shown in the following figures. Drawings of facilities planning are attached in Appendix G.



Source: JICA Study Team

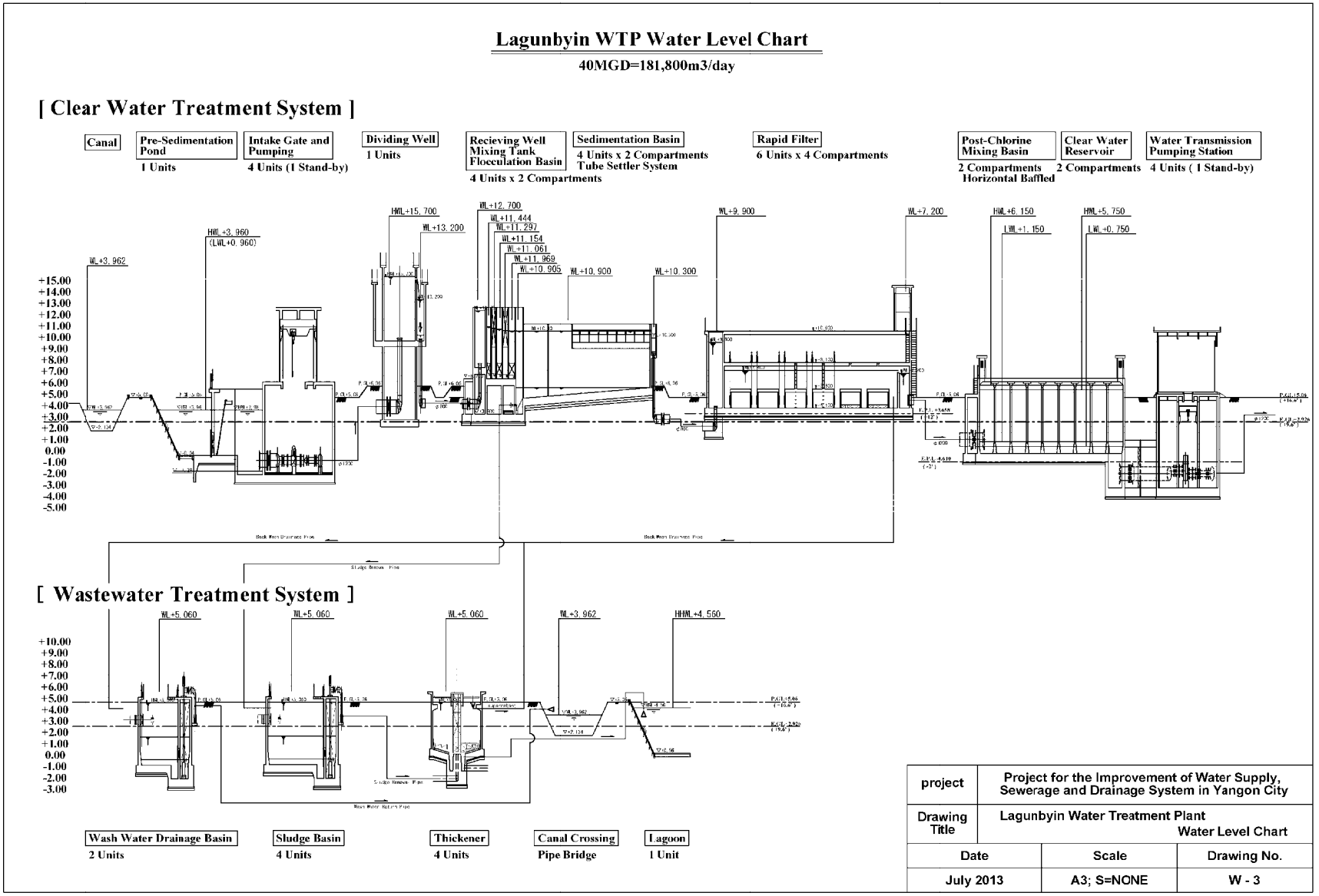
Figure 2.5 Layout Plan of Lagunbyin WTP at Ma-So (Whole)



Source: JICA Study Team

Figure 2.7 Layout Plan of Lagunbyin WTP at Ma-So (Part)

Source: JICA Study Team



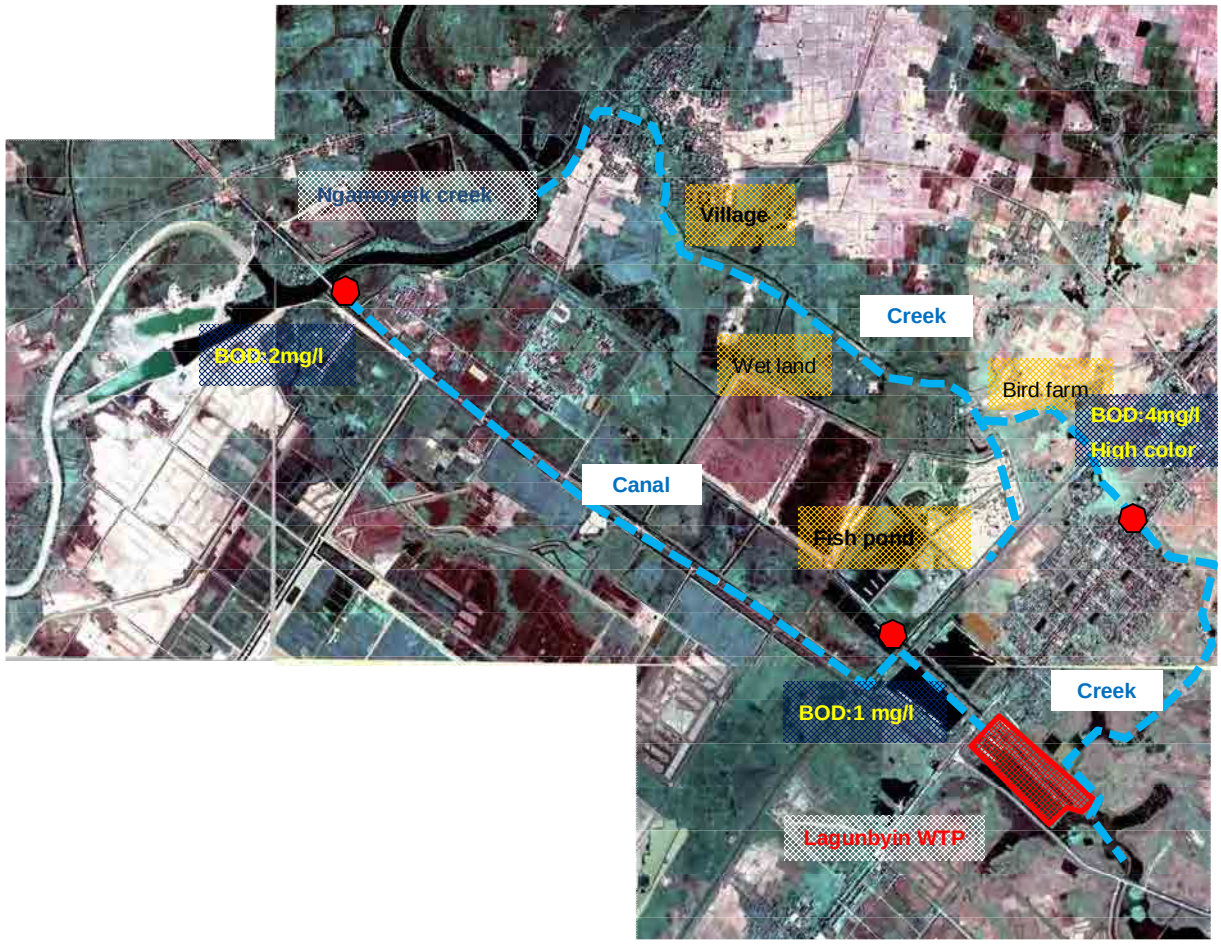
Source: JICA Study Team

Figure 2.8 Hydraulic Profile of Lagunbyin WTP

2.3.2 Raw Water Conveyance Facilities

The raw water is taken from Ngamoeyeik Creek and conveyed to Lagunbyin WTP. Two candidate routes for conveyance facility have been identified by field survey; a natural creek and irrigation canal. The conveyance facility is planned by YCDC in which existing canal or creek is used after rehabilitation. The Study team proposes the irrigation canal as conveyance facility because it is less polluted as a result of water quality analysis and is subjected to less pollution than the creek, along which many pollution sources such as village, wetland, bird farm, and fish pond are located.

Finally, the creek was decided as conveyance facility in October, 2013 as the result of discussion of YCDC and Ministry of Agriculture and Irrigation (MOAI).



Source: JICA Study Team

Figure 2.9 Proposed Route of Raw Water Conveyance

2.3.3 Intake Facilities

(1) Planned Facilities

Table 2.12 Planned Facilities

Facility	Number
Intake flow	200,000 m^3/day
Pre-sedimentation pond	1
Intake Pipe	None
Intake Pump	4 units

Source: JICA Study Team

(2) Intake Point

Intake point is planned at the YCDC-owned site located beside the irrigation canal which was previously used as a fish pond. However, it is doubtful whether this point is appropriate for intake point judging from the observations made in February 2013, dry period because of its shallow depth. Thus, the following three alternatives are considered:

- Alternative 1: Canal dredging
- Alternative 2: Intake at Ngamoeyeik river and convey water to Ma-So WTP
- Alternative 3: Intake and treatment at Ngamoeyeik river

JICA Study Team recommends Alt. 3 because;

- Intake at the irrigation canal seems unstable due to its shallowness and its inadequate hydraulic slope.
- Siltation will take place along the irrigation canal.
- Raw water quality may be worsened due to wastewater from the existing villages and future urbanization along the canal.
- Soil stability will take place for a long period in the former fish breeding pond.

However, intake point has been decided by YCDC because a) WTP needs to start operation in 2015 for supply to Dagon Seikkan, b) Construction should start in 2013, and c) Land acquisition period is minimal. YCDC started foundation piling for major facilities in April 2013. Canal dredging and widening for stable water intake can be asked to the irrigation department according to YCDC. Therefore, intake point is planned based on YCDC decision.

(3) Intake Facility

Intake facilities are planned to secure required amount of water throughout year. The following should be considered for the planning:

- No clogging of intake by flowing vegetables, trees, solid waste, etc.
- No clogging by plants, sand, etc., during flooding.
- Stable intake even during low water level during dry period.

Intake facilities consist of intake gates, conduits, pre-sedimentation pond and intake pumps.

Pre-sedimentation ponds are planned between intake gates and intake pumps to improve raw water quality. This will reduce consumption of high-cost coagulant and avoid unnecessarily large size of sedimentation basins and filters. Size of pre-sedimentation pond is equivalent to 12 hours volume of the daily maximum water demand based on the result of sedimentation tests made during the rainy period in 2013 by JICA Study Team (Appendix A). Backhoe shall be provided for periodical dredging in the pre-sedimentation pond.

Sand-trapping is also provided in intake pump well and the accumulated sand will be drained by pumps. Automatic bar screens are also planned to prevent damage to intake pump. In addition, old fence shall be installed to protect.

[Planned Intake Water Level]

- HWL+3.962 m (Source: YCDC)
- LWL+0.962 m

[Facilities Specifications]

(Pre-sedimentation Pond)

- Volume: 12 hours, Baffle walls are provided to prevent short-circuiting of flow
- Dimension: 45m width x 880m length x 4.0m depth (with 1.0m depth for accumulated sand) x 1 basin
- Effective Volume: 118,700m^3 (without 1.0m depth for accumulated sand)
- Accessory: Oil fence, Backhoe

(Intake pump well)

- Dimension: (2.0m width x 7.0m length + 4.0m widthx6.0m length) x 4.0m depth x 2 units
- Volume: 300 m^3 (effective capacity)
- Accessories: Intake Gates, Automatic Screen, Drain Pump (Sand Pump), Electrical Crane, Water Level Gauge (Electrode and Pressure type)

(Intake Pump Building)

- Dimension: 21.0 m width x 26.0 m length x16.0 m height
- Accessories: Intake Pumps, Flow Meter (Inflow): electromagnetic type

1) Gate and Screen

To protect pump equipment, sand, sediment, suspended solid, etc. shall be removed from the raw water. For effective maintenance, stop log, inlet gate, screen, water level meter, etc. shall be installed. The following are major equipment.

Table 2.13 Gate and Screen

Item	Specification	Number
Inlet Gate	Electrical-driven cast iron gate, 1.4 m width x 1.4m height	2
Manual Coarse Screen	Bar Screen 2.0 m width x 5.0m height x 100mm spacing	2
Mechanical Medium Screen	Net Screen with Electrical Raking 2.0m width x 5.0m height x 10mm Spacing	2

Source: JICA Study Team

2) Intake Pump

Four pumps (3 duty and 1 stand-by) are planned.

Table 2.14 Intake Pump

Item	Specification	Number
Intake Pump	Horizontal-axis double-suction Volute Pump 46.3 m^3/min. x approx.20m Head x 350 kW	4 (including 1 stand-by)
Discharge Valve	Electrical-driven Butterfly Valve 700 mm Dia. x 0.75 kW	4 (including 1 stand-by)

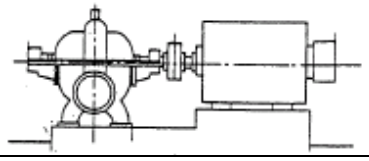
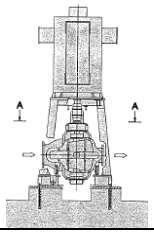
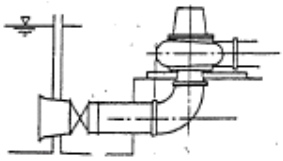
Source: JICA Study Team

a) Selection of Pump Type

The following pump types are generally used; horizontal shaft type double-suction volute pump, vertical shaft type double-suction volute pump, vertical shaft, volute type mixed flow pump. Among the above types, horizontal shaft type double-suction volute pumps are planned due to the following reasons;

- Easy operation and maintenance of pumps and motors
- Large number of this type of pumps are being used by YCDC
- Cost is economical

Table 2.15 Type of Intake Pump

	Pump Image	Maintenance	Initial Cost*
Horizontal Shaft Type Double-suction Volute Pump		Easy	1.0
Vertical Shaft Type Double- suction Volute Pump		Removal of motors is required for maintenance	1.1
Vertical Shaft, Volute Type Mixed Flow Pump		Removal of motors is required for maintenance	1.1

* Numbers show comparative number assuming mechanical mixing method which has been used widely in Japan, as 1.0.

Source: JICA Study Team

b) Intake Pump Control System

Intake pumps (and clear water transmission pump) should be operated continuously. Since intake canal level does not fluctuate much, speed control of the pumps is not required. Flows and operation pressures shall be monitored. The operation of pump shall be based on the water level in dividing well.

2.3.4 Treatment Facilities

(1) Planned Facility

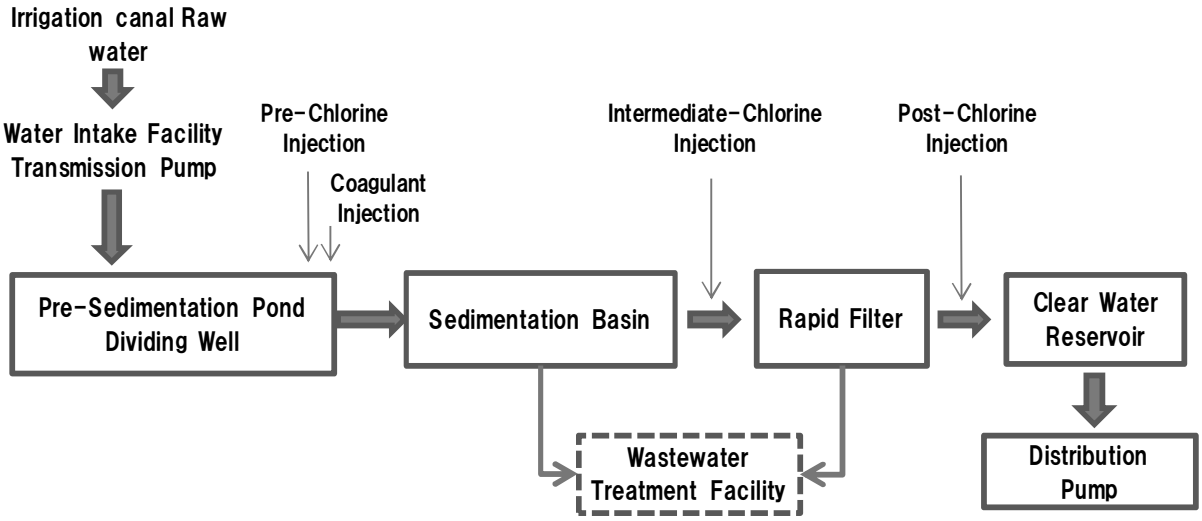
Table 2.16 Treatment Facilities

Facility	Number
Planned Quantity	190,900 m^3/day (40MGD)
Dividing Well	1 pond
Sedimentation Basin	8 basins
Filter	24 filters
Treated Water Reservoir	2 basins
Sludge Treatment	1 lot
Chemical Dosing	1 lot
Substation Facilities	1 lot
Administration Facilities	1 lot

Source: JICA Study Team

(2) Treatment Process

Soluble components such as odor, color, organic, inorganic substances and by-products of disinfection, and insoluble components such as turbidity, algae and microorganism are removed in the treatment process. Process of "Coagulation – Sedimentation – Filtration" is generally used for treating surface water. The same is employed for the Lagunbyin system, judging from the raw water quality analysis. This system has been adopted in other treatment plants in Yangon and designed by YCDC. The type of chemicals to be used and their dosing rates will be decided based on "jar tests" during the detailed design stage. For planning purpose, PAC as a coagulant is considered.



Source: JICA Study Team

Figure 2.10 Treatment Process Flow

(3) Dividing Well

Raw water pumped by intake pumps is sent to dividing well where water is distributed evenly by overflow weir to 4 trains (8 sedimentation basins). Its structure is of cylindrical shape because of strong structures and economical cost of this shape. The raw water shall be distributed by overflow weir. In addition, pre-chlorination and coagulant (PAC) shall be injected at this point and mixing shall be made in following receiving well.

(Design conditions)

- Detention time: 1.9 minutes (should be more than 1.5 minutes according to Japanese Guideline)

(Design)

- Dimension: dia. 9.0 m x 4.0 m (RC-made cylindrical shape)
- Accessories: Overflow pipe, drain pipe

(4) Receiving Well cum Rapid Mixing Basin

Receiving well cum a rapid mixing basin is attached to sedimentation basin. The raw water is conveyed from dividing well to receiving well, where rapid mixing will be made utilizing turbulent

flow energy from water falling from overflow weirs.

(Design conditions)

- Detention time:
  - Receiving well: 4.5 minutes in receiving well
  - Rapid mixing basin: 6.2 minutes (more than 1~5 minutes as per Japanese guideline)
- Water depth: more than 3.0 m and
- Water falling from overflow weirs: more than 1.0 m

(Design)

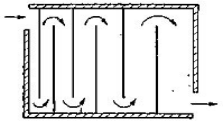
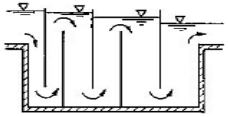
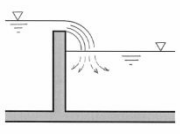
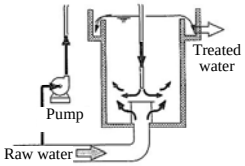
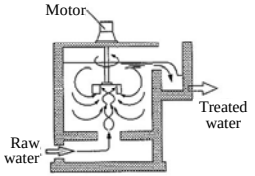
- Dimension:
  - Receiving well: 3.0m x 5.0m x 5.0m
  - Rapid mixing well: 3.0m x 5.0m x 4.25m
- Mixing method: turbulent flow mixing by water falling from overflow weirs
- Accessories: Overflow pipe, drain pipe, chlorine injection point, PAC injection point and weir for mixing

(Selection reasons for rapid mixing (see next table))

- cheap running cost
- no maintenance requirement without mechanical parts
- better mixing effect with more than 1.2 m of water drop

The following table shows comparison for selecting rapid mixing method. Inflow to flocculation basin will be from bottom and upward for effective mixing.

Table 2.17 Coagulant Mixing Method

	Method Using Flow Energy						Pump Mixing		Mechanical Mixing	
	Horizontal Zigzag Flow		Vertical Zigzag Flow		Hydraulic Jump					
Structure	 Horizontal baffled channel method (top view)		 Vertical baffled channel method (cross section)							
Mixing Effect	Need high flow speed for effective mixing	○	Need high flow speed for effective mixing	○	Large due to large water falling	◎	Flexible due to change of water circulation volume	◎	Flexible due to change of impeller rotation speed	◎
Effect by Flow Volume Change	Agitation Index will change	△	Agitation Index will change	△	Agitation Index will change	△	Agitation Index will slightly change	○	Agitation Index will be constant.	◎
Operation and Maintenance	Easy due to no mechanical parts.	◎	Easy due to no mechanical parts.	◎	Easy due to no mechanical parts.	◎	Needs operation and maintenance of mechanical parts.	△	Needs operation and maintenance of mechanical parts.	△
Required Motive Power	0	◎	0	◎	0	◎	1.4	△	1.0	△
Required Area	Medium (Need walls)	○	Medium (Need walls)	○	Small	◎	Large, Pump Room	△	Small	○
Initial Cost*	0.2	◎	0.2	◎	0.1	◎	1.6	△	1.0	○
Operation Cost*	0	◎	0	◎	0	◎	1.4	△	1.0	○
Experiences	Large	◎	Large	◎	Large	◎	Small	△	Large	◎
Overall	○		○		◎		△		○	

* Numbers show comparative number assuming mechanical mixing method which has been used widely in Japan, as 1.0.
Source: JICA Study Team

(5) Flocculation basin and Sedimentation Basin

1) Flocculation Basin

Small flocs will be produced after coagulants are mixed with raw water. These small flocs need to be developed into large ones so as to settle down effectively in the sedimentation basin. Flocculation basin is planned for this development after rapid mixing basin and before sedimentation basin. Of the mechanical and natural flocculation methods, natural one is employed in this plant. Horizontal and vertical zigzag flow flocculation method is planned in which mixed water is guided from bottom.

(Design condition)

- Detention time: 25 minutes (more than 20~40 minutes as per Japanese Guideline)

(Design)

- Dimension: average 1.5 m x 63.5 m x 4.3m
- Mixing method: Horizontal and vertical zigzag flow
- Accessories: Up-and down weir equipment

(Selection reasons)

- Low initial cost
- Low running cost comparing with mechanical type when enough water drop is available

2) Sedimentation Basin

Developed large flocs are settled in sedimentation basin. In general, sedimentation basin type is categorized as horizontal-flow basin, basins with inclined plate or inclined tube, high-speed accelerator (flocculent settling basin).

During the Study period, YCDC has already started driving piles based on 4 horizontal-flow sedimentation basins with inclined tube. The available land for WTP is not wide enough for horizontal flow and high rate coagulation methods and these types are excluded in selection. Horizontal-flow sedimentation basins with inclined plates require much maintenance in cleaning when sludge is accumulated on the plates in case of high turbidity raw water. There is high possibility of breaking and falling of inclined plates. Therefore, inclined tubes shall be selected to reduce required land for sedimentation.

(Design Conditions)

- Detention time: 2 hours (more than 1 hour as per Japanese Guidelines)
- Average flow velocity: 0.3 m/min
- Average up-flow velocity: less than 80 mm/min
- Surface load: less than 7 to 14 mm/min

(Design)

- Dimension: 12.5m x 38.6m x 4.2 m with inclined tubes 12.5 m x 22.5 m x 0.57m
- Sedimentation method: Horizontal-flow with inclined tube, 2 guiding walls for streamlining

flow at inlet and outlet sides and collecting troughs

- Sludge Discharge Valve: Automatic eccentric valve with timer control
- Accessories: inclined tube equipment, guiding walls, de-sludge equipment (valves, pipes), trough for water collection

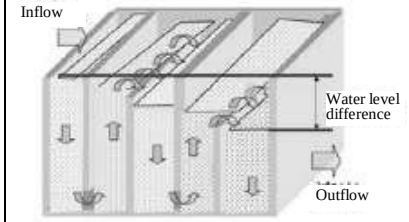
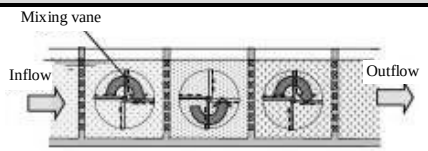
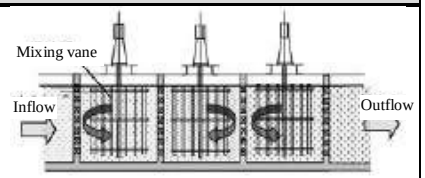
(Selection reasons)

- Small required land
- Many track records in neighboring country
- Stable treatment result in case of large fluctuation in turbidity of raw water

3) Intermediate Chlorination

Chlorine will be also injected into settled water channel in the sedimentation basin to remove iron and manganese and prevent hazardous tri-halo-methane development, when much of organic compound of raw water is included. The injecting point of chlorine will be set as end of sedimentation basin, and a contact time of approximately 20 minutes is secured.

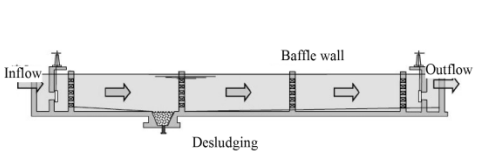
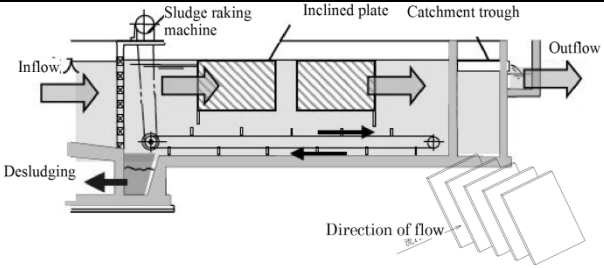
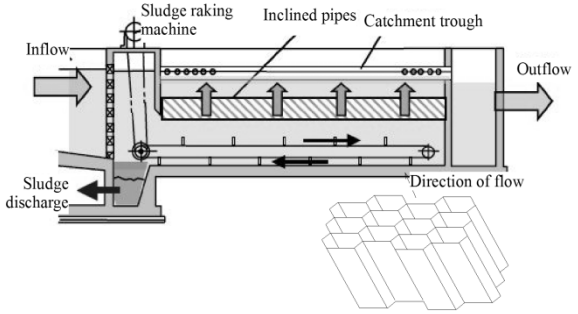
Table 2.18 Mixing Method of Flocculation Basin

	Method Using Flow Energy				Mechanical Mixing Method			
	Horizontal Zigzag Flow		Vertical Zigzag Flow		Horizontal Shaft Paddle		Vertical Shaft Paddle	
Structure	 (2) Horizontal baffled channel method (top view)							
Mixing Effect	0.5 meters water level difference is required.	○	0.5 meters water level difference is required.	○	Better by adjusting rotation numbers in each stage.	◎	Better by adjusting rotation numbers in each stage.	◎
Effect by Flow Volume Change	Agitation Index will change	△	Agitation Index will change (mixing is stronger than horizontal baffling)	○	Agitation Index will be constant.	◎	Agitation Index will be constant.	◎
Operation and Maintenance	Easy due to no mechanical parts.	◎	Easy due to no mechanical parts.	◎	Needs operation and maintenance of mechanical parts. Drive part is submerged and durability is not so good.	△	Needs operation and maintenance of mechanical parts. Drive part is not submerged and durability is good.	○
Required Motive Power	0	◎	0	◎	1.0	△	1.0	△
Required Area	Medium	△	Small	◎	Small	◎	Small	◎
Initial Cost*	0.2	◎	0.2	◎	1.0	△	0.6	○
Running Cost*	0	◎	0	◎	1.0	△	1.0	△
Overall	○		◎		△		○	

* Numbers show comparative number assuming horizontal-shaft paddle mixing method which has been used widely in Japan, as 1.0.

Source: JICA Study Team

Table 2.19 Sedimentation Method

	Conventional Horizontal Flow		Horizontal Flow with Sedimentation Effect Enhancement			
			Horizontal Flow with Inclined Plate		Upward Flow with Inclined Tube	
Structure						
Retention Time	3-5 hours		Approximately 1 hour		Approximately 1 hour	
Surface Load	15-30 mm/min		4-9 mm/min		7-14 mm/min	
Velocity	Less than 0.4 m/min		Less than 0.6 m/min		Less than 0.08 m/min	
Basin Depth	3-4m		4-5m		4-5m	
Required Area	100 %	△	30 to 40 %	◎	50 to 70 %	○
Turbidity of Settled Water	Low due to intermediate flow guiding wall, however, sometimes not low due to short-circuit and/or density flows	△	Low due to uniform flow	◎	Low due to uniform flow	◎
Flexibility	Good for change of raw water turbidity. Not good for change of raw water temperature. Good for change of raw water flow volume.	△	Not good for change of raw water turbidity. Good for change of raw water temperature. Good for change of raw water flow volume.	◎	Not good for change of raw water turbidity. Good for change of raw water temperature. Good for change of raw water flow volume.	◎
Operation and Maintenance	Continuous Monitoring is required because density flow and short-circuit flows take place often. Cleaning is easy.	○	Periodical cleaning is required to remove settled sludge on the plates. Removal of plates is required in cleaning.	△	Periodical cleaning is required to remove settled sludge on the tubes. Cleaning is not difficult.	○
Initial Cost*	1	◎	3	△	2	○
Running Cost*	0	◎	0	◎	0	◎
Experiences	Many	◎	Little (Many in Japan)	△	Relatively many	○
Overall	△		○		◎	

* Numbers show comparative number assuming conventional horizontal flow basin as 1.0.

Source: JICA Study Team

(6) Filter

Micro flocs which cannot be settled down in sedimentation basins should be caught in filters. Two-layer filter media of anthracite and sand is employed in the Nyaunghnapin water treatment plant. Similar process is planned for this plant as well. This should have an effective trap for micro flocs theoretically. However, its operation in the existing Nyaunghnapin water treatment plant does not show good results; particles are small, backwashing frequency speed is high, resulting in filter media being washed away. Two-layer media filter (anthracite and silica sand) is also adopted for this plant by reviewing design in this F/S. However, filter speed will be reduced to 150 m/day for single layer filter considering increase in turbidity in backwashing and duration time of filters.

Backwashing together with air washing method is adopted for two layer filter method. In Nyaunghnapin WTP, valves operation is conducted manually. However, for the proposed plant, electrically driven operation of valves is adopted because of large number of valves in 24 filters (6 basins x 4 trains). Automation will result in efficient and effective filter washing. Roofs are provided for filter to prevent algae generation, density flow etc.

(Design conditions)

- Filter flow speed: 150m/day
- Conventional rapid sand filter

(Design)

- Dimension: 5.5m x 12.0m x 6 basins x 4 trains
- Filter media: 2 layers (Anthracite: 20 cm thickness) and (Silica sand: 50 cm thickness), Uniformity coefficient: less than 1.7mm
- Washing method: Backwashing with air washing
- Accessories: Backwash pump, air wash equipment (compressor), under drain system (porous block), drain trough, drain pipe, inlet and outlet valves (electrically driven)

(7) Treated Water Reservoir

Theoretically, the treated water amount and treated water pumping should be the same. However, in case that the two flows are not same, treated (clear) water reservoir will be required to adjust the flows difference. The required volume is usually for 1 hour of the daily maximum demand. Additional 20 minutes will be added for the reservoir volume. This is for mixing of chlorine added as post-chlorination. Horizontal-flow mixing is proposed with 1 injection point per one compartment. The inside of the reservoir is divided into 2 compartments for convenient reservoir cleaning.

(Design conditions)

- Detention time: 20 minutes for post chlorination mixing basin (more than 1 minutes as per Japanese Guidelines)

1.0 hour for treated water reservoir (more than 1 hour as per Japanese Guidelines)

- Mixing method: Horizontal zigzag flow type

(Design)

- Dimension: 4.7m x 56.0m x 5.0m for past chlorination basin
  18.8m x 46.6m x 5.0m = 4,380m^3 x 2 basins
- Accessories: Chlorine injection point, water level gauge, overflow equipment, drain equipment (pipe and valve) and ventilator

(8) Water Flow and Water Quality Monitoring

Water flow and quality monitoring should be done continuously for producing good treated water to meet the water quality standards. The water quality parameters and flow to be monitored at different locations are listed in following table.

Table 2.20 Monitoring Points of Water Flow and Quality

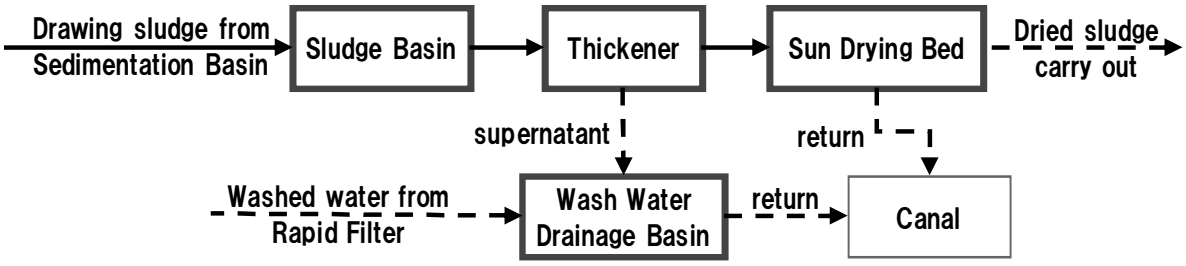
Item	Monitoring location	Monitoring items
Raw water	- Water quality: intake or dividing well - Flow: Between dividing well and receiving well	・Turbidity: PAC dosing rate control ・pH：PAC dosing rate control ・Raw water flow rate: Pre-chlorination and intermediate-chlorination control
Settled water	- Water quality: In settled water channel	・Turbidity ・pH ・Residual chlorine
Filtered water	- Water quality: Filtered water channel - Flow: Between filter and treated water reservoir	・Turbidity ・pH ・Filtered flow: `Post chlorination control
Treated water	- Water quality: after pumping - Flow: after pumping	・Turbidity ・pH ・Residual chlorine: residual chlorine control at the distribution points ・Transmission flow: understanding of transmission flow

Source: JICA Study Team

(9) Sludge Treatment

Sludge treatment method is decided considering raw water quality, quantity and quality of waste or washed water, characteristics of sludge, disposal method of generated sludge, operation requirements, land size of each method, construction cost of each method and so on. Though, sludge treatment facilities generally consist of sludge basin (for sludge from sedimentation basins), wash water drainage basin (from filters), sludge thickener and dehydration facilities such as lagoon, sun drying bed or mechanical facilities.

Use of lagoon for dehydration is a cheaper option. The fish pond owned by YCDC adjacent to the existing water treatment plant site can be converted to lagoon and utilized for it. Thickened sludge is transferred to lagoon where sludge is dehydrated by natural sunlight. Its supernatant is returned to the canal. Settled and accumulated sludge shall be removed during dry period.



Source: JICA Study Team

Figure 2.11 Sludge Treatment Process

1) Wash Water Drainage Basin (from Filter)

Wash water drainage basin temporarily stores back-wash water from filters. Volume of 2 basins should be equal to at least one day's back-washed water volume. Discharge pumps are provided for the basins.

[Facilities Specifications]

- Design Parameter: 2 basins, RC Structure
- Discharge Pump: 2 duty and 1 stand-by

2) Sludge Basin (form Sedimentation basins)

Sludge basins are provided before thickeners to adjust flow and quality of sludge discharged from sedimentation basins. Volume of the basins are planned to receive one day's discharged volumes from the above basins during rainy season when raw water turbidity is high.

[Facilities Specifications]

- Design Parameter: 4 basins, RC Structure
- Sludge Withdrawal Pump: 2 duty and 1 stand-by

3) Sludge Thickener

A Thickener is provided to accelerate dehydration of sludge and reduce sludge volume. Of the three types of commonly used sludge thickening processes; gravity thickening, floating thickening, and filtration thickening, the most generally used gravitational thickening is selected for this plant. The thickener will be provided with rotational sludge rake system.

[Facilities Specifications]

- Design Parameter: 4 tanks, RC Structure, Cylindrical-shape type
- Sludge Withdrawal Pump: 2 duty and 1 stand-by

4) Lagoon

Lagoon is planned to store and settle sludge discharged from thickeners. Supernatant from the lagoon is sent back to the canal. Lagoon is used as sludge drying bed during dry season, sludge is dried in the beds, settled and accumulated sludge is raked and collected. Access road and slope is provided for that purpose, collected sludge is used for reclamation purpose or as covering materials.

(10) Chemical Dosing Facility

1) PAC Dosing Equipment

Alum and PAC are generally used as coagulants. PAC is flexible to raw water quality change despite its relatively higher cost, therefore, used in YCDC. For this plant, PAC is recommended same as existing chemical. Accordingly, storage tanks and dosing pumps are provided for PAC dosing.

2) PAC Dosing Rate

Liquid PAC dosing rate is planned as 40 to 100 mg/L based on the trial experiments made in the end of June 2013 and referring to the actual dosing rate performed in the existing Nyaunghnapin water treatment plant.

In the Nyaunghnapin water treatment plant, water quality analyst has been carried out daily using jar test method for deciding best dosing rates. The decided dosing rates are as follow;

Dry season: Turbidity Average 60-70 NTU, PAC dosing rate 60 to 70 mg/L

Rainy season: Turbidity 100-500 NTU, Average 200-250NTU, PAC dosing rate 80 to 100mg/L

For this plant, pre-sedimentation basin with 12 hours volume is planned to reduce high turbidity. Raw water quality of 250 NTU was reduced by two-thirds to 75 NTU after 12 hours of pre-sedimentation, measured at the end of June 2013. Referring to these values, dosing rates are planned between 40 to 100 mg/L as shown below.

Table 2.21 PAC Dosing Rate

Season	Expected Turbidity after pre-Sedimentation Basin	Water Quantity	Dosing Rate
Dry	40NTU	Daily Average/ Daily Maximum	40mg/L
Rainy	75NTU	Daily Average	60mg/L
	250NTU	Daily Maximum	100mg/L

Note: Dosing rate is tentative and needs verification during detailed design period.

Source: JICA Study Team

3) Design Value of Chemical Dozing Equipment

The chemical dosing facility is design as following design criteria.

- Chemicals: Liquid PAC
- Doing rate: 40 to 100 mg/L

(11) Chlorination Facility

Chlorination facility is planned to provide safe water to consumers. Liquid sodium hypochlorite is planned as chlorination agents based on the comparison shown in table below. Although hypochlorite's costs are relatively high, dosing facilities are simple and can be imported. Liquid hypochlorite has already been used in the existing wastewater treatment plants in Yangon. Dosing points and purposes are as follows:

- Pre-chlorination: Dosing rate is set as the minimum rate in order to prevent algae generation and growth
- Intermediate-chlorination: Used as an alternative of pre-chlorination when the raw water is polluted by wastewater along the intake canal.
- Post-chlorination: Providing residual chlorine to take care of the potential pollutants seeping in the distribution system. The planned residual chlorine concentration will be 70 % of the original chlorine concentration after travelling 30 km pipe length.

Table 2.22 Chlorine Dosing Rate Plan

Item	Dosing Rate(mg/L)		
	Maximum	Average	Minimum
Pre-chlorination	1.0	0.5	0.3
Intermediate chlorination	1.0	0.5	0.3
Post chlorination	5.0	3.0	1.0

Note: Dosing rate should be decided based on water quality tests before the detailed design.
Source: JICA Study Team

Table 2.23 Chlorination Agents

	Purchase of Liquid Chlorine	Purchase of Liquid Hypochlorite	On-site Generation of Liquid Hypochlorite
Character	Liquid Chlorine contained in Gas Cylinder	Liquid	Liquid, Produced from salt by electrolysis
Effective Chlorine Concentration	More than 99.4%	Approximately 12.0%	Approximately 1% by non-diaphragm type Approximately 5% by diaphragm type
Stability	Stable	High Alkalinity More unstable when effective chlorine concentration is higher. More dissolved when salt concentration is higher.	Low Alkalinity Less stable than Liquid Chlorine but more stable than purchased liquid hypochlorite.
Storage	Should follow "Safety	Concentration may become	Long-term storage is possible

	Purchase of Liquid Chlorine	Purchase of Liquid Hypochlorite	On-site Generation of Liquid Hypochlorite
	regulation on general high-pressure gas" etc. in Japan.	lower, Long-term storage is difficult.	as salt.
Dosing Devices	Complex	Easy	Relatively Complex
Handling Remarks	Careful handling is required due to strong poisonous gas with irritating odor.	- Air bubble is generated by electrolyzing sodium hypochlorite. - So consideration should be taken to prevent pumps and pipes from airlock generation.	- Small chances of obstacles from air bubble and scale generation - Discharge after dilution of hydrogen generated during electrolysis.
Measures Against Leakage	Lead to heavy accidents when chlorine gas leaks. Gas detector, neutralizer and absorbers are mandatory for small-sized facility. In addition, neutralizing reaction towers are required for large-sized facility.	Barrier is required to prevent overflow. Prevention of mixing with PAC is required, which generates poisonous chlorine.	Barrier is required to prevent overflow. Hydrogen should be discharged sufficiently otherwise it will explode or catch fire.
Operation and Maintenance	Chlorine dosing device, vaporizer, detector, neutralizer, absorbers etc.	Dosing device	Electrolyzer
Overall	○	◎	△

Source; Guideline of Treatment Technology 2010, Waterworks Technology Research Center, Japan

(12) Mechanical Facility

1) Design Water Flow

Mechanical design for process and facility should be done with a view of economy and easiness of maintenance as well as review of the existing mechanical equipment used in YCDC. Design condition of each facility related to mechanical equipment is shown in the following table.

Table 2.24 Mechanical Equipment Design Condition for Each Facility

Facility	Design condition	
1) Receiving Well/Flocculation Basin 2) Sedimentation Basin, 3) Filter	190,900 m^3/ day Design inlet maximum turbidity 250 NTU Design inlet average turbidity 75 NTU	
4) Treated (clear) Water Reservoir/ Transmission Pump	181,800 m^3/ day (40 MGD)	
5) Wash Water Drainage Basin and Sludge Basin	190,900 m^3/ day	
6) Coagulation Facility	190,900 m^3/ day	
	PAC	Average dosage rate: 40 mg/L Maximum dosage rate: 100 mg/L
7) Chlorination Facility	190,900 m^3/ day	
	Pre or Intermittent chlorine	Average dosage rate: 1 mg/Leach
	181,800 m^3/ day	
	Post chlorine	Average dosage rate: 3 mg/L

Facility	Design condition	
8) Sludge Treatment Facility	190,900 m^3/ day	
	Inlet sludge concentration	approx. 0.5 %.
	Thickened sludge concentration	approx. 3.0 %

Source: JICA Study Team

2) Receiving and Distribution Well, Rapid Mixing Basin and Slow Mixing Basin

Eight inlet gates are provided.

Table 2.25 Mechanical Devices in Receiving and Distribution Well Cum Mixing Basin

Item	Specification	Number
Inlet Gate	Manual Iron Gate 0.6m Width x 0.6m Height	8

Source: JICA Study Team

3) Sedimentation Basin

Sludge in the existing treatment plants is withdrawn with a small number of withdrawal valves manually. However, withdrawal efficiency is not necessarily good because of manual operation of valves, improper locations of valves, insufficient volumes of sedimentation valves, wastewater basins etc.

To rectify the above issues and to achieve better quality of the treated water, sludge is planned to be withdrawn automatically. Electrically-driven valves are installed and controlled by timer. In addition, control consoles are placed on the above-ground level. However, sludge scraper is not planned and instead, accumulated sludge is collected manually and periodically same as the existing practices in other plants of YCDC. Prior to collection of the accumulated sludge and basin cleaning, water in the basin needs to be emptied through the above-mentioned electrically-driven valves. So, eccentric valves are planned which is not prone to clogging by sludge.

Table 2.26 Mechanical Devices in Sedimentation Basin

Item	Specification	Number
Sludge Withdrawal Valve	Electric-driven, eccentric-structure Valve Diameter 150 mmx0.4kW	32

Source: JICA Study Team

4) Rapid Sand Filter

Valves are operated manually in the existing filters of YCDC. In addition, Backwashing flow and pressure cannot be measured and controlled in the backwashing pumps. As a result, filtering process is not operated well. Therefore, as requested by the filter operating staff in the existing plants, automatic backwashing and surface washing systems are planned, which are operated both by timer and manually by monitoring water levels.

Table 2.27 Mechanical Devices in Filter

Item	Specification	Number
Inlet Gate	Electric-driven Iron Gate 1,650 mm width x 350 mm height x 2.2kW	24
Outlet Gate	Electric-driven Iron Gate 600 mm width x 600 mm height x 1.5kW	24
Surface Washing Valve	Electric-driven Butterfly Valve Dia. 400 mm x 0.2kW	24
Back Washing Valve	Electric-driven Butterfly Dia. 600 mm x 0.75kW	24

Source: JICA Study Team

5) Transmission Pump

Transmission pumps are installed at transmission pumping station which adjoins treated water reservoir of the plant. Since pressure tightness of a pipeline is 1.0 MPa, total pump heads should be set to maximum 90m. To decide the size of motor output, it is important to consider the experience of staff of YCDC in terms of repair. The capacity of pump is judged as maximum 800kw, which can be repaired by YCDC. Consequently, the number of pump to be installed is decided considering synchronization between intake pump and transmission pump.

[Pump Design Concept]

- Maximum Pump Head: 90 m corresponding to allowable pipe pressure of 1.0 MPa.
- Maximum Motor Output: 800kw (same capacity as YCDC is using)
- Countermeasures against water hammer: Surge tank/flywheel and/or non-return valve

Transmission pumps consisting of 4 pumps including 1 stand-by deliver 181,900 m^3/day water to the service reservoirs in Zone 7 and Zone 8 with a transmission pipe of dia. 1,200 mm and length 13,400 m. The above water includes demand in Thilawa SEZ. Water volumes are almost constant so that pumps are simply turned on and off based on water levels in both of the service reservoirs.

[Facilities Specifications]

Accessories such as non-return valves, surge tanks and/or flywheel should be provided near delivery side of the pumps to prevent developing negative water pressure due to water hammer phenomenon in case of long distance and flat pipeline routes. In addition, pressure gauges, motor operated discharge valves, etc. are also provided to the pumps. Bulk meters are also planned.

Table 2.28 Mechanical Device in Transmission Pump

Item	Specification	Number
Transmission Pump	Horizontal-shaft Double-suction Volute Pump 42.1 m^3/min x approx.40m Head x570 kW	4 (including 1 stand-by)

Source: JICA Study Team

6) Coagulation and Chlorination Facilities

a) Coagulation Facility

Tanks and dosing pumps constitute coagulation facility. Coagulants are dosed just before falling points at the end of receiving basin. Pumps consist of 2 duty and 1 stand-by. One duty of the pumps operates during dry season while 2 operate during rainy season. Pump type is simple and inexpensive diaphragm type, same as used in the existing WTPs. A total of 5 tanks are provided, their total storage volume is more than 1 day's requirement in rainy season and more than 2 days' requirement in dry season.

Table 2.29 Mechanical Devise in PAC Dosing Equipment

Item	Specification	Number
PAC storage tank	Cylindrical Tank 25 m^3	5 units
PAC dosing pump	Diaphragm 16 - 50 L/ min x 1.5 kW	3 units including 1 standby

Source: JICA Study Team

b) Chlorination Facility

Chlorine dosing facility consists of storage tanks and dosing devices. The dosing locations include one at the receiving well as pre chlorination, other at filter inlet channel as intermittent chlorination, and another at the clear well inlet channel as post chlorination. Total six dosing pumps including 2 stand-by for each are proposed. One is operated for pre chlorination, the other for post chlorination.

A total of three duty chlorine storage tanks are provided. At least ten days stock will be maintained at the proposed chlorinator building.

Table 2.30 Chlorination Facility

Item	Specification	Number
Chlorine Storage Tank	Cylindrical tank 25 m^3	3 units
Pre or Intermittent – chlorine dosing pump	Diaphragm 0.6 – 1.8 L/ min x 0.2 kW	3 units including 1 standby
Post - chlorine dosing pump	Diaphragm 1.9 – 5.7 L/ min x 0.4 kW	3 units including 1 standby

Source: JICA Study Team

7) Sludge Treatment Facility

a) Wash Waste Drainage Facility

Wash wastewater from filters are transferred to the wash water drainage basin by gravity. Supernatant water is returned to the pre-sedimentation basin by discharge pumps. A total of three pumps including

one standby are proposed. Major equipment is listed in the following table.

Table 2.31 Mechanical Device in Wash Water Drainage Basin

Item	Specification	Number
Discharge Pump	Non-clog centrifugal 6.6m^3/min x 22 kW	3 units including 1 standby

Source: JICA Study Team

b) Sludge Basin Facility

Sludge settled at the bottom of sedimentation basins is transferred to the sludge basin by gravity. The mixed sludge is transferred to the sludge thickener by sludge discharge pumps during daytime. A total of three pumps including one standby are proposed. One pump during dry season and two pumps during rainy season will be operated.

Table 2.32 Mechanical Device in Filter Wash Water Basin

Item	Specification	Number
Sludge Discharge Pump	Non-clog centrifugal 6.6m^3/min x 22 kW	3 units including 1 standby

Source: JICA Study Team

c) Sludge Thickening Facility

A total of four thickeners are proposed; which are designed as one duty and three stand-by during dry season and three duties during rainy season. Sludge of approx. 0.5 % concentration from sludge basin is thickened up to about 3 % concentration by gravity thickener, and thickened sludge is transferred to the proposed lagoon by thickened sludge pumps. A total of three pumps including one standby are proposed. One pump during dry season and two pumps during rainy season will be operated.

Table 2.33 Mechanical Devise in Sludge Thickener

Item	Specification	Number
Thickener	Gravity Thickener Dia. 30m x 2.2 kW	4 units
Thickened Sludge Pump	Non-clog centrifugal 1.4 m^3/min x 11 kW	3 units including 1 standby

Source: JICA Study Team

(13) Electrical Facilities

1) General

Electrical facilities are designed to achieve their continuous function and protection of the mechanical facilities of the plants. They are optimized to achieve economical requirements and to have the best practical maintainability of the plant. The situation and outstanding issues in the existing YCDC plants are taken into account. Design parameters of the electrical facilities are shown in the following table.

Table 2.34 Design Parameters of Electrical Facilities

Facility	Design Parameter	
Water Intake Facility and Water Treatment Plant (WTP)	1) Receiving Voltage	33kV, 50Hz, 1 circuit
	2) Receiving Transformer	5,000 kVA
	3) Installed Capacity	5,300 kW
	4) Operating Capacity	3,900 kW

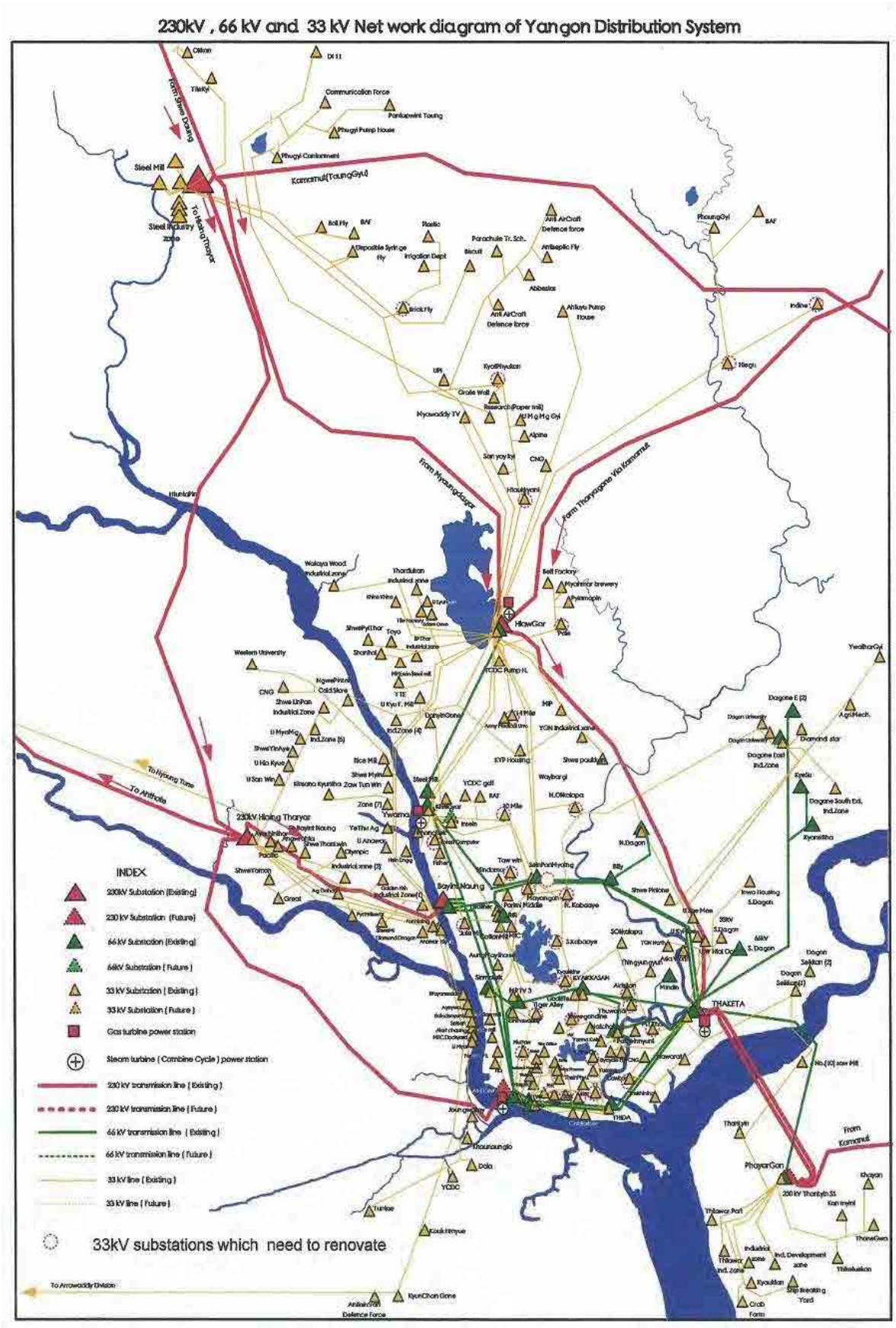
Source: JICA Study Team

2) Electricity Supply in the Yangon

YESB (Yangon Electrical Service Board) governs the electricity transmission and distribution in the area of the Plants located in Yangon city. Their main transmission network is 230kV and the sub network is 66kV and 33kV. YESB Electricity Network Diagram is shown in Figure 2.11. The town distribution for industry and home is 6.6kV and 400V, respectively, and there are planned or accidental power shutdowns very often. Electricity is available during working hours in the day time in some industrial areas, and the main receiving switches have been open for several months in some other industrial areas.

The Plants should receive electricity from 33kV sub network transmission line which corresponds to the YESB regulation for the plant with the receiving transformer capacity of 1MVA and above but less than 10MVA. There are existing YESB 33kV overhead lines dedicated for public utilities such as existing YCDC water treatment plants, and they are supplying electricity for 24 hours.

The Study Team collected a table of electricity bill for YCDC water and waste water plants in the fiscal years 2011 and 2012 (refer to Table 2.34). Electricity unit price is as low as 25 Kyats/kWh, and average electricity consumption is 1.6 million kWh per month and its bill is 45 million Kyats per month in the case of Nyaunghnapin water treatment plant. The table shows that the unit rate was increased to 35 Kyats/kWh from year 2012, but the recorded price figures indicate the original 25 Kyats/kWh. This inexpensive electricity and the supply from 33kV sub transmission network make it unnecessary to have a large size power generation facility in the Plant in view of economic feasibility of the project.



Source: JICA Study Team

Figure 2.12 YESB Electricity Network Diagram

Table 2.35 Electricity Consumption in the Existing YCDC Facilities

Electricity Consumption and Cost of Yangon Resion Water Systems

	Month	Apr. 2011	May. 2011	Jun. 2011	Jul. 2011	Aug. 2011	Sep. 2011	Oct. 2011	Nov. 2011	Dec. 2011	Jan. 2012	Feb. 2012	Mar. 2012
Nyaunghanpin Water Treatment	kWh	1,784,782	1,490,528	1,989,077	2,186,628	1,637,828	1,464,337	1,750,586	1,549,806	1,352,806	1,549,333	1,432,826	1,496,277
	Kyat	46,340,350	38,984,000	51,447,725	56,386,500	42,666,500	38,329,225	45,485,400	40,465,950	35,540,950	55,772,495	51,869,710	54,090,495
Gyobyu Water Treatment	kWh	888	528	1,515	1,172	1,314	1,181	1,294	1,210	2,429	1,786	2,098	1,816
	Kyat	38,000	26,600	53,675	45,100	48,650	45,325	48,150	46,050	76,525	78,310	89,230	102,960
North Dagon (South Dagon No.1) Water Treatment	kWh	706	551	551	66	60	50	60	100	2,178	651	414	607
	Kyat	23,050	19,175	19,175	7,050	6,900	6,650	6,900	7,900	58,850	28,185	19,890	26,645
South Dagon (South Dagon No.2) Water Treatment	kWh	52,008	48,736	51,040	49,896	47,344	45,232	44,000	49,984	44,088	56,936	62,040	58,784
	Kyat	1,372,800	1,166,000	1,348,600	1,320,000	1,256,200	1,203,400	1,172,600	1,322,200	1,174,800	2,065,360	2,244,000	2,130,040
Theaphyu Water Treatment	kWh	34,848	28,952	24,112	28,160	37,576	28,078	31,680	37,312	43,384	43,120	40,392	33,792
	Kyat	943,800	796,400	675,400	776,600	1,012,000	774,550	864,600	1,005,400	1,157,200	1,581,800	1,486,320	1,255,320
Yangonpauk Water Treatment	kWh	35,024	97,944	60,720	47,520	29,040	39,952	60,984	66,088	58,256	61,160	58,960	50,248
	Kyat	948,200	2,521,200	1,590,600	1,260,600	798,600	1,071,400	1,597,200	1,724,800	1,529,000	7,213,200	7,136,200	1,831,280
Aungtagon Pump Station	kWh	1,164,583	969,258	1,133,384	1,055,106	1,012,898	1,078,467	1,012,023	730,498	1,364,838	2,026,561	1,023,728	1,057,665
	Kyat	30,254,975	25,371,850	29,475,000	27,518,050	26,458,650	28,097,875	26,436,775	19,398,650	35,237,150	72,065,835	36,966,680	38,504,475
Hlawga Pump Station	kWh	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	33,255	36,020	40,800
	Kyat	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	1,322,775	1,319,500	1,486,800
Phugyi Pump Station	kWh	685,300	527,210	941,490	739,310	217,580	315,480	341,770	375,980	505,120	489,500	664,840	864,710
	Kyat	17,995,500	14,041,000	24,400,250	19,345,750	6,302,500	8,750,000	9,407,250	10,262,500	13,490,000	17,995,500	24,132,400	31,127,850
Yegu Pump Station	kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Kyat	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400
Gyobyu Pump Station -> Jointed in Gyobyu WT	kWh												
	Kyat												
Waste Water Treatment	kWh	15,576	13,552	13,992	15,048	14,960	14,784	15,488	15,400	13,904	15,312	13,640	13,258
	Kyat	462,000	411,400	422,400	448,800	446,600	442,200	459,800	457,600	420,200	808,520	550,000	537,680

	Month	Apr. 2010	May. 2010	Jun. 2010	Jul. 2010	Aug. 2010	Sep. 2010	Oct. 2010	Nov. 2010	Dec. 2010	Jan. 2011	Feb. 2011	Mar. 2011
Nyaunghanpin Water Treatment	kWh	1,651,057	1,501,798	1,471,814	1,685,196	1,709,906	1,598,181	1,634,303	1,531,458	1,325,033	1,524,999	1,797,648	1,798,764
	Kyat	42,997,225	39,265,750	38,516,150	43,850,700	44,468,450	41,674,076	42,578,376	40,007,250	34,846,625	42,345,277	46,662,080	46,662,000
Gyobyu Water Treatment	kWh	998	998	998	998	998	998	6,336	971	1,068	2,060	1,768	1,768
	Kyat	40,750	40,750	40,750	40,750	40,750	40,750	174,200	40,075	42,500	67,300	60,000	60,000
North Dagon (South Dagon No.1) Water Treatment	kWh	450	477	450	221	422	1,127	540	577	309	635	538	538
	Kyat	16,650	17,325	16,650	10,925	15,950	33,575	18,900	19,825	13,125	21,275	18,850	18,850
South Dagon (South Dagon No.2) Water Treatment	kWh	40,832	33,616	46,200	36,520	45,760	45,496	43,472	48,664	46,288	55,704	45,408	45,408
	Kyat	1,093,400	913,000	1,227,600	985,600	1,216,600	1,210,000	1,159,400	1,289,200	1,229,800	1,465,200	1,207,800	1,207,800
Theaphyu Water Treatment	kWh	21,648	22,176	24,112	32,208	29,128	25,608	33,352	32,120	32,208	37,336	40,216	39,600
	Kyat	613,800	627,000	675,400	877,800	800,800	712,800	906,400	875,600	877,800	1,056,000	1,078,000	1,062,600
Yangonpauk Water Treatment	kWh	41,712	11,352	24,904	19,360	2,112	39,360	41,536	41,096	34,056	57,024	37,048	37,048
	Kyat	1,115,400	356,400	965,200	556,600	92,200	996,600	1,111,000	1,100,000	924,000	1,498,200	998,800	998,800
Aungtagon Pump Station	kWh	70,301	1,201,218	1,272,322	1,300,861	714,254	1,085,774	1,122,264	969,517	991,322	882,457	1,007,202	969,800
	Kyat	18,722,925	31,170,850	32,948,450	33,661,925	18,996,750	28,284,750	29,197,000	25,378,325	23,923,450	23,201,825	26,320,450	25,385,400
Hlawga Pump Station	kWh	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000
	Kyat	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800
Phugyi Pump Station	kWh	1,048,850	772,640	806,300	766,700	877,800	662,640	684,200	704,990	872,820	817,430	573,210	573,210
	Kyat	26,869,850	19,964,600	20,806,100	19,816,100	22,593,600	17,214,600	17,753,600	18,273,350	22,461,600	16,084,350	14,978,850	14,978,850
Yegu Pump Station	kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Kyat	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400
Gyobyu Pump Station -> Jointed in Gyobyu WT	kWh												
	Kyat												
Waste Water Treatment	kWh	19,008	15,400	12,408	14,520	13,992	13,464	13,376	13,288	13,640	14,080	12,760	12,760
	Kyat	547,800	457,600	382,800	435,600	422,400	409,200	407,000	404,800	413,600	424,600	391,600	391,600

Fixed Charge Kyats	Variable Charge (Up to 2011) Kyats/kWh	Variable Charge (2012) Kyats/kWh
1,720,800	25	35
15,800	25	35
5,400	25	35
72,600	25	35
72,600	25	35
72,600	25	35
1,140,400	25	35
58,800	25	35
863,000	25	35
N/A	25	35
72,600	25	35

Source: JICA Study Team

3) Power Receiving Circuit

The receiving voltage is 33kV according to YESB regulation. There is one 33 kV overhead transmission line, along the Route #3, for four (4) infrastructure facilities including three existing water treatment plants like Nyaunghnapin WTP. YCDC agreed with YESB that the 33 kV overhead line will be tapped off at the cross-section of Routes #3 and #7 and YCDC extends a new 33 kV overhead line along Route #7 on their own land up to new water treatment plant (WTP) at Ma-So (Lagunbyin).

The estimated length of the new overhead line is 18 km.

Source: JICA Study Team

Figure 2.13 Proposed Lagunbyin Water Treatment Plant and 33kV Overhead Transmission Line

4) Receiving Substation

The 33kV receiving substation will consist of metal-enclosed switchgear in the electrical room, which is popular in most South-East Asian countries. However, some electrical manufacturers in Yangon said that outdoor switchyard is more popular in Myanmar not only because of cost but also because the indoor switchgears of this high voltage level often caused troubles due to dews produced therein when opening doors or in rainy season in general. Selection of outdoor switchgears will be evaluated during the basic design stage of the project. Outdoor switchyard is less expensive but requires more space as 10m x 20m (typical).

