CHAPTER 5

FACILITY PLANNING

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5.1 PLANNING POLICY

5.1.1 Development Policy

A development policy shall be set prior to water supply planning. Since the higher service level of the water supply system, the higher the required cost, the service level is governed practically by a financial capability of YCDC, an implementing agency. Its capability is greatly affected by the national economy. Though an overall economical situation is not favorable, planning goal was set after discussion with YCDC to meet the modern city standard; namely,

- Continuous water supply with reasonable quantity and quality to the existing supply area
- Provision of water to every people.
- Individual house connection.

Of course, the above goal cannot be met instantly and it might not be achieved even in the target year of 2020. However, the master plan was prepared to materialize these targets as far as possible taking account of practicality.

Towards the target year of 2020, service ratio will, for example, be gradually increased; 100% in the central areas and less percentage in the peripheral areas as already mentioned in the preceding chapters. With modest per capita consumption and service ratio scenario, and ambitious leakage reduction strategy, water demand was projected to increase about three times from 615,000 m^3/day to 1,912,000 m^3/day. This high increase projection results from the very low capital investment for the last decades despite YCDC's investment effort. In formulating the plan, therefore, full utilization of the existing system involving rehabilitation/renovation plan, if required, based on the evaluation of transmission/distribution pipe, clear water reservoir, etc. was considered as far as possible.

5.1.2 Groundwater Utilization

Currently, groundwater plays an important role in both of YCDC and none-YCDC water supply systems. There are two hundred and seventeen (217) existing wells and they can be classified as follows;

Wells in left bank of Hlaing River (Production Wells)	: 204 wells
Ditto (Hydrant)	: 3 wells
Wells in right bank of Hlaing River (Production Wells):	10 wells
Total	217 wells

Therefore, two hundred and fourteen wells (214) are supplying water to YCDC water supply system; and its share is large. However, it should be considered that the groundwater yield is in

the order of 200,000 m^3/day and will not increase even when the demand is almost 2,000,000 m^3/day in the year 2020. These wells' operations are not appropriate for Yangon central area. Also, direct injection from each well to the distribution pipes is not suitable from hygienically viewpoint. However, in the suburban Yangon area where the central reservoir water supply system does not serve, wells are still the main water source for such isolated water supply systems.

5.1.3 Surface Water Sources

In addition to the three existing reservoirs, Ngamoyeik reservoir system was constructed. When it was completed, available water source amount became almost double. However, demand in 2020 will exceed the increased supply amount. The only and last remaining nearby source is the Hlaing River. To obtain treatable raw water, however, construction of some 40 km transmission pipe inevitable. By adding the Hlaing river water, Yangon water source will almost meet the 2020 demand. From the past records (see Appendix A), however, there may be a shortage of supply capacity by 4,000,000 m^3/day for around 50 days in 3,650 days (10 years). During such a short period, some rationing will be inevitable.

After the Hlaing river development, an additional water source shall be secured. Though finding an additional source is a scope of beyond the 2020 target year, it can be said definitely that water should come from either nearby impounding reservoir constructed for irrigation water or diversion from the Ayeyarwaddy River. If the latter, which is possibly more feasible socially, is adopted, diverted water comes through the Hlaing River.

Table 5.1 Water Source Capacity for YCDC Water Supply System

	Current Water Source Capacity (m^3/day)	Proposed Water Source Capacity (m^3/day)
Existing System		
Gyobyu Reservoir System	93,200 (20.5 MGD)	118,200 (26 MGD)
Phugyi Reservoir System	227,300 (50 MGD)	245,400 (54 MGD)
Hlawga Reservoir System	75,000 (16.5 MGD)	75,000 (16.5 MGD)
Groundwater System	43,900	161,600
On-going System		
Ngamoeyeik Res. System	0	409,000 (90 MGD)
New System		
Hlaing River System	0	940,000
Total	439,400	1,949,200

5.1.4 Terminal Facility

Every water sources originates from the northern part of Yangon and most of water come to the Yegu pumping station from where water is sent to the Kokine service reservoir and other two

reservoirs. The system was constructed to meet the old Yangon city. The three reservoirs were strategically constructed at nearby and high elevated sites.

However, the time has already come for Yegu PS and the three reservoirs to stop their functions as a terminal. Their function will be converted to supply water for local area and downtown only. The controlling function should be shifted to the proposed "Terminal Reservoir". From hydraulic point of view, the terminal reservoir should be in the northern tip of Yangon so that water continues flow to the southward. At the same time, the existing facilities should be utilized as much as possible and utilize hydraulic advantages as much as possible too. Accordingly, the site "near the Hlawga reservoir" is recommendable as the future terminal point. All the water will reach here, then, water will be re-transmitted to the designated reservoirs. By this arrangement, water flow can be somehow controlled. Water supply, however, shall be also intentionally rationed when water source amount is in short.

5.1.5 Zoning System

Currently, the water supply system employs a gravity flow system. Water flows are governed simply by the hydraulic condition of the system including pumps, reservoirs and pipes. Therefore, service areas are clearly divided into areas where water is always available and areas where water is hardly available all the time. Of course, some artificial control is done to distribute water more equally by valve control with success. However, systems are neither modified to suit that requirement nor enlarged to meet the increasing population. Therefore, introduction of a controllable system shall be conducted in the future system. As described in Section 4.8, "Zoning System" was adopted as the optimum controllable system in terms of providing adequate pressure and quantity.

5.1.6 Water Treatment

The optimum water quality improvement countermeasure shall be prepared by water sources, namely (1) Reservoir, (2) River and (3) Groundwater. The followings are the proposed water quality improvement plan.

(1) Reservoir

1) Water Treatment

As aforementioned in Section 3.4.4, turbidity of raw water in the existing reservoirs are low (average turbidity = 3 NTU). Turbidity must be removed nevertheless but coagulated sedimentation is not applicable for such low turbidity. Flocculation is very slow in such low turbidity and sedimentation velocity is also low. It means that sedimentation effect is inferior and longer sedimentation time or installation of auxiliary sedimentation facility such as tube/plate settler is needed.

Plankton mainly causes turbidity in reservoir water and coagulation process for such water needs high operation technology and monitoring system. Considering the present technical

level of YCDC, coagulation process should not be employed for reservoir water treatment. Therefore, the following two treatment processes were proposed;

- Slow Sand Filter
- Biological Contact Aeration Process

2) Disinfection Agents

Disinfection is indispensable treatment procedure not only in Water Treatment Plant but also in Service Reservoirs. Since Coliform Group and bacteria were detected from water samples taken from water supply facilities in the City, additional chlorine dosage shall be conducted in service reservoirs to secure "Safe Water Supply".

At first, the most suitable chlorination agent shall be examined based on the site condition. Several chlorination agents available in Yangon City were compared as follows;

Table 5.2 Comparison of Chlorination Agents

	Liquid Chlorine	Liquid Sodium Hypochlorite	Bleaching Powder
Procurement	Imported from Thailand	Domestic Product	Imported from India and Thailand
O&M issues	• Highly toxic • Neutralize equipment is necessary as safety facility • Less unit cost	• In case of domestic product, quality and stable procurement rout must be confirmed • Resolution speed is larger in high temperature • Less O&M activity	• Operation of BP dissolving facility is troublesome • Auto injection rate control is difficult • Unit cost is high
YCDC operation	Yes	No	Yes
Evaluation	Suitable	Suitable	Not Applicable

Since YCDC used to apply liquid chlorine in Gyobyu WTP and Yegu P/S, they are experienced in handling of liquid chlorine. Considering the economical aspect, facility scale and necessary O&M activities, "Liquid Chlorine" is considered to be suitable for adoption in proposed Water Treatment Plant.

While, in case of service reservoir, "Liquid Sodium Hypochlorite" was selected because of following reasons;

- Less O&M activity
- Since planned and existing service reservoirs are located within City boundary, populated areas, safe chlorine agent must be applied

The optimum chlorination agents were selected based on their characteristics and operational conditions;

Liquid Chlorine Water Treatment Plant

Liquid Sodium Hypochlorite Service Reservoirs

Optimum chlorine dosing rate was confirmed by "chlorine requirement test" in laboratory. Chlorine requirement was below 1 mg/l. Considering the seasonal water quality fluctuation, capacity of chlorination equipment was proposed as follows;

Item	Chlorinator Capacity
Duty	1 mg/l
Maximum	5 mg/l

(2) Rivers

1) Water Treatment

On the contrary to reservoir water, turbidity of river water is high and coagulation is indispensable. The following is the results of the jar test on Hlaing river water conducted on water samples taken during rainy season and dry season. Alum was adopted as coagulant since it is the most popular and only available coagulant in Myanmar. Supernatant was extracted for analyze after Alum dosing and sedimentation.

Table 5.3 Turbidity of Supernatant after Coagulation and Sedimentation

Alum Dosing Rate (mg/L)	Turbidity	
	Rainy Season	Dry Season
0	200	86.1
10	114	65
20	30	46
30	15	29.6
40	1.2	19.9
50	3.8	13.2
60	7.4	14
80	-	14.9
100	-	15.7

40 mg/L and 50 mg/L were determined as optimum Alum dosing ratio during rainy and dry season, respectively. The reason for this seasonal alternation was assumed as follows;

- Compared with rainy season, granular of turbidity during dry season is much smaller and colloidal
- These resulted in inferior sedimentation velocity

Accounting this seasonal water quality fluctuation, the design Alum dosing rate was set by 50 mg/L.

As aforementioned, turbidity removal process is inevitable for Hlaing River water and therefore, the following treatment process was proposed;

- Coagulated Sedimentation and Rapid Sand Filter

Optimum chlorine dosing rate was confirmed by "chlorine requirement test" in laboratory. Test was conducted to supernatant of river water after coagulation and sedimentation. Chlorine requirement was below 1 mg/l. Considering the seasonal water quality fluctuation, capacity of chlorination equipment was proposed as follows;

Item	Chlorinator Capacity
Duty	1 mg/l
Maximum	5 mg/l

2) Coagulants

Based on the availability in Myanmar and easiness in storage, "Solid Alum" was adopted as coagulant.

(3) Groundwater

1) Hlaing River Left Bank

As aforementioned in the previous chapter, groundwater use in the following T/S should transfer to surface water due to inferior groundwater quality;

- Dagon South T/S
- North Okkalapa T/S
- Thaketa T/S

2) Hlaing River Right Bank

Townships belong to the right bank of Hlaing River are mainly served by groundwater, pond water, rainwater and boat water supply. While left bank area is planned to serve by surface water in near future, right bank area will remain to be served by the existing sources for several years until the introduction of surface water from left bank through transmission pipeline over the Hlaing River.

The water supply system in left bank area comprised of large-scale water treatment plant, P/S and pipeline network can be called as "Main System". On the other hand, the existing small-scale water supply system in right bank area can be classified as "Satellite System". The following table shows the results of water quality analysis conducted on 3rd September on four completed tube wells in outside of Hlaingthaya T/S. These wells were constructed to serve groundwater to township. However, since submersible pumps were not yet installed, stagnant groundwater was taken in the depth of around 15 m from the water surface;

Table 5.4 Analysis Results of Tube Wells in Hlaingthaya T/S

Parameter	unit	Myanmar Standard	No.1	No.2	No.3	No.4
Chloride	ppm	200 - 600	2.6	2.1	4.1	26.1
Total Hardness	ppm	500	102	112	98.8	128
Iron	ppm	0.5 – 1.5	0.11	1.19	0.75	0.45
Manganese	ppm	0.3	0.66	1.07	1.2	0.99
E Conductivity	μS/cm	-	277	309	290	403
Nitrogen-Ammonia	ppm	-	N.D.	N.D.	N.D.	N.D.

High concentration iron and manganese was confirmed. The following day, water analysis was performed again to examine whether high concentration of iron and manganese attributes to "No pump operation". Sample was taken from elevated tank of site office. Water was pumped from well located near by the said four wells. Air-lift Pump was installed.

Parameters	Results
Iron	0.07 ppm
Manganese	0.63 ppm

Although parameters were affected by air-lifting, manganese concentration was still high.

The table in below shows the water quality analysis results in the same well (No.1). Submersible pump was installed in the well in a day before the water sampling and pump was operated in 12 hours continuously to introduce fresh groundwater into the well.

Table 5.5 Analysis Results of Tube Well No.1 in Hlaingthaya T/S

Parameters	Unit	Myanmar Standard	2001			
			Sept.	Oct.	Nov.	Dec.
Turbidity	NTU	20	N.D.	N.D.	N.D.	N.D.
Color	TCU	5 – 50	N.D.	N.D.	N.D.	N.D.
pH		6.5 – 9.2	6.7	6.6	6.5	7.3
Iron	ppm	0.5 – 1.5	0.18	0.59	0.39	0.27
Manganese	ppm	0.3	0.05	0.10	1.0	1.0
Electric Conductivity	μS/cm	1,500	340	352		
Parameters	Unit	Myanmar Standard	2002			
			Jan.	Feb.	Mar	
Turbidity	NTU	20	N.D.	18	N.D.	
Color	TCU	5 – 50	N.D.	21	N.D.	
pH		6.5 – 9.2	6.7	8.3	7.1	
Iron	ppm	0.5 – 1.5	0.29	3.20	0.25	
Manganese	ppm	0.3	0.9	0.1	N.D.	
Electric Conductivity	μS/cm	1,500				

Fresh groundwater was introduced into well by enough pump operation and consequently, the water quality was satisfactory.

