CHAPTER 7

BASIC PLAN FOR DEVELOPMENT OF WATER SUPPLY SYSTEM

CHAPTER 7 BASIC PLAN FOR DEVELOPMENT OF WATER SUPPLY SYSTEM

7.1 Fundamentals for Planning of Basic Plan

7.1.1 Target Year

The target year for the Basic Plan is 2010. Phased development plan, however, shall be introduced in order to cope with rapid increase of water demand to the year 2010. For that reason, the intermediate target year is set at the year 2005.

7.1.2 Project Area

The project area for the Study is; the Chittagong city consisting of 41 wards with an area of 20,004 ha; a part of Hathazari Thana (P) having an area of 3,167 ha out of 11,400 ha in total; and a part of Sitakunda Thana (P) having a area of 3,744 ha of total 10,942 ha. Total study area is 26,915 ha. (Refer to Location Map)

7.1.3 Population of Project Area

The population of the project area in 2010 is estimated as follows:

Chittagong City	3,670,800
Out of Chittagong City	321,500
Project Area	3,992,300

The population of the project area in 2005 is estimated as follows:

Chittagong City	2,930,600
Out of Chittagong City	255,500
Project Area	3,186,100

7.1.4 Target Water Supply Service Level

The target water supply level in 2010 is set as follows:

(1) Ninety five percent (95 %) of households living in Pucca houses are supplied of water with house connections as well as 50 % of Semi-Pucca, and 20% of Kutcha.

(2) Remaining inhabitants of Pucca and Semi-Pucca houses are supplied of water with street hydrant as well as 20 % of peoples living in Kutcha houses. Remaining inhabitants in Kutcha houses are assumed to obtain water from other sources.

The intermediate target water supply level in 2005 is set as follows:

(1) Ninety five percent (70 %) of households living in Pucca houses are supplied of water with house connections as well as 30 % of Semi-Pucca, and 15% of Kutcha.
(2) Regarding remaining inhabitants, 10 % of Pucca and 30 % of Semi-Pucca houses are supplied of water with street hydrant as well as 20 % of peoples living in Kutcha houses. Other remaining people are assumed to obtain water from other sources.

7.1.5 Water Supply Planning Area

The water supply service area will cover whole study area in 2010. However, to cope with limited water sources including several sources to be developed by 2005, it will cover limited area in 2005 consisting of present service area and its adjacent expansion area.

7.1.6 Planned Water Supply Flow

The water demand in the service area in the target year 2010 will be 650,000 m^3/day or 143 MGD on distribution base. While, water demand in the project area in 2005 will be 344,000 m^3/day, water supply will be less due to limitation of water sources' capacity. Following water sources will fulfill the requirement in 2010:

(1) Existing/Under-processing and Planned Water Sources

i) Existing/Under-processing Water Sources

Following plants are operated or being implemented with definite schedule:

a.	Existing Mohara WTP:	91,000 m^3/day	(20 MGD)
b.	Kalurghat IRP including planned plant after the 2nd project (GOB)[1]:	68,000 m^3/day	(15 MGD)
c.	Madunaghat WTP Italian project (1st Phase):	46,000 m^3/day	(10 MGD)

[1] Present treatment capacity of the Kalurghat IRP is 15 MGD. In addition, construction project for 5 MGD new filters is under processing (out of scope of this project). Therefore total treatment capacity will be 20 MGD in 2010. However, due to shortage of production capacity of wells, water supply capacity of the Kalurghat BPS is estimated at 12 MGD in 2005 and 15 MGD in 2010.

Sub-total	205,000 m^3/day	(45 MGD)

ii) Planned Water Sources

Following plants are expected to be implemented in the future:

a. Mohara WTP expansion project planned under this Study:		
	91,000 m^3/day	(20 MGD)
b. Fatehabad IRP planned by GOB[2]:	46,000 m^3/day	(10 MGD)
c. Madunaghat WTP 2nd Phase expansion[3]:	46,000 m^3/day	(10 MGD)
Sub-total	183,000 m^3/day	(40 MGD)
Total of 1) and ii)	388,000 m^3/day	(85 MGD)

(2) New water source to be developed:

Additional water source shall be secured to fulfill the water demand in 2010 as follows:

Planned Water Demand in 2010	650,000 m^3/day	(143 MGD)
Capacity of Existing Water Source	388,000 m^3/day	(85 MGD)
Balance (Required New Water Source)	262,000 m^3/day	(58 MGD)

This additional water source shall be secured from surface water source, i.e. Karnaphuli river, because groundwater exploitation in the Study Area will be in near-limitation by the above mentioned development plans (i.e. b and c) and existing wells as discussed in Chapter 5. Since it is equivalent to 36 % of allowable groundwater exploitation in the study area, further groundwater development without adverse effect on the groundwater condition is judged to be difficult.

With regard to water sources in 2005, it will consists of existing water sources, on-going planned sources, and the Mohara WTP expansion plan. Total water source capacity in 2005 will be 282,000 m^3/day or 62 MGD[4], and distribution system will be developed in compliance with that source capacity.

---

[2] Implementation of this project is requested to GOB by CWASA. It is expected to be completed by 2005. However, in the F/S (2005), it is assumed to be an isolated water supply system to serve for the Chittagong University and the Cantonment. In 2010 plan, it is integrated with other systems.

[3] Capacity of this plant will be 20 MGD in total. After the Italian project (10MGD), expansion project (10MGD) will be implemented

[4] Capacity of Kalurghat IRP in 2005 is presumed at 12 MGD.

7.2 Basic Policy for Water Supply System Development

7.2.1 Design Policy of Existing System

Design policy of Chittagong WASA for the existing water supply system has not been clarified in the past record and reports, but it may be supposed as follows:

- The Kalurghat System was constructed in 1977 under IDA financed First Chittagong Water Supply Project. It covers the central area of Chittagong City by direct pump supply from the Kalurghat IRP & BPS with a balancing tank, i.e. the Battali Hill Reservoir. However, water has not been supplied to the Battali Hill Reservoir due to water shortage.
- In 1988, afore-mentioned Second Chittagong Water Supply Project was completed under the finance of IDA. In the project, the Mohara WTP, the ADC Hill Reservoir, the Patenga BPS, and the Dhaka Trunk Road BPS had been constructed, and the pipelines connecting those facilities and the Battali Hill Reservoir[5] were also installed.
- The Mohara WTP was constructed in 1987 to cope with the water supply capacity shortage of the Kalurghat System. The transmission line from the Mohara WTP does not distribute water in principle. Initially, it was designed to supply water to two reservoirs, i.e., the Battali Hill Reservoir and the ADC Hill Reservoir and two booster pump stations, i.e., the Dhaka Trunk Road BPS and the Patenga BPS. However, water has not been supplied to both reservoirs due to water shortage. Only the ADC Hill Reservoir has been used for water supply to its adjacent area with groundwater form wells located nearby.
- There are more two branch pipelines in the Mohara system extending to the Nasirabad Industrial Area, and one pipeline is used as an interconnection pipe with the Kalurghat system. Considering the following present operational status, additional reservoirs may be planned initially at the end of these two branches:
  - Nominal capacity of the existing clearwater reservoir of the Mohara WTP is 11,400 m^3 corresponding 3 hours retention time against the total water distribution of 20MGD (91,000 m^3/d). However, its effective capacity is less as follows:
    * By structural dimensions: 10,660 m^3, retention time = 2.8 hours
    * Effective volume taking account of inactive volume below effluent pipe: 6,720 m^3, retention time = 1.8 hours

    This short retention time indicates that the existing clearwater reservoir does not have enough capacity to function as "reservoir", which absorb hourly fluctuation of water usage.
  - Capacity of high lift pumps of the Mohara WTP is 15.80 m^3/min x 82.6 m x 5 units,

[5] The pipeline connecting the transmission line with the Battali Hill reservoir was also arranged for use as "Balancing Tank".

including one stand-by unit, and all pumps were installed at the time of commissioning of the WTP. The total pump capacity is enough to supply the water of 20 MGD (91,000 m^3/d) to the Battali Hill Reservoir as shown in Appendix 7.1.

- The Battali Hill Reservoir (13,636 m^3, retention time = 2.4 hours against 30 MGD) was constructed as a "balancing tank".

- Providing for emergency case, transmission pipes of the Mohara System and the Kalurghat System are connected by an interconnection pipe with a diameter of 600 mm and a valve.

Against above-mentioned supposed design policies, actual operational status is as follows (refer to sub-section 4.3).

- Several interconnection pipes connect the Kalurghat system with the Mohara system. They are partially opened usually in order to relieve water shortage of the Kalurghat system. Consequently, the Kalurghat system and the Mohara system cover one integrated water service area including areas served by two booster pump stations, i.e. Dhaka Trunk Road and Patenga. However, the service area has been suffered by chronic water supply interruption due to absolute water supply capacity shortage.
- Interconnection between the Kalurghat system and the Mohara system forces pump operation in lower pressure and larger discharge in the Mohara WTP. In the Mohara WTP, two units of distribution pumps are operated in daytime, while three units are operated during nighttime to supply water to high and far areas, but status of water supply interruption is not improved. Water pressure is still insufficient, and water does not reach to the Battali Hill Reservoir and the ADC Hill Reservoir.
- Since those reservoirs are not used efficiently, whole system cannot cope with peak water demand. During peak demand period, water pressure is further lowered and water supply interruption area expands.

7.2.2 System Development Policy for the Project

(1) Basic Policy

In order to cope with afore-mentioned circumstances and to improve/expand the existing facilities for the stable supply of safe drinking water, a system development plan shall be prepared based on the following policies:

- Water intake and treatment facilities shall be operated with constant load in order to maximize their capacity effectively. Especially, flow fluctuation in treatment process shall be avoided for effective and stable treatment.

- Currently, water is supplied by the system consisting of WTP, distribution pump stations, booster pump stations and reservoirs. Whole system shall be re-organized under the principle, "one reservoir serves one distribution area" for stable water supply. Inter-connection shall be provided between distribution areas providing for accidents.
- Transmission facilities, namely transmission pumps and distribution pipes, shall be designed appropriately corresponding to the average daily flow.
- Distribution facilities, namely distribution pumps, reservoirs and distribution pipes, shall be designed appropriately corresponding to the peak distribution flow. Necessary volume shall be restored prior to the peak flow period.
- In principle, water shall be supplied from reservoirs by gravity. If site with suitable high elevation is not available, ground reservoir at lower elevation and a pressure control head tank at high elevation will be provided, and water will be pumped from the reservoir to the head tank. If installation of elevated tank is unfavorable due to soil condition or whatever, water will be directly supplied through distribution pump. However, in case of direct distribution, pump control equipment will be needed to cope with water demand fluctuation and be consequently expensive.
- Reservoirs shall be provided between the treatment plants and service areas and shall be constructed near to the service area with large water demand.
- If transmission pipeline works as transmission-cum-distribution main, appropriate capacity as a distribution reservoir shall be secured at a clearwater reservoir of WTP. In case direct distribution volume is large, distribution flow shall be controlled by pump to cope with the fluctuation of water consumption, and service areas shall be delineated in appropriate extent to fit for the necessary restoration volume of reservoirs.
- Each distribution block shall be comprised of one reservoir or one distribution pump station. Shut-off valves shall be provided to the distribution pipes, which cross border of distribution blocks to divide the service area. In case of emergency, valves will be opened to enable interconnection with other service area. By these arrangements, water demand transition in each distribution block, status of water leakage and current problems in the existing system can be monitored through O&M activities. Further, data collection for future plan including facility amelioration will also be possible.
- Aged small-scale water supply system represented by "well – elevated tank – water supply by gravity" system will be used continuously for highly elevated isolated area as long as it works. However, groundwater source for such systems will be replaced with water from the recommended water supply system.
- New distribution mains and branch pipes shall be developed systematically with effective utilization of the existing distribution network in order to suppress investment cost.
- Existing tube wells scattered in MOD I area will be abolished after commissioning of new

system due to unsuitable water quality.

- To cope with rapid increase of water demand through the year 2010, phased implementation plan will be introduced with intermediate target year 2005.
- Since a period to intermediate target year 2005 is very short, only the source facilities with high possibility of realization shall be presumed as a base of water supply plan. Planned service area shall be limited in accordance with source capacity.

(2) System Development Policy

Taking account of the design policy for the existing water supply system and above-mentioned basic policies, following future system development policy is recommendable:

- Treatment Facility:

  Treatment facilities will be facilitated as follows:

a.	Mohara WTP (existing and proposed expansion):	182,000 m^3/day	(40 MGD)
b.	Kalurghat IRP (after on-going and future water source augmentation project):	68,000 m^3/day	(15 MGD)
c.	Fatehabad IRP (after 3rd WSRP):	46,000 m^3/day	(10 MGD)
d.	Madunaghat WTP (1st and 2nd phases):	91,000 m^3/day	(20 MGD)
e.	Karnaphuli WTP (Proposed)	273,000 m^3/day	(60 MGD)
	Total	660,000 m^3/day	(145 MGD)

  As presented above, a new water treatment plant will be constructed at the right bank of the Karnaphuli River, where the river slightly curves to left and river width is narrow. (Refer to Figures 7.4-1 and 7.4-2, and Supporting Report)

- Transmission / Distribution Facility:
  - The service areas will be subdivided by each reservoir. Each reservoir will cover the service block nearby them.
  - In order to secure the required reservoir capacity in whole system, several new reservoirs shall be provided at South Khulshi, Nasirabad, Salimpur, Madunaghat, Fatehabad, and the Patenga BPS. Augmentation of the capacity of the Kalurghat BPS Clearwater Reservoir and the Patenga BPS reservoir shall be conducted.
  - Distribution pipelines shall be augmented to distribute the produced water efficiently. Existing distribution pipes shall be utilized as far as possible. If the existing transmission pipelines or transmission-cum-distribution pipelines are determined to be usable as distribution pipelines, connection with the existing distribution network will be

re-arranged.

- Because of drastic increase of water demand implementation of the project shall be divided to 2 phases. First phase should be planned for the intermediate year, i.e. 2005. Based on the system to be completed in the 1st phase, 2nd phase project shall be planned.

7.3 Design Criteria

7.3.1 Water Treatment System

(1) Water Treatment Process

A treatment process with High Rate Sludge Blanket type Clarifier and Rapid Sand Filter is adopted for the existing Mohara WTP. Desilting Basins are also provided at upstream of these facilities to deal with high turbidity. The existing treatment facilities have the following characteristics;

- Raw water has turbidity of 30 to 50 NTU in the lowest level, which is advantageous for existing clarifier process.
- Desilting Basin enables peak-cut of turbidity. They are functioning effectively against high turbidity of raw water as discussed in Chapter 3.
- Flash Mixer was introduced for certain chemical dosing.
- Hydraulic loss is low
- Land requirement for existing treatment system is relatively small.

Judging from present operational status and above-mentioned characteristics, there is no reason not to select the method adopted in the existing system. Consequently, the treatment method adopted in the existing plant; i.e. High Rate Sludge Blanket Type Clarifier and Rapid Sand Filter will also be adopted for the new plant at Mohara. Proposed Karnaphuli WTP will also employ the same treatment process. Desilting basin shall be provided at upstream of these treatment facilities to lessen the turbidity during rainy season.

(2) Design Capacity

The design capacity of the Mohara WTP new plant shall be 20 MGD, and the Karnaphuli WTP shall have a capacity of 60 MGD. For determination of design capacity of the treatment facilities, water use within the yard of treatment plants and unpredictable loss shall be considered. It is totally counted as 10 percent of nominal treatment capacity.

(3) Drinking Water Standards

Proposed treatment plants shall produce drinking water in conformity with the Bangladesh Drinking Water Standard (July 1991).

(4) Intake Facilities

Intake facility with pumps will be installed. Appropriate flow control system shall be provided to pumps in order to keep stable intake flow against fluctuation of the river water level.

(5) Desilting Basin

Desilting basin will be RC made due to restriction of available land area. Suitable sludge removal device will be provided.

Surface Loading	Less than 10 mm/min
Average Velocity	Less than 0.3 m/s

(6) Rapid Mixing Chamber

Chambers and flash mixers will be installed.

Retention Time for Lime	0.16 minutes
Retention Time for Alum	0.12 minutes

(7) Clarifier

The high rate sludge blanket type clarifiers are operated in existing Mohara WTP, and its operational status is satisfactory with following condition. Same criteria will be adopted.

Upward Velocity	47.6 mm/min (40～60 mm/min)

(8) Filter

Taking account of the present condition of existing facilities, following design criteria are proposed:

Existing Plant:

Filtration Rate:	267 m/day (all units are operated)
	306 m/day (one unit is backwashed)
	297 m/day (one unit is suspended and one unit is backwashed)

New Plant:

Filtration Rate:	approx. 250 m/day (all units are operated)

Backwash Rate: approx. 1 m/min

Media Size: 0.85～1.2 mm

Media Depth: 1.2 m

(9) Clearwater Reservoir

More than 1 hour shall be secured as retention time of clearwater reservoir.

Retention Time: more than 1 hour

(10) Chemical Dosing Facilities

Though design turbidity for chemical dosage is set by 350 NTU, larger turbidity is frequently recorded including the maximum value of 830 NTU. Therefore, design maximum turbidity will be set by 850 NTU.

Since Manganese concentration of raw water is exceeding the National Standard of 0.1 mg/L, mid-chlorination shall be conducted periodically to facilitate Manganese removal by Manganese coated sand in Filter. In addition, pre-chlorination facility will be provided for algae control of desilting basins.

7.3.2 Water Transmission/Distribution System

The following design criteria was adopted for transmission and distribution pipe.

- Design flow for pipelines was decided as follows:
  Transmission pipeline: average daily flow
  Distribution pipeline: hourly peak flow
- Hazen-Williams Equation was adopted for pipe design:
  $H = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$
  where; H: head loss by friction (m)
  C: Hazen-Williams friction coefficient
  110 for Ductile Cast Iron pipe and existing Asbestos Cement pipe
  130 for PVC pipe.
  D: pipe diameter (m)
  Q: flow rate (m^3/sec)
  L: pipe length (m)

Required size of pipelines and capacity of pumps were decided based on computer based hydraulic

analysis with 72-hour long simulation. Capacities of reservoirs were also decided based on the results of simulation. Some extent of surplus capacity was added to adopted capacity.

Since reliable data is not available, the hourly peak flow is assumed to be 1.5 times[6] of average daily flow based on the investigation results in various cities in Japan (refer to the Supporting Report).

Water demand of each ward was equally distributed to nodes located in respective ward.

7.3.3 Electrical Equipment and Instrumentation

(1) General

All electrical design shall be in conformity to technical standards for electrical design applied in Bangladesh, Japan and other industrialized countries (refer to next sub-section (2)). Electrical equipment shall be selected so as to endure humidity and high temperature condition. The equipment will be simple and reliable to ensure stable and long services allowing easy and low cost operation and maintenance.

Electrical equipment will be provided at suitable location to ensure convenient inspection, cleaning and repairs without interrupting operation of the facilities. All electrical equipment and materials shall be suitable for operation under the local conditions.

(2) Design Criteria

The design criteria will be prepared conforming to the latest standard, such as ISO, BS, JIS, JEM, JEC, JCS, JEMIS, JMIF, JECA, IEC and others which has been applied for Power Development Board (PWD) electrical design works.

7.4 Recommended Chittagong Water Supply System

7.4.1 Outline of the System (refer to Figures 7.4-1 and 7.4-2)

Water sources of the proposed system are composed of three surface water treatment plants and two groundwater treatment plants as stated in sub-section 7.2.2 with a total capacity of 660,000 m^3/day or 145 MGD in 2010.

---

[6] Though measurement trials were carried out on several pipeline disposed portions in the distribution system using a portable ultrasonic flow meter, but they are failed maybe due to unsuitable internal condition of pipe. This ratio was decided based on actual investigation results in many cities in Japan.