Table 2.36 Receiving Substation

Item	Specification	Number
Receiving Panel	Metal-enclosed Switchgears VCB (Vacuum Circuit Breaker), 36 kV	1 set
Main Power Transformer	Oil-insulated, Naturally Oil-cooled Transformer 33 kV / 6.9 kV	1 set

Source: JICA Study Team

5) Power Distribution System

Voltage application of the power distribution system in the plant is as follows;-

Motors 132 kW and above: 6.6 kV

Motors below 132 kW: 400V

Motors shall be direct-on-line starting on condition that the voltage drop study proves it otherwise during the detail design stage. An emergency generator should be provided in the plant so that it covers plant control and monitoring system for minimum requirement and safe plant operation. Plant equipment will not be supported by the emergency generator in principle except ones required for safety of the plant and personnel. The emergency generator should not be larger than 1MVA.

Table 2.37 Power Distribution System

Item	Specification	Number
6.6 kV High Voltage Switchgear	Metal-enclosed Switchgears VCB (Vacuum Circuit Breaker), 7.2 kV Vacuum Contactor, 7.2 kV	1 lot
Distribution Transformer	Oil-insulated, Naturally Oil-cooled Transformer 6.6 kV / 400 V	1 set
400 V Low Voltage Switchgear	Metal-enclosed Switchgears and Motor Control Center Main Circuit Breaker: ACB, 400V Outgoing Feeder Circuit Breaker: MCCB Motor Starting: DOL (except in high voltage drop circuit)	1 lot
Uninterruptible Power Supply (UPS) for Control	Solid-state Rectifier-Inverter with Bypass Switch Battery Back-up: 60 minutes	1 lot
Emergency Diesel Engine Generator	Diesel Engine Driven Generator Continuous Rating 400 V, 50 Hz	1 set

Source: JICA Study Team

6) Basic Philosophy of Electrical Facilities

It is strongly advisable to adopt electrical equipment conforming to IEC standards and/or Japanese standards (JIS, JEC & JEM) with the type test records, in order to assure the quality and personnel safety.

On the other hand, products of electrical manufacturers in Myanmar have been adopted in the existing YCDC plants and the local manufacturers give large benefit to YCDC personnel in operation, maintenance and upgrading. As the results of survey in June, 2013 by JICA Study Team, the type-tested electrical equipment is limited to low capacity transformers only, and therefore there is less chance to apply those until they proceed with the type tests and pass them.

The Plants do not have any critically unsafe facilities in the system, electrical facilities should have very basic fundamental protection only, and does not require any special devices.

Electrical cables have large impact on the plant operation by their product quality. Cables, from India, China, etc., in stockist companies are, and have been, normally used in electrical construction in Myanmar, but for many of these, the factory inspection records for quality control cannot be traced. The cables provided with individual test records in accordance with IEC standards and/or Japanese standards shall be used in these plants.

As for the electrical construction, there are several companies involved in the existing YCDC plant constructions. They should also participate in this water treatment plant construction so that they will help YCDC to proceed with proper maintenance and upgrading after start-up. However, these construction companies shall be strictly evaluated in view of construction safety control.

(14) Administration Facilities

Administration facilities are planned as shown below.

Table 2.38 Administration Facility

Item	Contents
Central Administration Building	Water Control Center (SCADA) with UPS Uninterruptible Power Supply (Uninterruptible Power Supply)
Water Quality Laboratory	Jar Test
Water Supply	Small pumps units are installed in service reservoir
Warehouse	Chemicals Storage
Workshop	For Pump Maintenance
Parking	
Security Room and Guard Post	
Road	Asphalt Pavement and Green Buffer Belt
Fence	Steel

Source: JICA Study Team

2.3.5 Transmission Facility

(1) Transmission facility

Table 2.39 Transmission Facility

	Zone 7	Zone 8	Thilawa SEZ
Pump	Installed in Ma-So (Lagunbyin) WTP		Boosted from Service Reservoir Zone 8
Pipe	φ1200 x 13.46km Including for Zone 8	φ1000 x 4.06km	φ700mm x 29.5km
			Including Bago River Crossing x 0.68km

Source: JICA Study Team

(2) Transmission Pump

Refer to the previous section 2.3.4 (12) 5).

(3) Transmission Pipe

1) Pipe Route

Pipe routes are selected along wide roads for accommodating large-sized pipes and the shortest distances as much as possible.

2) Pipe Material

Steel pipes or ductile pipe for large-sized pipes (φ1100 mm and above) and ductile iron pipes for medium-sized pipes (φ200 to φ1000 mm) are recommended. Pipes will be laid on the ground beside roads in the suburbs. In this case, PC pipe and fiber reinforced plastic (FRP) pipe is not recommended which are weak in sunlight and in terms of absorbing impact/ shock. In the roads with heavy traffic in the city, pipes will be laid under roads. In this case, pipes need to bear heavy traffic loads.

3) Hydraulic Analysis

Hydraulic analysis result is shown in the following figure. Conditions of the analyses are set as below.

a) Minimum Water Pressure

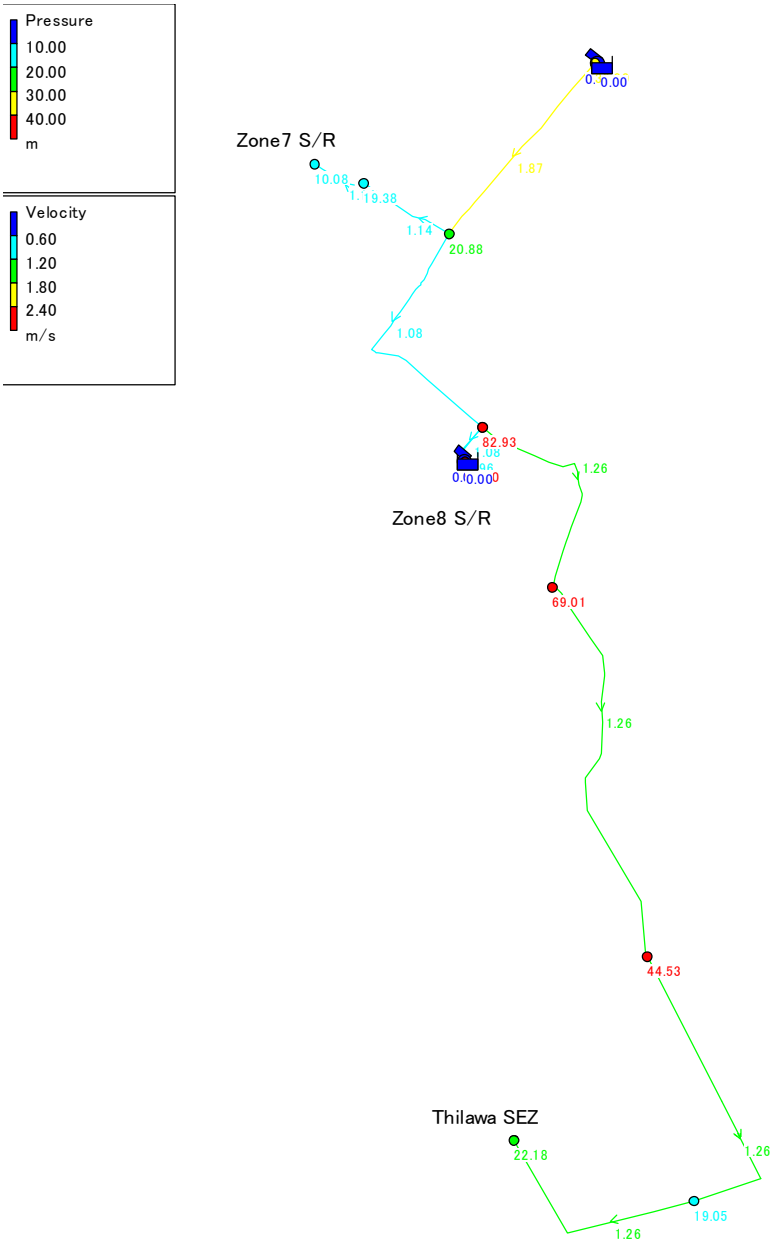
- 5 m: At the handing over point of Service Reservoirs and Thilawa SEZ

b) Nodal Data

- Ground Elevation: Obtained from the survey results by JICA Study Team supplemented by maps of 1:5,000 scale
- Nodal Demand: Demands for Zone 7, Zone 8, and Thilawa SEZ

c) EPANET with Hazen-William's C value of 110 is used to calculate frictional head-loss.

As discussed in the preceding sections, the transmission pipes are designed for daily maximum flow. The result of the analysis (the following figure) shows residual pressure at nodes, flow direction and velocity at pipes.



Source: JICA Study Team

Figure 2.14 Hydraulic Analysis for Zones 7, 8 and Thilawa SEZ Showing Nodal Pressure and Pipe Velocity

2.3.6 Distribution Main Facilities (Service Reservoir, Pump and Main Pipe)

(1) Distribution Main Facilities

Table 2.40 Distribution Main Facilities

Facility	Zone 7	Zone 8
Service Reservoir	RC-made 35,000 m^3	RC-made 23,000 m^3
Distribution pump	30.7m^3/m x 3 sets	28.1m^3/m x 3 sets 14.6m^3/m x 3 sets
Distribution main pipe	φ300-800 x 71.73 km (from reservoir to DMA inlet)	

Source: JICA Study Team

(2) Service Reservoir

Service reservoir is provided to store water sent from the treatment plant during low demand night period and distribute more water to consumers during high demand daytime period. The required volume depends on diurnal demand pattern; however, due to lack of accurate demand pattern data, 8 hours demand volume recommended by Japan Waterworks guideline is used.

[Facilities Specifications]

- Service Reservoir: RC made with flow guiding walls
- Distribution Pump Room: RC made
- Inlet Valve: Motor operated valve, Water level of service reservoir is controlled by SCADA
- Outlet Valve: Motor operated valve, Amount of outflows service reservoir is controlled by SCADA
- Water Level Gauge: Electrode with Pressure Type
- Water Flow Meter (Inlet and Outlet): Electro-magnetic Type

[Volume or Capacity]

- For Zone Demand: Daily Maximum Demand x (8 hours/ 24 hours)
- For Transmission to Other Zone: Adding Daily Maximum Demand x (1 hour/ 24 hours)

Daily maximum demand for 2040 will be three times of that for 2025. Therefore, the capacity of service reservoir for 2025 will be one-third of that for 2040. Space for future expansion of service reservoirs is considered in layout plan.

Table 2.41 Service Reservoir

Target year	Zone 7	Zone 8
Capacity for 2040	69MGD x 4546 ÷ 3 = 105,000 m^3	44MGD x 4546 ÷ 3 + 4.2MGD ÷ 24 = 69,000 m^3
Capacity for 2025	One-third of the above capacity 105,000 m^3÷ 3 = 35,000 m^3	One-third of the above capacity 69,000 m^3÷ 3 = 23,000 m^3

Source: JICA Study Team

(3) Distribution Pump

1) General

Planning parameters for mechanical devices are shown below.

Table 2.42 Planning Parameters for Distribution Pump

Target Area	Planning Parameter
Zone 7 East Dagon	78,085 x 1.5/24 = 4,880 m^3/ hr
Zone 8 South Dagon	65,307 x 1.5/24 = 4,082 m^3/ hr
Thilawa SEZ (Transmission from Z8 service reservoir)	42,000/24 = 1,750 m^3/ hr

Source: JICA Study Team

2) Pump Type

Horizontal-shaft double-suction Volute Pump is suitable. Refer to previous Table 2.14 for details.

3) Discharge Volume Control

Pumps are operated to meet demand fluctuation so that number of operating pumps is decided based on water pressures on the delivery side; when demand increases, water pressures drops, and then additional pumps should be turned on to regain water pressure.

a) Consideration for the number of pumps

Four large sized pumps would be more efficient as distribution pumps for Zone 7 or Zone 8 in 2040. However, flow control with a large-sized pump is not easy at the time of a small flow like in the early stages of pump installation, or nighttime. Therefore, instead of one large-sized pump, two small pumps are planned in order to make control easier during small flow condition.

[Determination of the number of pump]

Two sets of small pumps with VFD are installed from the viewpoint of easy operation to easy maneuverability during small flow and economic efficiency. Small size pumps will gradually be replaced with large ones with the increase in demand.

b) Method of Discharge Volume Control

VFD (Variable Frequency Drive) control devices are planned in some pumps. The following method (refer to the following Table) is usually used for Method of Discharge Volume Control;

- VFD: Speed control of pump rotation due to change of voltage and frequency by inverter.
- Valve Control: Flow control due to change of hydraulic losses by opening and closing of valves at delivery side.

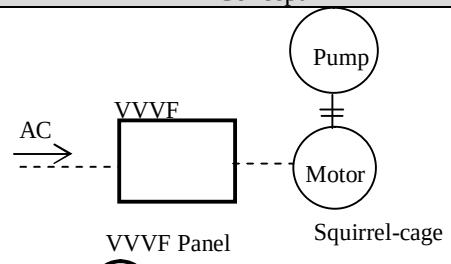
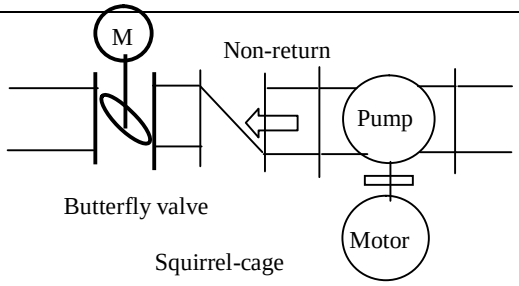
VFD control is superior to valve control due to the following reasons;

- Saving energy, thus lower power cost
- Easy operation (continuous flow change is possible)
- Flexible operation (Even if an amount demanded increases/ decreases rapidly, pump

discharges can meet demands)

However, direct cost for VFD is higher as bigger motor size is required. Especially, installation of high voltage receiving electrical equipment is more expensive. Therefore, capacity of motor output shall be limited up to 240kw to adopt VFD in which low voltage receiving is possible.

Table 2.43 Method of Discharge Volume Control

	Concept	Example of Operation Cost	Cost Ratio
VFD		Power Cost 230 kW x Load 71% x Efficiency 92% x 2 sets x 24 hours x 2.5 Kyat/ kWh ＝ 18,028 Kyat /day 6,580 thousand Kyat /year	100
Valve Control		Power Cost 230kW x Load 96% x Efficiency 92% x 2 sets x 24 hours x 2.5 Kyat / kWh ＝ 24,376 Kyat /day 8,897 thousand Kyat /year	66

Source: JICA Study Team

4) Pumps for Zone 7

A single pipe of 800 mm dia. and about 8,000 m in length and total three pumps facility including one standby are proposed for the flow of 78,085 m^3/ day from the Distribution Pump Station to the Distribution area for Zone 7. Distribution is by direct pumping. Distribution pumps will be operated with a combination of pump number control and VFD control based on measured pressure and flow.

In 2025 (F/S stage), three small pumps including one standby with VFD are planned considering water demand. Then four large pumps including one standby will be proposed for 2040. Planned major equipment is shown in table below.

Table 2.44 Distribution Pump for Zone 7

Item	Specification	For 2025	For 2040
Small Pump	Horizontal double suction volute 30.7 m^3/min x approx.32m Head x 230 kW (VFD)	3 units including 1 standby	—
Large Pump	Horizontal double suction volute 88.6 m^3/min x approx.32m Head x 800 kW	—	4 units including 1 standby

Notes: Flows and operation pressures shall be monitored. A surge control chamber will be connected near the discharge header to protect the piping and facility against water hammer. This option will be reviewed during the detailed design stage.
Source: JICA Study Team

5) Distribution Pump for Zone 8 and Booster Pump for Thilawa SEZ

Distribution pumps in this station consist of distribution pumps for Zone 8 and transmission pump for Thilawa SEZ.

A single pipe of 800 mm dia. and about 6,500 m in length and total three pumps facility including one stand-by are proposed to supply the flow of 65,307 m^3/day from the distribution pump station to the distribution area in Zone 8. Distribution is by direct pumping. The system of pump operation is the same as mentioned above in case of Zone 7. In F/ S stage, small three pumps including one standby with VFD will be proposed considering water demand, then, large three pumps including one standby will be proposed in M/P stage. Major equipment is shown in following table.

On the other hand, the system for Thilawa SEZ includes a single pipe of 700 mm dia. and about 30,200 m in length, and three pumps including one standby. The pipe will carry a flow of 42,000 m^3/ day from Zone 8 S/R to Thilawa SEZ until 2018. Major equipment is listed in the following table.

Table 2.45 Distribution Pump for Zone 8 and Transmission Booster Pump for Thilawa SEZ

Item	Specification	For 2025	For 2040
Small Pump	Horizontal double suction volute 28.1 m^3/min x approx.35m Head x 230 kW (VFD)	3 (including 1 stand-by)	—
Large Pump	Horizontal double suction volute 76.2 m^3/min x approx.35m Head x 630 kW	—	3 (including 1 stand-by)
Transmission Booster Pump for Thilawa SEZ	Horizontal double suction volute 14.6 m^3/min x approx.85m Head x 280 kW	3 (including 1 stand-by)	—

Notes: Flows and operation pressures shall be monitored. A surge control chamber will be connected near the discharge header to protect the piping and facility against water hammer. This option will be reviewed during the detailed design stage.
Source: JICA Study Team

(4) Electrical Facilities

1) General

Design parameters of the electrical facilities are shown in the following table.

Table 2.46 Design Parameters of Electrical Facilities

Zone	Design Parameters	
Zone 7 East Dagon	1) Receiving Voltage	33kV, 50Hz, 1 circuit
	2) Receiving Transformer	3,000 kVA
	3) Installed Capacity	3,100 kW
	4) Operating Capacity	2,100 kW
Zone 8 South Dagon	1) Receiving Voltage	33kV, 50Hz, 1 circuit
	2) Receiving Transformer	3,000 kVA
	3) Installed Capacity	3,100 kW
	4) Operating Capacity	2,100 kW

Source: JICA Study Team

2) Power Receiving Circuit

The receiving capacity of each pump station of zones 7 and 8 is 3 MVA, and the receiving voltage is 33 kV same as that of the WTP.

a) ZONE 7: Service Reservoir in East Dagon

A new 33 kV overhead transmission line needs to be installed from the existing YESB 33 kV substation near Dagon University. Estimated length is 3 km.

Source: JICA Study Team

Figure 2.15 Zone 7 Pumping Station and 33 kV Overhead Transmission Line

b) ZONE 8: Service Reservoir in South Dagon

An existing 33 kV overhead transmission line is extended from Route #2 to the existing YCDC 54 ward pump station. A new 33 kV overhead transmission line needs to be branched from the existing 33 kV line to the new pump station. Estimated length is 2 km.

Source: JICA Study Team

Figure 2.16 Pumping Station and 33 kV Overhead Transmission Line for Zone 8

3) Receiving Transformer and Distribution Equipment

As the installed capacity of receiving transformer and distribution equipment is same as that of Lagunbyin WTP, the previous section 2.3.4, (13) 4) shall be referred for receiving substation.

Table 2.47 Receiving Substation

Item	Specification	Number
Receiving Panel	Metal-enclosed Switchgears VCB (Vacuum Circuit Breaker), 36 kV	1 set
Main Power Transformer	Oil-insulated, Naturally Oil-cooled Transformer 33 kV / 6.9 kV	1 set

Source: JICA Study Team

(5) Distribution Main Pipe

1) Route

Short distance routes are selected as much as practicable between the service reservoir/ distribution pump and DMA inlets. Routes are selected considering that main pipes can be interconnected through the roads with less traffic volumes.

2) Material

Steel pipes or ductile iron pipe (φ1100 mm and above) and ductile iron pipes (φ200 to φ1000 mm) are planned for large-sized pipes similar to transmission pipes while uPVC pipes (φ75 to φ150 mm), which YCDC has currently been using, are planned for small-sized pipes.

3) Network Analysis Formula

Pipe sizes are determined through hydraulic analysis using EPANET2 which uses Hazen-Williams Formula as follows;

$H = 10.666\ C^{-1.85}\ D^{-4.87}\ Q^{1.85} \cdot L$

Where,

H: Head loss (m)

Q: Flow (m^3/sec)

D: Pipe Diameter (m)

L: Pipe Length (m)

C: Hazen-William's Coefficient (110 is used)

a) Minimum Water Pressure at inlets of DMA: 18 m as dynamic water pressure

b) Nodal Data

- Ground Elevation: Survey results by JICA Study Team supplemented by topographical maps of 1:5,000 scale
- Nodal Demand: Total demand is allocated in proportion to Nodal governing area size using Thiessen Polygon method

c) Pipe Data

- φ100 mm and above diameters new pipes are planned
- Pipe Length: Measured on GIS roads
- Existing Pipes are relatively new with less than 20 years of age so that these pipes are included in the plan as they are taken into restructuring design for creation of DMA

d) Analysis Results

Results are shown in Figure 2.16 and Figure 2.17 below.

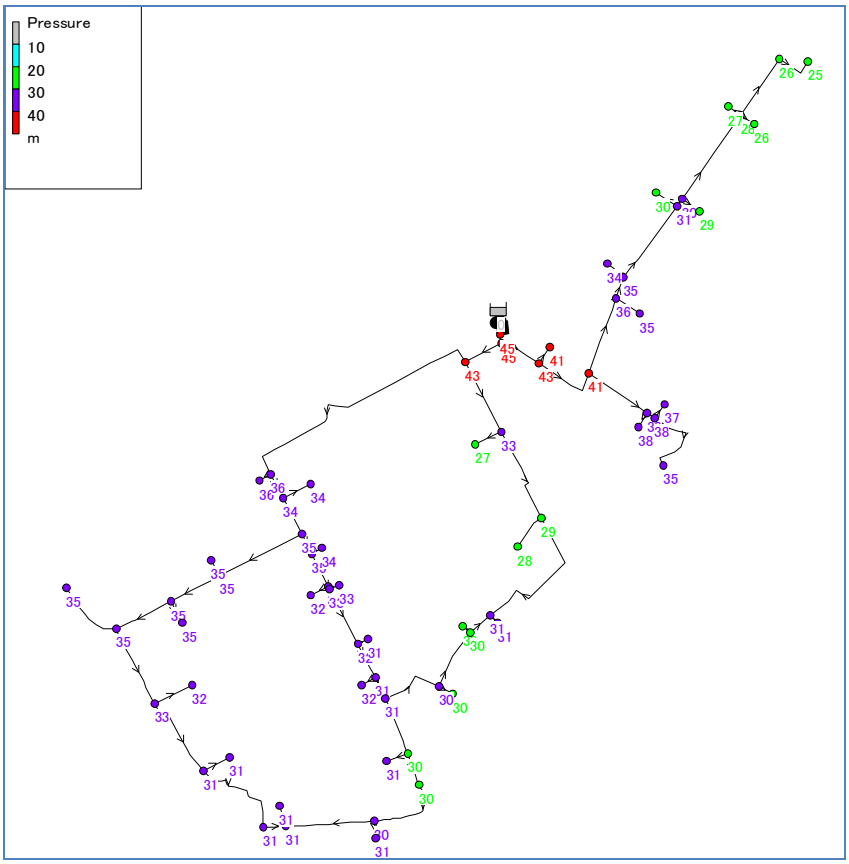
4) Main Pipes Length by Diameter

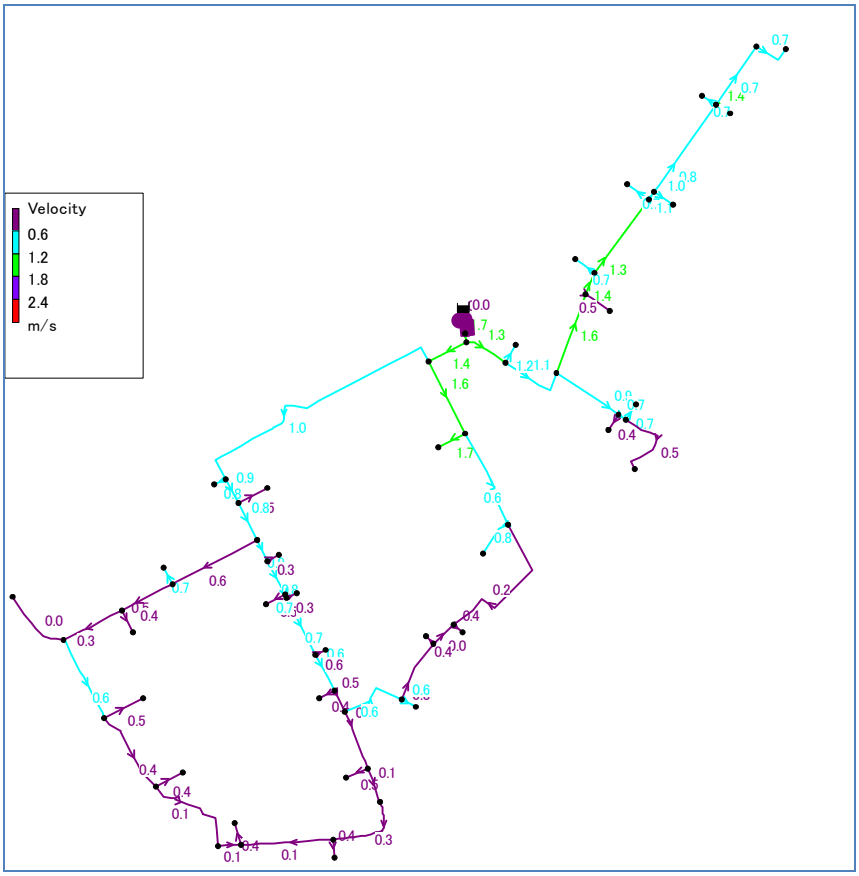
Lengths of the distribution main pipes for zones 7 and 8 are shown in the following table and Figure 2.18.

Table 2.48 Length of Distribution Main Pipe for Zones 7 and 8

Existing Distribution Main pipe (included in DMAs)				New Distribution Main pipe (included in DMAs)			Pipe Laying Method
Dia. (mm)	Zone 7	Zone 8	Length (m)	Zone 7	Zone 8	Length (m)	
150	34		34				
200	87		87				
300				4,311	2,960	7,271	Open Cut
400				16,466	7,781	24,247	Open Cut
500				4,408	27,693	32,101	Open Cut
600	8,906	4,829	13,735				Open Cut
700				7,156	952	8,108	Open Cut
800							Open Cut
Total	9.027	4,829	13,856	32,341	39,386	71,727	Total=85.58km

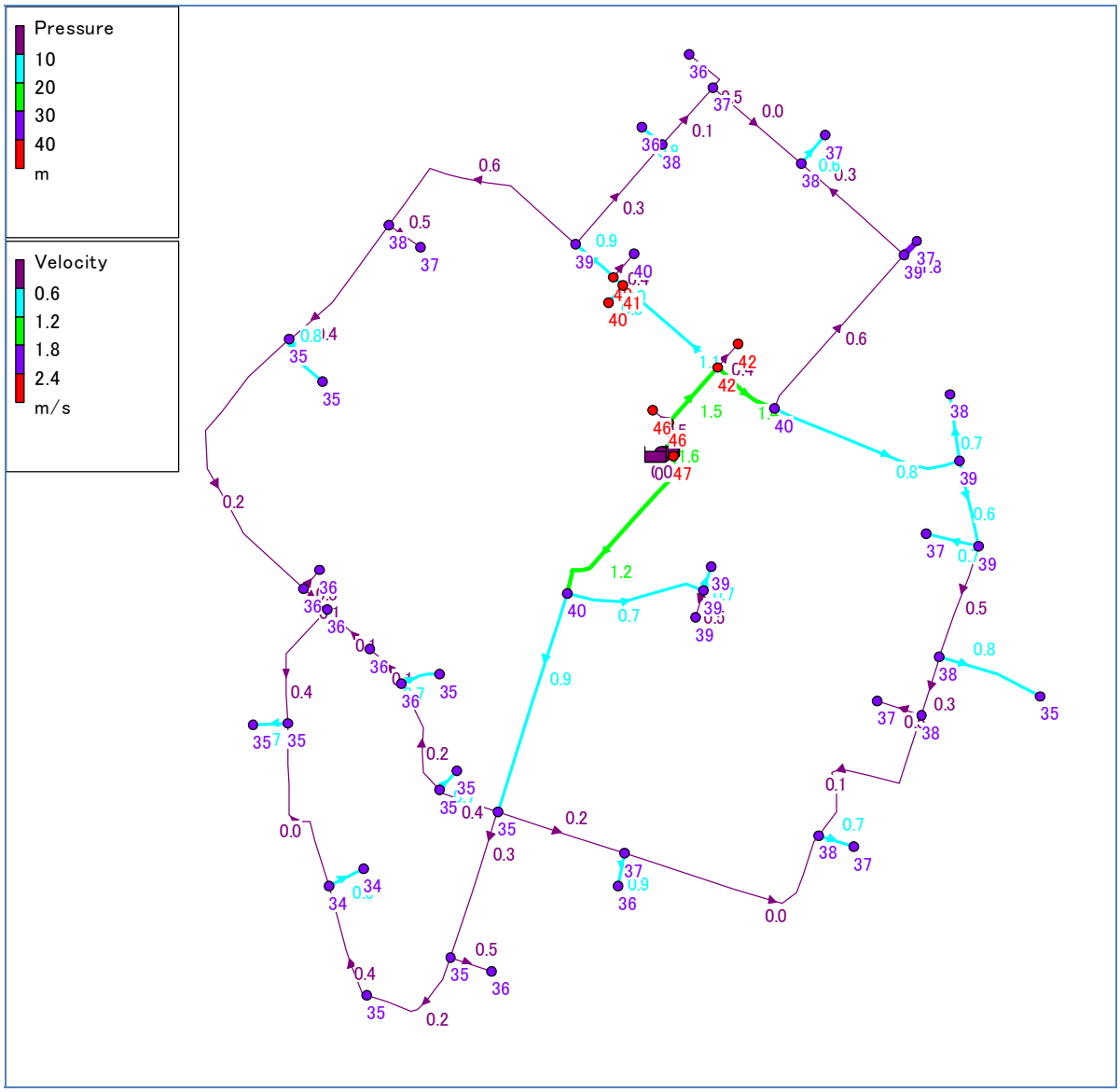
Source: JICA Study Team





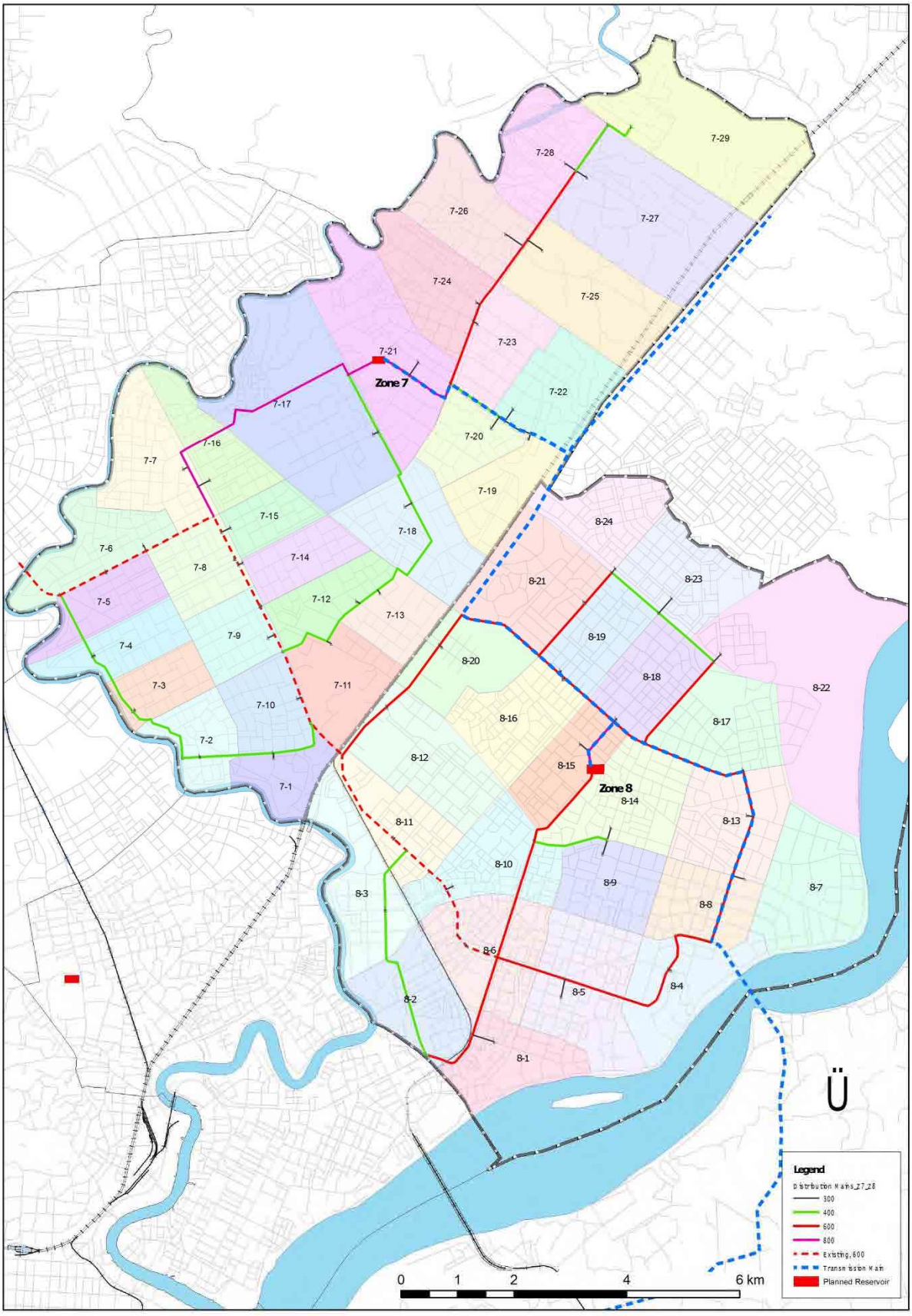
Source: JICA Study Team

Figure 2.17 Simulated Network Analysis Result for Zone 7



Source: JICA Study Team

Figure 2.18 Simulated Network Analysis Result for Zone 8



Source: JICA Study Team

Figure 2.19 Distribution Main Pipes for Zones 7 and 8 and Transmission Pipe for Thilawa SEZ

2.3.7 Distribution Facilities (DMA, Distribution Pipe and Service Connections)

(1) Distribution Facilities

Table 2.49 Distribution Facilities

Facilities	Number
Number of DMA	53 Nos.
Distribution Pipe	Dia. 100 to 200 mm x 224km
Number of Connections with Meters in 2018	55,613 connections

Source: JICA Study Team

(2) DMA and Distribution Pipe

1) DMA Plan

DMA is planned within each zone for equitable water distribution by monitoring and controlling inflow to each DMA. The planned DMA is also utilized to monitor non-revenue water (NRW) for each DMA by comparing inflow amount with total consumed amount. The smaller the size of DMA the more equal is water distribution to each DMA. However, for practical and easy distribution operation, DMA size is sometimes enlarged. IWWA recommends DMA size in the range of 500 to 3000 connections. In the study, DMAs are planned to have about 1,700 connections in year 2025 and 1,000 connections in year 2018, considering rapid increase of population by future urbanization in these zones. The planned DMA shall be formulated based on the planned town blocks, which already exists according to the town planning. As a result of planning, 29 and 24 DMAs are planned for zones 7 and 8, respectively which are shown in the Tables below and the following figure.

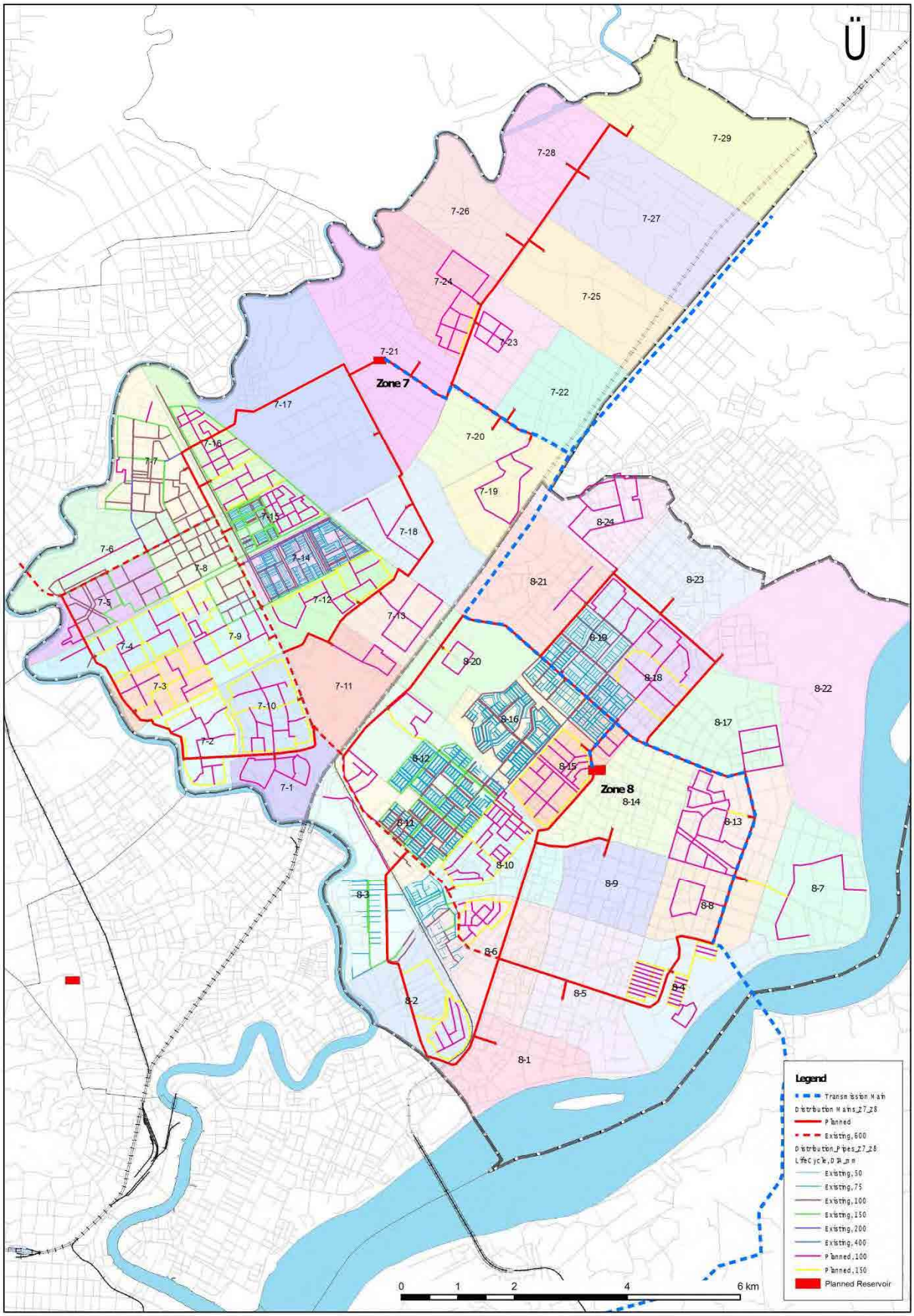
Pipes are planned so as to deliver hourly peak demand water from the zone service reservoirs through inlet of DMA to attain 24 hours continuous water supply. Once it is attained, private wells and individual storage tanks and pumps can be abolished and safe water can be supplied avoiding intrusion of polluted water.

Table 2.50 DMA Planning

Zone	Service population in 2011	No. of Service Connections in 2011	Demand in 2025 (MGD)	Service population in 2018	Estimated No. of Service connection *	No. of Connection/ DMA
7	86,613	10,489	17	175,978	27,933	963
8	103,713	6,760	14	174,386	27,680	1,153
Total	190,326	17,249	31	350,364	55,613	1,049

Zone	Number of DMA	Bulk Meter with Chamber	Isolation Valve with Chamber	Replacement/ Installation of Service Connection	Replacement/ Installation of Customer Meter
7	29	29	0	27,933	27,933
8	24	24	0	27,680	27,680
Total	53	53	0	55,613	55,613

Note: * 6.3person/connection
Source: JICA Study Team



Source: JICA Study Team

Figure 2.20 DMA and Distribution Pipe for Zones 7 and 8

2) Network Analysis within DMA

Network analysis is conducted for some large-sized DMAs. For the modeling, pipe size of 100 mm and above are considered in general but in some critical conditions of existing pipes, sizes of 75 mm or even 50 mm are included. Currently existing pipelines are considered for use because they are relatively new in these areas. New pipes are planned and added in the model as necessary to maintain a residual pressure of at least 15 m at the tapping point of house connection. New pipes are also added to cover uncovered new areas. The results are shown in Figure 2.20 to 2.22.

The simulation shows lower velocity of flow, mostly less than desirable minimum of 0.6 m/s in areas where YCDC has already installed pipes. This lower velocity was due to installation of pipes by YCDC in excess of number and sizes required hydraulically. However, velocity in such pipes will keep increasing with the increase of demand after year 2025.

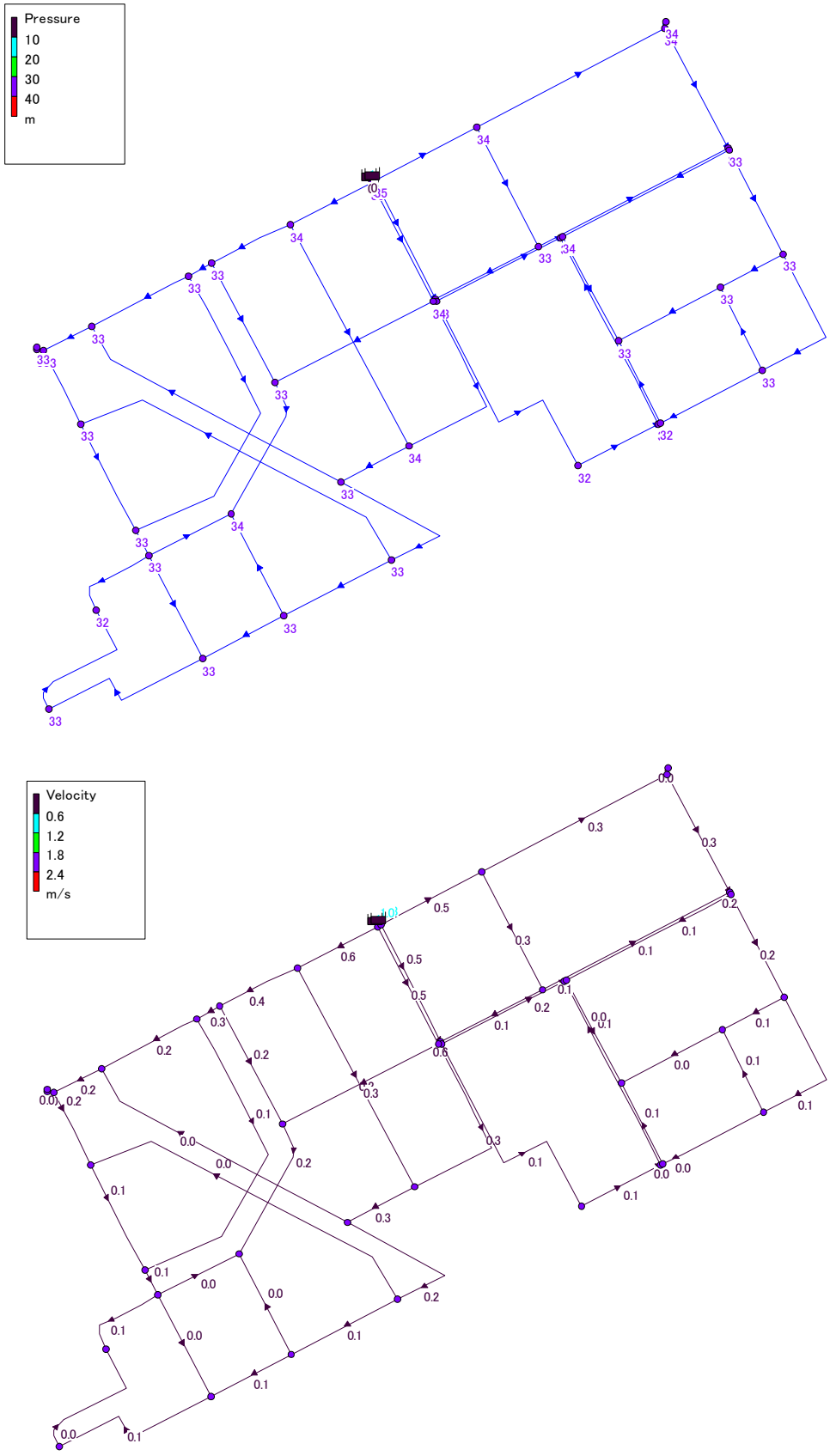
3) Distribution Pipe within DMAs for Zones 7 and 8

Length of distribution pipe is planned as shown above based on the network analysis. Distribution pipe layout is shown in Figure 2.19 together with DMA.

Table 2.51 Length of Distribution Pipe for Zones 7 and 8

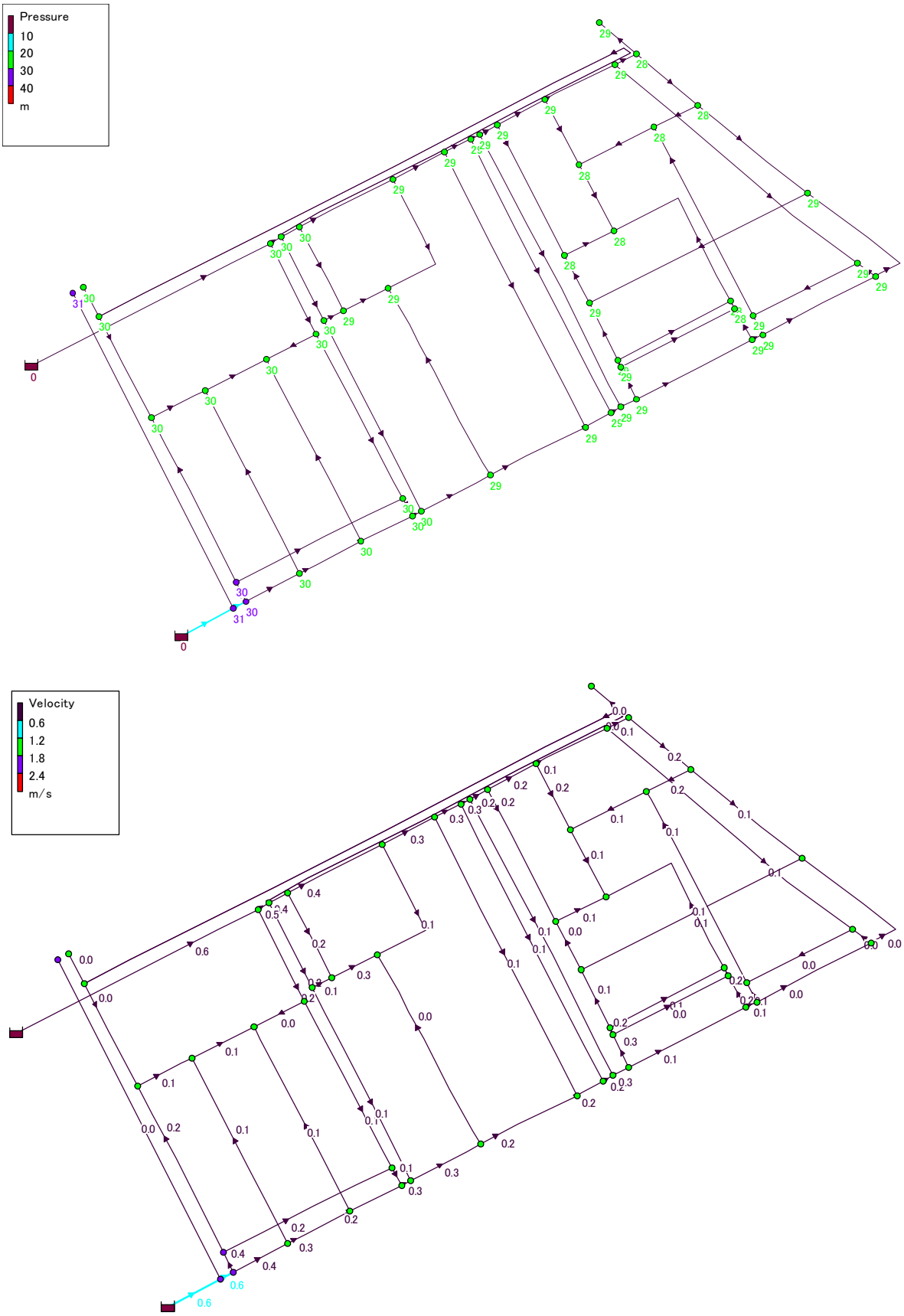
Dia. (mm)	Existing Distribution Pipe (included in DMAs)			New Distribution Pipe (included in DMAs)			Pipe Laying Method
	Zone 7	Zone 8	Length (m)	Zone 7	Zone 8	Length (m)	
50	33,661	109,798	143,459				Open Cut
75	14,359	87,959	102,318				Open Cut
100	66,658	58,685	125,343	72,706	80,680	153,386	Open Cut
150	41,593	25,008	66,601	38,318	31,958	70,276	Open Cut
200	6,379		6,379		354	354	Open Cut
Total	162,650	281,450	444,100	111,024	112,992	224,016	Total=668,116

Source: JICA Study Team



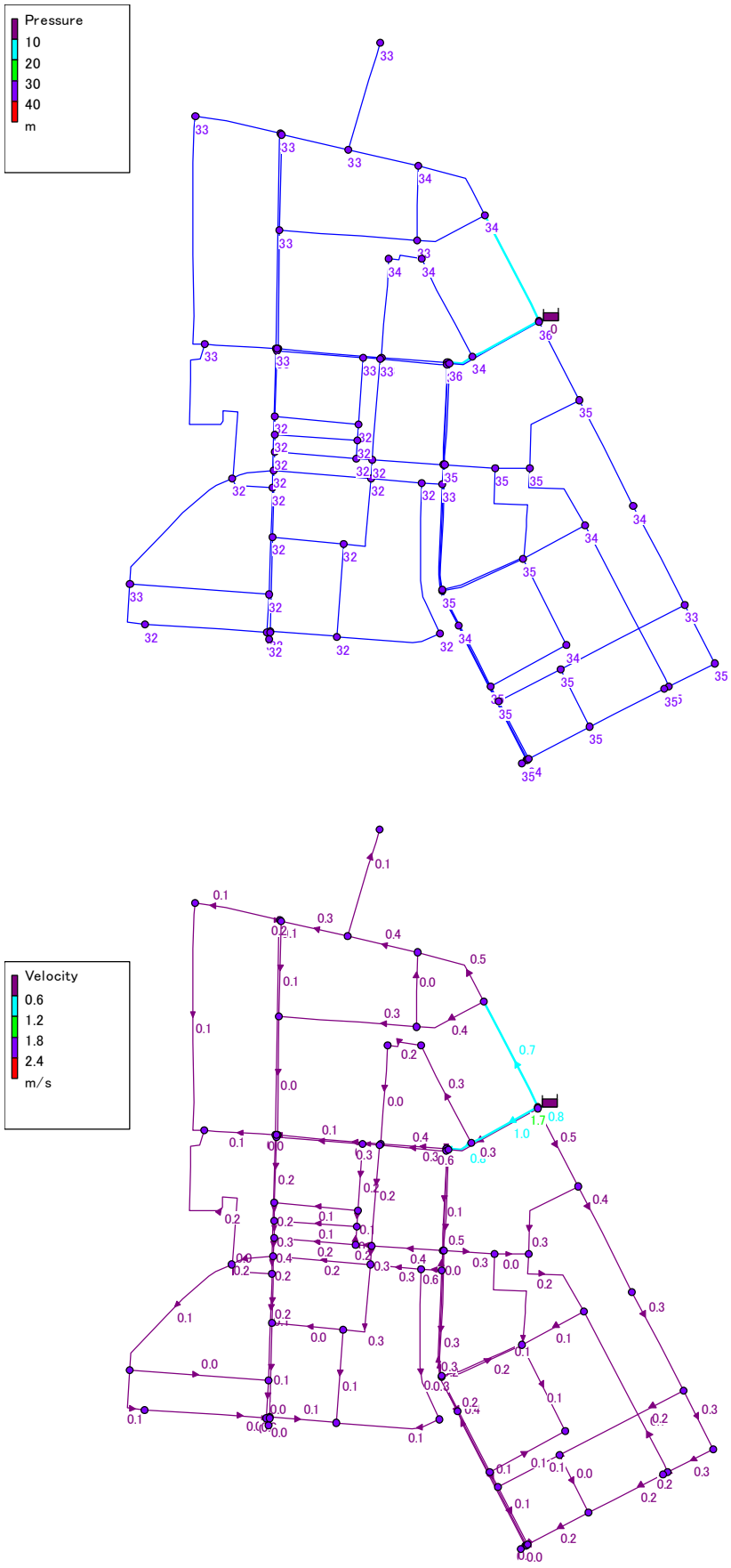
Source: JICA Study Team

Figure 2.21 Network Analysis in DMA 7-5



Source: JICA Study Team

Figure 2.22 Network Analysis in DMA 7-14



Source: JICA Study Team

Figure 2.23 Network Analysis in DMA 7-7

(3) Examination on Distribution of Surplus Water of Zone 8 to Existing Network in Zone 2

It is examined in this section whether or not surplus water produced in Zone 8 can be transmitted to the existing network in Zone 2. According to the water demand estimation, it requires several years after WTP completion until actual water demand in Zone 8 reaches the planned water demand, since the zone is developing area. Therefore, produced surplus water in Zone 8 will be temporarily conveyed to Zone 2 which adjoins Zone 8.

1) Conditions

i) Produced surplus water in 2018 - 2025 will be supplied to Zone 2.

ii) Produced surplus water in 2018 is 23,700 m^3/day.
65,307 m^3/day (Zone 8, 2025y) - 46,723 m^3/day (Zone8, 2018y) = 23,700 m^3/day

iii) Connecting pipe φ600mm, L=1.2 km of Zone 8 and Zone 2 will be constructed by YCDC, and isolation valve will be installed by this project.

iv) Distribution pump head in Zone 8 service reservoir will be set to H= 35 m.

2) Hydraulic analysis result

The result is shown as following figure. If isolation valve and flow meter will be installed in order to secure the demand for Zone 8, produced surplus water can be supplied to zone 2.

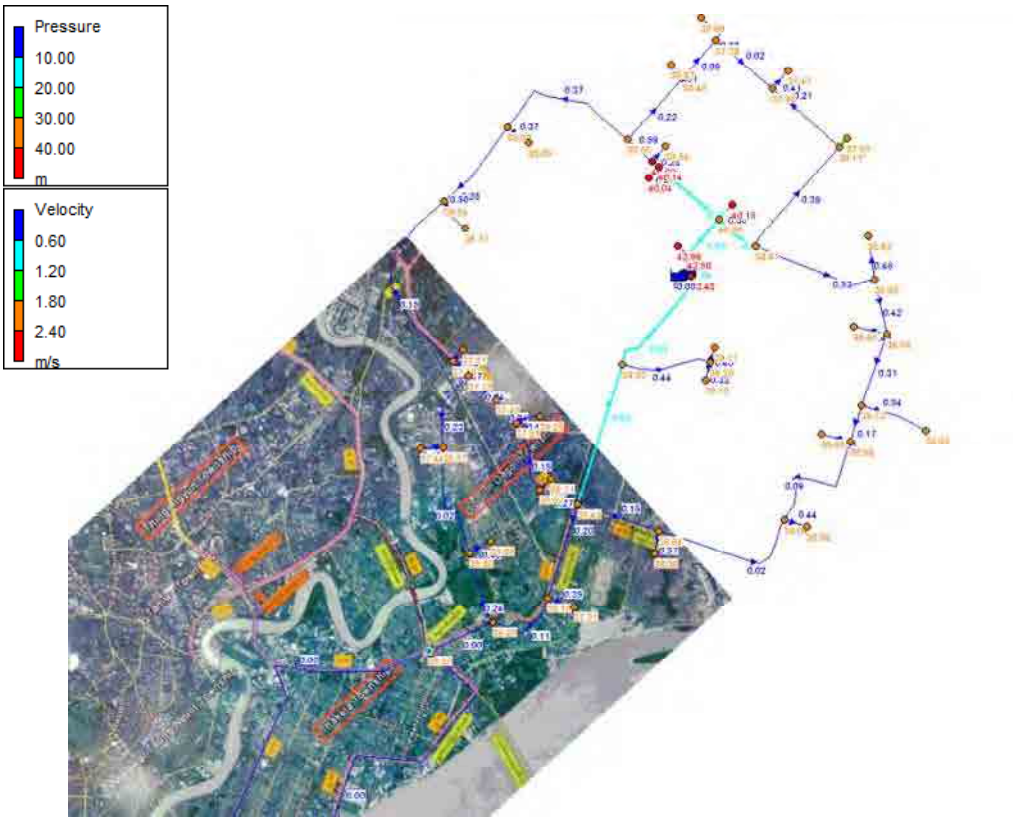
i) Zone 8 has a margin of approximately 1,000 m^3/hr demand in 2018.

ii) Although residual pressures in DMAs of the southwest end in the zone decreases from 38 m to 20 m when 1,000 m^3/hr water is supplied to Zone 2 through the connecting pipe, residual pressures in DMAs can exceed the design pressure of 20 m.

3) Conclusion

The surplus water can be transmitted from Zone 8 to Zone 2 without affecting network hydrology in Zone 8. To do this, isolation valve with a chamber and a flow meter shall be installed on the boundary of Zone 8 and Zone 2

Case1: Un-connecting



Case2: Supplying 1,000 m^3/hr from Zone8 to Zone2

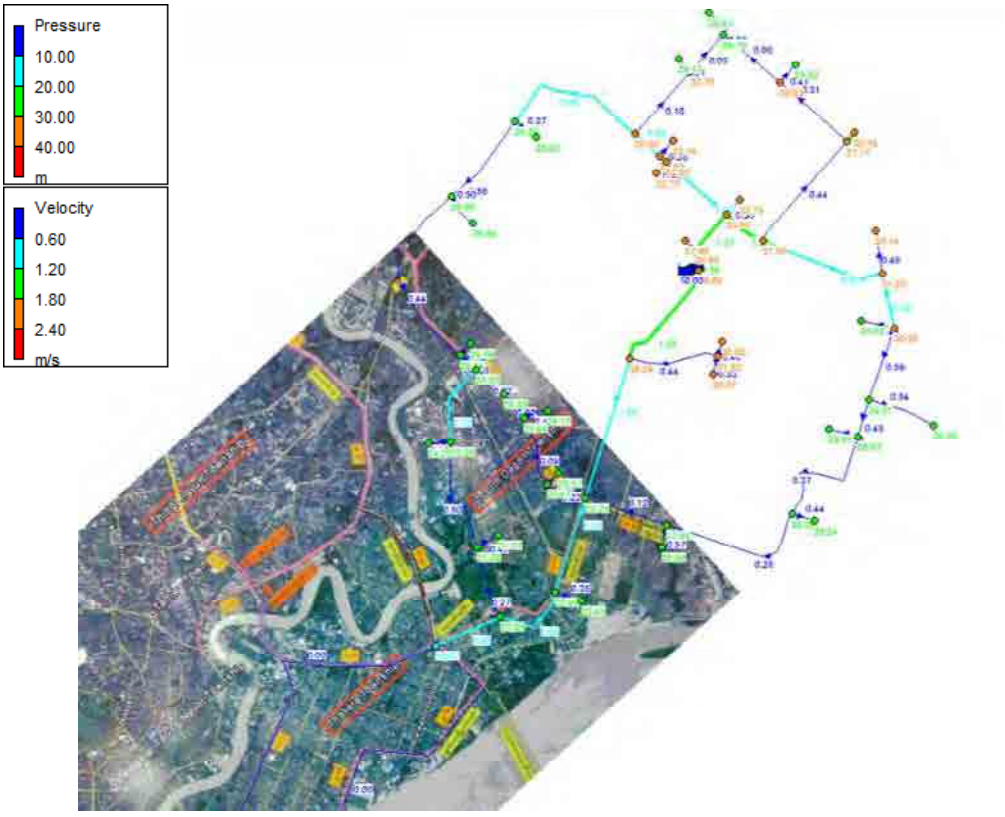


Figure 2.24 Hydraulic Analysis Result of Connection between Zone 8 and Zone 2

2.3.8 Monitoring and Control System (SCADA)

(1) General Policy

SCADA (Supervisory, Control and Data Acquisition system) will be applied to monitor and control the operational status of the service reservoirs and the water treatment plants, and the water status of the transferred water.

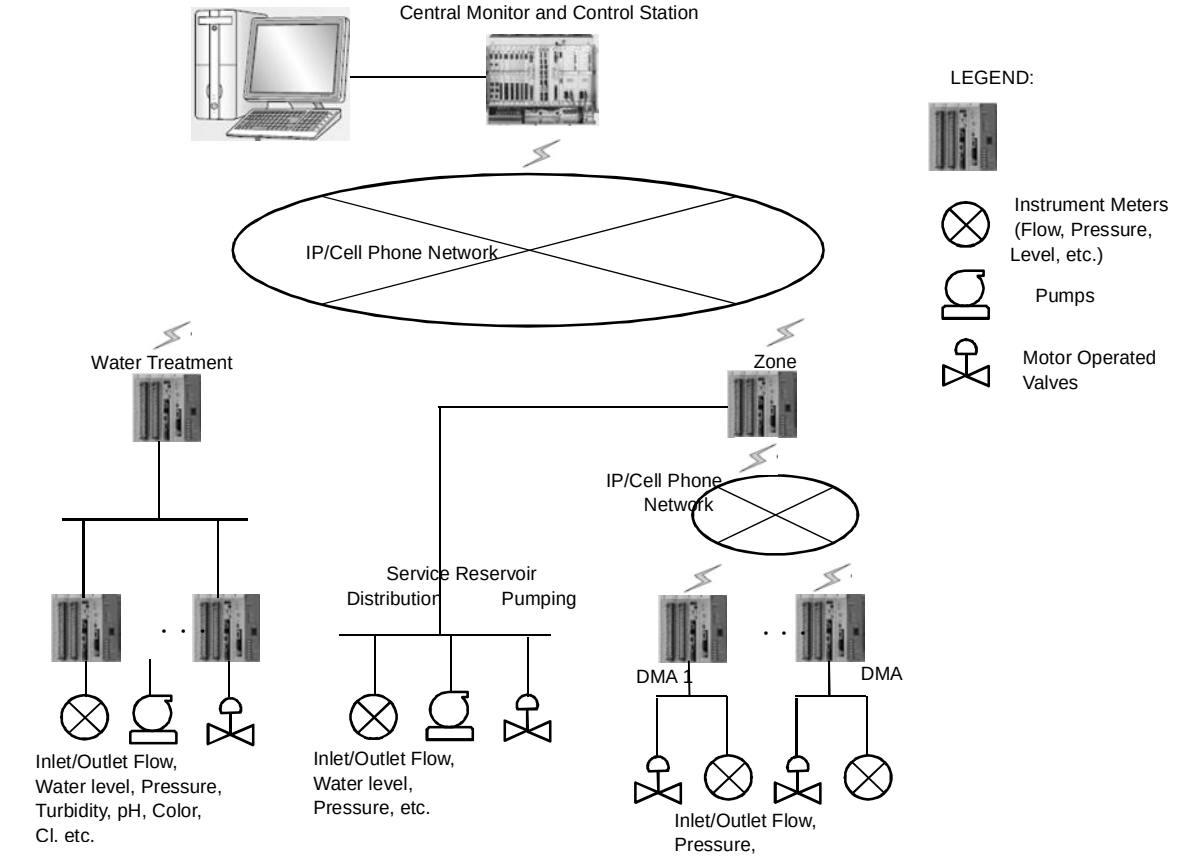
SCADA will be used to monitor and control the equipment in the service reservoirs and the water treatment plants, such as pumps, valves etc., and collect the value of the water flow and pressure at the specified point in a DMA.

Monitoring and control function will be centralized in the central control station for overall system monitoring and control.

The system configuration of the proposed SCADA is as follows;

- Server and HMI system will be installed in the central control station.
- Service reservoirs and water treatment plants will have instrument meters and telemeters for data transfer.
- Data from service reservoirs and water treatment plants will be transferred to the central control station through the wireless communication with the cell phone network.
- Data from DMA will be transferred to the central control station via the telemeter of the service reservoir to which a DMA belongs.

The basic SCADA concept is shown in following figure.