100 % water supply by treated surface water must be the ultimate goal of Yangon City water supply sector, but during transition period, transferring to surface water from current water sources, available sources must be optimized.

5.2 PROPOSED WATER SUPPLY SYSTEM

5.2.1 Design Criteria

Because there are no authorized water treatment facility design criteria in Myanmar, following design criteria commonly applied in Japan was adopted.

(1) Water Treatment Plant

Proposed treatment processes are as follows;

- Reservoir Water (Hlawga Reservoir) : Slow Sand Filter or Biological Contact Aeration Process
- River Water (Hlaing River, Bago River) : Coagulated Sedimentation and Rapid Sand Filter

Proposed design parameters by major treatment facilities are as follows;

Facilities	Design Parameter
Design Flow	: Daily Maximum Flow
Biological Contact Aeration Tank	: Filtration Rate = 120 - 150 m/day
Slow Sand Filter	: Filtration Rate = 5 m/day
Grit Chamber	: Surface Load = 200 – 500 mm/min
Mixing Chamber	: Retention Time = 1 – 5 min
Flocculation Basin	: Retention Time = 20 – 40 min
Sedimentation Basin	: Retention Time = 2.5 hours
	: Surface Load = 15 – 30 mm/min
	: Horizontal Velocity < 0.40 m/sec
Rapid Sand Filter	: Filtration Rate = 120 – 150 m/day
Chlorination Channel	: Contact Time > 2 min
Clear Water Reservoir	: Retention Time > 1 0 hour
Backwash Wastewater Storage Tank	: Retention Time = 1 hour
Sludge Lagoon	: Storage Period = 1 year
	: Water Content = 98% (Raw) – 60 %(Dried)

(2) Service Reservoir

Design Flow = Daily Maximum Flow
Retention Time = 8 hours

(3) Distribution Network

Design Flow = Hourly Maximum Flow
Hourly Peak Factor = 1.4 of Daily Maximum
Pipe Friction Formula
(Hazen-Williams Formula)

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

where;
H : Friction Head Loss (m)
C : Velocity Coefficient
D : Inner Pipe Diameter (m)
Q : Flow Rate (m^3/sec)
L : Pipe Length (m)

5.2.2 Comparison Study for Optimum Water Supply System

(1) Water Treatment Plant

1) Hlaing WTP

a) WTP Location

Location of proposed WTP was selected based on the following selection criteria;

- Hydraulically advantageous
- Maximum utilization of existing facilities
- Land acquisition is secured by the YCDC
- Safe from natural calamities, namely flooding or land erosion

In accordance with the feasibility study on the Hlaing River source done by the YCDC, Gwedanshe was selected as proposed site. The major advantages for selection were;

- No saline intrusion
- Land for proposed WTP is available nearby

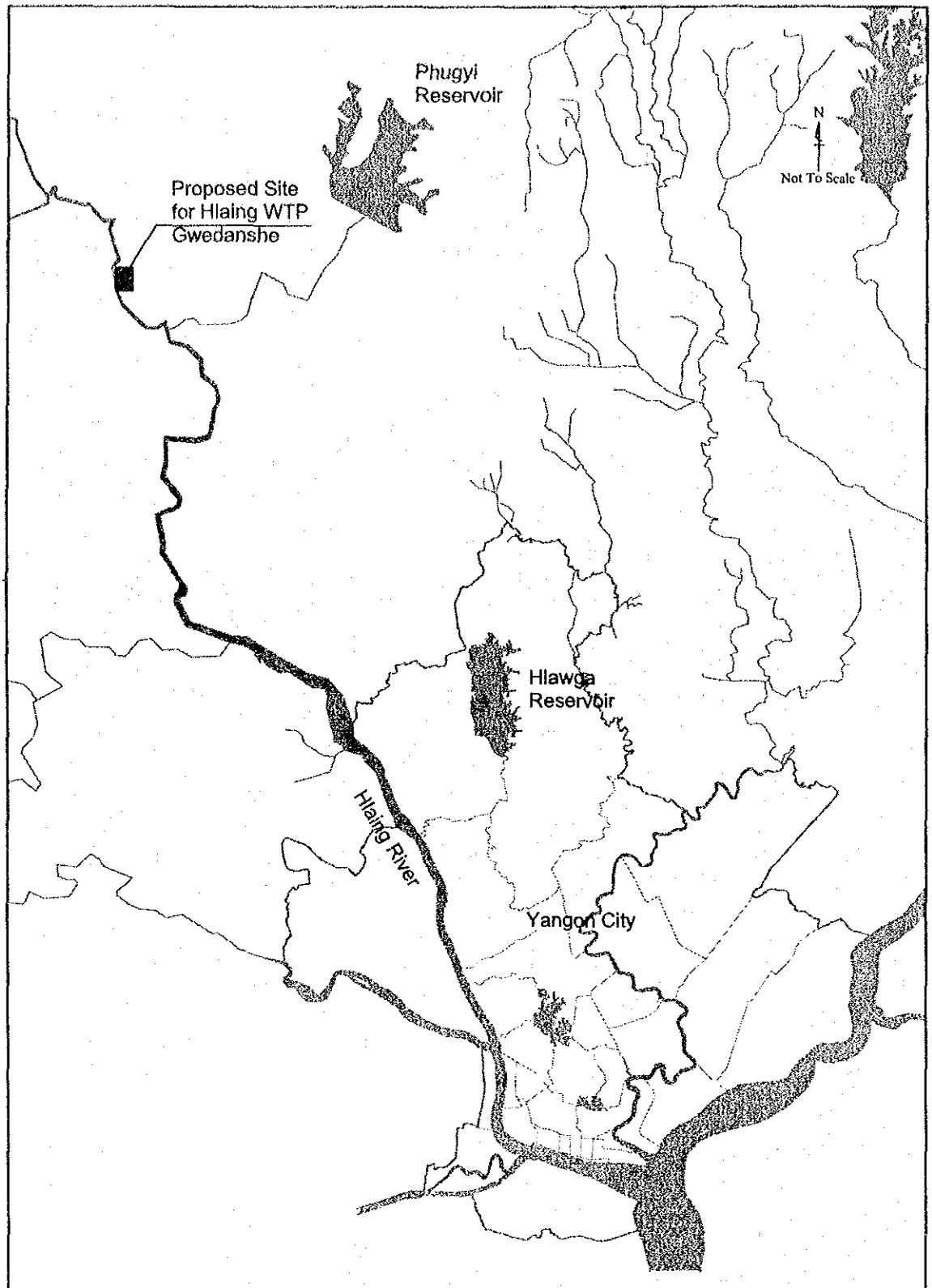
As presented in 3.4.4, "Saline Water Intrusion Survey" conducted showed no trance of salinity in Gwedanshe. Land for the proposed facilities is now owned by the Government but can be secured by the YCDC at the construction stage. Figure 5.1 shows the location of the proposed Hlaing WTP construction site.

b) Treatment Facility

i) Intake Facility

The following three intake facilities were selected as possible type of river water intake facility;

- Intake Weir
- Intake Tower
- Intake Gate



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 5.1
	Proposed Construction Site of Hlaing WTP	

The characteristics of these facilities are described on the table below;

Table 5.6 Comparison of Intake Facilities

Items	Intake Weir	Intake Tower	Intake Gate
Construction Condition	• Weir must be installed in straight portion of river bank and it length shall be two times of river width. • It is not applicable where boat is used as transportation.	• Not applicable where water depth in draught season is less than 2 m. • Tower must be settled in the flow center of river.	• River bed must be stable.
Intake Condition	• Water intake amount is stable since intake water level is secured by weir. • Saline water intrusion can be prevented.	• Intake water amount is affected by river flow fluctuation. • Intake is not available in case of saline water intrusion.	• Intake water amount is affected by river flow fluctuation. • Intake is not available in case of saline water intrusion.
Operation and Maintenance	• Sand discharge device shall be installed and be properly operated to prevent sand sedimentation at intake mouth.	• Sand inflow must be accounted but it can be controlled by gate operation.	• Sand inflow must be taken into account.
Construction Cost	• Cost is large since large scaled work is required	• Large but less than Intake Weir.	• Generally economical.
Total Evaluation	×	△	○

Legend: ○; Good, △; Fair, ×; Poor

Judging from above table, "Intake Gate" was selected as an optimum intake facility for the proposed Hlaing WTP.

ii) Treatment Process

As described in the preceding chapter, estimated intake amount from Hlaing River is;

- Q_{INTAKE} = 11.36 m^3/sec = 981,500 m^3/day

Since water turbidity of Hlaing River is high, it needs appropriate treatment to remove the turbidity and other suspended maters. The table below shows the river water turbidity of Hlaing River analyzed through the water quality survey conducted by the Study Team.

As presented in the table, though turbidity in the rainy season is rather high, it is much lower than the turbidity during dry season. In addition, effect of grit chamber is expected to some extent in the proposed treatment plant.

According to the feasibility study report on Hlaing River Source done by YCDC, design turbidity of 150 NTU was employed and thus, design turbidity for the water treatment plant is set at 150 as an average value considering the said seasonal fluctuation and effect of grit chamber.

Table 5.7 Seasonal Turbidity Fluctuation in Hlaing River

Month	Turbidity (NTU)	Sampling Points
May 2001	800	Gwedanshe, middle layer
June 2001	600	Ditto
July 2001	263	Ditto
August 2001	232	Ditto
September 2001	225	Ditto
October 2001	275	Ditto
November 2001	220	Ditto
December 2001	237	Ditto
January 2002	90	Ditto
February 2002	47	Ditto
Design Turbidity	150	From F/S Report

As suggested in Section 5.1.6, "Coagulated Sedimentation and Rapid Sand Filtration Process" was judged as suitable for the water quality of Hlaing River.
Based on the estimated intake amount, the design capacity of proposed WTP was derived. Generally, intake amount is set at the design capacity and 5 % of capacity as the water loss by filter washing wastewater and sludge discharge. Thus, design capacity is;

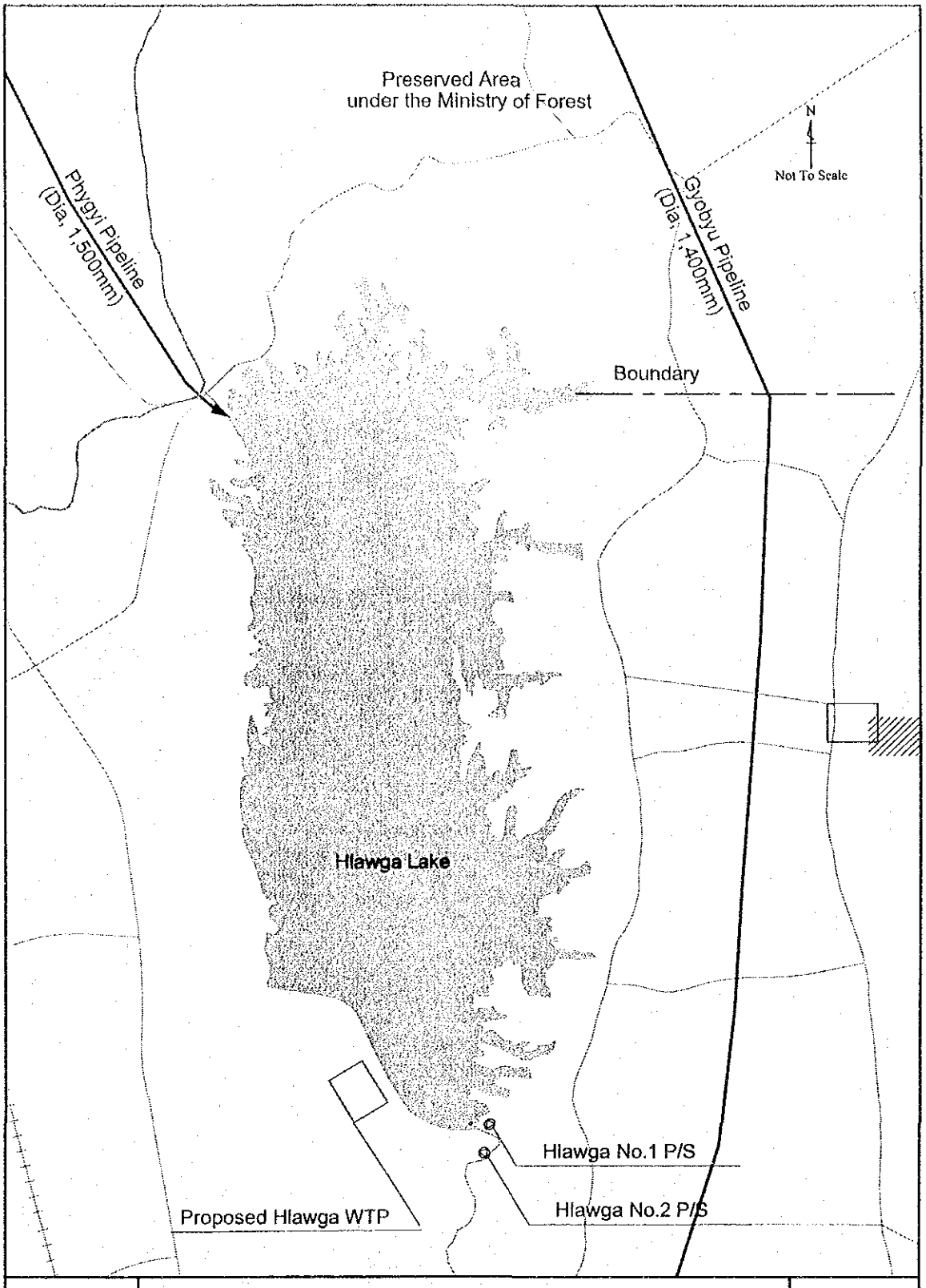
- Hlaing River WTP : $Q_D = 981{,}500\ m^3/day / 1.05 = 935{,}000\ m^3/day$*
  *: In the preliminary design, the WTP is designed with a nominal capacity of 940,000 m^3/day.