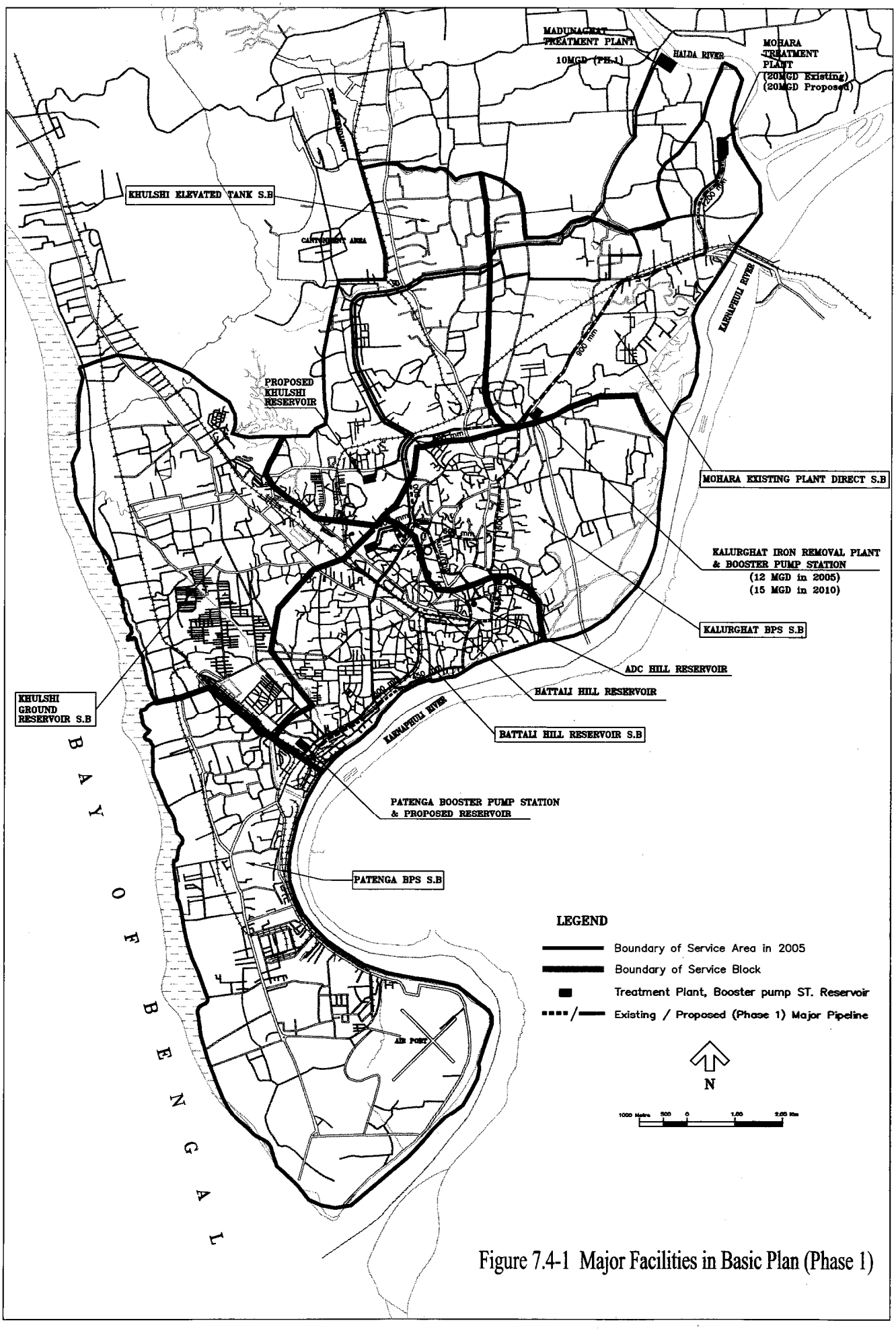


Figure 7.4-1 Major Facilities in Basic Plan (Phase 1)

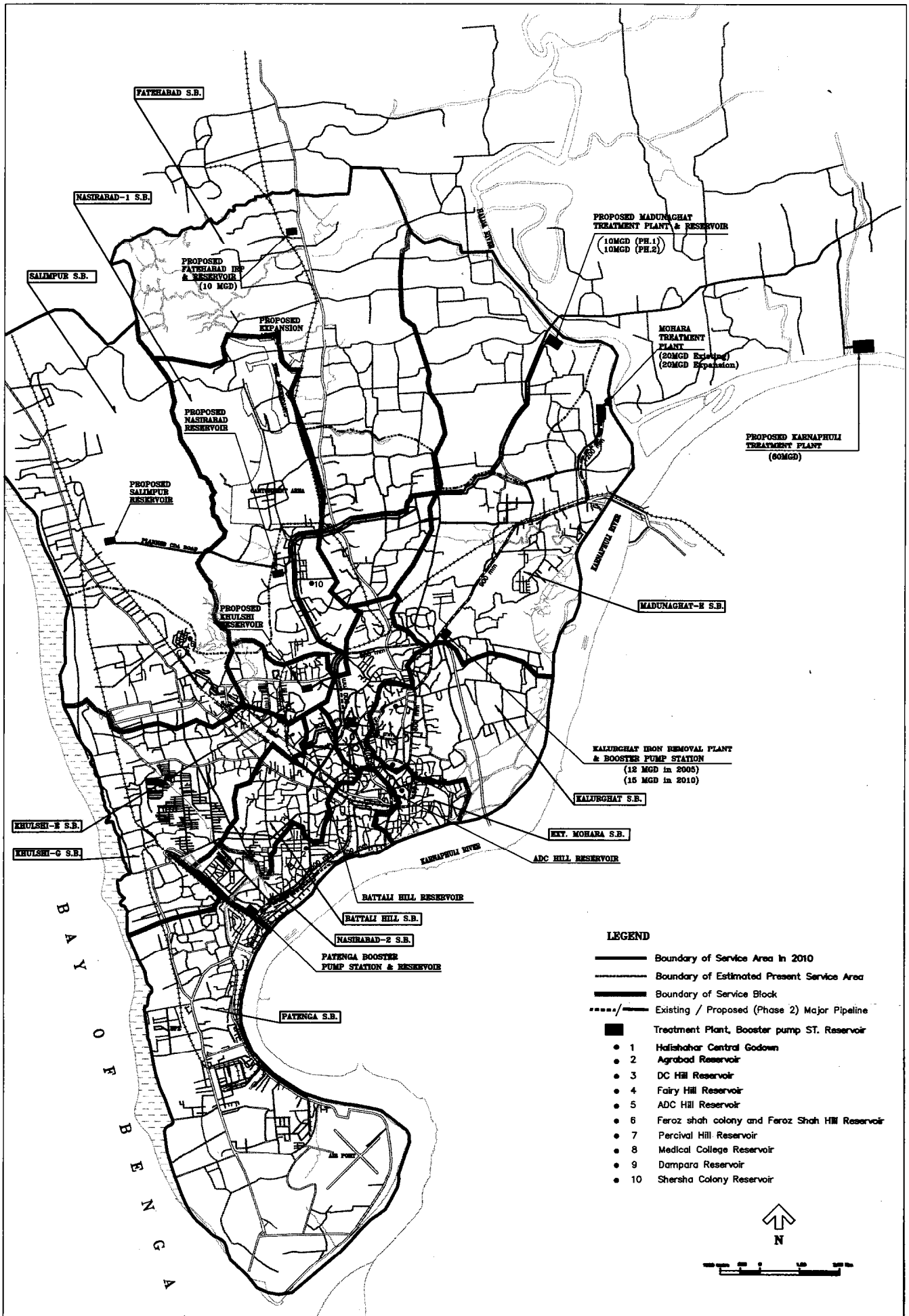


Figure 7.4-2 Major Facilities in Basic Plan (Phase 2)

The raw water will be taken from the Karnaphuli River for recommended Karnaphuli WTP to be constructed at the right bank of the river. At the Madunaghat and Mohara WTPs, raw water will be taken from the Halda River.

Besides of surface water sources, groundwater source will also be developed for the Kalurghat IRP and the Fatehabad IRP with a total distribution capacity of 113,000 m^3/day or 25 MGD. Iron and manganese contained in groundwater will be removed to allowable concentration level in both IRPs.

Usage of tube wells scattered in the MOD I area will be ceased as soon as possible after development of recommended system because of their high iron concentration and lack of on-site disinfection facilities.

Treated water of each WTP/IRP will be transmitted to 10 reservoirs and distributed to respective service blocks in 2010, while 6 reservoirs will be provided by the intermediate target year 2005. Besides of reservoirs to be constructed/augmented at the WTPs and IRPs, i.e. Karnaphuli, Kalurghat, Mohara new plant, and Patenga BPS, four new reservoirs, namely, Madunaghat, Fatehabad, Salimpur, and Khulshi, shall be constructed. Existing Battali Hill reservoir and the ADC Hill reservoir will be used effectively in the recommended system. Capacities of those reservoirs are listed in Table 7.4-1.

Table 7.4-1 Proposed Reservoirs

Reservoir	Water Source	2005	2010
1. Exist. Mohara WTP Clearwater/Distribution Reservoir	Exist. Mohara WTP	6,700 m^3	10,000 m^{3*}
2. Khulshi Ground Reservoir	Mohara WTP Exp.	19,600 m^3	19,600 m^3
3. Khulshi Head Tank	Mohara WTP Exp.	1,780 m^3	1,780 m^3
4. Exist. Kalurghat IRP Clearwater/Distribution Reservoir	Exist. Kalurghat IRP	12,700 m^{3**}	14,400 m^{3**}
5. Exist. Battali Hill Reservoir	Madunaghat WTP 1st	13,640 m^3	13,640 m^3
6. Madunaghat WTP 2nd Ground Clearwater/Distribution Reservoir, Head Tank	Madunaghat WTP 2nd	—	G: 10,000 m^3 H: 1,530 m^3
7. Fatehabad IRP Ground Clearwater/Distribution Reservoir, Head Tank	Fatehabad IRP	—	G: 10,000 m^3 H: 1,530 m^3
8. Nasirabad Reservoir Ground Reservoir, Head Tank	Karnaphuli WTP	—	G: 27,500 m^3 H: 3,620 m^3
9. Salimpur Reservoir	Karnaphuli WTP	—	11,200 m^3
10. Patenga BPS Ground Reservoir	Karnaphuli WTP#	12,000 $m^{3##}$	24,000 $m^{3##}$
(ADC Hill Reservoir)###	(Exist. Mohara WTP)	(4,500 m^3)	(4,500 m^3)
Total		66,420 m^3	139,800 m^3

*: Existing clearwater reservoir and new plant clearwater reservoir will be interconnected to be used as an integrated distribution reservoir.

**: Addition to existing clearwater/distribution reservoir of 8,500m^3 by 4,200m^3 in 2005, and by 1,700m^3 in 2010.
#: Till completion of Phase 2 project (2010) of Basic Plan, water source for Patenga BPS Reservoir will be supplied from Madunaghat WTP 1st phase through Battali Hill reservoir and Exist. Mohara WTP.
##: A half of total capacity will be completed by 2005.
###: To be utilized as a supporting reservoir in day time for the Battali Hill Reservoir in 2005, and for direct pump supply from existing Mohara Plant in 2010.

Treated water of the Kalurghat IRP and a part of treated water of the Mohara WTP old plant will be distributed directly from the plants through attached pump stations.

Existing small-scale reservoirs scattered in the service area will be utilized as far as possible for water supply to high-elevated isolated area by taking water from the recommended distribution network.

7.4.2 Proposed Treatment Facilities

Besides of existing plants and on-going projects, namely, the Mohara WTP old plant, the Kalurghat IRP, the Madunaghat WTP 1st phase, and the Fatehabad IRP, several treatment plants shall be constructed for the recommended system. Those are; the Mohara WTP new plant, the Madunaghat WTP 2nd phase, and the Karnaphuli WTP.

(1) Mohara WTP New Plant

This plant is the subject of the F/S (Phase 1 of Basic Plan). In addition to existing plant with a capacity of 20MGD, new plant with same capacity will be augmented beside of existing plant (refer to Figure 7.4-3). Details are discussed in Chapter 8.

(2) Madunaghat WTP 2nd phase

This project will be a succeeding stage of the 1st phase project being processed under the financial assistance of the Italian government. Total capacity of the Madunaghat WTP will be 91,000 m^3/day or 20 MGD and a half of it will be completed in the 1st phase project. It is assumed that this 2nd project will be completed by the year 2010.

(3) Karnaphuli WTP

This Karnaphuli WTP shall also be completed by the year 2010. Water source of the plant is the Karnaphuli river. Its flow is enough to take 66 MGD (= 60MGD x 110%) as discussed in Chapter 5. As shown in Figure 7.4-2, the WTP will be located at the right bank of the Karnaphuli River because of following reasons.

- Treated water shall be distributed in the right bank of the Karnaphuli River. If the plant is located at the right bank, river crossing of water pipeline will not be necessary.

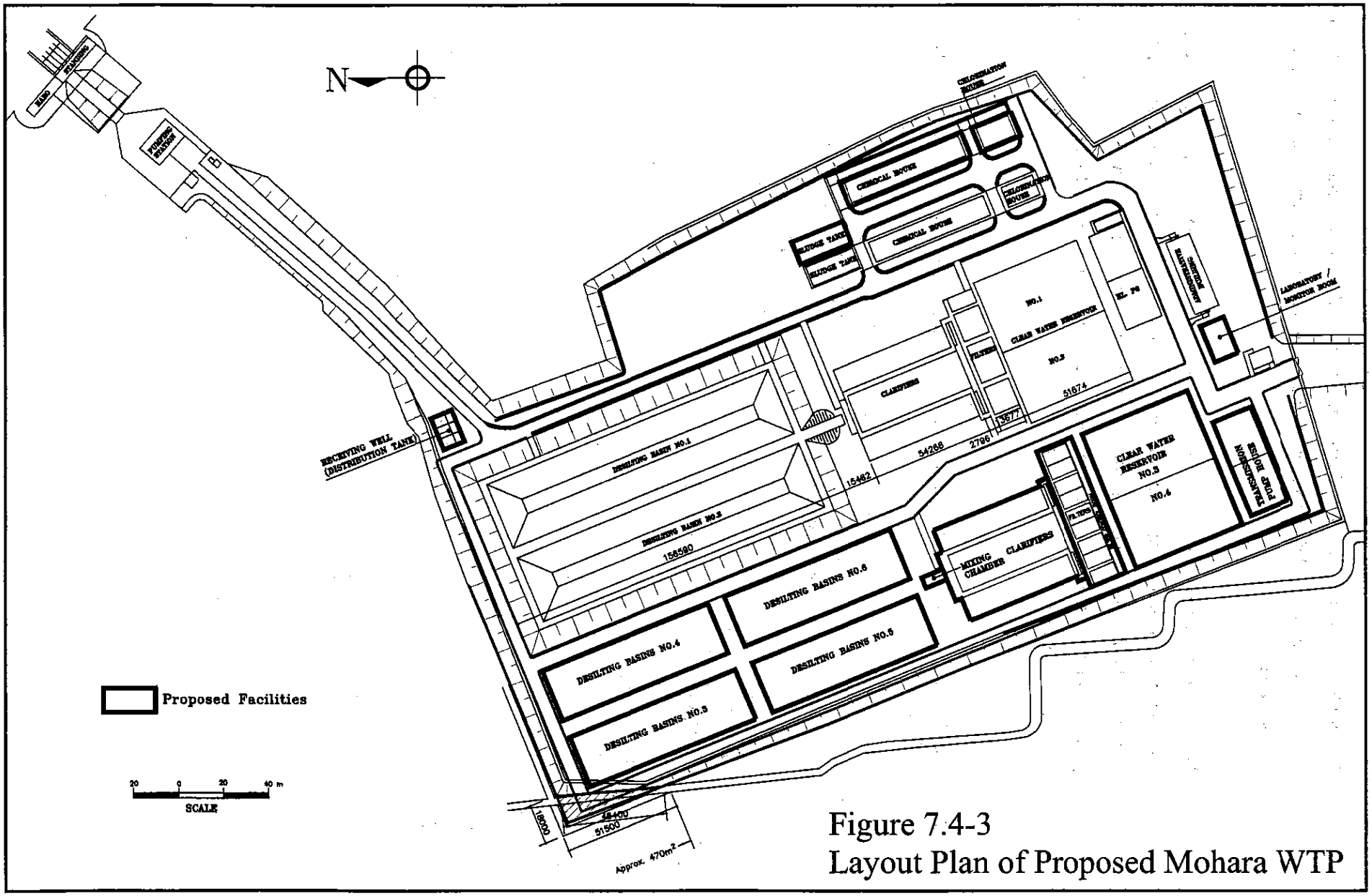


Figure 7.4-3
Layout Plan of Proposed Mohara WTP

- Right side of the river has deeper depth than other river section, because the river slightly curves to left direction at the proposed location (refer to the Supporting Report).

Layout plan of the WTP is presented in Figure 7.4-4. As shown in the figure, raw water withdrawn through the intake mouth will be lifted to a distribution basin, and then distributed to treatment process facilities consisting of two series. One series of treatment process will consists of four desilting basins, 72 units of clarifiers, 24 units of filters, and a clearwater reservoir. Required area for the plant including intake facilities will be about 10 ha.

Treatment plant development plan for the recommended system is as summarized in Table 7.4-2.

Table 7.4-2 Treatment Plants in Recommended System

Name	Production Capacity (m^3/day)	Implementation Phase (available source capacity)		
		Existing	Phase 1 (2005)	Phase 2 (2010)
Mohara WTP (existing plant)	20 MGD (90,900)	20 MGD	20 MGD	20 MGD
Mohara WTP (expansion plant)	20 MGD (90,900)	-	20 MGD	20 MGD
Kalurghat IRP (existing)	20 MGD (90,900)	10 MGD	12 MGD	15 MGD
Madunaghat WTP (1st phase)	10 MGD (45,500)	-	10 MGD	10 MGD
Madunaghat WTP (2nd phase)	10 MGD (45,500)	-	-	10 MGD
Fatehabad IRP**	10 MGD (45,500)	-	10 MGD	10 MGD
Karnaphuli WTP***	60 MGD(272,800)	-	-	60 MGD
Wells in MOD-I (existing)****	7 MGD (31,800)	7 MGD	-	-
Total*	157 MGD(713,800)	37 MGD	62MGD	145 MGD

Note: *: Existing tube wells are excluded.
**: The Fatehabad IRP will be developed outside of the service area in 2005. It will be integrated with the recommended system by 2010.
***: In order to compensate balances between capacity and water demand of other service blocks, capacity of the WTP shall be increased.
****: To be abolished after completion of the Phase 1 Project.

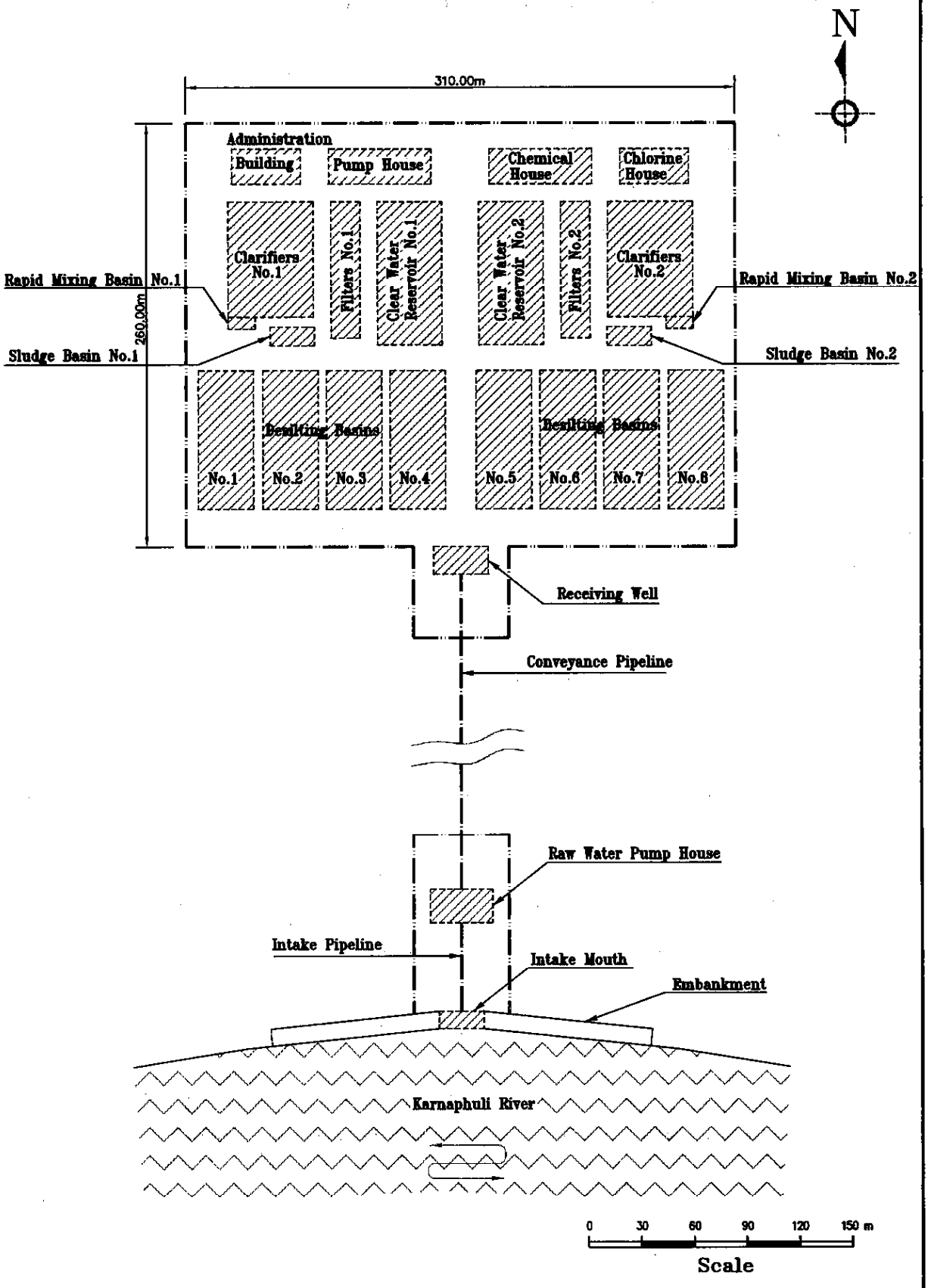


Figure 7.4-4 Layout Plan of Proposed Karnaphuli WTP

7.4.3 Comparison Study for Location of Distribution Reservoir

(1) Purpose of the study

Distribution reservoir functions as a buffer against hourly fluctuation of water demand. By this function, water treatment plant can be operated continuously with stable treatment flow, and required capacities of transmission pumps and pipeline can be less. In principle, distribution reservoirs are desirable to be located close to high water demand area to lessen cost for water distribution pipeline network. However, available land for a reservoir site is limited in general. This comparison study was conducted to identify the appropriate plan among various alternatives on location of reservoir site.

(2) Alternatives

The study was carried out on the following 7 alternatives taking account of location of land to construct the reservoir and distribution method[7] (refer to attached figures).

Case I-a:	Construction of a new reservoir at Khulshi Hill.
Case I-b:	Construction of a new reservoir at Nasirabad Hill (back of the Tea Board Factory).
Case I-c:	Construction of a new reservoir at the CWASA Nasirabad storage yard.
Case II-a:	Construction of a new reservoir beside of existing Battali Hill reservoir.
Case II-b:	Demolition of existing Battali Hill reservoir and reconstruction of a new reservoir with appropriate big capacity.
Case III-a:	Construction of new reservoir at new Mohara plant.
Case III-b:	Construction of new reservoir at new Mohara plant with a new reservoir and a booster pump station at CWASA Nasirabad storage site.

Case I-b above was further divided into the following 3 alternatives.

Case I-b-1:	Construction of a new ground reservoir at Nasirabad Hill with a head tank, and transmission to new Battali Hill reservoir through a branched pipeline.
Case I-b-2:	Construction of a new elevated reservoir at Nasirabad Hill. Other is the same to Case I-b-1
Case I-b-3:	Construction of new ground reservoir with a head tank at Nasirabad Hill

[7] Capacity of facilities, i.e. pumps, pipes and reservoirs were decided as minimum requirements for examined system. Actual facilities shall be designed including surplus capacity for ease of operation.

Case I-c above was also further divided into the following 2 alternatives.

Case I-c-1: Construction of new ground reservoir at CWASA Nasirabad storage yard with a head tank, and branched water is boosted to new Battali Hill head tank.

Case I-c-2: Construction of a new elevated reservoir at CWASA Nasirabad storage yard, and transmission to new Battali Hill reservoir through a branched pipeline.

Case III-a above was also further divided into the following 3 alternatives.

Case III-a-1: Direct distribution from a new reservoir at the Mohara plant without any head tank and reservoir outside of the plant.

Case III-a-2: Direct distribution from a new reservoir at the Mohara plant and through new Battali Hill head tank.

Case III-a-3: Direct distribution from a new reservoir at the Mohara plant through new Battali Hill head tank.

Note: Construction of a new reservoir at the Mohara WTP is possible in the premises of the plant without further land acquisition, though slight land acquisition for treatment facilities is needed.

(3) Evaluation Criteria

The following 9 items were set up for evaluation of each alternative.

a. Water supply stability against the adjustment of the "time fluctuation" related to water consumption a day
b. Ease of system control
c. Ease of maintenance
d. Construction cost
e. Operation cost for transmission and distribution pumps and riser pump for head tank
f. Net Present Value of capital cost and O&M cost
g. Availability of land
h. Workability and compensation
i. Necessity of Demolition of Existing Battali Hill Reservoir

1) Water supply stability:

In addition to transmission pumps at the new Mohara WTP, several alternatives require lift pumps to pump up water to reservoirs and head tanks. Though power will supply electricity

generators in case of power failure, it will take time to start up them and there is a possibility of failure of those generators. Consequently it would be better to store sufficient water in the reservoir from which water can be supplied by gravity. Evaluation was given as follows:

Evaluation A: gravity water supply from reservoirs.
Evaluation B: gravity water supply from head tanks at reservoirs.
Evaluation C: gravity water supply from head tanks.
Evaluation D: System without reservoirs and head tanks.