Source: JICA Study Team

Figure 2.25 Basic SCADA Concept

Terminal equipment shall be provided in each plant for transmitting and receiving signals for SCADA system to be located in the new Water Distribution Control Center. The communication media should be selected from the options such as telephone line, wired/wireless internet, and others. Although wireless high-speed internet would be less expensive and reliable, its service area is still limited to the central Yangon city (the following figure is a sample service area of a wireless internet provider). The service is already available at proposed Water Distribution Control Center and Zone 1 Pump Station. But conventional leased telephone lines are the most practical solution for other areas where high speed wireless internet service is not yet available. Faster expansion of the wireless internet service area is desirable for this project.

Source: RedLink Communication Co., Ltd. Oct-9-2012

Figure 2.26 WiMax WiFi Internet Service Coverage Area (Sample)

(2) Specification of SCADA

Monitoring points for Lagunbyin Water Supply System are planned as shown below.

Table 2.52 SCADA Monitoring Points

Monitoring Point	Measuring Parameters
Central Monitoring Station	Control room in Lagunbyin WTP
Treatment Plant	Water level of Raw Water (Canal) Water Flow of Intake Water
	Turbidity meter for Raw Water pH meter for Raw Water
	pH meter at location between Flocculation Basin and Sedimentation Basin
	Turbidity meter for Settled Water
	Water Level at Filters
	Water Level at Treated Water Reservoir Water Flow of Transmission Pump Inlet and outlet valve opening position
	Turbidity meter for Treated Water Reservoir pH meter for Treated Water Reservoir Residual Chlorine meter for Treated Water Reservoir
Service Reservoir for Zone 7	Water Level Flow meter (Inlet and Outlet) Inlet and outlet valve opening position
Service Reservoir for Zone 8	Water Level Flow meter (Inlet and Outlet) Inlet and outlet valve opening position
Inlet of DMAs for Zones 7	Inlet valve opening position, Flow and Pressure for Zone 7, Nos.=29

Monitoring Point	Measuring Parameters
and 8	Inlet valve opening position, Flow and Pressure for Zone 8, Nos.=24
Isolation valve for Zone2	Inlet valve opening position, Flow and Pressure for Zone 2 and 8, Nos.=1
Branch for Thilawa SEZ	Inlet valve opening position, Flow and Pressure

Source: JICA Study Team

(3) Monitoring System

Data on flows, pressures, and water quality at every monitoring point are sent to the central monitoring station constructed either at YCDC headquarters or at Yegu pumping station. These data are analyzed and stored.

[Components of Central Monitoring Station]

Central monitoring station consists of internet router, server, display monitor, printer and power source backup including UPS. Server will collect and store all data from the monitoring points. Historical trends and reports (daily, monthly and yearly) will be generated by use of application software from the collected data. Collected data for the past 1 year will be stored.

[Components of Monitoring Points]

Interface panels at monitoring points consist of converter and internet router. Data is collected every 15 minutes and the accumulated one day data is sent to central monitoring station once a day. Data is basically sent via Wi-Fi internet but, for zones 7 and 8 where Wi-Fi internet is not available, telephone lines will be used.

2.4 Construction Plan

Construction plan is as follows;

(1) Contents of Facilities

Table 2.53 Main Facilities

Item	Contents
Intake and Treatment	Coagulation and rapid filter system with a capacity of 40 MGD
Transmission	Transmission pump for zones 7 and 8 and Thilawa SEZ Booster pump for Thilawa SEZ Pipe φ1200-700, L=47.7 km
Service Reservoir and Distribution Pump	2 reservoirs, total Volume= 58,000 m^3
Distribution Main Pipe	φ300 - 800 mm, L=71.73 km
Distribution Pipe	φ200 - 100 mm, L=224 km
Service Pipe	55,613 connections
Meter	55,613 Nos.

Source: JICA Study Team

(2) Construction Works Requiring Special Attention

1) Measures against Land Subsidence

Site of Lagunbyin (Ma-So) water treatment plant which has been used until recently as fish breeding pond in the low-lying east Dagon is a reclaimed land and, therefore, susceptible to land subsidence. Pile foundation is being driven to support the structures of sedimentation basin, filters etc. while connecting pipes are not usually supported by piles. Therefore, different subsidence will likely occur between the structures and pipes. Flexible joints are thus planned to absorb different displacement of subsidence.

Table 2.54 Measures for Different Displacement of Subsidence

	Dia. (mm)	Measures
Treated Water	1100 and above	Steel Pipe with Flexible Joints
Treated Water	200 - 1000	Ductile Iron Pipe with Flexible Joints
Wastewater or Drain	All	Polyethylene Pipe

Source: JICA Study Team

2) Access Road

Access road to the proposed service reservoir for Zone 7 is required.

Table 2.55 Access Road for Service Reservoir Site in Zone 7

Specification	Number
Gravel Road	4m width x 4,060 m length

Source: JICA Study Team

3) Bago River Crossing

Pipes are planned to lie under or beside the existing roads. Transmission pipe of φ700mm to Thilawa SEZ needs to cross the Bago River. The planned crossing section is along the outer ring road with 640 m length. Potential river crossing methods include as follows:

- Construction of bridge
- Pipe laying on the river bed
- Pipe laying in underground of the river bed (trenchless).

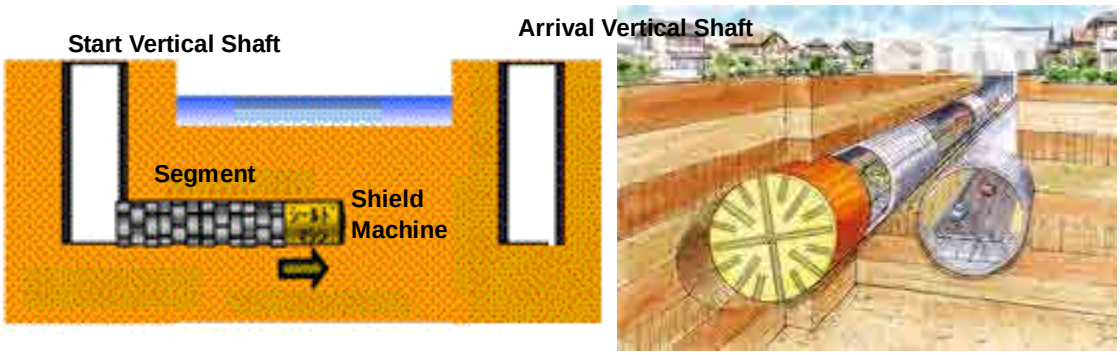
In the result of the river depth-sounding survey of JICA Study Team, the river depth of water is about 20 m at maximum. The Bago River has heavy traffic by transport ships. The pipe laying method on the river bed shall not be adopted since a pipeline installed by this method may be damaged by an anchor of ships. Therefore, bridge method and trenchless method were compared as shown in the Table below.

Table 2.56 Comparison of River Crossing Method

Method	Bridge Method		Trenchless method (Underground of the river bed)	
Type	Aqueduct Bridge	Bridge-attached Pipe	Pipe Jacking	Shield Driven
Outline	Water pipe bridge crosses over the river.	Bridge-attached pipe crosses over the river.	It is one of the trenchless methods. A pipe is pushed into the ground with jack, and crosses the river.	It is one of the trenchless methods. A shield machine moves inside of underground. At the same time, segments are assembled at the rear and build a tunnel.
				
Merit	Since a pipeline is exposed on the ground, O&M is easy.	If there is a suitable highway bridge for the neighborhood, this method is inexpensive.	This method is common in Japan as trenchless. The method is inexpensive compared with shield method.	Compared with pipe jacking, this method can perform long-distance construction, and revising of meandering is easy. Suitable for large pipe.
Demerit	Since the river width is exceeds 600 m, several bridge piers are required in the river.	Depending on the structure of highway bridge, medium/large pipes are not suitable. The loading of water pipe is not calculated on the Dagon bridge.	The maximum general work extension is about 100m-200m. With large pipe, the shield method is mainly adopted from a viewpoint of economic efficiency.	Since vertical shafts are large-scale work, pipe jacking has advantageous at economy/construction.
Evaluation	An uneconomical structure is required since the river has traffic of ships daily and pipe bridge must be made much higher than the river surface, In addition, construction of bridge piers are difficult and very large-scale work is required since the river flow is rapid and the river depth is deep.	In order to attach dia. 700mm pipe to existing highway bridge, a careful survey for checking of soundness of existing concrete of beam/abutments, a structural calculation of the bridge, a negotiation with the bridge administrator, etc. is required. Since there are neither as built drawings nor design documents at the time of execution management, survey and calculation will take a long time.	Since crossing extension exceeds 600 m, this method is not adopted from a viewpoint of maximum work extension.	Un-excavating method is excellent in safety/construction from a viewpoint of the traffic of ships.
Initial Cost	1,100 million yen 2.6	590 million yen 1.4	—	420 million yen 1.0
Overall	△	△	×	○

Source: JICA Study Team

Since safety from transport ships, easy construction and comparably lower cost, shield driving method is recommended. An example of this method is shown in the following Figure.



Source: Chubu Electric Power, Japan and Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan

Figure 2.27 Example of Shield Method

Pipes are recommended to lie at least 5 m below the river bed based on the Japanese experiences. The depth of the River near the crossing point is 20 m at maximum according to the survey conducted by JICA study team. Hence, depth of shafts on both sides of the River will be about 30 m. The proposed Bago River crossing pipeline is summarized in table below and shown in following figure.

Table 2.57 Bago River Crossing of the Transmission Pipe to Thilawa SEZ

Contents
640m length, Shield method of φ1350mm Water Pipe (Polyethylene pipe) φ700mm

Source: JICA Study Team

4) Pipe Material

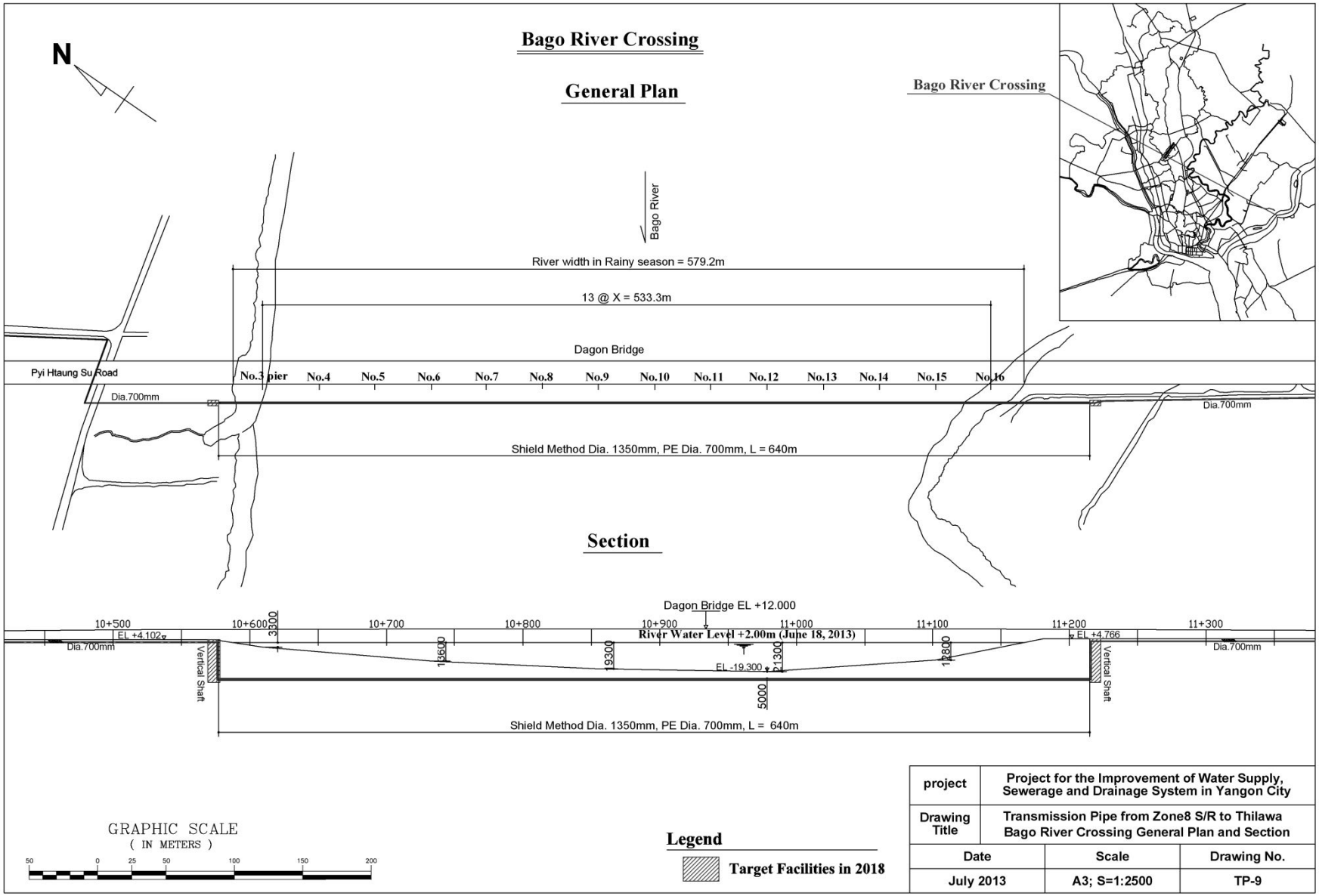
Pipe materials according to pipe size are planned as shown below.

Iron pipes, steel pipes and PVC pipes have been widely used in YCDC. Among them, steel pipes and PVC pipes are planned to continue their uses; steel pipes for large diameter while PVC pipes for diameters of 75, 100 and 150 mm. However, joints of PVC are planned to change from the bonded joints to push-on joints to prevent from possible leakage. Ductile iron pipes are planned to be used for medium-sized diameter (200 to 1000 mm) and PE pipes are planned for service pipes which are flexible for pipe bending.

Table 2.58 Pipe Material

Diameter (mm)	Pipe Material
50 and below	PE (Polyethylene Pipe)
75 – 150	PVC (Poly Vinyl Chloride pipe)
200 – 1000	DIP (Ductile Iron Pipe)
1100 and above	SP (Steel Pipe)

Source: JICA Study Team



Source: JICA Study Team

Figure 2.28 Proposed Bago River Crossing

2.5 Operation and Maintenance Management of Facilities

2.5.1 Investigation into Local Maintenance Management System

(1) Operational Management Tasks

This study proposes to construct a centralized monitoring control system. After understanding the situation of the plant (equipment operating conditions, water quality, water level, capacity etc.), necessary information will be collected into one place. This will make it possible to monitor entire facility with relatively small number of operation staff members.

However, operational status of the entire facility needs to be understood based on processed information, such as water quality and flow, and so monitoring tasks of water treatment plant will demand strong judgment ability based on knowledge and experience, for example whether equipment is being operated properly or whether or not there is an abnormality in processing conditions. This will play an important role in maintenance and continuation of a safe and stable water supply, such as determining conditions of changes in water quality and fluctuations in demand as well as taking an appropriate and prompt course of action when something goes wrong.

In particular, the water in the irrigation canal, which is the source, has high turbidity throughout the year and there are cases where the turbidity exceeds 500 degrees. This means that adjustments in the chemical dosing rate and equipment operation for these changes in water quality will become necessary, so it will be essential to constantly monitor the status of the water quality.

The scope of the principal operational monitoring work is:

- Monitoring and operation of the water treatment process and drainage process through SCADA
- Processing conditions, adjustments in the chemical dosing rate based on water quality data and equipment operation
- Water intake volume in response to demand for water supply, control and management of the transmission volume
- Monitoring of the processing state in each process by inspections
- Monitoring, operation and hygiene tasks that accompany preservation and maintenance tasks
- Working solutions and communication with related officials when some problem occurs

In addition, important points to pay attention to in performing these tasks are:

- Prevention of operational errors
- Prevention of errors in the assessment of situations
- Coordination with preservation and maintenance tasks and also water quality management tasks

- Construction of a system that can constantly monitor and operate the facility status, 24 hours a day, 365 days a year

In addition, it is necessary to prevent human error by operations monitoring staff by always working in teams of two or more and mutually checking each other's work.

(2) Maintenance Inspection Tasks

In order to enable normal operation of water treatment plant facility, it is important to implement maintenance inspections of electrical and mechanical equipment and to reliably maintain functions of these facilities. Therefore, it is necessary to have staff-members with required knowledge and techniques to carry out these inspections.

The following is the scope of the maintenance inspection tasks:

- Early detection of abnormalities and their indications in equipment through patrol inspections
- Periodic maintenance inspections, maintenance and life extension of equipment functions through maintenance work
- Management of periodic inspections and other tasks by experts
- Minor repair work

Furthermore, according to the performance of these tasks, the following points are important to note:

- Maintenance of work safety
- Acquisition of qualifications necessary for these tasks
- Tasks based on the expertise and techniques of electrical equipment and mechanical equipment
- Prompt and accurate judgments and responses

Considering these conditions, a maintenance inspection system will be formulated consisting of electrical and mechanical teams, for example, headed by the person in charge of maintenance preservation. A maintenance team with specialized skills will be established. This will enable the acquisition of highly specialized techniques and they will appropriately respond when there is equipment breakdown or in case of any emergency at the facility. They will acquire technological strength so that they can investigate the causes of these problems and will be able to perform safer and more secure operations

Thus, equipment inspection patrols will be carried out by maintenance staff based on the instructions of electrical and mechanical engineer.

1) Maintenance Inspections of Electrical Equipment

In Japan, installation personnel of non-utility electrical generation facilities (transformation of power receiving equipment etc.) must determine the safety regulations and notify them to the supervising body according to the provisions of "the Electric Utility Industry Law, Article 42, Paragraph 1".

In order to maintain reliability of water system, a secure and stable electricity supply is essential and it is important to systematically carry out regular inspections, periodic inspections and detailed inspections.

An example of the inspection methods and inspection categories in Japan is given in the following table.

Table 2.59 Example of Inspection Methods and Inspection Categories

Electrical Facilities	Inspection Method	Inspection Period			
		During Patrol	Periodic Inspection (1 year)	Detailed Inspection (3-5 years)	As the Occasion Calls
Section switches that become the boundary of responsibility Service wires etc. (overhead electrical lines, support cables)	Exterior inspection	○	○	○	Carried out as necessary
	Insulation resistance measurement		○	○	
	Section switch operation test		○	○	
Disconnectors, power fuses, circuit breakers, high-voltage load switches	Exterior inspection	○	○	○	
	Insulation resistance measurement		○	○	
	Circuit breaker and load switch operation test		○	○	
	Circuit breaker and load switch internal inspection			○	
Transformers, capacitors, generating lines, reactors, lightning arresters, meter transformers and other high-voltage equipment	Exterior inspection	○	○	○	
	Insulation resistance measurement		○	○	
	Internal inspection of transformers			○	
Power distribution panels Control circuits	Record the voltage, current and electric energy	○	○	○	
	Exterior inspection	○	○	○	
	Insulation resistance measurement		○	○	
	Protective relay operation test		○	○	
	Protection relay operational properties test			○	
	Control circuit test		○	○	
Accumulators	External inspection	○	○	○	
	Voltage measurement		○	○	
	External inspection	○	○	○	
Grounding devices	Ground resistance measurement		○	○	
	External inspection	○	○	○	

Electrical Facilities	Inspection Method	Inspection Period			
		During Patrol	Periodic Inspection (1 year)	Detailed Inspection (3-5 years)	As the Occasion Calls
Building power receiving equipment and metal box office cubicles	External inspection	○	○	○	

Source: Summary of Annex table 2 Patrol Inspection Measurements and Repair Standards of the non-utility electric facility safety regulations.

2) Maintenance Inspections of Mechanical equipment

There are various important mechanical equipment of water supply facilities, ranging from pumps and electric motor devices to valves and agitators. Breakdowns of these equipment lead to decrease of water flow, suspension of water supply and deterioration of treated water quality.

Therefore, for minimizing equipment failure, standby equipment of pumps etc. are provided for continuation of operation in the event of a breakdown. However, in order to lower the failure of duty equipment and reliably operate the standby equipment whenever needed, regular maintenance inspections should be properly carried out. This will increase the reliability of the water supply system.

Inspections that exercise all five senses are necessary for mechanical equipment, such as the equipment condition during operation, abnormalities, offensive smells, vibrations, overheating, leakages, oil spills and more. Determinations of abnormalities by expertise acquired from experience are essential and it makes possible early detection of problems.

An example of inspection and maintenance of pumps and related mechanical equipment is provided in the following table.

Table 2.60 Example of Pump Inspection and Maintenance

Classification	Target Equipment	Inspection Contents	Inspection Period			
			During Patrol	One Year	5- 10 Years	As the Occasion Calls
Daily Inspection	All	Exterior, vibrations, strange noises, temperature, changes in color, damage, leakages	○			
	Pumps	Oil amount of the axis bearing lubricant (oil, grease), oil spills, operation of oil rings, condition of the fuel filler opening and connectors, ground packing heat, amount of water dripping from seals	○			
	Control Unit and Meters	High water level detectors, low water volume detectors, operating conditions of the solenoid valves, pressure gauges, compound gauges, vacuum gauges, thermometer, readings of ammeters etc., conditions inside the control panel	○			
Periodic Inspection	All	Looseness in parts, corrosion, abrasion, deterioration, damage		○		
	Pumps	Replacement of axis bearing lubricant (oil, grease), conditions of replenishment, cleaning and coating, tightening of pressure nuts and bolts, exchange of Bush coupling rubber, adjustments, replacements and exchange of gland packing		○		
	Control Unit and Meters	High water level detectors, low water volume detectors, operating conditions and properties of the solenoid valves, calibration of pressure gauges, compound gauges, vacuum gauges and thermometers		○		
Detailed Inspection	Pumps	Overhaul inspections of impellers, casing, sleeves and axis bearings, replacement of worn parts, replacement of nuts and bolts, replacement of Bush coupling rubber, centering adjustments			○	
	Control Unit and Meters	Properties inspections and defective product replacement of high water level detectors, low water volume detectors and solenoid valves and properties inspections and replacement of defective gauges			○	
Test Measurements	Pumps	Sequence testing for vibrations, discharge flow, pressure and activation time etc., protective device operating tests for temperature relays etc.		○		
Replacement Parts	Pumps	Bearings, gland packing, seals				○

Source: Excerpt from *Guidelines for Waterworks Technical Management* 2006, by the Japan Water Works Association)

(3) Repair Tasks

In order to maintain and extend the original function of equipment, it is important to implement periodic inspections as well as replace equipment parts and consumable goods. Type and duration of each repair work are considered according to the method recommended by the manufacturer, in consideration of the actual consumption condition and trouble frequency of each equipment in order

to formulate a realistic work plan and ensure implementation.

1) Electrical Equipment Repair

Electrical equipment is divided into electrical receiving, transforming and power facilities, monitoring and control facilities, and water quality instrumentation facilities. Electrical receiving, transforming and power facilities are combined in order to adapt many purposes of machines, and those of the individual parts can be replaced. On the other hand, most of monitoring and control facilities as well as water quality instruments are general-purpose products, and repair needs of their individual parts are not many.

Therefore, repair method and period of each electrical equipment is different based on type of the equipment. Based on formulating conscientious repair plan including the importance of that equipment, and implementation of comprehensive management including procurement of spare parts and equipment, maintenance and life-extension of equipment functions and reduction of operation and maintenance cost shall be achieved together.

2) Mechanical Equipment Repair

The operation parts of mechanical equipment like pump get deteriorated as time passes by and as a result, functions like efficiency and reliability become lower. Therefore, it is important to grasp correctly the situation of each machinery through periodic inspection and overhaul, in order to execute equipment change suiting the condition of their consumption and deterioration. In particular, in case of troubles or bad conditions of important equipment such as water intake pump, water conveyance pump, and water transmission pump, the water treatment plant becomes unable to operate as usual. Thus, it is essential to draft a repair plan in consideration of preventive maintenance.

3) Check and Repair by Manufactures

Most of the equipment proposed in the F/S do not require special maintenance and can be maintained and repaired by YCDC. However, electrical equipment such as VFD panels and SCADA system contains control circuits in black box and may require checking and repairing by manufactures in a breakdown. At the detail design stage, it shall be examined that backup system or dual system should be included so that manual operation can be performed and facilities should be operated if these equipment are break down. In addition, these equipment shall be procured from manufacture which has aftercare service agent in Yangon at the construction stage. Furthermore, YCDC should keep spare parts of equipment that breakdown is frequently occurred and secure budget for checking and repairing them by manufactures.

(4) Water Quality Management Tasks

1) Outline of National Standards for Quality of Drinking Water

Draft version of drinking water quality standard is available in Myanmar. Based on this standard, a water-quality test plan should be prepared. Water quality laboratory should be established in order to perform the water quality tests.

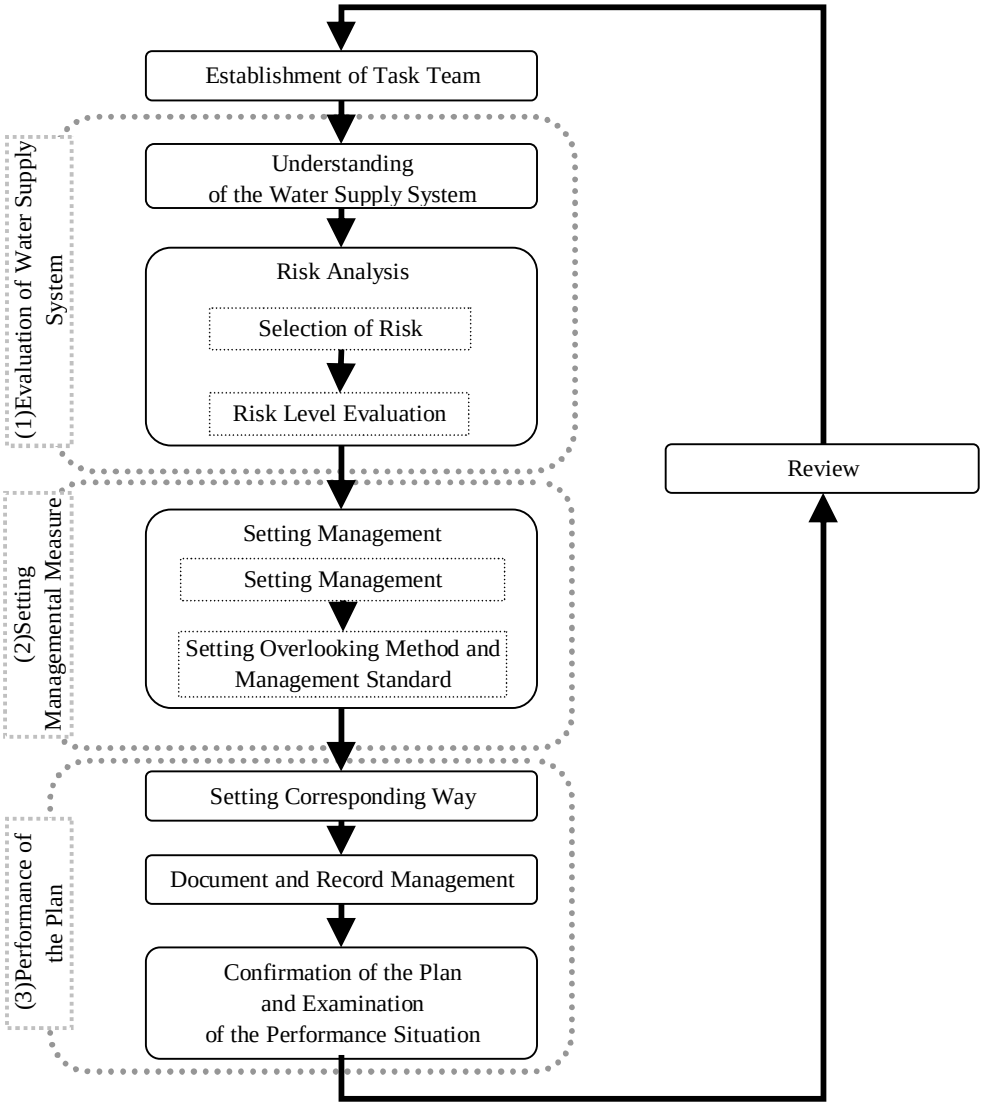
2) Water Quality Management Techniques

It is very important to conduct water quality management in each process so as to produce treated water always meeting quality standards regardless of raw water quality.

The concept of Hazard Analysis and Critical Control Point (HACCP) has been introduced in the World Health Organization (WHO) Water-quality Guidelines (Third Edition) as a Water Safety Plan (WSP) which has been established in the food manufacturing sector.

In Japan, based on these techniques, the Ministry of Health, Labor and Welfare formulated the Guidelines for Water Safety Planning and the Japan Water Works Association compiled water safety planning case data in typical water treatment processes. In small and medium sized business entities as well it has become possible to formulate comparatively simple plans.

Heading into the future, in order to supply safe and high quality tap water, it is vital to formulate, manage and operate a water safety plan for this project.



Source: Excerpt from the Ministry of Health, Labor and Welfare's Guidelines for Water Safety Planning

Figure 2.29 Flowchart of the Water Safety Plan Formulation and Operation

3) Water Quality Management System

Supplying good quality and safe tap water is one of the most important issues from the aspect of ensuring public health. Therefore, it is necessary to establish a water quality management system. Along with monitoring the water quality along the flow of the water supply system and taking an appropriate response to meet these conditions, in the event that there are fears about the safety of tap water, a system is required which quickly takes the best course of action.

The items that are required in water quality management are listed below:

- Formulation of a water quality management plan based on National Standards for Quality of Drinking Water
- Formulation of a water quality inspection plan
- Water quality inspection and results analysis

- Determination of chemical dosing rate in all water treatment processes in response to the quality of raw water
- Management of water quality data
- Investigation of necessary operational methods to maintain and improve water quality.

Moreover, in performing the tasks, it is necessary to consider the following points.

- Compliance with the inspection items and frequencies as specified
- Prompt investigations to determine the cause of a problem and a clear course of action to be taken in the event of occurrence of any abnormality
- Ensuring the reliability of water quality inspection results

To satisfy these conditions, water quality management tasks will be carried out by one person responsible for water quality management also in cooperation with expert engineers. Furthermore, in order to manage water quality strictly, it is essential to establish an organization with experts that perform these tasks independently and which is given a strong authority.

(5) Drainage Management Tasks

The sludge discharged from sediment basins and filter wash water from filter basins are separated into liquids and solids by the sludge treatment facility, sludge concentration is increased and it is then naturally dried in lagoon.

It is necessary to dispose of the cakes that are sun dried appropriately. In this F/S, it is expected that transferring work will be done by using heavy machinery and trucks. Therefore, it is vital to construct a system that specializes in management and implementation of these waste processing tasks.

2.5.2 Pipeline Management Tasks

Accidents and damages on transmission and distribution main pipelines will not only stop water supply suddenly or convey turbid water but also result in secondary disasters, such as road collapse, traffic disorder and flooded housing. The social impact has a large effect. In order to prevent these in advance, periodic inspections and maintenance are important and it is necessary to establish frequent patrols and inspections and systematically conduct them.

The scope of the transmission and distribution pipeline maintenance tasks is displayed below:

- Management of pipeline information and pipeline maps
- Patrol inspections of the entire pipeline once a week by a maintenance vehicle
- Detection of leakages, signs of leakages and events that lead to leakages by patrols
- Inspection of operation conditions of all water distribution equipment such as valves, pumps

etc.

- Water quality tests (residual chlorine concentration, turbidity, etc.)
- Detection of water theft

Inspection patrols will be conducted by an inspection team where one person will manage these tasks and have a full responsibility for transmission and distribution main pipeline.

2.5.3 Security System

In the event of a terrorist attack such as poison injection in the water supply facility (for example a substance being thrown into the source of water), it would create an extremely serious situation where people's lives and physical safety would be threatened and it would also paralyze people's daily lives and urban activities.

A 24-hours 365-days security system will be established in addition to the water supply management system. For example, a security guard will be stationed to monitor the entrance and exit at the main entrance of the water treatment plant and security officers will patrol inside the plant.

CHAPTER 3. FACILITIES MODERNIZATION IN ZONE 1

3.1 Water Demand

3.1.1 Served Area

(1) Characteristics of the Served Area

Zone 1 covering the CBD (Central Business District) is a political and economic center of Yangon. The 50 m high Sule Pagoda is situated in the center of CBD, around which there is a rotary and YCDC office is at the corner of the rotary. With Sule Pagoda at crossing point, Mahabandoola road stretches in east-west direction and Sule pagoda road stretches in north-south direction.

Zone 1 consists of CBD and IUR (Inner Urban Ring zone), which were initially developed areas together with the water supply systems during British rule. The same water supply systems are basically used even at present. They are most likely deteriorated and result in high leakage. Therefore, modernization of the water supply system for this zone is planned as one of the priority projects in the Feasibility Study.

Current water supply condition for Zone 1 is as shown below.

Table3.1 Water Supply Condition for Zone 1 in 2011

item	Number
Population (person)	875,783
Served Population (person)	624,785
Coverage Rate	71.3%
Number of Connections	74,977
Daily Maximum Water Demand	237,049 m^3/day
	52 MGD

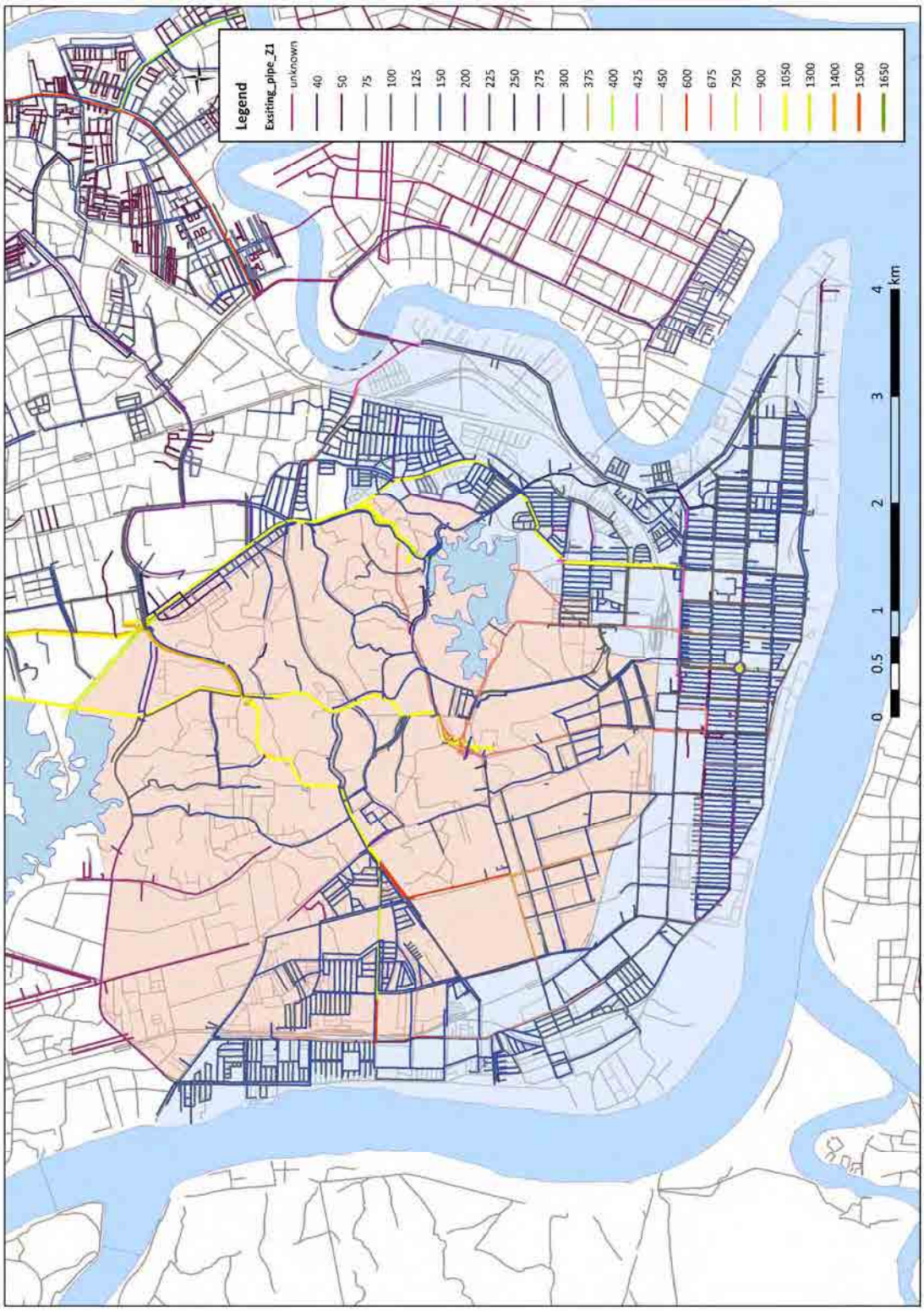
Source: JICA Study Team

(2) Distribution System by Pumping and Gravity

Zone 1 is divided into 2 sub-zones; high and low zones. Water is to be distributed by pumping in high zone and by gravity in low zone. Hill stretches along north-south direction and low areas surround hill areas and also expand along the rivers. The existing two working service reservoirs and abandoned one service reservoir are located on the hills. The working Kokine service reservoir (20 MG) is in the north of Zone 1 while the working Shwedagon service reservoir (1 MG) and the abandoned Central service reservoir (10 MG) are in the south. Total service reservoir capacity is 31 MG.

Water supply duration is not 24 hours and short in townships of Dagon, Bahan, Sanchaung, etc. because they are in the hill areas with elevation of more than 10 to 20 m. Therefore, supply system is to be changed from the currently used gravity flow system to pumping system in such areas. Although

pump can be provided in any reservoir, pumps are planned in the Central service reservoir after its reconstruction. Then, Kokine service reservoir, whose elevation is slightly higher than the Central service reservoir, will be the station for gravitational distribution system.



Source: JICA Study Team

Figure 3.1 Existing Pipe Network in Zone 1 with Proposed High and Low Sub-Zones

3.1.2 Population

Planning parameters are shown below.

Table3.2 Planning Parameters for Zone 1

(1) Estimated Population

(unit: person)

Sub-zone	2011	2018	2020	**2025**	2040
Gravity	570,560	577,102	579,198	**584,933**	607,293
Pump	305,223	313,134	315,668	**322,603**	349,641
Total	875,783	890,237	894,866	**907,535**	956,934

(2) Served Population

(unit: person)

Sub-zone	2011	2018	2020	**2025**	2040
Gravity	442,700	492,627	503,786	**521,473**	587,302
Pump	182,085	224,676	237,857	**262,157**	338,604
Total	624,785	717,303	741,643	**783,630**	925,906

(3) Coverage Rate

(unit: %)

Sub-zone	2011	2018	2020	**2025**	2040
Gravity	77.6%	85.4%	87.0%	**89.2%**	89.2%
Pump	59.7%	71.8%	75.4%	**81.3%**	82.5%
Total	71.3%	80.6%	82.9%	**86.3%**	86.8%

(4) Number of Connections

(unit: number)

Sub-zone	2011*	2018	2020	**2025**	2040
Gravity	57,585	91,604	91,936	**92,846**	96,396
Pump	17,392	49,704	50,106	**51,207**	55,499
Total	74,977	141,308	142,042	**144,053**	151,895

Note: Records in 2011, for 2018 and afterwards, Numbers are calculated as served population divided by 6.3 person per household.

Source: JICA Study Team

3.1.3 Water Demand

Daily maximum demand will increase by 1.2 times in 2025 and by 1.6 times in 2040 compared to 2011. Facilities are planned for 63 MGD, the daily maximum demand in 2025.

Table3.3 Daily Maximum Water Demand

m^3/day	2011	2018	2020	**2025**	2040
Gravity	154,827	180,602	183,337	**191,209**	239,272
Pump	82,222	82,881	87,051	**96,122**	137,951
Total	237,049	263,483	270,389	**287,331**	377,223
MGD	2011	2018	2020	**2025**	2040
Gravity	34	40	40	**42**	53
Pump	18	18	19	**21**	30
Total	52	58	59	**63**	83

Source: JICA Study Team

3.2 Planning Parameters

Planning parameters for Zone 1 are shown below and facilities are planned for 2025. The planned water demand is set as the daily maximum water demand in the target year 2025. The planned DMA and distribution mains for Zone 1 in 2025 are shown in following figure.

Table3.4 Planning Parameters for Zone 1

	2011	2018	2020	**2025**	2040
Population	875,783	890,237	894,866	**907,535**	956,934
Served Population	624,785	717,303	741,643	**783,630**	925,906
Number of Connections	74,977	141,308	142,042	**144,053**	151,895
Coverage rate	71.3%	80.6%	82.9%	**86.3%**	96.8%
Leakage rate	50 %	37	33	**25**	10
Per Capita Consumption	95 Lpcd	126	133	**150**	200
Daily Average Demand	215,499 m^3/d	239,529	245,808	**261,210**	342,929
	47 MGD	53	54	**57**	75
Peak Factor	1.09	1.10	1.10	**1.10**	1.10
Daily Maximum Demand	237,049 m^3/d	263,483	270,389	**287,331**	377,223
	52 MGD	58	59	**63**	83
Number of DMA	0	35	35	**35**	35

Source: JICA Study Team

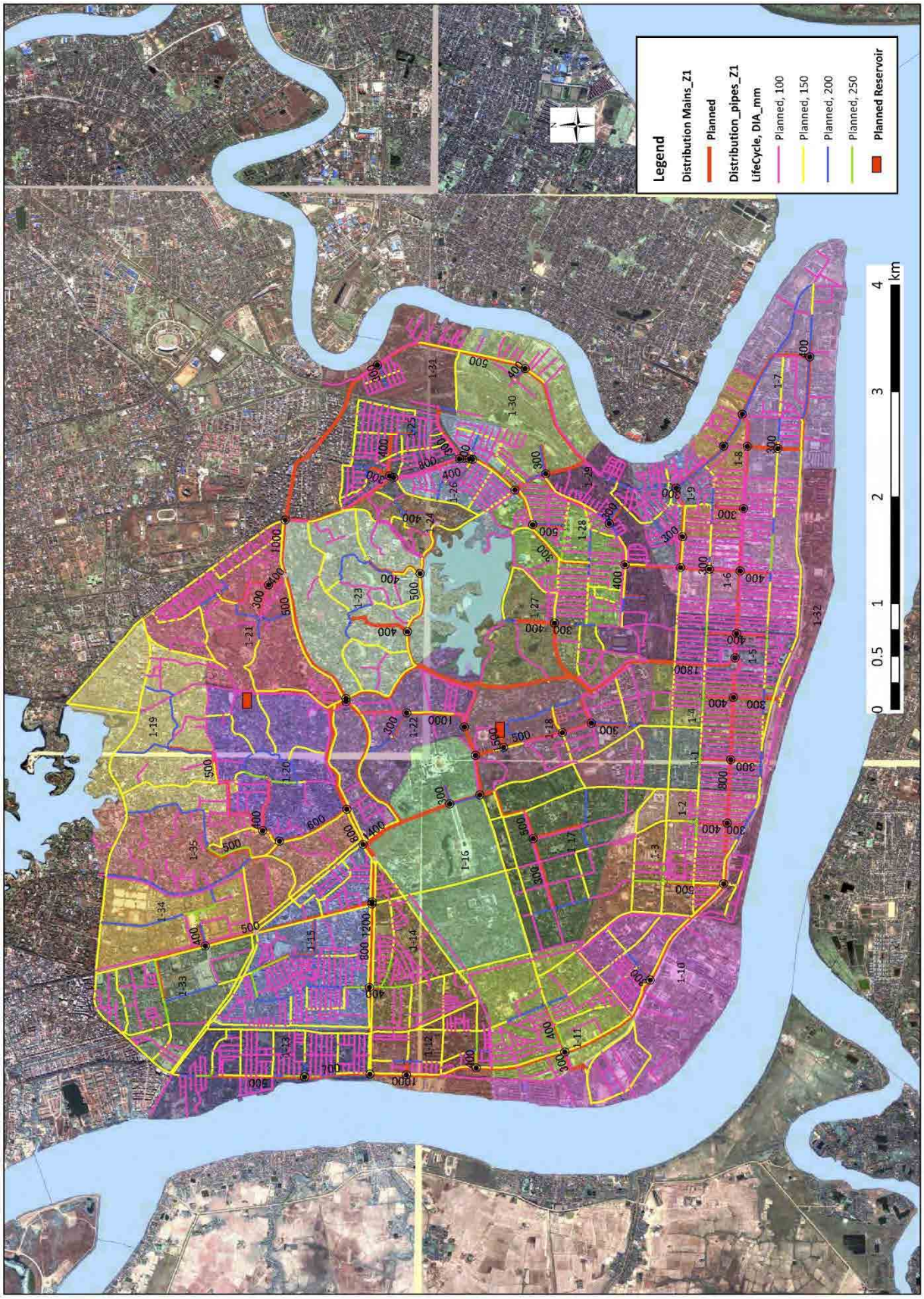


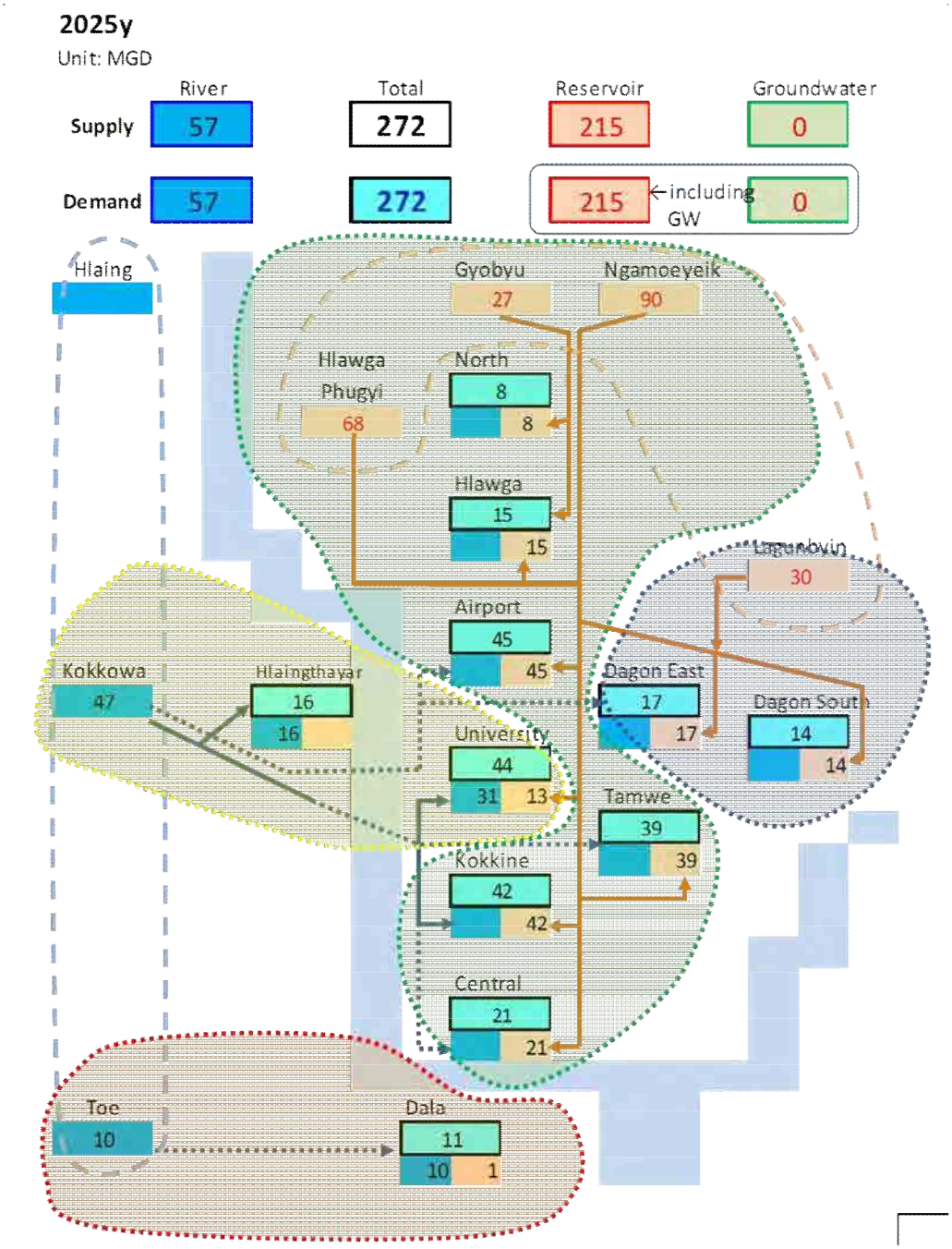
Figure 3.2 DMA and Distribution Mains for Zone 1 in 2025

Source: JICA Study Team

3.3 Facility Planning

3.3.1 Transmission Facility

The water demand in 2025 and allocation of water sources to each of the 10 zones are shown below, which has been modified from the master plan, including only water demand in the YCDC area and excluding demand in peripheral 6 townships.



Source: JICA Study Team

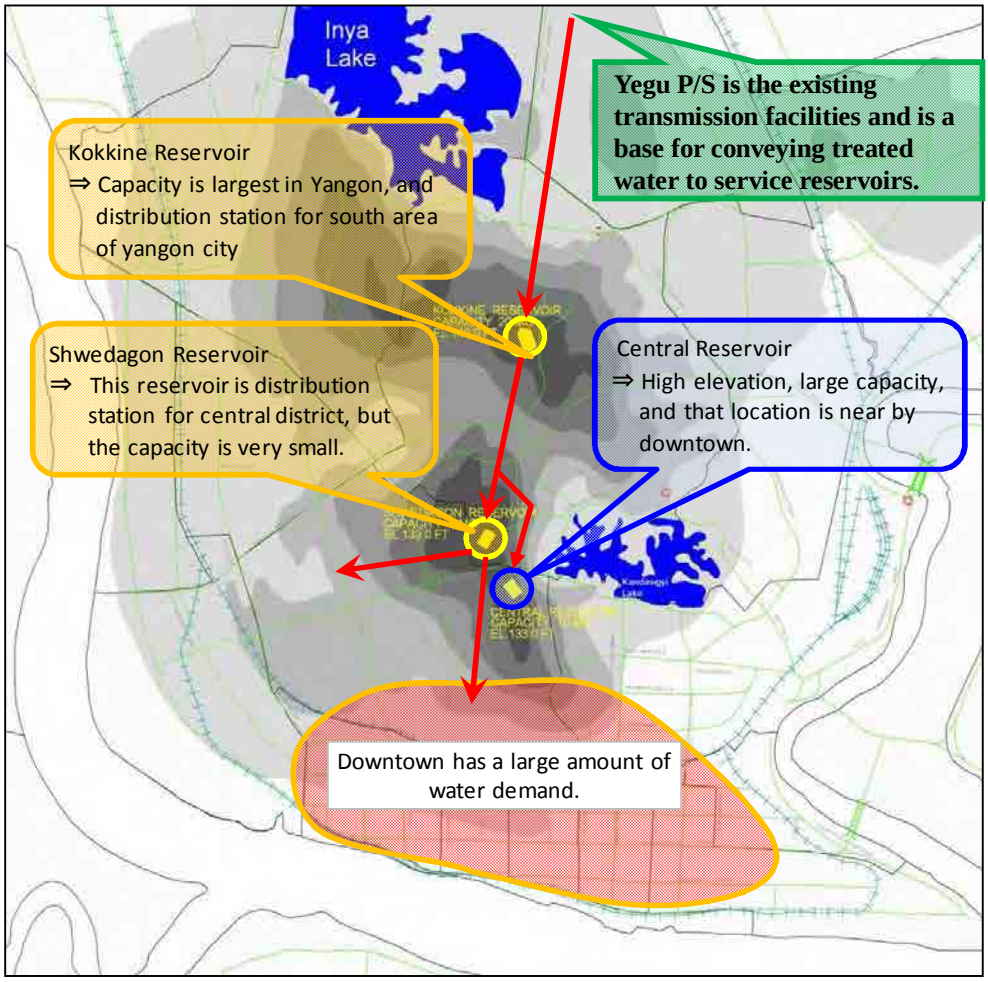
Figure 3.3 Water Source for Each Zone in 2025 (Modified from Master Plan)

In the master plan, pump capacities at water sources and treatment plants are modified so that water can convey to every service reservoir without use of the existing Yegu booster pumping station. Water is mostly brought from Hlawga, Phyugi and Ngamoeyeik into Zone 1 in 2025. Afterwards, instead of the above water sources which are allocated from the northern part of Yangon city, treated river water at Kokkowa will gradually prevail in Zone 1.

The location of Yegu pumping station and the existing service reservoirs in Zone 1 is shown in following figure. Transmission pipeline shall not be included in this plan as the existing transmission pipes from the Yegu pumping station to Kokine service reservoir and further to the Central service reservoir is also utilized.

Zone 1 modernization works is planning to start prior to pump capacity modifications in the above pumping stations. Therefore, as a transitional measure, the Yegu pumping station is utilized until the above-mentioned modification works are completed.

The Yegu pumping stations will be demolished when the Kokkowa water comes into Zone 1 and Zone 3 in 2030 according to the master plan. Therefore, rehabilitation of the Yegu pumping station is not included in the Feasibility Study. However, it should be monitored carefully and rehabilitation might become necessary as it is very old.



Source: JICA Study Team

Figure 3.4 Existing Service Reservoirs in Zone 1

3.3.2 Distribution Main Facilities (Service Reservoir, Pumping Station and Main Pipeline)

(1) Distribution Main Facilities

The outline of planned distribution main facilities (service reservoir, pumping station and main pipeline) is given in the table below.

Table3.5 Outline of Distribution Main Facilities

Facility		Capacity, length and specification
Existing Kokine	Service Reservoir	RC-made 91,000 m^3 x1 basin
	Distribution Pump	None (by gravity flow for distribution)
Reconstructed Central	Service Reservoir	RC-made 45,000 m^3 x1 basin
	Distribution Pump	26.0 m^3/min x 2 sets 88.6 m^3/min x 3 sets
Main Pipeline		φ300-1800 x70.5 km (from reservoir to DMA inlet)

Source: JICA Study Team

(2) Service Reservoir

Two service reservoirs are planned; existing Kokine for gravity sub-zone and reconstructed Central for pump sub-zone.

Table3.6 Service Reservoir

Existing Kokine S/R	Reconstructed Central S/R
20MGDx4546=91,000 m^3	10MGD x 4546 = 45,000 m^3
For gravity sub-zone	For Pump sub-zone

Source: JICA Study Team

1) Kokine Service Reservoir

a) Existing Condition

The service reservoir (Figure 3.6) was constructed in 1926 for high area at that time. Actual condition of structure itself is not known; however, no leakage is reported. Therefore, it is planned to use as it is. However, silt accumulation of about 1.5 m (5 feet) height was reported in 2007, resulting in decrease of effective volume. It was drained in 2007; however, silt has again piled up reaching a thickness of 0.6 m (2 feet). Therefore, periodical cleaning is required. More fundamentally, turbidity needs to be removed in the treatment plants.

Table3.7 Characteristics of Kokine Service Reservoir

Item	Specification
Construction Year	1925 to 1926
Site Size	559 feet x 286 feet
Structure	Underground RC
Volume	90,920 m^3 (20MG)
Water Level	HWL +42.7m (140feet), LWL +36.6 m (120feet)
Water Depth	6.1 m
Inlet Pipe	φ1400 mm Steel Pipe from Yegu PS
Outlet Pipe	φ1050mm for Shwedagon Service Reservoir φ1050mm Iron Pipe for north townships φ1050mm Iron Pipe for southeast townships

Source: JICA Study Team

Retention time of the Kokine service reservoir (excluding small 1 MG capacity Shwedagon Pagoda service reservoir, constructed in 1894) is calculated as shown below. Retention time is almost 8 hours up to 2025, which is the minimum retention time for diurnal demand fluctuation. However, after 2025, additional reservoir capacities are required to maintain a retention time of 8 hours.

Table3.8 Retention Time of the Kokine Service Reservoir without Reconstruction of Central Service Reservoir

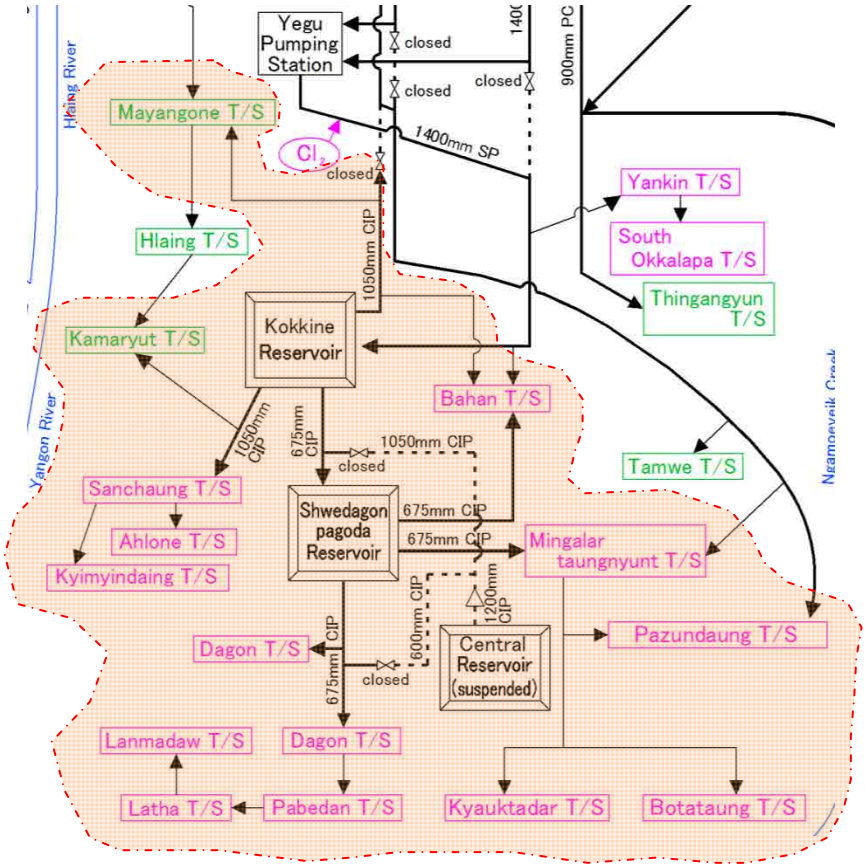
	2011	2018	2020	**2025**	2040
Daily Maximum Demand (MGD)	52	58	59	**63**	83
Retention Time (hr)	9.2	8.3	8.1	**7.6**	5.8

Retention time is calculated as 20 MG divided by daily maximum demand.

Source: JICA Study Team

b) Implementation Plan of Kokine Service Reservoir Cleaning

Structural soundness of the Kokine service reservoir needs to be ascertained after draining the reservoir. During that time, water supply will be suspended for large area as shown below.



Source: JICA Study Team

Figure 3.5 Area of Water Supply Suspension During the Cleaning of Kokine Service Reservoir

In order to survey the Kokine service reservoir, several steps as follows are required as a part of reconstruction of Central service reservoir, which will be mentioned in the section later:

Step 1: Providing direct pipelines from the Yegu P/S to the Central S/R (By-pass pipeline at inlet pipeline at Kokine S/R), and it is checked that water reaches Central S/R from Yegu P/S.

Step 2: Pipelines will be newly laid and the existing pipes will be replaced in Zone 1 according to the proposed routes and sizes.

Step 3: Reconstruction of the Central S/R and installation of pumps.

Step 4: In order to divide the Low zone and the High zone, disinfected water will be tentatively pumped from the Central S/R to entire High zone (pumping flow).

The steps for surveying inside of the Kokine service reservoir are:

Step 5: Draining and cleaning Kokine service reservoir.

Step 6: Analyzing structurally Kokine service reservoir and rehabilitating it, if necessary.

Step 7: The Kokine S/R and improved distribution main pipelines will be connected, and disinfected water will be able to supply from the Kokine S/R to entire Low zone (gravity flow).

Step 8: Operation of Shwedagon Pagoda service reservoir will be stopped.

Although it may require rehabilitation of the Kokine service reservoir, it is assumed that it can be used as a part of service reservoir system in Zone 1. The Kokine service reservoir will serve a part of Zone 1 by gravity flow as is mentioned earlier. Accordingly, the demand will be decreased because it will serve only a part of Zone 1. This will result in retention time of more than the required 8 hours.

Table3.9 Retention Time of Kokine Service Reservoir (for Gravity Sub-Zone)

	2011	2018	2020	**2025**	2040
Daily Maximum Demand (MGD)	52	40	40	**42**	53
Retention Time (hr)	9.2	12	12	**11**	9

Note 1: Retention time is calculated 20 MG divided by daily maximum demand.
Note 2: Demand in 2011 is for entire Zone 1 while demands after 2018 is low sub-zone only.
Source: JICA Study Team

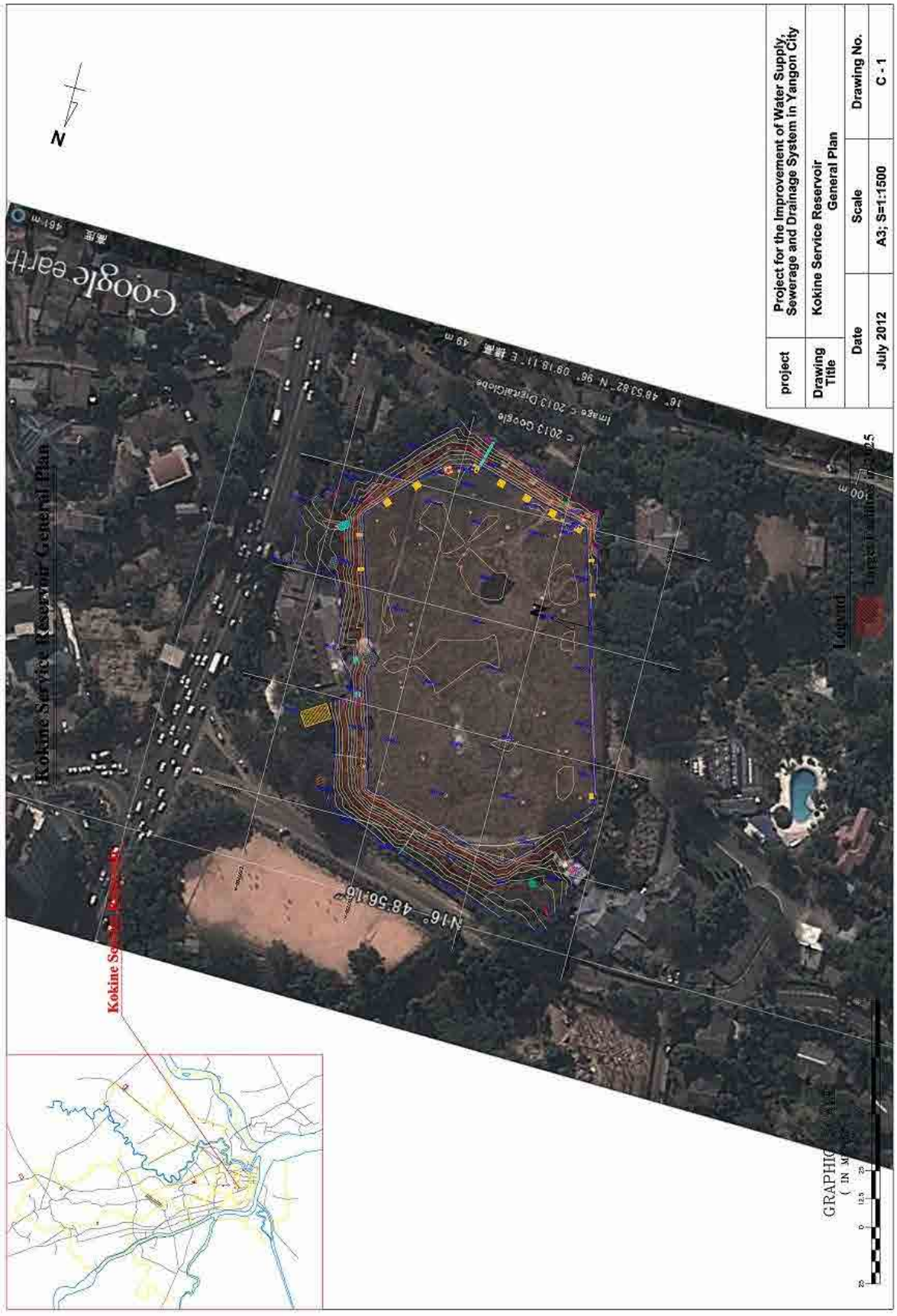


Figure 3.6 Plan View of the Existing Kokine Service Reservoir

Source: JICA Study Team

2) Central Service Reservoir

Central service reservoir (Figure 3.7) has not been used since its completion 48 years back due to leakage from the structure. It is located at a strategic high elevation near downtown so that after its reconstruction, it is planned as a base reservoir for pump-area sub-zone.

a) Condition of the Central Service Reservoir

It is located at a hill top near the Shwedagon Pagoda. The site belongs to the Army Department and is surrounded by pagoda and housing in the north and west sides. The existing RC flat slab structure is covered with earth on top and bottom-half is underground. It has no partition wall and its total capacity is 10MG (=45,460 m^3).