2) Hlawga WTP

a) Location of WTP

As aforementioned, water of three existing reservoirs, namely Gyobyu, Phugyi and Ngamoeyeik, will be gathered to Hlawga reservoir for integrated treatment and for appropriate water distribution control in terms of distribution volume and pressure. The optimum site was for the proposed WTP was surveyed around the Hlawga reservoir.

Northern part was excluded from the scope because the Ministry of Forest strictly preserves it as "Wildlife Reservation Area". As shown in the Figure 5.2, proposed WTP construction site was selected in south of the reservoir because of the following reasons;



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 5.2
	Proposed Construction Site for Hlawga WTP	

- The site is adjacent to the existing Hlawga No.1 and No.2 P/S and it is advantageous because treated water is sent to these P/S for further water conveyance.
- Existing power supply facilities can be optimized.

b) Treatment Facility

The following two treatment processes were selected as suitable for the reservoir water quality;

- Biological Contact Aeration Process
- *Slow Sand Filter Process*

Characteristics of both treatment processes are as follows;

i) Biological Contact Aeration Process

- Since filtration rate is high (150 m/day), required land area is much smaller than the *Slow Sand Filter Process.*
- Air is supplied from the bottom of contact tank so dissolved oxygen concentration is almost even from filter surface to bottom. To accelerates treatment efficiency.
- Filter washing is done by backwashing water together with air scouring. Filter washing time is much less than Slow Sand Filter, and thus, rate of filter operation is also larger than that.

ii) Slow Sand Filter Process

- Vast land is necessary due to low filtration rate (5 m/day).
- Dissolved air concentration is decreased at the bottom of filter.
- Sand filter surface must be scraped periodically, but huge surface area needs large labor and long scraping time affects the rate of operation.

The following table shows the comparison of these processes;

Table 5.8 Comparison of Water Treatment Process

Items	B.C.A.P	Slow Sand Filter
Construction Cost	○	○
(Million US$)	137	123
Implementation Period	○	○
O&M Activities	○	△
Land Acquisition	○ (100 m x 100 m)	△ (400 m x 450 m)
Treatment Efficiency	○	△
Overall Evaluation	○	△

Legend: ○; Good, △; Fair

Based on the above evaluation results, "Biological Contact Aeration Process" was selected as the optimum process.

Design capacity was set by the available total water amount comprising of incoming water from Gyobyu, Phugyi, Ngamoeyeik reservoir and possible intake amount from Hlawga reservoir;

Reservoirs	Intake Amount (MGD)	Intake Amount (m^3/day)
Gyobyu	26.0	118,170
Phugyi	54.0	245,430
Ngamoeyeik	90.0	409,050
Hlawga	16.5	75,000
Total	186.5	847,650

Water loss of 3 % shall be counted as loss by filter backwashing and sludge drainage. Thus, design capacity of Hlawga WTP is;

- Hlawga WTP : $Q_D = 847,650/1.03 = 820,000$ m^3/day

(2) Transmission Pipeline

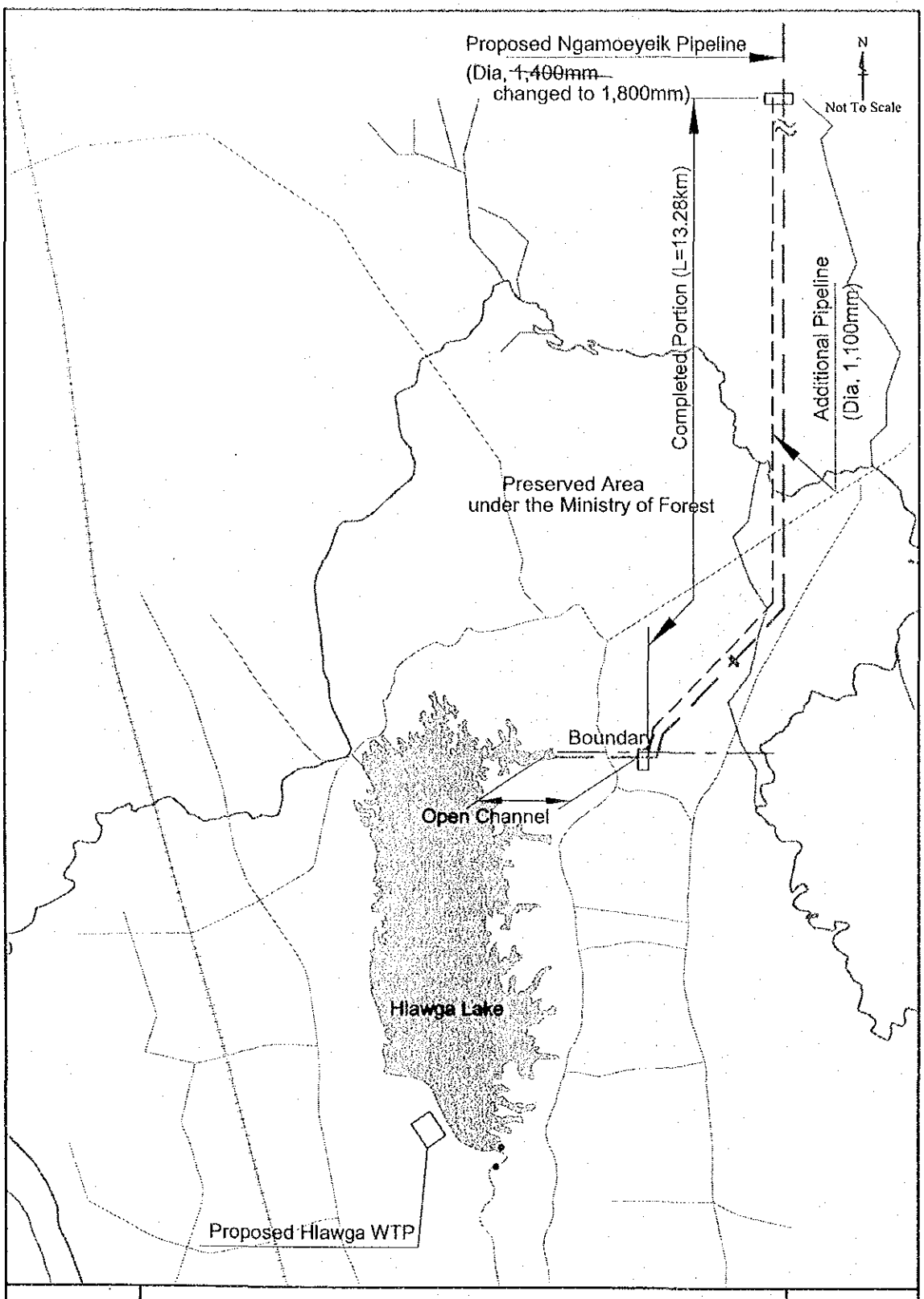
1) Reservoir Water Transmission Pipeline

a) Ngamoeyeik Transmission Pipeline

To relieve the water shortage, the construction of Ngamoeyeik pipeline shall have the top priority. As shown in Figure 5.3, some portion in downstream has already been completed. The existing pipeline shall also be utilized. But, since its diameter is too small as 1,400 mm, velocity was calculated at 3.03 m/sec for the design pumping volume of 409,050 m^3/day (90 MGD), which resulted in high friction loss.

To relieve this problem, additional pipeline must be installed along with the existing one. Thus, Ngamoeyeik pipeline was planned as dual pipelines in the completed portion nearby the Hlawga Reservoir. For the new installation section, pipe diameter of 1,800 mm was adopted. Detailed pipeline specifications are described in the next section.

Direct connection of the Ngamoeyeik pipeline to the Hlawga WTP was examined. Due to the large friction loss owing to the huge pumping volume, however, direct connection was regarded as uneconomical. Thus, Ngamoyeik reservoir water will be poured into the Hlawga reservoir.



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 5.3
	Ngamoeyeik Transmission Pipeline	

b) Phugyi Transmission Pipeline

Direct connection of Phugyi transmission pipeline to the WTP was also examined. The existing pumps cannot send water to the proposed site because of insufficient capacity. Therefore, Phugyi reservoir water will be pumped and poured into the Hlawga reservoir as it is.

c) Gyobyu Transmission Pipeline

A transmission pipeline from Gyobyu reservoir will be directly connected to the WTP. Pipeline specification is shown in the next section. As to detailed pipe friction calculation, refer to Appendix J.

2) Clear Water Transmission Pipeline

a) Hlaing WTP to Terminal Reservoir

Water treated in the Hlaing WTP will be conveyed to the Terminal Reservoir, which was planned within the site of the proposed Hlawga WTP. New transmission pipeline shall be provided.

b) Terminal Reservoir to Service Reservoir

Water stored in the Terminal Reservoir will be supplied to service reservoirs within the City. The target service reservoirs are;

- Kokine Service Reservoir (Existing)
- CB Hlawga Service Reservoir (New)
- CB West Service Reservoir (New)

Transmission pipelines must be provided optimizing the existing transmission pipelines.

(3) Pumping Station

1) Existing P/S

a) Gyobyu P/S

The existing three pumps of Gyobyu P/S were manufactured in 1962 and were already deteriorated. They must be replaced to secure stable reservoir water supply to the proposed Hlawga WTP.

b) Phugyi P/S

Based on the hydrological examination, possible intake amount from the Phugyi reservoir was increased from 50 MGD to 54 MGD. To cope with this pumping amount increase, one additional pump is needed.

2) New P/S

a) Ngamoeyeik P/S

Together with the construction of the Ngamoeyeik transmission pipeline, pumping station must be provided also, because the design flow of 90 MGD cannot be conveyed to the Hlawga reservoir by gravity.

b) Transmission P/S in WTP

Two WTPs are planned, namely the Hlaing and the Hlawga WTPs, and transmission P/S to supply the treated water shall also be provided in both plants

(4) Service Reservoir

As examined in the previous chapter, "Combined System" was proposed and reservoirs were designed based on the design water demand of each reservoir.

5.2.3 Proposed Water Supply System

As presented in Figure 4.18, proposed water supply system consists of two (2) new WTPs, existing and newly drilled tube wells, one (1) terminal reservoir which will be constructed within the site of the Hlawga WTP, 13 service reservoirs (existing 3, new 10), one (1) existing booster P/S (Yegu P/S) excluding those attached to reservoirs, and transmission and distribution pipelines. In addition to these facilities, there is one (1) existing WTP, namely the Gyobyu WTP. The followings are the details of those facilities;

(1) Water Treatment Plant

1) Existing WTP

a) Gyobyu WTP

As aforementioned in Chapter 3, the existing Gyobyu WTP has several deficits, such as insufficient flocculation and sedimentation effect. Generally, water quality of Gyobyu Reservoir water is satisfactory including low turbidity. However, this low turbidity hinders the formation of flock and its sedimentation. Insufficient sedimentation causes carry-over of flock. To relieve this problem, sand filter is necessary, but there is no available land nearby.

According to the operation record and results of the interview to the relevant YCDC officers, the Gyobyu WTP seldom operated except the occasion when raw water turbidity becomes high. However, since the sedimentation capacity of the plant is insufficient, turbidity of treated water is not be improved so much and no serious water quality issues have ever been reported. Thus, it can be regarded that "existing deficit in sedimentation effect of the plant doesn't cause fatal damage on whole water supply system".

Further, raw water of three existing reservoirs, namely Gyobyu, Phugyi and Ngamoeyeik, will be integrated into the Hlawga Reservoir and be treated by the proposed Hlawga WTP.

Rehabilitation of the Gyobyu WTP was excluded from the scope because of the following reasons;

- Rehabilitation work will be large because additional sand filter must be provided
- Existing plant deficit will not cause crucial damage on the whole system

Therefore, the existing Gyobyu WTP will be operated until the completion of the proposed Hlawga WTP and then it will be abandoned.