2) Ease of system control:

In the operation of supply system of the new Mohara plant, some alternative will require high-level control technology to stabilize and secure the required water supply pressure. Evaluation was given as follows:

Evaluation A: water supply from distribution reservoir by gravity.
Evaluation B: intermediate
Evaluation C: water supply directly by pumps.

3) Ease of maintenance:

Some alternatives require new pump station in addition to new pump station at the Mohara WTP. Evaluation was given as follows:

Evaluation A: to give the system with Mohara WTP pump station only.
Evaluation B: to give the system with several reservoirs/head tanks, and Mohara WTP pump station.
Evaluation C: to give the system with Mohara WTP pump station and other pump stations.

4) Construction cost:

The cost includes distribution pumps, transmission pipe, reservoir, distribution pipe and land cost for the comparison. Costs for works common to each alternative are excluded from the evaluation. The extension and expansion of distribution main pipe regarding the existing Mohara and new Madunaghat WTPs is not included in this cost.

Evaluation was given as follows:

Evaluation A: Alternative with least cost and others within 5% increase.
Evaluation B: Alternatives within 15% increase against the lease cost.
Evaluation C: Alternatives within 25% increase against the lease cost.
Evaluation D: Alternatives more than 25% increase against the lease cost.

5) Operation and maintenance cost:

Pump operation cost is estimated for operation period of 30 years for comparison. In addition,

3% of mechanical and electrical equipment cost is added annually as maintenance costs.

Evaluation was given as follows:

Evaluation A: Alternative with least cost and others within 5% increase.

Evaluation B: Alternatives within 15% increase against the lease cost.

Evaluation C: Alternatives within 25% increase against the lease cost.

Evaluation D: Alternatives more than 25% increase against the lease cost.

6) Net Present Value of capital cost and O&M cost:

Net present value (NPV) of capital cost and O&M cost during operation period of 30 years was calculated based on 7% discount rate. Evaluation was given as follows:

Evaluation A: Alternative with least NPV and others within 5% increase.

Evaluation B: Alternatives within 15% increase against the least NPV

Evaluation C: Alternatives within 25% increase against the least NPV

Evaluation D: Alternatives more than 25% increase against the least NPV

7) Availability of land:

Evaluation A: to give CWASA's land

Evaluation B: to give Government land

Evaluation C: to give private land

Evaluation D: to give no available land for construction of reservoir having a required capacity

The land price was given by CWASA as a reference price only for comparison purpose.

8) Workability and Compensation:

Evaluation A: No serious difficulty for the construction work

Evaluation B: Limited space for pipeline construction work (at Battali Hill)

Evaluation C: Same as above + Limited land area for reservoir construction work

9) Necessity of Demolition of Existing Battali Reservoir:

Evaluation A: Not necessary (No work on Battali Hill)

Evaluation B: Not necessary (Work will be done on Battali Hill)

Evaluation D: Necessary

(4) Cost Estimates

1) Construction cost

Direct construction costs of each case by work item including land cost are summarized below.

Table 7.4-3 Direct Construction Costs of Each Case

Unit: Tk million

Items[*4]	I-a	I-b-1	I-b-2	I-b-3	I-c-1	I-c-2	II-b [*6]	III-a -1	III-a -2	III-a -3	III-b
1.MWTP, Civil work[*1] (plant)	65	65	65	65	65	65	65	112	120	120	65[*7]
2. Civil work[*2] (pipes)	284	378	378	206	410	393	396	—	28	444	144
2. M&E[*1]	207	206	206	184	156	206	206	343	294	333	160
3.Reservoir[*3], Civil Work	170	95	49	205	202	54	—	—	—	—	157
4. M&E[*4]	93	78	—	193	247	—	—	—	—	—	175
5.Battali new reservoir, Civil work	—	122	123	—	78	123	160	—	83	104	83
6.Battali old reservoir, Civil work	—	114	114	—	—	123	123	—	—	—	—
7.Distribution pipe	204	190	190	258	200	198	221	587	674	232	544
8.Land cost	145	39	17	112	73[*5]	17[*5]	0	0	0	0	73[*5]
Total	1,168	1,287	1,146	1,223	1,433	1,179	1,171	1,042	1,199	1,233	1,401
Ratio to Case I-a (=1.00)	**1.00**	**1.10**	**0.98**	**1.05**	**1.23**	**1.01**	**1.00**	**0.89**	**1.03**	**1.06**	**1.20**

Note:

*1. Cost consists of Clearwater Well or Distribution Reservoir, Pumps, In-plant pipeline, and Power Supply Facilities. Costs for works common to each case are excluded from above estimates.

*2. The transmission pipe installation cost with material.

*3. Costs for reservoirs outside of Mohara WTP.

*4. Difference of the M&E cost in reservoir depends on big riser pump capacity for its head tank. The pump capacity is decided on hourly maximum demand flow, average demand flow x 1.5, while operation time of the pump is calculated by 16 hours (24 x 1/1.5).

*5. Cost of land acquisition for new storage.

*6. Case II-a; construction of a new reservoir beside the existing Battali Hill reservoir, is not examined because of difficulty of the construction work due to limited land space.

*7. Required capacity of the reservoir can be accommodated with the capacity of clear water well.

2) Comparison condition of construction and operation costs

The comparative cost is estimated for a period of 30 years. The material life for M&E is estimated for 15 years and adapted power charge is Tk 2.95/kwh.

Net present value is computed based on the discount rate of 7.0 %.

3) Summary of cost comparison

Construction cost, operation and maintenance cost, and net present value of both costs are summarized as shown in the following table (refer to attached tables):

Table 7.4-4 Cost Comparison

Unit: Tk million

Items	I-a	I-b-1	I-b-2	I-b-3	I-c-1	I-c-2	II-b	III-a -1	III-a -2	III-a -3	III-b
1.Construction Cost	1,424	1,603	1,423	1,501	1,770	1,469	1,465	1,302	1,498	1,543	1,733
Ratio to Case I-a (=1.00)	1.00	1.13	1.00	1.05	1.24	1.03	1.03	0.91	1.05	1.08	1.22
2.Annual O & M Cost	46.1	41.8	37.7	47.1	43.3	37.7	38.8	35.3	36.8	42.8	42.4
Ratio to Case I-a (=1.00)	1.00	0.91	0.82	1.02	0.94	0.82	0.84	0.77	0.80	0.93	0.92
3.Net Present Value	1,692	1,796	1,596	1,771	1,965	1,635	1,640	1,477	1,656	1,754	1,920
Ratio to Case I-a (=1.00)	**1.00**	**1.06**	**0.94**	**1.05**	**1.16**	**0.97**	**0.97**	**0.87**	**0.98**	**1.04**	**1.13**

Note: 1) Construction cost includes overhead and profit of contractor (25% of direct. cost) and land cost.
2) Net Present Values are calculated for 30 years operation after 3-year construction period based on 7% discount rate.

(5) Evaluation Results

The evaluation results of each item are summarized as shown below.

Table 7.4-5 Evaluation Results

Items	I-a	I-b-1	I-b-2	I-b-3	I-c-1	I-c-2	II-b	III-a -1	III-a -2	III-a -3	III-b
1. Stability	B	B	A	B	C	A	A	**D**	**D**	C	**D**
2. Ease of System Control	A	A	A	A	A	A	A	**D**	**C**	B	**C**
3. Ease of Maintenance	C	C	B	C	C	B	B	A	A	A	C
4. Construction cost	B	C	B	B	D	B	B	A	B	C	D
5. O & M Cost	D	C	B	D	C	B	B	A	A	C	C
6. Total Cost NPV	B	C	B	C	D	B	B	A	B	C	D
7. Availability of land	C	C	C	C	A	A	A	A	A	A	A
8. Workability and Compensation	A	C	C	A	C	C	C	A	C	C	C
9. Necessity of existing Battali Hill reservoir demolition	A	**D**	**D**	A	B	**D**	**D**	A	B	B	B
Evaluation Result*	3A 3B 2C 1D (1)	1A 1B 6C 1D (10)	2A 4B 2C 1D (6)	3A 2B 3C 1D (5)	2A 1B 4C 2D (9)	3A 4B 1C 1D (3)	3A 4B 1C 1D (4)	7A 0B 0C 2D (2)	3A 3B 2C 1D (8)	2A 2B 5C 0D (7)	1A 1B 4C 3D (11)

*: Numbers in parentheses indicate the order based on weighted pointing evaluation (refer to Supporting Report).

1) As a result of comparison study, Case I-a; a plan of construction of new reservoir at Khulshi is given the highest point, but availability of land is evaluated as C. Even if land cost increase 1.5 times its position in ranking will be down under next ranked case. Among the practical cases, i.e. Cases I-a, I-b-3, I-c-1, and III-a-3 that are evaluated without D for items 1 and 9, Case I-a is most economical followed by Cases III-a-1 and I-b-3.

2) Case III-a-1, a plan of direct distribution from Mohara WTP reservoir given the 2nd highest

point. Since this system requires high-level control technology and techniques for stable water supply, this alternative is not recommendable from technical point of view.

3) Case I-c-2; a plan of construction of an elevated reservoir at CWASA Nasirabad storage site and an elevated ground reservoir at Battali Hill is given the 3rd highest point. This plan, however, requires demolishment and reconstruction of existing Battali Hill reservoir and a religious monument. In addition, pipeline construction work along the access road to the Hill requires permanent and/or temporary relocation of residents along the road.

4) Case II-b, a plan of demolition of existing Battali Hill reservoir and reconstruction is given the 4th highest point. But pipeline construction work along the access road to the Hill requires permanent and/or temporary relocation of residents along the road. In addition, this case needs the demolition and reconstruction of existing Battali Hill reservoir.

5) Case I-b-3, a plan of construction of a new reservoir and a beamed head tank at Nasirabad, is given the 5th highest point though O&M cost is the highest.

6) Case I-b-2; a plan of demolition of existing Battali Hill reservoir and reconstruction with Nasirabad elevated reservoir is given the 6th highest point. Pipeline installation work along the access route to the hill requires careful consideration as same as Case II-b.

7) Case III-a-3, a plan of direct distribution through Battali Hill head tank is given the 7th highest point. Among the practical cases, this option is economical next to Case I-a. However, construction work at Battali Hill and pipeline along the access route to the hill requires careful consideration as same as Case II-b.

(6) Recommendation

1) From technical viewpoint, Case I-b-2, Case I-c-2, and Case II-b are recommendable because of their highly evaluated system stability and ease of operation. These cases, however, require demolishment and reconstruction of existing Battali Hill reservoir. The cases ranked following to them are Case I-a, Case I-b-3, Case I-b-1, and Case III-a-3. They do not require demolishment of existing Battali Hill reservoir, except Case I-b-1.

Case III-a-1 is not recommendable because high-level control technology is needed for stable water supply.

2) From economical viewpoint, judging based on NPV of total costs during construction period and 30-year operation period, Case III-a-1, Case III-a-2, Case I-b-2, Case I-c-2, Case II-b, and Case I-a, are recommendable followed by Case I-b-1, Case III-a-3 and Case I-b-3.

   Among the practical options, Case I-a has a stable position even if the land price increases to 1.5 times of assumed price. Though its O&M cost is high, NPV of total cost is the least due to the least capital cost among the practical options.

3) From practical viewpoint, provided relocation of the religious monument on the top of Battali Hill is not allowed, only Cases I-a, I-b-3, I-c-1, III-a-1, III-a-2, III-a-3 and III-b are possible to be implemented.

   In addition, further provided land acquisition from other party is impossible, only Cases I-c-1, III-a-1, III-a-2, III-a-3 and III-b are possible to be implanted. However, those cases are ranked at rather low position, except Case III-a-1. However, it is not recommendable because of technical reason.

4) As a conclusion, assuming demolishment of existing Battali Hill reservoir and relocation of the religious monument are not allowed, Case I-a is the most recommendable plan followed by Case I-b-3, and Case III-a-3. If the land acquisition at Khulshi site is not possible, Case I-a cannot be implemented. While, availability of the land behind the Nasirabad Tea Board Factory land is the key factor of Case I-b-3. Case III-a-3 has a difficulty to some extent in the construction work of pipeline in access route to the Battali Hill. Permanent/temporary relocation of the residents along the access rote is necessary.

5) If demolishing of existing Battali Hill reservoir and relocation of the religious monument are allowed, Case I-c-2 is the second recommendable plan.

6) Because of technical reason, Case III-a-1; direct distribution system by pumps from the new reservoir at the Mohara plant, should not be selected unless other cases cannot be implemented.

7.4.4 Transmission / Distribution Facilities

(1) Water Supply Service Block

The distribution system shall be improved and enhanced because the capacity of water sources will be

augmented to about 1.7 times of present capacity in 2005 and about 3.9 times in 2010. As stated in previous sections, whole water supply system will be fractionalized into 6 service blocks being consisted respective water source and distribution reservoir by the year 2005. And in target year 2010, it will be further fractionalized into 10 blocks in total. Construction of reservoirs shall be implemented in accordance with progress of water source development program as shown in Table 7.4-6:

Each area to be served from those reservoirs will form an individual service block. Valves will separate boundaries of each service block. Location of boundaries was decided based on the results of hydraulic analysis of pipeline network.

Table 7.4-6 Proposed Service Blocks

Service Block	Reservoir	Type of Dist.	Construction of Reservoir	
			2005	2010
1. Exist. Mohara WTP	Exist. Mohara CW/Dist. Reservoir	Pumped Flow	cont. use	connection w/new plant
2. Mohara WTP Exp.-1	Khulshi Ground R.	Gravity Flow	new	cont. use
3. Mohara WTP Exp.-2	Khulshi Head Tank	Gravity Flow	new	cont. use
4. Kalurghat IRP	Kalurghat CW/Dist. R.	Pumped Flow	expansion	expansion
5. Madunaghat WTP 1st	Exist. Battali Hill R.	Gravity Flow	repair	cont. use
6. Madunaghat WTP 2nd	Madunaghat CW/D R. (ground + head tank)	Gravity Flow	—	new
7. Fatehabad IRP	Fatehabad CW/D R. (ground + head tank)	Gravity Flow	—	new
8. Karnaphuli WTP-1	Nasirabad R. (ground + head tank)	Gravity Flow	—	new
9. Karnaphuli WTP-2	Salimpur R.	Gravity Flow	—	new
10. Karnaphuli WTP-3	Patenga R.	Pumped Flow	new	expansion

Legend: cont. use - continuous use as it is
connection w/new plant – connect existing reservoir with a reservoir of new plant to utilize a half of its capacity

(2) Distribution Network

Existing pipeline network model for the hydraulic analysis was established based on the various data, record, and information in design section and MOD sections. Based on this present network model, future pipeline network models were developed as presented in Figures 7.4-5 and 7.4-6 for Phase 1 and Phase 2 respectively, and hydraulic analyses were conducted for both models. Boundaries of service blocks were also presented in both figures.

In the network analysis, following considerations were given:

- Existing pipelines shall be utilized in the proposed network system as far as possible.

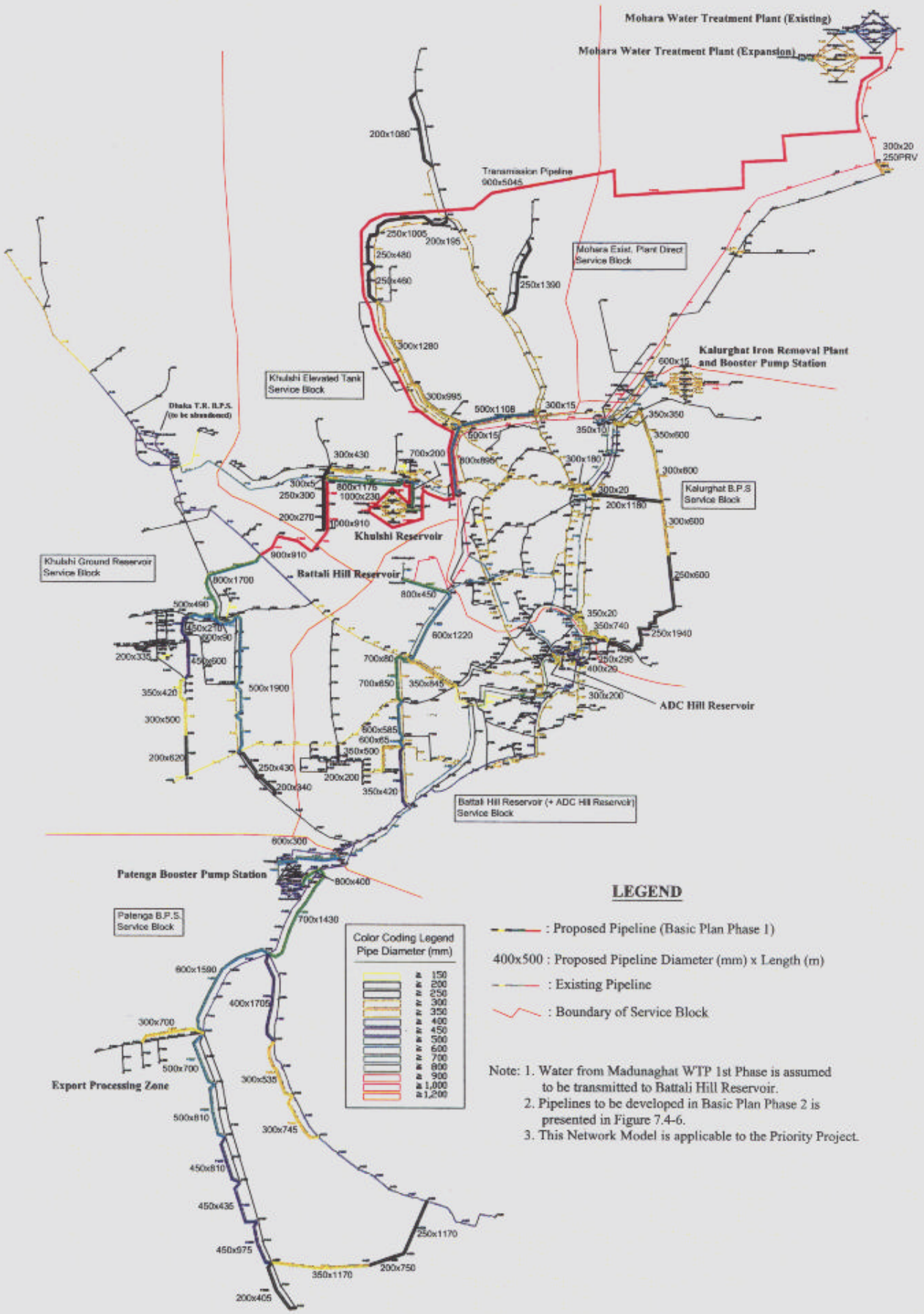


Figure 7.4-5 Proposed Pipeline Network for Basic Plan (Phase 1, 2005)

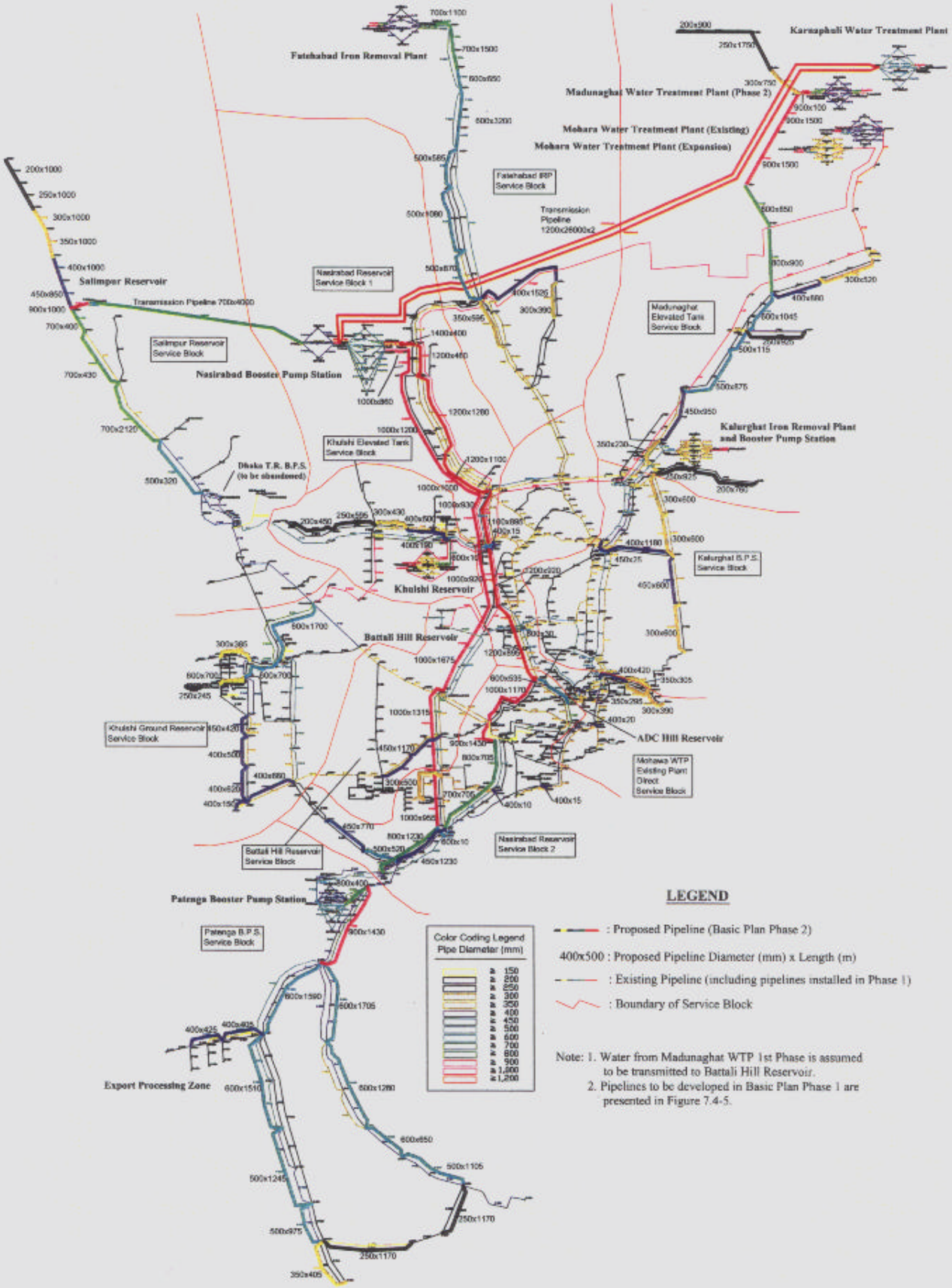


Figure 7.4-6 Proposed Pipeline Network for Basic Plan (Phase 2, 2010)

- Pipelines development program is scheduled in two phases, namely Phase 1 for 2005 and Phase 2 for 2010 because of large difference of the water demand between both years.
- Hydraulic analysis was conducted on primary distribution system consisting of pipelines with a diameter of 200mm or larger. Cost for development of secondary distribution system was estimated separately based on the assumed area to be developed[8].
- Minimum hydraulic pressure at any node in the distribution network was designed to be maintained at 98 kPa or 10m of hydraulic column.