This structure has been left un-used for more than half a century. Rehabilitation efforts were made in past; in 2009 by SIKA, Switzerland and recently by SEGA, Thailand. However, it cannot be used anymore; cracks are observed and reinforcement bars are exposed without concrete as shown below. So, reconstruction is planned in the Study.

The small-sized (1 MG) Shwedagon Pagoda service reservoir exists near the Central service reservoir. After the Central service reservoir is put into operation, it will be demolished due to small-size and weak structure of its roof.

Photo 3.1 External View (Roof) of the Reservoir	**Photo 3.2 Internal View of the Reservoir**
	
Photo 3.3 Deteriorated Column	**Photo 3.4 Rehabilitated Trace by SIKA**
	

Table3.10 Characteristics of Central Service Reservoir

Item	Specification
Construction Year	1965
Site Size	W 347 feet x L 220 feet
Structure	Underground RC
Volume	45,460 m^3 (10MG)
Water Level	HWL +38.1m (125feet), LWL +32.0m (105feet)
Water Depth	6.1 m
Inlet Pipe	φ1050 mm Iron Pipe branched off from "Kokine – Shwedagon" transmission Pipe
Outlet Pipe	Existing inlet pipe is used both as inlet and outlet, and type is φ1200mm cast iron pipe.

Source: JICA Study Team

b) Reconstruction of Central Service Reservoir

The Central service reservoir should be reconstructed because of the unreliability of the existing structure. It was constructed 48 years ago. In Japan, statutory durable years are set as 60 years. Its reconstruction will bring in the following advantages;

- Increase retention time in Zone 1 to the required 8 hours.
- It will serve as a high-pumped sub-zone.
- The operation of Kokine service reservoir, which has only one compartment, can be stopped temporarily for cleaning, inspection and rehabilitation, if required.

c) Reconstruction Plan

Constraints and basic policy for the reconstruction is explained below.

【Constraints】

- High water level should be the same as that of the Kokine service reservoir.
- Volume extension is rather difficult.
- 10 MG capacity of service reservoir, same as the existing one, will be reconstructed.

【Basic Policy】

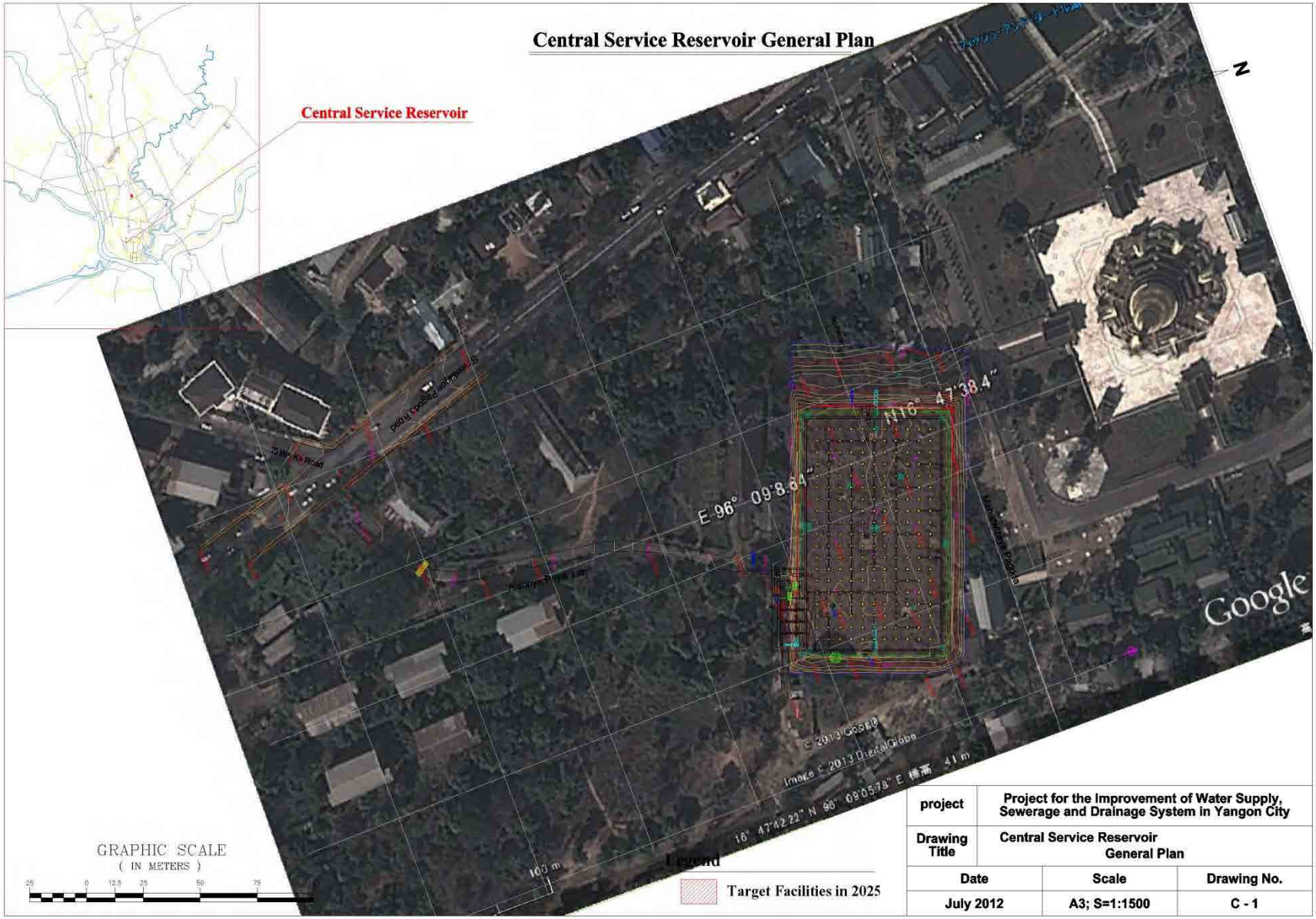
- The existing wall will be utilized as a temporary structure during construction.
- Excavation area will be minimized because of the surrounding structures.
- Guiding walls will be provided to prevent short-circuit flow.
- Mitigation measures for noise and vibration will be adopted during demolishing and construction works.

Retention time of the Central service reservoir for pumped high sub-zone is shown below.

Table3.11 Retention Time of Central Service Reservoir (for Pumped Sub-Zone)

	2011	2018	2020	**2025**	2040
Daily Maximum Demand (MGD)	Not Used	18	19	**21**	30
Retention Time (hr)		13.3	12.6	**10.0**	8.0

Note: Demand is for high pumped sub-zone only.
Source: JICA Study Team



Source: JICA Study Team

Figure 3.7 Plan View of Central Service Reservoir

(3) Distribution Pump

Distribution pumps are installed in the Central service reservoir for supplying water to the high sub-zone of Zone 1.

1) Planning Parameter

Planning parameters are shown below.

Table3.12 Planning Parameter of Distribution Pump in Zone 1

Name	Planning parameters
Central Service Reservoir, Zone 1	96,122 m^3/day x 1.5/24=6,007 m^3/hr

Source: JICA Study Team

Flywheel and/or non-return valves are provided in the distribution pumps to mitigate water hammer phenomenon. Electrically-driven discharge valves, flow meters, pressure gauges etc. are also planned. The planned pumps will also include stand-by pumps.

- Maximum Pump Head: 90 m corresponding to allowable pipe pressure of 1.0 MPa.
- Maximum Motor Output: 800 kW (the capacity same as YCDC is using)
- Countermeasures against Water Hammer: Flywheel and/or non-return valve

2) Pump Type

Horizontal-shaft double-suction Volute Pump (refer to Table 2.14)

3) Discharge Volume Control

Pumps are operated to meet demand fluctuation so that number of operating pumps is decided based on water pressures on the delivery side; when demand increases, water pressures drops, and then additional pumps should be turned on to recover water pressure. In addition, VFD control devices are planned in some pumps. Details are shown in Table 2.42.

4) Distribution Pump

Pumps are planned to distribute 6,007 m^3/h to the sub-zone through 1,300 mm main pipe. A total of 5 pumps are planned; 3 large volume pumps and 2 small volume pumps. Motor outputs for small pumps are limited to 240 kW for VFD controlled motors which can be operated under low receiving voltage. Such motors are cheaper and easier to operate.

Table3.13 Distribution Pump for Zone 1

Item	Specification	For 2025	For 2040
Small Pump	Horizontal-shaft Double-suction Volute Pump 26.0 m^3/min x approx.42m Head x230 kW (VFD)	2	—
Large Pump	Horizontal-shaft Double-suction Volute Pump 88.6 m^3/min x 800 kW	2 (including 1 stand-by)	1

* Surge tanks are planned at the pump delivery side as countermeasures for water hammer.

Source: JICA Study Team

(4) Electrical Facilities

1) General

Design parameters of the electrical facilities are shown below. Electricity supply situation is explained in 2.3.4(13).

Table3.14 Design Parameters of Electrical Facilities in Zone 1

Design Parameters	
1) Receiving Voltage	33kV, 50Hz, 1 circuit
2) Receiving Transformer	3,000 kVA
3) Installed Capacity	2,400 kW
4) Operating Capacity	1,800 kW

Source: JICA Study Team

2) Power Receiving Circuit

The receiving capacity of pump station is 3 MVA, and the receiving voltage is 33 kV.

Zone 1: Dagon Township (Central Service Reservoir)

A 33 kV cable shall be installed underground from the nearest YESB substation. The estimated length of the cable is less than 1 km.

Source: JICA Study Team

Figure 3.8 Zone 1 Pump Station and Expected 33 kV Cable Route

3) Receiving Transformer and Distribution Equipment

Installed capacity is the same as Ma-So water treatment plant. Please refer to the section 2.3.4(13). Receiving transformer is not planned. Alternatively, electricity is directly connected to the indoor closed-switchboard in the pumping station.

(5) Distribution Main Pipe

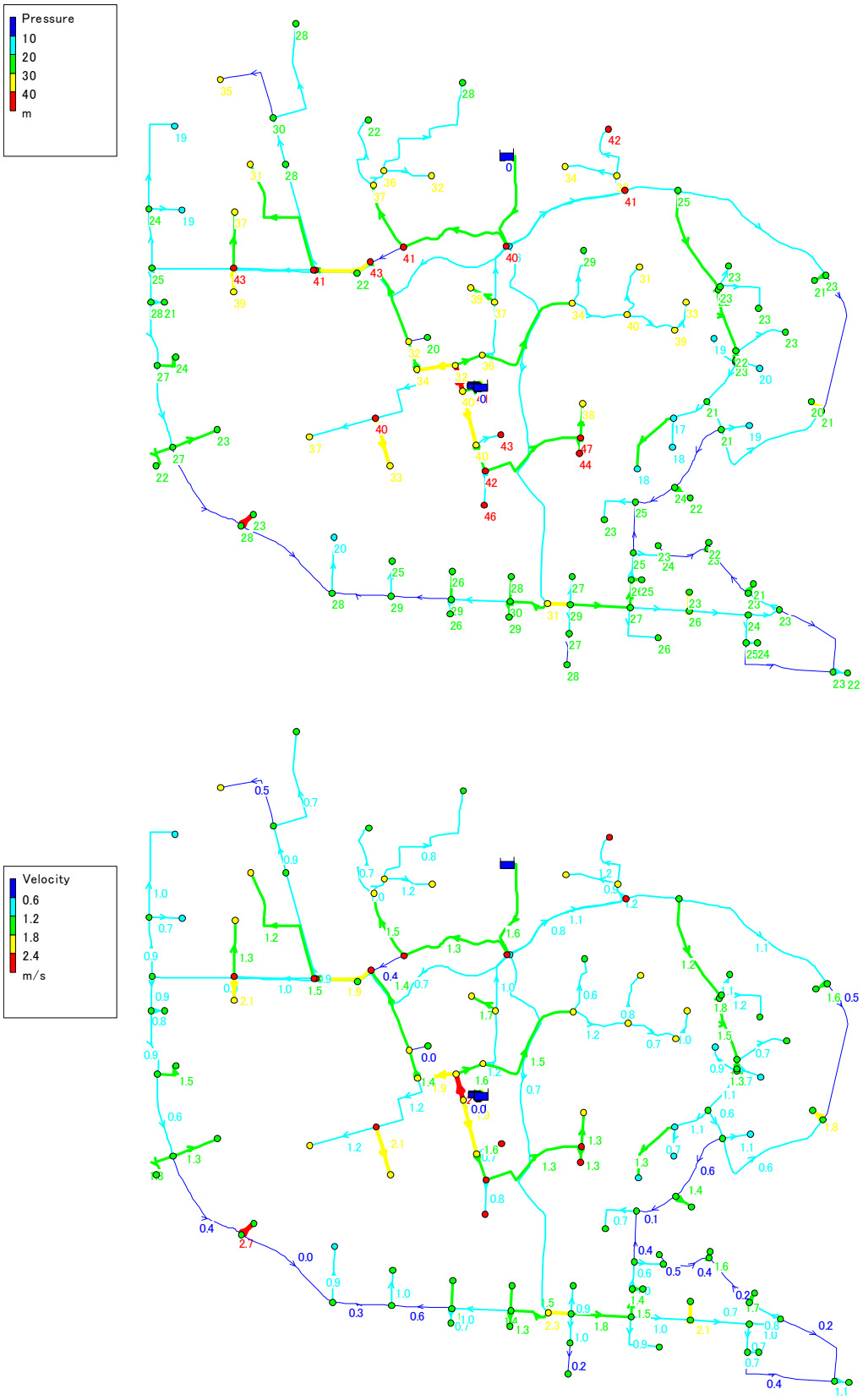
Network analysis results are shown in Figure 3.9. Conditions of analysis are same as described before for Zone 7 and Zone 8 (refer to 2.3.6. (5)). A minimum residual pressure of 18 m was aimed at the inlet of DMAs. The major pipes were designed to work in a looped system while smaller mains branched from the major ones.

As a result of the network analyses, lengths, sizes and locations of the distribution main pipes are obtained as shown below. And distribution main pipes are shown in Figure 3.10-11.

Table3.15 Length of Distribution Main Pipe for Zone 1

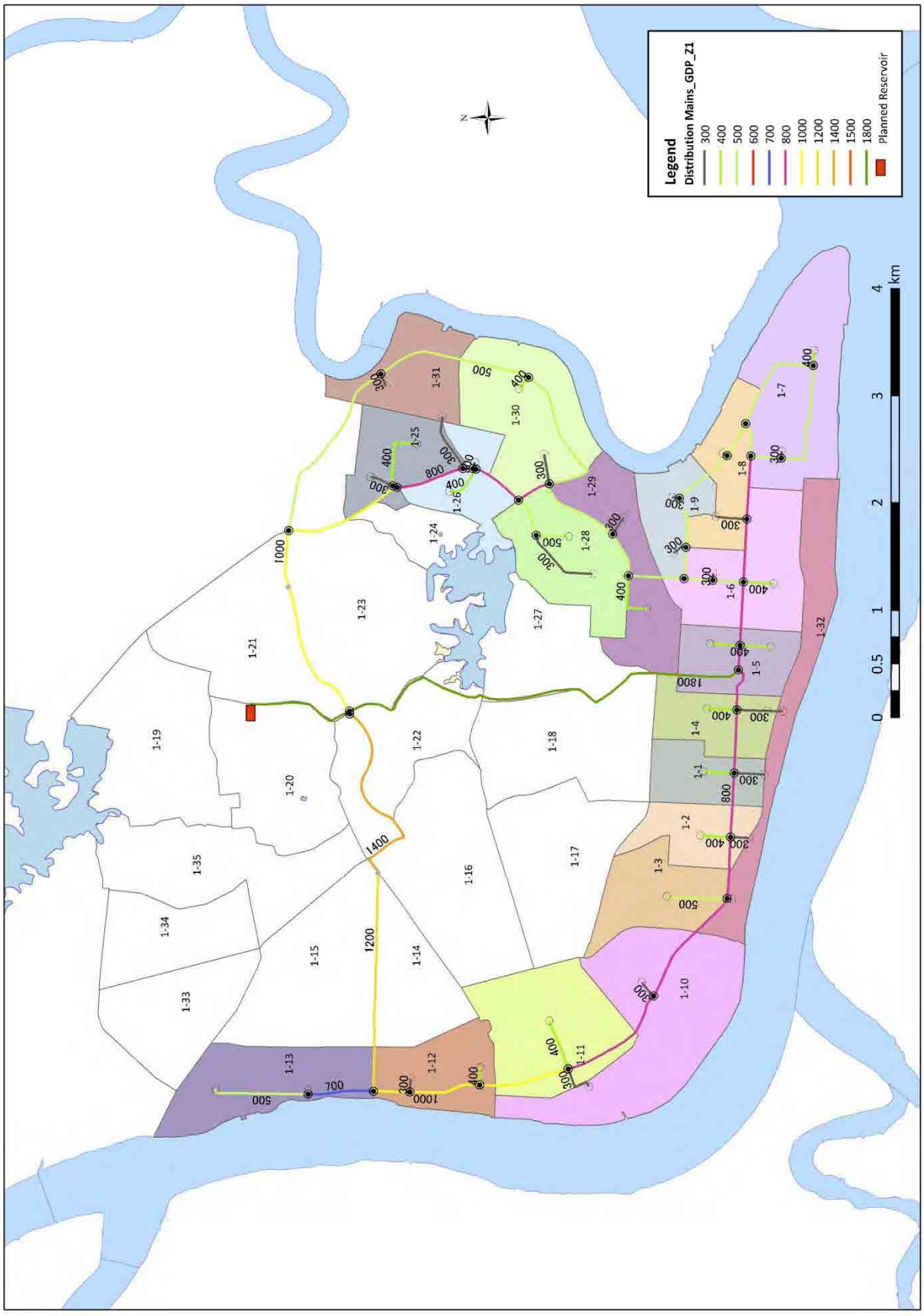
Existing Distribution pipe		New Distribution pipe	Remarks
Dia.(mm)	Length(m)	Length(m)	
300	55,962	7,634	Open Cut
375	1,750		
400		6,895	Open Cut
425	4,084		
450	4,263		
500		26,277	Open Cut
600	4,035	900	Open Cut
675	16,282		
700		596	Open Cut
750	8,528		
800		12,448	Open Cut
900	2,601		
1000		6,551	Open Cut
1050	15,245		
1200		2,038	Open Cut
1300	82		
1400	1,572	1,958	Open Cut
1500		166	Open Cut
1800		4,997	Shield method
	114,403	70,460	Total = 70.5km

Source: JICA Study Team



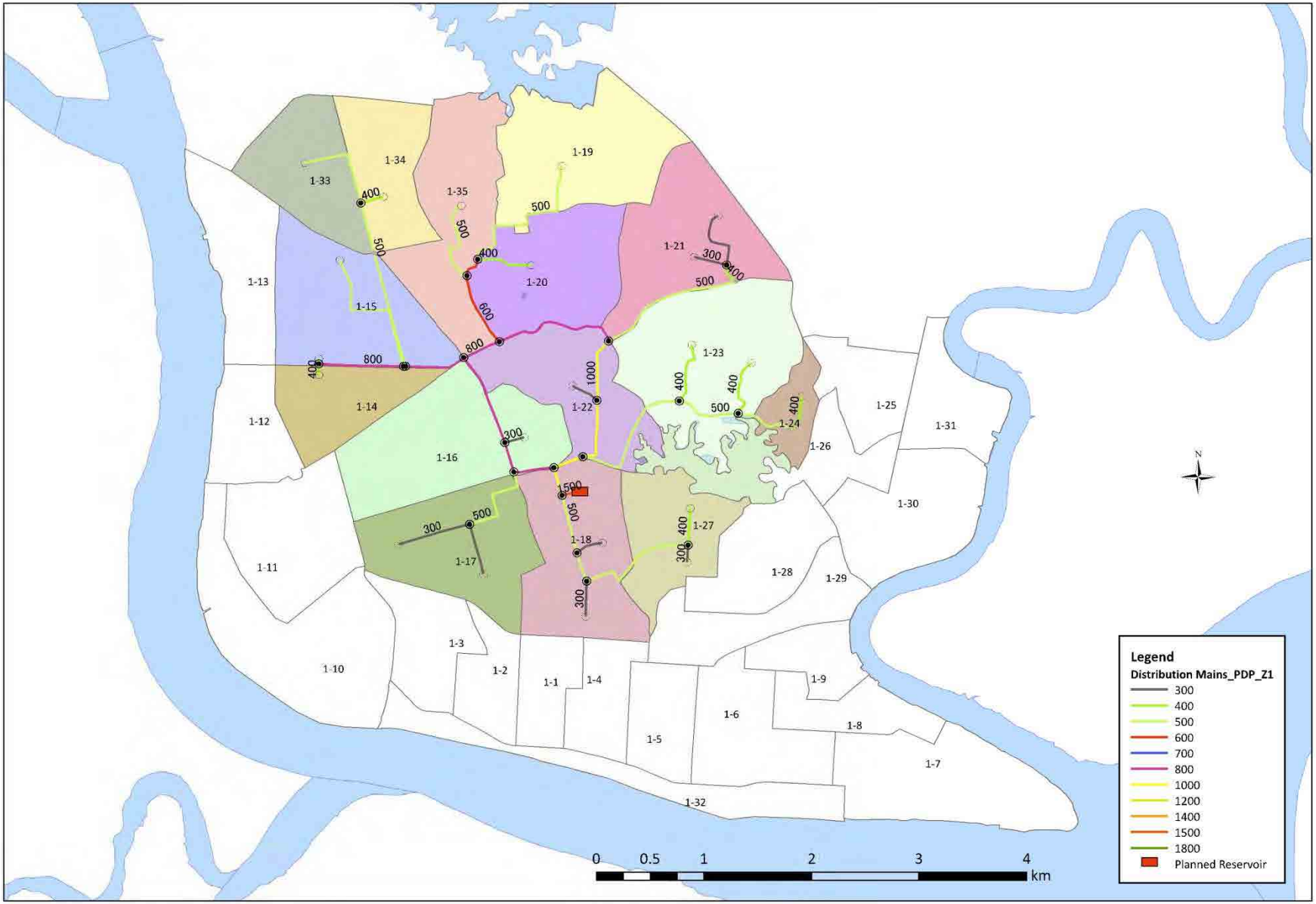
Source: JICA Study Team

Figure 3.9 Hydraulic Analysis Result of Distribution Main Pipe (from Service Reservoir to DMA Inlet) for Zone 1



Source: JICA Study Team

Figure 3.10 Distribution Main Pipes for Zone 1 Gravity System from Kokine Service Reservoir



Source: JICA Study Team

Figure 3.11 Distribution Main Pipes for Zone 1 Pump System from Central Service Reservoir

3.3.3 Distribution Facilities (DMA, Distribution Pipe and Service Connections)

(1) Distribution Facilities

Table3.16 Distribution Facilities

Facilities	Number
Number of DMA	35
Distribution Pipe	φ100-200 x 413.2 km
Number of Connections with Meters	124,386

Source: JICA Study Team

(2) DMA and Distribution Pipe

1) DMA Plan

DMA is planned within Zone 1 for equitable water distribution by monitoring and controlling inflow to each DMA. The planned DMA will also be utilized to monitor NRW for each DMA by comparing inflow amount with total consumed amount. The smaller the size of DMA the more equal is water distribution to each DMA. However, for practical and ease of distribution operation, DMA size has been enlarged. IWWA recommends DMA size in the range of 500 to 3000 connections. Boundaries of DMA are planned along backyards of the high-rise buildings, resulting in short lengths of distribution pipes for gravity flow area where high-rise buildings exist with high population density. On the contrary, areas with pump system distribution have mainly large sized bungalow-type housing. So DMA boundaries often coincide with the roads. The DMAs are planned to have about 3,500 connections each for Zone 1 which are shown in Table 3.17.

Table3.17 DMA Planning for Zone 1

Service population in 2011	No. of Service Connections in 2011	Demand in 2025 (m^3/d) (MGD)	Service population in 2025	Estimated No. of Service connection *	No. of Connection/DMA
593,389	64,907	287,331 63 MGD	783,630	124,386	3,554

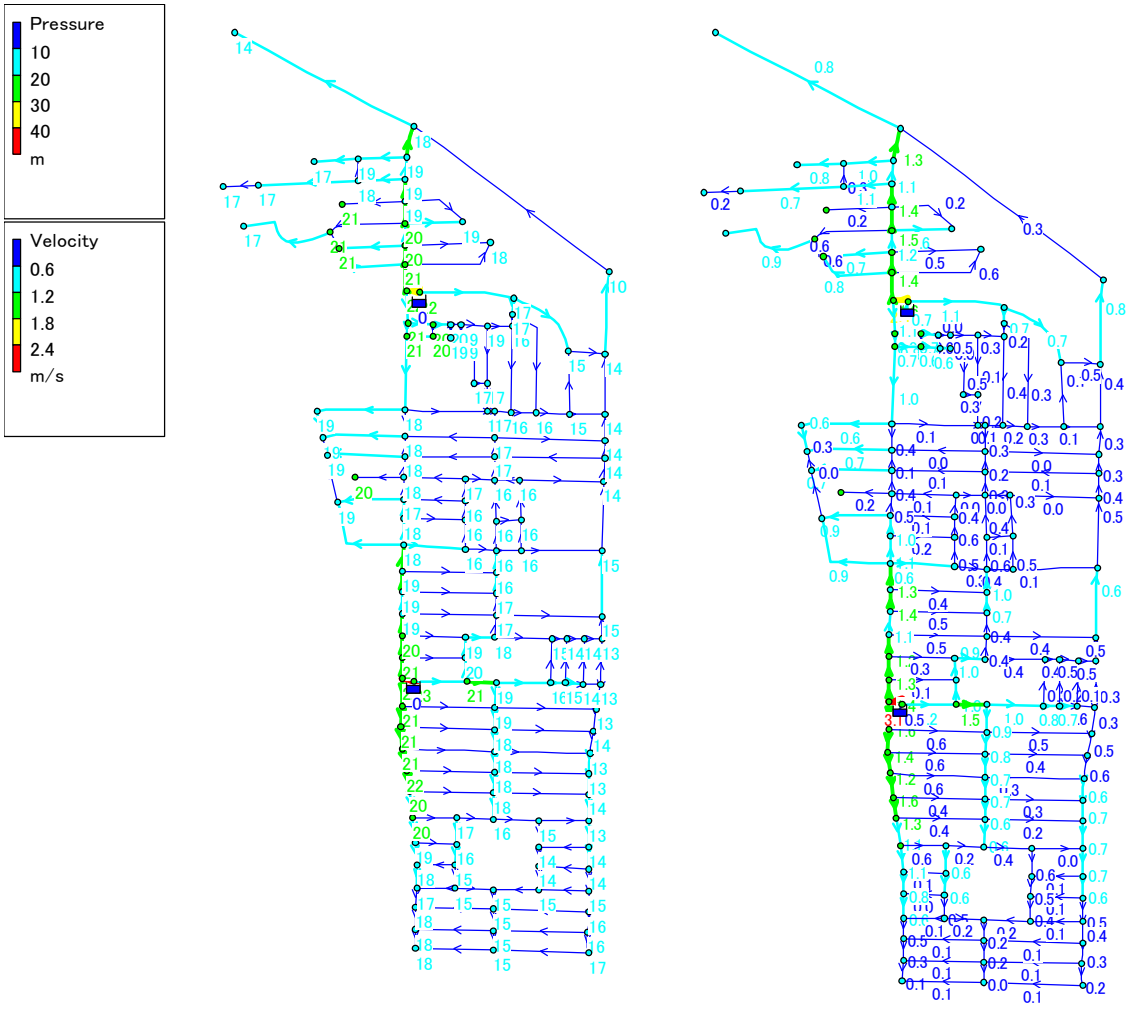
Number of DMA	Bulk Meter (BM) Chamber	Bulk Meter	Isolation Valve with Chamber	Replacement/Installation of Service Connection	Replacement/Installation of Customer Meter
35	59	59	72	124,386	124,386

Note: * 6.3person/connection
Source: JICA Study Team

2) Network Analysis within DMA

Network analysis is conducted for some large-sized DMAs. Minimum water pressures at nodes, which are the tapping points for house connections, are maintained at 15 m. The simulated pressure at the inlets of DMAs is generally in the range of 20 to 35 m but in some DMAs it is only 18 m, which is the minimum requirement. In such cases maximum allowable head-loss from the DMA inlet to the tertiary

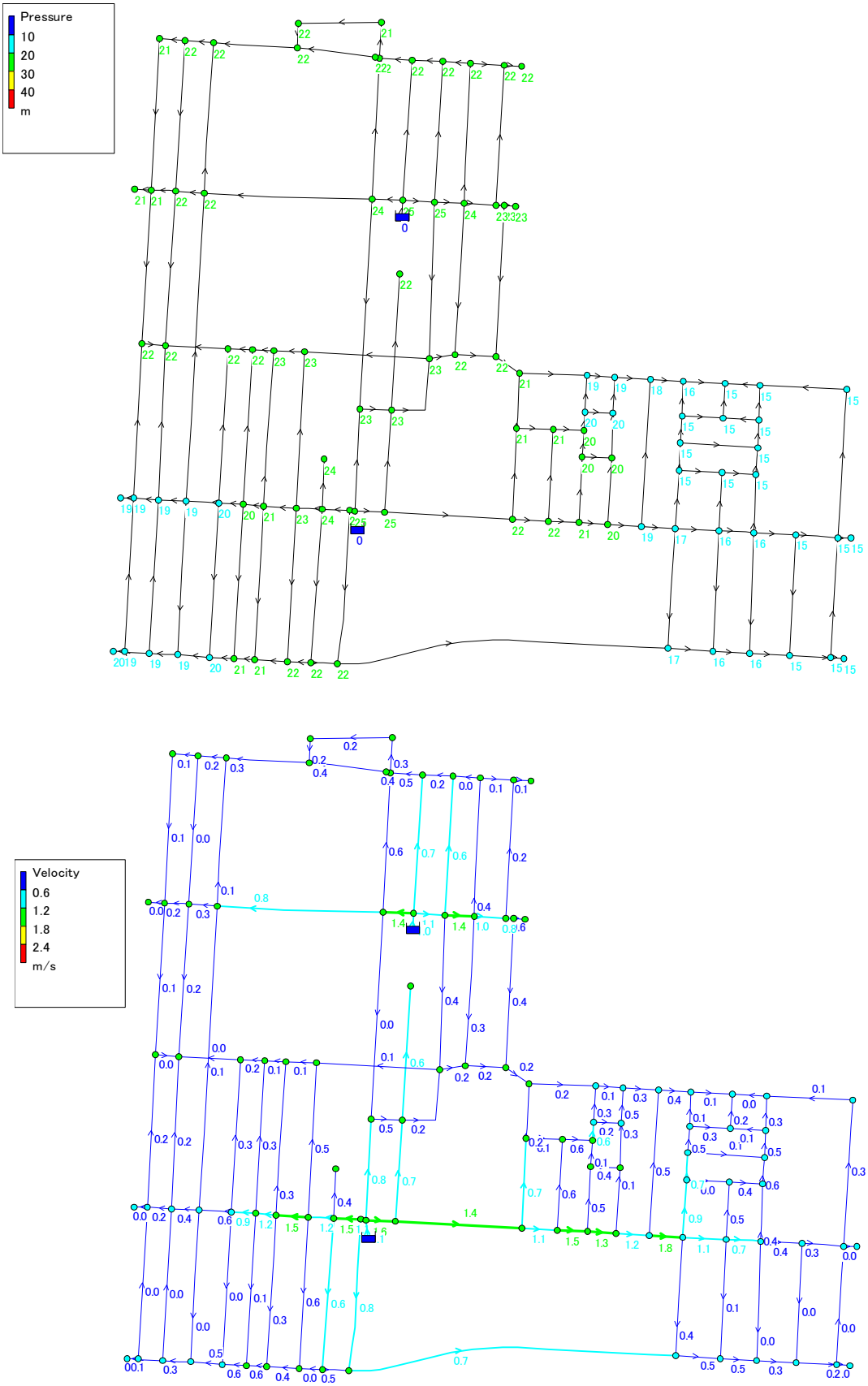
pipe, where tapping will made for house connection, cannot be more than 3 m. The results are shown below. The upper figure shows nodal pressure while the lower shows flow velocity in pipes. The flow velocities are generally in the lower range. Because of the relatively flat terrain of the area, it was necessary to have bigger pipes to reduce frictional head-loss and maintain minimum required residual head at tapping points. Flow velocities became lower due to this reason.



Source: JICA Study Team

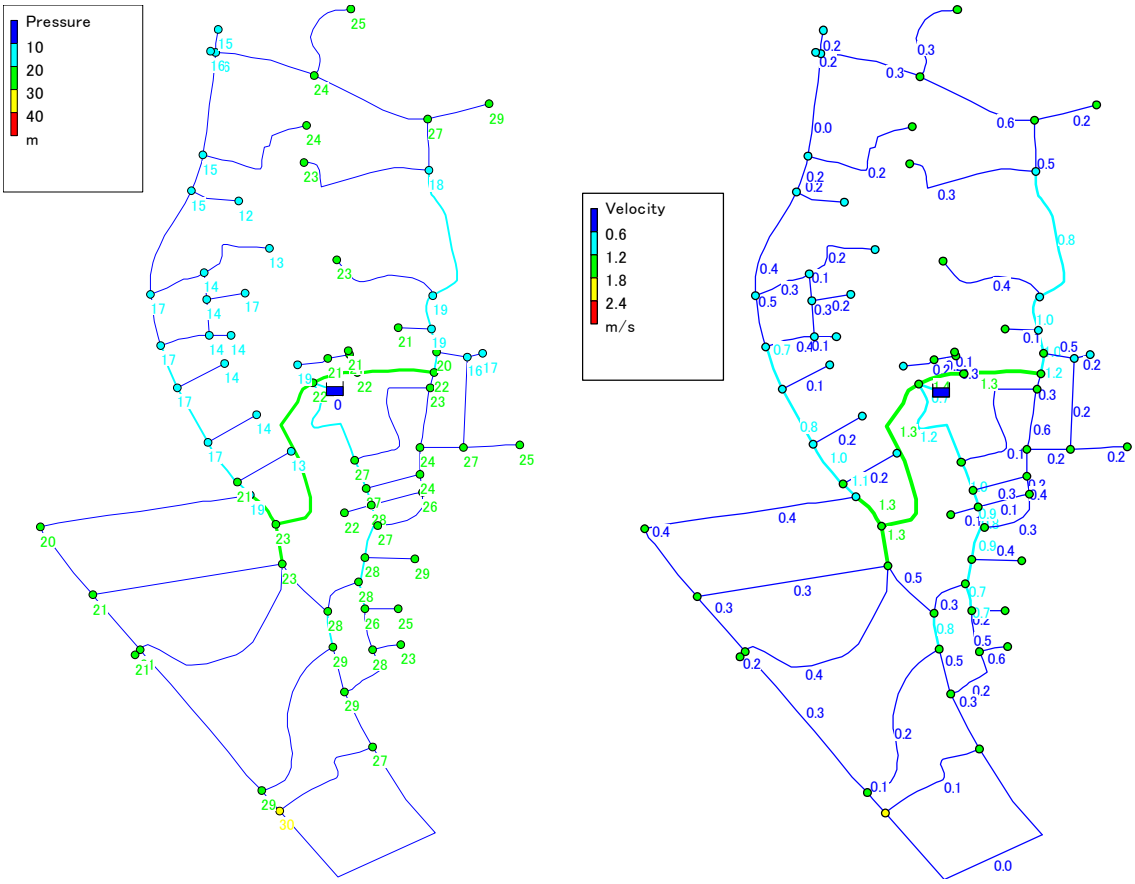
Figure 3.12 Network Analysis Results for DMA 1-13

(Nodal pressure: left, velocity: right side)



Source: JICA Study Team

Figure 3.13 Network Analysis Result for DMA 1-6



Source: JICA Study Team

Figure 3.14 Network Analysis Results for DMA 1-35

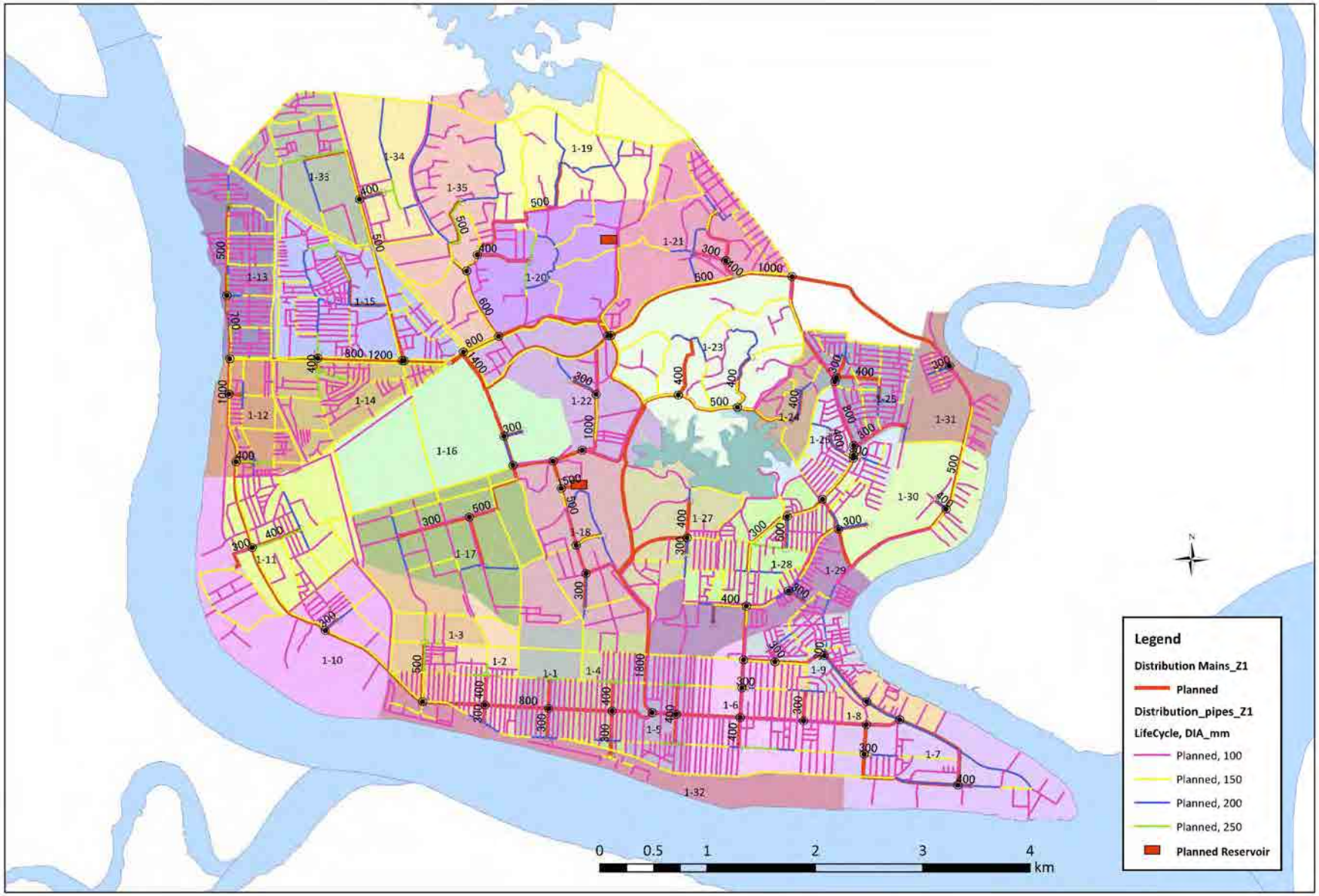
3) Distribution Pipe within DMAs for Zone 1

Length of distribution pipe is planned as shown below based on the network analysis. Distribution pipe layout is shown below together with DMA.

Table3.18 Length of Distribution Pipe for Zone 1

Existing Distribution pipe		New Distribution pipe	Remarks
Dia (mm)	Total Length (m)	Total Length (m)	
40	2,304		
50	1,778		
75	8,624		
100	71,892	260,072	Open Cut
125	1,304		
150	230,615	117,457	Open Cut
200	6,578	27,942	Open Cut
225	23,054		
250	2,195	7,714	Open Cut
275	2,823		
	351,167	413,184	Total = 413km

Source: JICA Study Team



Source: JICA Study Team

Figure 3.15 DMA and Distribution Pipe for Zone 1

3.3.4 Monitoring and Control System (SCADA)

The concept of SCADA is same as the Water Supply Zone of Lagunbyin System (refer to section 2.3.8). The monitoring points and contents are shown in table below.

Table 3.19 SCADA Monitoring Points

Monitoring Point	Measuring Parameters
Central Monitoring Station	Water and Sanitation Department, YCDC or Yegu Pumping Station
Service Reservoir for Zone 1	Water Level at Kokine Service Reservoir Inlet and outlet Flow at Kokine Service Reservoir Inlet and outlet valve opening position
	Water Level at Central Service Reservoir Inlet and outlet Flow at Central Service Reservoir Inlet and outlet valve opening position
Inlet of DMAs for Zones 1, 7 and 8	Inlet valve opening position, Flow and Pressure for Zone 1, Nos.=35 Inlet valve opening position, Flow and Pressure for Zone 7, Nos.=29 Inlet valve opening position, Flow and Pressure for Zone 8, Nos.=24

Source: JICA Study Team

3.3.5 Disinfection Facilities

Disinfection facilities are not required here because disinfected water comes from the Yegu pumping station (Refer to Chapter 4).

3.4 Construction Plan

Construction plan is as follows;

(1) Contents of Planned Main Facilities

Table3.20 Planned Main Facilities

Item	Number
Service Reservoir and Distribution Pump	Rehabilitation of Central Service Reservoir 10MG Construction of Distribution Main Pump in Central Service Reservoir Existing Kokine Service Reservoir (Gravity Flow) 20MG
Distribution Main Pipe to DMA	Φ300 - 1800 mm, 70.5km
Distribution Pipe within DMA	Φ100 - 250mm, 413.2km
Service Pipe	124,386 connections
Meter	124,386 Nos.

Source: JICA Study Team

(2) Construction Works Requiring Special Attention

1) Pipe Installation by Shield Method

Pipes are planned to install under existing roads or right of way limit and installation method is open-cut method except the route along the section from the Kokine service reservoir to Sule Pagoda, where shield method is proposed not so as to affect traffic flow since the traffic of this route is very heavy and large diameter pipe should be installed. Following is the outline of shield method.

Table3.21 Outline of Shield Method

Dia. (mm)	Contents
1800	4,997m, Karate Pagoda road

Source: JICA Study Team

2) Reconstruction of Central Service Reservoir

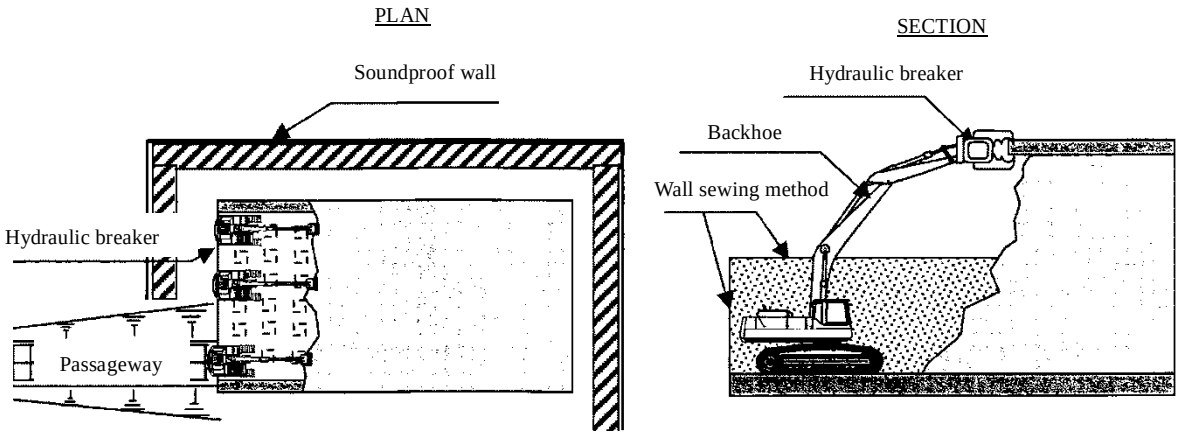
There exists Pagodas to the north and west of the Central service reservoir. Demolishing the existing walls may cause some damage to the adjacent Pagodas. For this reason, instead of demolishing the existing walls, they are planned to be used as retaining walls during site excavation. This will also result in cost reduction.

The temporary design is as follows. A H-shaped steel beam will be temporarily used as waling, in order to support existing service reservoir‘s walls. A strut supports this waling and is hung into the reservoir. And the pile installed at the bottom of the reservoir at the grid pattern will support the strut (refer to Figure 3.16). After the wall and bottom of the new sructure will be made, waling will be removed, and this pile will become unnecessary, probably, this pile will exist in the concreted bottom. Then, this pile will be cut from the surface of bottom into several 10 cm deep. Finally, the newly made hollows will be filled up with concrete. Since there is a possibility that leakage of water may result from bottom if filling process is bad, work and inspection should be carried out carefully.

Source: Kitachiba Water Supply Authority

Figure 3.16 Example of Temporary Earth Retaining Wall

Demolishing of the structures other than some walls should be made with low-noise and low-vibration methods not to affect the adjacent pagodas and houses. The wall-sewing method using hydraulic breaker will meet this requirement as shown in following figure.



Source: METI Report

Figure 3.17 Outline of Removal Plan of Existing Structure

(3) Facilities drawing

Facilities drawings are given in Attachment-G.

3.5 Operation and Maintenance of Facilities

Refer to sections 2.5.1 and 2.5.2.

CHAPTER 4. DISINFECTION FACILITY

4.1 Present Condition of Disinfection

(1) Present Condition of Chlorination

Chlorination equipment was not installed in any of the existing WTPs; the only place it exists is Yegu pump station. However, even in Yegu pump station the installed equipment does not have sufficient capacity required to disinfect the amount of water supplied from the station. It is only injected once per 1 - 2 weeks. The condition is such that un-disinfected water is supplied to a great part of the city.

(2) Water Quality of Water Supply Tap

In M/P study, water quality of water supply tap was investigated. Parameters analyzed included turbidity, residual chlorine, total coliforms and fecal coliforms. Purpose of this survey was to understand the effect of chlorination in YCDC water distribution network. In YCDC water supply system, chlorination is implemented in Yegu P/S. Therefore, sampling points (water supply tap) were selected in the Yegu P/S water distribution area. Summary of water quality analysis is shown below;

- Total coliforms and fecal coliforms were detected from all samples.
- Therefore, the effect of chlorination in Yegu P/S is estimated very low.
- Increasing of EC and decreasing of residual chlorine was observed between Yegu P/S to Yankin T/S. The reason of this change in water quality is assumed that the interfusion of pollutant (e.g. interfusion of wastewater) in the water distribution system between Yegu P/S and Yankin T/S.
- 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 change in water quality is assumed that the interfusion of pollutant (e.g. interfusion of wastewater) in the water distribution system between Dagon T/S and Pabedan T/S or Latha T/S.

4.2 Planning Target

(1) Planning Purpose

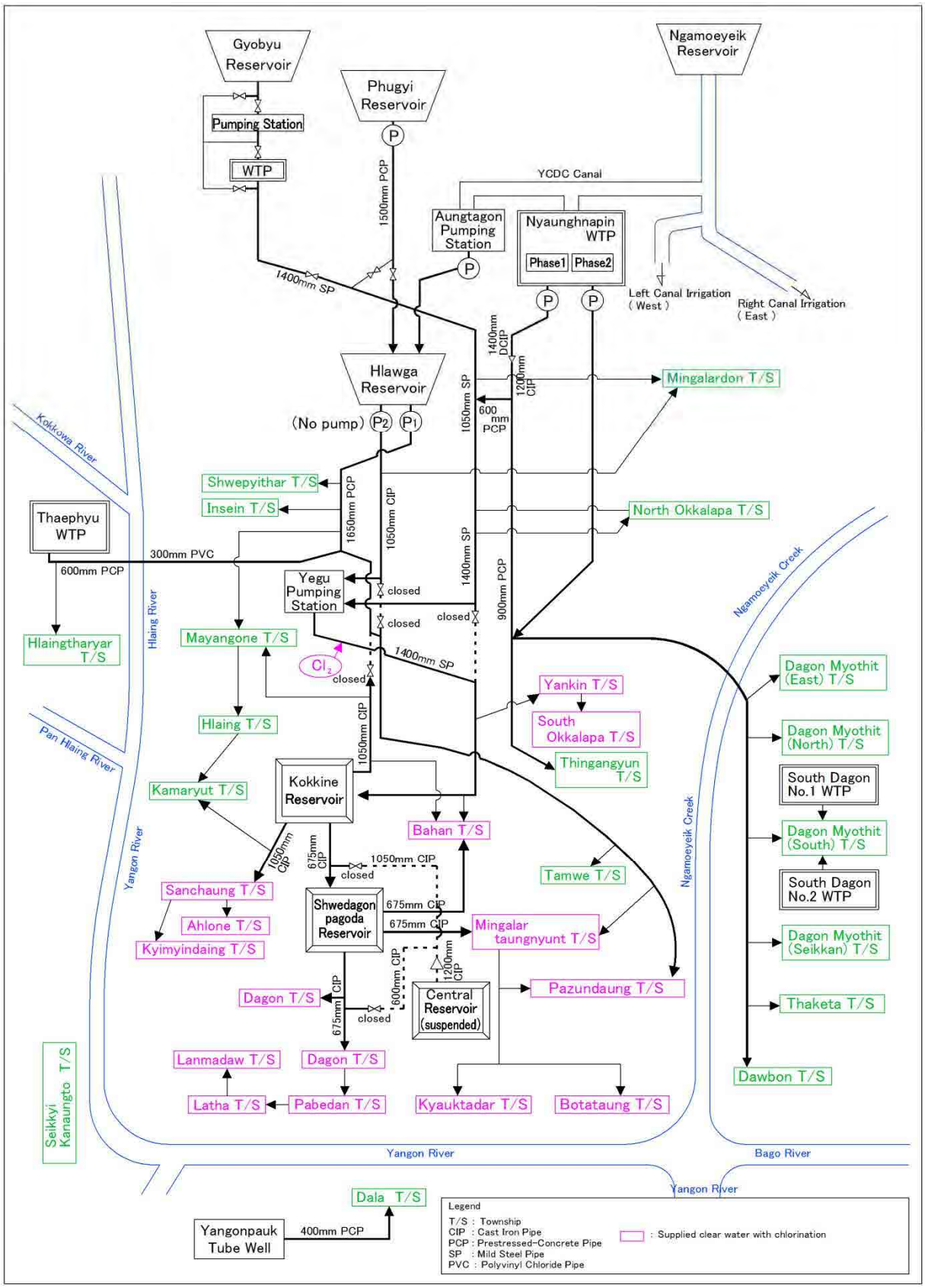
"Provision of the treated water with chlorination" is adopted by M/P for the purpose of water quality improvement in water supply. The target of this F/S is that chlorination facilities will be installed in the existing water supply system, and safe water will be supplied.

(2) Current Situation of Chlorination

Diagram of existing water supply system is shown in following figure. Disinfected water is supplied to the Townships named in rose–colored fonts. The quantity is not enough although it seems that disinfected water is supplied to many T/Ss.

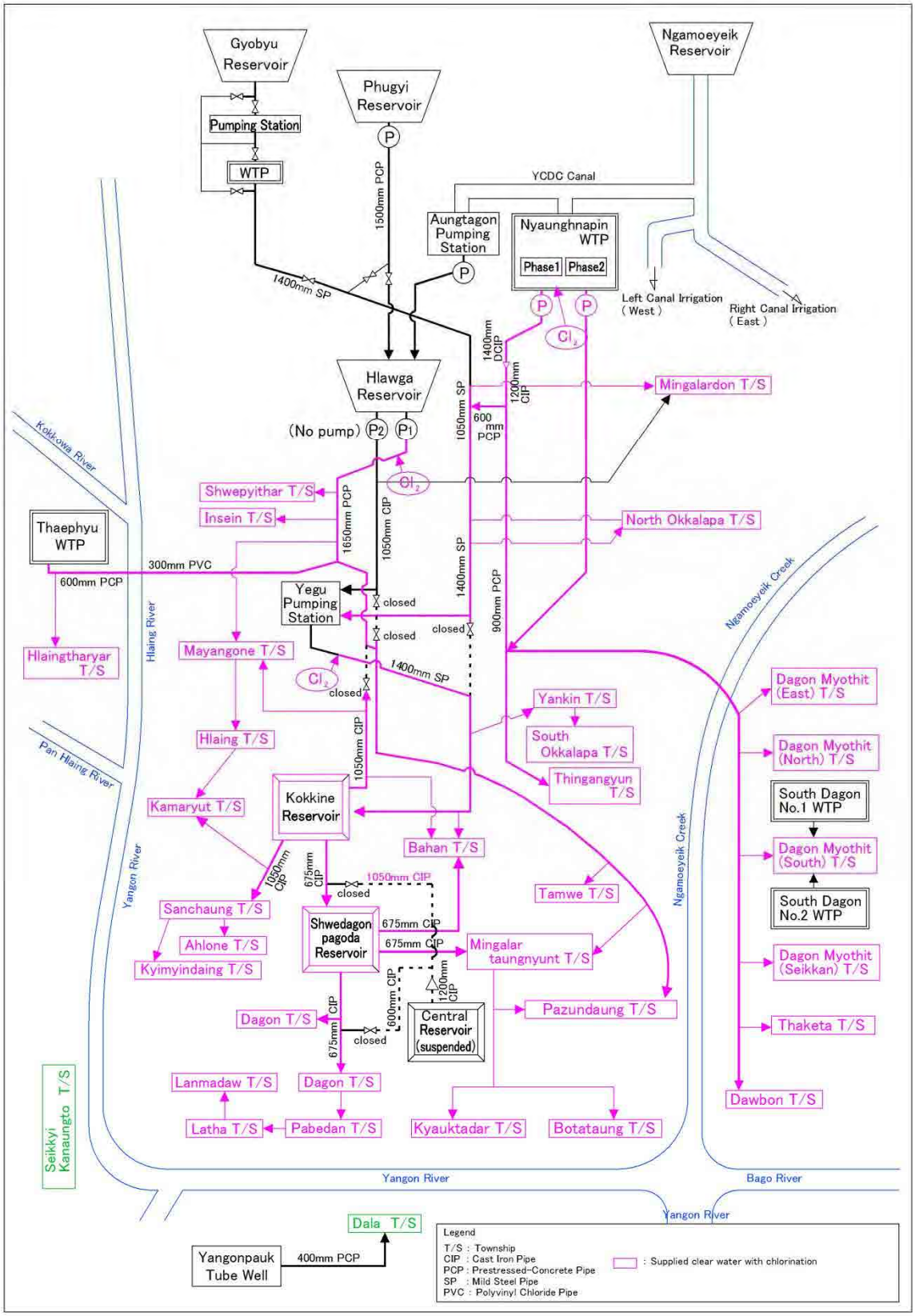
(3) Situation of Improved Water Quality after Installation of Chlorine Facilities

The quality of supplied water will improve after installation of chlorination facilities, and the disinfected water will mostly be supplied throughout the city, as shown in following figure.



Source: JICA Study Team

Figure 4.1 Diagram of Existing Water Supply System (2013)



Source: JICA Study Team

Figure 4.2 Diagram of Improved Water Supply System after Installed Equipment

4.3 Operation and Maintenance of Facilities

Refer to the section 2.5.1 (4) for details.

4.4 Preliminary Design

4.4.1 Target Facilities

(1) Target Facilities

Installing chlorination facilities to the existing facilities shown below is proposed.

- Nyaunghnapin Water Treatment Plant
- Hlawga No.1 Pumping Station
- Yegu Booster Pumping Station

(2) Situation of Target Facilities

1) Nyaunghnapin WTP

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

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

2) Hlawga Reservoir and Pumping Station

Constructed in 1906, this reservoir has a capacity of 63,600 m^3/day (14 MGD). Capacity of pumping station is 309,000 m^3/day, which is capable of handling 245,000 m^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 stations.

<u>No.1 pumping station</u>

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

No.2 pumping station

Pumps in this pumping station are being shut down now. The transmission water amount is the remaining water after deduction of distribution amount from No. 1 pumping 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.

3) Yegu Booster Pumping Station

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.

4.4.2 Planned Water Amount

Water amounts used for mechanical facility design are set as follows from the capacity of the existing facilities.

Table 4.1 Planned Water Amount for Design of Chlorination Facility

Location	Planned Water Amount	Remarks
Nyaunghnapin WTP	409,200 m^3/day	45 MGD x 2 Phase
Hlawga No.1 P/S	239,000 m^3/day	Capacity of existing transmission facilities 52.6 MGD
Yegu P/S	187,000 m^3/day	Capacity of existing transmission facilities 41.1 MGD

Source: JICA Study Team

4.4.3 Type of Chlorine

Refer to the section 2.3.4 (11) for details.

4.4.4 Mechanical Facility Design

(1) General

Mechanical design for process and facility should be prepared focusing on economy and ease in maintenance. Design condition of each facility related to mechanical equipment is shown in the following table.

Table 4.2 Mechanical Equipment Design Condition for Expansion of Chlorination Facilities

Facility Name	Design condition
For Nyaunghnapin WTP Phase 1 and 2	204,600 m^3/d x 2 series Pre or Intermittent chlorination Average dosage rate 1 mg/L Post chlorination Average dosage rate 3 mg/L
For Hlawga Pumping Station No. 1	239,000 m^3/d Average dosage rate 3 mg/L
For Yegu Booster Pumping Station	187,000 m^3/d Average dosage rate 3 mg/L

Source: JICA Study Team

(2) Expansion of Chlorination Facility

1) Chlorination Facility for Nyaunghnapin WTP Phase 1 and 2

Since chlorination facility is not installed in Nyaunghnapin WTP, installation of equipment is considered by this F/ S.

Chlorine dosing facility consists of storage tanks and dosing devices. The dosing points are one at the receiving well as pre-chlorination or filter inlet channel as intermittent chlorination, and the other at the clear water well inlet channel as post-chlorination. A total of six dosing pumps including two stand-by for each WTP are proposed. One is operated for pre-chlorination, the other for post-chlorination. A total of eight duty chlorine storage tanks are provided at the proposed chlorination building which will be adequate to keep 10 days stock .

Table 4.3 Chlorination Facility for Nyaunghnapin WTP Phase 1 and 2

Item	Specification	F/S
Nyaunghnapin WTP Phase 1 and 2	204,600 m^3/d x 2 series	
Chlorine storage tank	Cylindrical tank 22 m^3	8 units
Pre or Intermittent – chlorine dosing pump	Diaphragm 0.6 – 2.3 L/ min x 0.4 kW	6 units including 2 standby
Post - chlorine dosing pump	Diaphragm 2.1 – 7 L/ min x 0.4 kW	6 units including 2 standby

Source: JICA Study Team

2) Chlorination Facility for Hlawga Pumping Station No. 1

Since chlorination equipment is not installed in Hlawga Pumping Stations, installation of equipment is considered by this F/S.

Chlorine dosing facility consists of storage tanks and dosing devices. The dosing point is the header pipe from Hlawga reservoir by pumping line as post-chlorination. A total of three dosing pumps including one standby are proposed. A total of four duty chlorine storage tanks are provided at the proposed chlorinator building which will be adequate to keep ten days stock.

Table 4.4 Chlorination Facility for Hlawga Pumping Station No. 1

Item	Specification	F/S
Hlawga Pumping Station No. 1	239,000 m^3/d	
Chlorine storage tank	Cylindrical tank 25 m^3	4 units
Chlorine dosing pump	Diaphragm 2.4– 8 L/ min x 0.4 kW	3 units including 1 standby

Source: JICA Study Team

3) Chlorination Facility for Yegu Pumping Station

Although electro chlorinator is experimentally installed in existing Yegu P/S, there is no spare machine. Since machine's operational time is restricted to daytime, the equipment's capacity is insufficient to inject required dosing rates. Therefore, extension of equipment capacity is planned in this F/S.

The planned chlorine dosing facility consists of storage tanks and dosing devices. The dosing point is the existing reservoir or discharge header pipe as post-chlorination. A total of three dosing pumps including one standby are proposed. A total of four duty chlorine storage tanks are provided at the proposed chlorination building which will be adequate to keep ten days stock.

Table 4.5 Chlorination Facility for Yegu Pumping Station

Item	Specification	F/S
Yegu Pumping Station	187,000 m^3/d	
Chlorine storage tank	Cylindrical tank 18 m^3	4 units
Chlorine dosing pump	Diaphragm 1.9– 7 L/ min x 0.4 kW	3 units including 1 standby

Source: JICA Study Team

4.4.5 Electrical Facilities

(1) General

Electrical facilities have been designed to achieve their continuous function and protection of the mechanical facilities of the plants. They are optimized to achieve economical requirements and to have the best practical maintainability of the plant. The situation and outstanding issues in the existing YCDC have been taken into account. Design parameters of the electrical facilities are shown in the following table.

Table 4.6 Design Parameters of Electrical Facilities

Facility	Design Parameter
Nyaunghnapin WTP 1 and 2	To be branched from existing 400V Distribution Board
Hlawga Pumping Station No.1	ditto
Yegu Booster Pumping Station	ditto

Source: JICA Study Team

(2) Electricity Supply in the Area

Refer to section 2.3.4(13) above.

(3) Power Distribution

As the required load (kW) is low, the spare feeder of the existing 400 V distribution should be used. If no spare feeders are available, an additional circuit breaker box will be provided to branch from the existing circuit feeder.

The feeder to the chlorination system will be provided with an earth leakage circuit breaker to protect from personnel electrical shock and fire accident.

4.4.6 Layout Planning

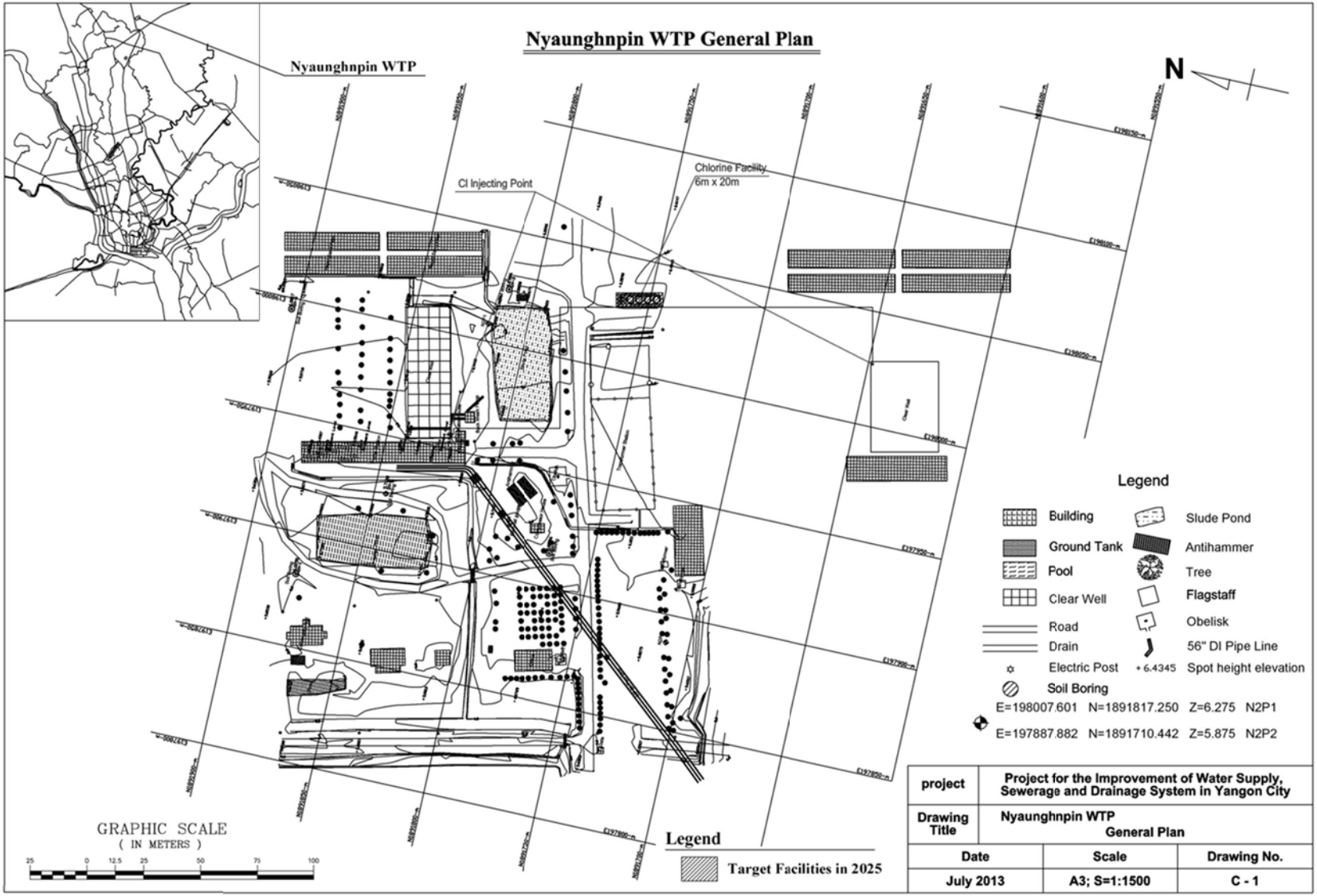
Chlorination facilities will be installed in the existing building, or in a vacant lot. Supply of sodium hypochlorite solution will be conveyed by a tank lorry. Therefore, in order to make easy delivery in storage tanks from a tank lorry, location for extension equipment on road side in the existing site is proposed.