2) New WTP

a) Hlaing WTP

The "Coagulation, Sedimentation and Rapid Sand Filter Process" was adopted, and dimension of major facilities are shown below;

Table 5.9 Dimension of Major Facilities in Hlaing WTP

Facilities	Dimension
Grit Chamber	^{L} 42.0 m x ^{W} 14.0 m x ^{D} 3.0 m (LWL) x 4 channels
Intake Pump	115 m^3/min x 750 kW x 30 m x 7 units (1 unit stand-by)
Receiving Well	^{L} 10.0 m x ^{W} 6.0 m x ^{D} 6.0 m x 2 units
Flocculation Basin	24 units of the following channels
	^{W} 1.3 m x ^{L} 22.0 m x ^{D} 3.3 m x 2 channels/unit
	^{W} 1.8 m x ^{L} 22.0 m x ^{D} 3.3 m x 2 channels/unit
	^{W} 2.4 m x ^{L} 22.0 m x ^{D} 3.3 m x 2 channels/unit
Sedimentation Basin	^{W} 22.0 m x ^{L} 80.0 m x ^{D} 3.8 m x 24 units
Rapid Sand Filter	^{W} 5.8 m x ^{L} 14.8 m x 88 units (8 units stand-by)
Chlorination Channel	^{W} 6.0 m x ^{L} 36.0 m x ^{D} 3.0 m x 4 channels
Clear Water Reservoir	^{W} 42.0 m x ^{L} 84.0 m x ^{D} 3.0 m x 4 units
Transmission Pump	85 m^3/min x 1,150 kW x 55 m x 9 units (1 unit stand-by)
Backwash Wastewater Storage Tank	^{W} 12.0 m x ^{L} 36.0 m x ^{D} 3.0 m x 4 units (1 unit stand-by)
Sludge Lagoon	^{W} 46.0 m x ^{L} 180.0 m x ^{D} 3.0 m x 6 units

b) Hlawga WTP

The "Biological Contact Aeration Process" was adopted. To cope with the anticipated water quality deterioration by urbanization, rapid sand filter process was also proposed. Dimension of major facilities are shown in Table 5.10;

Table 5.10 Dimension of Major Facilities of Hlawga WTP

Facilities	Dimension
Receiving Well (A)	^{Dia} 36.0 m x ^{D} 3.0 m x 1 unit
Receiving Well (B)	^{L} 30.0 m x ^{W} 14.0 m x ^{D} 6.0 m x 1 unit
Receiving Well (C)	^{L} 16.0 m x ^{W} 8.0 m x ^{D} 6.0 m x 2 units
Biological Contact Aeration Filter	^{W} 5.8 m x ^{L} 14.8 m x 112 units (8 units stand by)
Chlorination Channel	^{L} 36.0 m x ^{W} 6.0 m x ^{D} 3.0 m x 8 channels
Clear Water Reservoir	^{L} 84.0 m x ^{W} 42.0 m x ^{D} 3.0 m x 8 channels
Backwash Wastewater Storage Tank	^{L} 50.0 m x ^{W} 16.0 m x ^{D} 3.0 m x 2 units (1 unit stand by)
Sludge Lagoon	^{L} 48.0 m x ^{W} 29.0 m x ^{D} 3.1 m x 3 units

The "Terminal Reservoir" and its transmission P/S was planned as well within the WTP site. Three P/Ss were planned to pump water to;

- Kokine service reservoir (Existing)
- Central Block Hlawga service reservoir (New)
- Central Block West service reservoir (New)

Their specifications are as follows;

Table 5.11 Specifications of Terminal Reservoir and Pumping Station

Facilities	Dimension and Specifications
Terminal Reservoir	^{L} 84.0 m x ^{W} 42.0 m x ^{D} 3.0 m x 8 units
P/S to Kokine Service Reservoir	80.0 m^3/min x 1,150 kW x 79 m x 5 units (1 unit stand-by)
P/S to CB Hlawga Service Reservoir	80.0 m^3/min x 640 kW x 38 m x 6 units (1 unit stand-by)
P/S to CB West Service Reservoir	80.0 m^3/min x 640 kW x 38 m x 8 units (1 unit stand-by)

Upon completion of P/S and transmission pipeline to the Kokine service reservoir, the existing Yegu P/S and the Hlawga No.2 P/S will be abandoned because said P/S will convey water directly to the reservoir. However, the existing Hlawga No.1 P/S will be optimized to serve Hlawga reservoir water through on-going RC mains.

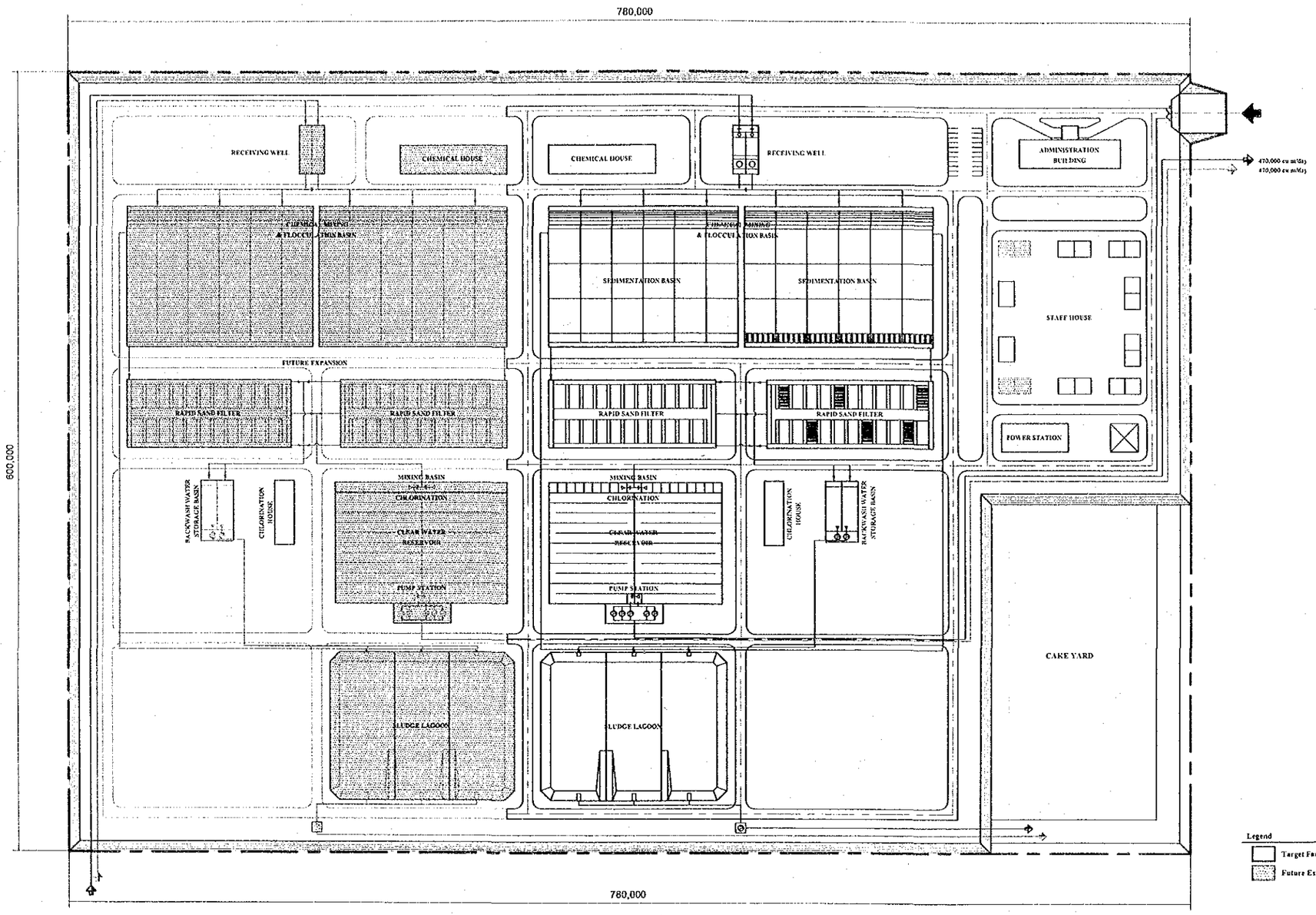
General plans of both WTP are shown in Figure 5.4 to 5.5.

(2) Transmission Pipeline

1) Reservoir Water Transmission Pipeline

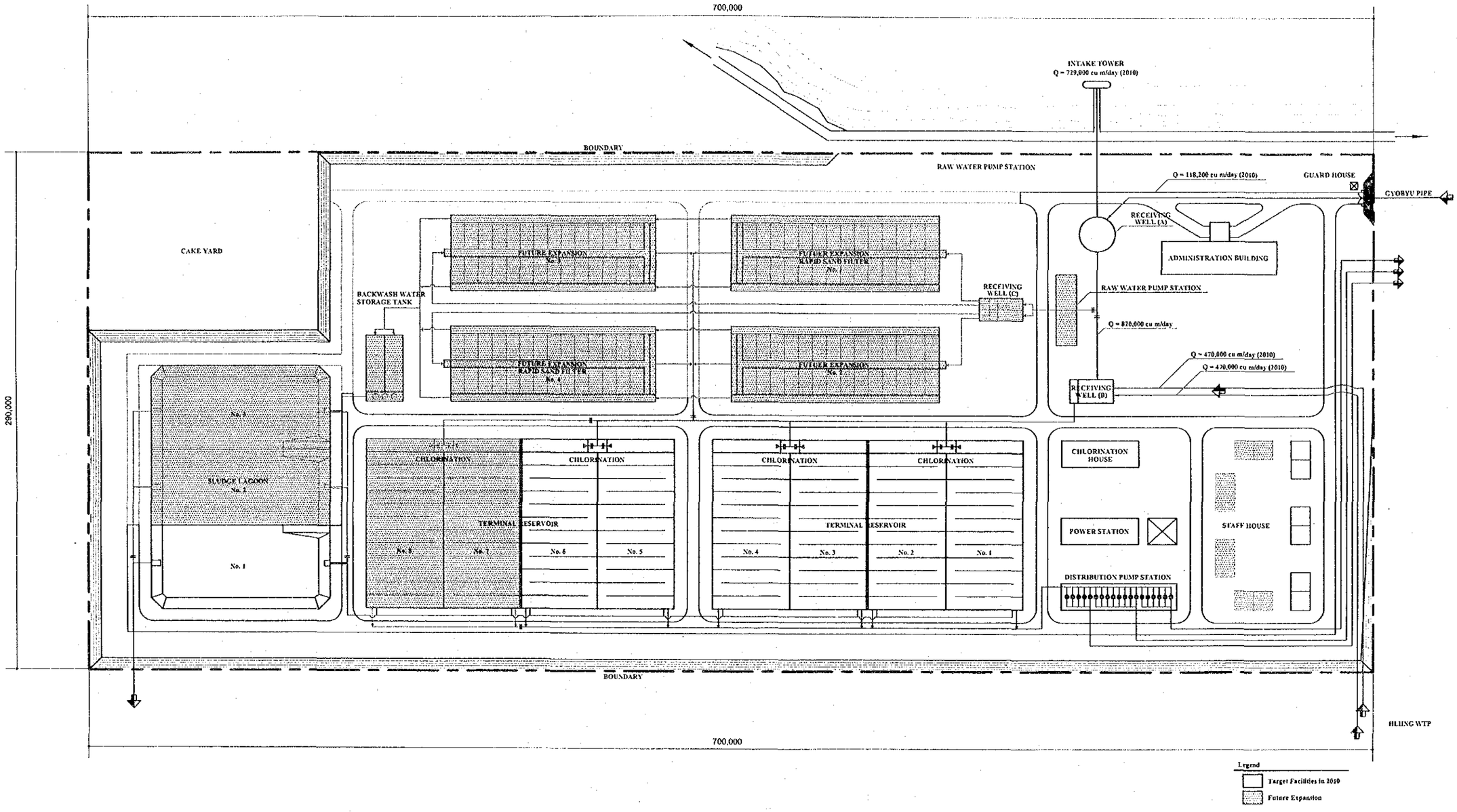
a) Ngamoeyeik Transmission Pipeline

Installation of Ngamoeyeik transmission pipeline was proposed to mitigate the current water shortage. As described in the previous section, pipeline of 1,400 mm diameter has already been installed nearby the Hlawga reservoir and the "dual pipeline" was employed



W.T.P FACILITIES

JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 5.4
	Layout of Hlaing Water Treatment Plant	



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 5.5
	Layout of Hlawga Water Treatment Plant	

in this portion to prevent high friction loss. The other section was planned by pipe with 1,800 mm diameter. Specification of pipe is as follows;

Dia. 1,800 mm x 30.75 km (New)
Dia. 1,100 mm x 13.28 km (Additional)

b) Gyobyu Transmission Pipeline

As aforementioned in the previous section, the Gyobyu transmission pipeline will be directly connected to Terminal Reservoir and the following is the specification of additional pipeline needed.