As a result of analysis with above considerations, most of pipelines to be developed is planned as reinforcement pipelines paralleling with existing pipelines as presented in Figures 7.4-5 and 7.4-6.

The transmission pipeline from the Karnaphuli WTP will be laid along the Kaptai Road and the Planned CDA Road. A reservoir receiving the water from the Karnaphuli WTP will be constructed at Nasirabad.

(3) Distribution Reservoir

By the year 2010, several reservoirs shall be developed or rehabilitated as follows:

a) Clearwater Reservoir of Mohara WTP Old Plant (Phase 1)

Since capacity of the existing old plant clearwater reservoir is not enough for planned distribution system in 2010, a half of the new clearwater reservoir of the proposed new plant will be interconnected with the one of the old plant. Existing transmission pumps has enough capacity for planned supply system.

Water treated at the Mohara WTP old plant will be transmitted to the Battali Hill reservoir. Remaining will be distributed directly in the central area of the city. Therefore, the service blocks for the Mohara WTP old plant are the area covered by the Battali Hill reservoir and the direct distribution area including the ADC Hill reservoir.

b) Battali Hill Reservoir (Phase 1)

Though physical soundness of the Battali Hill reservoir is under examination by CWASA, it is assumed that the Battali Hill reservoir is used as it is after required repair work as a

[8] Refer to the Supporting Report.

distribution reservoir receiving water transmitted from the Madunaghat WTP 1st phase project and excess of transmitted water from the Mohara WTP old plant.

An exclusive transmission pipeline will transmit water from the Madunaghat WTP 1st phase plant.

Existing 600mm dia. distribution line connecting the reservoir with the Kalurghat system shall be replaced with 800mm dia. DCIP pipeline to secure required flow capacity, because, in this section, width of the road is very narrow and is judged it is hard to install a required 600mm dia. additional pipeline without shifting existing pipeline. Considering the difficulty of construction work and cost requirement, it was judged appropriate to replace the pipeline with a new one.

c) ADC Hill Reservoir (Phase 1)

Water source providing to this reservoir is the Mohara WTP old plant. Since capacity of the reservoir is not enough to serve the adjacent area fully, it will function as a balancing tank; in other words, it will work as a supplemental water supply source during water demand peak hours. Connection with distribution system with two pipelines is assumed in the hydraulic analysis.

d) Khulshi Reservoir (Phase 1)

A new distribution reservoir for water transmitted from the Mohara WTP new plant shall be provided. Based on the comparison study on various alternatives, a site at South Khulshi was judged recommendable because of its economical cost (refer to sub-section 7.4.3).

Water transmitted from the Mohara WTP new plant will be sent via a new transmission pipeline to the proposed ground reservoir. Discussion about the transmission pipeline route is presented in Chapter 8.

From proposed Khulshi reservoir, water can be distributed by gravity from the ground reservoir to western area of the city. However, other inland area, such as Khulshi Hills and Nasirabad Industrial Area, shall be supplied from an elevated reservoir to be located at the site. Water will be lifted up to an elevated tank by lift pumps, and then distributed to the service area.

Existing transmission pipeline to the Dhaka Trunk Road BPS will be connected with the proposed ground reservoir. Since water can reach to the end of northward pipeline in Sitakunda Thana, operation of the Dhaka Trunk Road BPS may be ceased after Phase 1 project.

Following facilities will be provided at the Khulshi reservoir site.

Ground Reservoir: 19,600 m^3
Lift Pump: 13.1 m^3/min x 25m x 90 kW x 4 units (incl. 1 stand-by unit)
Elevated Tank: dia. 18m x 7mD x 25mH (to LWL)

e) Kalurghat BPS (Phase 1, Phase 2)

The Kalurghat BPS is attached to the IRP. Direct pumping distribution method will be adopted in the Kalurghat System because there are no heights around the Kalurghat BPS and service areas.

Since the capacity of the existing clearwater reservoir is not enough for the planned distribution system, augmentation of the reservoir with a capacity of about 4,200 m^3 is needed in the Phase 1, and additional 1,700 m^3 in 2010. Capacity of existing pumps is enough for planned distribution volume in 2010.

f) Madunaghat Reservoir (Phase 2)

A new distribution reservoir for treated water of the Madunaghat WTP 2nd phase shall be provided at the location inside the WTP site of nearby land. Water shall be lifted to an elevated tank by pumps for gravity flow distribution. Therefore, clearwater reservoir of the plant shall have enough capacity of 10,000m^3as a distribution reservoir.

Following facilities will be provided at the Madunaghat reservoir site.

Lift Pump: 15.6 m^3/min x 35m x 150 kW x 4 units (incl. 1 stand-by unit)
Elevated Tank: dia. 18m x 6mD x 25mH (to LWL)

g) Fatehabad Reservoir (Phase 1, Phase 2)

A new distribution reservoir for treated water of the Fatehabad IRP shall be provided at the location outside of present service area. Though the Fatehabad IRP will be developed by the year 2005, it will function for an isolated separate water supply system. In Phase 2, it

will be integrated to the recommended water supply system as presented in Figure 7.4-3. Water shall be lifted to an elevated tank by pumps for gravity flow distribution. Therefore, the clearwater reservoir of the plant shall have enough capacity of 10,000m^3as a distribution reservoir.

Following facilities will be provided at the Fatehabad reservoir site.

Lift Pump: 15.6 m^3/min x 35m x 150 kW x 4 units (incl. 1 stand-by unit)
Elevated Tank: dia. 18m x 6mD x 25mH (to LWL)

h) Nasirabad Reservoir (Phase 2)

Treated water at the Karnaphuli WTP will be sent to the Nasirabad ground reservoir through exclusive transmission pipelines consisting of paralleling two 1200mm dia. pipelines. .

A part of water will be distributed from an elevated reservoir to be constructed in the Nasirabad reservoir site. Remaining water will be lifted up to an elevated ground tank to be constructed at Salimpur by lift pumps, and then distributed to the service area. Diameter of transmission pipeline to the Salimpur reservoir will be 600 mm with a length of 4,000 m.

In addition, a transmission pipeline with a diameter of 1,000 mm and a length of 11,300 m will be provided for exclusive use for transmission to the Patenga BPS. For this purpose, transmission pumps will also be provided at the Nasirabad reservoir.

Transmission pump at the Karnaphuli WTP is as follows:

Transmission Pump: 48m^3/min x 71.5m x 920 kW x 5 units (incl. 1 stand-by unit)

Following facilities will be provided at the Nasirabad reservoir site.

Ground Reservoir: 50,000 m^3
Lift Pump: 38.4 m^3/min x 28.5m x 300 kW x 4 units (incl. 1 stand-by unit)
Elevated Tank: dia. 24m x 8mD x 25mH (to LWL)
Transmission Pump to Patenga BPS:
38.7 m^3/min x 22.5m x 240 kW x 3 units (incl. 1 stand-by unit)
Transmission Pump to Salimpur reservoir:
18 m^3/min x 48.5m x 240 kW x 3 units (incl. 1 stand-by unit)

i) Salimpur Reservoir (Phase 2)

A new distribution reservoir for water transmitted from the Nasirabad reservoir will be provided at the location on a hill in Salimpur. This elevated ground reservoir will distribute the water by gravity to the service area spreading along the Dhaka Trunk Road.

Following facilities will be provided at the Salimpur reservoir site.

Elevated Ground Reservoir: 1,400m^2 x 8mD (to be located on a hill with 47 m LWL)

j) Patenga BPS (Phase 1, Phase 2)

Water source for the Patenga BPS will be the Mohara WTP old plant after the Phase 1. In the Phase 2 project, water source will be shifted to the proposed Karnaphuli WTP to cope with increasing water demand in the service block. An exclusive transmission pipeline via the Nasirabad reservoir and pump station will transmit water from the Karnaphuli WTP to the BPS.

New distribution pumps shall be provided at the Patenga BPS to augment present pumping capacity drastically. In addition, a ground distribution reservoir cum receiving well with a capacity of 12,000 m^3 to receive water transmitted from the Mohara WTP old plant in the Phase 1 and additional reservoir with a capacity of 12,000 m^3 to receive water transmitted from the Karnaphuli WTP, via Nasirabad BPS, shall be provided in Phase 2. Existing pumps shall be used till completion of phase 2 pumps.

Capacity of new distribution pumps to be added to existing pumps is as follows:

19.2 m^3/min x 37 m x 200 kW x 3 units (incl. 1 stand-by) (Phase 1)

27.6 m^3/min x 37 m x 280 kW x 3 units (incl. 1 stand-by) (Phase 2)

7.4.5 Summary of Proposed Facilities

Proposed facilities for B/P are summarized in Table 7.4-7. Out of the Phase 1 Project, components to be implemented as a minimum requirement to receive and distribute the water from the Mohara WTP new plant are extracted as an urgent project.

Table 7.4-7 Proposed Facilities in Basic Plan

Facilities	Diameter (mm)	Material	Phase 1		Phase 2	Total
			Urgent*	2005	2010	
1 Mohara WTP New Plant Service Area						
WTP Treatment Plant 20MGD			20MGD	-	-	20MGD
Transmission Pump 15.8m3/min x 84 m x 350 kW x 4 (+1)			5 units	-	-	5 units
Transmission Pipeline	900	DCIP	15,045 m	-	-	15,045 m
2 Khulshi Distribution Reservoir Service Area						
Khulshi Distribution Reservoir						
Ground 2,800m2 x 7mD (35m-28m) 19,600m3			19,600m3	-	-	19,600m3
Lift Pump 13.1m3/min x 25m x 90kW x 3 (+1)units			-	4 units	-	4 units
Elevated dia. 18m x 7mD (52m-45m) x 16mH (LWL)			-	1,780m3	-	1,780m3
Distribution Pipeline	1000-200	DCIP/PVC	7,725 m	13,260 m	7,880 m	28,865 m
3 Mohara WTP Old Plant Service Area						
WTP Rehabilitation Work (Filters, Intake/Transmission Pumps)			-	1 l.s.	-	1 l.s.
Distribution Pipeline	600-300	DCIP/PVC	-	20 m	1,170 m	1,190 m
4 Kalurghat BPS Service Area						
IRP Rehabilitation Work (Filters, Power Generator)			-	1 l.s.	-	1 l.s.
Clearwater Reservoir (add.)						
Ground 2,060m2 x 2.87mD (3.33m-0.46m)		exist. 2,940m2	-	1,470m2	590m2	2,060m2
(5,910m3)		(8,440m3)		(4,220m3)	(1,690m3)	(5,910m3)
Distribution Pipeline	600-200	DCIP/PVC	-	7,150 m	3,910 m	11,060 m
5 Battali Hill Reservoir Service Area						
Distribution Pipeline	800-200	DCIP/PVC	-	5,505 m	1,170 m	6,675 m
6 Madunaghat 2nd Phase Reservoir Service Area						
WTP Treatment Plant 10MGD			-	-	10MGD	10MGD
Madunaghat Distribution Reservoir						
Ground 2,000m2 x 5mD (7m-2m) 10,000m3			-	-	10,000m3	10,000m3
Lift Pump 15.6m3/min x 35m x 150kW x 3 (+1)			-	-	4 units	4 units
Elevated dia. 18m x 6mD (36m-30m) x 25mH (LWL)			-	-	1,530m3	1,530m3
Distribution Pipeline	900-200	DCIP/PVC	-	-	15,475 m	15,475 m
7 Fatehabad Reservoir Service Area						
Reservoir						
Ground 2,000m2 x 5mD (17m-12m) 10,000m3			-	-	10,000m3	10,000m3
Lift Pump 15.6m3/min x 35m x 150kW x 3 (+1)			-	-	4 units	4 units
Elevated dia. 18m x 6mD (46m-40m) x 25mH (LWL)			-	-	1,530m3	1,530m3
Distribution Pipeline	700-300	DCIP/PVC	-	-	10,495 m	10,495 m
8 Karnaphuli WTP						
WTP Treatment Plant 60MGD			-	-	60MGD	60MGD
Transmission Pump 48m3/min x 71.5m x 920kW x 4 (+1)			-	-	5 units	5 units
Transmission Line	1,200	DCIP	-	-	52,000 m	52,000 m
9 Nashirabad Reservoir Service Area						
Reservoir						
Ground 5,500m2 x 5mD (28m-23m) 27,500m3			-	-	27,500m3	27,500m3
Lift Pump 38.4m3/min x 28.5m x 300kW x 3 (+1)			-	-	4 units	
Elevated dia. 24m x 8mD (53m-45m) x 25mH (LWL)			-	-	3,620m3	3,620m3
Transmission Line to Patenga BPS			-			
Lift Pump 38.7m3/min x 22.5m x 240kW x 2 (+1)			-	-	3 units	3 units
Transmission Line	1000-600	DCIP	-	-	10,505 m	10,505 m
Transmission Line to Salimpur Reservoir			-			
Lift Pump 18m3/min x 48.5m x 240kW x 2 (+1)			-	-	3 units	3 units
Transmission Line	700	DCIP	-	-	4,000 m	4,000 m
Distribution Pipeline	1400-300	DCIP/PVC	-	-	12,725 m	12,725 m
10 Salimpur Reservoir Service Area						
Salimpur Distribution Reservoir						
Ground 1,400m2 x 8mD (55m-47m) 11,200m3			-	-	11,200m3	11,200m3
Distribution Pipeline	900-200	DCIP/PVC	-	-	10,120 m	10,120 m
11 Patenga BPS Service Area						
Patenga Distribution Reservoir						
Ground 4,000 m2 x 6mD (7m-1m)	24,000m3		-	2,000m2	2,000m2	4000m2
				(12,000m3)	(12,000m3)	(24,000m3)
Dist. Pump 19.2m3/min x 37m x 200kW x 2 (+1)			-	3 units	-	3 units
27.6m3/min x 37m x 280kW x 2 (+1)			-	-	3 units	3 units
Distribution Pipeline	900-200	DCIP/PVC	-	14,630 m	15,465 m	30,095 m
12 Small Size Dia. Distribution Pipelines	200-150	PVC	1 l.s.	1 l.s.	1 l.s.	1 l.s.
13 Staff Quarters and Zone Officees						
Staff Quarters	100m2			40 flats	40 flats	80 flats
Zone Offices	800m2		-	5 offices	5 offices (exp.)	5 offices
Summary of Facilities to be Developed						
Water Treatment Plants			1 plant	-	2 plants	3 plants
Capacity of WTPs			20MGD	-	70MGD	90MGD
Pump Stations			1 station	2 stations	5 stations	8 stations
Number of pump units			5 units	7 units	26 units	38 units
Reservoirs**						
Ground Reservoir			1 rsvr.	2 rsvrs.	4+2(exp.) r.	7 rsvrs.
total capacity			19,600 m3	3,470 m3	61,290 m3	84,360 m3
Elevated Tank			-	1 tank	3 tanks	4 tanks
total capacity			-	1,780 m3	6,680 m3	8,460 m3
Pipelines***			22,770 m	25,935 m	129,450 m	178,155 m
Transmission Pipeline Total Length		DCIP/PVC	15,045 m	-	66,505 m	81,550 m
Ditribution Pipeline Total Length		DCIP/PVC	7,725 m	40,565 m	62,945 m	111,235 m

Note: Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Urgent project consists of minimum required facility for production and distribution of Mohara WTP new plant. It includes Mohara WTP new plant, transmission pipeline, ground distribution reservoir and a part of main distribution pipeline.

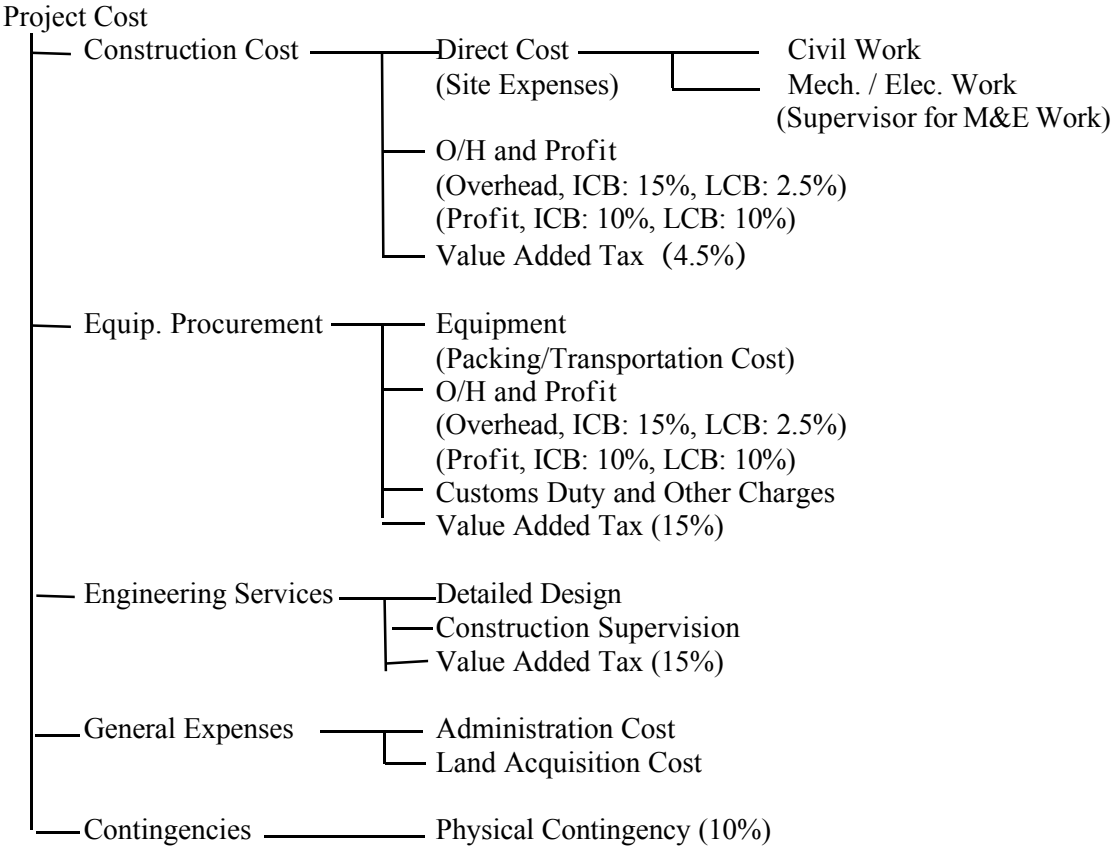
**: Clearwater reservoirs in WTP are not included.

***:Pipeline length in this table does not include secondary (small size dia.) distribution pipeline network.

7.5 Project Cost

7.5.1 Composition of Project Cost

The composition of project cost is shown below:



7.5.2 Conditions for Cost Estimate

(1) Conditions

1) Basic conditions

The project cost is estimated on the basis of the preliminary design. Unit prices and lump sum prices are established taking into considering local conditions, sub-contractors, hiring equipment, available construction equipment and materials as well as the suitability of the construction method.

Assumptions and conditions applied for the cost estimate are as follows:

Price level: as of September 2000

Foreign exchange rate: Tk. 54.00 = US$1.00 = Japanese Yen 106

2) Direct cost

a. Unit prices obtained from the CWASA and PWD, a local consultants, and a contractor

are compared and adopted unit costs are established as of September 2000.

b. Administration cost mainly covers mobilization/demobilization for the construction works. The magnitude of the project is too large for local contractors.

3) Land acquisition cost

Land acquisition costs for the new facilities are estimated for required land area based on layout plans for facilities. Unit prices of land were estimated based on information from CWASA. The required land should be secured prior to the commencement of construction. Required lands for the project are as follows:

	Facilities	Required Area (ha)	Year to be Acquired*
a)	Mohara WTP	0.05**	by 2002
b)	Khulshi Reservoir	1.7	by 2002
c)	Patenga Reservoir	1.8	by 2002
d)	Karnaphuli WTP	10	by 2006
e)	Nasirabad Reservoir	2.6	by 2006
f)	Salimpur Reservoir	1.3	by 2006

*: Year when detailed design will start.
**: at north-west corner of present premises

4) Contingency

A 10 percent of contingency fund is included in the project cost as a physical contingency for unforeseeable cost and incidental change of scope of work.

7.5.3 Project Cost

The total cost of the proposed Basic Plan is estimated at US$ 450 million, of which, Phase 1 project requires US$ 111 million, while Phase 2 needs US$ 339 million, as presented in Table 7.5-1. Costs for following projects are not included in said cost estimates.

- Madunaghat WTP Phase 1 project and its transmission pipeline
- Battali Hill Repair Work
- Fatehabad IRP project
- Kalurghat IRP groundwater source augmentation project
- NRW reduction program
- Engineering costs for small diameter distribution pipelines
- Service Connection

Details of cost estimates are presented in the Supporting Report.