Table 4.7 Layout Plan for Each Facility

Location	Size	Note
Nyaunghnapin WTP	Width 6 m × Length 40 m	Outdoors
Hlawga No. 1 Pumping Station	Width 4 m × Length 20 m	Outdoors
Yegu Pumping Station	Width 4 m × Length 20 m	Equipment will be installed in the existing building.

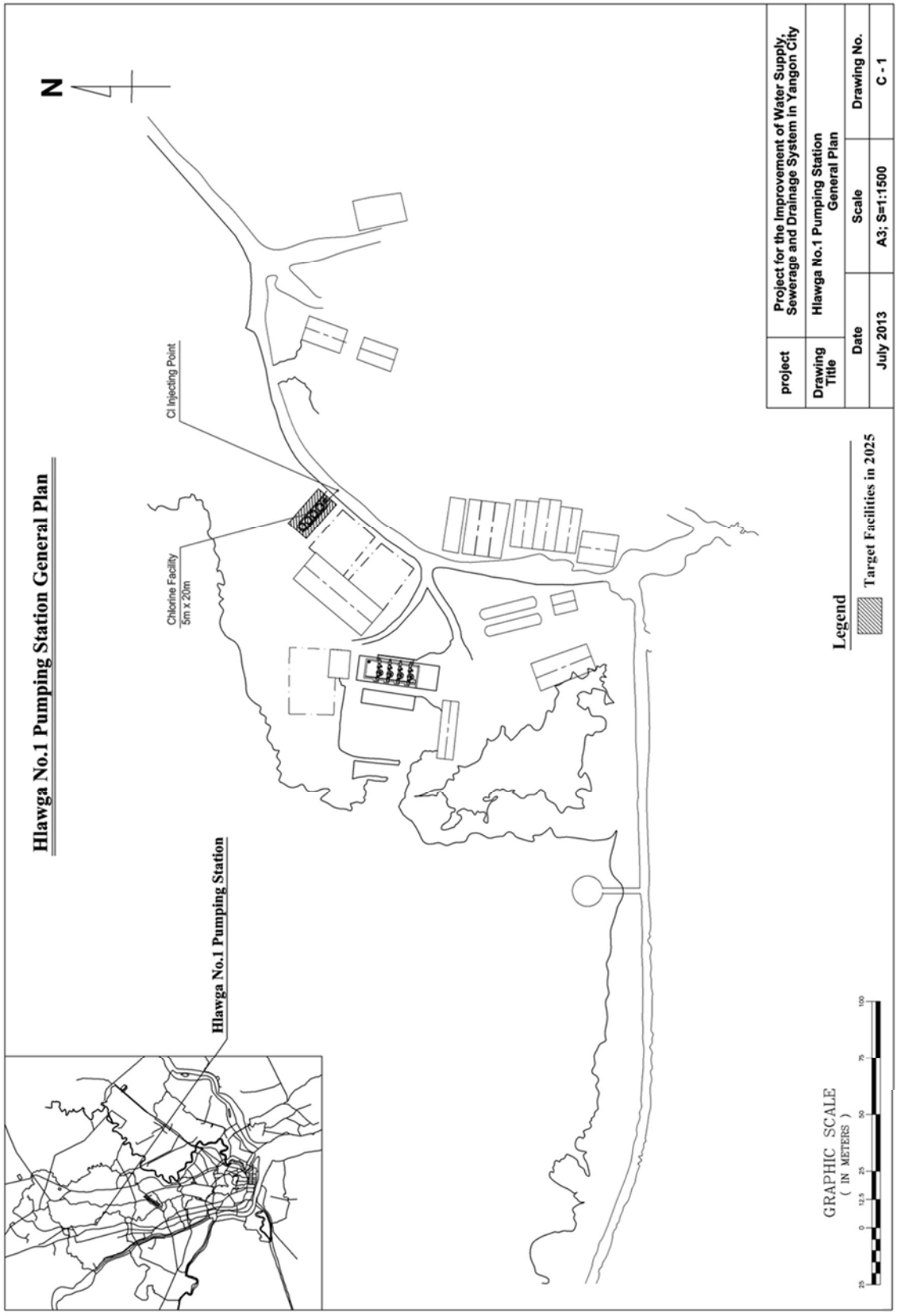
Source: JICA Study Team

The layout plan of the chlorination facilities are shown in following figures and Appendix G.



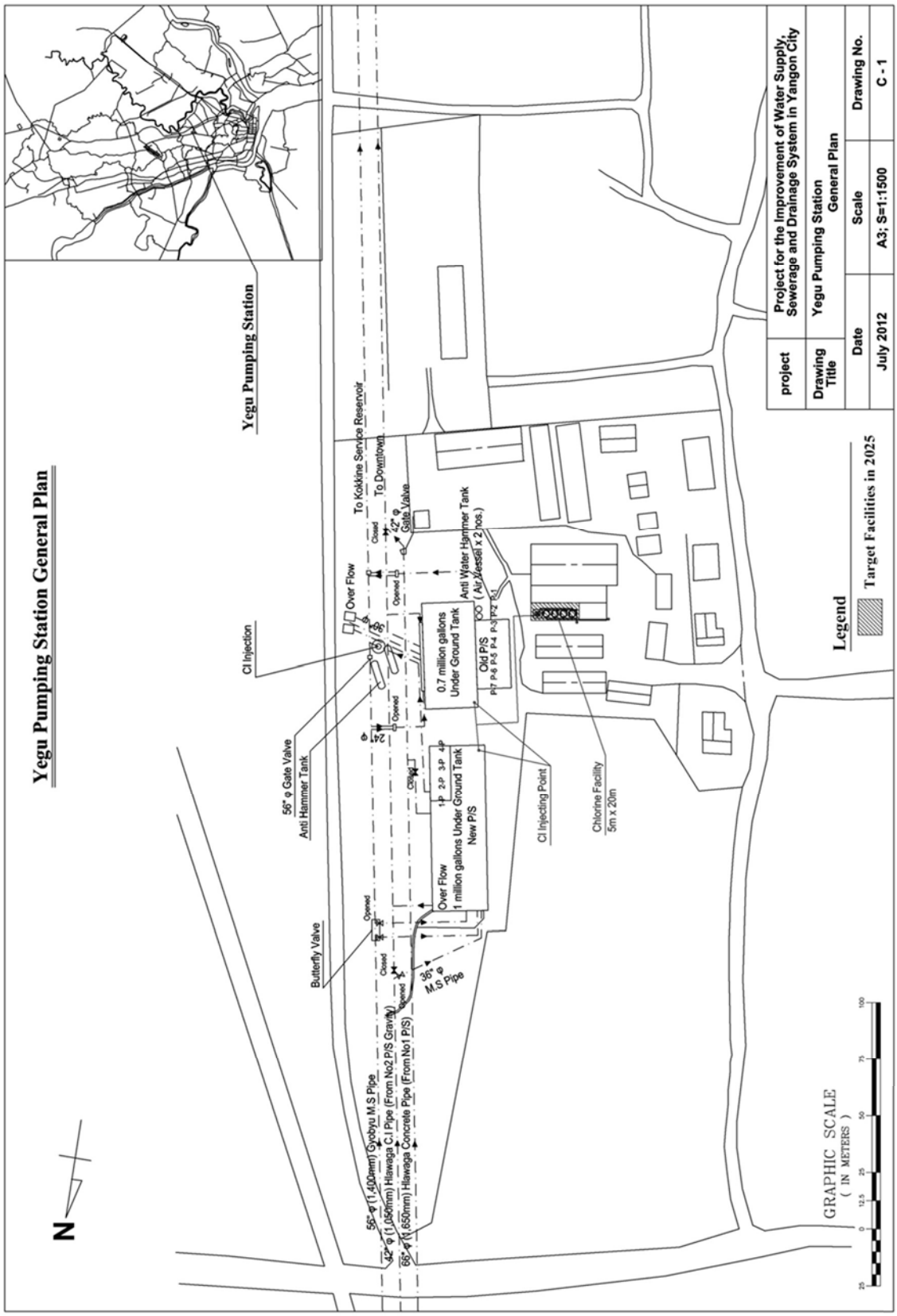
Source: JICA Study Team

Figure 4.3 Layout Plan of Chlorination Facilities for Nyaunghnapin WTP



Source: JICA Study Team

Figure 4.4 Layout Plan of Chlorination Facilities for Hlawga No.1 Pumping Station



Source: JICA Study Team

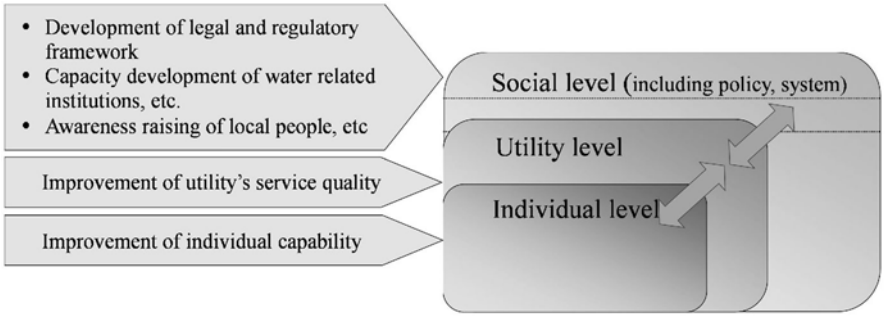
Figure 4.5 Layout Plan of Chlorination Facilities for Yegu Pumping Station

CHAPTER 5. CAPACITY DEVELOPMENT PLAN

5.1 Outline of Capacity Development

5.1.1 Concept of Capacity Development

Capacity development is defined as "the process by which individuals, organizations, institutions, and societies develop abilities to perform functions, solve problems and set and achieve objectives" by JICA. Capacity development not only in technical aspects but also in overall organizational aspects including management and financial issues is essential for water and sewerage utilities to operate their organization and infrastructure facilities on sustainable basis. In order to support this, capacity development at individual and social level also plays a crucial role.



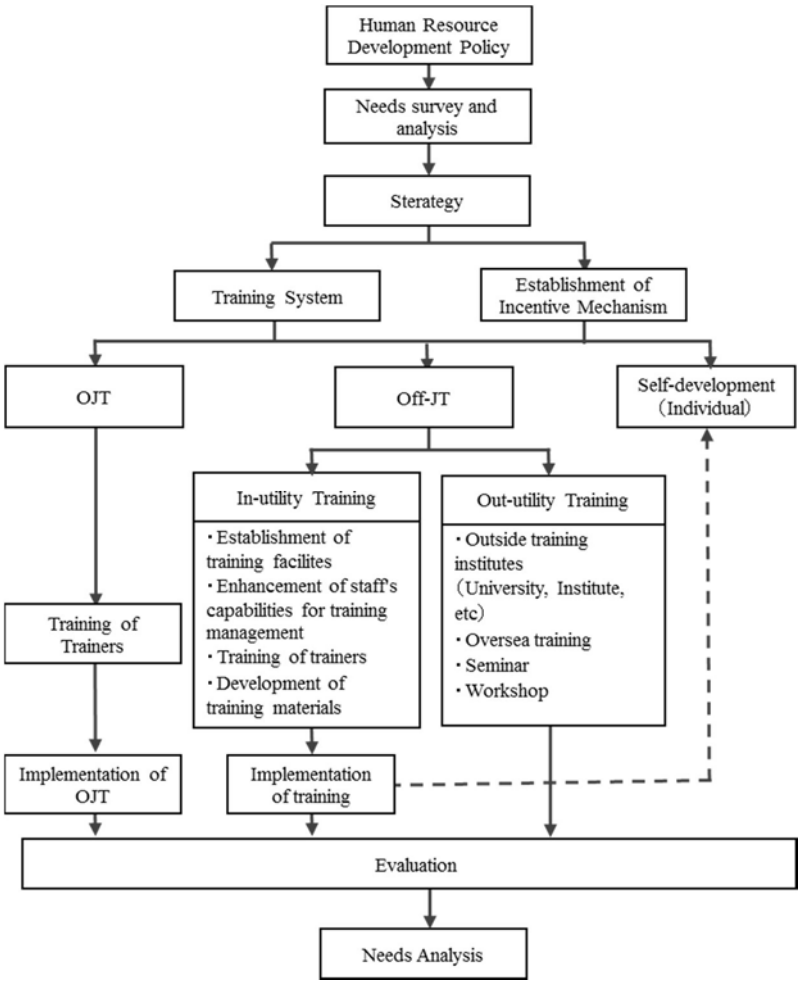
Source: JICA (2008) Capacity Assessment Handbook

Figure 5.1 Concept of Capacity Development

5.1.2 Capacity Development Methods

Training mechanism and capacity development methods are indicated in following figure. Capacity development should follow a utility's basic policy for human resource development and should be planned based on the result of needs assessment. Main methods of capacity development are the following three: (1) OJT, (2) Off-JT, (3) self-development.

OJT enhances capacity in terms of necessary technology and capability through a form of training on practical works and trial and error in normal working situation. Off-JT is a form of training through external lectures or education either inside or outside of utility. Self-development is a form of training to develop own capability by individual learning.



Source: JICA (2008) Capacity Assessment Handbook

Figure 5.2 Capacity Development Mechanism and Methods

For effective capacity development of YCDC, combination of all methods of capacity development such as OJT, Off-JT and self-training are essential. Currently the training subjects of YCDC central training center is limited to general engineering and accounting etc., so that a training opportunity to study specialized knowledge and experience on water supply and waterworks management is very few. Since the development of water supply infrastructure in Yangon city according to rapid demand increase is expected, nurturing of experienced trainers capable of providing guidance and acquisition of broader and deeper knowledge and technology by trainers are necessary.

From the long-term view, it is expected to nourish resource persons effectively, and that they teach obtained knowledge and experiences to the next middle or young staff members. At the same time, creation of incentive mechanism and awareness-raising, and development of surrounding environment where the obtained lessons learnt by training are effectively utilized are necessary.
At the initial stage, it is considered that the assistance of dispatch of external experts by aid agencies etc. and a technical cooperation project are useful for entire capacity development.

5.2 Necessity of Capacity Development of DEWS

In accordance with the JICA Capacity Assessment Handbook, capacity assessment is conducted targeting DEWS of YCDC which is responsible for water and sewerage works. Key check items are selected in overall items because the number of check item in the list is many in various fields.
An assessment is implemented in the following three areas; (1) technical capacity, (2) core capacity (non-technical) capacity, (3) enabling environment.

Main target areas of capacity assessment in the above three areas is indicated as following table.

Table 5.1 Target Area of Capacity Assessment

Target Area	Assessment area
Technical Capacity	(1) Design and planning capability of infrastructure facilities (2) Operation and maintenance capability of infrastructure facilities (3) Water quality management capability, etc. (4) Others - Knowledge, skill, organizational knowledge and information sharing system and the quality
Core Capacity (Non-technical Capacity)	(1) Organizational management capability including organizational improvement and its functions, capability of appropriate staffing and personnel management (2) Capability of financial planning, funding source procurement, accounting processing (3) Capability of customer service such as customer ledger management, water meter reading, issuance of billing invoice, revenue collection (4) Others - Organizational behavior, mind set (decision-making), various organizational systems(management, personnel management, incentive, etc.)
Enabling environment	(1) Capability of institutional arrangement such as laws, ordinances, system etc. (2) Financial basis (3) Assets of water infrastructure, etc. (4) Others - Financial system, human capital, material assets, social capital

Source: JICA Study Team

Results of Capacity Assessment (Summary)

The result of capacity assessment (summary) is shown below.

Overall result of capacity assessment is attached in Appendix 7.1. The assessment results of non-revenue water, water quality management and business management of waterworks are mentioned in the following sections.

Table 5.2 Summary Result of Capacity Assessment

Category (large)	Category (middle)	Category (small)	Results
Technical capacity	NRW reduction	Leakage detection technology and skill	• Leakage reduction unit exists in township offices • Response to leakage and repair reported by customer is supportive • Lack of knowledge, equipment and facilities for leakage reduction • No future plan on NRW reduction • No equipment and facilities for checking the performance of customer meter and bulk meter • Malfunctioning customer meter is replaced • The percentage of malfunctioning and performance degradation meter is unknown, but estimated as 1/4-1/3 of the total
	Water quality management	Operation of waterworks facilities	• Daily operation procedure and emergency procedure are not established. • Water quality analysis data is not reflected on the operation.
		Water quality analysis	• Implementation of water quality analysis and data management is very limited.
Core capacity(Non-technical aspects)	Financial strength	Financial stability	• No tariff setting guideline • The trend of financial balance of current account of DEWS is slightly positive • A concerned issue is a rapid growth of expenditure during 5 years, equivalent to 60%
		Procurement of funds	• General account and special account from the central government
		Accounting	• Public account using single-entry accounting system • Not financially autonomous
		Tariff	• A mixture of tariff system both of flat and metered does not secure equity for the same customer type • Preferable tariff system is applied to governmental institutions • In overall the tariff rate level presumably remain at low level
		Budgeting	• Budgetary process is basically top-down from the central government • However, each dept. have an opportunity to submit the necessary budget beforehand
		Meter reading, billing and collection	• No manual • No regular rotation system of meter reader • In principle, payment is in cash
	Governance/ management/ personnel affairs	Organizational function and performance	• Organization is clearly established • Division of role and responsibility is partly defined, but limited • No waterworks management by using PIs
		Employment/ transfer/ turnover	• No personnel management section, administration division is concurrently served • Engineer is recruited by an examination • Turnover rate is assumed to be low
		Personnel management and incentives	• No commendation system • Promotion depends upon capability, educational background and vacancy • No. of promotion post is limited, there is a personnel transfer to upper posts from other governmental institutions • Performance evaluation is considered only in promotion
		Communication	• Regular meetings are held for manager class • Organization is a chain-of-command structure
	Training	Plan	• Training is implemented every year, but no clear training plan • No special budget for human resource development
		Training program	• Engineering training exists in YCDC − Materials: none − Trainer: YCDC management class of each dept. • Training on plumbing of large pipe exists − Materials: available

Category (large)	Category (middle)	Category (small)	Results
			− Trainers: manager class in the relevant sections • Training on maintenance and welding of steel pipe, GI pipe − Materials: none
		OJT	• OJT, but not systematic
		Training system	• Training system exists (DEWS, YCDC) • 4 times per year (training on plumbing of large pipe)
		Certification system	• Certificate system for WS engineer and plumber exists organized by DEWS • Certificate system for civil and architecture exists
		Knowledge sharing and culture	• There is a potential if systemized
		Staff's motivation	• No regular evaluation system, no incentive mechanism for capacity development • Training achievement is considered in the promotion stage
Enabling environment	External influence	Governance and political influences	• Not an independent utility • Influence on tariff setting is unknown
		Regulatory bodies	• No regulatory agency
		Procurement	• No procurement rules • No function for reduction of corruption
		Cooperation with donors, other water utilities	• Cooperation by aid agencies such as M/P and F/S exists • Some minutes of understanding with foreign companies, municipal governments exists
	Law, regulations and guidelines	Laws and regulatory framework	• Water supply act is not established • Water and sanitation works is referred to the Yangon City Development Law and rules, but not covered sufficiently
		Regulation and standards	• No tariff setting guideline
	Others	Public awareness and IEC	• No IEC activities by DEWS

Source: JICA Study Team

5.3 Current Situation of Human Resource Development by YCDC

Among overall training activities undertaken by YCDC or each department, the information on five trainings is indicated below.

Table 5.3 Training by YCDC or Department

Venue	Executing department	Main Target Trainees
YCDC Central Training Center	YCDC administration dept.	All dept.
YCDC City Hall	Each dept.	Dept. of City Planning and Land, Dept. of Public Relation and Information
Yegu Pumping Station	DEWS	Mainly DEWS (applicable to other dept. and private companies)
Hlawga Reservoir, workshop	DEWS	Mainly DEWS (applicable to other dept.)
Ah Lone	Dept. of Motor Transport and Workshop	No information

Source: Interview with YCDC Central Training Center

Of these five training, a primary training with the highest frequency and the largest number of trainees, could be the training implemented in YCDC central training center.

Dept. of City Planning and Land, Dept. of Public Relation and Information organize their trainings in the city hall separately from the training center. Dept. of Motor Transport and Workshop hold training on repair of motor vehicles and driving technique at Ah lone. DEWS organizes two training at Yegu pumping station and at a workshop in the Hlawga reservoir. In case of the specialized subjects such as practical civil works and experiment, the training is held at a private company, outside of these two places. The situation of representative trainings is described below.

5.3.1 YCDC Central Training Center

(1) Outline of YCDC Central Training Center

The central training center was opened in March 1996, and the director of the center is concurrently serving as a deputy director of administration department. The staffing composition of the center consists of 7 persons including director, deputy director, training unit and assistant, against the sanctioned 14 posts. Main duties are development of training plan, application for training budget and implementation of training courses.

(2) Purpose of Training Center

The central training center has organized trainings with the following purposes.

- Improvement of operational works
- Enhancement of understanding on operational works of committee and other departments
- Having experience of mutual cooperation
- Enhancement of understanding on national development and legal and regulatory framework etc.
- Human resource development of resourceful staffs

(3) Training course

Training courses, the planned number of trainees, and conditions of current training courses held in the central training center are indicated in the following table. The participants of training are mainly divided into two types, general staffs and management class. Training subjects on water and sanitation are integrated into engineering training as a part, and it is planned to hold twice a year in FY 2014. Meanwhile, a training for skilled labor targets skilled labors as trainees including training on subjects of electrical, mechanical, civil engineering and heavy machinery. Also, in emergency case, an unplanned training may be held requested by YCDC committee which is not included in the training schedule based on a training plan. For instance, in FY2014, English courses are newly requested and added to the initial training plan.

Table 5.4 Training Courses by Central Training Center (FY 2014)

Target	Training course	No. of course	No. of trainees	Condition
General staffs	Civil servant basics	1	50	General staffs
	Engineering training	2	50	More than Sub Assistant Engineer
	Accounting basics	1	100	General staffs
	Training for skilled labors	1	No information	Labor
Management class (higher than assistant chief engineer(ACE))	Management of employees	1	50	Management class
	Management of administrative staffs	1	50	
Others	English course English course	1 1	92 108	Management class
Total		9	500	

Source: Interview with YCDC Central Training Center

(4) Training budget

The central training center prepares the budgetary plan and training plan for next year, and applies to department of administration. After internal confirmation within YCDC, YCDC obtains approval from the Mayor. The budget for one training course amounts to about 400,000 kyat. The overall budget of 7 courses for FY2014 is about 2.8 million kyat. In addition, the center pays 50,000 kyat for lecture fee to a lecturer if invited from outside except for YCDC.

(5) Trainer

There is no specialized trainer as a regular lecturer, the center asks the necessary trainers for chief engineer, deputy chief engineer of each dept. in accordance with the training subjects. Also they invite a lecturer from the union/ regional government, each ministry, a central university of civil servant and other university etc.

(6) Trainees

The training course targets all department of YCDC in principle. The approximate ceiling number of trainees is 100 persons per course. This is determined by the capacity of a training room of the training center. According to training courses, the target trainees are distinguished as either management class or general staffs. The participants of engineering training are limited to the department relevant to engineering. In case of English course, the fixed number of trainees is 200 persons (management class 92 persons, general staffs 108 persons).

(7) Training period

The training period of all courses is one month. Ordinary training is held during week days from Monday to Friday, and an examination of the learnt subjects is held on every Saturday.

In case of English course, the training is planned to be held twice a week, for 1.5 hours per lecture, for 1.5 months.

(8) Outline of Engineering training course

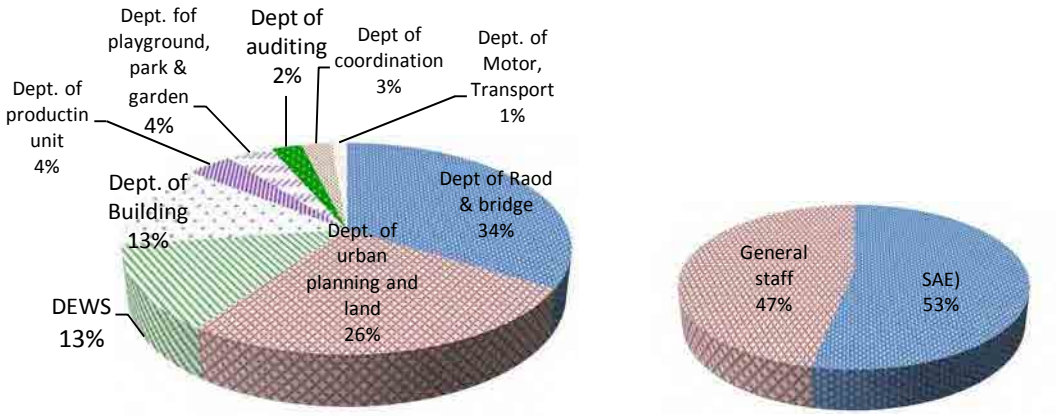
Training subjects on water and sanitation is included in this engineering training. Outline of engineering training is indicated as follows.

1) Trainers

Most of trainers are executives or management class responsible for the engineering works of relevant department. Since the contents of training are basic engineering related to YCDC daily operational activities, the center utilizes internal human resources effectively.

2) Trainees

Trainees of the engineering training, which was held in May 2013, are participants from department of road and bridge, urban planning and land, building, DEWS, production unit, playground, park and garden, auditing, motor transportation and workshop, and coordination. In terms of the composition of trainees, the largest dept. is Road and Bridge with 34%, followed by Urban Planning and Land with 26%, and DEWS with 13%, Building with 13%. Regarding to composition of trainee's position, SAE and general staffs shared about 53% and 47% of the total, respectively. Composition of trainees and the position are indicated in following figure.



Source: YCDC

Figure 5.3 Composition of Trainees (Left) and Its Position (Right)

3) Training subjects

Training subjects cover engineering subjects related to YCDC activities such as general civil engineering and architecture, road, bridge, urban planning, water and sanitation etc. Hence the contents are designed for SAE or general staffs to learn basic knowledge on engineering. In addition, non-engineering subjects such as management, public relation, project implementation and

introduction of private companies are also integrated into the course.

In the subjects of water and sanitation, general knowledge on water supply system, reservoir, water treatment facilities, treatment process are covered. The contents of lectures tend to share general engineering knowledge related to each dept. activity, since engineers with various different background are gathered from each department, according to one of lecturer. In most of classes, textbooks are most likely not utilized.

The training subjects and the training hours are indicated in the following table.

Table 5.5 Training Subjects of Engineering Course

Area	Training subjects	Class unit
General	Engineering subjects	4
	Engineering knowledge	2
	Rules and discipline	3
	Administrative areas	3
Civil engineer	Civil engineering	1
	Architecture process	2
	Project management and rehabilitation process	4
Architecture & Urban planning	Architecture	3
	Electricity	2
	Architectural standards	1
	Building structure	2
	Urban development planning/ project	2
Road	Geometric design for road design	3
	Asphalt	6
	Concrete and road maintenance	4
	Road sign, lightening, reduction of traffic jam	3
Bridge	Strengthening beam, slab	2
	Building bridge and maintenance	2
	Deep foundation	1
	Structure of building and maintenance	4
Water supply	Reservoir	3
	Water supply	2
	Electrical equipment of water supply infrastructure	2
	Water treatment plant	2
	Water quality conservation and the analysis	3
	Manufacturing of concrete pipe	1
Sewerage	Wastewater treatment plant	2
	Sewerage system management	2
	Construction of Septic-tank (Johkaso)	1
Management/ Public Relation	Management	4
	Public relation	6
	Leadership	4
Others	Project introduction(bridge construction)	2
	Introduction by private companies	2

[Note] 1 Class: 40 minutes
Source: interview with YCDC

Photo 5.1 Training Room of Training Center

(9) Remarks

It is evaluated that YCDC established a training center aiming at human resource development of YCDC staff, and organized and operated training courses even if their budget and human resources were limited. The training contents are primarily basics for civil servants, basic engineering for SAE and general staffs, accounting, management training targeting management class. The main purpose of engineering course is put on acquisition of basic knowledge. Therefore the advanced and specialized engineering subjects currently depend upon the training like OJT and Off-JT organized by each dept.

5.3.2 Yegu Pumping Station

A training course on “plumbing and installation of large pipeline” has started since 2012 aiming at cultivating skilled labor. This course will be held four times per year. The outline is indicated as follows.

(1) Trainees

The fixed number of the participants in this course is 15. Trainees are not only from DEWS but also from other depts. Also this course is opened to external private companies, and some trainees are received. In case of private companies, the training fee is free. The training organized in May 2013 was attended by 12 participants, 1 person from DEWS, 6 persons from other depts., 5 persons from private companies (construction companies). Only 1 person joined from DEWS, for which the works is directly related to. YCDC explained that it does not mean that private companies obtain any opportunity for an order of this work by the training.

(2) Trainers

The trainers are SAE, EE or other persons of management class in DEWS responsible for the lectures and practical field training. In the training course of May, resource persons belonging to three division of distribution, house connection, and maintenance and repair played the role of trainers.

(3) Training period

Training period is 1.5 months including field training for 1 week.

(4) Training subjects

The characteristics of pipes (CI, MS, GI, PVC, PCC, DI, HDPE) and connection parts, plumbing method and maintenance are the main contents. The course consists of lecture in the training room of Yegu pumping station, and a field training. The plumbing and connection works of HDPEφ800mm was implemented by using a heating board. The field training was held at the actual pipe installation site under construction. Examination is held at the end of the course and a trainee is judged to clear the training if he/she obtains 50% or above marks.

Photo 5.2 A Field Training of φ800 HDPE Pipe in Plumbing of Large Pipe Course

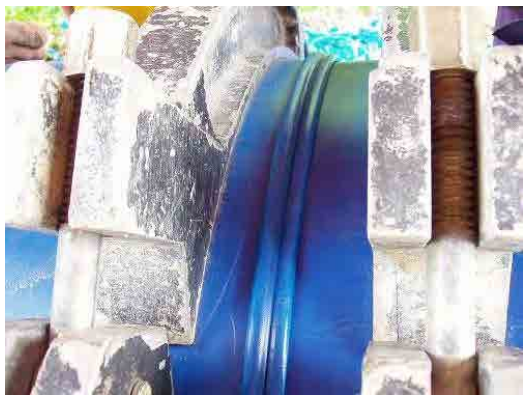


Photo 5.3 Training Room in Yegu Pumping Station (Left:Indoor, Right:Outdoor)

(5) Remarks

It is highly evaluated that; (1) DEWS design, organizes and implement training courses by themselves on the specialized subjects of water supply, (2) the course is open to outside private companies free of charge. Since the study team has not seen the actual training scene, the detail is unknown. However it becomes clear that there are resource persons capable of providing lectures to trainees even in the limited range of learnt knowledge. The provision of training on more advanced and specialized knowledge to these resource persons through a scheme of training of trainers could be one of effective training methods.

Meanwhile, the training materials are very limited to a few pipes at Yegu pumping station. It should be considered to enrich training materials and video presentation device and its peripheries, to exercise ingenuity in teaching to trainees in a simple and understandable way, and to consider the contents. In addition, one thing necessary to be considered is that trainees from other depts. are seemed not to have direct linkage with their operational works, thus the composition of participants may be rethought.

5.3.3 Workshop at Hlawga Reservoir

A training on "Maintenance and welding for Steel and GI pipe" was held in May 2013 at a workshop of Hlawga reservoir. This training is ad hoc base designed on requests from other depts., not regular. Total 25 staff members, 10 permanent and 15 persons non-permanent, are working in the workshop under the training.

(1) Trainees

The fixed number of trainees is 10 persons targeting YCDC staffs except for DEWS.

(2) Trainers

Staffs of DEWS at the workshop of Hlawga reservoir are responsible as the trainers.

(3) Training period

1.5 hours

(4) Training subjects

Main subjects are break of pipeline, maintenance for pipe corrosion (steel and GI pipe). The training consists of on-site training and training at the workshop.

(5) Remarks

The contents of training seem to be for skilled labors without any room-type lecture as far as the information from YCDC because the study team could not attend this training. The level of skilled

labor is unknown but it becomes clear that there are some resource persons capable of giving lectures to other depts.

Presently this training is on ad hoc base, and it can be possible to integrate with some lectures and apply as trainings for skilled labors and for employees of DEWS in future. However, the equipment and facilities at the workshop has been getting old without organization. This workshop may be developed and used both as a training space and as a working space for repair and welding works.

5.3.4 Qualification System of Water and Sanitation Engineers and Plumbers

DEWS has established a qualification system for plumbing engineers engaged in installation works of water supply equipment.

Plumbing works of service pipeline (including installation of customer meter as necessary) are carried out by: (1) Qualified water and sanitation engineer (WS engineer), (2) Master plumber, and (3) Working plumber. Out of three, (1) and (2) requires an authorized qualification.

The combination of three types of plumber is differentiated by the scale of works. Plumbing works for high building with more than 9 floors should be carried out by a qualified WS engineer. Even it is a small scale work, it is not allowed that only working plumber implement the installation works

There is no training for obtaining a certificate, and an applicant can get the certificate by passing an examination prepared by DEWS. However, this examination has not been held recently.

(1) Prerequisite of WS engineer and plumber

WS engineer and plumbers who are engaged in the installation works need to apply for license with registration fees to DEWS. The validity period is 1 year, license fees needs to be repaid if the plumber wishes to continue owning the license. If qualified engineer or plumbers violate license rules, the license will be taken off, or suspended to participate as bidder for a certain period. Also the applicants need to meet the following prerequisite, which is indicated as follows.

Table 5.6 Prerequisite for WS Engineer and Plumbers

Type	Certificate	Prerequisite		
		Education	Practical plumbing experiences	Examination
WS engineer	Authorized qualification	Higher than Bachelor of Engineering, graduation of technical university	More than 1 year	Successful applicant of a practical examination by DEWS
		Higher than graduation of technical college or technical (industrial) school	More than 3 years	Successful applicant of a practical examination by DEWS
Master plumber	Authorized qualification	Higher than graduation of junior high school	More than 3 years	Successful applicant of a practical examination by DEWS
Working plumber	Non certificate	Higher than graduation of elementary school	More than 5 years	None

Source: interview with YCDC

(2) Current situation of qualification system

Presently the number of registered engineer and plumbers are; WS engineer 17, master plumber 66, working plumber 37.

It is highly evaluated that DEWS establishes and operates a qualification system for engineers and plumbers regarding installation of water supply facilities. On the other hand, in order to make this system more effective, it is necessary to clear the following challenges and to improve them.

- It seems that the WS engineer or plumber who is able to make a living by installation works of water supply facilities are limited, because the number of new connections is currently restricted. In that case, he concurrently serves other means of livelihoods.
- The examination for certificate has not been conducted during approximately 10 years, so that the system seems to be not functioning well without active improvements.
- As far as our site visit and observation, the skill and the expertise, and supervision capability of WS engineer and plumbers need to be improved somehow although we cannot know exact level. In order to achieve continuous improvements in supervision capability, regular trainings should be strictly mandated at the renewal or re-registration of the certificate.

5.3.5 Overseas Training

With regard to overseas trainings, as of July 2013, the number of training is limited. YCDC made minutes of understanding with the Japanese private companies and waterworks bureau of municipal governments, as a result approximately 10 people from DEWS participated in the training in Japan.

In the abovementioned training, in a period of about 2 weeks, the trainees had a lecture in the training center and site visits to water supply facilities of municipal waterworks bureau and to private manufacturing factory of pipe, and water meter.

It is expected that overseas training opportunity of YCDC certainly increases according to the active participation of foreign aid agencies, foreign municipal governments and private companies.

5.4 Current Status of Personnel Management of YCDC

(1) New recruit

Each department is not authorized to recruit new staffs. Each department applies for candidate of new recruit staffs to an elected council of YCDC, consisting of mayor, committee members and each department. Then a final approval is made by the council. The number of sanctioned posts and job types of YCDC are determined. The overall number is 17,185 persons as of March 2013.

Meanwhile, in terms of new recruit of engineers related to water and sanitation of DEWS, successful applicants who pass the engineer examination is newly employed. The prerequisite of applicants are that the candidates need to graduate one of the following schools or universities.

- Yangon Institute of Technology
- Technical University
  → 3 universities in Yangon city (Hmawbi, Hlaing Thar Yar, Thanlyin)
- Government Technical Institute
  → currently the institute is closed

(2) Turnover and retirement

Retirement age is defined as 60 years old in general. The rate of intermediary turnover of YCDC staffs is assumed to be low although there are some turnover in staff depending upon the reasons attributed to working environment and family environment. The number of private companies is still not many, and some YCDC staffs explained that the working environment of YCDC is better than private companies, so job hopping to private companies does not frequently occur at present. However, it is predicted that the turnover rate for job transfer to private companies would gradually increase in the long-term in accordance with economic growth.

(3) Staff transfer

Staff transfer does not occur frequently. Basically staff transfer is necessary, but there is no clear standard for staff transfer. Thus, the staff cannot be informed the appointment period exactly after the transfer. For instance, one example is the staff transfer from a township engineer to a supervisor of construction works on site when the project is launched.

(4) Promotion

Promotion and the next position are differently determined by the elements of type of jobs and educational background. In case of engineer, it normally takes 1.5 – 2.0 years to get promoted to the position of SAE, however the reality depends on the actual vacancy of the position in addition to capability and educational background. Also it will necessarily take 5-7 years at least to get promoted from SAE to ACE. In case of a non-technical staff and a lower staff with education qualification lower than high school level, the final stage of carrier path is department supervisor and manager respectively. These carrier path indicated here are, however, not applicable to all.

The promotion posts are not necessarily many, thus the number of posts becomes smaller at higher position levels. Also personnel appointment from other governmental institutions is commonly exercised.

Table 5.7 Carrier Path of Staff (Example)

	① Engineer	② Non-engineer	③ Less than high school graduation
5 years	Chief Engineer ↑ Deputy Chief Engineer		
6 years	↑ Assistant Chief Engineer		
7 years	↑ Executive Engineer		Manager
Promotion is determined by capability, educational background, vacancy situation	↑ Assistant Engineer ↑ Sub Assistant Engineer ↑ Junior Engineer ↑ Graduation of technical college/ university (master)	Dept. Supervisor ↑ Office Supervisor ↑ Lower Clerk ↑ Graduation of technical school/ university (master)	↑ Assistant manager ↑ Sub assistant manager ↑ Expert ↑ Less than graduation of high school

[Note] horizontal level of ①～③ does not mean the level of position
Source: Interview with YCDC

(5) Salary, allowance, welfare

The salary level may be around 250,000-300,000 Kyat for committee members, 140,000-150,000 Kyat for executive engineer, 35,000-70,000 Kyat for permanent staff (lower than executive staffs) even these are approximate information. The average salary of the staff more than executive class is around 118,500 Kyat, and that of the staff lower than executive class is around 51,500 Kyat.

YCDC employees are equivalent to national public servants, the employment system such as the salary, allowance, pension are followed according to the standards of the central government. Hence YCDC

are not allowed to change this salary system by itself.

Employee's accomplishment and results of training are directly not reflected to their salary. However, if an employee graduates from a national university of public servants, which allows only permanent governmental staffs to enter and participate in, the achievement is reflected to salary.
Meanwhile, allowance of 20,000 Kyat is paid to the participants from the government when they join training courses and annual meetings.

In the aspect of welfare, some preferential treatment such as discount on mobile communication fee, provision of apartment, free rental of vehicle, discounted procurement of land are provided depending upon the class of employees.

(6) Performance evaluation

Performance evaluation of staffs is not regularly conducted in a systematic way and without an evaluation sheet. However, the aspects of past performance, attitude, training status, certificates are considered at the time of promotion.

(7) Incentive mechanism for capacity development

There is no special incentive mechanism for capacity development. Trainees do not have any opportunity and any system to get higher salary by joining in YCDC training, the certificate of completion is considered only while evaluation for promotion.
Meanwhile, a system of payment for lecture fee and allowance of trainers does not particularly exist.

5.5 Necessary Areas for Capacity Development Up to 2025

The necessary areas for capacity development of DEWS in water supply sector in the short-term up to 2025 are summarized in the following table. Priority is given in the range of high and low. High priority or low priority means that capacity development is necessary within 3years or up to 2025 respectively.

Table 5.8 Necessary Areas for Capacity Development of DEWS

Category		Necessary areas for capacity development	Priority		
			3y high	5y	～2025 low
Technical capacity	Design	1. Designing of pipeline facilities	●		
		2. Pipeline system and hydraulic analysis		●	
		3. Design of water treatment plant		●	
		4. Design of electric and mechanical equipment		●	
	O&M	O&M of treatment plant and pumping facilities			
		5. - Development of O&M plans	●		
		6. - Development of an operational plan for equipment items	●		
		7. - Recording of O&M and management (daily, monthly, yearly)		●	
		8. - Development of a maintenance and inspection plan for electrical and mechanical equipment		●	
		9. − O&M of electrical and mechanical equipment		●	
		10. − Development plan for improvement and renovation works		●	
		11. − Continuous and efficient management of treatment plant			●
		O&M of pipeline infrastructure			
		12. - Inspection and survey of pipeline infrastructure	●		
		13. - Cleaning and dredging of pipeline infrastructure		●	
		14. - Restoration and repair of pipeline infrastructure		●	
		15. - Recording of O&M practice and management		●	
		16. - Continuous and efficient management of pipeline infrastructure			●
		17. Maintenance and performance check of customer meter	●		
		18. Development of O&M manual	●		
	NRW management	19. Formulation of Non-Revenue Water section	●		
		20. Development of a NRW reduction plan	●		
		21. Implementation of leakage detection		●	
		22. Monitoring and evaluation of NRW reduction activity			●
		23. Distribution system management and Information management system by SCADA		●	
	Civil works	24. Pipe laying and installation of water meter	●		
	Water quality analysis	25 Water quality analysis methods using simple assay	●		
		26 A fundamental technique of water quality analysis and data analysis	●		
		27 Continuous practice on water quality analysis and data analysis		●	
		28 Formulation of a manual for water quality accidents and disaster		●	
		29 Establishment of a laboratory for water quality analysis equipped with advanced analysis facilities		●	
		30 Advanced water quality analysis(responding to trace contaminant)			●
	Water quality management	31 Strengthening water quality management section	●		
		32 Improvement of O&M capacity on treatment process		●	
		33 Improvement of O&M of disinfection process		●	
		34 Formulation of a manual for water quality accidents and disaster		●	
		35 Upgrading water quality management (micro-pollutant)			●
Core capacity(Non-technical capacity)	Organization	36 Institutional strengthening and expansion	●		
		37 Division of role and duty	●		
		38 Human resource management plan	●		
		39 Personnel management		●	

Category		Necessary areas for capacity development		Priority		
				3y high	5y	～2025 low
		40	Good governance and prevention measure for corruption			●
	Management and efficiency	41	Planning and development for sustainable waterworks management	●		
		42	Setting Performance Indicators (PIs) and improvement of waterworks management	●		
		43	Performance monitoring and evaluation		●	
		44	Computerization and data processing and editing	●		
		45	Computer literacy and improvement of computer skill	●		
		46	Establishment of management information system (MIS)		●	
		47	Public procurement management and supervision		●	
		48	Quality management(ISO9001, ISO14001)			●
		49	Occupational health and safety management			●
	Finance	50	Budgetary planning for development of water infrastructure	●		
		51	Consideration of water tariff policy	●		
		52	Socio-economic condition of local people and water tariff		●	
		53	Water tariff design and cost analysis, projection of financial balance		●	
		54	Digitalization of customer ledger	●		
		55	Water balance and NRW management		●	
		56	Asset management		●	
		57	Double-entry accounting system			●
	Public/ Society	58	Utility's social responsibility and accountability for people	●		
		59	Customer management and water service	●		
		60	Public awareness and education on public health and environmental conservation for residents		●	
		61	Development of IEC materials for awareness rising and education		●	
		62	Environmental impact assessment on water supply infrastructure		●	
		63	People's participation and public involvement		●	
Enabling environment	Formulation of regulatory framework	64	Formulation of policy and regulatory frameworks on water sector	●		
		65	Formulation of Water Supply Act/ By-law/ ordinance	●		
		66	Formulation of by-law on water tariff		●	
		67	Formulation of industrial water supply Act			●

Source: JICA Study Team

From the above list, current situation, challenges and the necessity of three priority areas for capacity development are described in the following section.

5.6 Current Situation and Challenges

Current situation and challenges for business management of waterworks are summarized in the following table.

Table 5.9 Current Situation and Challenges and Necessity of Capacity Development

No.	Areas	Current Situation and Challenges	Necessity of Capacity Development
1	Business management of waterworks		
1.1	Planning and monitoring	• There is no section to formulate a systematic policy, plan, strategy, business plan for future water supply project. • There is no clear project target in short-, mid- and long-term. Supportive measures tend to be taken rather than preventive measures.	• It is desirable to establish planning and monitoring section in the head quarter. • The project targets and business plan need to be developed and set up for short-, mid- and long-term.
1.2	Performance Indicators(PIs)	• Waterworks management by using PIs has not been implemented.	• It is desirable to establish a project management system by using PIs. • It is necessary to select and set up key PIs and regularly monitor the performance. Reports should be prepared based on the result.
1.3	Division of duty and responsibility	• The role and responsibility of department and executive experts is defined, however it was told that these are not defined for sub-section under the department and ordinary staffs. • The organization is hierarchic and authority tends to be concentrated to a part of experts. It causes taking time for decision-making.	• It is necessary to enhance staff's responsibility and self-awareness, independence while defining the role and the responsibility • The authority should be dispersed as much as possible, and need to shift from a bureaucratic organization to a service provider from a long-term view point
1.4	Shifting to customer focus management	• Current YCDC is a bureaucratic organization specialized in technology, • There is no section (unit) specialized in customer service in HQ and township offices • The window of customer claim is DEWS staffs of each township offices. Usually the contents of claim and status of feedback is not recorded by documents. Response to customer's claim is supportive basis as necessary • Also, the awareness of HQ staffs that water supply is a public service projects is still tenuous	• It is necessary to change constitution of current management to a public service provider for citizens, which focus more on customer service. • A customer service and public relation section (unit) needs to be established in the head quarter and township offices in order to strengthen the function of customer service.
1.5	Policy and standards for customer service	• Policy and standards on customer service are not yet developed. Therefore the response procedure such as desirable days for reply and methods is not unified. It entirely depend upon staff's discretion in township offices	• Improvement of service quality and unification of service need to be enhanced by creating the section, developing customer service policy and standards.
1.6	Computerization of operational works	• Computer is installed in HQ and division offices partly, but only for management classes. Overall computerization of operational works is very limited in certain area. • As mentioned above, hand-written documents including customer ledgers are still widely utilized by DEWS.	• There is a large room for efficient management of operational works by installation of computer. • In long-term, it is expected that management information system which enables mutual communication between HQ and township offices is established. However in short-term, it

No.	Areas	Current Situation and Challenges	Necessity of Capacity Development
		• Also it takes a lot of time to output the necessary information, and storage of documents and materials tends to be not well arranged.	could be reasonable to start to develop customer database.
2.	Finance and accounting		
2.1	Financial projection	• Recent financial balance of waterworks indicates a steady growth. Presently a financial balance of current account is slightly positive, however increase rate of expenditure is faster than that of revenue. • There is no projection of financial balance of current account and capital account for long-term	• A financial projection for long-term is necessary to consider the level of water tariff rates and need for tariff rates revision • A financial balance of capital account including an investment plan is necessary.
2.2	Asset management	• A ledger for asset management is not yet prepared	• From long-term view, it is necessary to prepare assets management ledger, evaluate the economic lifetime, and reflect the depreciation cost on financial statements
2.3	Financial autonomy	• A single-entry account form is adopted. Corporate accounting system with double-entry account form for independent financial system is not yet applied. • Therefore the principle of financial autonomy which recovers the cost of waterworks from water sales is not yet established. The budget is allocated from a common basket of entire YCDC budget.	• In future, an independent account system focusing on financial autonomy is desirable together with the budgetary system. Since this issue is related to national public accounting management system, YCDC does not have an authority to change the system. This remains as a long-term challenge.
2.4	Financial statements	• A cost and benefits statement for water and sewerage works is prepared by DEWS • Information of capital revenue is not arranged for the balance sheet, it is difficult to understand the financial situation of capital account.	• In a long-term, it could be preferable for financial management by double-entry account system to be applied, in order to identify management situation and financial status. • This is considered by national upper organization
3.	Water tariff		
3.1	Understanding of exact production cost and average tariff	• It is possible to estimate approximate production cost and average tariff, however exact information is not available for the identification • Staff's awareness on production cost and average tariff is not strong	• The installation of bulk meters and flow meters are needed to understand the exact production costs and average tariff • It is necessary to support an staff's understanding on production costs and average tariffs as a service provider, and consider a measure to know exactly
3.2	Relatively low level of tariff rate	• Tariff rates is relatively at low level from the aspect of people's income level • It is seemingly recognized to have a good financial performance, because O&M costs is recovered by revenue collection	• Considering the situation mentioned in the left column, relationship between service level and current tariff rates level need to be reconsidered from the viewpoint of an appropriate

No.	Areas	Current Situation and Challenges	Necessity of Capacity Development
		even at current low tariff rates level. • However it should be reconsidered whether O&M is sufficiently implemented by current practice. Particularly, the following issues are raised as challenges; (1) more than 20% of households are not satisfied with water quality like high turbidity and non-hygienic water, (2) chlorination is conducted only at Yegu pumping station.	maintenance and safe water supply
3.3	Securing equity	• Different tariff structures of metered rate and flat rates are applied. From the viewpoint of equity, there is a lack of consistency	• In order to secure equity, it is necessary to enhance metering and consider a new water tariff structure
3.4	Incentive on environmental conservation	• It is pointed out that flat rate system does not contribute to give any incentive of environmental conservation as a problem	• A tariff structure needs to be defined to send a message of environmental conservation and saving water to consumer
3.5	Necessity of pro-poor tariff structure	• Present revenue collection policy of YCDC provide water to religious facilities free of charge, while a social tariff policy aiming to reduce the burden on the poor is not taken. Usually water utilities in developing countries have other supply types such as public taps and community-based for a pro-poor measure with relatively low tariff rates. • According to interview of YCDC, they used to provide water by public taps and community tanks before, however these methods are currently not followed.	• It is thought that Pro-poor tariff structure considering cross-subsidy to the poor is necessary as one of the social policies
3.6	Guideline and rules for tariff setting	• There is no clear policy, guideline, rules and procedure for water tariff setting in Myanmar and YCDC.	• Policy, guideline, rules and procedure for water tariff setting at YCDC level is necessary for the time being.
4.	Customer management	• Customer management in township office is done by hand-written customer ledgers, thus an efficient management is not applied • Computerization of customer management is applied to domestic, and commercial and industrial customers in HQ except for departmental customers.	• Development of management basis by computerization is necessary in order to shift to a customer focus service provider • Customer information needs to be updated by secondary data and a comprehensive field survey on a steady basis.
5.	Billing and revenue collection	• Issuance of invoice is collectively prepared by HQ and distributed to each township offices • In each township office, a billing and collection management is based on many hand-written documents such as meter reading book, tariff recording book for customer billing. The submission of reading record to HQ is also done in hard copies • Revenue collection capability is	• At first, simplification of meter reading book and recording book needs to be enhanced • A common format should be developed and unified for all township offices. • In long-term, a modern method of revenue collection such as mobile, banking, and kiosk needs to be utilized.

No.	Areas	Current Situation and Challenges	Necessity of Capacity Development
		vulnerable	
6.	Customer meter and metering	• Capability of O&M and repair of water meter remains at a limited range. Equipment for checking the performance by testing and calibration, and the performance standard are not arranged. • Repair and maintenance of water meter is seldom implemented according to an interview. In case of performance degradation and malfunction, usual way is to replace and renew the meter. • It is reported that the percentage of performance degradation and malfunction of existing water meter is not low according to an investigation in a pilot area. Since meter replacement is responsible for customer with the cost, there are many meters which have been not replaced for long years. In a rough estimation, it is anticipated that 1/4-1/3 of the total meters are in performance degradation and malfunction. • Therefore apparent loss is probably not so small.	• In future, a workshop for maintenance and repair of water meter will be established in YCDC, and regular testing, calibration and repair expects to be done by YCDC. • To do so, strengthening capability of meter testing and the system, and staff's awareness rising are essential. YCDC needs to deepen their understanding on an increase of accuracy of reading data links to reduction of NRW and equity of cost-sharing. • The metering policy need to be changed. Replacement of meter in performance degradation and malfunction is currently depending upon customer's decision. However a new system that YCDC bear the necessary cost for replacement is necessarily considered.
7.	Public awareness and PR activities	• DEWS does not implement hygiene education and public awareness activity on water tariff. • Meanwhile, public relation on water supply activities has been implemented through radio, newspapers, magazine, but IEC text and materials such as leaflet, booklet and poster are not prepared yet.	• Master plan proposes expansion of coverage area and revision of water tariff, and YCDC needs to deepen their understanding on the necessity of water supply system and the importance, beneficiaries-pay-principle for appropriate cost-sharing by enriching IEC materials and by enhancing IEC activity.

Source: JICA Study Team

5.7 Current Situation and Challenges of NRW Management

Current situation and challenges for NRW management are summarized in the following table.

Table 5.10 Current Situation and Challenges and Necessity of Capacity Development

No.	Areas	Current situation and Challenges	Necessity of Capacity Development
1	Organization for NRW control	• No special section / unit exists with the responsibility of NRW reduction	• It is recommended to establish a central 'NRW Reduction and Monitoring Unit' in YCDC Headquarters within Water Distribution Division of Engineering Department (Water and Sanitation) and sub- units in each Township; with enough staffing, resources, and clearly identified duties and responsibilities. • Proposed organization along with the staffing requirement is given at the end of this note.
2	Training	• Some basic training on installation of small pipes (not specially house connection) and water meter installation provided by YCDC staff themselves based on the knowledge gained from similar trainings overseas and working experience in Yangon. • There is no organized training unit within YCDC to provide training on water & wastewater system. • Plumbing courses are taught in some technical institutes; basic level at technical high schools, intermediate level at government institutes (AGTI), and engineer level at universities.	• Training is required on various aspects; starting from simple computer operations to NRW and O&M related technical and management courses. • The trainings should be both classroom training as well as practical on-the-job trainings. Establishment of training center along with required facilities and resources should be considered for mid to long term.
3	Technical aspects for NRW management		
3.1	Overall schematics of the bulk water system	• It is available, prepared by the 2012 JICA M/P	• Continuous updating to reflect change in system configuration due to new projects is required.
3.2	Bulk metering	• There are a few bulk meters installed on main lines but they are not working	• A systematic bulk metering program is required. Its implementation should start from WTPs and then move to pumping stations, service reservoirs, and DMAs.
3.3	Pipe network data and map	• Pipe network data is available in AutoCAD format for at least 24 Townships. The process of these map preparation is that paper based maps are prepared at Townships and sent to YCDC HQ Design and Estimation section for digitization in AutoCAD format. • Map quality has improved significantly in recent drawings (that	• Mapping will be a very crucial starting point for NRW management. It is recommended to establish a separate unit for mapping. It is necessary to develop standardized procedure and format for mapping. • Ultimately GIS system should be established and used but the use of current AutoCAD system can be

No.	Areas	Current situation and Challenges	Necessity of Capacity Development
		of North, East, and South Dagon Townships) but still they do not have any defined coordinate system and many attributes of pipe network such as material and age are missing.	continued for the time being. However, it is advisable to use satellite image procured by JICA Urban Planning Project as background and use its coordinate system (WGS 1984) in all AutoCAD drawings from now onwards.
3.4	Water auditing	• Is not practiced, required infrastructures like bulk meters, zoning etc. are not available.	• Water audit at YCDC (Yangon city) level and Distribution zone level should be aimed for short term. This should be gradually expanded to DMA level in the long term.
3.5	Service pipe	• Unplasticized PVC (uPVC) is used as service pipe. Due to lack of sufficient secondary and tertiary pipe lines (in areas other than down-town areas) service pipes become very long. • Installation of service pipe is done by YCDC qualified plumbers who pass through an exam organized by YCDC. However, no such exam has been organized in the last 10 years.	• Extension of tertiary pipe to shorten service pipe length is required, specialized training should be provided to the technicians/private plumbers who install service pipe.
3.6	Zoning	• No zoning system exists	• Three-tier system, starting from top tier and gradually moving to DMAs is recommended
3.7	Leakage survey	• Not practiced, no equipment, no expert manpower	• Procurement of minimum necessary equipment, development of standard procedures and formats, establishment of training body in YCDC, and training of trainers (engineers and technicians) should be considered.
4	Material and equipment resources	• Current situation needs improvement	• There will be long list of material and equipment required but as a starting point the following minimum material and equipment should be prepared: (1) Office based drawing, data records, functional equipment and computer with GIS for staff, • (2) Equipment and transport for fieldwork including simple sounding tools, portable flow and pressure measuring devices, and pipe detectors, • (3) Repair materials, tools and equipment to enable quick repairs.

Source: JICA Study Team

5.8 Current Situation and Challenges of Water Treatment and Water Quality Management

Current situation and challenges for business management of waterworks are summarized in the following table.

Table 5.11 Current Situation and Challenges of Water Treatment and Water Quality Management and Necessity of Capacity Development

No.	Sector	Current status and Issues	Necessity of Capacity building
1	Enhancement of water quality management section		
1.1	Enhancement of water quality management section of YCDC	Number of personnel of water quality management section of YCDC is 3.	To enhance the ability of water quality management section, increase of personnel is necessary.
		Authority of water quality management section of YCDC is not strong.	Water quality management section have task of not only water quality measurement but also instruct other section to improve water quality. From this reason, the authority of water quality management section has to be enhanced.
2	Water quality testing		
2.1	Implementation of water quality test	Water quality test is done by outside Agency (National Health Laboratory: NHL) Sampling and analysis schedule is decided by the schedule of NHL	To keep a distinctiveness of work schedule and to obtain a quick reaction capability to water quality trouble, establishment of water quality analysis laboratory which is operated and managed by YCDC is necessary.
2.2	Periodical water quality test	Periodical water quality test is not implemented (see.2.1)	To maintain tap water quality, periodical water quality test is necessary. At least, turbidity, taste/ odor, residual chlorine, total coliform test and fecal coliform test are necessary to keep a public hygiene.
2.3	Standard operation manual	Standard operation manual is not established.	Standard operation manual of laboratory is necessary to prevent false laboratory work and to maintain quality of laboratory work. In addition, standard operation manual is required to prevent injury and accident caused by false laboratory work.
2.4	Periodical checks of laboratory equipment	Not implemented	Periodical check and calibration of analysis equipment is necessary.
2.5	Water quality test record	Water quality data is recorded but not analyzed statistically.	Obtained water quality data should be leveraged to improve service quality of YCDC. Therefore, ability of data

No.	Sector	Current status and Issues	Necessity of Capacity building
			acquisition and data analysis should be improved.
3	Water quality control		
3.1	Implement appropriate water quality control	Capacity is not enough	In YCDC, distribution of hygienic tap water is not effectuated. At least, clarified and disinfected (chlorinated) tap water should be distributed. To satisfy this requisition, ability of all involved parties (YCDC officer and operating staff of WTP) should be enhanced.
3.2	Water source protection from serious contamination	Water source is protected but not well.	To maintain a tap water quality and public hygiene, protection of water source is important. When YCDC utilize surface water (river water) as water source, water source protection become most important issue.
3.3	Water quality management capacity during non-typical periods (e.g. heavy rain, disaster, water quality accident)	Capacity is not enough	To maintain a tap water quality and public hygiene, management capacity during non-typical periods is important. This ability is established based on the knowledge of water quality and operation ability of water works facility.
3.4	Water quality standard and regulations	Water quality standard is established, but they are scattered over different places	Water quality standard and applicable laws need to be gathered and store at a given place.
3.5	Document control	Both water analysis data and water quality regulation are scattered over different places	These documents should be referable on a steady basis. Establishment of archive is necessary.
4	Operation of waterworks facilities		
4.1	Operation manual of water works facility (WTP, P/S, S/R)	Daily operation procedure and emergency procedure are not established. Water quality data is not reflected on the facility operation.	To maintain a quality of tap water, operation manual of daily operation should be established. In addition, contingency plan of WTP, P/S and S/R in the disaster and accident (e.g. flooding, fire disaster, major power outage) should be established. These manuals will be leveraged for textbook of education or training.
4.2	Training of operator of waterworks facilities	Specialized training for waterworks facilities is not enough.	To development an ability of operation of waterworks facilities based on the operation manual and

No.	Sector	Current status and Issues	Necessity of Capacity building
			contingency plan of WTP, P/S and S/R operation To maintain of good water quality, not only training of operation, but also training of water quality management is necessary These training is done in the phase of technical assistant project
5	Training and self-development of personnel		
5.1	Training	Specialized training for water quality management is not carried out.	In the future, specialized training including OJT should be carried out.
5.2	On-the -job training	Some OJT is carried out, but in an unorganized way	*ditto*
5.3	Knowledge-sharing	Not active	To maintain an ability of personnel, knowledge-sharing and accession is important.
6	Public awareness campaigns		
6.1	Accountability of water quality management (Public relations)	Public relations newsletter/leaflet is published seasonally.	Relative to public awareness campaigns (see 5.2), constructive public relations should be done.
		Some information is selected from the annual report for disclosure through the internet, etc.	*ditto*
6.2	Public awareness campaigns	An awareness campaign about the importance of a good quality water supply is not enough.	To enhance a personal hygiene, awareness campaign in community, school, etc. is important.

Source: JICA Study Team

5.9 Priority Areas for Capacity Development

5.9.1 Priority Areas for Capacity Development (Business Management of Waterworks)

(1) Development of Business Management Basis for Waterworks

1) Establishment of Planning and Monitoring Section

A planning and monitoring section responsible for developing and managing orientation, plan and strategy at high level will be formulated in DEWS

2) Collection of Basic Information for Setting Performance Indicators (PIs)

In order to select appropriate PIs, DEWS can obtain the data, basic information on the current situation of business management, O&M of existing water facilities, and water quality management. A trial of recording data and improving the practice may help to distinguish obtainable data or non-obtainable

data which need a long-term development for the arrangement.

3) Establishment of Business Management System by Performance Indicators (PIs)

It is recommended to use PIs for business management of waterworks. A newly created planning and monitoring section takes the primary role for setting key indicators, and establishing monitoring and evaluation system. The performance results will be compiled in reports, and it should be utilized for the top management to understand the service situation and for quick decision-making.

4) Formulation of a Short-term Plan for Business Management of Waterworks

A short-term plan for business management up to 2025 will be formulated mainly by planning and monitoring section.

(2) Enhancement of Capacity on Customer Management and Revenue Collection

1) Development of Customer Management Database

In the headquarter, customer management database for departmental customers will be developed. In township offices, PCs will be installed in all offices and will assist to make customer management database from hand-written customer ledger and collection records.