Dia. 1,400 mm x 4.2 km

2) Clear Water Transmission Pipeline

a) Hlaing WTP to Terminal Reservoir

Water treated in the Hlaing WTP will be conveyed to the Terminal Reservoir through the proposed transmission pipeline with the following specification;

Dia. 2,000 mm x 33.3 km x 2 units

b) Terminal Reservoir to Service Reservoirs

Water stored in the Terminal Reservoir will be pumped to the existing and the proposed service reservoirs within the City. In case of transmission pipeline to the existing Kokine service reservoir, the existing Hlawga No.1 and No.2 pipelines shall be fully utilized. The followings are the pipeline specifications;

Pumped to	Pipeline Specification
Kokine S.R.	Dia. 1,650 mm x 1.0 km (to Hlawga No.1 pipeline)
	Dia. 1,100 mm x 1.3 km (to Hlawga No.2 pipeline)
CB Hlawga S.R.	Dia. 2,200 mm x 3.9 km (New)
CB West S.R.	Dia. 2,700 mm x 7.5 km (New)

Note) S.R. = Service Reservoir

c) Other Transmission Pipelines between Service Reservoirs

As presented in Figure 4.18, ten (10) new service reservoirs were proposed. They are allotted by distribution zone-wise and will be mutually connected by pipelines. The following transmission pipelines were proposed;

Table 5.12 Specifications of Transmission Pipelines between Service Reservoirs

Block	Facilities	Pipeline Specification
Central Block	CB Hlawga S.R. to CB North S.R.	Dia. 900 mm x 6.1 km
	CB Hlawga S.R. to EB North S.R.	Dia. 1,400 mm x 15.2 km
	CB West S.R. to CB DT East S.R.	Dia. 1,800 mm x 12.2 km
East Block	EB North S.R. to EB Central S.R.	Dia. 1,350 mm x 7.3 km
	CB DT East S.R. to EB South S.R.	Dia. 1,200 mm x 7.6 km
West Block	Terminal R. to WB North S.R.	Dia. 500 mm x 9.8 km

(3) Pumping Station

1) Existing Transmission P/S

a) Gyobyu and Phugyi P/S

The new pumps with following specifications must be installed in Gyobyu and Phugyi P/S respectively to optimize available intake amount.

Name of P/S	Pump Specification
Gyobyu P/S	3,310 m^3/hr x 13.7 m x 184 kW x 3 units (Replacement)
Phugyi P/S	5,160 m^3/hr x 24 m x 450 kW x 1 unit (Additional)

2) New Transmission P/S

a) Ngamoeyeik P/S

There is one proposed P/S in the Ngamoeyeik Reservoir site. Based on the design flow of 90 MGM and hydraulic conditions, pump specification was determined as follows;

Name of P/S	Pump Specification
Ngamoeyeik	71.0 m^3/min x 1,200 kW x 78 m x 5 units (1 unit stand-by)

b) Other P/S

Three transmission P/S were proposed within the site of Hlawga WTP and its detail was described in previous section. These P/Ss must be implemented in early stage because the existing P/Ss have total capacity around 350,000 m^3/day only and they cannot cope with the future available water amount calculated as 848,000 m^3/day. Therefore, strengthening of water conveyance system is indispensable to optimize the available water and to improve the present water supply status.

(4) Service Reservoirs and Distribution Network

1) Service Reservoirs

The following service reservoirs were proposed. Some reservoirs are equipped with distribution pumps and others supply water by gravity.

Table 5.13 Specifications of Service Reservoirs and Distribution Pumps

Block	Zone	Reservoir	Specifications
Central Block	2	CB DT East S.R.	V = 100,000 m^3, pump supply
		(Distribution P/S)	158 m^3/min x 900 kW x 27 m x 3 units (1 SB)
	3	CB West S.R.	V = 100,000 m^3, gravity supply
	4	CB Hlawga S.R.	V = 100,000 m^3, gravity supply
	5	CB North S.R.	V = 10,000 m^3, gravity supply
East Block	6	EB South S.R.	V = 50,000 m^3, pump supply
		(Distribution P/S)	70 m^3/min x 350 kW x 24 m x 3 units (1 SB)
	7	EB Central S.R.	V = 50,000 m^3, pump supply
		(Distribution P/S)	65 m^3/min x 350 kW x 24 m x 3 units (1 SB)
	8	EB North S.R.	V = 20,000 m^3, pump supply
		(Distribution P/S)	60 m^3/min x 350 kW x 27 m x 2 units (1 SB)
West Block	9	WB South S.R.	V = 10,000 m^3, pump supply
		(Distribution P/S)	24 m^3/min x 125 kW x 24 m x 2 units (1 SB)
	10	WB Central S.R.	V = 10,000 m^3, pump supply
		(Distribution P/S)	23 m^3/min x 140 kW x 27 m x 2 units (1 SB)
	11	WB North S.R.	V = 30,000 m^3, pump supply
		(Distribution P/S)	94 m^3/min x 550 kW x 27 m x 2 units (1 SB)

Note) SB : Stand-by

2) Distribution Network

Pipelines consisting of distribution network were classified into the following two categories by their pipe diameters;

- Primary Mains : Dia. Greater than 300 mm
- Secondary Distribution Pipes : Dia. 75 mm to 250 mm

The following tables are showing the pipe length of these distribution mains by diameter. PVC pipe was adapted to the pipes with diameter 200 mm or less and DICP was employed for the diameter larger than 200 mm.

Table 5.14 Pipeline List of Primary Mains

Pipe Dia. (mm)	300	350	400	500	600	700	800
Materials	DCIP	DCIP	DCIP	DCIP	DCIP	DCIP	DCIP
Pipe Length (m)	6,310	1,090	10,810	17,920	10,540	8,800	11,450
Pipe Dia. (mm)	900	1,000	1,100	1,200	1,350	1,400	1,500
Materials	DCIP	DCIP	DCIP	DCIP	DCIP	DCIP	DCIP
Pipe Length (m)	3,760	6,750	1,260	2,410	5,260	1,230	80
						Total	87,670

Table 5.15 Pipeline List of Secondary Distribution Pipes

Pipe Dia. (mm)	75	100	150	200	250
Materials	PVC	PVC	PVC	PVC	DCIP
Pipe Length (m)	20,500	40,900	198,300	14,600	17,400
				Total	291,700

3) Rehabilitation of Aged Pipelines

First installation work of distribution pipelines have been conducted on 1879 and therefore, most of them have already been deteriorated and have become major cause of water leakage. From viewpoint of rational water use, such water leakage must be curtailed immediately. Since water supply system development was launched at downtown area, aged pipelines are concentrated in this area.

The target T/S was screened by their age of existing pipelines. T/S has pipeline with average age over 50 years was selected as scope of this work. Aged pipelines in the following 14 T/S will be replaced;

Average Pipe Age	Name of T/S
Over 80 Years	Ahlone, Botataung, Kyauktada, Kyeemyindaing, Lanmadaw, Latha, Pabedan, Pazundaung, Tamwe (9 T/Ss)
50 to 80 Years	Sanchaung, Mingalartaungyunt, Dagon, Bahan Yankin (5 T/Ss)

Table shows the length of pipelines to be replaced classified by T/S and diameter. Pipe replacement was planned in five years and higher implementation priority was given to T/S with older pipelines.

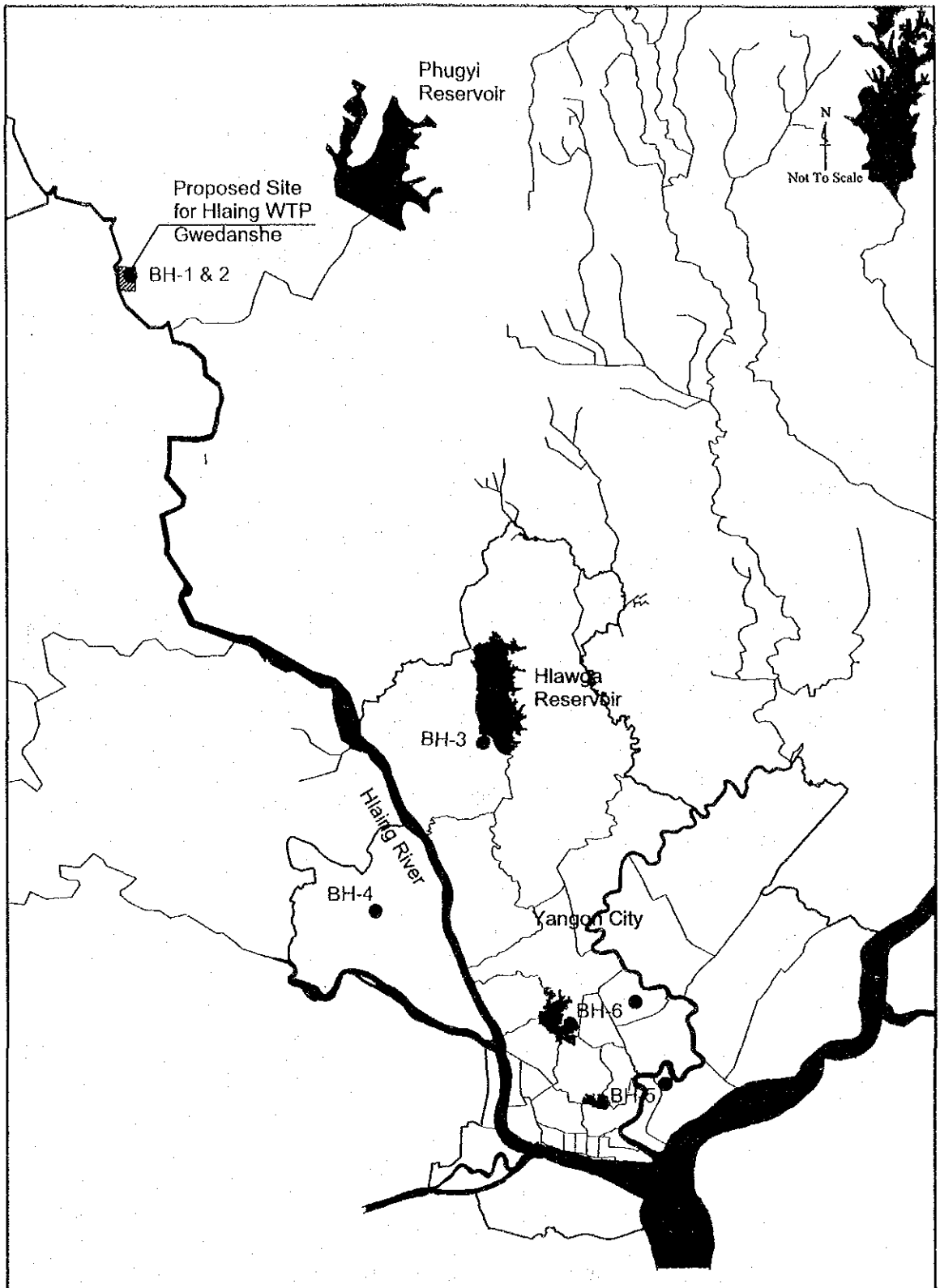
Table 5.16 Pipeline List for Rehabilitation

Pipe Dia. (mm)	75	100	150	200	250
Materials	PVC	PVC	PVC	PVC	DCIP
Pipe Length (m)	14,300	50,800	197,100	2,400	27,500
Pipe Dia. (mm)	300	350	400	450	Total
Materials	DCIP	DCIP	DCIP	DCIP	
Pipe Length (m)	51,400	300	400	4,700	348,900

(5) Foundations for Proposed Water Supply Facilities

Soil investigation was conducted at the following six points to determine the optimum facility foundation type;

- Hlaing WTP : Sedimentation Tank and Clear Water Reservoir (2 points)
- Hlawga WTP : Terminal Reservoir (1 point)
- CB Downtown East Service Reservoir (1 point)
- EB South Service Reservoir (1 point)
- WB North Service Reservoir (1 point) Total 6 points



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 5.6
	Location Map of Soil Investigation Sites	

Their site location is shown in Figure 5.6.

According to the N values acquired by Standard Penetration Test and necessary bearing values, "Cast-in-place Concrete Pipe" was adopted. Figure 5.7 show the results of SPT and necessary pile length. As to the facilities were not included in the scope of this soil test, pipe length was assumed based on the test results conducted nearby. Pipe length and number were summarized as follows;

Table 5.17 Foundation Pile List

Facilities	Pile Diameter (mm)	Pipe Length (m)	Pile Number
Hlaing Water Treatment Plant	500	21	60
	500	20	2,800
	500	19	40
	500	18	1,080
	500	17	1,820
	500	15	60
	500	13	140
CB DT East Service Reservoir	500	31	1,120
EB South Service Reservoir	500	31	560
EB Central Service Reservoir	500	31	560
EB North Service Reservoir	500	31	500
WB South Service Reservoir	500	45	250
WB Central Service Reservoir	500	45	250
WB North Service Reservoir	500	45	330

As to Hlawga WTP, CB Hlawga Service Reservoir and CB West Service Reservoir, "Direct Foundation" was employed because their base ground have enough bearing values (See Figure 5.7 (3/6)).