Table 7.5-1 Project Cost of Basic Plan

(unit: US$)

Facilities	Phase 1 (2005)			Phase 2 (2010)			Total
	Local	Foreign	Total	Local	Foreign	Total	
I. Direct Construction Cost**							
1. Mohara WTP New Plant Service Area	6,584,000	13,857,000	20,441,000	0	0	0	20,441,000
2. Khulshi Distribution Reservoir Service Area	4,074,000	4,884,000	8,958,000	367,000	801,000	1,168,000	10,126,000
3. Mohara WTP Old Plant Service Area	355,000	2,275,000	2,630,000	49,000	86,000	135,000	2,765,000
4. Kalurghat BPS Service Area*	1,915,000	4,244,000	6,159,000	408,000	412,000	820,000	6,979,000
5. Battali Hill Reservoir Service Area*	-	-	-	55,000	117,000	172,000	172,000
6. Madunaghat 2nd Phase Reservoir Service Area	-	-	-	6,654,000	7,902,000	14,556,000	14,556,000
7. Fatehabad Reservoir Service Area	-	-	-	2,544,000	3,312,000	5,856,000	5,856,000
8. Karnaphuli WTP	-	-	-	26,968,000	46,044,000	73,012,000	73,012,000
9. Nashirabad Reservoir Service Area	-	-	-	7,284,000	15,448,000	22,732,000	22,732,000
10. Salimpur Reservoir Service Area	-	-	-	1,749,000	1,566,000	3,315,000	3,315,000
11. Patenga BPS Service Area*	1,381,000	2,331,000	3,712,000	2,638,000	4,557,000	7,195,000	10,907,000
12. Small Size Distribution Pipelines	5,878,000	8,469,000	14,347,000	20,246,000	29,171,000	49,417,000	63,764,000
13. Staff Quarters and Zone Offices	1,480,000	0	1,480,000	1,480,000	0	1,480,000	2,960,000
Sub-Total I	**21,667,000**	**36,060,000**	**57,727,000**	**70,442,000**	**109,416,000**	**179,858,000**	**237,585,000**
II. Overhead and Profit							
Overhead and Profit (ICB - 25% of DC 1 to 11)	0	10,475,000	10,475,000	0	32,240,000	32,240,000	42,715,000
Overhead and Profit (LCB - 12.5% of DC 12,13)	1,978,000	0	1,978,000	6,362,000	0	6,362,000	8,340,000
Sub-Total II	**1,978,000**	**10,475,000**	**12,453,000**	**6,362,000**	**32,240,000**	**38,602,000**	**51,055,000**
III. Procurement of Equipment							
1. Water Meter (20-150mmx25,000units) x 2 phases	0	589,000	589,000	0	589,000	589,000	1,178,000
2. Vehicles (Sedan x 2, 4WD x 2) x 2 phases	0	93,000	93,000	0	93,000	93,000	186,000
3. Computers (8 sets with printers) x 2 phases	0	22,000	22,000	0	22,000	22,000	44,000
Sub-Total III	**0**	**704,000**	**704,000**	**0**	**704,000**	**704,000**	**1,408,000**
IV. Administration							
1. CWASA Administration Cost	128,000	0	128,000	128,000	0	128,000	256,000
2. Land Acquisition Cost	3,370,000	0	3,370,000	8,715,000	0	8,715,000	12,085,000
Sub-Total IV	**3,498,000**	**0**	**3,498,000**	**8,843,000**	**0**	**8,843,000**	**12,341,000**
V. Duties, Taxes, and Charges							
1. Custom Duty and Other Import Charges	12,595,000	0	12,595,000	37,724,000	0	37,724,000	50,319,000
2. VAT for Civil Work (4.5%)	1,518,000	0	1,518,000	4,607,000	0	4,607,000	6,125,000
3. VAT for M&E Equipment	6,010,000	0	6,010,000	18,437,000	0	18,437,000	24,447,000
4. Pre-Shipment Inspection Fee	302,000	0	302,000	936,000	0	936,000	1,238,000
Sub-Total V	**20,425,000**	**0**	**20,425,000**	**61,704,000**	**0**	**61,704,000**	**82,129,000**
VI. Engineering Cost							
1. D/D + C/S (8% of I+II)	849,000	4,810,000	5,659,000	2,611,000	14,798,000	17,409,000	23,068,000
2. VAT for Engineering Cost (5.25%)	297,000	0	297,000	914,000	0	914,000	1,211,000
Sub-Total VI	**1,146,000**	**4,810,000**	**5,956,000**	**3,525,000**	**14,798,000**	**18,323,000**	**24,279,000**
VII. Contingencies							
1. Physical Contingency (10% of I+II+III+IV+V+VI)	**4,871,000**	**5,205,000**	**10,076,000**	**15,088,000**	**15,716,000**	**30,804,000**	**40,880,000**
2. Price Contingency (LCP: 0.7%p.a., FCP: 2%p.a.)	-	-	-	-	-	-	-
VIII. Total Project Cost	**53,585,000**	**57,254,000**	**110,839,000**	**165,964,000**	**172,874,000**	**338,838,000**	**449,677,000**

Note: Costs for Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are consideredas existing facilities.

*: Costs in 2005 for distribution pipelines outside of Khulshi S.A. excluding small size pipes are summed in the column of Kalurghat BPS service area.

**: Direct Cost of each category from 1 to 12 incledes costs of all faciliteies such as transmission/main distribution pipelines, treatment plant, reservoirs, and booster pumps.

7.5.4 Implementation Schedule

In connection with the target years for this Study (2005 and 2010), Phase 1 is an urgent and priority project and is expected to be completed by the end of 2005, while the overall project in Phase 2 are considered to be completed by the end of 2010.

Phase 1

2000-01	Preparation of project
2002-03	Detailed design, Bidding
2003	Commencement of construction & procurement of equipment
2003-05	Construction
2005	Commencement of operation

Phase 2

2005-06	Preparation of project
2006-07	Detailed design, Bidding
2008	Commencement of construction & procurement of equipment
2008-10	Construction
2010	Commencement of operation

7.6 Selection of Priority Project

As mentioned in sub-section 7.1.6, three new WTPs are required to meet the projected water supply capacity for the target year of 2010 in addition to the planned/on-going projects, namely the Kalurghat expansion plant under the 3rd interim rehabilitation project, and the Madunaghat 1st phase project.

Present water supply population is 1,140,000 or 44.7% service coverage ratio with intermittent water supply due to shortage of water, and unit water distribution is 140 lpcd including commercial /industrial usage.

After completion of the planned/on-going projects under GOB finance, the water supply situation is required to be 60 lpcd in unit water distribution for the projected water supply population in 2010. Otherwise it is required to restrict the population with water supply service within 1,460,000 which is equivalent to 36% in service coverage ratio in the year 2010 and 45% in 2005 in order to maintain the present water supply conditions. These projection mean no improvement of coverage ratio and more severe service supply conditions than present one taking account of rising of life style of the inhabitants and increasing demand for industrial usage in the future.

To cope with such conditions, a water treatment plant with middle size capacity must be constructed. With such circumstance, the Mohara WTP extension project is recommendable as an urgent project,

which is one of the projected WTPs in the basic plan.

The reasons why the expansion of Mohara WTP is selected among the three projected WTPs in the basic plan are as follows:

(1) The land for the project is already secured and it is good for extension of existing WTP by same capacity.
(2) Construction work of the Madunaghat WTP 1st phase plant is not yet started, and the size of 2nd phase plant is too small for relief present water supply situation. While the Karnaphuli WTP requires huge amount of investment cost and it is too large for stringent financial situation of CWASA. The Mohara WTP extension project has an appropriate project size and financial requirement.
(3) It meets the contents of S/W and M/M agreed between CWASA and JICA.

After completion of the project in the Feasibility Study, it is expected that the water supply condition be improved as follows:

(1) Population with water supply service is to be 1,580,000 or 50% in coverage ratio in 2005
(2) Unit water distribution volume can be increased to 174 lpcd, which is sufficient amount for improved life style of inhabitants.
(3) Supply volume for industrial usage is to be three times of present supply level.
(4) Quality of supplied water in Mode I area with existing groundwater sources, such as high iron content and no disinfection, will be improved with treated water supplied by new system.

CHAPTER 8

FEASIBILITY STUDY ON PRIORITY PROJECT

CHAPTER 8 FEASIBILITY STUDY ON PRIORITY PROJECT

8.1 Fundamentals for Planning

A part of components in the Basic Plan (Phase 1) was selected as a priority project. The priority project is a subject for the feasibility study. Fundamentals for the planning of the priority project is as follows:

8.1.1 Target Year

The target year for the feasibility study is set at 2005, which is the intermediate year to the year 2010, taking account of drastic change of water demand between two years[1].

8.1.2 Project Area

The total project area is 26,915 ha as same as the Basic Plan. The specific project area for the priority project is 13,986 ha[2].

8.1.3 Population of Project Area

The population in the project area in 2005 including outside of service area is projected as follows:

Chittagong City	2,930,600
Out of Chittagong City	255,500
Project Area	3,186,100

Out of them, the target service population[3] of the priority project area is estimated as follows:

Chittagong City	1,801,300	
Out of Chittagong City	137,700	
Project Area	1,939,000	say 1,940,000

The service population, which is the resticted population of target service population due to limited Water source, will be as follows:

Chittagong City	1,570,280

[1] The demand in 2010 is equivalent to 1.9 times of 2005 demand.
[2] Summation of multiplication of each word's area by demand coverage ratio
[3] Target service population was derived from target water supply service and projected population.

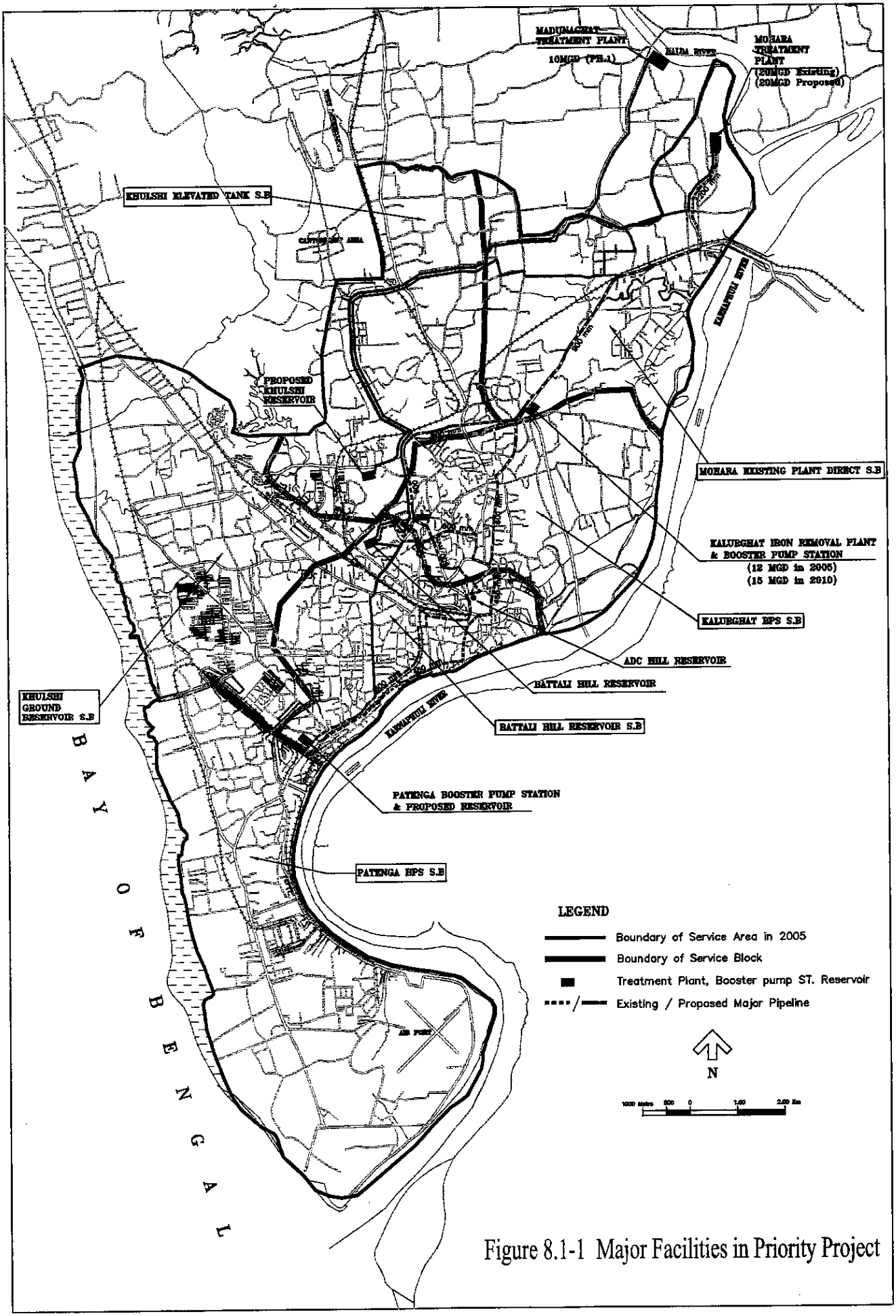


Figure 8.1-1 Major Facilities in Priority Project

The served population after priority project is estimated as follows:

Chittagong City	1,570,280	
Out of Chittagong City	10,080	
Project Area	1,580,360	say 1,580,000

Difference between the served population and the target service population originates in restriction due to limited water sources after priority project.

8.1.4 Target of Water Supply Service Level

The target of water supply level is set as follows:

(1) Seventy percent (70 %) of households living in Pucca houses are supplied of water with house connections as well as 30 % of Semi-Pucca, and 15% of Kutcha.

(2) Out of the remaining inhabitants, 10 % of Pucca and 30 % of Semi-Pucca houses, are supplied of water with street hydrant as well as 20 % of peoples living in Kutcha houses.

8.1.5 Water Supply Service Area

Taking account the present water distribution network status and the expected available water source in 2005, the service area after the priority project should be limited within the present Chittagong WASA service area consisting of 40 wards (J.D. Pahartali will be excluded). In addition, a part of Salimpur Union in Sitakunda Thana will be served as it is. Expansion of the service area was limited only for the area adjacent to existing network so that demand in the service area will be less than the capacity of available water sources.

8.1.6 Planned Water Supply Flow

The total potential water demand in the project area is estimated at 344,000 m^3/day or 76 MGD. Though it is desirable to fulfill the demand by the target year if enough time and fund are available, it is difficult to achieve it due to limited time and fund. Consequently, out of total demand, the planned water supply flow in target year 2005 is set at about 282,000 m^3/day or 62 MGD on distribution base taking account of possible service area and available water source. Out of water sources stated in sub-section 7.1.6, following water sources will be developed by the year 2005:

- Existing Mohara WTP: 91,000 m^3/day (20 MGD)
- Kalurghat IRP including a plant planned in the 2nd project (GOB): 55,000 m^3/day (12 MGD)[4]

[4] Total treatment capacity of the IRP will be 20 MGD by the year 2005. However, due to shortage of water

- Madunaghat WTP including Italian project (1st Phase):46,000 m^3/day (10 MGD)
- Expansion of Mohara WTP project planned under this Study: 91,000 m^3/day (20 MGD)

Total 283,000 m^3/day (62 MGD)

Besides above demand, the Chittagong Cantonment has been requested CWASA to supply 3 MGD. This F/S was conducted presuming that the on-going Fatehabad IRP project, which is expected to be completed by 2005 will fulfill that demand together with supply to the Chittagong University. Since this IRP will be located out of the planned service area of the distribution network system, the water supply system of the Fatehabad IRP is treated as an isolated separate system[5] for supply to the Cantonment and adjacent area to be developed temporarily.

Existing CWASA tube wells scattered in the MOD-I area will be abolished after the commissioning of the new distribution system, because their water quality needs treatments to accomplish allowable quality level for drinking and difficulties in providing such facilities at each well.

8.2 Design Policy

8.2.1 Water Treatment Plant

(1) Mohara WTP Expansion Plant

As stated in section 8.1.6, the Mohara WTP Expansion Project shall be completed by 2005. Its production capacity is 91,000 m^3/day or 20MGD, and a total production capacity after the project will be 282,000 m^3/d or 62 MGD. Design policy for the Mohara WTP Expansion Project is as follows:

- Intake Facility

  Generally, intake quantity of a water treatment plant adopting conventional horizontal flow sedimentation and rapid filtration process with backwash water recovery facility is considered to be 105% of production capacity taking account of in-yard water use and production loss.

  Though reliable data is not available regarding such volume in existing facility, quantity of wastewater is considered to be large because of high turbidity of raw water. In the designing of new plant it was judged to be 110% because of no wastewater recovery system and high turbidity of wastewater, which increase sludge discharge volume from desilting basins. Consequently capacity of new intake facility is designed so as to take 110% of production capacity or 44MGD

---

production capacity of groundwater wells, distribution capacity of the Kalurghat BPS in 2005 is set at 12 MGD.

[5] The Fatehabad system will be integrated with the distribution network system planned in the Basic Plan.

and to convey water to a receiving well (distribution chamber) to be constructed in the project. Since intake structure was constructed with room for expansion facilities, only intake pumps will be installed.

- Treatment Facility

Treatment method of the existing facility is high rate sludge blanket type clarifier – sand filtration system. The same treatment method will be employed in new treatment facility taking account of performance of existing plant, required cost, required land area, and ease of operation and maintenance. Design capacity of new treatment facility will be 91,000 m^3/d or 20 MGD, while design flow for from intake to clarifiers is 22 MGD, 21 MGD to filters and 20MGD after that.

- Transmission Pump Facility

New transmission pumps will be installed so as to transmit water to the Khulshi reservoir with 900 mm dia. ductile cast iron pipe. Pumps will be operated separately from the existing ones and are controlled by water levels of the Khulshi reservoir and clearwater reservoir of the new plant. Those water levels are monitored in the monitoring room of new plant.

(2) Rehabilitation of Existing Plant

Rehabilitation of existing facilities will be concentrated on improvement of deteriorated or insufficient functioning facilities of the Mohara WTP and the Kalurghat IRP. Distribution facilities and tube wells are not included in the scope.

Rehabilitation work is divided into two scopes as follows.

Scope-1: Rehabilitation of filters to improve water quality.

Scope-2: Repair and replacement of deteriorated equipment and their accessory equipment.

8.2.2 Transmission and Distribution System

(1) Transmission Pipeline

Existing transmission pipeline from the Mohara WTP with a diameter of 1,200 mm cannot be utilized because the required pressure of proposed transmission pumps is differ from existing one. New transmission pipeline from the Mohara WTP will be provided with 900 mm dia. ductile cast iron pipe. Other transmission pipeline is not provided in the priority project.

(2) Distribution Reservoir

In order to cope with hourly peak demand, several distribution blocks will be provided with respective distribution reservoir and distribution network. In the area where high-elevated area with enough space is available, water is distributed by gravity. If no suitable high-elevated area is available in the area, gravity flow system with lift pumps and a head tank, or direct pump supply system was adopted.

A new reservoir will be provided at South Khulshi Hill as stated in Chapter 7. This reservoir will cover service areas located at northern part and western part of the city. Because of difference in elevations of service areas, the western part will be supplied from a ground reservoir by gravity flow, while northern part and the Khulshi area will receive the water from elevated tank via a lift pump station, which will be constructed in the premises at Khulshi.

Through the dynamic hydraulic analysis of distribution system, it was found that the distribution reservoir of existing Kalurghat BPS (the clearwater reservoir of the IRP) does not have a sufficient capacity as a distribution reservoir. Consequently, it shall be augmented. Pumping facility, however, has been augmented by the second rehabilitation project by GOB. It will have an enough capacity for planned distribution amount of 12 MGD by 2005 with replacement and augmentation of new 2 pumps.

The Battali Hill Reservoir, which is expected to receive water from Madunaghat WTP 1st phase plant and existing Mohara WTP, is presumed to be utilized as it is after proper repair work in accordance with the policy of CWASA.

Presently, the Patenga BPS does not have any water storage facility with it. Since it also be expected to receive water from Madunaghat WTP 1st phase plant and existing Mohara WTP, new reservoir with proper capacity shall be provided. Because of lack of present pump capacity against projected demand, pump capacity shall be augmented with new pumps.

Existing small-scale reservoirs including the ADC Hill reservoir will also be used to augment the lacking reserve capacity for existing Mohara and Kalurghat systems. Especially, isolated local small-scale reservoirs and attached lift pump stations shall be used for high-elevated isolated service area in the distribution network system.

(3) Distribution Pipeline

Existing distribution pipes shall be utilized as far as possible. If the existing transmission pipes

or transmission – distribution pipes is determined to be usable as distribution pipe, connection with the existing network will be changed and valves shall be installed. Augmentation of pipeline capacity will be accomplished by providing new pipes paralleling with existing pipelines. As stated previously, extension of distribution main will not be conducted due to limited water source capacity. However, installation of new distribution main at Chandgaon Thana at eastern part and Chittagong Port Thana at southern part will be conducted in order to reinforce the capacity of pipeline network.

8.3 Water Treatment Plant

8.3.1 Mohara Water Treatment Plant (Expansion Plant)

(1) General

Proposed capacity of the Mohara WTP expansion plant is 91,000 m^3/d or 20 MGD on distribution base, so the total plant capacity will be 182,000 m^3/d or 40 MGD. The existing Mohara WTP was designed and constructed taking account the future expansion. The new plant will be constructed in the reserved land beside existing plant.

Intake capacity will be 22 MGD, including 10 % of plant use and production loss. Intake facilities comprised of intake mouth, intake pipe and intake pump house was constructed considering the future expansion. Therefore, additional equipment will be intake pumps and necessary piping only.

The treatment facilities to be provided are; receiving well which can be used as distribution chamber, desilting basin, rapid mixing chamber, chemical clarifier, rapid sand filter, clearwater reservoir, chemical dosing facilities for alum and lime, chlorination facilities, transmission pumps, and central monitoring/laboratory house. Layout of these facilities is presented in Figure 7.4-2.

Intake facility is located at northeast of the plant and the receiving well will be installed just upstream of the existing desilting basins. New desilting basins will be constructed beside the existing basins. As to clarifier and filter, structure and dimensions same to the existing facilities will be adopted with minor modifications[6]. Twenty-four units of clarifiers and nine units of filters will be constructed. The existing clearwater reservoir will be exploited with necessary minor amelioration together with a new reservoir. Providing against accidental plant operation

[6] Existing filters employed deep filtration layer and surface washing device. However, air washing is commonly employed for thick filtration layer, and surface washing is common for thinner filtration layer. It shall be further examined in detailed design stage with regard to filtration method.

suspension, interconnection between both plants is needed to enable mutual supply of treated water. Therefore, water level in the clearwater reservoir should be the same. Since the existing plant and new plant will have different service blocks and transmission pipeline routes, specifications of transmission pumps for the new plant will be different to those of existing one.

In addition to expansion plant work, some improvement works shall be conducted for existing plant. Those are; introduction of automated backwashing system; replacement of filter media, purchase of reserve filter media, filter media washing machine; and replacement of intake pump and transmission pump.

Details of installation conditions, scales and necessary improvements are described below (refer to drawings in the Supporting Report):

(2) Outlines of Facilities (refer to drawings in the Supporting report)

1) Intake Facilities

Existing intake structure and the intake pump house were designed and constructed considering the future expansion. Therefore, scope of work for this project is limited to provision of an intake pump, piping including valves and a check valve, and a conveyance pipeline to the new receiving well. Diameter of conveyance pipe will be 900 mm and length is approximately 220 m.

Existing intake pump house has a space for five units of intake pumps. At present, four intake pumps including one stand-by unit are already installed.