2) Improvement of Revenue Collection Operational Works

Improvement points and main challenges on current operational work methods, procedure and the contents will be identified. Training on revenue collection will be held for township officers. The countermeasure on simplification of recording works, improvement of revenue collection, reduction of tax defaulters and illegal connection will be planned and implemented.

3) Implementation of NRW Reduction (Apparent Loss) in Model DMAs

A research for checking meter performance on reduction of functionality or non-functionality will be conducted. These meters should be replaced, NRW caused by error and insensitiveness will be decreased. At the same time, OJT on checking methods of meter performance, easy maintenance etc. will be provided to township officers.

The model area should be selected same as the areas mentioned in section 7.8.4.

4) Improvement of Customer Metering in Model DMAs

In addition to the above activities, a metering plan needs to be established targeting non metering customers, and translate it into practice. Regarding metering, training on IEC activities will be planned and held for customer service and public relation division (section), and assistance provided to deploy the IEC activities to residential people by DEWS.

(3) Consideration of Revision of Water Tariff Structure

1) Implementation of Socio-Economic Household Survey

Customer service and public relation division primarily implement a household socio-economic survey, and collects the basic information on people's willingness to pay, household income and so on which are essential for water tariff setting.

2) Enhancement of Understanding on Cost Recovery and Affordability to Pay

The staff of DEWS will deepen their understanding on production cost, average tariff, financial balance of current account, cost recovery, people's affordability to pay etc., and learn basic information for water tariff setting.

3) Consideration of Water Tariff Setting Policy

Based on 1) and 2), a water tariff setting policy of DEWS will be considered. At the same time, they will deepen their understanding on tariff policy for poor people, cross-subsidy, subsidy options etc. through training.

4) Design of New Water Tariff Structure and Simulation

DEWS will understand various types of tariff structure and characteristics, and the optimal tariff rates structure will be designed and considered. In addition, they need to deepen the issue of financial sustainability of DEWS.

5.9.2 Priority Areas for Capacity Development (NRW Management)

(1) Establishment of NRW Management and Monitoring Unit

1) Establishment of NRW Management and Monitoring Unit in DEWS

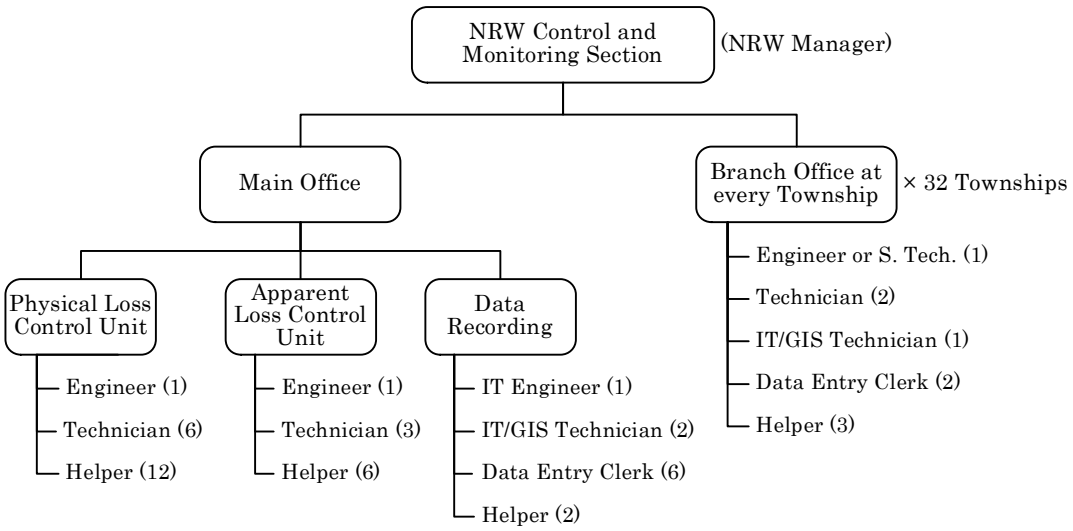
NRW Management and Monitoring Unit will be established in DEWS. It is desirable and effective method to establish separate units for Physical Loss Management and Apparent Loss Management within the NRW Management and Monitoring section due to different natures of these activities.

2) Establishment of NRW Management and Monitoring Unit in Township Offices

NRW Management and Monitoring Sub-Units will be established in each township office to evolve the activity at frontline of township level.

3) Definition of Duties and Responsibilities

Duties and responsibilities of these units and personnel should be clearly defined since NRW Management and Monitoring Unit will be a new section. It precisely will support staff to understand their own duties.



Source: JICA Study Team

Figure 5.4 Proposed Organization of NRW Control & Monitoring Section

(2) Development of Activity Basis for NRW Reduction

1) Survey and data collection on current situation of NRW

2) Development of an action plan for NRW reduction

DEWS will formulate action plan for NRW reduction and disseminate to every township offices.

3) Development of format and standard operation manual for mapping and database development

4) Establishment of attribute information basis on distribution network (diameter, pipe type, location, pipeline length, year of installation, etc.)

(3) Establishment of a System for Training of Trainers (ToT) on NRW Management

1) Selection of trainers from sections related to NRW management

Several trainers will be selected from the NRW management section of headquarter and township offices.

2) Implementation of capacity development training for trainers

Training s for capacity development of trainers will be implemented by the Japanese experts, in which the trainers will obtain necessary knowledge and technology, skills etc. on NRW management.

3) Development of training program by trainers

Training plan including training curriculum, training methods and training schedule will be formulated

by trainers.

4) Development of training materials by trainers

Trainers will develop teaching materials for their training in collaboration with the Japanese experts. In the process of development, it should be paid attention that the materials need to be easy to learn knowledge, technology, skills and to understand the contents.

5) Implementation of training by trainers

The selected trainers will implement trainings to staffs relevant to NRW management by using the developed training materials. A feedback system of lessons learnt through the training will be established.

(4) Implementation of Leakage Reduction Activities in DMA model 1-2 area(s)

1) Selection of model DMA areas and development

One or two DMA model area(s) will be selected. DEWS and relevant township offices will formulate an action plan for leakage reduction in the DMA model areas.

2) Development of database and drawings on pipeline, installation of necessary materials and equipment

Pipeline and mapping information by using GIS will be developed and necessary materials and equipment will be installed.

3) Implementation of OJT

OJT on analysis of NRW, leak detection technology, and repair method will be transferred to staffs.

4) Implementation of NRW reduction activities in model DMA areas

Leak detection works will be evolved by using leak detection materials and equipment (sound bar, water leak detector). Priority for action should be given to the leakage area where visible leaks were found by customers or to emergency cases.

5) Monitoring and evaluation of results of NRW reduction activity

Results of NRW reduction activity will be recorded and monitoring will be continued. Evaluation will be conducted regularly, and the improvement points will be suggested.

Table 5.12 Capacity Levels and Indicator Tasks

Level	Indicators
High	✓ Be able to maintain NRW within the targeted level
	✓ Be able to set annual reduction target and implement program to achieve it
Moderate	✓ Be able to evaluate relevancy and significance of NRW reduction measures proposed by third parties (e.g., construction contractors) during contracted out NRW reduction measures; be able to monitor third party works
	✓ Be able to prioritize actions, and areas for NRW reduction
	✓ Be able to identify (roughly) the proportion of water lost by physical (real) losses and apparent losses
	✓ Be able to clarify how much water is produced and distributed
Basic	✓ Be able to understand the importance of NRW reduction, concept of NRW and its terminology as per Standard IWA water balance

Source: JICA Study Team

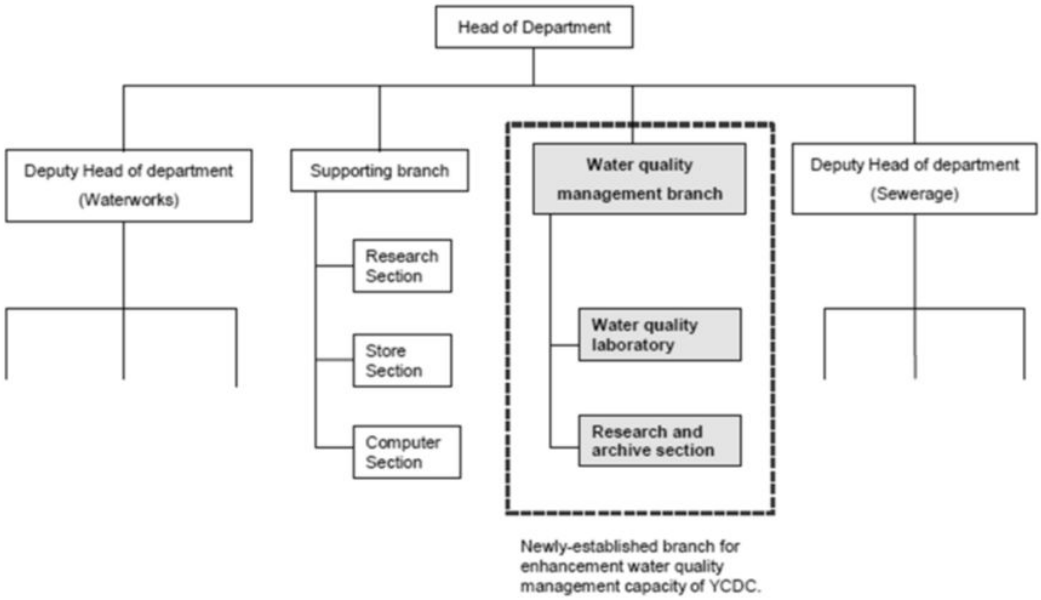
5.9.3 Priority Areas for Capacity Development (Water Treatment and Water Quality Management)

(1) Enhancement of Water quality management section

1) Re-formation of "Water quality management section" under supporting branch to independent "Water quality management branch".
2) Based on the routine water quality monitoring and water quality management, "Water quality management section" provides information and advice to other department and section about improvement of service and water quality.
3) Proposed organogram is shown in following figure. "Water quality management branch" have 2 sections. One is Water quality laboratory, and the other is Research and archive section. Function of each section is as follows;

<u>Water quality laboratory</u>
- Implementation of periodical water quality monitoring
- Water quality monitoring in case of accident and disaster
- OJT for YCDC personnel

<u>Research and archive section</u>
- Storage and management of water quality analysis data
- Storage and management of related laws and regulations
- Provide information and advice to other department and branch



Source: JICA study team

Figure 5.5 Proposed YCDC DEWS Organogram Including Enhanced Water Quality Management Function

(2) Establishment of water quality monitoring system of YCDC

1) Existing water quality test facility is modified to training facility of water quality testing.

2) In the first step of water quality management, water quality monitoring system using simple assay should is established.

3) Through the operation of this water quality monitoring system, YCDC personnel will learn the fundamental technique of water quality analysis and data analysis.

4) In the early stage of the establishment of water quality monitoring system, basic water quality item (See Table below) is monitored periodically.

5) After water quality monitoring system using simple assay is established, an advanced water quality monitoring system should be established. New water quality analysis facility which is installed advanced water test equipment and highly-trained specialist should be established.

Table 5.13 Monitoring Item and Analytical Method

Monitoring item	Purpose of monitoring	Target value*	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 unit	Color meter
Turbidity		5 NTU	Turbidimeter
Fecal coliforms	Maintain biological safety	Not detected	Simple test kit
Residual chlorine		> 0.0 mg/L To be detected (at individual water tap	Colorimetric analysis (Simple test kit)

Monitoring item	Purpose of monitoring	Target value*	Analytical method
		or inlet of storage tank)	
Zinc (Zn)	Avoid coloring trouble	< 1.0mg/L	Colorimetric analysis (Simple test kit)
Aluminum (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	
Chloride ion		< 200mg/L	
Sulfide		< 200mg/L	

*Target value is selected from Highest Desirable value in Myanmar and Japanese drinking water quality standard.
Source: JICA Study Team

(3) Collaborate with National Health Laboratory (NHL)

1) In the early stage of capacity development, collaboration of existing public health research institution is important.
2) For this purpose, collaboration with National Health Laboratory (NHL) is expected.
3) Through this collaboration of NHL, further advancement of skills and knowledge about water quality analysis and data-analysis is expected.

(4) OJT of WTP operation

1) In the early stage of capacity development, OJT through actual WTP operation (e.g. Nyaunghnapin WTP) is available.
2) Through this OJT, YCDC personnel can learn actual WTP operation and practical water quality management skill.

On the OJT, following training item is necessary.

- Water quality management of raw water and treated water
- Operation of coagulation - sedimentation process and filtration process
- Operation of chlorination process

Detailed training subjects are described in following table.

Table 5.14 Detailed Training Items of WTP Operation

Subject	Content	Methodology
Management of raw water and treated water quality	Periodical monitoring of raw water quality	Regular monitoring item: pH, Color and Turbidity Zn, Al, Fe, Cu, Mn, Hardness, Chloride and Sulfide are monitored as need arises
	Periodical monitoring of treated water quality	Regular monitoring item: pH, Color, Turbidity, Residual chlorine, Total coliform and Fecal

Subject	Content	Methodology
		coliform Zn, Al, Fe, Cu, Mn, Hardness, Chloride and Sulfide are monitored ad libitum (e.g. 1time/month)
Operation and management of coagulation, sedimentation and filtration process	Management of coagulation process	Decide coagulant injection rate and appropriate pH value; − Decide coagulant injection rate and pH using Jar tester − Preparation of Coagulation map
	Management of sedimentation process	Decide appropriate flocculation process through OJT of WTP operation (e.g. operation of flocculator, flow control of labyrinth flocculator)
	Management of filtration process	Decide appropriate filtration process through OJT of WTP operation (e.g. appropriate maintenance / cleaning method of filter)
Operation and management of chlorination	Management of chlorination process	Decide appropriate chlorine injection rate through OJT of WTP or P/S, S/R In this training, monitoring of residual chlorine, total coliform and fecal coliform is fundamental.

Source: JICA study team

(5) Capacity levels and indicator tasks of WTP operation

Through this OJT, YCDC personnel can learn actual WTP operation and practical water quality management skill. Detailed capacity levels and indicator tasks of WTP operation is shown below.

Table 5.15 Capacity Levels and Indicator Tasks

Level	Indicator
High	✓ Be able to implement water quality management in a time of disaster or accident
	✓ Be able to water quality measurement and management of trace pollutant (heavy metal, agricultural chemicals)
Moderate	✓ Be able to improvement of WTP operation and water quality management through water quality analysis
	✓ Be able to find out a problem of water quality through water quality analysis
	✓ Be able to operate water works facilities in an appropriate manner
Basic	✓ Be able to understand the meaning of water quality items ✓ Be able to measure of water quality of raw water and treated water
	✓ Be able to understand the meaning of water treatment processes

Source: JICA study team

(6) Road map to accomplish safe water supply

Table 5.16 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 skill up						
4	Construction of chlorination facilities						
5	Implementation of chlorination and skill up						
6	Construction of laboratory						
7	Training of water quality engineer in the laboratory						
8	Improvement of water quality (turbidity) through adequate O&M of WTP						
9	Accomplishment of water quality standards						

Source: JICA study team

5.9.4 Project Design Matrix of Capacity Development Project (PDM)

Based on current situation of DEWS and consideration in the aforementioned section, the following capacity development project by technical cooperation will be proposed.

Priority areas within the three fields such as business management of waterworks management, NRW reduction, and water treatment are indicated as below. Activity components and Target to be achieved are shown in the Project Summary (left box) and in the Performance Target (right box), respectively.

Table 5.17 Outline of Technical Cooperation Project for Capacity Development (Draft)

Project Period:	3.5 – 4 years
Executing Agency:	YCDC Department of Engineering (Water and Sanitation)(DEWS)
Beneficiaries:	Direct Beneficiaries: DEWS staffs relevant to business management of waterworks, NRW reduction, water treatment and water quality management (Head Quarter, Township office) In-direct Beneficiaries Approximately 2.02 million people served by YCDC in the greater Yangon city(2013 estimated)

Project Summary	Targets
Overall Goal: Water service quality and service coverage in the greater Yangon areas provided by YCDC DEWS will be improved	1. Coverage ratio of population served will be increased toward the target level 2. Supplied water will always meet the water quality standard
Project Purposes: Capacity on overall waterworks management by YCDC will be enhanced through improvement of business management and O&M capacity	1. Selected performance indicators (PIs) will be improved through the project 2. Technology and technical skills will be utilized for daily operational works

Project Summary	Targets
Outputs: 1. Improving DEWS' Capacity on Waterworks (Business) Management 2. Enhancing DEWS' Capacity on NRW Reduction 3. Strengthening DEWS' Capacity on Water Quality Management	• A short-term business plan for waterworks management will be formulated • NRW ratio in the model DMAs will be reduced by XX % • Water quality in water treatment plant and consumer taps will meet water quality standards
Activities: **1. Improving DEWS' Capacity on Business Management of Waterworks**	
1-1 Development of waterworks (business) management basis (1) Establishment of planning and monitoring unit (2) Establishment of Business management system by performance indicators (PIs) (3) Formulation of short-term plan for waterworks (Business) management	1-1 A short-term business plan for waterworks management will be formulated
1-2 Enhancement of Capacity on Customer Management and Revenue Collection (1) Development of Customer Management Database (2) Improvement of Revenue Collection Operational Works (3) Implementation of NRW reduction (Apparent Loss) in Model DMAs (4) Improvement of Customer Metering in Model DMAs	1-2 Customer management database will be established Apparent Loss will be reduced in model DMAs
1-3 Consideration of Revision of Water Tariff Structure (1) Implementation of Socio-Economic Household Survey (2) Enhancement of Understanding on Cost Recovery and Affordability to Pay (3) Consideration of Water Tariff Setting Policy (4) Design of New Water Tariff Structure and Simulation	1-3 Simulation on new water tariff structure will be carried out
2. Enhancing DEWS' Capacity on NRW Reduction	
2-1 Establishment of NRW Management and Monitoring Unit (1) Establishment of NRW Management and Monitoring Unit in DEWS (2) Establishment of NRW Management and Monitoring Unit in Township Offices (3) Definition of Division of Duties and Responsibilities	2-1 Establishment of NRW management and monitoring unit
2-2 Development of Activity Basis for NRW Reduction (1) Survey and data collection on current situation of NRW (2) Development of an action plan for NRW reduction (3) Development of format and standard operation manual for mapping and database development (4) Establishment of attribute information basis on distribution network	2-2 An action plan for NRW reduction will be developed
2-3 Establishment of a System for Training of Trainers on NRW Management (1) Selection of trainers from sections related to NRW management (2) Implementation of capacity development training for trainers (3) Development of training program by trainers (4) Development of training materials by trainers (5) Implementation of training by trainers	2-3 Trainers will be selected and a training plan will be developed
2-4 Implementation of Leakage Reduction Activities in DMA model areas (1) Selection of model DMAs and development of an action plan (2) Development of database and drawings on pipeline,	2-4 NRW ratio in the DMA model areas will be reduced

Project Summary	Targets
installation of necessary materials and equipment (3) Implementation of OJT (4) Implementation of NRW reduction activities in model DMAs (5) Monitoring and evaluation of results of NRW reduction activity	
3. **Strengthening DEWS' Capacity on Water Quality Management**	
3-1 Establishment of Water Quality Management system (1) Enhancement of Water quality management section	3-1 Enhancement of Staffing of Water Quality Management Unit
3-2 Establishment of water quality monitoring system of YCDC (1) Improvement of existing laboratory (2) Implementation of Training on Improvement of Water Quality Test Capacity (3) Starting water quality monitoring by using simple assay method (4) Analysis of Result of Water Quality Monitoring	3-2 Water quality monitoring system is established by using simple assay method and continued
3-3 Establishment of water quality monitoring system (1) Installation of Chlorination Equipment and Optimization of Chlorine Dosing (2) Improvement of Water Quality by Efficient Operation and Maintenance at WTP	3-3 Safe water is continuously provided by establishing operational standards for water treatment plant and improving water quality management capacity
3-4 Upgrading water quality management capacity (1) Formulation of a manual for water quality accidents and disaster	3-4 A manual for water quality accidents and disaster is formulated

Input:

Japanese Expert

1.Chief Advisor
2. NRW management
3. NRW reduction technology
4. Waterworks (business) management
5. Customer management/
6. Revenue collection
7. Water treatment
8. Water quality management, etc.

Equipment and materials

(1) Activity on NRW reduction
- Sounding bar
- Ground microphone (leak detector)
- Water - pressure gauge
- Metal detector
- Sluice valve
- Flow meter
- CAD Software for distribution network drawing
- GIS software
- Software for hydraulic analysis of pipeline
- Vehicle for leak detector
- PC and & Printer(HQ 5, Township 33)*

(2) Activity on improvement of business management of waterworks
- Customer database software
- PC and peripheral devices(HQ10,Township 33)
- Customer meter

(3) Activity on improvement of water treatment
- Water quality test facilities and equipment
- Reagent

(4) Training
- Training by the experts
- Training in the neighboring countries
- Counterparts training (Japan) etc.

External conditions

- A major change of institutional system of YCDC by policy change etc. does not occur
- Electricity is continuously supplied
- Trained personnel do not quit or are not transferred during the Project period

* Same PC and peripheral devices for township offices provided by business management activity are utilized.

Source: JICA Study Team

5.9.5 Implementation Schedule of Capacity Development Project

The implementation schedule of capacity development project is indicated in following table.

Table 5.18 Implementation Schedule of Capacity Development Project

JICA Study Team

Activity			Year: 2013 (1st Year)	2014 (2nd Year)	2015 (3rd Year)	2016 (4th Year)
Waterworks (Business) management	1	**Improving Capacity on Waterworks(Business) Management of**				
	【1-1】	**Development of Waterworks (Business) Management Basis**				
	【1-1-1】	Establishment of Planning and Monitoring Unit				
	【1-1-2】	Establishment of Business Management System by Performance Indicators (PIes)				
	【1-1-3】	Formulation of Short-term Plan for Waterworks (business) Management				
	【1-2】	**Enhancement of Capacity on Customer Management and Revenue**				
	【1-2-1】	Development of Customer Management Database				
	【1-2-2】	Improvement of Revenue Collection Operational Works				
	【1-2-3】	Implementation of NRW reduction (Apparent Loss) in DMA Model Areas				
	【1-2-3】	Improvement of Customer Metering in DMA Model Areas				
	【1-3】	**Consideration of Revision of Water Tariff Structure**				
	【1-3-1】	Implementation of Socio-Economic Household Survey				
	【1-3-2】	Enhancement of Understanding on Cost Recovery and Affordability to Pay				
	【1-3-3】	Consideration of Water Tariff Setting Policy				
	【1-3-4】	Design of New Water Tariff Structure and Simulation				
NRW Reduction Measure	2	**Enhancing Capacity on NRW Reduction of DEWS**				
	【2-1】	**Establishment of NRW Management and Monitoring Unit**				
	【2-1-1】	Establishment of NRW Management and Monitoring Unit in DEWS				
	【2-1-2】	Establishment of NRW Management and Monitoring Unit in Township Offices				
	【2-1-3】	Definition of Division of Duties and Responsibilities				
	【2-2】	**Development of Activity Basis for NRW Reduction**				
	【2-2-1】	Survey and data collection on current situation of NRW				
	【2-2-2】	Development of an action plan for NRW reduction				
	【2-2-3】	Development of format and standard operation manual for mapping and database				
	【2-2-4】	Establishment of attribute information basis on distribution network				
	【2-3】	**Establishment of a System for Training of Trainers on NRW**				
	【2-3-1】	Selection of trainers from sections related to NRW management				
	【2-3-2】	Implementation of capacity development training for trainers				
	【2-3-3】	Development of training program by trainers				
	【2-3-4】	Development of training materials by trainers				
	【2-3-5】	Implementation of training by trainers				
	【2-4】	**Implementation of Leakage Loss Reduction Activities in DMA model**				
	【2-4-1】	Selection of model DMA areas and development of an action plan				
	【2-4-2】	Development of database and drawings on pipeline, installation of necessary materials and equipment				
	【2-4-3】	Implementation of OJT				
	【2-4-4】	Implementation of NRW activities in model DMA areas				
	【2-4-5】	Monitoring and evaluation of results of NRW reduction activity				
Water Treatment	3	**Strengthening Capacity on Water Quality Management of DEWS**				
	【3-1】	**Establishment of Water Quality Management system**				
	【3-1-1】	Enhancement of Staffing of Water Quality Management Unit				
	【3-2】	**Enhancement of Capacity on Water Quality Test and Improvement of Water Quality**				
	【3-2-1】	Implementation of Training on Water Quality Test and Development of Manual				
	【3-2-2】	Installation of Chlorination Equipment and Optimization of Chlorination Dozing				
	【3-2-3】	Development of O&M Manual for Water Treatment Plant				
	【3-2-4】	Improvement of Water Quality by Efficient O&M of Water Treatment Plant				
	【3-3】	**Establishment of Water Quality Monitoring System**				
	【3-3-1】	Commencement of Water Quality Monitoring and Continuous Monitoring				
	【3-3-2】	Analysis of Result of Water Quality Monitoring				
	【3-4】	**Upgrading Water Quality Management Capability**				
	【3-4-1】	Formulation of a manual for water quality accidents and disaster				

Source: JICA Study Team

5.9.6 Toward Sustainable Capacity Development System

The proposed technical cooperation project is a method for DEWS to effectively develop their capacity in a short-term.
In addition, from the long-term viewpoint, the following issues are necessarily considered for sustainable capacity development.

(1) Restructuring a qualification system for WS engineer and plumber
As water supply system is developed, it is anticipated that increase in the number of master plumbers and working plumber, and cultivation of their capability are necessary. The restructuring of a qualification system could be a challenge for YCDC.

It is defined by the Yangon City Development Law that plumbing works of water supply pipe is supervised by the qualified engineer or plumber. However, this qualification system is not followed during recent 10 years, and it seems to be not functioning sufficiently.

Meanwhile, plumbing skills and materials has been changing, so to mandate the qualified engineers and plumbers joining the training for renewal on regular basis could be an effective method. In addition, a working plumber without the certification needs to work under the supervisor of a master plumber or a WS engineer, and the actual plumbing work is done by working plumbers on-site in many cases. Because the quality of plumbing works depends upon a supervising capability of construction by a supervisor, in this sense, re-training for a WS engineer and a master plumber is essential.

(2) Strengthening a training system of DEWS
As mentioned before, opportunities to obtain specialized knowledge and technology on water supply through trainings are very limited. To enrich their trainings which provide overall specialized knowledge and technology is essential for a sustainable capacity development system. These training should take a balance including both technical aspect and other aspect such as waterworks management, financial management, organization and institution, customer service, etc.

For this purpose, there are many challenges such as formulation of a training plan, securing budget, development of training equipment and facilities, water supply materials and equipment for practical training, preparation of training materials. With regard to the training place, Yegu pumping station is assumed to be a training place for the time being. In mid-and long-term, as training subjects are expanded, other training venues with enough training spaces are expected to be arranged.

From the broad viewpoint of bottom-up of water sector, if a training center of DEWS is established, there is a possibility that this training center becomes a center of capacity development at regional or national level, and plays an important role.

Although detail information on other water utilities in local municipalities is not available because the study team does not have an opportunity to visit these agencies, it is expected that the concept of a center of human resource development in water sector of Myanmar is possible in future, depending upon the sector needs. In Cambodia, one good example is a training center set up within Phnom Penh water supply authority, which has expanded their function to be increasingly a national human resource development base. It is expected that YCDC focuses on trainings not only for YCDC staffs but also for water sector, and contributes to human resource development as a front runner in Myanmar.

CHAPTER 6. COST ESTIMATION AND IMPLEMENTATION SCHEDULE

6.1 Conditions of Project Cost Estimation

6.1.1 Condition of Cost Estimation

Based on condition mentioned below, the Project cost is estimated.

- The project cost comprises construction cost, administration cost, consulting cost, contingency (physical and price escalation), land acquisition and compensation, interest during construction, commitment charge and relevant tax.
- The project cost is composed of the local currency potion (L.C.) and foreign currency portion (F.C.).
- Administration cost in recipient country is assumed to be 5.0 percent of the construction cost.
- Consulting cost is estimated based on man-months of consulting services.
- Physical contingency is considered as 5.0 percent of total of construction cost, consulting cost, land acquisition and compensation.
- Price escalation of 6.1 percent per annum for the local currency portion and 1.2 percent per annum for the foreign currency portion are applied in estimates based on implementation schedule.
- The base period of cost estimation is June 2013 and the exchange rate considered is 1 Kyat=0.114 Yen, 1 USD=101.1 Yen and 1 USD=885 Kyat.
- Interest during construction is estimated taking into consideration that Project cost is financed by Japanese ODA loan. (Loan condition: Preferential terms / Standard, Interest rate of main components=0.01%, Interest rate of consulting services=0.01%, Repayment period=40year, Grace period=10year)
- Commitment charge is not added.
- Instead of VAT, commercial tax rate is added in Myanmar and rate is 10%. Import tax is 2.0%.
- Construction cost, consulting cost and contingency (physical and price escalation) are eligible portions while interest during construction, administration cost, land acquisition and compensation, and relevant tax are non-eligible portions taking into consideration that Project cost is financed by Japanese ODA loan.
- Project cost is estimated through JICA's guideline at the time of loan and it has possibility to change.

6.1.2 Condition of Construction Cost

- It is possible to procure civil and building material, labor 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 in 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 to be conducted by the local contractor.
- The local contractors don't have any experiences in 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 construction plan is established with the considerations of local natural condition (topographic aspects, geotechnical condition and meteorological condition) and legislation/custom.

6.2 Cost Estimation of the Project

Non-disclosure Information

Table 6.1 Project Cost

Non-disclosure Information

Table 6.2 Construction Cost

Non-disclosure Information

Non-disclosure Information

6.3 Implementation Schedule

If the Project is financed through Japanese ODA loan, the Government of the republic of the union of Myanmar must follow JICA procurement guidelines for the selection of the consultants and contractors to implement the Project.

Implementation schedule starting from signing of Loan Agreement has been developed as shown in Table 6.3 taking into account necessary steps that would be required. Implementation of the project has been estimated to extend over 80 months (6.7 years) in total. Herewith Loan Agreement should be signed in the beginning of 2014 for operation to start in 2020.

Table 6.3 Implementation Schedule

	Period	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Signing of L/A	-								
Selection of Consultant	8 months								
Detailed Design	12 months								
Preparation of Specification & Bidding Documents	9 months								
Selection of Contractor	9 months								
Construction Works	49 months								
Trial Operation Period	12 months								

Source: JICA Study Team

Duration necessary for selection of the consultant and the contractor has been decided considering the JICA's standard procedures and estimated as 8 months for selection of the consultants and 9 months for selection of the contractor, respectively. Detailed implementation schedule are shown in Table 6.4 and Table 6.5.

Table 6.4 Detailed Implementation Schedule of Selection of Consultant

Month	Period	1	2	3	4	5	6	7	8
Preparation of shortlist and request for proposal	1.5 months								
Concurrence to request for proposal by JICA	1 month								
Issuing request for proposal to consultant	1.5 months								
Evaluation of proposals	1.5 months								
Concurrence to evaluation by JICA	1 month								
Contact negotiation with candidate	1 month								
Concurrence to contract by JICA	0.5 month								
Contract award	-								

Source: JICA Study Team

Table 6.5 Detailed Implementation Schedule of Selection of Contractor

Month	Period	1	2	3	4	5	6	7	8	9
Concurrence to bidding documents by JICA	1 month									
Bidding period	2 months									
Technical evaluation and Price evaluation	2 months									
Concurrence to technical evaluation and price evaluation by JICA	1 month									
Contract negotiation with candidate	2 months									
Concurrence to contract by JICA	1 month									
Contract award	-									

Source: JICA Study Team

Duration necessary for construction works has been planned to ensure the proper execution of the work considering conditions including ability of contractors, procurement of materials and labor force, manner of construction in Myanmar and construction scale. The construction schedule is mainly estimated according to procedure and working volume of construction such as excavation and concrete casting since there is rarely restriction regarding procurement. Implementation schedule of the construction has been estimated to extend over 49 months in total and shown in Table 6.6.

Table 6.6 Detailed Implementation Schedule of Construction Works

	Year 1	Year 2	Year 3	Year 4	Year 5
Lagunbyin WTP					
Transmission Main					
Zone 7 Distribution Facility					
Zone 8 Distribution Facility					
Distribution Main					
NRW Zone 7					
NRW Zone 8					
Disinfection Facility					
Zone 1 Distribution Facility					
Testing and commissioning					

Source: JICA Study Team

One year of trial operation period including on the job training is planned after the construction so that YCDC, which is responsible for operation and maintenance, takes over operation of the constructed facilities smoothly.

6.4 Consulting Service

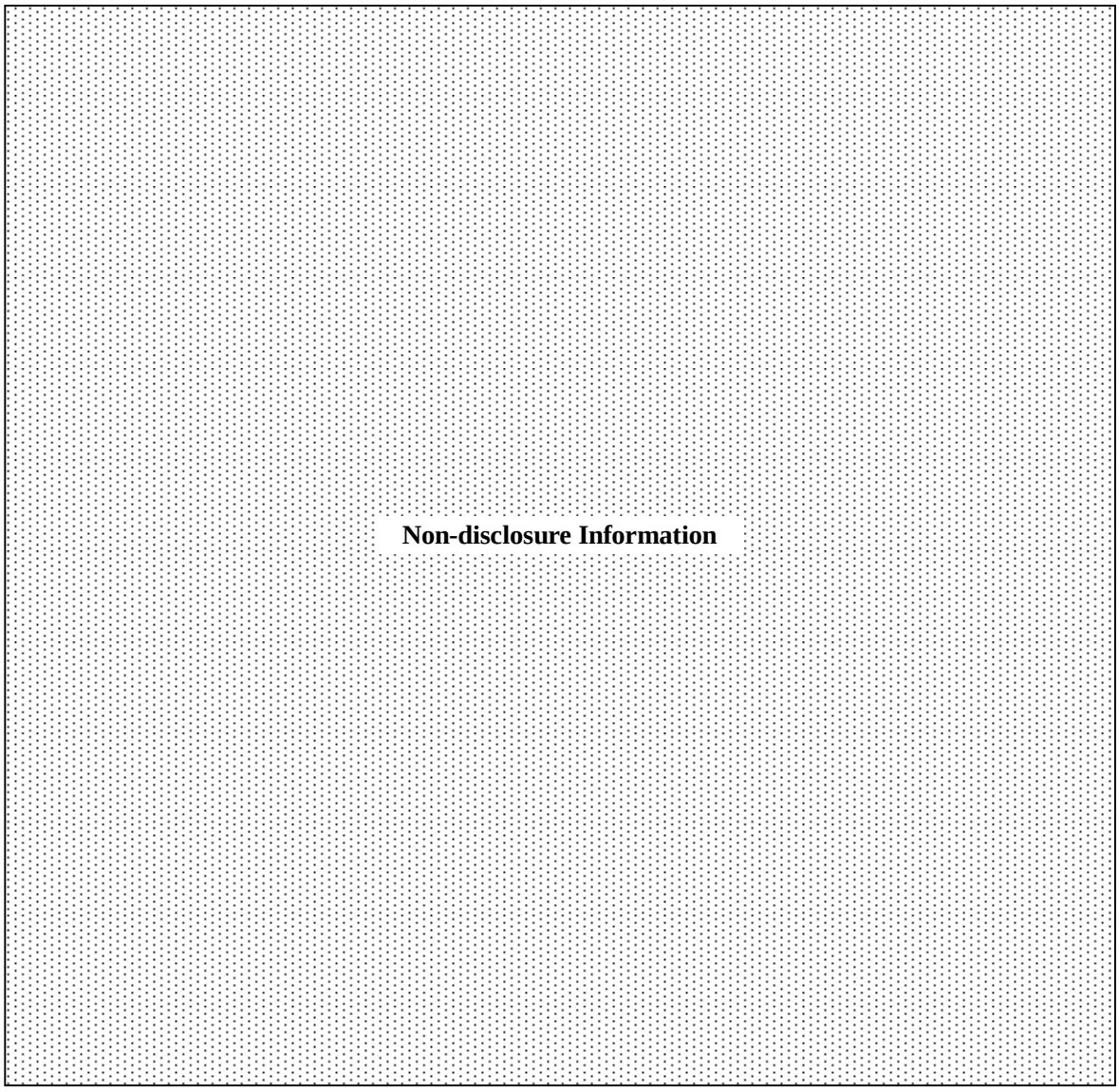
If this Project is financed through Japanese ODA loan, the procurement procedure of Design-Bid-Build contract applying "FIDIC Conditions of Contract for Construction Multilateral Development Bank (MDB) Harmonized Edition for Building and Engineering Works Designed by the Employer" is a common practice for the construction project. In the procurement of Design-Bid-Build contract, detailed design and supervision of the construction works is done by the consultants. Consulting services including the followings will be required for smooth implementation of the

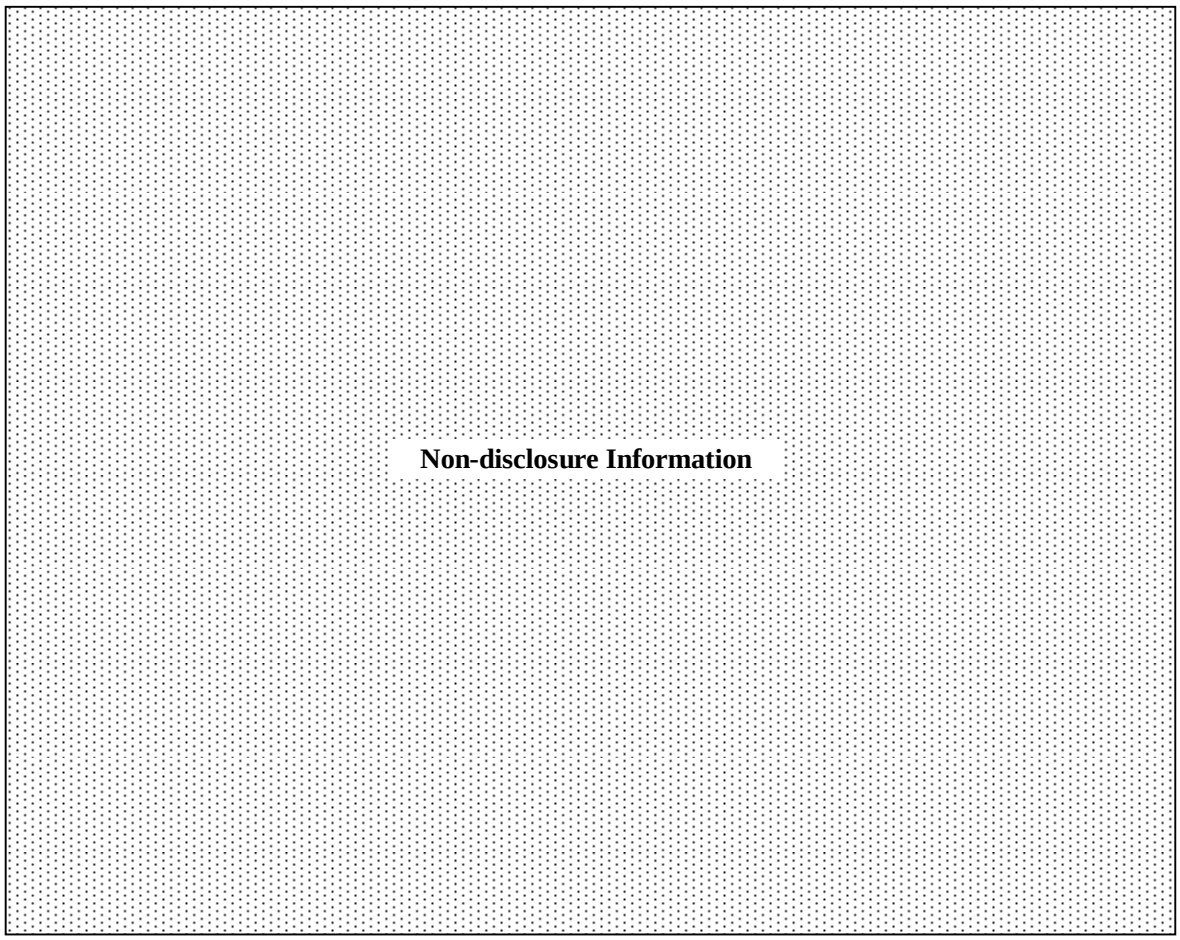
Project by assisting YCDC, the executing agency.

- Implementation of detailed design
- Preparation of tender documents for the contract
- Assistance in tender/qualification evaluation and contract negotiation
- Supervision of the construction works
- Technical assistance of management, operation and maintenance

The consultants are composed of international and local experts. The local experts should support international experts in all the activities of the Project. The proposed work schedule of the consultants should accord with the implementation schedule. Required international and local experts along with man-months for consulting services for the implementation of the Project are presented in Table 6.7. Based on the estimation of required man-months, [redacted] of international experts and [redacted] of local experts would be required for assisting the executing agency for the Project.

Table 6.7 Man-Months required for Consulting Service





6.5 Estimation of O&M Cost

The required operation and maintenance (O&M) cost for following planned facilities is estimated.

- Lagunbyin WTP
- Distribution pumping stations
- Chlorination facilities in Nyaunghnapin WTP (phase 1 and 2), Hlawga P/S and Yegu P/S

The O&M cost comprises labor cost, electrical cost, maintenance cost (check and repair), chemical cost and other cost and the unit cost of these items are shown below.

Table 6.8 Unit Cost for Estimation of O&M Cost

Item	Unit cost/base of cost	Remarks
Monthly salary (USD/month) (engineer)	209	
(technician)	109	
(common)	95	
Electricity (USD /kWh)	0.041	
Chlorine (USD /kg)	0.51	Purchase of Liquid Hypochlorite
Coagulant (USD /kg)	0.50	PAC
Maintenance (%)	1.6	% of mechanical and electrical costs

Source: JICA Study Team

The annual total cost of operation and maintenance related to the priority projects is approximately 11,271 thousand USD (1.14 billion JPY) with operation of full capacity. The detailed breakdown of O&M cost is given in Appendix D.

Table 6.9 O&M Cost

(USD/Year)

Items	Lagunbyin Water Supply System		Modernization of Network	Chlorination Facility			Total
	Lagunbyin WTP	Distribution PS for Zone 7&8	Distribution PS for Zone 1	Nyaunghnapin WTP I&II	Hlawga PS	Yegu PS	
Salary	69,960	0	0	0	0	0	69,960
Electricity	346,589	405,851	249,616	0	0	0	1,002,056
Maintenance	721,808	147,488	52,912	11,664	5,456	4,784	944,112
Chemical	6,546,293	0	0	1,269,543	666,727	551,314	9,033,878
Other cost	153,693	11,067	6,051	25,624	13,444	11,122	221,000
Total	7,838,344	564,406	308,579	1,306,831	685,627	567,220	11,271,006

Source: JICA Study Team

6.6 Organizational Structure for Implementing the Project

6.6.1 Organizational Structure for Implementing the Project

An organizational structure for the Project consists of Project Executing Agency (PEA), Project Management Unit (PMU), and Project Coordination Committee (PCC).

Table 6.10 Roles and Responsibilities of Project Organizations

Project organization	Institutions responsible	Role and responsibility
Project Executing Agency: PEA	YCDC DEWS	• Comprehensive management of project implementation according to loan contract • Allocation of budget • Guidance to project management unit
Project Management Unit: PMU	YCDC DEWS	• Project management • Supervision • Monitoring and coordination • Budgetary management
Project Coordination Committee:PCC	Regional government, YCDC, Ministry of Environment, Ministry of Construction	• Project coordination for planning and implementation

Source: JICA Study Team

(4) Project Executing Agency(PEA)

YCDC shall be the PEA and responsible for overall supervision and execution of the Project. DEWS will be responsible for water, sewerage and sanitation works. Main role and duty is to supervise

overall activities during the project implementation. In addition, DEWS will be responsible for management and monitoring of the project activities by their expertise and specialized knowledge from the technical view point.

The main functions of PEA will be shown as follows;

- To be comprehensively responsible for the project implementation in accordance with a loan contract
- To coordinate and manage the Project activities
- To establish a monitoring and evaluation system that would track the progress of the Project
- To support the PMU for planning and implementation of project activities technically and financially
- To Provide timely feedback on project planning and implementation to PMU
- To report to the government on the overall progress of the Project
- To call regular meetings for the duration of the Project, and special meetings should the need arise

(5) Project Management Unit(PMU)

A PMU shall be established within DEWS and shall be created in the DEWS as a principal entity for the project implementation. PMU is an ad hoc entity to be established for the project implementation. PMU is aimed at enhancing management and monitoring of the project, and be an independent organization to implement the specified project during the limited period. It will be headed and staffed by a full-time Project Director (PD), probably by the Chief Engineer, and creates the project office consisting of the staff members of technical section, management section, and administration section in the DEWS of YCDC.

PMU shall be tasked with managing and monitoring the day-today activities of the project at the field level. The Project Director has the responsibility and authority for overall activities including coordination between sections and with construction companies to ensure the progress of the project within the implementation period. PMU will be managed under PEA and PCC.

A technical section supervises reduction of NRW and water quality management, etc. A management of waterworks section is responsible for improvement of water tariff rates, operational works by using performance indicators, revenue collection. It is recommended that administration section include the function of finance and accounting for ensuring financial resources and smooth payment works, of legal and contract management. Main functions of PMU are as follows.

- Supervising and monitoring the day-to-day project activities
- Preparing project implementation and work plan and reporting the progress of the project with the assistance of the consultant;

- Arranging and supervising construction works
- Arranging procurement of goods, works and services for the project
- Organizing monitoring and evaluation activities;
- Receiving and distributing funds for project activities
- Maintaining accounts of the project and arrange audit

(6) Project Coordination Committee(PCC)

Project Coordination Committee: PCC is a supreme organization on project implementation. The committee meeting will be held regularly, for instance quarterly in addition to at the beginning of the project, and the terminal occasion. PCC shall be co-chaired by the project director and development affairs of regional government. PCC coordinates the necessary issues for agreement, discussion and cooperation on the project activities. It regularly reviews the progress of project activities and gives instruction and guidance for project implementation. The main composition member of PCC will be development affairs of regional government, department of finance, accounting, road and bridge of YCDC, and township offices and so on.

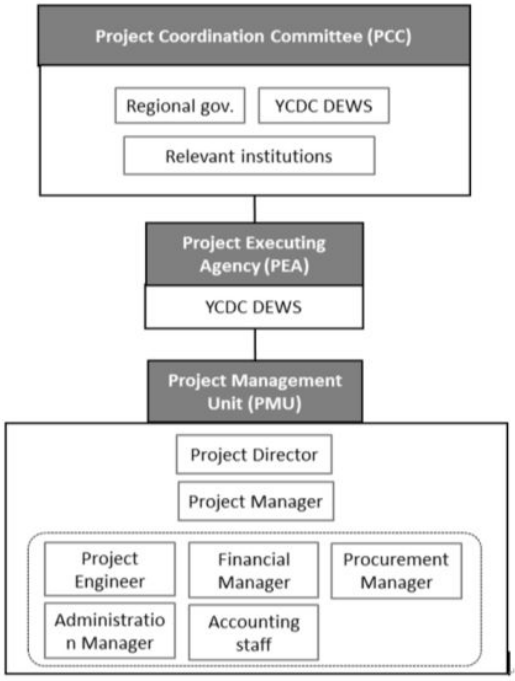
The main functions of PCC will be as follows:

- Approving work plans and budgets for the project
- Monitoring and reviewing progress of activities of various concerned agencies
- Opening of regular meetings for committee
- Coordinating stakeholders relevant to the project activities of other institutions, dispute settlement, enhancing a smooth project implementation
- Monitoring and reviewing the activity progress by the relevant institutions
- Identifying problems and bottlenecks in course of implementing various activities by the concerned agencies and suggest ways and means to solve those.
- Identifying issues which need to be considered, discussed, coordinated
- Coordinating follow-up actions

6.6.2 Division of Duties for PIA and Organizational Arrangement

(1) Organizational arrangement of project management unit

An organizational arrangement of PEA, PCC, and PMU is assumed to be established as follows.



Source: JICA Study Team

Figure 6.1 Organizational Arrangement for Project Implementation

PMU should be created in order to ensure smooth works for ODA loan and project implementation. The PMU likely consists of administration, financial and technical sections. It will be effective to employ expert or specialized consultants in order to enhance the ODA procedure smoothly.

PMU generally consists of project manager, engineering manager, technical engineers, procurement manager, financial manager, administration manager, accountants, and so on.

Project director should have responsibility and authority of all activities such as planning, coordination between sections, its management and so on. Also PD should have an authority to coordinate private companies and supervise financial and accounting section of PMU as well in order to secure sufficient financial resources and appropriate payment for smooth implementation of construction works.

(2) Staffing of Project Management Unit (PMU)

The following staffing for PMU is recommended. The duty of PD may be taken by Chief Engineer and that of project manager may be played by Deputy Engineer or Assistant Chief Engineer. It is desirable that these personnel are appointed from DEWS of YCDC from the viewpoint of capacity development of staff members and synergy effects. The number of persons is not necessarily limited to this table, and is just an indicative figure.

Table 6.11 Staffing for PMU

Areas	Position	Section	No.
Management			
1	Project Director	Chief Engineer	1
2	Project Manager	Deputy Chief Engineer, or Assistant Chief Engineer	1
Technical section(including manager)			
3	Engineer	Distribution division(Civil 1), Water quality section 1	3
4	Assistant Engineer	Distribution division(Civil 1), Water quality section 1	3
Waterworks management(including manager)			
5	Sewerage tariff/ Revenue collection	Financial division	2
6	Plan for waterworks management	Planning and monitoring division	1
Administration and Finance(including manager)			
7	Finance and accounting	Financial division	2
8	Administration	Administration division	1
9	Procurement	Administration division	1
Total			15

Source: JICA Study Team

(3) Technical level of executing agency and relevant experiences

DEWS has no experience to establish PMU for any development project yet.

YCDC has operated water supply system consisting of water reservoir, raw water transmission main, water treatment plant, transmission and distribution facilities. The capacity of water supply system is 115 MGD (523,000 m^3/day). The planning and design of water system in addition to maintenance of these facilities has been conducted by YCDC. Various training is also organized and implemented by YCDC. Hence, it can be said that some knowledge and expertise on water supply system has been accumulated in DEWS at a certain level.

In terms of construction work experience, pile driving works of Lagunbyin WTP has been carried out by contracting out to a local construction firm. DEWS has despatched some engineers for supervising the construction works of Nyaunghnapin WTP (phase 1 and 2) and Pile driving works of Lagunbyin WTP and employ many daily labours.

In this sense, DEWS has experiences of the construction of water infrastructure and the supervision works, it can be said that DEWS has some experience of project management at a certain level.

6.7 Remarks for Project Implementation

In this section, issues on procurement methods to be necessarily considered is described and proposed in case of implementation of a water supply/ sewerage development project financed by ODA Loan.

6.7.1 Procurement Environment of Relevant Experiences of the Myanmar Side

(1) General environment of local construction companies.

In Myanmar, after the democratization, local companies who have experience in civil construction works mainly in Yangon city has increased and it can be said that their technical level has reached to a certain level. In civil and construction works, local engineers and skilled workers are engaged.

Meanwhile, it can be recognized that local private firms who have experiences of construction works in water and sewerage sector are very limited according to the interview survey etc. One of the reasons is that YCDC has directly conducted the construction works of water and sewerage infrastructures in Yangon city managed by YCDC, by appointing some YCDC engineers and employing daily contract labours. There are, however, some local companies engaged in construction works of water and sewerage in other cities such as Mandalay.

Thus, a joint venture with these local firms having experiences of water and sewerage construction works or utilization of local subcontractors of civil construction firms could be effective ways for Japanese construction firms to implement the project smoothly and reduce the costs efficiently. In addition, domestic pipe manufacturing firms can be seen in Myanmar, even though the numbers are very limited.

Information on local construction firms and local materials manufacturing firms are indicated in the following table.

Table 6.12 Information on Local Construction Firms and Local Materials Manufacturing Firms

Company	Outline	
[Design and Construction Works]		
Authentic Group of Companies	Establishment: Field: Experience: Size: Others:	2010 Design of water, sewerage and drainage system, construction, trading, import and sales, water and sewerage, since 2012. 3 years' experience in the above fields Small and medium The firm has an executive who designed Nyaunghnapin WTP and pumping stations Water treatment plant in Naypyidaw and private wastewater

Company	Outline	
		treatment.
Waterworks Engineering Group Services Company Limited (WEG)	Establishment: Field: Experience: Size: Others:	2004 Design of water and wastewater system, construction, water quality test Main activity is water quality test, others are import and sales of wastewater treatment facilities, borehole drilling for well. The firm has experiences in groundwater development and water supply facilities for private firms. Small and medium The firm has a laboratory, namely ISOTECH, which was utilized by JICAs activity.
Supreme Group, water doctor related to water activities	Establishment: Field: Size: Others:	1990s Water related activity (water and sewerage treatment, water treatment plant), construction, trading, fertilizer, pesticide Small and medium The firm started import and sales of small water filtration equipment and currently expands to sell various types of water filtration machines. A subsidiary company, water doctor, was established in 1994 aiming water treatment, plumbing, construction works etc.
Dagon International Company Limited	Field: Experience: Others:	Estate developer, land developer, construction, woods selling business, agriculture and plantation, hotel, hospitality and secondhand vehicles sales, etc. The firm was started from estate developer, currently civil works can be one of their works. The firm is one of the largest Burmese conglomerates
Chan Tha Construction	Establishment: Field: Experience: Size:	1990s Estate development, construction Experience of civil works Large construction contractor
Royal Gandamar Construction Co., Ltd	Establishment: Field: Experience: Size: Others:	2006 Civil works, mainly railway construction works Firm has many experiences such as civil works of station and railway construction Middle-size construction contractor The firm has a concrete block factory for railway construction works except for construction works
[Manufacturing and sales of Materials]		
Tokyo Pipe Co., Ltd	Field: Experience: Size: Others:	Pipe sales and manufacturing Only one HDPE pipe manufacturing firm in Myanmar Large pipe manufacturing firm The firm has the largest factory in Myanmar, and produces pipe products by using machineries made in China and Germany. HDPE pipe manufactured in Tokyo Pipe has been applied in Nyaunghnapin/Ngamoeyeik (Phase 2) construction works. Their activities focus on only pipe manufacturing and sales, not construction works.

Company	Outline	
Po Seng Pipe Co., Ltd	Field: Experience: Size: Others:	Manufacturing pipe, construction Pipe installation works in Naypyidaw Large manufacturing company Company size is smaller than Tokyo Pipe co., Ltd but is famous in Myanmar. The strong point in comparison to Tokyo Pipe co., Ltd is that they can provide with construction works services as well.
Han Sein Thant Engineering and Trading Co., Ltd	Field: Size: Others:	Import and sales, and installation works of pump Small and medium Providing with only installation of machineries. Sales agency of KSB pump.

Source: JICA Study Team

(2) Local Procurement Environment

Materials and equipment for water supply system construction are basically procured from Myanmar, however in case of difficulty of domestic procurement, procurement from third countries and Japan may be assumed. The procurement environment of main materials and equipment, and construction machineries are shown in the following table.

Table 6.13 Procurement Environment of Main Materials and Equipment, and Construction Machinery

Items	Myanmar	Japan	Third Country
Cement	○		
Aggregate	○		
Reinforcing bars	○		
Fuel (gasoline/diesel)	○		
Form work materials	○		
Ductile cast iron pipe		○	○
u-PVC pipe	○		
HDPE pipe	○		
Painted Steel pipe		○	○
Valves		○	○
Water meter		○	○
Screw steel pipe pile with toe wing		○	
Base course	○		
Asphalt	○		
Scaffolding and support materials	○		
Sheet pile and earth retaining materials		○	○
Mechanical equipment (pump)		○	○
Electrical equipment (panel)		○	○
Monitoring and instrumentation		○	○

Construction machineries	Myanmar	Third countries	Japan
Backhoe	○		
Track crane	○		
Track equipped with crane	○		

Construction machineries	Myanmar	Third countries	Japan
Dump truck	○		
Automobile sprinkler	○		
Grader	○		
Roller mobile for compaction	○		
Asphalt finisher	○		
Concrete pumper truck	○		
Vibration roller	○		
Tamping machine	○		
Pavement cutter machine	○		
Cutter machine for reinforcing steel bar	○		
Processing machine for reinforcing steel bar	○		
Generator	○		
Air compressor	○		
Submersible pump	○		
Drilling machine(Non-suspension)			○
Vibrohammer pile-driver	○		

Source: JICA Study Team

6.7.2 Bidding Methods and Setting of Contract Conditions

The project requires a high technical level, so that the procurement by international bidding is appropriate. A general procedure of international bidding is indicated as follows.

1. Public advertisement is done to construction firms for prequalification through newspapers, etc.
2. Tender documents is distributed to the prequalified firms
3. A proposal is submitted by firms who received tender documents according to the contents of tender documents on the determined date and venue
4. A successful bidder that is eligible for contractual negotiation among all the bidders is decided through the bidding procedure such as confirmation of bidding documents, opening, contents evaluation, etc.
6. A successful bidder has a contractual negotiation with the executing agency of Myanmar as a client.
7. A successful bidder make a contract with the executing agency of Myanmar
8. The construction works is started
9. Necessary inspections are conducted at each stages of the works
10. Preliminary operation for the completed facilities is implemented, and the firm obtains consensus from the Myanmar side.
11. Water/ sewerage facilities are handed over to Myanmar side
12. The firm needs to respond any actions during the warranty period
13. The final inspection is conducted at the end of warranty period
14. The firm obtains a final consensus from Myanmar side then finally hands over the facilities.

6.7.3 Selection Policy for Consulting Firms

Quality and Cost Based Selection (QCBS) is recognized appropriate for selection of consulting firms. QCBS is a selection method considering quality of a proposal and cost of services, so it is recommended for the selection of consulting firms particularly for the project, which requires a high technical level.

For instance, the first step is to select 3-5 consulting firms to meet the following criteria, and to prepare a short list.

① To have consulting experiences of overseas projects in the relevant sector
② To have experiences on acceptance of order for consulting in south-east or south Asian countries
③ To have experiences of the Japanese ODA projects

The invitation letter for the project will be sent to all short-listed consulting firms. In case of QCBS, submission of technical and cost proposals are required. At first, evaluation of the technical proposal will be implemented in accordance with the following criteria.

① General experiences of consulting firms in the relevant areas which is indicated in Terms of Reference (TOR)
② Appropriateness of the proposed approach, methodology and work plan
③ Staff's experiences and achievements

The cost proposal will not be opened and sent back to a consulting firm in case that; 1) the evaluation result of technical proposal submitted by the consulting firm does not reach to the minimum score required for passing, or 2) the consulting firm does not meet the requirement indicated in the invitation letter for the submission of proposal.

The cost proposal will be opened only if a consulting firm meets the minimum score requirement in case of evaluation of technical proposal. Total scores will be calculated by considering weighted value of both technical and cost scores, and then the final rank will be determined by the total scores.

6.7.4 Selection Policy for Contractors

(1) Pre-Qualification(P/Q)

This project requires high technical level, so that invitation for bids should be targeted on the technically and financially capable contractors. Prior to the bidding, pre-qualification procedure is necessary. Prequalification needs to consider the following issues in order to judge on whether candidate bidders are capable of undertaking the specified contract or not.

① Experience and achievement in the similar contracts

② Capability of staffing and equipment
③ Financial situation

(2) Bidding System

Two Envelop Bidding could be appropriate for the selection of contractors. The bidding system requires submission of technical and cost proposals separately and simultaneously. At first, technical proposals are opened and considered to check on whether the submitted proposal meets TOR or not. After the consideration, the cost proposals of only the successful bidders who meet the minimum requirement are opened.

If technical proposal does not meet the minimum requirement, the cost proposal is returned to the bidders. Two Envelop Bidding is desirable for enhancing cost competition between only qualified bidders and for securing the quality.

6.7.5 Bidding Package

Non-disclosure Information


Non-disclosure Information

CHAPTER 7. PROJECT EVALUATION

7.1 Economic Evaluation

7.1.1 Identification of Economic Benefit

Economic benefit of the priority projects are calculated by subtracting benefit "without project case" from the total benefit "with the project case". Economic benefit can be divided into quantitative and non-quantitative. This analysis targets quantitative benefits.

Economic analysis is conducted for the following three priority projects. The Standard Conversion Factor (SCF) is used to convert financial costs to economic costs (Appendix E.4).

①	Lagunbyin Water Supply Project
②	Zone1 Non-Revenue Reduction Project
③	Development of Disinfection Facilities Project

(1) Types of Economic Benefit

Economic benefits are categorized into 2 types as follows; ① Benefits from replacement of alternative water sources by conventional water sources, ②newly generated benefits by providing adequate amount of water of good quality at reasonable price. With regard to ①, water price of alternative water resources is regarded as saving in case of with project scenario. In terms of ②, people's willingness to pay is mainly recognized as benefits. Willingness to pay is the value given to the newly generated water by people.

Table 7.1 Economic Benefit of Priority Projects

	Type of economic benefit	Item
1.	Cost reduction effect	1-1 Saving of alternative water procurement cost other than public water supply
		1-2 Saving of incurred costs by public water supply stoppage
		1-3 Saving cost for purchasing bottled water
2.	Improvement of public health situation	2-1 Saving effect of medical expenditure
		2-2 Saving effect of personnel income loss
3.	Willingness to pay	3-1 People's willingness to pay

Source: JICA Study Team

(2) Matrix Table of Economic Benefits by Priority Project

Economic benefit of each priority project is summarized in the following matrix table.

Project	Economic benefit					
	Saving alternative water procurement costs other than public water supply	Saving of incurred costs by public water stoppages	Saving costs for purchasing bottled water	Saving medical expenditures by decrease of waterborne diseases	Saving Amount of Personnel Income Loss	Willingness to pay
①Lagunbyin Water Supply Project	○			○	○	○
②Zone 1 Non-Revenue Reduction Project		○	○	○	○	○
③Development of Disinfection Facilities Project				○	○	○

Source: JICA Study Team

(3) Saving Alternative Water Procurement Costs

In case of "without the Project", public water supply system will not be able to cover the increasing water demand in future. Thus, increased amount of water demand shall be satisfied with alternative water sources. Alternative costs of water acquisition shall be saved by incremental water supply by priority project. The amount of saved costs multiplying unit costs of water acquisition from each water sources by the incremental supply amount is the economic benefits of the projects. This benefit shall be applied to Lagunbyin water supply project.

To simplify the calculation, public well/tap, neighbor's well/tap and rain/creek/canal/pond, and bottled water and water vender are combined together respectively, and then both unit costs are calculated. The detail of the percentage of alternative water acquisition methods and the acquisition costs are attached in Appendix E.1.

(4) Saving of Incurred Costs by Public Water Supply Stoppage

This benefit is applied to modernization of Zone 1 project. Currently, approximately 40% of piped household utilize water tank probably influenced by water interruption due to water leakage, according to JICA-HIS survey.

The project is expected to reduce the duration of public water supply interruptions. After the completion of the project, it is assumed that the existing water-tank users do not need to invest in the renovation and construction of water-tank. It can be thought as the economic benefit by improving the situation of water supply interruptions.

In this analysis, it is assumed that 10% of all households shall stop using the facilities additionally up to 2025.

(5) Saving Cost for Purchasing Bottled Water

According to JICA-HIS survey, approximately 55% of households with house connection replied that they buy bottled water.

In case of With the Project scenario, the number of bottled water bought by household shall decline due to the reduction of NRW of public water supply thereby increasing the amount of supplied water of desired quality. This incremental revenue water volume shall be supplied to customer, thereby it is likely predicted that the number of bottled water purchased by users will decline. In this case, this incremental bottled water cost generated by increase of revenue water shall be assumed as saving.

(6) Saving Effect of Medical Expenditure for Water Borne Disease

This benefit is applied to all ① - ③ projects. In case of With the Project scenario, public health condition shall be improved by water quality improvement and the increase of coverage ratio of public water supply. Thereby, it would contribute to saving in the medical expenditure by decrease of waterborne diseases. The reduction amount is estimated based on the information of Regional Department of Health.

It is assumed that the percentage of patients in total population will be decreased by 30% in implementation of the Project. The information obtained from Regional Department of Health is indicated in the following table. The calculation results are attached in Appendix E.2.