Figure 5.7 Soil Investigation Results (1/6)

BORING LOG

Borehole No. : B.H - 1

PROJECT NAME : YANGON CITY WATER IMPROVEMENT PROJECT-SITE INVESTIGATION WORK
LOCATION : HLAING WATER TREATMENT PLANT (MYAUNGTAGAR VILLAGE)(Sedimentation Basin)
BORING METHOD : ROTARY, Direct circulation method
BORING EQUIPMENT : A2-B

DATE : FROM 12.03.02 TO 15.03.02
ORIENTATION : VERTICAL
ELEVATION : EL.+8.28 (m)
WATER LEVEL : GL.-3.46 (m)

SCALE	ELEVATION (m)	DEPTH (m)	THICKNESS (m)	DIAGRAM	COLOUR	SOIL NAME	DESCRIPTION	Date & Depth (m)	Casing Depth (m)	Water Depth (m)	DEPTH (m)	Blows / cm	STANDARD PENETRATION TEST CURVE OF BLOW (0 10 20 30 40 50)	SAMPLE&T TEST METHOD	SAMPLE&T TEST DEPTH GL.(m)	SCALE (m)
1							Medium to stiff, silty Clay with peat pieces and gravels of 4mm, low water content, light gray.			-1.75	1.00	8/30				1
2					Light Gray	Silty Clay				13.3.02 -1.20	2.00	7/30				2
3										14.3.02 -3.46	3.00	12/30		P3		3
4	4.28	4.00	4.00					12.3.02 3.50	112mm 12.3.02	15.3.02	4.00	5/30		P4		4
5	3.28	5.00	1.00		Light Gray	Clay	Medium, Clay with recayed roots, low water content, light gray.							T1	5.00 64/70	5
6							*Soft to medium, silty Clay with recayed roots,* moderate water content, dark gray.				6.00	3/30		P5	5.70	6
7					Dark Gray	Silty Clay					7.00	5/30		P6		7
8											8.00	7/30		P7		8
9	-0.92	9.20	4.20								9.00	15/30		P8		9
10	-2.17	10.45	1.25		Dark Gray	Sand	Loose, fine to medium Sand with gravels of 1cm, traced with clay, moderate water content, dark gray.				10.00	8/30		P9		10
11					Bluish Gray	Silty Clay	Stiff, silty Clay with organic spots, low water content,bluish gray.	13.3.02 11.00	112mm 13.3.02		11.00	14/30		P10		11
12	-3.72	12.00	1.55								12.00	13/30				12
13	-4.72	13.00	1.00		Dark Gray	Silty Clay	Stiff, silty Clay, low water content, dark gray.				13.00	26/30		P12		13
14							Medium to dense, fine to coarse Sand, traced with gravels of 2mm to 5mm, moderate water content, dark gray at upper portion, gray at lower portion.				14.00	28/30		P13		14
15											15.00	41/30		P14		15
16					Gray & Dark Gray	Sand					16.00	48/30		P15		16
17									112mm		17.00	50/30		P16		17
18								14.3.02 17.50	14.3.02		18.00	50/30		P17		18
19									83mm		19.00	39/30		P18		19
20	-12.22	20.50	7.50						15.3.02		20.00	41/30		P19		20
21								15.3.02 20.50								21
22																22
23																23
24																24
25																25
26																26
27																27
28																28
29																29
30																30
31																31
32																32
33																33
34																34
35																35
36																36
37																37
38																38
39																39
40																40

Base Elevation = +2.4 m to + 10.0 m

Pile Length = 13 m to 21 m

Rock Classification
Weathered Rock : Weathered rock with abundant fragments or soil
Soft rock 1 : Rock with slightly abundant fragments
Soft rock 2 : Rock in considerable fresh condition
Semi hard rock : rock in almost fresh condition
Hard rock : Rock in fresh condition

NOTES

RELATIVE DENSITY
VL VERY LOOSE
L LOOSE
M MEDIUM
D DENSE
VD VERY DENSE

CONSISTENCY
VS VERY SOFT
S SOFT
M MEDIUM
St STIFF
VSt VERY STIFF
H HARD

SAMPLE METHOD
UNDISTURBED : □ (T:Thin Wall Sampler, D : Denison Sampler)
PENETRATION : ●
CORE : ■
WATER SAMPLING : □ W

DEPTH
UPPER
RECOVERY cm/cm
LOWER

FUKKEN

Figure 5.7 Soil Investigation Results (2/6)

BORING LOG

Borehole No. : B.H - 2

PROJECT NAME : YANGON CITY WATER IMPROVEMENT PROJECT -SITE INVESTIGATION WORK
LOCATION : HLAING WATER TREATMENT PLANT (MYAUNGTAGAR VILLAGE)(Clear Water Reservoir)
BORING METHOD : ROTARY, *Direct circulation method*
BORING EQUIPMENT : A2-B

DATE : FROM 12.03.02 TO 16.03.02
ORIENTATION : VERTICAL
ELEVATION : *EL.+8.50* (m)
WATER LEVEL : GL -1.0 (m)

SCALE	ELEVATION (m)	DEPTH (m)	THICKNESS (m)	DIAGRAM	COLOUR	SOIL NAME	DESCRIPTION
1					Light Blue & Bluish Gray	Silty Sand	Very loose to loose, silty Sand with clay, light blue & bluish gray with peat pieces, low water content.
2							
3	5.10	3.40	3.40				
4	4.25	4.25	0.85		Bluish Gray	Sand	Medium, fine Sand, bluish gray, low water content.
5	3.50	5.00	0.75		Light Gray	Clay	Clay with spotted peat pieces, low water content.
6					Light Gray	Silty Clay	Stiff, silty Clay, light gray, low water content.
7							
8	0.50	8.00	3.00				
9					Dark Gray	Silty Clay	Soft to medium, silty Clay, dark gray, moderate water content.
10							
11	-2.50	11.00	3.00				
12					Gray & Dark Gray	Sand	Loose to very dense, fine to medium Sand, traced with clay at 11.0m and traced with gavels of 3mm to 5mm, moderate water content, gray and dark *gray*.
13							
14							
15							
16							
17							
18							
19							
20							
21	-13.00	21.50	10.50				
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							

Date & Depth (m)	Casing Depth (m)	Water Depth (m)	STANDARD PENETRATION TEST DEPTH (m)	Blows / cm	CURVE OF BLOW (0 10 20 30 40 50)	SAMPLEST TEST METHOD	SAMPLEST TEST DEPTH GL-(m)	SCALE (m)
	112mm	-0.80	1.00	3/30		P1		1
12.3.02	12.3.02	13.3.02						
1.50		-0.25	2.00	2/30		P2		2
		14.3.02						
		-2.00	3.00	6/30				3
		15.3.02						
		-1.00	4.00	10/30		P4		4
		16.3.02						
						D1	5.00	5
							50/50	
			6.00	9/30		P5	5.50	6
	112mm		7.00	9/30		P6		7
13.3.02	13.3.02							
7.50			8.00	4/30		P7		8
			9.00	2/30		P8		9
								10
	112mm		10.50	6/30		P9		
14.3.02	14.3.02		11.00	9/30		P10		11
10.80	15.3.02							
			12.00	10/30		P12		13
			13.00	27/30		P13		14
			14.00	50/30		P14		15
15.3.02			15.00	26/30		P15		16
13.50			16.00	37/30		P16		17
			17.00	36/30		P17		18
			18.00	33/30		P18		19
	83mm		19.00	37/30		P19		20
	16.3.02		20.00	43/30		P20		21
			21.00	46/30				22
16.3.02								23
21.50								24
								25
								26
								27
								28
								29
								30
								31
								32
								33
								34
								35
								36
								37
								38
								39
								40

Base Elevation = +2.4 m to + 10.0 m

Pile Length = 13 m to 21 m

Rock Classification

Weathered : Weathered rock with abundant
Rock : fragments or soil
Soft rock 1 : Rock with slightly abundant fragments
Soft rock 2 : Rock in considerable fresh condition
Semi hard rock : rock in almost fresh condition
Hard rock : Rock in fresh condition

NOTES

RELATIVE DENSITY

VL	VERY LOOSE
L	LOOSE
M	MEDIUM
D	DENSE
VD	VERY DENSE

CONSISTENCY

VS	VERY SOFT
S	SOFT
M	MEDIUM
St	STIFF
VSt	VERY STIFF
H	HARD

SAMPLE METHOD

UNDISTURBED : □ (T:Thin Wall Sampler, D : Denison Sampler)
PENETRATION : ●
CORE : ■
WATER SAMPLING : ▭ W

DEPTH

UPPER
RECOVERY cm/cm
LOWER

FUKKEN

Figure 5.7 Soil Investigation Results (3/6)

BORING LOG

Borehole No. : B.H - 3

PROJECT NAME : YANGON CITY WATER IMPROVEMENT PROJECT -SITE INVESTIGATION WORK
LOCATION : HLAWGA DAM (HLAWGA WATER TREATMENT PLANT)
BORING METHOD : ROTARY, Direct circulation method
BORING EQUIPMENT : A2-B

DATE : FROM 19.03.02 TO 20.03.02
ORIENTATION : VERTICAL
ELEVATION : EL+9.153 (m)
WATER LEVEL : GL.-2.1 (m)

SCALE	ELEVATION (m)	DEPTH (m)	THICKNESS (m)	DIAGRAM	COLOUR	SOIL NAME	DESCRIPTION	Date & Depth (m)	Casing Depth (m)	Water Depth (m)	STANDARD PENETRATION TEST DEPTH (m)	Blows / cm	CURVE OF BLOW 0 10 20 30 40 50	SAMPLE/ TEST METHOD	DEPTH GL-(m)	SCALE (m)
1							Hard to very hard,silty Clay,at 10.0m, silt component is increased, 0.0m to 3.0m color is yellow and 3.0m to 10.0 m gray, 1.0 m to 6.0m, no water content and 6.0 to 10.0m a little water content occurs.		112mm 19.3.02		1.00 "	50/30		P1		1
2										-2.10	2.00 "	50/13		P2		2
3										20.3.02	3.00 "	50/12		P3		3
4											4.00 "	50/11		P4		4
5					Yellowish and Gray	Silty Clay					5.00 "	50/10		P5		5
6								19.3.02 5.50			6.00 "	50/9		P6		6
7											7.00 "	50/8		P7		7
8											8.00 "	50/8		P8		8
9											9.00 "	50/17		P9		9
10	-1.347	10.50	10.50								10.00 "	50/27		P10		10
11								20.3.02 10.50								11
12																12
13																13
14																14
15																15
16																16
17																17
18																18
19																19
20																20
21																21
22																22
23																23
24																24
25																25
26																26
27																27
28																28
29																29
30																30
31																31
32																32
33																33
34																34
35																35
36																36
37																37
38																38
39																39
40																40

"Direct Foundation" was adopted

Rock Classification

Weathered Rock : Weathered rock with abundant fragments or soil
Soft rock 1 : Rock with slightly abundant fragments
Soft rock 2 : Rock in considerable fresh condition
Semi hard rock : rock in almost fresh condition
Hard rock : Rock in fresh condition

NOTES

FUKKEN

RELATIVE DENSITY

VL	VERY LOOSE
L	LOOSE
M	MEDIUM
D	DENSE
VD	VERY DENSE

CONSISTENCY

VS	VERY SOFT
S	SOFT
M	MEDIUM
St	STIFF
VSt	VERY STIFF
H	HARD

SAMPLE METHOD

UNDISTURBED : ☐ (T:Thin Wall Sampler, D : Denison Sampler)
PENETRATION : ●
CORE : ■
WATER SAMPLING : ☐ W

DEPTH

UPPER
RECOVERY cm/cm
LOWER

Figure 5.7 Soil Investigation Results (4/6)

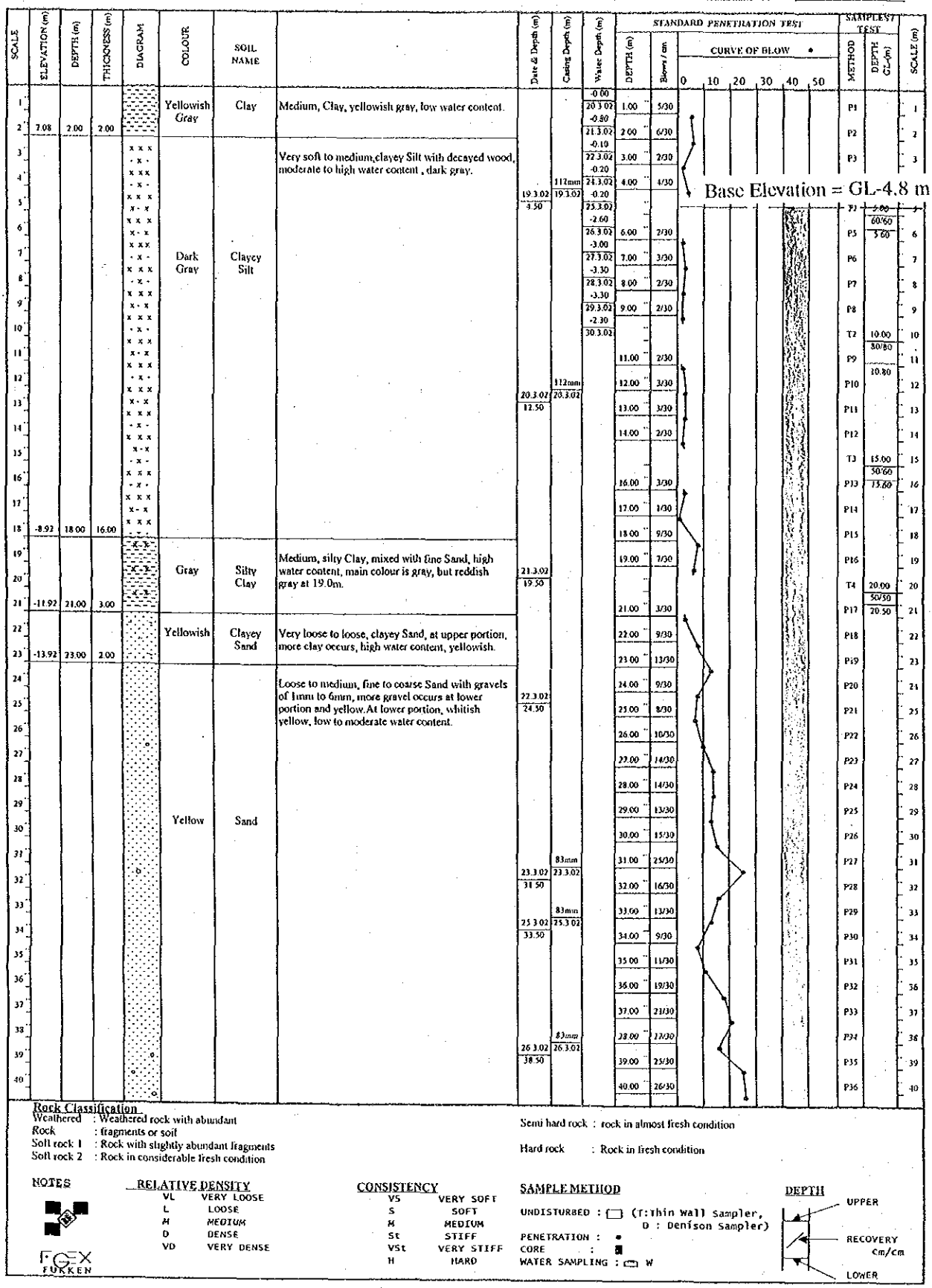


Figure 5.7 Soil Investigation Results (4/6)