One of the existing four units of pump has a manual discharge control device. Purpose of this installation is to secure volumetrically constant intake against water level fluctuation of river affected by tide. Pump head of the existing intake pump is 14.3 m, while water level fluctuation in the Halda River is 3 m with an interval of 6 to 8 hours. At present, this discharge control pump is out of order. Such constant intake cannot be attained by valve operation and thus present fluctuation in intake volume is affecting chemical dosage control and consequently to plant capacity. Therefore, the additional pump shall be the discharge control type. Capacity of pump shall be increased comparing with existing one to secure required intake amount at 44MGD because of increased water head to new distribution chamber[7]. Same vertical shaft type pump

[7] Existing pumps will have less capacity due to increase of required head for distribution chamber. To compensate this decrease of pump capacity, new pumps shall have larger capacity. Refer to Supporting Report.

will be adopted. Two new pumps shall be provided with following specifications:

42.1 m^3/min x 15.3 m x 185 kW x 2 units (incl. 1 standby unit) with inverter control

A conveyance pipeline will be installed in parallel with existing pipeline starting from existing tee branch. Dimension of conveyance pipe is as follows:

Diameter 900 mm x length 220 m, ductile cast iron pipe

2) Receiving Well (Distribution Chamber)

A receiving well will be provided to receive intake water for existing and new plants. This well will also act as a distribution chamber supplying raw water to desilting basins of both plants. Flow meters will be provided on each of old and new conveyance pipes to control the flow to old and new plant by operation of flow control valves to be provided upstream of the well. When turbidity of raw water is high, alum will be dosed at this well. Outline of the well is as follows;

Dimensions:	(Old)	Width 5 m x Length 5.5 m x Depth 4 m x 1 unit
	(New)	Width 7 m x Length 5.5 m x Depth 4 m x 1 unit
Capacity:	264 m^3	
Retention Time:	2.8 minutes	

3) Desilting Basin

The existing desilting basins have a structure of earth embankment with inner brick lining. Four sludge drainage pipes are installed at the bottom of each basin and a part of settled sludge is discharged into sludge channel then discharged to the Halda river via the wastewater discharge basin. However, due to its limited effect, sludge is gradually accumulated at bottom. Therefore, during dry season from January to March, when raw water turbidity is low, accumulated sludge on the bottom of the basins shall be dried and removed manually.

New desilting basins will have RC structure due to the restriction of proposed site. A traveling bridge over the basin with a sand pump will be provided to each basin to enable continuous removal of sediments. A total of four basins will be provided. Specifications of basins are as follows;

Dimensions:	Width 23.0 m x Length 76.0 m x Depth 3 m (effective depth 2.5 m) x 4 units
Surface Loading:	9.93 mm/min. (normal operation) 11.24 mm/min. (in case old desilting basins are suspended for maintenance work)

Average Velocity: 30 cm/sec. (normal operation)
32.4 cm/sec. (in case old desilting basins are suspended for maintenance work)
Capacity: 17,480 m^3 in total
Retention Time: 4.2 hours (normal operation)
Outflow Weir Length: 56 m/basin
Outflow Weir Loading: 446 m^3/m/d (normal operation)

4) Rapid Mixing Chamber

The existing chamber consists of two units of flash mixer arranged in series and lime and alum is injected. Although mixing time of the existing chamber is short, i.e. 0.14 minutes for lime and 0.11 minutes for alum, both of mixing condition and flocculation status are satisfactory. Same facility will be newly constructed. Specifications are as follows:

Chamber for Lime
Dimensions: Width 2.29 m x Length 2.29 m x Depth 1.91 m x 1 unit
Capacity: 10.0 m^3
Retention Time: 0.14 minutes (normal operation)

Chamber for Alum
Dimensions: Width 2.29 m x Length 2.29 m x Depth 1.45 m x 1 unit
Capacity: 7.6 m^3
Retention Time: 0.11 minutes (normal operation)

5) Clarifier

At present, 24 units of high rate sludge blanket type clarifier are operated. Though they have been affected by intake volume fluctuation, treatment status is satisfactory.

Following issues found through present operation shall be reflected in designing of new clarifier:

- Floc tends to settle in inlet channel. Floc accumulation reaches 3 feet in thickness before annual cleaning. Cleaning shall be executed more frequently and heavy concrete cover shall be changed to light weight cover such as grating to ease the work. Measures for easy sludge removal, such as sludge drainage pits at the bottom of inlet channel, longitudinal slope of channel, shall be provided.
- Inlet pipe with a diameter of 300 mm is suspended horizontally to the center of clarifier then lowered down to the bottom. Further, diameter of this pipe is reduced to 200 mm at the end of the pipe to make jet flow. At said horizontal portion and reduced portion,

floc tends to settle. Horizontal portion shall be inclined and reduced portion shall be changed to reducer type to minimize the hydraulic loss.

Specifications of clarifiers will be as follows:

Dimensions: 7.62 m x 7.62 m (25' x 25') x 24 units
Capacity: 202 m^3 per unit
Slurry Zone: 127 m^3
Upward Velocity: 50 mm/min

6) Filter

At present, 8 units of rapid sand filters are operated. Condition of filter media is poor due to improper washing process, defected washing facilities, and lack of maintenance.

Taking account of present issues of the existing filters, following considerations shall be reflected in the designing of new filter[8]:

- Surface washing pipes shall be replaced with steel or ductile cast iron pipes instead of existing PVC pipe. Jetting angle shall be corrected to appropriate angle.
- Current filtration rate of existing filters is rather high, i.e. 268 m/day when all units are operated, 306 m/day when one unit is backwashed, 357 m/day when one unit is suspended and one unit is backwashed. In order to lessen such high filtration rate, filtration area of the new plant shall be larger than existing on. In the F/S, one unit of common stand-by filter is planned, so the total number of filter will be nine.
  Backwashing facility will be provided for following water volume:
  44.60 m^2 x 0.98 m/min = 43.71 m^3/min = 62,940 m^3/day
  This volume is less than the filtration volume of 83,526 m^3/day during operation of 7 filters.
- To relieve the current inappropriate filter washing status, automated washing devices shall be introduced. It shall also be introduced to existing facility as well.
- For efficient washing and proper supply of filter media, stockyard for reserve filter media shall be prepared. Sand washing equipment, sieves for grading control and reserve filter media shall also be prepared.

Specifications for filters are as follows;

[8] It shall be further examined in detailed design stage with regard to filter washing method. Refer to footnote on page 8-7.

Dimensions:	9.14 m x 2.44 m (30' x 8') x 2 filters/unit x 9 units
Filtration Area:	44.60 m^2/unit x 9 units = 401.4 m^2
Filtration Rate:	238 m/day (all unit are operated)
	268 m/day (one unit is backwashing)
	306 m/day (one unit suspension and one unit backwashing)
Backwashing Rate:	0.98 m/min
Surface Washing Rate:	0.15 m/min
Media Size:	0.85 to 1.0 mm
Media Depth:	1.22 m (4 ft)

7) Clearwater Reservoir

Though nominal capacity of existing clearwater reservoir is 2.8 hours, effective capacity is 1.8 hours based on the calculation taking account of the dead space below suction pipe of transmission pump. The chlorination basin is provided at the inlet of the reservoir. The reservoir is divided into two compartments but chlorination basin is not separated. Therefore, no cleaning work has been conducted after commissioning.

If transmission pumps should be operated for transmission purpose exclusively, necessary capacity of clearwater reservoir may be 1 hour, because it is operated to store the treated water for slight fluctuation of pump discharge, not for control of demand fluctuation. Capacity of new clearwater reservoir will be the same to the existing one, providing for accidents, such as power interruption.

Following considerations on present issues of the existing clearwater reservoir shall be reflected on design of new one;

- Two compartments of clearwater reservoir including a part of chlorination basin is needed for maintenance.
- An interconnection pipe shall be provided to connect with existing clearwater reservoir providing for augmentation to its lacking capacity in Phase 2 and for accident. HWL and LWL shall be set equal to the existing one to enable the said interconnection.

  HWL +5.334 m (17.50 ft), LWL +2.452 m (8.04 ft), Effective Depth 2.882 m
- In addition to provision of lime injection for pH control before mixing of alum, CWASA also requested to provide lime injection at Clearwater reservoirs for pH control after chlorine injection. Needs and points of lime injection shall be further studied in detailed design stage.

Specifications for the new clearwater reservoir will be as follows;

Dimensions:	Width 29.97 m x Length 39.11 m x Depth 2.88 m x 2 compartments
Capacity:	6,751 m^3 in total
Retention Time:	1.78 hours

8) Chemical Dosing Facilities

Design turbidity for existing chemical dosing facility was set at 350 NTU, while design maximum turbidity shall be considered at 850 NTU.

Alum as coagulant and lime as pH adjustment agent has been injected to raw water. Injection rate has been determined based on turbidity, pH and results of jar tests. Reinforcement of existing chemical dosage facilities shall be considered to cope high such high turbidity. Measures for reinforcement will be as follows:

- When the turbidity of raw water is high, alum injection pump will be used for desilting basin and rapid mixing chamber. One unit of injection pump shall be installed as stand-by.
- Lime injection pump is operated for rapid mixing chamber and for pH control at clearwater reservoir. One unit shall be equipped as stand-by.
- Alum solution concentration is set at 45% for high turbidity and at 40 to 30% for lower turbidity. Facilities for less concentration shall be augmented.

New chemical dosing facility will be designed reflecting above issues. New equipment will be as follows;

- Alum injection pump – 3 units
- Alum solution mixing tank – 3 units
- Lime injection pump – 3 units
- Lime solution mixing tank – 3 units

Necessity of lime injection, however, shall be further examined because total alkalinity of raw water seems to be enough for operation without lime injection under normal turbidity condition. During the period before implementation stage, it shall be examined through jar tests in various actual conditions.

Though alum is employed for the project in this study taking account of availability of chemicals and capital and O&M costs, possibility of adoption of PAC shall be examined in detailed design stage.

9) Chlorination Facilities

At present, post-chlorination is conducted for disinfection and pre-chlorination is also executed once or twice a month for 4 to 5 hours to remove algae or insects. Pre-chlorination rate is 1.2 mg/l and post-chlorination rate is 2.4 mg/l, and two 750 kg containers are consumed in 10 days.

Since Manganese concentration of raw water is exceeding the National Standard of 0.1 mg/L, mid-chlorination shall be conducted periodically to facilitate Manganese removal by Manganese coated sand in Filter.

In the new plant, chlorination facilities shall be provided for several chlorine injection points, which are; inlet of desilting basin for killing algae, germs and insects in desilting basins, inlet of mixing chamber for killing germs and insect in clarifiers, inlet of filters for oxidization of manganese in water to facilitate manganese removal in filters, and inlet of chlorination basin for disinfection. Points and rate of chlorine injection shall be controllable by valve operation.

Though liquid chlorine disinfection method is employed in the plan taking account of availability of chemicals and capital and O&M costs, possibility of introduction of safer disinfection method, such as sodium hypochlorite, shall be examined in D/D stage for safe of neighboring residents.

10) Transmission Pump

Total design capacity of new transmission pumps to be installed in new pump house at new plant shall be 91,000 m^3/day or 20 MGD, equivalent to the existing ones. Pumps shall be operated automatically by water levels of the Khulshi reservoir and the clearwater reservoir of the new plant. Four pumps and one standby pump will be installed in a pump house together with power generators as same as existing facility. Water for in-yard consumption, cleaning of facilities, chemical solution, chlorine solution, and so on will be obtained by branching the transmission pipe after pressure reduction. Based on the calculation results of calculation presuming 900 mm dia. 15.1 km long transmission pipeline to the proposed Khulshi reservoir, specifications shall be as follows;

15.8 m^3/min x 84 m x 350 kW x 5 units (incl. 1 standby unit)

11) Wastewater Discharge Facilities

The existing wastewater discharge facility is discharging wastewater generated at clarifiers and filters to the Halda River by gravity when river water level is low, while it is stored in a

wastewater basin and then automatically pumped to the river by pumps. Since existing sludge discharge pumps have an enough capacity to discharge wastewater from both of existing and new plants, only a wastewater basin will be provided with an interconnection pipe between basins. Dimensions of the basin will be as follows;

Width 9.14 m x Length 22.86 m x Avg. Depth 4.3 m

12) Central Monitoring / Laboratory Building

Since the existing central monitoring room and the laboratory room are too small to handle required work for both plants, new building will be constructed beside of the existing administration building to house both rooms and storage.

13) Power Supply Equipment

a) Power Requirement

The provision of a stable power supply is essential for operation of a Water Treatment Plant, especially for operation of intake, treatment, distribution and transmission facilities. The power requirement of existing Mohara WTP is 2,540 kW (refer to the Supporting Report). But maximum daily power consumption for operation of the plant is computed at 1,400 kW or 55.2 percent (55.2 %) of the total power capacity of the Plant.

The power requirement of Mohara WTP expansion plant is about 1,800 kW. However, maximum daily power consumption for the operation of new plant is 990 kW or 55 percent (55%) of the total power capacity of the expansion plant.

b) Power Receiving Equipment Plan

- Distribution Line Voltage for Transformer

  Bangladeshi standard for voltage and capacity is as follows:

Supply voltage	Transformer capacity
33 kV	more than 4 MVA
11 kV	less than 4 MVA

  In spite of this standard, incoming voltage of existing plant is 33 kV. Capacity of the existing primary power supply line from sub-station is 10 MVA. Electrical power for the new plant, therefore, can be blanched from this existing line.

- Power Receiving Line Numbers (refer to Figures 8.3-1 and 8.3-2)

  The two-line incoming system is recommended to avoid risks of power failure. One

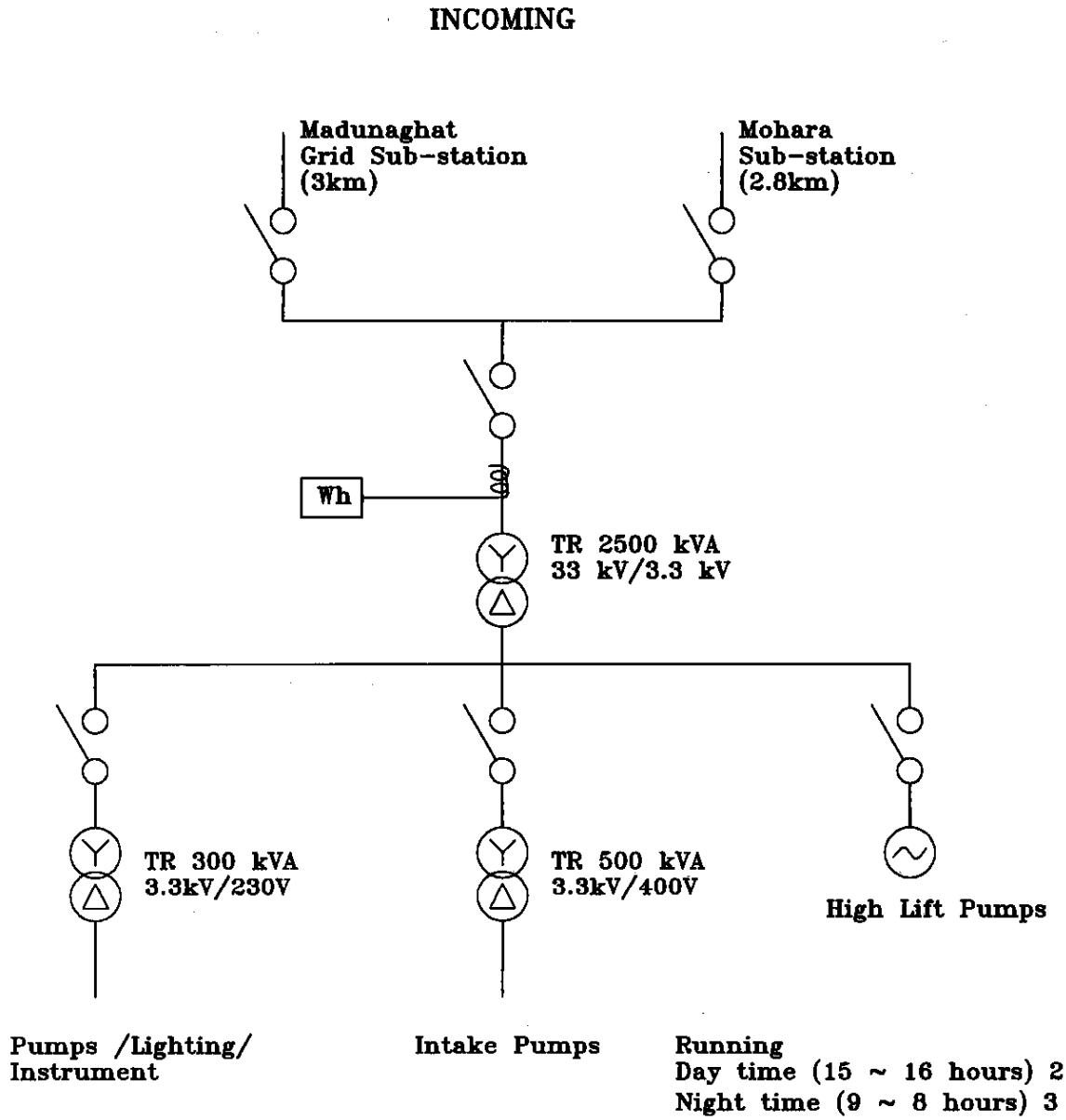


Figure 8.3-1 Single-Line Diagram of Existing Plant Power Receiving System

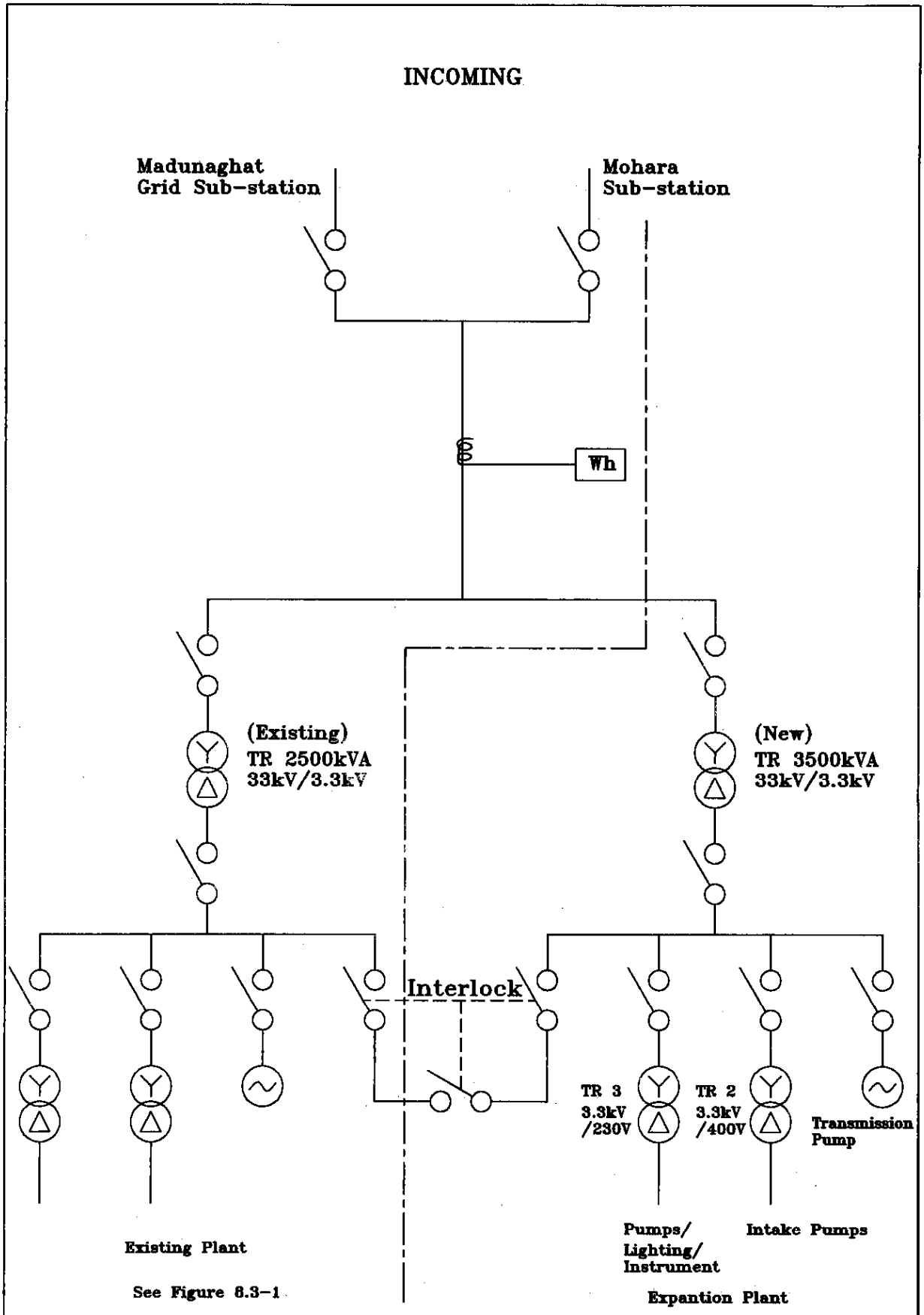


Figure 8.3-2 Single-Line Diagram of Expantion Plant Power Receiving System

supply line shall be normal service and other for stand-by. For existing plant, electricity has already supplied by two-lines incoming with 33 kV respective transmission line. Existing plant, however, has only one transformer. In order to ensure the continuous stable power supply to the plant, main transformer shall be two sets in line. Basically, parallel running of two-circuit supply line shall be applied. Therefore, Circuit Breaker of distribution line of transformer shall be normally open with interlock double throw switch.

c) Measures against Fluctuation of Power Supply Voltage

According to the past operation record, fluctuation of voltage ranged from –11% to +3%. Several equipment of the existing plant has been damaged by this voltage fluctuation. Measures adopted in the new plant against this fluctuation will be as follows:

- Introduction of Tap-change Transformer

  Tap-change Transformer will be introduced so that the transformer maintain stable voltage supply by the automatic change step tap.
- Introduction of Uninterrupted Power Supply System (UPS)

  Filters of water treatment plant will be operated with Sequence Controllers. Those devices and other important equipment for operation cannot be stop by power failure. Because of this reason, some control panel will be equipped with UPS with battery charger.
- Provision of Power Generator

  The diesel fuel engine driven power generator having direct coupling of engine and alternator on common base will be provided for operation of whole equipment in new plant. The capacity of generator will be 2500 kVA. Detail specification will be identified in detailed design stage in accordance with the final power requirement of the plant.

d) Selection of Type of Power Generator (Refer to Supporting Report)

In the comparison study about type of power generator, the case with power supply only from PDB shows the least cost NPV, though it is not recommendable because of the least reliability. The option with continuous power generation by Gas Engine Generators is the second economical option. For the adoption of Gas Engine Generator, however, the most important issue is availability of reliable operation & maintenance staff members and organization. Buck up support service is also requisite for reliable continuous operation. Provided those requirement are fulfilled and increase of initial cost is allowed, continuous

power generation by Gas Engine Generators is recommendable from economical point of view. Before final decision for application of Gas Engine Generators, reliability of gas supply system and availability of operation and maintenance services for both of normal operation and emergency situation, shall be verified in the beginning of the detailed design stage. In the feasibility study, however, the option with the least capital cost, i.e. emergency diesel engine power generation was tentatively applied for proposed plant.

8.3.2 Rehabilitation of Mohara Water Treatment Plant (Existing Plant)

In addition to the expansion plant work, some improvement works shall be conducted for the existing plant. Those are; introduction of automated filter washing system, replacement of filter media, purchase of reserve filter media and filter media washing machine, and replacement of an intake pump and a transmission pump.

(1) Rehabilitation of filters

Any cleaning, supplement, or replacement work on filter media of existing sand filters has not been carried out since the beginning of operation, so the filter media and filter layer is deteriorated.

It is difficult to produce good water because particle of the filter media has been enlarged by dirt and coated iron and manganese substance. In addition, it is suspected that under drain system and gravel layer might be damaged and choked partially.