Table 7.2 Occurrence of Waterborne Diseases

Waterborne disease	2008	2009	2010	2011	2012	Average occurrence rate	Ratio to all population (%)
Diarrhea	17,462	13,166	11,851	10,969	15,713	13,832	0.199%
Dysentery	9,489	6,135	6,361	4,436	4,099	6,104	0.088%
Typhoid & Para Typhoid	71	55	98	47	27	60	0.001%
Viral Hepatitis	251	14	271	205	212	191	0.003%
Malaria	5,741	4,605	4,374	2,226	1,539	3,697	0.053%
Population (1,000 persons)	6,944						

Source: Central Statistical Organization, Statistical Year Book 2010,
Regional Department of Health

Table 7.3 Average Days of Treatment for Waterborne Diseases and Treatment Costs

	Diarrhea	Dysentery	Typhoid & Para Typhoid[*1]	Viral Hepatitis	Malaria
Average Days of Treatment					
In-patient	3	3	5	5	5
Out-patient	1	1	1	1	1
Treatment cost					
In-patient	6,000	4,000	10,000	7,000	4,000
Out-patient	2,800	1,500	2,000	2,500	1,000

Source: Regional Department of Health

(7) Saving Amount of Personnel Income Loss

This benefits is applied to all ① - ③ projects. In case of the with project scenario, occurrence of waterborne diseases is expected to decrease due to increase of water supply coverage and improvement of water quality. As a result, there will be saving in personnel income due to reduced expenses on medical services. In this analysis, it is assumed that the number of patients of waterborne diseases reduces by 30% of total patient upon implementation of project.

(8) Willingness to Pay

Estimation result of willingness to pay is attached in Appendix E.3.

7.1.2 Identification of Economic Cost

Economic costs are calculated based on financial costs. With regard to the development of disinfection facilities project, however, the difference from financial cost is that economic costs account for only the costs of replacement and repair, and chlorine necessary for the new facilities. This reason is that economic benefits take into account only incremental willingness to pay amount regarding improvement of water quality by chlorine injection as economic benefit

For the calculation of economic costs, Standard Conversion Factor (SCF) is multiplied to financial costs of local currency portion. SCF is attached in Appendix E.4.

Economic cost during the overall project period is indicated in table below.

Table 7.4 Economic Cost of Priority Project

(1000 US$)

	Lagunbyin Water Supply Project	Zone 1 Non-Revenue Reduction Project	Development of Disinfection Facilities Project
Construction costs	**Non-disclosure Information**		
Replacement and repair costs			
O&M costs			
Total			

Source: JICA Study Team

7.1.3 Economic Evaluation

The result of calculation of economic costs and benefits during the project evaluation period is indicated in the following table.

Project	EIRR	B/C Ratio
① Lagunbyin Water Supply Project	11.0%	1.73
② Zone 1 Non-Revenue Reduction Project	10.6%	2.63
③ Development of Disinfection Facilities Project	3.5%	1.00

As a result of the economic analysis, both ① Lagunbyin water supply project and ② Modernization of zone 1 project indicate relatively high EIRR as 11.0% and 10.6 % respectively. In these cases, the B/C ratio is 1.73 and 2.63 respectively. With regard to ③ Disinfection project, the result of EIRR shows 3.5% with the B/C ratio as 0.83.

Generally, it could be said that the project is considered worthy for implementation if EIRR of the project is higher than the applied discount rate as an opportunity cost of capital. From this viewpoint, the EIRR of all projects ① - ③ is higher than the discount rate, thereby it is recognized that the projects are economically feasible.

International institutions such as World Bank, WHO and UNDP suggest that 5% is a benchmark criteria of IRR for basic human needs project as a public works in developing countries. From this perspective, the results of ① and ② cleared the defined benchmark.

7.1.4 Sensitivity Analysis in Economic Aspect

The analysis is conducted for the variation of the cost and benefits change in plus minus 10% respectively.

The results of sensitivity analysis are indicated by project in the following table.

① Lagunbyin Water Supply Project

		Economic benefits		
		-10%	Base	+10%
Economic costs	-10%	11.0%	12.7%	14.3%
	Base	9.4%	11.0%	12.5%
	+10%	8.0%	9.5%	11.0%

② Zone 1 Non-Revenue Reduction Project

		Economic benefits		
		-10%	Base	+10%
Economic costs	-10%	10.6%	11.7%	12.7%
	Base	9.6%	10.6%	11.6%
	+10%	8.8%	9.7%	10.6%

③ Development of Disinfection Facilities Project

		Economic benefits		
		-10%	Base	+10%
Economic costs	-10%	3.5%	56.8%	68.5%
	Base	N.A.	3.5%	55.5%
	+10%	N.A.	N.A.	3.5%

*N.A.--- FIRR is not available.

In evaluation of Lagunbyin project, the variation of change of economic benefits more influence on FIRR rather than economic costs. The change ranges between 8.0% and 14.3%.

In terms of modernization of Zone 1 project, the change is relatively smaller ranging between 8.8～12.7%. The computable change in case of disinfection project is large ranging between 3.5%～68.5% as quantifiable results, however the results of some cases are not obtained.

Every EIRR estimation of projects ① - ③ exceeds 3% probably as a social discount rate line. Also, in cases of project ① and ②, the results of EIRR clear the hurdle of 5% as a benchmark criteria of human needs project as a public work in developing countries. Thus, it can be considered that these projects are economically feasible.

While, in the case of project ③, the result of EIRR icon of the 6 cases indicate more than 3 % value, therefore it could be evaluate economically feasible. Other 3 cases of project ③ does not indicate the available value of EIRR. The B/C ratio is within the range between 0.81 and 1.22.

7.2 Financial Evaluation of Priority Project for Water Supply

7.2.1 Condition for Financial Analysis

Financial analysis of priority project is conducted according to the following conditions. The financial evaluation calculates the FIRR of 3 projects together shown in the section of 7.1.3 different from economic evaluation. The evaluation period is 40 years from 2014 to 2054. In the analysis, 3% of discount rate is applied to the calculation of present value, B/C and FIRR.

(1)	Base year	: Year 2014
(2)	Evaluation period	: 2014-2054
(3)	Discount rate	: 3%
(4)	Revenue water ratio	: Assumed 33% (2013) without no improvement, however, except for zone 7 and zone 8 targeted by Lagunbyin Water Supply Project
(5)	Tariff rates	: Based on current rates, 88 Kyat for domestic, 110 Kyat for non-domestic
(6)	Loan condition	: Low-Income Least Developed Countries, General Terms, Standard (JICA: FY2013), Repayment Period 40 years (Grace period 10 years), interest rate 0.01%

7.2.2 Identification of Financial Cost

Financial costs of the proposed project consist of initial construction costs, replacement and rehabilitation costs and O&M costs.

Replacement and rehabilitation costs of infrastructure are calculated in accordance with the condition below.

- Electrical and mechanical equipment are replaced every 15 years for pumping station and 20 years for water treatment plant respectively with the costs of 100%
- Lifetime of civil engineering infrastructure is expected to be 50 years. Lifetime of electrical and mechanical equipment is expected to be 15 years for pumping station and 20 years for water treatment plant respectively. The residue value of infrastructure is calculated according to age of service in 2054, the end of the evaluation period, and then it is accounted as benefits.

Financial costs of priority project with 0% present value up to 2054 are accounted as indicated below. The financial costs include price escalation.

Composition	Amount
Initial construction costs	**Non-disclosure Information**
Replacement and rehabilitation cost	
O&M costs	1,058 million US$

7.2.3 Identification of Financial Benefit

Financial analysis of priority project is firstly conducted in conventional way such that people's willingness to pay and affordability to pay are accounted as financial benefits.

(1) Financial Evaluation of Project in Conventional Way

2 options as follows are assumed for the calculation based on JICA-HIS survey: ① people's willingness to pay (WTP), ② people's affordability to pay (ATP)

Option	Amount	Remark
① Willingness to pay Overall in median value 24h supply, drinkable water	1,500 Kyat/household/month	145 Kyat/m^3 estimated from average water consumption
② Affordability to pay Low income group, bottom 20%	3,150 Kyat/household/month	3% of monthly household income, 105,000 Kyat(median value)

In the estimation of the amount of affordability to pay, the growth rate projection of Gross Regional Domestic Products (GRDP) is not considered because the financial costs do not include price escalation. Therefore the estimation is based on the actual amount value in 2013.

Each option of financial evaluation is indicated in the following table.

Table 7.5 Financial Evaluation by WTP and ATP

Non-disclosure Information

B/C and FIRR of Option ① are at low level as 0.54 and not available respectively. In contrast, B/C and FIRR of ATP is 1.03 and 1.4% respectively, and FIRR is higher than the discount rate of 3%.

The main reason behind this can be explained that current level of water tariff remain at relatively low even if there is bias on the result of the household interview survey.

(2) Financial Evaluation of Project based on tariff revenue

In addition to WTP and ATP mentioned above, financial evaluation based on tariff revenue is carried out in this section. Main conditions for calculation are shown below.

Table 7.6 Condition for Financial Evaluation Based on Tariff Revenue

Item	Condition	Standard year
Water consumption per capita	236 L/household/month	2013
Average family size	6.22 persons/household	2013
Tariff rates	Domestic 88 Kyat/m^3	2013
	Non-domestic 110 Kyat/ m^3	
	Thilawa SEZ 0.88 US$/ m^3	

	2011	2018	2020	**2025**
Average supply amount of Zone 1 (m^3/day)	624,785	717,303	741,643	**783,630**
Average supply amount of Zone 7 (m^3/day)	86,613	175,978	211,404	**319,437**
Average supply amount of Zone 8 (m^3/day)	116,931	174,386	196,256	**267,161**
Estimated population in overall Yangon city	1,933,689	2,742,337	3,061,819	**3,764,310**
Estimated connection in overall Yangon city	306,935	456,296	517,199	**659,2491**
Estimated revenue water (Overall)	33%	49%	54%	**65%**
Estimated revenue water (Zone 1)	33%	10%	10%	**10%**
Household income of low income group (Bottom 20%)	105,000	134,010	147,746	**188,565**

Source: JICA Study Team

Coverage area of Lagunbyin water supply project and modernization of Zone 1 project is Zones 7 and 8 and Zone 1, respectively. Calculation is carried out according to the supply plan which assumes 30 MGD for zone 7 and 8, and 10 MGD for zone 1 eventually. Also modernization of zone 1 project has set the final target of NRW as 10% in zone 1. Meanwhile, in the calculation of financial benefits of disinfection project, revenue is estimated according to the planned supply amount as 30 MGD.

7.2.4 Financial Evaluation

(1) Calculation Simulation for Financial Evaluation

In financial analysis, four simulation cases in the following table are set up and calculated.

Table 7.7 Simulation Cases for Financial Evaluation

Simulation case	Initial construction costs	O&M costs Replacement and rehabilitation costs
	YCDC/ Gov. funding	Tariff revenue
【Simulation A】:Full cost recovery (Annual increase rate of water tariff 0% / year)	100%	100%
【Simulation B】:Full cost recovery (Annual increase rate of water tariff 0% / year) (Initial construction costs 50% by YCDC/Gov. funding source)	50%	100%
【Simulation C】:Cost recovery (Annual increase rate of water tariff 0% / year) (O&M costs, replacement and rehabilitation costs)	0%	100%
【Simulation D】:Cost recovery (Annual increase rate of water tariff 3% / year) (O&M costs, replacement and rehabilitation costs)	0%	100%

Source: JICA Study Team

【Simulation A】All costs including initial construction costs, O&M costs, replacement and rehabilitation costs will be recovered by tariff revenue. Annual tariff increase rate is 0%.

【Simulation B】50% of initial construction costs will be recovered by YCDC or governmental funding source, the remaining 50% is recovered by tariff revenue. Annual tariff increase rate is 0%.

【Simulation C】O&M costs, replacement and rehabilitation costs will be recovered by tariff revenue. Annual tariff increase rate is 0%.

【Simulation D】O&M costs, replacement and rehabilitation costs will be recovered by tariff revenue. Annual tariff increase rate is 3%.

(2) Results of Financial Evaluation

The results of financial evaluation are indicated in the following table.

Financial simulation was conducted in the following 5 cases, and the results of NPV, B/C and FIRR in case of discount rate as 3% are shown.

Table 7.8 Results of Financial Simulation

	FIRR	B/C
【Simulation A】:Full cost recovery (Annual increase rate of water tariff 0% / year)	-10.0%	0.55
【Simulation B】:Full cost recovery (Annual increase rate of water tariff 0% / year) (Initial construction costs 50% by YCDC/Gov. funding source)	-9.3%	0.67
【Simulation C】:Full cost recovery (Annual increase rate of water tariff 0% / year) (O&M costs, replacement and rehabilitation costs)	-8.4%	0.84
【Simulation D】:Cost recovery (Annual increase rate of water tariff 3% / year) (O&M costs, replacement and rehabilitation costs)	10.8%	1.24

N.A. --- the calculation result is not indicated by Microsoft Excel

Source: JICA Study Team

In 3 cases of【Simulation A】【Simulation B】【Simulation C】 with 0% of annual tariff increase, all the balance of NPV and B/C are not positive and are less than 1.0 during the overall evaluation period. It is indicated that only the case of 【Simulation D】 satisfies with this criteria.

From the viewpoint of cost and benefit analysis, full cost recovery is possibly indicated in 【Simulation D】with 3% of annual tariff increase, however this case is not able to achieve full cost recovery. Meanwhile, if we look at the results of 【Simulation A】,【Simulation B】,【Simulation C】

with 0% of annual tariff increase, these results are less than 1.0 which cannot recover even the costs of O&M, replacement and repair.

The FIRR is less than the criteria of 3% as discount rate in cases of【Simulation A】,【Simulation B】, 【Simulation C】with 0% of annual tariff increase. The FIRR of 【Simulation D】, with 3% annual tariff increase and cost recovery of O&M costs and replacement and repair costs is more than 10%. Its result is higher than 3% of social discount rate and a benchmark of human basic needs project as 5%, therefore, it is assumed to be financially feasible.

(3) Cashflow Analysis of 【Simulation C】

The cashflow for the scenario of【Simulation C】with 0% annual tariff increase and cost recovery of O&M costs and replacement and repair costs is presented in the following table.

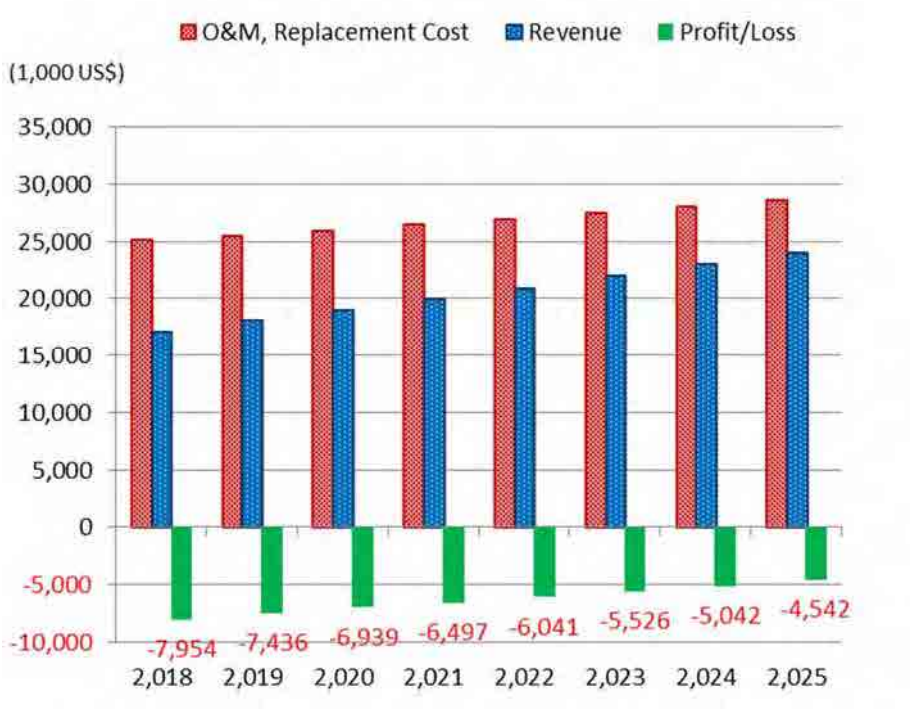
Table 7.9 Cashflow Stream of Priority Project (Simulation C)

Non-disclosure Information

With regard to the cashflow balance by 2025, the deficit will be generated amounting for between [redacted] US dollars (NPV 0%) every year. Hence, YCDC will be not able to earn sufficient income to cover the cost of O&M and replacement and rehabilitation. These deficit need to be compensated by subsidies either from the YCDC overall account or the central government account. Or an alternative option may be to consider raising the tariff rate level.

The tariff rate level needs to be increased with 19% in average during 7 years up to 2025 if the financial revenue and expenditure are balanced as of 2025. In that case, it is estimated by simply dividing the period that the average annual percentage of tariff rate increase is 2.7%.

The cashflow balance projection is shown as the following figure.



Source: JICA Study Team

Figure 7.1 Cashflow Balance Projection by 2025 (Simulation C)

(4) Sensitivity Analysis

Out of these parameters, the financial costs of O&M and the financial benefits from tariff revenue are the most influencing determinants of the financial analysis. In this section, the analysis is conducted for the variation of the costs and benefits changes in plus minus 10%. The results of sensitivity analysis are illustrated in the following table.

Table 7.10 Results of Sensitivity Analysis of Priority Project (Simulation C)

		Tariff revenue		
		-10%	Base	10%
O&M Costs	-10%	-8.2%	-2.3%	4.5%
	0%	N.A.	-8.4%	-2.7%
	+10%	N.A.	N.A.	-8.6%

* Shadow parts indicate more than 5% of FIRR,
N.A. indicates that the value is not available
Source: JICA Study Team

The change of tariff revenue and O&M costs are equally very influential on the result of sensitivity analysis. FIRR is variably ranged from 4.5 % as the best performance to N.A. as the lowest performance.

The project is financially feasible in the case that FIRR is larger than the discount rate of 3% under

the conditions of plus 10% of tariff revenue and minus 10% of O&M costs.

7.2.5 Consideration of People's Affordability to Pay

In this section, people's affordability to pay is considered under the condition of 3% of annual tariff increase until 2040 respectively. Assuming household income will grow at 3% per annum which is approximately half of the growth rate projection of GRDP, the estimated household income in 2025 and 2040 and household spending for water are indicated in the following table.

Table 7.11 Average Household Spending for Water and Affordability to Pay

Item	Unit	2025		2040	
		Lowest 20%	**Overall**	Lowest 20%	Overall
Tariff rate with 3% annual growth	Kyat/m^3	**108**		168	
Average household income (est.) with 3% of annual tariff growth	Kyat/HH/month	**149,705**	**249,508**	233,235	388,726
Average household spending (est.)*	Kyat/HH/month				
With 3% of annual tariff growth		**2,160**		4,368	

* Average household consumption is estimated to be 20.0 m^3/HH/month (2025), 26.0 m^3/HH/month (2040)
Source: JICA Study Team

Table 7.12 Result of Affordability Consideration

		in 2025		in 2040	
		Lowest 20% income group	**Overall**	Lowest 20% income group	Overall
Household income: Annual growth (%)	= 3%	**1.44%**	**0.87%**	1.87%	1.12%

Source: JICA Study Team

The affordable level of household income is assumed in the range between 3-5% as a benchmark. From the result in the above table, all result meet 3% line of household income, therefore it can be said that the level of tariff rates is under the affordable level in general. The water spending level of lower 20% income group of household who is necessarily paid special attention is less than 3% in 2040 and it could be evaluated within the affordable level.

7.2.6 Pro-Poor Tariff Rates

The implementation of governmental policy to support specified poor people is not unusual in developing countries. The identification of poor people from household income, however, is mostly not possible and is still a challenge. Individual and company business owner is imposed to report the income amount of individual or employees, however the enforcement is weak in reality and the actual progress and the recording situation are unknown according to an interview with YCDC. In addition,

the identification by residential area is not impossible in the periphery area of Yangon city, but difficult in the downtown areas.

Hence it is difficult to distinguish poor people from household income and to take a subsidizing policy, and it is recommended as an effective measure that tariff rates is differentiated between large consumers and small consumers.

For instance, an application of a progressive tariff structure is possibly considered, the feature of structure is that water tariff rates are set up more expensive for large consumers and cheaper for small consumers. In concrete term, one example is that tariff rates of the first block remain at low level same as current rate for a pro-poor measure. On the other hand, tariff rates per m^3 of the succeeding blocks will be set up at higher rates with extra as consumption volume grows up.

The basic assumption of background is based on the empirical hypothesis that poor people tend to consume less water volume rather than large consumers generally. This could be one of pro-poor alternative measure for poor households assumed as small consumers. Furthermore, its structure enables to send a message to consumers on environmental conservation and saving water resources and to gain its effectiveness.

Current tariff structure is a mixture both of flat rate system and metered rate system with uniform tariff rate. This unit rate of uniform metered rate is constant without extra increase, therefore it may be equal for all metered customer. It is not subsidizing rate setting in a sense, and it is required to pay attention to prop-poor rates in the tariff rate setting.

7.2.7 Development of Recommendable Tariff Structure

As mentioned before, increasing-block tariff rate (progressive rate) is recommended in order to raise awareness on saving water resources and pay attention to poor people. Currently, a mixture of flat rate and metered rate is practiced, and metering of customer need to be enhanced to foster a united tariff rate structure.

In this section, new tariff rates structure is considered for future reference based on customer consumption information by customer type (except for public sector).

The distribution trend of average monthly household consumption for domestic users indicates that approximately 40% of total users consume 10 m^3 per household monthly. Tariff rate block range distinguished by 10 m^3 is desirable by considering the above current situation and practicality. Tariff

rate of the first block is set up as 88 Kyat/m^3 for domestic and as 110 Kyat/m^3 for non-domestic even though consisting of various current rates. An example of increasing-block tariff rate structure is shown in the following table.

Table 7.13 Increasing-Block Tariff Rate Structure (Example)

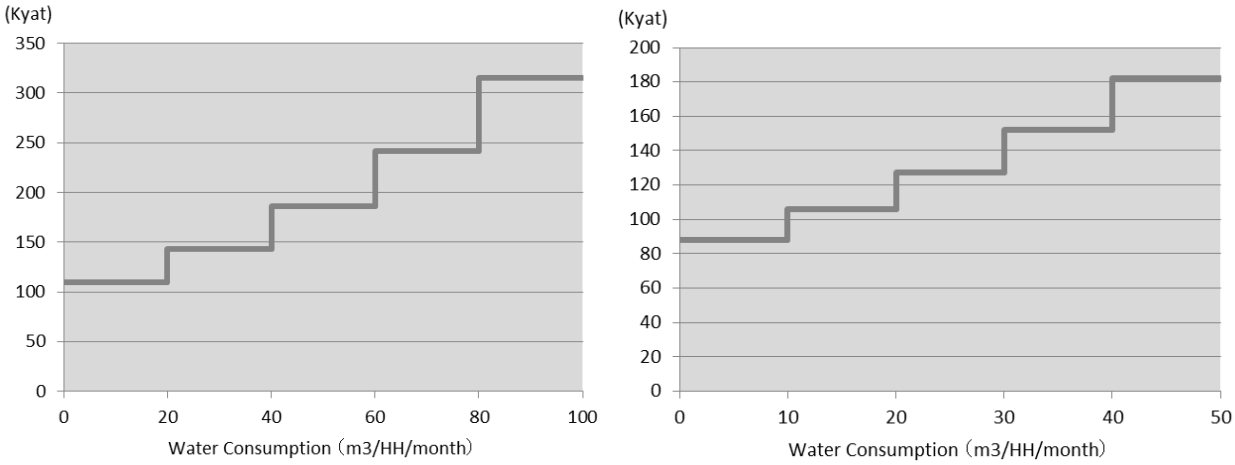
Domestic

Tariff rate block (m^3)	0-10	11-20	21-30	31-40	41～
Unit price (Kyat/m^3)	88	106	127	152	182
% of number of connection by consumption block	40%	35%	15%	5%	5%
Price ratio to the 1st block	1.00	1.20	1.44	1.73	2.08
% of tariff revenue by consumption block	32.6%	34.2%	17.6%	7.1%	8.5%
Increase/ decrease ratio to number of connection	7.4%	0.8%	-2.6%	-2.1%	-3.5%

Non-domestic

Tariff rate block (m^3)	0-20	21-40	41-60	60-80	80～
Unit price (Kyat/m^3)	110	143	186	242	315
% of number of connection by consumption block	46%	24%	15%	10%	5%
Price ratio to the 1st block	1.00	1.30	1.69	2.20	2.86
% of tariff revenue by consumption block	33.1%	22.5%	18.3%	15.8%	10.3%
Increase/ decrease ratio to number of connection	12.9%	1.5%	-3.3%	-5.8%	-5.3%

Source: JICA Study Team



Source: JICA Study Team

Figure 7.2 IBT Rate Structure (Example) (Left: Domestic, Right: Non-domestic)

Comparing the percentage of number of connection with the percentage of tariff revenue, the percentage of tariff revenue is relatively smaller up to the second block. This can be interpreted that cross-subsidy from large consumer to small consumer is possibly structured by providing lower rates for small consumers and higher rates for large consumers, even if total revenue amount is same.

Current tariff rate is applied to the domestic customer consuming less than 10 m^3, and progressive tariff rates are applied to the remaining 60% of total customers.

Similar to domestic customers, the current tariff rates is applied to 46% of total customers with less than 20 m^3 consumption per month, and progressive rates is adopted to the remaining customers with more than 20 m^3 consumption per month. It needs to pay attention that this example case, however, is simplified. In real case, the customer type of commercial and industrial customers are categorized into more varied types, and the consumption pattern of public and departmental customer is not taken into account, so that these points should be necessarily considered in future tariff setting.

7.3 Project Evaluation

7.3.1 Outline of Effects by the Project

The direct effects by implementation of the priority projects are expected as follows.

1. The service population with treated safe water will be increased.
2. The water consumption per capita will be increased.
3. The quality of supplied water will be improved.
4. The duration of water supply will be increased.

The indirect effects are expected as follows.

1. Improvement in water supply conditions mentioned above shall contribute to reduction of occurrence of water related diseases such as cholera, typhoid and diarrhea, and skin & eye diseases and is expected to improve health conditions of the people, which contribute to reduction of medical expenditure of household.
2. The current cost for obtaining water will be reduced and the household expenditure on water will be reduced, which will indirectly contribute to improvement in the livelihood of the people.
3. Water use will be more convenient, i.e., whenever required, water will be supplied.
4. Water fetching time and efforts will be reduced and mitigated. As a result, working and education opportunity for them will be enhanced.
5. The improvement of the water supply service will contribute to improved living conditions of low income households along with water tariff strategy for low income household.
6. It will contribute to the stabilization of people's livelihood in the area and political stability.
7. Working opportunities will be created during construction and operation & maintenance of water supply facilities
8. The industry and business that are now affected by dirty water supply will be activated and

contribute to the development of the country.

9. The prevention of expecting land subsidence and salinization of ground water is expected to be reduced by reduction of groundwater withdrawal.

7.3.2 Quantitative Effects

The quantitative effects by the component are shown in the table below.

Table 7.14 Quantitative Effects by the Component

Item	Development of Lagunbyin Water Supply System	Modernization of Water Supply System in Distribution Zone 1	Provision of Disinfection Facilities
Operation Indicator			
Increase of population served	◎	○	
Increase of water consumption	◎	◎	
Increase of water consumption per capita	○	○	
Increase of rate of facility utilization	○		○
Decrease of non-revenue water ratio	○	◎	
Increase of compliance rate of residual chlorine in WTP	◎		○
Increase of compliance rate of turbidity in WTP	◎		○
Effect Indicator			
Increase of percentage of population serviced	◎	○	△
Increase of net water supply per capita for residential use	○	○	
Increase of supply hour	◎	◎	
Increase of compliance rate of residual chlorine at customer tap	◎	○	◎
Increase of compliance rate of turbidity at customer	◎	○	

◎:Large effect, ○Medium effect, △Effect

Source: JICA Study Team

The operation and effect indicators of quantitative effects are shown in the tables below. As quantitative effect, the effect indicators by overall YCDC operation and by each component are presented.

Table 7.15 Operation Indicator

Component	Indicator	Calculation method	2011	2022	**2025**	Objectives
Overall	Population served within Yangon City	Population of 33 townships whom the water is supplied by the system On yearly base	1,920,471	3,342,816	3,764,310	To grasp the general effect of development of water supply system
Overall	Maximum amount of water supply within Yangon City (m^3/day)	Maximum daily water supply = the maximum amount among daily water supplies	673,000 (8 + 27 + 54 + 14 + 45) = 148 MGD	1,059,000 (8 + 27 + 54 + 14 + 45x2 + 40) = 233 MGD	1,023,000 (27 + 54 + 14 + 45x2 + 40) = 225 MGD 4)	Same as above
Lagunbyin System	Rate of facility utilization (Water treatment plant)	Rate of facility utilization (max) = (daily maximum water supply amount) / (facility capacity) x 100, Rate of facility utilization (average) = (daily average water supply amount) / (facility capacity) x 100 On monthly base	-	72% 66%	92% 87%	To evaluate the rate of facility utilization of Lagunbyin WTP
Chlorination facility	Rate of facility utilization (Chlorination facilities)	Rate of facility utilization (max) = (daily maximum water supply amount) / (facility capacity) x 100, Rate of facility utilization (average) = (daily average water supply amount) / (facility capacity) x 100 On monthly base	0%	100% 90%	100% 90%	To evaluate the rate of facility utilization of three chlorination facilities
Distribution Zone 1	Non-revenue water (NRW) ratio	(Amount of water unbilled to custom) / (water supply amount) x 100 On monthly base	67%	41% 3)	35%	To evaluate the activities to reduce NRW within distribution zone 1 of the project area
Lagunbyin system and Chlorination facility	Compliance rate of residual chlorine in WTP	(the number of samples which comply with the standards) / (Total number of samples) x 100 On monthly base	-	90%	95%	To evaluate operation status of Lagunbyin WTP and chlorination facilities
Lagunbyin system	Compliance rate of turbidity in WTP	(the number of samples which comply with the standards) / (Total number of samples) x 100 On monthly base	-	90%	95%	To evaluate the operation status of Lagunbyin WTP

Note: 1) Target concentration of residual chlorine of treated water at treatment plant shall be decided so that tap or individual storage tank water complies with the target.
1) The target turbidity is less than 5 NTU.
2) The vale in 2022 is calculated exploration between the values in 2011 and 2025.
3) It was planned that groundwater use is abandoned in 2025.
Source: JICA Study Team

Table 7.16 Effect Indicator

Component	Indicator	Calculation method	2011	2022 1)	**2025**	Objectives
Overall	Percentage of population served (%)	(Served population) / (population of the area) x 100 (33 townships in Yangon City)	37%	54%	**58%**	To grasp the general effect of development of water supply system
Lagunbyin system	Same as above	Same as above (Lagunbyin system area)	22%	36%	**40%**	Same as above
Distribution Zone 1	Same as above	Same as above (Distribution Zone 1 area)	71%	84%	**86%**	Same as above
Overall	Net water consumption per capita for residential use (L/capita/day)	(Daily average of water supply amount by meter) / (served population by meter)	96L	127L	**135L**	To evaluate the effect on quality of life
Lagunbyin system	Same as above	Same as above (Lagunbyin system area)	55L	93L	**100L**	Same as above
Distribution Zone 1	Same as above	Same as above (Distribution Zone 1 area)	103L	140L	**150L**	Same as above
Overall	Compliance rate of residual chlorine at customer (%)	(the number of samples which comply with the standards) / (Total number of samples) x 100	0	80%	**85%**	To evaluate the effect of disinfection of Lagunbyin WTP and chlorination facilities
Lagunbyin system	Compliance rate of turbidity at customer tap (%) 2)	(the number of samples which comply with the standards) / (Total number of samples) x 100	-	80%	**85%**	To evaluate the effect of Lagunbyin WTP

Note:
The number of samples for water quality test in Water Safety Plan:
Population more than 500,001: 600 samples + 12 samples every 50,000 population
For Yangon city: 600＋682＝1,282 samples/year
1) The value in 2022 is estimated interpolating the values between 2011 and 2025.
2) Residual chlorine should be detected at tap or entrance of household tank.
Source: JICA Study Team

7.3.3 Qualitative Effects

The qualitative effects described below can be expected by the project implementation.

Item	Development of Lagunbyin Water Supply System	Modernization of Water Supply System in Distribution Zone 1	Provision of Disinfection Facilities
1. Contribute to reduction of water related diseases, reduction of medical expenditure of household, improvement of health conditions of the people	◎ The disinfected safe water supply and prevention of pollution by the continuous water supply with proper pressure	○ Prevention of pollution by the continuous water supply with proper pressure	◎ The disinfected safe water supply
2. Reduction of water purchase cost and household expenditure on water	○ Safe water supply		○ Safe water supply
3. Increase in convenience of water use, i.e., whenever required, water will be supplied	◎ Increase of water supply amount by construction of WTP and control of water flow and pressure	○ Increase of water supply amount by reduction of unaccounted-for water and control of water flow and pressure	
4. Reduction of water fetching time and efforts and increase of working and education opportunity	◎ Increase of served population	○	
5. Improvement of living conditions of low income household by improvement of water supply services	◎ Increase of served population		○ Safe water supply
6. Contribution of the stabilization of people's livelihood and political stability	◎ Increase of served population and stable water supply	○ Stable water supply	○ Safe water supply
7. Creation of working opportunities by construction and O&M of water supply facilities	◎	◎	
8. Activation of industry and business activities and contribution of economic development of the country	○ Water supply service to industry and commerce	○ Water supply service to industry and commerce	○ Safe water supply to industry and commerce
9. Prevention of expecting land subsidence and salinization of groundwater by reduction of groundwater withdrawal	○ Reduction of groundwater intake in the east area of Yangon City	◎ Reduction of groundwater intake in the downtown of the Yangon City	

CHAPTER 8. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

8.1 Framework for Environmental and Social Considerations and Baseline Data

The framework for environmental and social considerations mentioned below and environmental and social baseline data are described in Appendix F.2.

- Laws and Regulations related to the environmental and social considerations
- Administrative framework for environmental and social considerations
- Procedures of environmental and social considerations
- Land acquisition and resettlement

8.2 Outline of the Components Which Requires Environmental and Social Considerations

No.	Components	Facility	Beneficiary
1	Lagunbyin Water Supply System	Water supply to Zone 7 and 8, water transmission to Thilawa • Water treatment plant with 40 MGD capacity • Transmission pipe (Zone7: φ1200×13.46km, zone 8: φ1000×4.06km, Thilawa:φ700mm×25.2km) • Two service reservoirs • Distribution main (71.64km) φ300-800 • Distribution branch (224km), φ100-200 • Water meter: 55,613	Area of zone 7 & 8: 38.41 ㎢ 2 Zone 7: East Dagon, North Dagon (Year 2011: 86,613 person, Year 2025: 319,437 person) Zone 8: South Dagon, Dagon Seikan (Year 2011: 103,713person, Year 2025: 267,161 person) Thilawa: Thilawa SEZ
2	Modernization of Distribution zone 1	Modernization of DMA in Zone 1 and reduction of NRW • Rehabilitation of old distribution pipe • Meter installation	Zone 1 area: 170.81km^2 CBD (Latha, Lamdaw, Pabedan, Kyauktada, Botataung, Pazundaung) IUR (Ahlone, Kyeemyindaing (east side), Sanchaung, Dagon, Bahan, Tarmwe, Mingalar Taung Nyunt, Seikan) (Year 2011: 624,785 person, year 2025: 783,630 person)
3	Construction of chlorination facilities	Construction at the following facilities • Nyaunghnapin WTP • Hlawga No.1 Pumping Station • Yegu Pumping Station	The supplied population can enjoy disinfected safe water

8.3 Development of Lagunbyin Water Supply System

8.3.1 Analysis of Alternatives

(1) With/Without Project

The rapid increase of population will be expected in the east side of Yangon City. The zone 7 and 8 are located in the east side of the City and the water demand is expected to increase. In four townships, North Dagon, South Dagon, East Dagon and Dagon Seikkan, the water supply service ratio is less than 30 % and the demand for the stable water supply system is high. By the implementation of the

project, the existing service ratio of 23.6 % in zone 7 and 23.8 % in zone 8 will be improved to 33.8% and 32.8 % in 2025 respectively and to 70.0% and 68.7% in 2040.

The development of SEZ in Thilawa is under planning and the water supply to this area will be inevitably required.

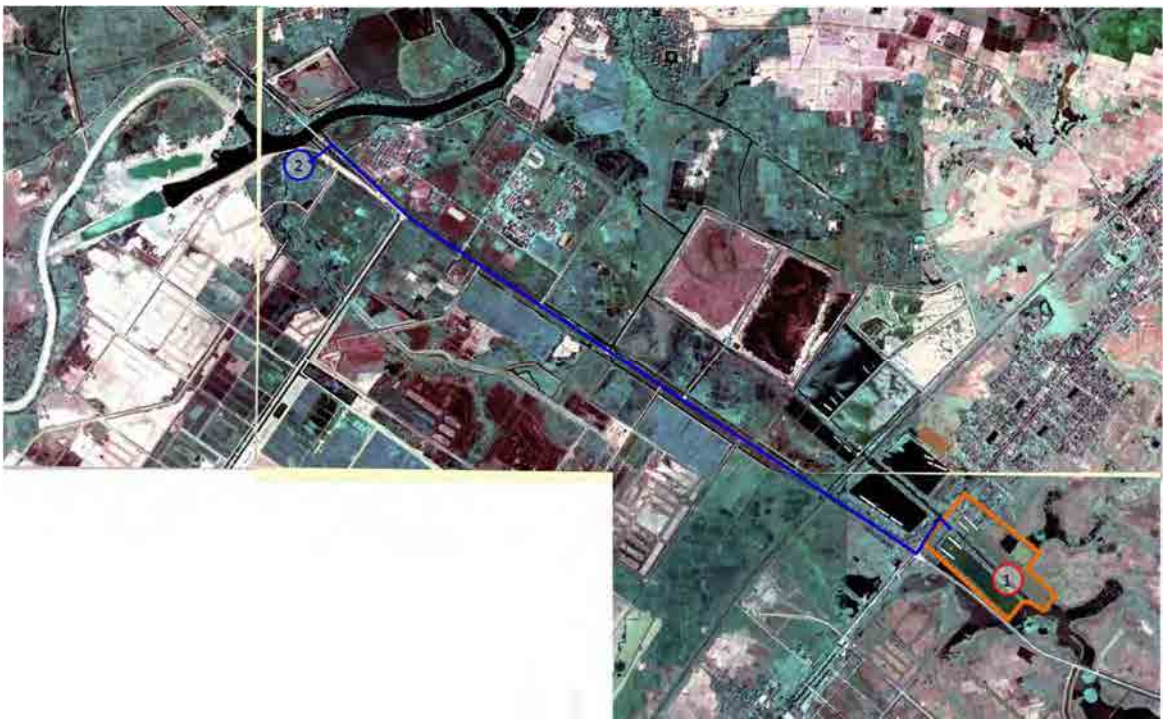
(2) Alternatives for the location of WTP

The plan to construct the WTP at Lagunbyin has been prepared by YCDC and the location was selected (no.1 of Figure 8.1). JICA Study Team studied the selected site from the following viewpoints.

- Conditions of the facility planning (the route between intake point and water consumption area, area of the proposed site, flood situation, sea water intrusion, etc.)
- Environmental and social considerations (the ownership of the proposed site, land use, involuntary resettlement, etc.)

Before the foundation works was started in the WTP site, JICA Study Team recommended the location no. 2 in the Figure 8.1 to YCDC as WTP site. The reasons were: the proposed site (location no.1) was used as the fish pond, the stable water intake is location no. 2 which is away from the location no.1 of WTP site and to construct WTP near the intake point is recommended from the view point of operation and maintenance. The land of location no. 2 belongs to the private people, the land owner is around 1 or 2 persons and it is said that the negotiation was not difficult for land acquisition. However, YCDC acquired the budget for land reclamation, the water was drawn out from the fish pond and fundamental work has started at the location no. 1. Based on these situations, JICA Study Team abandoned the plan to use the land of location no. 2 and the location no. 1 was selected as the WTP site in the figure below.

From the facility planning view, the conditions about route, area size and sea water intrusion are confirmed to be satisfied. The strength of the ground seems weak as the area was used as fish pond but the bearing piles have been constructed so that this issue can be cleared. The right to use the land belongs to YCDC. The Production Department of YCDC owned the right but for the WTP the right was already transferred to DEWS. The land acquisition is not necessary, involuntary resettlement and impacts on livelihood of the people can be avoided. From the above reason, the area YCDC selected for WTP can satisfy the requirements of JICA Study Team and the area location no.1 in the figure below was selected.



Source: JICA Study Team

Figure 8.1 Alternatives of Intake Location

(3) Alternatives of Intake Point

The intake point for Lagunbyin WTP should be located near the WTP. The two locations were studied as alternatives

- The small canal which is located inside of proposed WTP and MOAI specified (marked as 1 in the Figure 8.1).
- The location near the Ngamoeyeik Creek which flows into the small canal (marked as 2 in the Figure 8.1).

The outline, problem and benefit are summarized in the table below.

Table 8.1 Analysis of Alternatives of Intake Location

	Alternative 1 (①of Figure 8.1)	Alternative 2 (②of Figure 8.1)
Outline	The proposed WTP site is owned by YCDC, was previously used as fish pond and now dried up. The proposed intake is the canal nearby the WTP site.	The proposed WTP site is same as the Alternative 1. The proposed intake is nearby area of Ngamoeyeik creek. Intake pumping station is required at the intake site.
Land Acquisition	No land acquisition is required as the area for WTP and intake belongs to YCDC.	Land acquisition for intake and pumping station is required. (small)
Problem	• Land subsidence may occur and underground pipe in WTP may be affected. • Rehabilitation, dredging and widening of creek is required and very costly. • Unstable intake: Even if creek is rehabilitated stable intake is not sure	• The operation and maintenance of two facilities of intake pump station and WTP are separately required. • The cost for raw water transmission pipe is required. • The area of proposed intake location belongs to the private and it takes time and

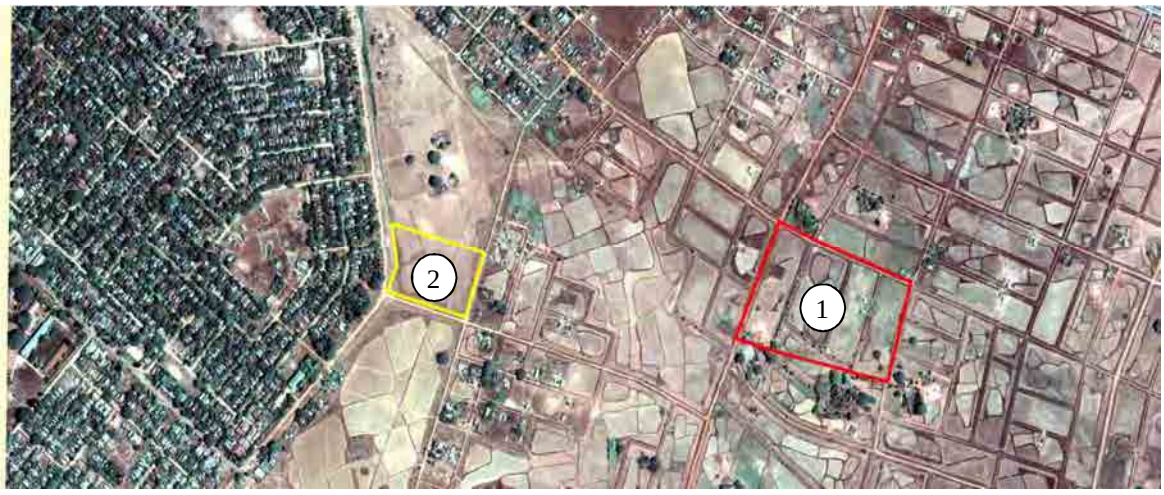
	Alternative 1 (①of Figure 8.1)	Alternative 2 (②of Figure 8.1)
	during the flood in rainy season ● Water quality may be deteriorated by the pollution from urbanization nearby the WTP in future.	tough negotiation from the recent acquisition cases.
Benefit	● The land acquisition is not required. ● The facilities which require operation and maintenance are located in one location.	● Stable water intake and quality can be expected.

Source: JICA Study Team

The problems of alternative 1 are necessity of dredging, rehabilitation and widening of creek and the strengthening of the ground by bearing pile. The land acquisition is required for alternative 2. In Myanmar, the laws and regulations related to land acquisition is developing and the land acquisition process which reflects the international standards are not fixed yet, so that the problems related land acquisition comes out in these years. The land acquisition should be avoided as much as possible, so that the alternative 1 is selected. But the dredging, rehabilitation and widening of the canal and land improvement are required.

(4) Alternatives of Service reservoirs

For the location of service reservoirs, relatively higher area is suitable to distribute the water by gravity but the zone 7 and 8 is flat area so that the locations of reservoirs are proposed in the center of the distribution zone. The proposed location for zone 7 is owned by YCDC and the land is not used for any purpose so that this location is selected without analysis of alternatives. For the service reservoir of zone 8, the proposed site was no. 1 of figure below but YCDC recommended the location no. 2 because the location no. 1 belongs to the private. The location no. 2 is suitable from the technical point of view and from the environmental and social point of view, the land acquisition and impact on land use can be avoided. Therefore, the location no. 2 was selected for reservoir of zone 8.



Source: JICA Study Team

Figure 8.2 Alternative Locations for Reservoir of Zone 8

(5) Alternatives of Transmission main to Thilawa

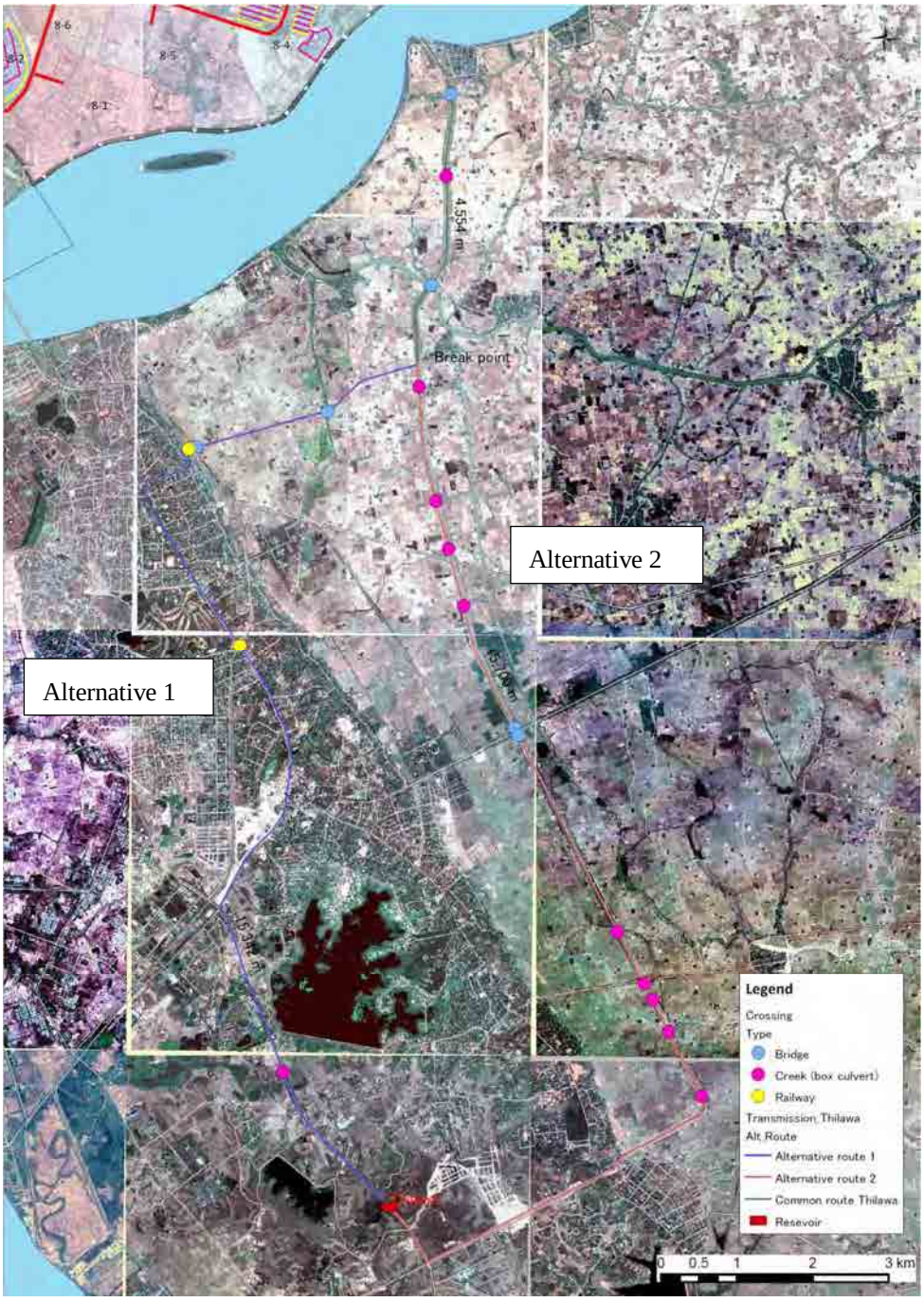
The alternative routes of transmission main from the Lagunbyin WTP to Thilawa SEZ were analyzed. The transmission main will pass the common route from Lagunbyin WTP to 4.5 km ahead of No. (2) Yangon-Thanlyin Bridge, then the alternative route no.1 will pass through the farm road, center of the Thanlyin City and reach to the connection point with Thilawa SEZ. The alternative route No.2 will go southward and turn to the west direction till the connection point.

Table 8.2 Comparison of Alternatives for Transmission Pipeline to SEZ

	Alternative 1 (Thanlyin Route)	Alternative 2 (MAX Road Route)
Length (from the breakpoint)	15.4 km	15.7 km
Owner of the road	*From Bridge till breakpoint*: Owned by MOC, operated by MAX *Till Thanlyin*: ID of MOAI *Thanlyin*: Owned by MOC, operated by MAX *Till class A*: Owned by MOC, operated by SEZ committee	*From Bridge till the entrance of Class A*: Owned by MOC, operated by MAX *Class A*: Owned by MOC, operated by SEZ committee
Crossing (except No. (2) Yangon-Thanlyin Bridge)	River: 5 locations Creek (box culvert): 2 locations Railway: 1 location	River: 4 locations Creek (box culvert): 10 locations
Difficulties	● Need the approval from MOAI, MOC and MAX for installation ● Need the schedule arrangement with Thanlyin Road Construction (ODA Loan) ● Need to confirm the land owner of the route from the breakpoint till Thanlyin Road ● Need to close the farm road of both sides during construction period due to the narrow road ● Provide large negative impacts to citizens as the route passes the center of the city	● Need the approval from MOC and MAX for installation

Source: JICA Study Team

The approval of MAX and the crossings of several river and box culvert are required for either route. In addition, the length of the transmission main is almost same so that the alternative 2 is selected considering the difficulties.



Source: JICA Study Team

Figure 8.3 Alternative Route

8.3.2 Scoping and TOR for Environmental and Social Survey

The scoping to identify the important environmental and social items and decide the method of survey was implemented. “Scoping” means choosing alternatives for analysis, a range of significant and potentially significant impacts, and study methods. The results of scoping and the study method of the items identified as A to C are shown in the table below.

Table 8.3 Scoping and TOR for Environmental and Social Survey

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
Involuntary resettlement and land acquisition	C-	D	**P/C:** The area for Lagunbyin WTP belongs to YCDC. The land for two service reservoirs is required and if the owner is private, the land acquisition is necessary. The involuntary resettlement can be avoided.	• Confirmation of right • Procedures of land acquisition	• Hearing survey of related organizations • Site survey
Local economies, such as employment, livelihood, etc.	B+/C-	D	**P/C:** The increase of employment by the construction can be expected. The livelihood of user of the land might be affected by land acquisition.	• Confirmation of land use	• Site survey
Land use and utilization of local resources	C-	D	**P/C:**If the areas for two service reservoirs are used for any purpose the impact on land use can be expected.	• Confirmation of land use	• Hearing survey of related organizations • Site survey
Social institutions	D	D	The impact is not expected. To enhance the public involvement and information disclosure and obtain the cooperation and understanding, the stakeholder meeting was implemented.	-	-
Existing social infrastructures and services	B-	D	**P/C:** By construction of transmission, distribution main and branch, traffic disturbance due to the road closing and detour, the access to existing infrastructure may be disturbed. **O:**No impact is expected.	• Situation of infrastructure service around project site.	• Hearing to related organization • Site survey
The poor, indigenous & ethnic people, gender and children's right	C-	C-	**P/C:** The poor might be included in the affected people by land acquisition. No indigenous and ethnic people exist in and around the project site. No impact is expected on gender and children's right. **O:**The increase of water bill by meter installation might provide the impacts to the poor.	• Situation of the poor	• Result of interview survey
Misdistribution of benefits and damages	D	D	Through the development of water supply system, the citizens can enjoy the water.	-	-
Cultural heritage	C-	D	**P/C:** The heritage building might be located in zone 7 and 8.	• Location of cultural heritage in project area	• Hearing survey of related organizations • Site survey
Local conflicts of interest	D	D	The impact is not expected.	-	-
Water usage or water rights and rights of common	C-	B+	**P/C:** The water intake from the Lagunbyin dam used for irrigation purpose may affect the water use of agriculture. **O:**The increase of water supply amount will provide positive benefits on water use of the citizens.	• Water use	• Hearing to related organization
Hazards (Risk) infectious diseases	B-	D	**P/C:** The infectious diseases may increase by the influx of construction worker. **O:** No influx of population will be expected by the operation of the	• Data of infectious diseases	• Hearing of related organization

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
			facilities so no impact is expected during operation.		
Accidents	B-	B-	**P/C:** The increase of traffic may lead the increase of the accidents during construction. **O:** The use of Sodium hypochlorite solution might lead to the accidents.	• Traffic situation of the route • Preventive measures	• Site survey
Topography and geographical features	D	D	No impact is expected as the scale of the project is not large.	-	-
Soil erosion	D	D	No impact is expected.	-	-
Groundwater	D	D	No groundwater intake is planned.	-	-
Hydrological situation	D	D	No discharge to the rivers is planned.	-	-
Coastal zone	D	D	No impact is expected.	-	-
Protected area	D	D	No protected area in the project site.	-	-
Flora, fauna and biodiversity	D	D	No impact is expected. The Lagunbyin Canal is the artificial construction for the agriculture.	-	-
Meteorology	D	D	No protected species exist in and around the project site.	-	-
Landscape	B-	C-	**P/C:** The landscape gets worse due to the dig up of the road and storage of excavated soil during construction. **O:** There is no special landscape in and around the project site. The service reservoirs might affect the landscape of the residences nearby.	• Proposed site situation	• Site survey
Air pollution	B-	D	**P/C:** The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary. **O:** No facility which emits the pollutant to the air is included.	• Air quality standards • Air quality of the site	• Hearing from the related organization
Water pollution	D	D	No water pollution is expected by the construction of intake facility and WTP.	-	-
Soil pollution	B-	D	**P/C:** The compaction of soil due to vehicle movement, and ground contamination from the spillage of materials such as vehicle fuel, chemicals might be expected. **O:** No impact is expected.	• Preventive measures	• Collection of the related project information
Waste	B-	B-	**P/C:** The spoil will be generated during installation of pipelines and construction of WTP. **O:** The sludge will be generated from WTP.	• Waste management regulations • Disposal method of construction waste • Situation of waste disposal sites	• Hearing survey of related organizations • Site survey
Noise and vibrations	B-	C-	**P/C:** Construction machines will cause noise and vibration during construction. **O:** The facilities which create noise will be installed inside the building of WTP	• Noise standards	• Hearing from the related organization

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
			site. The impact may not be occurred.		
Ground subsidence	C-	C-	**P/C,O:** As the proposed area for WTP was used for the pond fish so that the ground subsidence may be expected.	• Strength of the ground	• Review of design done by YCDC
Offensive odors	D	D	No door is expected.	-	-
Bottom sediment	D	D	No impact is expected.	-	-
Global warming	D	D	No impact is expected.	-	-

P: Planning, C: Construction, O: Operation
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.
Source: JICA Study Team

8.3.3 Results of the Environmental and Social Surveys

(1) Involuntary resettlement, Land Acquisition and Land Use

The required area for each facility is shown in the table below. The involuntary resettlement may not occur due to the Project implementation.

Table 8.4 Necessary Area for Each Facility

Facility	Necessary area	Ownership	Situation
Lagunbyin WTP	21 ha	YCDC	The right to use the land was transferred to DEWS from Production Dept. of YCDC.
Service reservoir in zone 7	2.5 ha (1/3 of land is required for year 2025)	YCDC	The land belongs to YCDC but three persons are using the land for agriculture.
Service reservoir in zone 8	1.6ha (1/3 of land is required for year 2025)	Yangon Regional Government (transferred to YCDC in October 2013)	The area belongs to Yangon Regional Government (in October 2013 the area was transferred to YCDC) but there are two houses inside the area and one person is using the land for agriculture.
River crossing point of Thilawa transmission pipe	Temporary use	Yangon side: MOC Thanlyin side: MOAI	The area belongs to the government.
Installation of transmission / distribution pipes	-	YCDC, MOC	The pipes are installed under the road and bywalk. No impact is expected to private land.

Source: JICA Study Team

1) Lagunbyin WTP

The right to use the land of the proposed Lagunbyin WTP was possessed by the Production Department of YCDC and the area was used as fish pond. As the DEWS requested to use this area for WTP, the transfer of the right to use was done and the now DEWS owns the right. The water was drawn from the pond in March 2013 and area was dried up by the sun. In April 2014 the fundamental work has been started.

Source: JICA Study Team

Figure 8.4 Lagunbyin WTP Location

2) Service Reservoir of Zone 7

The proposed area for the service reservoir of zone 7 belongs to YCDC. The whole area is 9.4 acre (3.8 ha). The yellow marked area in the figure below is around 3 ha and the necessary area for reservoir is 2.4 ha. It is confirmed that one house is located within the area and other two houses are located near the area. The reservoir can be constructed without any damage to these houses. The houses are constructed without the permission of YCDC. To check the land use, the site surveys during dry and rainy season were conducted but there is no access road to this area and the land use was confirmed from near this area. This area is not used as agriculture area in dry and rainy season. The situations in dry season were confirmed by several satellite images of the past and this area was always dry and not used for any purpose. The situation of rainy season is shown in the figure below, the area is poorly-drained and looked like a swamp. The grass was grown but there was no sign of any crops in this area.

Source: JICA Study Team

Figure 8.5 Proposed Area for Service Reservoir of Zone 7

By the detail survey of the right of land use by YCDC, it was identified that the all area does not belong to YCDC, but one part belongs to private. It is difficult to construct the facilities avoiding the private area so that YCDC have changed the location of service reservoir and the new location is shown in the figure below.

Figure 8.6 New Location of Service Reservoir of Zone 7

The right to use this marked area was given to YCDC in 1992-1993 from the Ministry of Housing Department for the expansion of the Yangon City. The proposed reservoir site (6.88 acre, 2.78 ha) is used by some farmers. YCDC identified the users, interviewed to the identified three users.

- User 1's main occupation is farming and laborer, and he uses 2.42 acre since 1990.
- User 2 uses 2.20 acre since 1981-1982.
- Famer 3's main occupation is farming, he uses 2.26 acre since 1990.

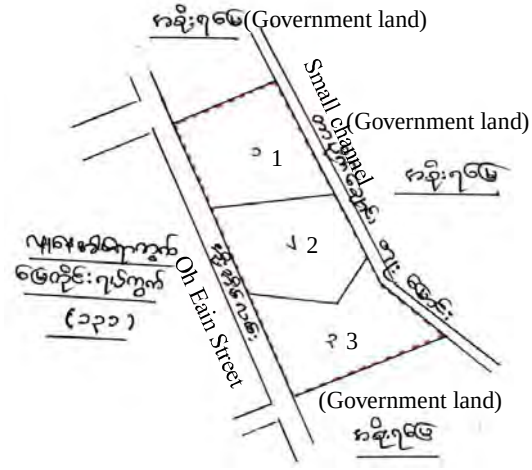


Figure 8.7 Usage Conditions

The area belongs to YCDC so that land acquisition is not required. Those users use the area for farming knowing that the area belongs to Government. However, the construction will provide the negative impact on users' life so that YCDC considered providing compassionate grant to users. For those, YCDC interviewed and consulted closely with the users and the users understood the necessity of construction of the facilities and agreed to stop using the land. Base on the consultation with users, YCDC requested Yangon Regional Government for the appropriate compassionate grant amount for the users in this area and the Yangon Regional Government suggested the amount per acre by the letter dated 4 February 2014. In the same letter, the group formation for paying compassionate grant consisting of YCDC (DEWS, Town Planning and Land Management Dept.), District, Township, and Ward/Village Land Management Committee, Ministry of Housing Department and Yangon Regional Land Department was directed.

Based on the letter from Yangon Regional Government, YCDC consulted with the users and agreed on the contract on 10 February 2014 including;

- The user receives the compassionate grant for the loss of livelihood by construction of service reservoir.
- The compassionate grant amount is fixed per acre.
- The user agrees to transfer the land to YCDC and promises not to cultivate nor live in the transferred land.

3) Service Reservoir of Zone 8

There are six houses around the proposed site of service reservoir of zone 8. The land marked yellow in the figure below will be used for the reservoir and this may not cause any impacts on the houses and no involuntary resettlement is expected. The right to use the land belongs to Yangon Regional Government and YCDC requested to transfer the right to YCDC. The crops are not cultivated in the dry and rainy season but some cattle were observed as walking inside the area.

Source: JICA Study Team

Figure 8.8 Proposed Area for Service Reservoir of Zone 8

Based on the request from YCDC, Yangon Regional Government surveyed the right of land use, and the right to use was already given to private for residential development. Thus, Yangon Region Government proposed to YCDC for another area (location no. 2 in the figure below) and the location of service reservoir was changed.

Source: JICA Study Team

Figure 8.9 Proposed Site for Reservoir of Zone 8 (Changed)

Within the area of new proposed site, there are two houses. Two residents live in one house and earn the living by catching the fishes around the creek. The other house is empty. The facility for year 2025 will require less than one third of the marked area in Figure 8.9 so that the facility can be constructed without displacement of the houses. The part of the land is used by the resident nearby for production of the rice. YCDC identified the user, interviewed and the information is as follows:

- One person uses the land for farming.
- The area was owned by the step-father of the user till 1996. In 1996, the areas with adjacent areas were transferred to the Housing Department of Yangon Regional Government for housing development plan.
- The housing development plan was not implemented, so that the user continues the farming in the area knowing that the using the land is illegal after 1996.

Figure 8.10 Usage Condition

- The land was re-transferred to YCDC from Yangon Regional Government on 21 October 2013 and the user knows this land transfer.
- The user said that he has the documents to show the continuous use of the land after 1996 but the documents are not submitted to YCDC.
- The total area for reservoir is 4.35 acre.
- The user cultivates the rice, the amount is 33,456 kg (160 basket) / year and the income is 640, 000 Kyat / year.

- The time of harvest is November.

The area belongs to Government so that land acquisition is not required. The user uses the area for farming knowing that the area belongs to Government. As the rice is annual plant and there are plenty time till the construction, the construction can be started after the cropping. YCDC agreed to wait after the cropping so that the compensation of lost assets is not required. However, the construction will provide the negative impact on user's life so that YCDC considered providing compassionate grant to users. For those, YCDC interviewed and consulted closely with the user and the user understood the necessity of construction of the facilities and agreed to stop using the land. Base on the consultation, YCDC requested Yangon Regional Government for the appropriate compassionate grant amount for the user in this area and the Yangon Regional Government suggested the amount per acre by the letter dated 4 February 2014. In the same letter, the group formation for paying compassionate grant consisting of YCDC (DEWS, Town Planning and Land Management Dept.), District, Township, and Ward/Village Land Management Committee, Ministry of Housing Department and Yangon Regional Land Department was directed. YCDC took the same procedures with reservoir of Zone 7 and signed the contract with user on 13 February 2014.

4) River crossing point of Thilawa transmission pipe

The transmission pipe to Thilawa needs to cross Bago River and the bridge No. (2) Yangon-Thanlyin as the crossing point was selected where the crossing distance is the minimum. The area of Yangon side belongs to MOC and Thanlyin side belongs to MOAI. The location of Yangon City side is used to store the materials and dry the earth and sand by the permission from the government. The pipe will be installed under the river, the shaft will be constructed during construction and the maintenance hatch will be used for operation. The land use may not be disturbed after construction.

Source: JICA Study Team

Figure 8.11 Proposed Area of River Crossing for Thilawa Transmission Pipe (Temporal Use)

5) Installation of transmission / distribution pipes

The transmission pipe will be installed under the road and the land acquisition is not required.