BORING LOG

Borehole No. : B.II - 4

PROJECT NAME : YANGON CITY WATER IMPROVEMENT PROJECT -SITE INVESTIGATION WORK
LOCATION : HLAINGTHAYA WB :NORTH SERVICE RESERVOIR
BORING METHOD : ROTARY, Direct circulation method
BORING EQUIPMENT : TW Machine

DATE : FROM 19.03.02 TO 30.03.02
ORIENTATION : VERTICAL
ELEVATION : EL. 9.08 (m)
WATER LEVEL : GL.-2.3 (m)

SCALE	ELEVATION (m)	DEPTH (m)	THICKNESS (m)	DIAGRAM	COLOUR	SOIL NAME	DESCRIPTION	Date & Depth (m)	Casing Depth (m)	Water Depth (m)	STANDARD PENETRATION TEST DEPTH (m)	Blows / cm	CURVE OF BLOW 0 10 20 30 40 50	SAMPLE/ TEST METHOD	SAMPLE/ TEST DEPTH GL-(m)	SCALE (m)
1											41.00	23/30	Pile Length = 45 m			1
2											42.00	27/30		P38		2
3									83mm		43.00	25/30		P39		3
4	-34.92	44.00	21.00					27.3.02 43.50	27.3.02		44.00	35/30		P40		4
5											45.00	47/30		P41		5
6					Whitish Yellow	Gravelly Sand	Dense,gravelly Sand, gravel size is 2mm to 20mm, whitish yellow, low water content.				46.00	35/30		P42		6
7	-37.92	47.00	3.00								47.00	33/30		P43		7
8									83mm		48.00	18/30		P44		8
9							Medium to dense, fine to medium Sand, yellowish gray, moderate water content.	28.3.02 48.50	28.3.02		49.00	31/30		P45		9
10											50.00	39/30		P46		10
11					Yellowish Gray	Sand			83mm		51.00	31/30		P47		11
12								29.3.02 51.00	29.3.02		52.00	32/30		P48		12
13											53.00	33/30		P49		13
14	-45.42	54.50	7.50						83mm		54.00	36/30		P50		14
15								30.3.02 54.50	30.3.02							15
16																16
17																17
18																18
19																19
20																20
21																21
22																22
23																23
24																24
25																25
26																26
27																27
28																28
29																29
30																30
31																31
32																32
33																33
34																34
35																35
36																36
37																37
38																38
39																39
40																40

Rock Classification

Weathered Rock : Weathered rock with abundant fragments or soil
Soft rock 1 : Rock with slightly abundant fragments
Soft rock 2 : Rock in considerable fresh condition
Semi hard rock : rock in almost fresh condition
Hard rock : Rock in fresh condition

NOTES

RELATIVE DENSITY

VL	VERY LOOSE
L	LOOSE
M	MEDIUM
D	DENSE
VD	VERY DENSE

CONSISTENCY

VS	VERY SOFT
S	SOFT
M	MEDIUM
St	STIFF
VSt	VERY STIFF
H	HARD

SAMPLE METHOD

UNDISTURBED : ☐ (T:Thin Wall Sampler, D : Denison Sampler)
PENETRATION : ●
CORE : ■
WATER SAMPLING : ▭ W

DEPTH

UPPER
RECOVERY cm/cm
LOWER

FOEX INDEX

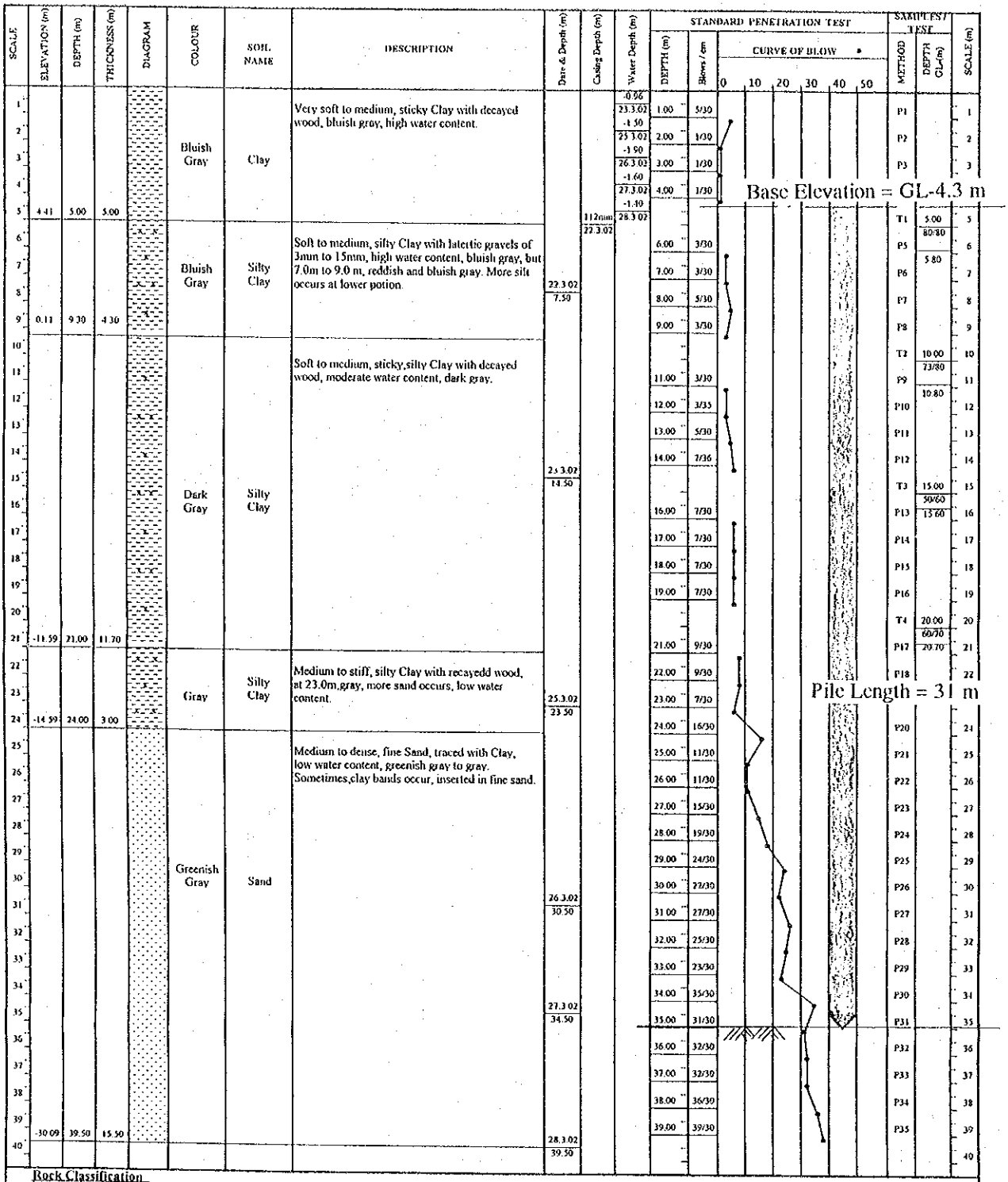
Figure 5.7 Soil Investigation Results (5/6)

BORING LOG

Borehole No. : B.H - 5

PROJECT NAME : YANGON CITY WATER IMPROVEMENT PROJECT - SITE INVESTIGATION WORK
LOCATION : THAKETA (EB ;SOUTH SERVICE RESERVOIR)
BORING METHOD : ROTARY, Direct circulation method
BORING EQUIPMENT : A2-B

DATE : FROM 22.03.02 TO 28.03.02
ORIENTATION : VERTICAL
ELEVATION : EL+9.405 (m)
WATER LEVEL : GL.-1.4 (m)



SCALE	ELEVATION (m)	DEPTH (m)	THICKNESS (m)	DIAGRAM	COLOUR	SOIL NAME	DESCRIPTION
1-5	4.41	5.00	5.00		Bluish Gray	Clay	Very soft to medium, sticky Clay with decayed wood, bluish gray, high water content.
6-9	0.11	9.30	4.30		Bluish Gray	Silty Clay	Soft to medium, silty Clay with laterite gravels of 3mm to 15mm, high water content, bluish gray, but 7.0m to 9.0 m, reddish and bluish gray. More silt occurs at lower potion.
10-21	-11.59	21.00	11.70		Dark Gray	Silty Clay	Soft to medium, sticky,silty Clay with decayed wood, moderate water content, dark gray.
22-24	-14.59	24.00	3.00		Gray	Silty Clay	Medium to stiff, silty Clay with recayedd wood, at 23.0m,gray, more sand occurs, low water content.
25-40	-30.09	39.50	15.50		Greenish Gray	Sand	Medium to dense, fine Sand, traced with Clay, low water content, greenish gray to gray. Sometimes,clay bands occur, inserted in fine sand.

Date & Depth (m)	Casing Depth (m)	Water Depth (m)
		-0.96
23.3.02		-1.50
25.3.02		-1.90
26.3.02		-1.60
27.3.02		-1.30
28.3.02	112mm	
	22.3.02	
22.3.02		
7.50		
25.3.02		
14.50		
25.3.02		
23.50		
26.3.02		
30.50		
27.3.02		
34.50		
28.3.02		
39.50		

STANDARD PENETRATION TEST DEPTH (m)	Blows / cm	SAMPLE / TEST METHOD	DEPTH GL-(m)
1.00	5/30	P1	
2.00	1/30	P2	
3.00	1/30	P3	
4.00	1/30		
		T1	5.00
			80/80
6.00	3/30	P5	
			5.80
7.00	3/30	P6	
8.00	5/30	P7	
9.00	3/30	P8	
		T2	10.00
			73/80
11.00	3/30	P9	
			10.80
12.00	3/35	P10	
13.00	5/30	P11	
14.00	7/36	P12	
		T3	15.00
			50/60
16.00	7/30	P13	15.60
17.00	7/30	P14	
18.00	7/30	P15	
19.00	7/30	P16	
		T4	20.00
			60/70
21.00	9/30	P17	20.70
22.00	9/30	P18	
23.00	7/30		
24.00	16/30	P20	
25.00	11/30	P21	
26.00	11/30	P22	
27.00	15/30	P23	
28.00	19/30	P24	
29.00	24/30	P25	
30.00	22/30	P26	
31.00	27/30	P27	
32.00	25/30	P28	
33.00	23/30	P29	
34.00	35/30	P30	
35.00	31/30	P31	
36.00	32/30	P32	
37.00	32/30	P33	
38.00	36/30	P34	
39.00	39/30	P35	

Rock Classification
Weathered : Weathered rock with abundant
Rock : fragments or soil
Soft rock 1 : Rock with slightly abundant fragments
Soft rock 2 : Rock in considerable fresh condition
Semi hard rock : rock in almost fresh condition
Hard rock : Rock in fresh condition

NOTES

RELATIVE DENSITY

VL	VERY LOOSE
L	LOOSE
M	MEDIUM
D	DENSE
VD	VERY DENSE

CONSISTENCY

VS	VERY SOFT
S	SOFT
M	MEDIUM
St	STIFF
VSt	VERY STIFF
H	HARD

SAMPLE METHOD
UNDISTURBED : ☐ (T:Thin Wall Sampler, D : Denison Sampler)
PENETRATION : ●
CORE : ■
WATER SAMPLING : ☐ W

DEPTH
UPPER
RECOVERY cm/cm
LOWER

FOKEN

Figure 5.7 Soil Investigation Results (6/6)

BORING LOG

Borehole No. : B.H - 6

PROJECT NAME : YANGON CITY WATER IMPROVEMENT PROJECT -SITE INVESTIGATION WORK
LOCATION : SOUTH OKKALAPA (COMPOUND OF T.D.C),CB :Downtown East Service Reservoir)
BORING METHOD : ROTARY, Direct circulation method
BORING EQUIPMENT : A2-B