Proposed rehabilitation plan consists of rehabilitation of filters and introduction of automated backwash process. Though required work shall be identified through precise investigation during detailed design stage, following work is prospected:

1) Replacement of filter media
2) Rehabilitation of under drain system
3) Rehabilitation of surface wash system
4) Rehabilitation for adjustment of weir level for backwash water
5) Introduction of automate backwashing system
6) Purchase of reserve filter media and sand washing machine

Construction for rehabilitation work will be executed after commissioning of new plant so as not to stop water supply services.

(2) Repair and replacement of deteriorated equipment and their accessory equipment

1) Alum feeding devices

Existing solid alum feeding facility is deteriorated and is difficult to feed sufficient amount of solution against high turbidity because 20% concentration alum solution is the highest practically in actual operation instead of design concentration of 40%. As a result, the coagulate dosing rate is insufficient and treated water quality from clarifiers become poor. Consequently high load is transferred to filters.

In the proposed plan, new alum dosing system will be designed for 10% alum solution to improve performance of the system. Items to be executed are as follows:

- Augmentation of alum solution equipment
- Augmentation of titrating pumps
- Rehabilitation of dosing pipeline

2) Intake facility

Fine silt is accumulated at the inlet of the intake facility. That will cause difficulty to take enough raw water when river water level is low. Provisional sludge removal equipment will be provided to dredge it regularly. Items to be executed are as follows:

- Provision of portable sand pumps and power outlet at the site.
- Replacement of flashing valves installed on intake pump pipeline

3) Replacement of pumps

Frequent troubling intake pump will be replaced. In addition, cost for replacement of a transmission pump is considered in cost estimates for the project.

8.3.3 Rehabilitation of Kalurghat Iron Removal Plant and Booster Pump Station

(1) Policy for Improvement of Kalurghat System

Large scale water sources, which will be newly developed, shall be surface water, in general, as present prospective projects are Expansion of the Mohara WTP (20 MGD) and Construction of the Madunaghat WTP (10 MGD). However, even though these projects are completed, water demand will not be fulfilled, and thus, development of wells, as well as exploitation of existing wells, shall also be continued. Accordingly, the Kalurghat System served with groundwater shall be utilized through the future.

Based on the following policies, improvement works shall be conducted to cope with the present issues in the Kalurghat IRP & BPS (refer to drawings in the Supporting Report):

- Efficiency of iron removal facility of Kalurghat IRP shall be improved to lower iron content in treated water.
- Since existing clearwater reservoir in the IRP does not have an enough restoration volume for stable distribution, another reservoir is needed to be constructed to compensate the volume shortage and to cope with the peak demand.

(2) Recommendations for Kalurghat Plant Improvement Plan

The following improvement plan is recommendable for the Kalurghat Plant.

1) Adoption of Chlorination

Raw groundwater pumped from production wells contains high concentration of iron and manganese as follows:

- Iron: 4.8 mg/L (average), 12.4 mg/L (max) to 1.0 mg/L (min)
- Manganese: 0.079 mg/L (average), 2.80 mg/L (max) to 0.002 mg/L (min)

For efficient oxidization, chlorine injection is recommendable rather than aerator. Oxidization time will be shortened and filter sand will be coated by Manganese that will be effective for Manganese removal.

2) Provision of Oxidation-Sedimentation Basin

To remove the oxidized iron before entering to the rapid sand filter, oxidation-sedimentation basins shall be provided. Twenty to thirty minutes of retention time will be needed for oxidation-sedimentation basin to facilitate iron oxidation to refractory trivalent form and sedimentation. Since the sedimentation area will become much small from existing sedimentation basin, cleaning work will be easy and frequent cleaning can be conducted. Dimensions of the basin will be as follows;

Width 8.5 m x Length 18.0 m x Avg. Depth 2.5 m x 3 basins

3) Abolishment of Sedimentation Basin

Existing sedimentation basins will be abolished since it will become unnecessary. Open

space will be used for new oxidation-sedimentation basins for old filter and additional reservoirs.

4) Provision of New Reservoir

Existing clearwater reservoir will be utilized as a distribution reservoir and insufficient volume will be augmented by an additional reservoir. Required capacity was confirmed through the dynamic hydraulic analysis for 72 hours. Dimensions of the reservoir will be as follows;

Width 16.8 m x Length 47.6 m x Avg. Depth 2.87 m x 2 basins

5) Rehabilitation of Filters

The plant has been operated without proper cleaning and maintenance. Filter media has been enlarged with iron and manganese substances. Many mud-ball and cracks are observed on surface of filter beds, and surface of filter beds is not even.

Degree of deterioration of filters of the plant is worse than Mohara WTP, so that immediate rehabilitation work is needed. Items to be executed are as follows.

- Replacement and repair of filter media, gravel layer and under drain system
- Improvement of quantity and pressure of backwash water
- Provision of filter media washing machine
- Provision of drainage troughs in filters
- Introduction of air-washing facility to old filters, which was once planned in the second water supply project under IDA.
- Separation of each existing filter cell by means of valves and gates for easy maintenance.

6) Introduction of Power Generator

Existing distribution pumps will be used as they are. After on-going second rehabilitation project by GOB fund, distribution pumps of BPS will have an enough capacity through future. However, power generator will be provided in the project to compensate abolishment of two diesel engine driven pumps under said GOB project. Capacity of generators will be enough to operate a half of motor driven pumps.

8.4 Transmission Pipeline and Distribution Facility

8.4.1 Design Criteria for Pipeline

For the transmission system, average daily flow was adopted as design flow presuming provision of reservoirs. While, distribution system was designed with hourly peak flow. Peak flow rate was assumed to be 150% based on past survey results in Japan because of non-availability of reliable data in CWASA.

Required volume of distribution reservoirs, and pump capacities were obtained and verified through 72-hour dynamic hydraulic analysis of distribution network system.

Following design criteria was adopted for transmission and distribution pipeline.

- Hazen-Williams Equation be adopted for pipe capacity design.
- Following friction coefficients be adopted;

  C=110 for Ductile Cast Iron pipe and Asbestos Cement pipe

  C=130 for PVC pipe.
- Minimum pressure in the network be 98 kPa, in general.
- Peak flow rate is assumed to be 1.5.

8.4.2 Selection of Transmission Route

Along with the expansion of the Mohara WTP, a new transmission pipeline shall be installed starting from the Mohara WTP to the proposed reservoirs, which will be constructed on a hill located in South Khulshi or foot of hill located at west of the Chittagong Tea Bored in Nasirabad Industrial Estate. Three alternative routes exist for examination of appropriate transmission pipeline route as presented in Figure 8.4-1. Their characteristics are as presented in Table 8.4-1.

Table 8.4-1 Characteristics of Proposed Transmission Pipe Route

Route	Characteristics
1. Existing Mohara transmission line (Arakan Road)	• Road is wide (15 m) but pipe installation will be difficult because the road is congested with transmission/distribution pipes, gas pipe, telephone cable. • Heavy traffic • Work will be costly due to above-mentioned difficulties.
2. Planned CDA Road	• Brick paved road with width of 11 m and planned to be paved by asphalt. • Work completion might be delayed due to budgetary constraints. • Work will not be completed before the proposed commencement date of this project.
3. Abdul Karim Road (adopted)	• Road is narrow but workability is good since few underground utilities exists. • Some portion is needed to be widened and/or paved. • Some portion will be overlapped with above CDA planned road.

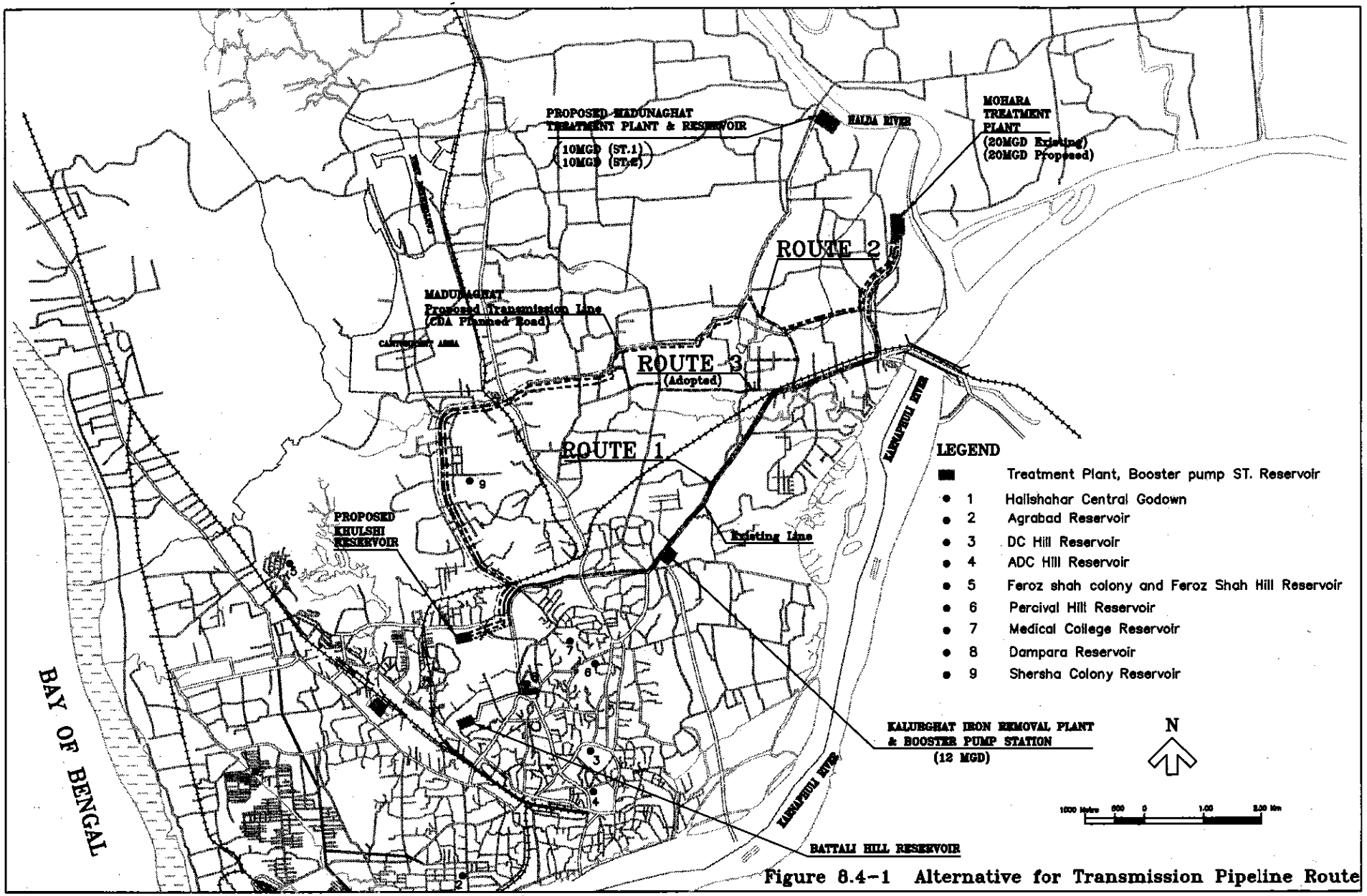


Figure 8.4-1 Alternative for Transmission Pipeline Route

(1) Existing Mohara transmission pipeline (Arakan Road)

The transmission pipeline starting from the existing Mohara WTP to the Battali Hill Reservoir and to the ADC Hill Reservoir passes the Arakan Road via the CWASA exclusive road. The Arakan Road, the major trunk road to Dohazari and Cox's Bazar, starting from the east end of the Asia Highway (CDA Link Road) extends to north-northeast, passing in front of the Kalurghat IRP & BPS, and runs to northeast to pass the Karnaphuli River then go down the left bank of the river to south. There is a bus station close to the Kalurghat BPS and this two-lane road is always crowded since there is no detour route.

At present, several pipelines are installed in the Arakan Road, namely, the transmission pipeline from the Mohara WTP; dia. 900 mm, the raw water transmission pipeline from wells to Kalurghat IRP; dia. 600 mm, the transmission–distribution pipeline from the Kalurghat BPS; dia. 600 mm and the distribution pipeline; dia. 300 mm, and other utilities such as gas and telephone. Road was widened but since the widening direction was not fixed, locations of said existing pipelines are not definite. Therefore, locations of these pipelines shall be investigated prior to the installation work for the new transmission pipeline, and crossing and/or shifting of pipes might be needed.

Considering above-mentioned current status, pipe installation work in the Arakan Road will be difficult and result higher construction cost. Because of such difficulties, traffic disorder and nuisance to shops along the road, it is recommendable that this route be avoided.

(2) Planned CDA Road

Chittagong Development Authority (hereinafter referred to as CDA) planned the road shown in Figure 6.4-2. This road was planned as "by-pass road" connecting the Industrial Estates of Kalurghat and Nasirabad and the Dhaka Trunk Road. Although the Asia Highway located in south is available, this intersection is crowded all the time. Upon completion of this road, traffic jams will be mitigated and transportation to both industrial estates will be facilitated. Total construction cost for Stage 1 construction work covering the section between the Kaptai Road and the Hathazari Road, with a length of 6.09 km was estimated to be Taka 154 million. According to the original plan, the work would start from 1995 or 1996 and be completed in 2000 or 2001.

Based on the current status, land acquisition cost is not ready due to budgetary constraints. Land acquisition for Stage 1 work will be finished in 2001 and commencement of construction work will be in 2002. Depending on the said budgetary constraints, start of work might be further

postponed. After one-year land acquisition, four years will be needed for construction work so work completion will be in the year of 2005, even if there is no delay. However, 2005 is the target completion year of this Project.

Besides, though the road will work as a by-pass road only upon completion of Stage 2 work, construction schedule for Stage 2 work is not prepared yet. Most of transmission pipeline will be laid in the route covered by Stage 1 work, but as stated above, it may be judged that the work will not be completed by the year of 2003, which is the expected commencement year of the Mohara Expansion and Extension Project. Therefore, the new transmission pipeline cannot be installed in the planned CDA road.

In the Italy-financed Madunaghat Project being processed prior to the Mohara Project, adopted this planned CDA road as a transmission pipeline route for the new WTP which will be constructed at the side of the Madunaghat Bridge. The route starts from the WTP, runs the Kaptai Road to south to the Mohara WTP, then passes the planned CDA road, and runs the Baizid Bostami Road, penetrating the Nasirabad Industrial Estate, and reaches the Battali Hill Reservoir via the Asia Highway (CDA Link Road). However, based on the results of meeting held on 6 March 2000 between CWASA and Italian side, the proposed transmission pipeline will be installed in the Arakan Road if said planned CDA road will not be completed by the commencement of pipe installation work.

(3) Abdul Kalim Road

As the third alternative, transmission pipeline routing analysis on the Abdul Kalim Road was carried out. This route starts from the Mohara WTP, runs the CWASA Road and brick-paved road running along the Arakan Road and reaches to the Kaptai Road. Then, it goes along with the Kaptai Road for 500 m to south, via road in the Kalurghat Noxious Zone, industrial estate, and then runs on the Abdul Karim Road to west. About 900 m after entering the Abdul Karim Road, vehicles cannot enter due to narrow road width. The road turns to unpaved for another 900 m. Road width of this section is ranging from 2 to 3 m and needed to be widened and paved. Then, go along with the Haji Chondmia Road until reaching to the Old Mosque. Road heading to north has a width of 5 m and length of 400 m. The route turns left at VIP Mosque then goes west. Width of this road is about 4 m and length is 900 m. After crossing Panchlaish Road, road width is increased to 6 m and arrives to the Hathazari Road. The Hathazari Road has a width of 17 m and going along this road by 100 m, reaches to rotary zone at intersection of the Hathazari Road and the Baizid Bostami Road. The route goes down on the Baizid Bostami Road by 1,800 m to south and diverged to the proposed construction site in the Nasirabad Industrial Estate.

Another route still goes along the Baizid Bostami Road by 2.8 km to south after divergent point then arrives at the Asia Highway. It runs the Asia Highway by 1 km to west, and then goes along the Zakir Hossain Road by 900 m to west. Proposed site at South Khulshi is located in the distance of 200 m from there. Total length of new transmission pipe will be about 15 km (Road No.1 to 19 in Table 8.4-2). Pavement condition, road length and width of each road are shown in Table 8.4-2.

Table 8.4-2 Proposed Transmission Line Route

Name of Roads		Road Pavement	Road Width (m)	Road Length (m)	Distance from WTP (m)	Pavement Width (m)
1	CWASA	Asphalt	5 to 6	860	860	4m
2	Unknown	Brick	4 to 6	1,195	2,055	3m
3	Kaptai	Asphalt	12	470	2,525	8m
4	Road No.3	Brick	15	1,130	3,655	4 to 5m
5	CDA	Asphalt	5 to 6	245	3,900	4 to 5m
6	Abdulkarim	Asphalt	5 to 6	100	4,000	3 to 4m
7	Abdulkarim	Unpaved	2 to 4	1,375	5,375	
8	Haji Chondmia	Brick	5	100	5,475	3m
9	Abdulkarim	Brick	8 to 10	530	6,005	5m
10	Unknown	Brick	5 to 6	585	6,590	4m
11	Unknown	Asphalt	5 to 6	190	6,780	4m
12	Unknown	Brick	4 to 5	410	7,190	3m
13	Wazieda	Brick	5 to 6	1,410	8,600	4m
14	Hathazari	Asphalt	17	65	8,665	7.5m
15	Baizid Bostami	Asphalt	25	1,680	10,345	10.5m
16	Baizid Bostami	Asphalt	25	2,755	13,100	10.5m
17	Asia Highway	Asphalt	35 to 40	895	13,995	35 to 40m
18	Zakir Hossain	Asphalt	12	795	14,790	12m
19	Unknown	Unpaved	5	100	14,890	South Khulshi Hill proposed site
20	Tara Campany	Unpaved	4 to 6	200	10,545	connect to 15
21	Unknown	Unpaved	4	200	10,745	Nasirabad Hill proposed site

Note: Road width with underline stands for typical width.

Because of afore-mentioned reasons, the route on Abdul Kalim Road is recommendable for the transmission pipeline from the Mohara WTP new plant to the new reservoir. However, since implementation of afore-mentioned CDA planned road is on-going, its availability shall be verified at the time of implementation of the project. If it is available for the project at that time, required cost and difficulty of construction work can be lessened.

8.4.3 Proposed Water Distribution System

(1) Water Supply Service Block

In the Chittagong water supply system, there will be four major water sources in the year 2005, namely, the Mohara WTP, the Kalurghat IRP, and the Madunaghat WTP. Taking account of availability of reservoirs and effective use of existing large diameter transmission/distribution pipelines, water produced in those plants will be distributed through distribution reservoirs as follows:

a) Mohara WTP Old Plant[9]: i) Pumped supply from clearwater reservoir
ii) Gravity-flow supply from Battali Hill reservoir and ADC Hill reservoir
iii) Pumped supply from Patenga BPS

b) Mohara WTP New Plant: Gravity-flow supply from a proposed reservoir

c) Kalurghat IRP: Pumped supply from the clearwater reservoir

d) Madunaghat WTP: Gravity-flow supply from Battali Hill reservoir (the same block with above a) ii))

Each of the areas to be served from those reservoirs forms an individual service block. Valves will separate boundaries of each service block. Location of boundaries was decided based on the results of hydraulic analysis of distribution network.

(2) Distribution Network

The network model for the distribution pipeline network hydraulic analysis was established based on the various data, record, and information in design section and MOD sections. Based on this network model, hydraulic analysis for F/S was conducted for the demand in the year 2005 for the network model presented in Figure 8.4-2. Boundary of service blocks in 2005 is also presented in Figure 8.1-1 and Figure 8.4-2.

In the network analysis, following considerations were given:

- Existing pipelines shall be utilized in the proposed network system as far as possible.
- Because of shortage of water source capacity, service area shall be limited within the present service area.
- Extension of new pipeline shall be limited except for the Chandgaon Thana and Chittagong Port Thana.

[9] Dhaka Trunk Road BPS may be abolished based on the results of hydraulic analysis.

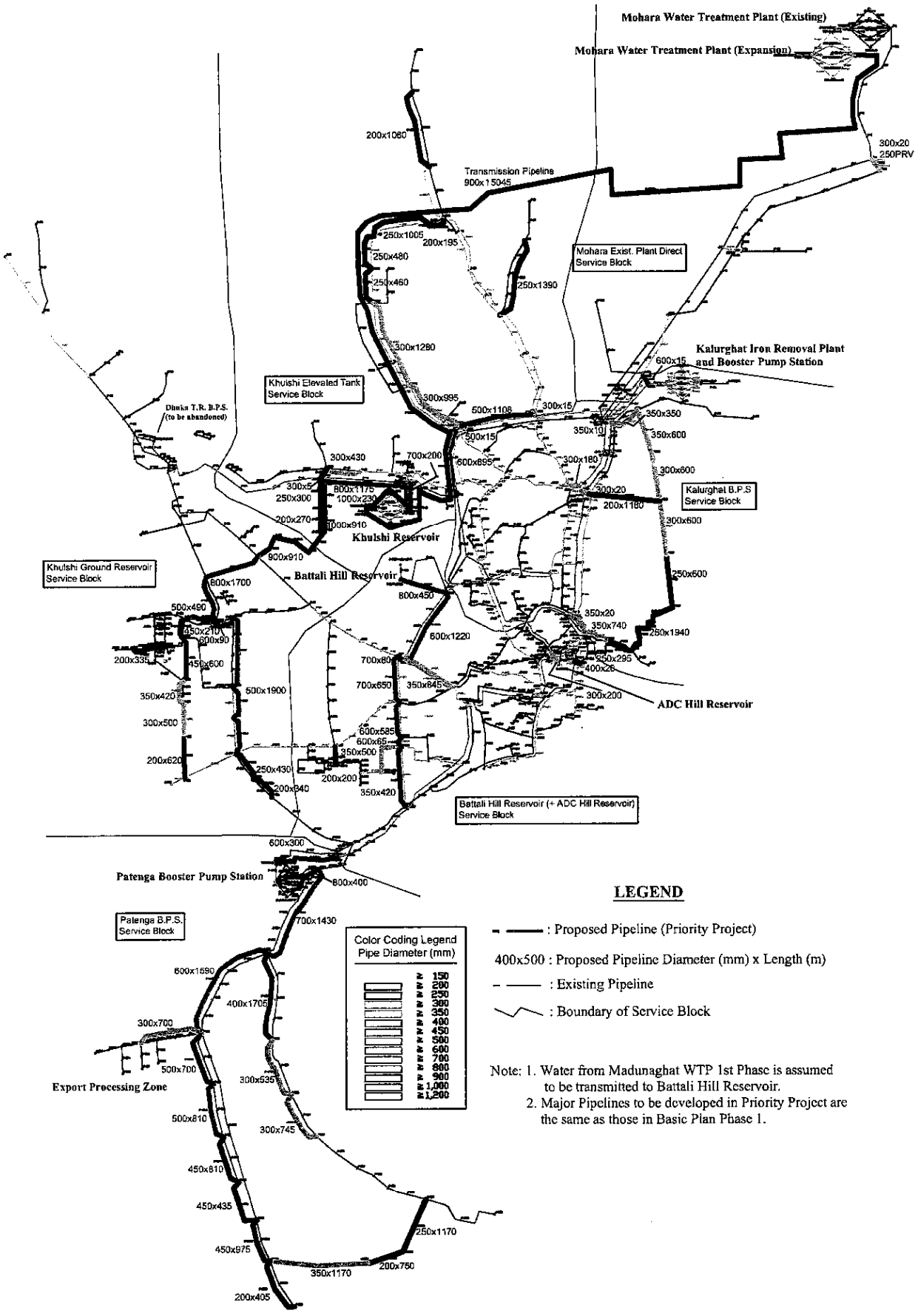


Figure 8.4-2 Proposed Pipeline Network for Priority Project

- Due to shortage of water source against water demand in 2005, coverage of secondary distribution system is assumed to be limited as discussed in Chapter 3.
- Hydraulic analysis shall be conducted on primary distribution system consisting of pipelines with a diameter of 200mm or larger. Cost for development of secondary distribution system shall be estimated separately based on the assumed area to be developed.