(2) Existing social Infrastructures and Services

The zone 7 and 8 are located in the suburb area of Yangon City and the traffic volume is not heavy. The impact can be mitigated to select the construction time when the traffic volume is less. The numbers of accident by township are shown in the table below and the number of the accidents was less compared with the city center.

Table 8.5 Number of Accidents by Township

Township	No. of Accidents			Population (2011)	Area (sq. mile)	Per 10,000 pop	Per sq. mile
	Death	Injured	Total				
South Dagon	13	51	64	370,403	30.55	1.73	2.1
North Dagon	6	23	29	221,299	23.27	1.31	1.2
East Dagon	11	54	65	145,505	35.15	4.47	1.8
Dagon Seikkan	8	42	50	120,161	32.97	4.16	1.5

Source: 2012 JICA-HIS

(3) The poor, indigenous & ethnic people, gender and children's right

There are eight major races in Myanmar. The result of household interview survey shows that more than 90 % is Myanmar. Within the four townships there is no special area and all the ethnic people are living together.

Table 8.6 Race Distribution in Yangon

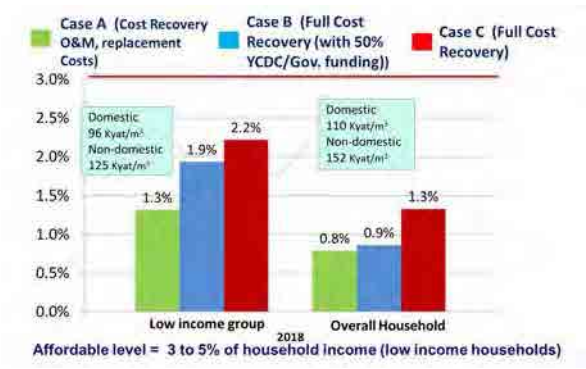
Township	Kachin	Kayar	Karin	Chin	Myanmar	Mon	Rakhine	Shan	Others
North Dagon	0.5%	0.3%	3.0%	0.3%	90.0%	1.1%	1.6%	0.3%	3.0%
South Dagon	0.2%	-	1.2%	0.3%	91.6%	0.7%	1.9%	-	4.2%
East Dagon	0.4%	-	2.2%	-	90.3%	0.9%	2.2%	0.9%	3.1%
Dagon Seikkan	-	-	1.4%	-	95.9%	0.5%	0.5%	0.0%	1.8%
Yangon	*0.2%*	*0.1%*	*2.1%*	*0.2%*	*88.1%*	*0.7%*	*1.7%*	*0.4%*	*6.5%*

Source: 2012 JICA-HIS

As shown in Appendix F.2.3, the income distribution of Zone 7 and 8 are lower than the average. The definition of poor by UNDP sets as people having income below three dollar per day (75,000 Kyat/month), and accordingly 5 % to 12 % are categorized as poor in the four townships.

It is said that the affordable level of water payment is assumed 3-5 % of household income of low income group. By the financial analysis, even in case of the full cost recovery, the water payment will be 2.2 % of the monthly income of low income group. So it can be concluded that if the water tariff will be increased, it is within the affordable level of low income group so that the impact may not be expected.

As a suggestion to YCDC, the pro-poor structure should be considered for future revision of water tariff. JICA Study Team recommends adopting the increasing-block tariff rates (progressive). This structure is designed such that even the poor can have access to at least a minimum quantity of safe water at a subsidized price.



Source: JICA Study Team

Figure 8.12 Financial Analysis Results of Water Payment Ratio in Future

(4) Cultural Heritage

In Yangon City, 189 heritage buildings, which were constructed before 1950, were listed up for protection by YCDC. There is no heritage building in the zone 7 and 8. Thus, no impact is expected in this respect.

(5) Water Use

The Lagunbyin Dam which will be used as water supply source was constructed for irrigation purpose by MOAI and the full tank capacity is 148,800 acre feet (40,000 MGD, 1.83 million m^3). The planned irrigation area is 8,800 acre (3,560 ha) but at present the water is used for 4,000 acre (1,620 ha) of agriculture field. As the intake is planned from the irrigation canal, the permission of MOAI should be necessary. The permission to intake 40 MGD of water was already given to YCDC so that the impact on irrigation is not expected.

(6) Hazards (Risk) infectious diseases

The HIV/AIDS is becoming serious problem recently in Myanmar. According to the UNAIDS, the disease rate of HIV among adult is 1.3 % in 2005. The infection is spread among the drug-addicted people and sex workers. The rate in Yangon Region is 0.25 % in 2010, 0.15 % in 2011 and it shows the decreasing trend comparing 0.55 % in 2005. The table below shows the number of the cases and deaths who received the ART (antiretroviral therapy) treatment.

Table 8.7 Number of Patients Who Received ART Treatment

		2013 January						2013 February						2013 March					
		AIDS Case (on ART, alive)			AIDS Death (on ART)			AIDS Case (on ART, alive)			AIDS Death (on ART)			AIDS Case (on ART, alive)			AIDS Death (on ART)		
		M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
1	Specialist Hospital by NAP	2,146	1,627	3,773	14	3	17	2,143	1,651	3,794	6	1	7	2,166	1,675	3,841	5	4	9
2	Specialist Hospital by UNION-NAP	807	633	1,440	5	5	10	841	609	1,450	4	3	7	877	645	1,522	10	6	16
3	Specialist Hospital by NAP	10	10	20	0	0	0	10	10	20	0	0	0	10	10	20	0	0	0

		2013 January						2013 February						2013 March					
		AIDS Case (on ART, alive)			AIDS Death (on ART)			AIDS Case (on ART, alive)			AIDS Death (on ART)			AIDS Case (on ART, alive)			AIDS Death (on ART)		
		M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
4	Specialist Hospital by NAP	16	10	26	1	0	1	15	12	27	0	0	0	17	14	31	0	0	0
5	AMI	372	323	695				372	326	698				376	327	703			
6	Alliance	432	375	807				437	376	813				485	401	886			
7	MSF (Holland)/AZG	8,040	5,893	13,933				8,040	5,893	13,933				8,040	5,893	13,933			
8	MSF (Swiss)	147	102	249				154	110	264				161	111	272			
9	PSI	79	27	106				87	29	116				88	29	117	0	1	1
	Total	12,049	9,000	21,049	20	8	28	12,099	9,016	21,115	10	4	14	12,220	9,105	21,325	15	11	26

M: male, F: Female, T: Total
Source: Yangon Regional Health Department, Ministry of Health

The situation of other infectious diseases is shown in the table below. The data is for Yangon Region.

Table 8.8 Number of Case and Death of the 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
Dysentery	8,507	0	9,489	-	6,135	0	6,361	0	4,436	0
Typhoid & Para Typhoid	103	1	71	1	55	0	98	0	47	0
Meningitis/ Encephalitis	32	5	24	2	1	4	9	4	10	2
Viral Hepatitis	188	6	251	1	14	4	271	3	205	2
Malaria	5,155	36	5,741	26	4,605	27	4,374	16	2,226	3

Source: Yangon Regional Health Department, Ministry of Health

The regulations related to working condition are not yet established in Myanmar. To prevent the infectious diseases among the construction workers, the contractor should implement the awareness training to them.

(7) Accident

The traffic accident situation is described in (2) Existing social infrastructures and services.

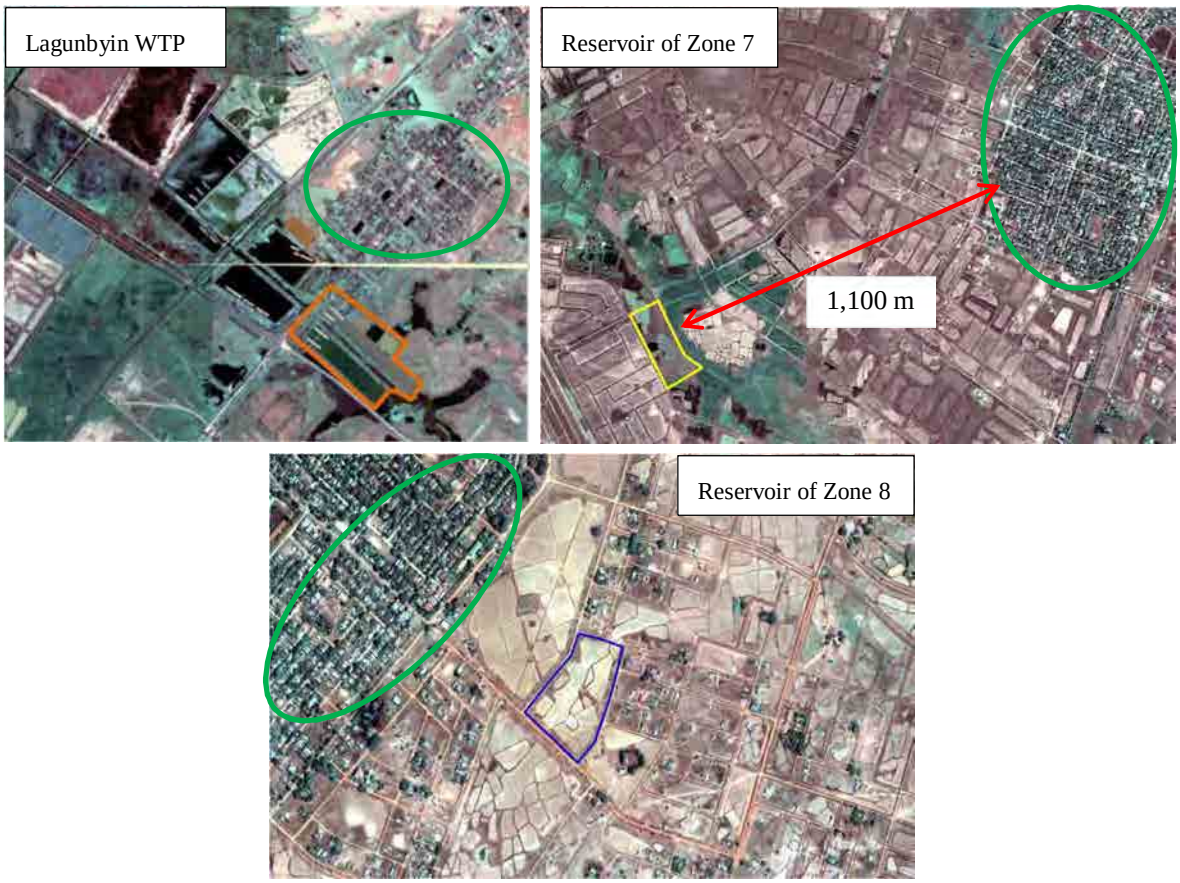
The contractor is responsible for the prevention of the accidents and the awareness and education to the construction workers should be implemented. The safety measures for the workers should be prepared and implemented by the contractor. For the preparation, the standards for ILO shall be applied.

(8) Landscape

There are no special landscapes such as tourist spot and heritage buildings. The landscape will be temporally worsening due to the dig up of the road, storage of excavated soil and construction

materials. To mitigate, the fence to cover the construction site should be considered. The excavated solid should be removed quickly from the site.

During operation, the landscape for the residents might worsen due to the WTP and reservoirs. The road (No. 2 Main Road) is passing at the north of the Lagunbyin WTP and along the road the residential area is developed. The highest point of WTP is around 3-4 m and the oppressive feeling might develop among nearby residents. The reservoir of zone 7 will be located 1,100 m away from the residential area so that any significant impact on residents is not expected. The residential areas are located in the east side of the service reservoir of zone 8, and the height of the reservoir might provide an oppressive feeling to the residents. The design of WTP and reservoir of zone 8 should be of lower height to minimize the oppressive feeling. If the height cannot be low, the mitigation measures such as plantation of tree should be considered.



Source: JICA Study Team

Figure 8.13 Surrounding Area of WTP and Service Reservoirs

(9) Air pollution

YCDC is not monitoring the air quality regularly. The existing data of air quality is the results of the measurements of April 2007 and January 2008 by NCEA (see Appendix F.2.6). 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.

To mitigate the impact during construction, the measures such as proper maintenance of construction vehicles, machinery and equipment, idling off, installation of muffler should be taken not to exceed the WHO standards.

(10) Soil Contamination

The regulations related to EIA are still developing in Myanmar so that the EIA reports of similar project are not found. Hence, the EIA reports of other countries were examined.

A silt fence and/or staked hay bales can be installed at the limit of work before construction begins to prevent sediment and debris being transported to down gradient areas. The silt fence/hay bale barrier should be inspected weekly and after all larger storm events, and repaired if needed.

(11) Waste

The excavated soil will be generated and need to be disposed properly. The regulations about solid waste management are not yet established so that the excavated soil and construction waste is disposed at the municipal waste dumping site. Yangon City has two dumping sites (see Appendix F.2.8) and the excavated soil will be disposed of at these landfill sites. The waste generated from the dredging of the bottom sediment will be disposed at the existing waste disposal site.

The sludge will be generated from WWTP. The average daily amount of wastewater will be 20 ton/day. Till the regulation of sludge disposal is developed, the waste will be disposed at the waste treatment site. The dried sludge can be utilized as fertilizer for the agriculture as the heavy metal may not be included in the sludge.

(12) Noise and Vibration

The standards of noise and vibration are not fixed yet in Myanmar. The measurement of the noise and vibration has not been monitored. JICA Urban Plan Study 2012 measured the noise at two locations and it shows the equivalent noise level for one hour was 50 dB(A), the max varied from 47.7 dB(A) to 96.8 dB(A). The route of trunk main has a lot of traffic. The installation of trunk main is done by pipe-jacking method so that the generation of noise is limited to the construction of the shaft. As there are no standards in Myanmar, the standards of IFC are used to regulate the noise generation. Temporary noise pollution due to construction works should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers.

Table 8.9 Noise Level (One Hour LAeq (dBA))

Receptor	Daytime (7:00 – 22:00)	Night time: (22:00 – 7:00)
Residential / Institutional / Educational	55	45
Industrial / commercial	70	70

Source: FC General Health, and Safety (EHS) Guidelines, April 2007

(13) Ground Subsidence

YCDC has started the fundamental work to install the piling. By the review of the design about the piling, enough strength can be secured in the present plan and the possibility of ground subsidence may not occur.

8.3.4 Environmental Evaluation, Mitigation Measures and Cost

Table 8.10 Environmental Evaluation, Mitigation Measures and Cost

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
Social Environment	Involuntary resettlement and land acquisition	C-	D	D	D	The right to use the land of Lagunbyin WTP and two reservoirs of zone 7 and 8 belong to the government (YCDC and Yangon Regional Government) so that land acquisition is not required. The houses are located near the area of reservoirs but no disruption is expected on the houses.	-	-	-
	Local economies, such as employment, livelihood, etc.	B+/ C-	D	B+ B-	D	The increase of employment by the construction can be expected. The land for reservoir of zone 7 and 8 are used for agriculture and the impact on livelihood of user might be expected.	The land belongs to the government and land acquisition is not required, but construction of the facilities will provide the negative impact on users' life so that the compassionate grant shall be required. YCDC organized the interview and the users did not opposed about the construction. Yangon Regional Government suggested the compassionate grant amount per acre and based on this, YCDC made the agreement with users and paid the compassionate grant.	YCDC Yangon Regional Government	Paid
	Land use and utilization of local resources	C-	D	B-	D	The proposed reservoir site for zone 7 and 8 are used for agriculture and impact on land use is expected.	Ditto	Ditto	Ditto
	Existing social infrastructures and services	B-	D	B-	D	By construction of transmission, distribution main and branch, traffic disturbance due to the road closing and detour, the access to existing infrastructure may be disturbed.	The construction schedule should be prepared considering the traffic volume to minimize the impacts on traffic. The traffic authorities should be notified of the planned works in a timely manner so that alternative traffic routes can be formed and the public alerted. The rules of construction work and transportation of the construction materials should be established and the compliance by the driver and workers should be controlled by the contractor. Traffic accidents can be avoided by collaborating with the traffic police and posting warning signs and directions to alternative routes. The office which accepts the complaints and demand from the citizens should be established.	Contractor YCDC Traffic police	Contractor

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
	The poor, indigenous & ethnic people, gender and children's right	C-	C-	D	D	The poor, indigenous & ethnic people will not be affected by the land acquisition as land acquisition is not required. The increase of the water bill might be expected. According to the financial analysis, the water payment will be maximum 2.2 % of the monthly income for low income group (see chapter 7.2.6) and it is concluded that the water charge is affordable for low income group. The progressive water tariff system is recommended to YCDC for future tariff revision.	-	-	-
	Cultural heritage	C-	D	D	D	No heritage buildings exist in the area of zone 7 and 8.	-	-	-
	Water usage or water rights and rights of common	C-	B+	D	B+	The permission of water intake was given by MOAI, and the capacity of the dam is enough for the irrigation.	-	-	-
	Hazards (Risk) infectious diseases	B-	D	B-	D	The infectious diseases may increase by the influx of construction worker.	The educational plan to reduce the risk of infectious diseases by Influx of the construction workers should be prepared and implemented by the contractor.	Contractor	Contractor
	Accidents	B-	B-	B-	B-	The increase of traffic may lead to the increase of the accidents during construction. By the operation of chlorination facility, the impacts such as accident, air pollution and odor by the improper maintenance can be expected.	The measures to protect the citizens are described in the item "Existing social infrastructures and services". The safety considerations to the construction workers should be prepared by the contractor which should meet the requirement of ILO standards to secure the safety of working conditions. The safety training such as wearing working clothes and work shoes, use of temporary toilet, traffic safety and public health should be provided by the contractor. As for the mitigation measures, the following considerations should be implemented in the design and during operation.	Contractor YCDC Traffic police YCDC	Contractor Included in O&M cost

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
							− To generate the solution at the site is risky so that the solution should be purchased. − The solution should not be stored at the site. The solution should be supplied before the effective concentration decrease (every ten days) − FRP tank which is strong against the acid should be used. − The chemical should be applied to the FRP tank. − The tank should be installed on the concrete and the preventive bank should be constructed not to flow outside when the solution is spilled out. − The spilled solution should be washed out by the water − The workers should wear the safety equipment (mask, latex gloves, gum boots, glasses etc.) − Neutralization should be necessary if the solution mixes with the acid.		
	Landscape	B-	C-	B-	B-	The landscape gets worse due to the dig up of the road and storage of excavated soil during construction. The Lagunbyin WTP and service reservoir of zone 8 might affect the landscape of the residences nearby.	The landscape will be worsening due to the dig up of the road, storage of excavated soil and construction materials. To mitigate, the fence to cover the construction site should be considered. The excavated solid should be removed quickly from the site. The design of WTP and reservoir of zone 8 should be of lower height to minimize the oppressive feeling. If the height cannot be low, the mitigation measures such as plantation of tree should be considered.	Detail design consultant, Contractor YCDC	Contractor
Natural Environment	Air pollution	B-	D	B-	D	The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary.	Construction vehicles, machinery and equipment should be in good working condition and well maintained. Dust emissions from piles of soil or any other material during earthwork, excavation and transportation should be controlled by wetting surfaces, using temporary wind breaks and covering truck loads. The office which accepts the complaints and demand from the citizens should be established.	Contractor YCDC	Contractor
Pol luti	Soil pollution	B-	D	B-	D	The compaction of soil due to vehicle movement, and ground contamination from	A silt fence and/or staked hay bales can be installed at the limit of work before construction begins to prevent sediment and	Contractor YCDC	Contractor

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
						the spillage of materials such as vehicle fuel, chemicals might be expected.	debris being transported to down gradient areas. The silt fence/hay bale barrier should be inspected weekly and after all larger storm events, and repaired if needed.		
	Waste	B-	B-	B-	B-	The spoil will be generated during installation of pipelines and construction of WTP. The sludge will be generated from WTP.	The excavated soil should be disposed of at the waste dumping site and the discussion with DPCC is necessary. The sludge should be re-used as much as possible and the remains should be disposed at the waste dumping site of YCDC. The plan of incinerator construction is in progress, the sludge can be treated at the incinerator in future.	Contractor YCDC (DEWS, DPCC)	Disposal cost of sludge is included in the cost estimation.
	Noise and vibrations	B-	C-	B-	B-	Construction machines will cause noise and vibration during construction. During operation, the noise and vibration can be expected from the pumping stations of the reservoir.	The standards for noise and vibration are not yet established in Myanmar. The standards of IFC (70 dB) shall be applied till the standards will be established. The noise level should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers to keep the ELV set by the regulations. The selection of construction machinery will be examined during detailed design. Before the construction of distribution pipeline, the notice of the construction schedule should be issued to the houses and buildings along the route to request the cooperation and understanding. The low noise and vibration equipment for the reservoir of zone 8 which is closely located to the residential area should be considered at the detail design stage.	Contractor YCDC	Contractor
	Ground subsidence	C-	C-	D	D	The proposed area for WTP was used as the fish pond and in such area the ground subsidence may be expected. However, the preventive measures of piling are under construction so that no ground subsidence occurs.	-	-	-

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.
Source: JICA Study Team

8.3.5 Monitoring Plan

The monitoring is necessary during construction and operation. The monitoring item, location, frequency, responsible organization and budget are summarized in the table below. The monitoring result should be informed to YCDC and JICA. The monitoring form is attached in the Appendix F.4.

Table 8.11 Monitoring Plan

Item	Monitoring location	Monitoring item	Frequency	Responsible organization	Budget*
[Construction]					
Noise	Boundary of the WTP Route of distribution main	Noise level (max)	Every day (peak time)	Contractor	- (contractor should arrange)
Air quality	Boundary of the WTP Route of distribution main	NOx,SOx,PM10	Once / month (peak time)	Contractor	- (contractor should arrange)
Complaints and demand from citizens		Number and contents of complaints/ demand	As needed during construction period.	Contractor YCDC	-
[Operation]					
Water quality	Raw water	Turbidity	Once/ month	YCDC (DEWS)	Included in the O&M cost
	Treated water	BOD, COD, SS, pH, turbidity, color, odor, residual chlorine, total coliforms, fecal coliforms	Once/ month	YCDC (DEWS)	Included in the O&M cost
	Water at the end of distribution	Residual chlorine	Once/ month	YCDC (DEWS)	Included in the O&M cost
Amount of water distribution	Flow meters at Service reservoirs of zone 7 & 8	Operating record of amount of water supply	Once/ month	Operator of the WTP of YCDC (DEWS)	-*

*: personal expenses are not included.
Source: JICA Study Team

8.4 Modernization of Water Supply Zone 1

8.4.1 Analysis of Alternative (With/Without)

The objectives of this component are to reduce the NRW and interrupted water supply and enable water supply for 24 hours continuously. By the modernization of water supply zone 1, the NRW ratio can be decreased from 50 % to 10 % and the DMA (District Metering Area) will be developed for sustainable water supply. By this component, the water supply ratio will be increased from 71.3 % in 2011 to 86.3 % in 2025 and 86.8 % in 2040. The beneficiaries will be increased from 0.62 million in 2011 to 0.78 million in 2025 and 0.93 million in 2040. The 24 hour continuous water supply and

increase of water use can lead the improvement of quality of life for citizens. The reduction of NRW will improve the financial situation of YCDC.

By this component, two reservoirs will be necessary but the existing two reservoirs will be rehabilitated and reconstructed, and the block is decided by the technical point (high and low area, boundary of township and ward, etc.), there are no alternatives for this component.

8.4.2 Scoping and TOR for Environmental and Social Survey

The scoping to identify the important environmental and social items and decide the method of survey was implemented. "Scoping" means choosing alternatives for analysis, a range of significant and potentially significant impacts, and study methods. The results of scoping and the study method of the items identified as A to C are shown in the table below

Table 8.12 Scoping and TOR for Environmental and Social Survey

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
Involuntary resettlement and land acquisition	D	D	Neither land acquisition nor involuntary resettlement is required as the reservoirs are rehabilitation and reconstruction of existing two reservoirs.	-	-
Local economies, such as employment, livelihood, etc.	B+	D	The increase of employment by the construction can be expected.	-	-
Land use and utilization of local resources	D	D	No impact is expected as land acquisition is not required.	-	-
Social institutions	D	D	The impact is not expected. To enhance the public involvement and information disclosure and obtain the cooperation and understanding, the stakeholder meeting was implemented.	-	-
Existing social infrastructures and services	B-	D	By construction of transmission, distribution main and branch, traffic disturbance due to the road closing and detour, the access to existing infrastructure may be disturbed. No impact is expected during operation.	• Situation of infrastructure service around project site.	• Hearing to related organization • Site survey
The poor, indigenous & ethnic people, gender and children's right	D	C-	The increase of water bill by meter installation might provide the impacts to the poor. No indigenous and ethnic people exist in and around the project site. No impact is expected on gender and children's right.	• Situation of the poor	• Result of interview survey
Misdistribution of benefits and damages	D	D	No impact is expected.	-	-
Cultural heritage	C-	D	The heritage building might be located	• Location of	• Hearing survey of

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
			in zone 1.	cultural heritage in project area	related organizations • Site survey
Local conflicts of interest	D	D	The impact is not expected.	-	-
Water usage or water rights and rights of common	D	B+	The increase of water supply amount will provide positive benefits on water use of the citizens.	-	-
Hazards (Risk) infectious diseases	B-	D	The infectious diseases may increase by the influx of construction worker.	• Data of infectious diseases	• Hearing from related organization
Accidents	B-	D	The increase of traffic may lead to the increase of the accidents during construction.	• Traffic situation of the route	• Site survey
Topography and geographical features	D	D	No impact is expected as the scale of the project is not large.	-	-
Soil erosion	D	D	No impact is expected.	-	-
Groundwater	D	D	No groundwater intake is planned.	-	-
Hydrological situation	D	D	No discharge to the rivers is planned.	-	-
Coastal zone	D	D	No impact is expected.	-	-
Protected area	D	D	No protected area in the project site.	-	-
Flora, fauna and biodiversity	D	D	No impact is expected.	-	-
Meteorology	D	D	No protected species exist in and around the project site.	-	-
Landscape	B-	D	The landscape gets worse due to the dig up of the road and storage of excavated soil during construction. There is no special landscape in and around the project site. The service reservoirs might affect the landscape of the residences nearby.	• Proposed site situation	• Site survey
Air pollution	B-	D	The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary.	• Air quality standards • Air quality of the site	• Hearing from the related organization
Water pollution	D	D	No water pollution is expected.	-	-
Soil pollution	B-	D	The compaction of soil due to vehicle movement, and ground contamination from the spillage of materials such as vehicle fuel, chemicals might be expected.	• Preventive measures	• Collection of the related project information
Waste	B-	D	The spoil will be generated during installation of pipelines and rehabilitation of reservoirs	• Waste management regulations • Disposal method of construction waste • Situation of waste disposal sites	• Hearing survey of related organizations • Site survey
Noise and vibrations	B-	D	Construction machines will cause noise and vibration during construction. No impact is expected during operation.	• Noise standards	• Hearing from the related organization

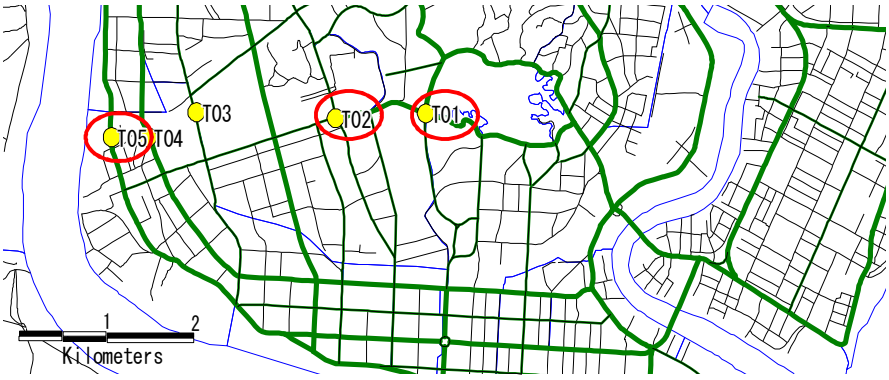
Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
Ground subsidence	D	D	No impact is expected.	-	-
Offensive odors	D	D	No odor is expected.	-	-
Bottom sediment	D	D	No impact is expected.	-	-
Global warming	D	D	No impact is expected.	-	-

P: Planning, C: Construction, O: Operation
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.
Source: JICA Study Team

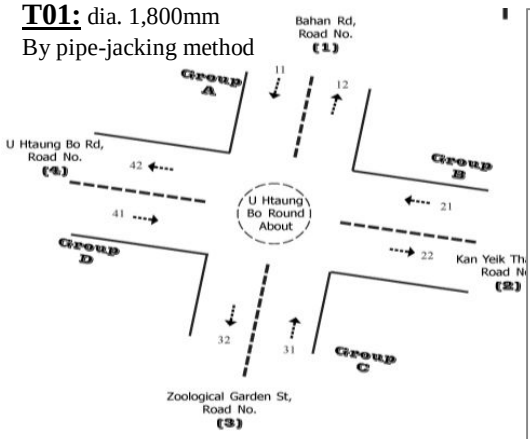
8.4.3 Results of the Environmental and Social Surveys

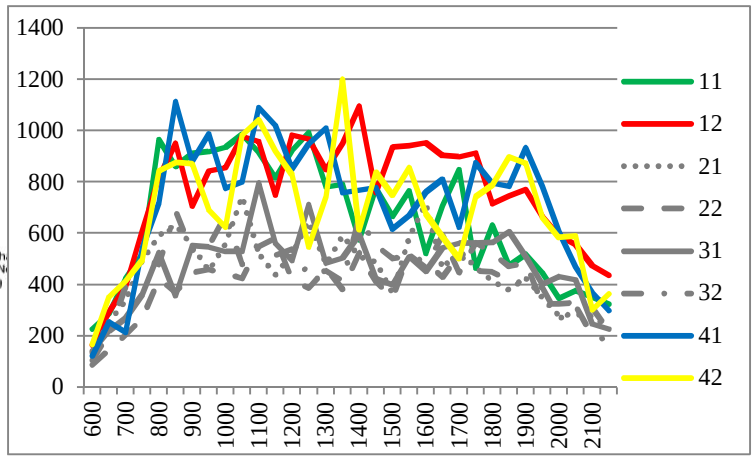
(1) Existing social infrastructures and services

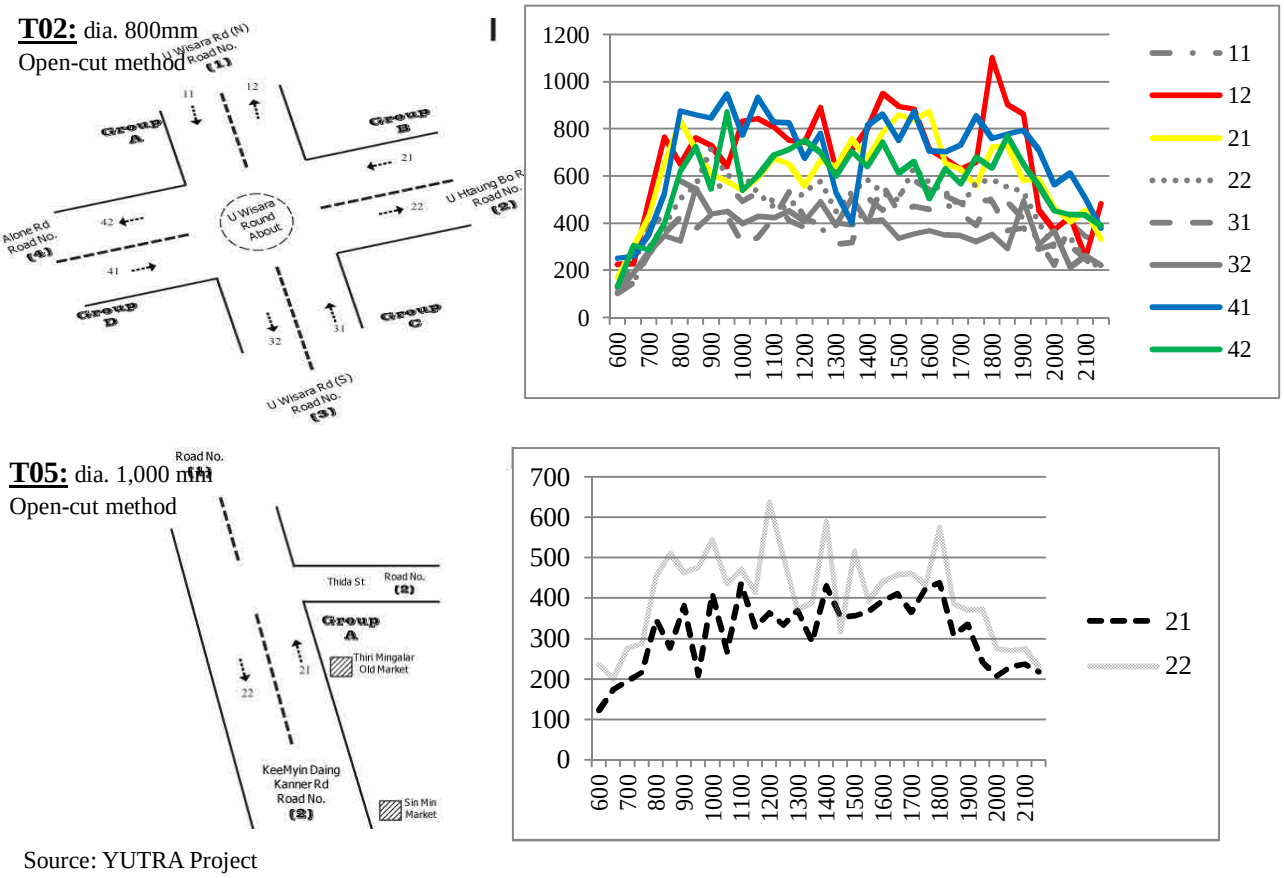
The main roads along which the distribution main with diameter 1,000 mm will be installed are Maha Bandura (east-west direction), Sule / Zoological garden / Bahan / Kabayee Pagoda (north-south direction), and Bargayar / Shwegondaing / Tha Mein Ba Yan / Upper Pazundaung (east-west direction). The flyover is under construction along the Bahan and Kabayee Pagoda road and the two lanes out of three on both sides are closed and the traffic jam is serious problem now. The traffic volumes which were identified by the survey of YUTRA Project are shown in the figure below.



T01: dia. 1,800mm
By pipe-jacking method







Source: YUTRA Project

Figure 8.14 Volume of the Traffic

The distribution main with diameter 1,800 mm will be installed at the junction of T01 where the traffic volume is heavy. As stated the traffic jam due to the construction of flyover is observed, the construction by open-cut method seems to be difficult for such a large diameter pipeline. Thus the pipe-jacking method is adopted for five km route of diameter 1,800 mm pipeline. For other routes, the open-cut method will be adopted but the impact can be mitigated through implementation of construction during the time of less traffic volume.

The table below shows the number of accidents in township in 2011. The zone 1 is dense area and the number of accident is high compared with other townships. Especially in CBD area, the number of accident per square mile is quite high.

Table 8.13 Number of Accident in Township in 2011

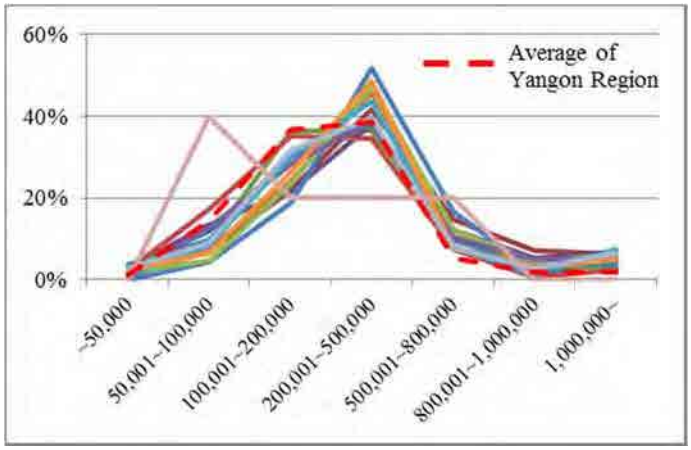
Township	No. of Accidents			Population (2011)	Area (sq. mile)	Per 10,000 pop	Per sq. mile
	Death	Injured	Total				
Latha	0	12	12	34,125	0.31	3.52	38.7
Lanmadaw	6	21	27	43,137	0.54	6.26	50.0
Pabedan	1	9	10	37,551	0.28	2.66	35.7
Kyauktada	0	21	21	34,797	0.28	6.04	75.0
Botahtaung	2	47	49	49,134	0.96	9.97	51.0
Pazundaung	2	8	10	53,648	0.39	1.86	25.6
Ahlone	1	20	21	65,510	1.04	3.21	20.2
Kyeemyindaing	5	25	30	115,841	4.81	2.59	6.2
Sanchaung	2	47	49	105,208	0.96	4.66	51.0

Township	No. of Accidents			Population (2011)	Area (sq. mile)	Per 10,000 pop	Per sq. mile
	Death	Injured	Total				
Dagon	1	41	42	24,492	1.96	17.15	21.4
Bahan	11	106	117	100,695	3.41	11.62	34.3
Tarmwe	2	40	42	191,114	1.71	2.20	24.6
Mingalar Taung Nyunt	2	37	39	155,767	1.96	2.50	19.9
Seikkan	2	0	2	2,241	6.41	8.92	0.3

Source: JICA Study Team

(2) The poor, indigenous & ethnic people, gender and children's right

CBD and IUR areas included in distribution zone 1 are the center of the Yangon City and the income level is higher than the average. However, the poor is also included in this area. The water supply system was developed in the zone 1 in the old time so that the ratio of meter ownership is low and the payment for water uses is estimated through the flat system. The impact due to meter installation will be expected.



Source: JICA Study Team

Figure 8.15 Income Distribution of Zone 1

Table 8.14 Rate of Meter Ownership and Payment Mode of Zone 1

Township	Meter Ownership		Payment Mode	
	Yes	No	Flat Rate	Metered
Latha	63%	37%	44%	56%
Lanmadaw	46%	54%	61%	39%
Pabedan	38%	63%	69%	31%
Kyauktada	41%	59%	67%	33%
Botahtaung	68%	32%	36%	64%
Pazundaung	67%	33%	54%	46%
Ahlone	43%	57%	73%	27%
Kyee Myin Daing	57%	43%	54%	46%
Sanchaung	60%	40%	47%	53%
Dagon	67%	33%	56%	44%
Bahan	73%	27%	31%	69%
Tarmwe	75%	25%	42%	58%
Mingalar Taung Nyunt	55%	45%	45%	55%
Seikkan	0%	100%	100%	0%
Yangon	75%	25%	*37%*	*63%*

Source: 2012 JICA-HIS

As stated in the Section 8.3.3 (3), the future water cost can be affordable for the low income group so that the impact is not expected.

(3) Cultural Heritage

Within the fourteen townships of zone 1, 114 heritage buildings which are decided by YCDC are located. Building Department of YCDC manages the heritage buildings. The discussion with Building Department was held to discuss about the necessary measures when the pipe will be installed under the road along which the heritage building is situated. Any considerations for heritage building are not required and in the past no mitigation measures were taken. The meeting was also held with Yangon Heritage Trust, NGO works for protection of the heritage building and it is concluded that no mitigation measures are required during the construction of the pipeline.

(4) Hazards (Risk) infectious diseases

Same as 8.3.3 (6).

(5) Accident

The traffic accident situation is described in (1) Existing social infrastructures and services.

The contractor is responsible for the prevention of the accidents and the awareness and education to the construction workers should be implemented. The safety measures for the workers should be prepared and implemented by the contractor. For the preparation the standards of ILO shall be applied.

(6) Landscape

There are no special landscapes such as tourist spot and heritage buildings. The landscape will be temporarily worsening due to the dig up of the road, storage of excavated soil and construction materials. To mitigate, the fence to cover the construction site should be considered.

(7) Air Pollution

Same as Section 8.3.3 (9).

(8) Soil Contamination

Same as Section 8.3.3 (10).

(9) Waste

The excavated soil will be generated and need to be disposed properly. The regulations about solid waste management are not yet established so that the excavated soil and construction waste is

disposed at the municipal waste dumping site. Yangon City has two dumping sites (see Appendix F.2.8) and the excavated soil will be disposed of at these landfill sites. The waste generated from the dredging of the bottom sediment will be disposed at the existing waste disposal site.

(10) Noise and Vibration

Same as Section 8.3.3 (12).

8.4.4 Environmental Evaluation, Mitigation Measures and Cost

Table 8.15 Environmental Evaluation, Mitigation Measures and Cost

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost P/C
		P/C	O	P/C	O				
Social Environment	Existing social infrastructures and services	B-	D	B-	D	By construction of distribution main and branch, traffic disturbance due to the road closing and detour, the access to existing infrastructure may be disturbed.	The construction schedule should be prepared considering the traffic volume to minimize the impacts on traffic. The traffic authorities should be notified of the planned works in a timely manner so that alternative traffic routes can be formed and the public alerted. The rules of construction work and transportation of the construction materials should be established and the compliance by the driver and workers should be controlled by the contractor. Traffic accidents can be avoided by collaborating with the traffic police and posting warning signs and directions to alternative routes. The office which accepts the complaints and demand from the citizens should be established.	Contractor YCDC Traffic police	Contractor
	The poor, indigenous & ethnic people, gender and children's right	D	C-	D	D	The increase in the water bill might be expected. According to the financial analysis, the water payment will be maximum 2.2 % of the monthly income for low income group (see chapter 6) and it is concluded that the water charge is affordable for low income group. The progressive water tariff system is recommended to YCDC for future tariff revision.	-	-	-
	Cultural heritage	C-	D	D	D	There are heritage buildings in the zone 1. Based on the discussion with Building Department of YCDC and Yangon Heritage Trust, the mitigation measures are not required.	-	-	-
	Hazards (Risk)	B-	D	B-	D	The infectious diseases may increase by the influx of construction worker.	The educational plan to reduce the risk of infectious diseases by Influx of the construction workers should	Contractor	Contractor

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost P/C
		P/C	O	P/C	O				
	infectious diseases						be prepared and implemented by the contractor.		
	Accidents	B-	D	B-	D	The increase of traffic may lead to the increase of the accidents during construction.	The measures to protect the citizens are described in the item “Existing social infrastructures and services”. The safety considerations to the construction workers should be prepared by the contractor which should meet the requirement of ILO standards to secure the safety of working conditions. The safety training such as wearing working clothes and work shoes, use of temporary toilet, traffic safety and public health should be provided by the contractor.	Contractor YCDC Traffic police	Contractor
Natural Environment	Landscape	B-	D	B-	D	The landscape gets worse due to the dig up of the road and storage of excavated soil during construction. The existing facilities will be utilized so that no impact is expected during operation.	The landscape will be worsening due to the dig up of the road, storage of excavated soil and construction materials. To mitigate, the fence to cover the construction site should be considered. The excavated solid should be removed quickly from the site.	Contractor YCDC	Contractor
Pollution	Air pollution	B-	D	B-	D	The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary.	Construction vehicles, machinery and equipment should be in good working condition and well maintained. Dust emissions from piles of soil or any other material during earthwork, excavation and transportation should be controlled by wetting surfaces, using temporary wind breaks and covering truck loads.	Contractor YCDC	Contractor
	Soil pollution	B-	D	B-	D	The compaction of soil due to vehicle movement, and ground contamination from the spillage of materials such as vehicle fuel, chemicals might be expected.	A silt fence and/or staked hay bales can be installed at the boundary of work before construction begins to prevent sediment and debris being transported to down gradient areas. The silt fence/hay bale barrier should be inspected weekly and after all larger storm events, and repaired if needed.	Contractor YCDC	Contractor
	Waste	B-	D	B-	D	The spoil will be generated during installation of pipelines and rehabilitation /reconstruction of reservoirs.	The excavated soil should be disposed of at the waste dumping site and the discussion with DPCC is necessary.	Contractor YCDC (DEWS, DPCC)	Disposal cost of sludge is included

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost P/C
		P/C	O	P/C	O				
									in the cost estimation .
	Noise and vibrations	B-	D	B-	D	Construction machines will cause noise and vibration during construction.	The standards for noise and vibration are not yet established in Myanmar. The standards of IFC (70 dB) shall be applied till the standards will be established. The noise level should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers to keep the ELV set by the regulations. The selection of construction machinery will be examined during detailed design. Before the construction of distribution pipeline, the notice of the construction schedule should be issued to the houses and buildings along the route to request their cooperation and understanding.	Contractor YCDC	Contractor

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.
Source: JICA Study Team

8.4.5 Monitoring Plan

The monitoring is necessary during construction and operation. The monitoring item, location, frequency, responsible organization and budget are summarized in the table below. The monitoring result should be informed to YCDC and JICA. The monitoring form is attached in the Appendix F.4.

Table 8.16 Monitoring Plan

Item	Monitoring location	Monitoring item	Frequency	Responsible organization	Budget*
[Construction]					
Noise	Route of distribution main	Noise level (max)	Every day (peak time)	Contractor	- (contractor should arrange)
Air quality	Boundary of the reservoir construction site Route of distribution main	NOx,SOx,PM10	Once / month (peak time)	Contractor	- (contractor should arrange)
Complaints and demand from citizens		Number and contents of complaints/ demand	As needed during construction period.	Contractor YCDC	-
[Operation]					
Water quality	At the end of distribution	Residual chlorine	Once / month	YCDC (central control center of DEWS)	-*
Amount of water supply	Flow meters at Kokine and Central Service reservoirs	Water amount	Once / month	YCDC (central control center of DEWS)	-*

*: personal expenses are not included.
Source: JICA Study Team

8.5 Construction of Chlorination Facilities

8.5.1 Analysis of Alternatives (With/Without)

There is only one chlorination facility at the Yegu Pumping Stations. At Yegu, the equipment to measure the injection rate and residual chlorine is not installed and the capacity is not enough as the chlorination is done once a week or two weeks. According to the results of water quality survey of tap water, the coliform and faecal coliform groups were found at all the surveyed locations and the safe water cannot be distributed to the citizens. By the implementation of this component, the safe water can be provided to almost all the water supply area.

8.5.2 Scoping and TOR for Environmental and Social Survey

The scoping to identify the important environmental and social items and decide the method of survey

was implemented. "Scoping" means choosing alternatives for analysis, a range of significant and potentially significant impacts, and study methods. The results of scoping and the study method of the items identified as A to C are shown in the table below

Table 8.17 Scoping and TOR for Environmental and Social Survey

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
Involuntary resettlement and land acquisition	D	D	The chlorination facilities will be constructed at the existing facilities of WTP and pumping stations so that neither land acquisition nor involuntary resettlement is expected.	-	-
Local economies, such as employment, livelihood, etc.	D	D	No impact is expected.	-	-
Land use and utilization of local resources	D	D	No impact is expected as land acquisition is not required.	-	-
Social institutions	D	D	The impact is not expected. To enhance the public involvement and information disclosure and obtain the cooperation and understanding, the stakeholder meeting was implemented.	-	-
Existing social infrastructures and services	D	D	The construction is implemented in the area of the existing facility so that no impact is expected.	-	-
The poor, indigenous & ethnic people, gender and children's right	D	D	No impact is expected.	-	-
Misdistribution of benefits and damages	D	D	No impact is expected.	-	-
Cultural heritage	D	D	No impact is expected.	-	-
Local conflicts of interest	D	D	No impact is expected.	-	-
Water usage or water rights and rights of common	D	B+	The citizen can enjoy safe water.	-	-
Hazards (Risk) infectious diseases	D	D	The construction scale is small and influx of many construction workers is not expected.	-	-
Accidents	D	B-	The use of Sodium hypochlorite solution might lead to the accidents.	• Preventive measures	• Information collection of related project
Topography and geographical features	D	D	No impact is expected as the scale of the project is not large.	-	-
Soil erosion	D	D	No impact is expected.	-	-
Groundwater	D	D	No groundwater intake is planned.	-	-
Hydrological situation	D	D	No discharge to the rivers is planned.	-	-
Coastal zone	D	D	No impact is expected.	-	-
Protected area	D	D	No protected area in the project site.	-	-
Flora, fauna and biodiversity	D	D	No protected species exist in and around the project site.	-	-
Meteorology	D	D	No impact is expected as the scale of the project is not large.	-	-

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
Landscape	D	D	The facilities are located within the existing site so that no impact on landscape is expected.	-	-
Air pollution	D	B-	Gaseous chlorine might be emitted if the maintenance is not properly done.	• Preventive measures	• Information collection of related project
Water pollution	D	D	No impact is expected as no discharge to river.	-	-
Soil pollution	D	D	No impact is expected.	-	-
Waste	D	D	No waste generation is expected	-	-
Noise and vibrations	D	D	No noise and vibration is expected.	-	-
Ground subsidence	D	D	No impact is expected.	-	-
Offensive odors	D	B-	Gaseous chlorine might be emitted if the maintenance is not properly done.	• Preventive measures	• Information collection of related project
Bottom sediment	D	D	No impact is expected.	-	-
Global warming	D	D	No impact is expected.	-	-

P: Planning, C: Construction, O: Operation
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.
Source: JICA Study Team

8.5.3 Environmental Evaluation, Mitigation Measures and Cost

By the operation of chlorination facility, the impacts such as accident, air pollution and odor by the improper maintenance can be expected. The sodium hypochlorite gas is unstable and requires sensitive handling so that the sodium hypochlorite solution is adopted for the chlorination facilities. The solution is easy for handling but the effective concentration is rapidly decreased by the dissolution under the sun. The effective concentration will be decreased from 12 % to 10 % within twenty days and the high temperature speed up the dissolution. The sodium hypochlorite has the strong oxidation effect and erodes the metals and fibers.

As for the mitigation measures, the following considerations should be implemented in the design and during operation.

- To generate the solution at the site is risky so that the solution should be purchased.
- The solution should not be stored at the site. The solution should be supplied before the effective concentration decrease (every ten days)
- FRP tank which is strong against the acid should be used.
- The chemical should be applied to the FRP tank.
- The tank should be installed on the concrete and the preventive bank should be constructed not to flow outside when the solution is spilled out.
- The spilled solution should be washed out by the water
- The workers should wear the safety equipment (mask, latex gloves, gum boots, glasses etc.)
- Neutralization should be necessary if the solution mixes with the acid.

8.5.4 Monitoring Plan

The negative impacts during construction are not expected so that the monitoring is not necessary. However, the complaints and demand from the citizens can be expected. The monitoring during operation is the responsibility of DEWS of YCDC. The monitoring report will be delivered to YCDC and JICA. The monitoring form is annexed in the Appendix F.4.

Table 8.18 Monitoring Plan

Item	Monitoring location	Monitoring item	Frequency	Responsible organization	Budget*
[Construction]					
Complaints and demand from citizens		Number and contents of complaints/ demand	As needed during construction period.	Contractor YCDC	-
[Operation]					
Water quality	At the end of distribution	Residual chlorine	Once / month	YCDC (central control center of DEWS)	-*
Amount of water supply	Nyaunghnapin WTP , Hlawga No.1 PS ,and Yegu PS	Operating record of amount of water supply	Once / month	YCDC (central control center of DEWS)	-*

*: personal expenses are not included.
Source: JICA Study Team

8.6 Stakeholder Meeting

The public consultation seminar was organized on 17 July 2013. The objectives are as follows.

- To incorporate stakeholder opinions into decision-making processes regarding environmental and social considerations (basic principles of JICA Guidelines)
- To disclose the results of the project including facility planning, tariff setting, and environmental and social impacts
- To obtain the comments and opinions from stakeholders

The agenda of the public consultation seminar is as follows.

Date: 17 July (Wednesday), 2013
Time: 14:00 p.m. to 16:30 p.m.
Venue: Kandawgyi Palace Hotel

Time	Agenda
13:45 – 14:00	Registration
(1) Opening Session	
14:00- 14:10	Opening Speech (Secretary of YCDC) Opening Remarks (Senior Representative of JICA Myanmar Office)
14:10- 14:30	Photo session Coffee Break
(2) Presentation on the Priority Projects for Water Supply, Sewerage and Drainage System	
14:30- 14:50	Outline of the JICA Project Components of Priority Projects for Water Supply
14:50-15:00	Priority Project for Sewerage System and Improvement of Kandawgyi Lake
15:00- 15:20	Tariff Setting
15:20- 16:00	Results of Environmental and Social Impacts and mitigation measures
16:00- 16:30	Questions and Answers
(3) Closing Session	
16:30	Closing Remarks (YCDC)
	Announcement for closing seminar

More than 130 participants attended the meeting and are listed as follows. The project affected people from each townships of zone 1, 7 and 8 were invited.

- Yangon regional government: 2
- Professors and advisors: 3
- Donors: 7
- Representatives of townships: 47
- NGO: 6
- Media: 25
- YCDC: 34
- JICA Study Team: 12

There are a few questions and comments.

- The explanation about the tariff should be announced to the public by YCDC and discussions should be held in future.
- The tariff for sewerage system on public is a little bit early. It is better to start from hotels, restaurant, condominium, industrial zone, etc. as a test case.

The Minutes of Meeting is attached in Appendix F.5.

8.7 Measures for Climate Change

8.7.1 Climate Change and Myanmar

The impacts by climate change might affect the Myanmar, however the documents such as national report are not submitted to UNFCCC and the detail information is not available. The expected impacts on Myanmar are:

- Increase of rainfall during monsoon period (5 % of rainfall will increase by the presentation of conference of UNECF)
- Increase of temperature (0.5 degrees increase during June to November, 0.6 degrees during December to May by the presentation of conference of UNECF)
- Impacts to the coastal area by the rise of sea level and tidal waves
- Increase of water-borne diseases by rise of temperature and flood

8.7.2 Measures against Climate Change

(1) Development of water supply facility

The residents in the area of zone 7 and 8 mainly use the tube well as water source and some use the rain/creek/pond. By the Project the safe and clean water will be distributed to these area and this contributes to mitigate the water supply problem due to irregular rainfall by climate change.

(2) Contribution to the health problem by water-borne diseases

The water-borne diseases might be increased due to the increase of temperature by climate change, but the water supply system will contribute to decrease the risk of water-borne diseases.

(3) Water quality control by chlorination facility

The deterioration of water quality of water source might be expected due to the rainfall change and temperature increase, but the chlorination facility will contribute to sustain the water quality.

(4) Decrease of electricity consumption

The modernization of water distribution network in Zone 1 will decrease the water loss due to the leakage. The leakage reduction will lead the less consumption of electricity to produce the water and it will contribute to the measures against climate change.

CHAPTER 9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The following three priority projects have been selected in the Master Plan.

1. Development of Lagunbyin Water Supply System
2. Modernization of Water Supply System in Distribution Zone 1
3. Provision of Disinfection Facilities

The source of Lagunbyin water supply system is Lagunbyin reservoir. The raw water is taken from Ngamoeyeik Creek and conveyed to the proposed new water treatment plant (tentative name "Lagunbyin WTP"). A distribution reservoir and a pump station shall be constructed each in the distribution zone 7 (Dagon North and Dagon East) and the distribution zone 8 (Dagon South and Dagon Seikkan). The treated water in Lagunbyin WTP is transmitted to each distribution reservoir and pumped up to each zone from pumping station through existing and proposed new distribution network. The network is divided into 53 DMA (District Metered Area) and water supply flow and pressure will be monitored and controlled by SCADA (Supervisory Control and Data Acquisition).

Out of 40MGD of the water source, 10MGD is secured as the water source of Thilawa SEZ. The treated water is transmitted from Lagunbyin WTP to Thilawa SEZ by pump through pump station in the distribution zone 8.

The estimated service population and the coverage ratio in 2025 in these distribution zones are 586,000 and 40%, respectively. The water demand in these zones is approximately 31MGD in 2025 and total water demand including that of Thilawa SEZ is approximately 40MGD. The target leakage and non-revenue water ratios are 25% and 37%, respectively.

In modernization of water supply system in distribution zone 1, reconstruction of Central Reservoir (10MGD) and complete replacement of aged pipelines in distribution zone 1 are included. This zone shall be separated into high and low zones. The existing Kokine Reservoir and Central Reservoir shall be used for low and high zone, respectively, after reconstruction of Central Reservoir. Water is distributed from Kokine Reservoir by gravity and from Central Reservoir by pump. The network is divided into 35 DMA and water supply flow and pressure will be monitored and controlled by SCADA (Supervisory Control and Data Acquisition).

The estimated service population and the coverage ratio in 2025 in these distribution zones are 783,000 and 86%, respectively. The water demand in this zone is approximately 63MGD in 2025. The target leakage and non-revenue water ratios are 10% and 22%, respectively.

"Provision of the treated water with chlorination" is adopted by M/P to improve the quality of water supply. The target of this F/S is that chlorination facilities will be installed in the existing water supply system, and safe water will be supplied. The facilities shall be installed at the following three locations.

- Nyaunghnapin WTP
- Hlawga No. 1 Pump Station
- Yegu Pump Station

After installation of these facilities, most of the water supply area in the city will be covered by chlorinated water supply. The estimated service population by chlorinated water supply in 2025 in the target area except the distribution zone 1 and 2 will be approximately 3,178,000 and the service coverage will be 64%.

The outline of water supply facilities for the priority projects are shown in the table below.

Project component	No.	Facility	Capacity/Quantity
Development of Lagunbyin Water Supply System	1	Construction of Lagunbyin WTP	181,800 m^3/day- 40 MGD
	2	Installation of transmission mains	17.5 km
	3	Construction of water distribution facilities for Distribution Zones 7 and 8	
		3.1 Distribution reservoir (2 locations)	DZ7: 35,000 m^3 / 7.7 MG DZ8: 23,000 m^3 / 5 MG
		3.2 Distribution pump station (2 locations)	DZ 7: 4,880 m^3/hr DZ8: 4,082 m^3/hr
	4	Installation of transmission mains to Thilawa SEZ	
		4.1 Pipeline from DZ8 PS to Thilawa SEZ	29.5 km + River crossing 0.7km
		4.2 Pump Station in DZ8	1,750 m^3/hr
	5	Development of distribution network	
		5.1 Distribution mains	72 km
		5.2 Secondary mains	DZ7:: 111 km DZ8: 113 km
		5.3 Service pipe and water meters	
		5.4 DMAs	DZ7: 29 DMAs, DZ8:24 DMAs
		5.5 SCADA for transmission and distribution management	One set
Modernization of Water Supply System in Distribution Zone 1	6	Development of distribution network	
		6.1 Distribution mains	71 km
		6.2 Secondary mains	413 km
		6.3 Service pipe and water meters	
		6.4 DMAs	35 DMAs
		6.5 SCADA for transmission and distribution management	
	7	Reconstruction of Central Reservoir	45,000 m^3 / 10 MG

Project component	No.	Facility	Capacity/Quantity
	8	Construction of pump station for high zone in Central Reservoir	6,007 m^3/hr
Provision of Disinfection Facilities	9	Provision of 3 disinfection facilities	Nyaunghnapin WTP: 409,200 m^3/day (90MGD) Hlawga No.1 PS: 239,000 m^3/day (52.6MGD) Yegu PS: 187,000 m^3/day (41.1MGD)

The necessary areas for capacity development of Department of Engineering (Water and Sanitation) -DEWS in water supply sector in the short-term up to 2025 are identified and the highest priority areas which shall be implemented within 3 years are selected as shown below.

1. Business Management of Waterworks	・ Development of Business Management Basis for Waterworks ・ Enhancement of Capacity on Customer Management and Revenue Collection ・ Consideration of Revision of Water Tariff Structure
2. NRW Management	・ Establishment of NRW Management and Monitoring Unit ・ Development of Activity Basis for NRW Reduction ・ Establishment of a System for Training of Trainers (ToT) on NRW Management ・ Implementation of Leakage Reduction Activities in DMA model area(s)
3. Water Treatment and Water Quality Management	・ Enhancement of Water quality management section ・ Establishment of water quality monitoring system of YCDC ・ Collaborate with National Health Laboratory (NHL) ・ OJT of WTP operation

The direct construction costs of the priority projects are estimated below.

1. Development of Lagunbyin Water Supply System:
2. Modernization of Water Supply System in Distribution Zone 1:
3. Provision of Disinfection Facilities:

The economic internal rates of return (EIRR) are estimated at 3.3 % for Development of Lagunbyin Water Supply System and 6.1 % for Modernization of Water Supply System in Distribution Zone 1. EIRR for Provision of Disinfection Facilities cannot be calculated. It is recognized that the first two projects are economically feasible.

The financial internal rate of return (FIRR) is estimated as follows with the different cases.

Case	Conditions	FIRR
【Simulation A】:Full cost recovery	Annual increase rate of water tariff 6% / year	-10.0%
【Simulation B】:Full cost recovery	Annual increase rate of water tariff 3%/ year	-9.3%
【Simulation C】:Cost recovery	Annual increase rate of water tariff 3%/year Initial construction costs 50% by YCDC/Gov. funding source	-8.4%
【Simulation D】:Cost recovery	Annual increase rate of water tariff 3% /year O&M costs, replacement and rehabilitation costs	10.8%

The FIRR is higher than criteria of 3% as discount rate in cases of 【Simulation A】with 6% of annual tariff increase, and【Simulation C】with subsidizing 50% of the initial construction costs. Both cases are assumed to be financially feasible. Also these results are higher than the benchmark for human basic needs project as 5%. In this financial calculation, price escalation of 1.2% for foreign currency portion and 6.1% for local currency portion are considered. The 6% of annual tariff increase is almost equivalent to the level of the price escalation of local currency portion.

A study was made on affordability of household for water tariff if water tariff increases 3 % annually. The affordable level of household income for water is assumed in the range between 3-5% as a benchmark. As a result, all results show that increased tariff rates are below 3% of household income. Therefore it can be said that the level of tariff rates is within the affordable level in general. In the case of 3% annual increase of household income, the water spending level of the lower 20% of income group of household is not exceeds 3% line in 2040 and the increased tariff could be evaluated within the affordable level.

By implementation of the projects, the traffic disturbance, accidents, air pollution, waste, noise and vibration may be expected during the construction. These impacts will be for limited period and can be mitigated by the proposed mitigation measures. During the operation, the generation of the sludge, noise and vibration may be expected and these also can be mitigated. To ensure the implementation of mitigation measures, the monitoring plan has been proposed.

The direct effects by implementation of the priority projects are expected as follows.

1. The service population with treated safe water will be increased.
2. The water consumption per capita will be increased.
3. The quality of supplied water will be improved.
4. The duration of water supply will be increased.

The indirect effects are expected as follows.

1. Improvement in water supply conditions mentioned above shall contribute to reduction in occurrence of water related diseases such as cholera, typhoid and diarrhea, and skin & eye diseases and is expected to improve health conditions of the people, which contribute to reduction of medical expenditure of household.
2. The current cost for obtaining water will be reduced and the household expenditure on water will be reduced, which will indirectly contribute to improvement in the livelihood of the people.
3. Water use will be more convenient, i.e., whenever required, water will be supplied.
4. Water fetching time and efforts will be reduced and mitigated. As a result, working and education opportunity for them will be enhanced.

5. The improvement of the water supply service will contribute to improved living conditions of low income households along with water tariff strategy for low income household.
6. It will contribute to the stabilization of people's livelihood in the area and political stability.
7. Working opportunities will be created during construction and operation & maintenance of water supply facilities
8. The industry and business that are now affected by dirty water supply will be activated and contribute to the development of the country.
9. The prevention of expecting land subsidy and salinization of ground water is expected to be reduced by reduction of groundwater withdrawal.

9.2 Recommendations

The major problems of water supply conditions are low service coverage, low water pressure and short duration of water supply and undrinkable water supply. The major problems of water supply facilities are limited water production, aged facilities, and deficiency of disinfection in water supply system. The major problems of management of water works include high NRW ratio and inefficiency of business management basis for waterworks. To tackle these problems, the proposed priority projects for infrastructure development and capacity building shall be implemented as soon as possible as a first step.

For the long time, investment to infrastructure has been deferred and the service level of public water supply is at low level. Therefore, development of water supply facilities to improve water supply service requires input of a large amount of fund. To meet this requirement, the most favourable loan, soft loan of donor at low interest rate, shall be utilized to reduce financial burden of YCDC, or the country. In addition, the assistance to enhance the capacity of YCDC on water works management shall be obtained from the countries with high technology and management skills such as Japan for effective and quick transfer of technology and management skills.

To improve water supply service through development of infrastructure, it is inevitable to raise water tariff level and optimize its system. For this purpose, YCDC has to work with the public through public awareness activities and consider poor people in tariff setting.

In environmental impact evaluation, minor impacts are identified during construction and operation stages of the projects and mitigation measures have been prepared. The monitoring of mitigation measures shall be ensured.