DATE : FROM 30.03.02 TO 05.04.02
ORIENTATION : VERTICAL
ELEVATION : EL: 9.801 (m)
WATER LEVEL : GL -4.00 (m)

SCALE	ELEVATION (m)	DEPTH (m)	THICKNESS (m)	DIAGRAM	COLOUR	SOIL NAME	DESCRIPTION	Date & Depth (m)	Casing Depth (m)	Water Depth (m)	STANDARD PENETRATION TEST: DEPTH (m)	Blows / cm	CURVE OF BLOW 0 10 20 30 40 50	SAMPLE/ST TEST: METHOD	DEPTH GL-(m)	SCALE (m)
1	8.80	1.00	1.00		Gray	Clay	Soft, Clay, low water content, gray.			-2.30						1
2					Dark Gray	Clay	Very soft to soft, Clay with decayed roots, dark gray, low water content.			1.4.02 -1.60	1.00	4/30		P1		2
3										2.4.02 -2.90	2.00	3/30		P2		3
4	5.80	4.00	3.00							3.4.02 -3.60	3.00	1/30		P3		4
5					Reddish and Bluish Gray	Clay	Soft to stiff, Clay with Interitic gravels of 5mm to 10mm, reddish and bluish gray, low water content.		112min	4.4.02 -4.00 5.4.02	4.00	3/30		P4		5
6									30.3.02					T1	5.00 40/50	6
7	2.80	7.00	3.00								6.00	12/30		P5	5.50	7
8					Dark Gray	Silty Clay	Soft to medium, silty Clay with decayed wood, dark gray, moderate water content.	30.3.02 7.50			7.00	5/30		P6		8
9											8.00	4/35		P7		9
10											9.00	3/30		P8		10
11														T2	10.00 80/80	11
12	-2.20	12.00	5.00								11.00	3/30		P9	10.80	12
13	-3.45	13.25	1.25		Bluish Gray	Silty Clay	Soft to stiff, silty Clay, at 13.0m, more sand occurs, moderate water content.				12.00	4/30		P10		13
14					Gray	Sandy Silt	Medium, sandy Silt, traced with clay, low water content, gray.				13.00	14/30		P11		14
15											14.00	11/30		P12		15
16	-6.20	16.00	2.75								15.00	14/30		P13		16
17											16.00	8/30		P14		17
18					Bluish Gray	Silty Clay	Medium to very stiff, silty Clay, at 18.0m, mixed with fine sand, low water content, bluish gray.	1.4.02 18.50			17.00	7/30		P15		18
19											18.00	9/30		P16		19
20											19.00	17/30		P17		20
21														T3	20.00 75/80	21
22	-12.20	22.00	6.00								21.00	20/30		P18	20.80	22
23											22.00	11/30		P19		23
24					Dark Gray	Silty Clay	Stiff, silty Clay, dark gray, low water content.				23.00	9/30		P20		24
25											24.00	11/30				25
26								2.4.02 25.50						T4	25.00 70/80	26
27	-17.20	27.00	5.00								26.00	14/30		P22	25.80	27
28					Bluish Gray	Silty Clay	Stiff to very stiff, silty Clay, low water content, bluish gray.				27.00	15/30		P23		28
29											28.00	17/30		P24		29
30	-20.20	30.00	3.00								29.00	15/30		P25		30
31											30.00	21/30		P26		31
32					Dark Gray	Sand	Medium to very dense, fine Sand interbeded with *clayey silt, low water content, dark gray.*	3.4.02 30.50			31.00	39/30		P27		32
33											32.00	32/30		P28		33
34											33.00	33/30		P29		34
35											34.00	50/23		P30		35
36	-26.70	36.50	6.50					4.4.02 35.50 5.4.022 36.50			35.00	50/22		P31		36
37											36.00	50/20		P32		37
38																38
39																39
40																40

Base Elevation = GL-4.2 m

Pile Length = 31 m

Rock Classification

Weathered Rock : Weathered rock with abundant fragments or soil
Soft rock 1 : Rock with slightly abundant fragments
Soft rock 2 : Rock in considerable fresh condition
Semi hard rock : rock in almost fresh condition
Hard rock : Rock in fresh condition

NOTES

RELATIVE DENSITY

VL	VERY LOOSE
L	LOOSE
M	MEDIUM
D	DENSE
VD	VERY DENSE

CONSISTENCY

VS	VERY SOFT
S	SOFT
M	MEDIUM
St	STIFF
VSt	VERY STIFF
H	HARD

SAMPLE METHOD

UNDISTURBED : ☐ (T:Thin Wall Sampler, D : Denison Sampler)
PENETRATION : ●
CORE : ■
WATER SAMPLING : ▭ W

DEPTH

UPPER
RECOVERY cm/cm
LOWER

FGEX LIMITED

(6) Groundwater Development

As described in the previous chapter, groundwater development plan in Yangon City can be roughly classified into two (2) groups, namely;

- Tube well rehabilitation belonging to the main system in Hlaing River Left Bank Area
- New tube well construction in the satellite townships in Hlaing River Right Bank Area

1) Tube well rehabilitation

There are 204 existing tube wells in left bank areas of the Hlaing River. They can be divided into i) 104 regular wells, which will be utilized through the future and to ii) 100 independent wells which will be used as stand by for regular wells. Some tube wells were estimated to abandon until 2020 due to their capacity deterioration and groundwater quality. Remaining number was assessed as follows;

- Regular Well : 75 wells (29 wells are abandoned)
- Independent Well : 10 wells (90 wells are abandoned)

To multiply the production volume, daily pump operation hour shall be increased from eight hours, current average operation hour, to 16 hours.

Since some of the existing submersible pumps have been deteriorated and been repaired frequently, 20 submersible pump units will be purchased as spare unit.

2) New tube well construction

Developed surface water will be conveyed to right bank areas. While introduction of surface water to left bank areas is planned, actual implementation will be done in the later stage of the proposed construction schedule. Therefore, remote T/Ss in the right bank areas must rely on groundwater or other available water sources until they get sufficient surface water in future. The following is the number of necessary new well per T/S estimated based on the projected water demand.

Township	Number of new Wells
Dala T/S	21
Seikkyi Kanaungto T/S and Kyeemyindaing T/S (Right Bank)	21
Hlaingthaya T/S	78
Total	120

5.3 PHASING OF PROJECT IMPLEMENTATION

The project implementation period was divided into two (2) phases as follows;

Phase	Implementation Year
Phase-1	2004 to 2010
Phase-2	2011 to 2020

The implementation schedule was planned by major work items and shown in Table 5.18.

Table 5.18 Work Item List and Phasing (1/3)

No.	Facility	Dimension	Phase-1	Phase-2
1	**Rehabilitation**			
1.1	**Replacement of Aged Distribution Pipe (> 80 years old)**			
1.1.1	Botataung, Kyauktada, Lanmadaw, Latha, Pabedon, Pazundaung		O	
1.1.2	Tamwe		O	
1.1.3	Ahlone, Kyeemyindaing		O	
1.2	**Replacement of Aged Distribution Pipe (50 to 80 years old)**			
1.2.1	Sanchaung		O	
1.2.2	Mingalartaungnyunt		O	
1.2.3	Dagon, Bahan, Yankin		O	
2	**Development of Reservoir System**			
2.1	**Ngamoeyeik Reservoir System**			
2.1.1	Transmission Pipeline	Dia.1800 x 30.75 km	O	
2.1.2	Pumping Station	409,000 m3/d	O	
2.1.3	Duplication of Dia.1100 mm line	Dia.1100 x 13.28 km	O	
2.2	**Strengthen of Existing Reservoir System**			
2.2.1	Gyobyu Pump Rehabilitation (3 pumps)	3,310 m3/hr	O	
2.2.2	Phugyi Additional 1 Pump	5,160 m3/hr	O	
3	**Hlaing River System**			
3.1	**Intake Facility**			
3.1.1	Intake Facility	491,000 m3/d	O	
3.2	**Hlaing River System (1/2)**			
3.2.1	Raw Water Main	Dia.2500 x 7km	O	
3.2.2	Pumping Station	491,000 m3/d	O	
3.2.3	Water Treatment Plant	470,000 m3/d	O	
3.2.4	Transmission Pumping Station	470,000 m3/d	O	
3.2.5	Transmission Main	Dia.2000 x 33.3km	O	
3.3	**Hlaing River System (2/2)**			
3.3.1	Raw Water Main	Dia.2500 x 7km		O
3.3.2	Pumping Station	491,000 m3/d		O
3.3.3	Water Treatment Plant	470,000 m3/d		O
3.3.4	Transmission Pumping Station	470,000 m3/d		O
3.3.5	Transmission Main	Dia.2000 x 33.3km		O
4	**Terminal System**			
4.1	**Connections**			
4.1.1	Intake Facilities and Raw Water Main	729,000 m3/d	O	
4.1.2	Gyobyu Connection Pipeline	Dia.1400 x 4.2km	O	
4.1.3	Connection Pipelines to Existing Transmission Pipelines	Dia.1650 x 1.0 km	O	
		Dia.1100 x 1.3 km	O	

Table 5.18 Work Item List and Phasing (2/3)

No.	Facility	Dimension	Phase-1	Phase-2
4.2	**Terminal Reservoir (TR)**			
4.2.1	TR (2/4)	40,000 m3	O	
4.2.2	TR (1/4)	20,000 m3	O	
4.2.3	TR (1/4)	20,000 m3		O
4.2.4	Water Treatment Plant	820,000 m3/d		O
4.3	**Transmission Pumping Station**			
4.3.1	PS for Downtown		O	
4.3.2	PS for Central West, DT East, East South		O	O
4.3.3	PS for Central North, Hlawga and East North and Central		O	O
5	**Transmission and Distribution System**			
5.1	**Downtown (Zone 1)**			
5.1.1	Stengthening of Existing Transmission Pipeline	Dia. 1400 x 1.35 km	O	
5.1.2	Rehabilitation of Central Reservoir	45,450 m^3		O
5.1.3	Distribution Network		O	O
5.2	**Downtown East (Zone 2)**			
5.2.1	Transmission Pipeline (from CB West SR)	Dia.1800 x 12.2 km	O	
5.2.2	Service Reservoir	50,000 m^3 x 2 Phases	O	O
5.2.3	Distribution Pumping Station		O	
5.2.4	Distribution Network		O	O
5.3	**Central West (Zone 3)**			
5.3.1	Transmission Pipeline (From TR)	Dia.2700 x 7.5 km	O	
5.3.2	Service Reservoir	50,000 m^3 x 2 Phases	O	O
5.3.3	Distribution Network		O	O
5.4	**Hlawga zone (Zone 4)**			
5.4.1	Transmission Pipeline (From TR)	Dia.2200 x 3.9 km	O	
5.4.2	Service Reservoir	50,000 m^3 x 2 Phases	O	O
5.4.3	Distribution Network		O	O
5.5	**Central North (Zone 5)**			
5.5.1	Transmission Pipeline (From CB Hlawga SR)	Dia.900 x 6.1 km		O
5.5.2	Service Reservoir	10,000 m^3		
5.5.3	Distribution Network		O	O
5.6	**East South (Zone 6)**			
5.6.1	Transmission Pipeline (From DT East SR)	Dia.1200 x 7.6 km	O	
5.6.2	Service Reservoir	25,000 m^3 x 2 Phases	O	O
5.6.3	Distribution Pumping Station		O	
5.6.4	Distribution Network		O	O

Table 5.18 Work Item List and Phasing (3/3)

No.	Facility	Dimension	Phase-1	Phase-2
5.7	**East Central (Zone 7)**			
5.7.1	Transmission Pipeline (From East North)			O
5.7.2	Service Reservoir			O
5.7.3	Distribution Pumping Station			O
5.7.4	Distribution Network		O	O
5.8	**East North (Zone 8)**			
5.8.1	Transmission Pipeline (From CB Hlawga SR)			O
5.8.2	Service Reservoir			O
5.8.3	Distribution Pumping Station			O
5.8.4	Distribution Network		O	O
5.9	***West South (Zone 9)***			
5.9.1	Groundwater Development (including GW Transmission Pipeline)			O
5.9.2	Service Reservoir	10,000 m^3		O
5.9.3	Distribution Pumping Station			O
5.9.4	Distribution Network			O
5.10	**West Central (Zone 10) - S.khansungto**			
5.10.1	Groundwater Development (including GW Transmission Pipeline)			O
5.10.2	Service Reservoir	10,000 m^3		O
5.10.3	Distribution Pumping Station			O
5.10.4	Distribution Network			O
5.11	**West North (Zone 11) - Hlaingthaya**			
5.11.1	Groundwater Development (including GW Transmission Pipeline)		O	O
5.11.2	Service Reservoir	30,000 m^3	O	
5.11.3	Distribution Pumping Station		O	
5.11.4	Distribution Network		O	O
5.11.5	Transmission Pipeline (From TR)	Dia.500 x 9.8 km	O	O
6	**Connections**			
6.1	Connection to Hlawga No1 PS to 36 inch pipe now under construction for Dagon Myothit area	Dia.1,200 x 2.0 km	O	
7	Groundwater Management in Central Block		O	