As a result of above considerations, most of pipelines to be developed in the priority project is reinforcement pipelines paralleling with existing pipelines as presented in Figure 8.4-2.

(3) Distribution Reservoir

By the year 2005, several reservoirs shall be developed or rehabilitated as follows:

a) Clearwater reservoir of Mohara WTP Old Plant

Since capacity of the existing clearwater reservoir of the old plant is not enough for planned distribution system, a half of the new clearwater reservoir of the proposed new plant will be interconnected with the one of the old plant. Existing transmission pumps has enough capacity for planned supply system.

b) Battali Hill Reservoir

Though physical soundness of the Battali Hill reservoir is under examination, it is assumed that the Battali Hill reservoir is used as a distribution reservoir receiving water transmitted from the Madunaghat WTP and excess of transmitted water from the Mohara WTP old plant.

c) ADC Hill Reservoir

Since capacity of the reservoir is not enough to serve the adjacent area fully, it should function as a balancing tank; in other words, it will work as a supplemental water supply source during water demand peak hours. Connection with distribution system with two pipelines is assumed in the hydraulic analysis.

d) Kalurghat BPS

The Kalurghat BPS is attached to the IRP. Since the capacity of the existing clearwater reservoir is not enough for the planned distribution system, augmentation of the reservoir with a capacity of about 4,200 m^3 is needed. Capacity of existing pumps is enough for planned distribution in 2005.

e) Patenga BPS

New distribution pumps shall be provided at the Patenga BPS to augment present pumping capacity to cope with projected water demand. In addition, a ground distribution reservoir cum receiving well for transmitted water from the Mohara WTP old plant with an effective capacity of 12,000[10] m^3 shall be provided. Dimensions of the new reservoir will be as follows;

Width 17.5 m x Length 35.0 m x Depth 6.0 m x 4 units
(HWL: 7 m, LWL: 1 m)

Capacity of new distribution pumps to be added to existing pumps is as follows:

19.2 m^3/min x 37 m x 200 kW x 3 units (incl. 1 stand-by)

f) Khulshi Reservoir

A new distribution reservoir for water transmitted from the Mohara WTP new plant shall be provided. Based on the field investigation, two candidate sites, i.e. South Khulshi and Nasirabad were selected. Out of these sites, the South Khulshi site may be judged recommendable because of its location. From proposed Khulshi reservoir, water can be distributed by gravity from the ground reservoir to western area of the city. However, inland area, such as Khulshi Hills and Nasirabad Industrial Area, shall be supplied from an elevated reservoir.

Water transmitted from the Mohara WTP new plant will be received by the ground reservoir. A part of water will be distributed from the ground reservoir directly. Remaining water will be lifted up to an elevated tank by lift pumps, and then distributed to the service area.

Transmission pipeline to the Dhaka Trunk Road BPS will be connected with the proposed ground reservoir. Since water can reach to the end of northward pipeline in Sitakunda Thana, operation of the Dhaka Trunk Road BPS may be ceased.

Following facilities will be provided at the Khulshi reservoir site.

Ground Reservoir:	19,600 m^3 (effective capacity) Width 19 m x Length 46 m x Depth 7 m x 4 units (HWL: 35 m, LWL: 28 m)
Lift Pump:	25 m x 13.1 m^3/min x 90 kW x 4 units (incl. 1 stand-by unit)

[10] This capacity shall be increased to cope with increased demand of 2010.

Elevated Tank: dia. 18 m x 7 mD x 16mH (LWL)
(HWL: 52 m, LWL: 45 m)

(4) Small Diameter Distribution Pipelines

In addition to the primary distribution system, the distribution pipeline network identified in the hydraulic analysis, secondary distribution system, i.e. small diameter distribution pipelines consisting of pipelines with a diameter of 200 mm or less, shall be developed to transfer water from primary distribution system to consumers. Those pipelines have been installed by CWASA through its history. In the central area of the city, such pipelines were already installed except for minor roads. In the future, it will be installed at the time of developing of residential area, commercial area, and industrial area. In the priority project, costs for them were estimated only for the area identified by CWASA to be developed immediately to solve water shortage. Details of method for cost estimates are presented in the Supporting Report.

8.5 Operation and Control System of Mohara WTP

Operation and control method of major equipment in the Mohara WTP expansion plant, which closely related to the instrumentation system, are described in this section. Flow diagram of control system is presented in Figure 8.5-1.

(1) Raw Water Intake Pump

The raw water for the new plant will be taken from the Halda River by pumping together with the raw water for existing plant. Because of fluctuation of river water level, volume of pumped water also fluctuates due to change of suction head.

Therefore, pumps will be equipped with automatic inverter speed control system for constant water intake, which will be monitored at flowmeters of intake water located on conveyance pipes. Operation condition of these pumps will be monitored at the central monitoring room and controlled at the local intake pump control room.

(2) Desilting Basin

This basin will be equipped with sand pumps on traveling bridge for the continuous discharge of sand in raw water. This traveling bridge will travel on the basin automatically, pump will be discharge the silt and sand from the bottom of basin. The sand will be discharged to the Halda River through discharge conduit by gravity. Operation and monitoring of the bridges and the pumps shall be carried out locally.

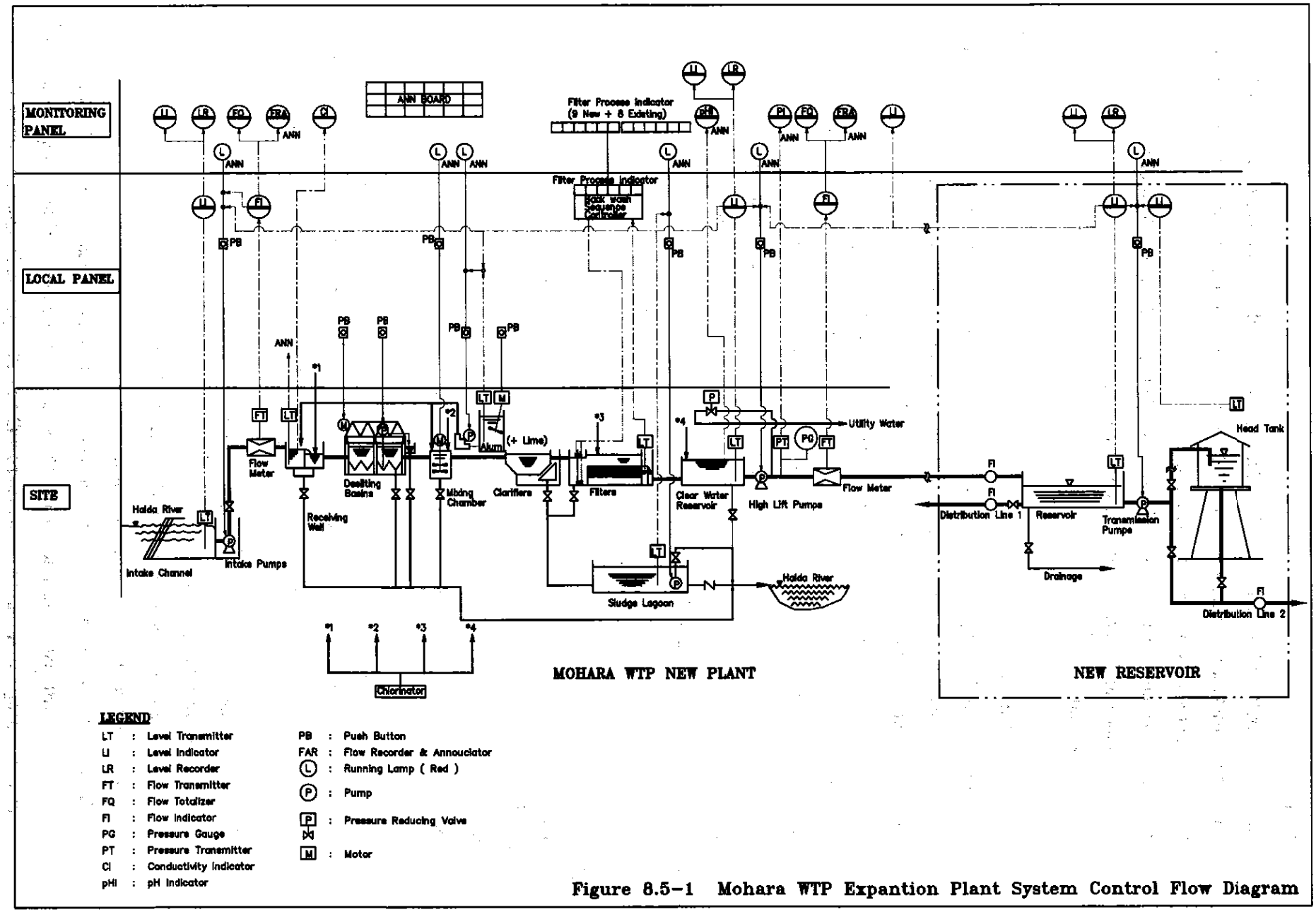


Figure 8.5-1 Mohara WTP Expantion Plant System Control Flow Diagram

(3) Filters

Sequence Controller will control operation of filters automatically. Sequence Controller will also control filter backwash system from the local control panel located in the filter control room. Backwashing process will be started as follows:

- Automatic start by length of filtration time recoded by the Sequence Controller
- Automatic start by differential pressure of sand layer
- Manual start

(4) Transmission Pumps

Starting device shall be applied to lessen voltage drop by using star-delta starter for the reason of reliability. Pumps will be operated automatically in accordance with water level of the Khulshi Reservoir and the clearwater reservoir of the new plant. They automatically stop at low water level (LWL) of the clearwater reservoir of the new plant. When the water level of the clear water reservoir will drop below low low water level (LLWL), alarm for LLWL will sound until the level return to LWL. Pumps will also be automatically stop at HWL of the new reservoir, but should any problem occur, a double interlock system will stop the pumps and the alarm will sound. All operation switches will be at the reservoir and clear water reservoir, and alarms and control systems will be provided on the local control panel. Alarm and operation indicators will also be provided at the central monitoring room.

(5) Central Monitoring Room

Basic information relating to plant operational condition will be monitored on the monitoring panel in the Central Monitoring Room. .

- Monitoring panel

The monitoring panel has the graphic board with following operation status lamps.

- Indication lamp and signal lamp

  Operational condition of major equipment in WTP will be monitored on this panel by lamps. Globes and lamps will be designed to permit easy replacement from the front of the panel. Gloves will be of round or square type and will be of synthetic resin glass. The lamps will be red for running condition.

  * Running Lamps of Pumps (incl. high lift pumps at Khulshi)
  * Operation Lamp of Mixers
  * Process Indicator of Filters (Service, Backwash etc.)

- Fault (ANN [annunciator]) indication lamp

  The indication lamps will have front windows of acrylic resin or glass. The windows will be engraved or lettered in black to fault. The windows will be removable for replacement of lamps or change of indication. The lamps will be bulb type and is lighten in red to indicate

an alarm. A buzzer is rung and lamps blink at both Local Control Panel and Center Monitoring Panel. Major items to be indicated are as follows.

* Flow rate
* Water Level
* Pressure
* pH
* Running Equipment

- Instrumentation Panel

This panel will indicate the value of each site instrument. These values will be recorded for day and check the data for normal operation.

- Indicator
  * Flow Rate (Raw Water, Treated Water)
  * Water Level (River, Clearwater Reservoir, Khulshi Ground Reservoir / Head Tank)
  * pH (Clear Water Reservoir)
  * Pressure (Transmission Pipe)
  * Conductivity (Raw Water)
- Recorder
  * River Water Level
  * Flow Rate (Raw Water, Treated Water)
  * Total Flow (Raw water, Treated water)

(6) Local Control Panel

Equipment will be operated through local control panels at field. The operation and control will be done by operators manually or by the sequence controller automatically.

(7) Khulshi New Reservoir

This new reservoir will consists of following equipment.

- Ground reservoir
- High lift pumps
- Head tank
- Generator
- Level meter
- Electric equipment
- Pipe
- Valves

High lift pumps are normally operated by automatic control linking with level meters at the ground

reservoir and the head tank. This control signal will also be monitored in the central monitoring room at the Mohara WTP.

8.6 Summary of Proposed Facilities

Proposed facilities for F/S are summarized in Table 8.6-1.

8.7 Project Cost

8.7.1 Composition of Project Cost

The composition of project cost is shown in Figure 8.7-1.

8.7.2 Conditions for Cost Estimate

(1) Conditions

1) Basic conditions

The project cost is estimated on the basis of the preliminary design. Unit prices and lump sum prices are established considering local conditions, sub-contractors, hiring equipment, available construction equipment and materials.

Assumptions and conditions applied for the cost estimate are as follows:

Price level: as of September 2000

Foreign exchange rate: Tk. 54.00 = US$1.00 = Japanese Yen 106

2) Direct cost

Unit prices obtained from the CWASA and PWD, a local consulting firm, and a contractor were compared and adopted unit costs are established as of September 2000.

3) Land acquisition cost

Land acquisition costs for the new facilities are estimated for required land area based on layout plans for facilities. Unit prices of land were estimated based on information from CWASA. The required land should be secured prior to the commencement of construction. Required lands for the priority project are as follows:

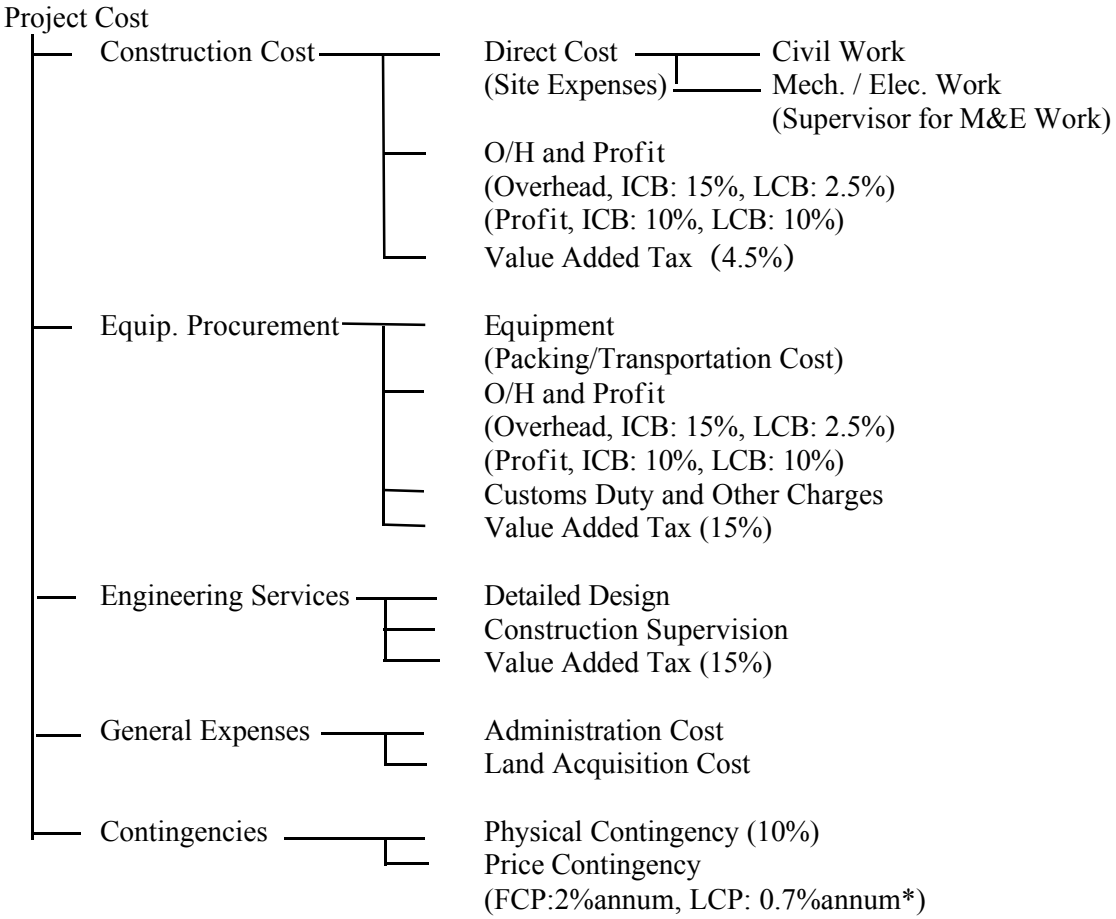
Table 8.6-1 Proposed Facilities of Priority Project

Facilities	Diameter (mm)	Material	Quantity
1 Mohara WTP New Plant Service Area			
WTP Treatment Plant 20MGD			20MGD
Transmission Pump 15.8m3/min x 84 m x 350 kW x 4 (+1)units			5 units
Transmission Pipeline	900	DCIP	15,045 m
2 Khulshi Distribution Reservoir Service Area			
Khulshi Distribution Reservoir			
Ground 2,800m2 x 7mD (35m-28m)			19,600m3
Lift Pump 13.1m3/min x 25m x 90kW x 3 (+1)units			4 units
Elevated dia. 18m x 7mD (52m-45m) x 16mH (LWL)			1,780m3
Distribution Pipeline	1000-200	DCIP/PVC	20,985 m
3 Mohara WTP Old Plant Service Area			
WTP Rehabilitation Work (Filters, Intake/Transmission Pumps)			1 l.s.
Distribution Pipeline	600-300	DCIP/PVC	20 m
4 Kalurghat BPS Service Area			
IRP Rehabilitation Work (Filters, Power Generator)			1 l.s.
Clearwater Reservoir (add.)			
Ground 1,470m2 x 2.87mD (3.33m-0.46m)		exist. 2,940m2	1,470m2
		(8,440m3)	(4,220m3)
Distribution Pipeline	600-200	DCIP/PVC	7,150 m
5 Battali Hill Reservoir Service Area			
Distribution Pipeline	800-200	DCIP/PVC	5,505 m
6 Patenga BPS Service Area			
Patenga Distribution Reservoir			
Ground 2,000 m2 x 6mD (7m-1m)			12,000m3
Dist. Pump 19.2m3/min x 37m x 200kW x 2 (+1)units			3 units
Distribution Pipeline	900-200	DCIP/PVC	14,630 m
7 Secondary (Small Dia.) Distribution Pipelines			
Small Diameter Pipelines	200-100	PVC	1 l.s.
8 Staff Quarters and Zone Offices			
Staff Quarters	100m2		40 flats
Zone Offices	800m2		5 offices
Summary of Facilities to be Developed			
Water Treatment Plants			1 plant
Capacity of WTPs			20MGD
Pump Stations			3 stations
Number of pump units			12 units
Reservoirs*			
Ground Reservoir			3 rsvrs.
total capacity			35,820 m3
Elevated Tank			1 tank
total capacity			1,780 m3
Pipelines**			63,335 m
Transmission Pipeline Total Length			15,045 m
Ditribution Pipeline Total Length			48,290 m

Note: Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Clearwater reservoirs in WTP are not included.

**: Pipeline Length does not include secondary distribution (small dia.) pipeline network.



(*: Because of devaluation of Taka against US$, net inflation rate presented in US$ is far less than nominal inflation rate. Refer to 8.7.2 (1) 4))

Figure 8.7-1 Composition of Project Cost

Table 8.7-1 Required Land Acquisition for Proposed Facilities

Facilities	Required Area (ha)	Year to be Acquired*
a) Mohara WTP	0.05**	by 2002
b) Khulshi Reservoir	1.7	by 2002
c) Patenga Reservoir	1.8	by 2002

*: Year when detailed design will start.
**: at north-west corner of present premises

4) Contingency

A 10 percent of contingency fund is included in the project cost as a physical contingency for unforeseeable cost and incidental change of scope of work.

A price contingency is considered in the project disbursement schedule against price escalation of the project cost. Price escalation rate of foreign currency portion (FCP) is assumed to be 2% per annum during construction period for calculation price contingency. The price contingency for the local currency portion (LCP) shall be estimated taking into

account a devaluation factor of Taka against US Dollar in addition to inflation rate. Price escalation rate of local currency portion can be obtained by following equation:

$$Ep = (((1+Pr/1000) / (1+Er/1000)) - 1) \times 100$$

where: Ep; annual price escalation rate of LCP, %
Pr; average increasing rate of Price index, %
Er; average devaluation rate of exchange rate, %

Based on the general construction price index and exchange rate in last 10 years tabulated below, annual price escalation rate of LCP, Ep, was derived at 0.7% .

	1991	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**A.I .R***
General Construction Price Index	1449	1525	1540	1547	1657	1763	1810	1897	1999	2087	4.17%
Exchange Rate	26.0	29.9	30.6	31.2	32.1	32.9	35.7	38.1	39.1	40.0	3.49%

Source: Statistical yearbook, BBS
*: Average increasing rate per annum – derived from approximate exponential curve analysis

(2) Scope of work to be implemented under foreign finance

The following works are recommended to be implemented under foreign financial assistance.

1) Procurement of engineering services for detailed engineering design and construction supervision.
2) Construction work including procurement of equipment and materials as identified in the preliminary design and project cost estimates.

(3) Scope of work to be implemented by the counterpart fund

The following indigenous works are to be implemented by the counterpart fund of the Bangladeshi Government:

1) Land acquisition and relocation of local residents from the proposed construction sites and along the proposed pipeline routes.
2) Any taxes, duties, and charges levied by Bangladesh Government.
3) Administration cost of CWASA.
4) Cost of electricity, fuel and chemicals required for the testing activities at the water treatment plant prior to actual operation.

8.7.3 Project Cost

The total cost of the proposed priority project is estimated at US$ 94 million without price contingency, and US$ 99 million with it as presented in Table 8.7-2. Costs for following projects are not included in said cost estimates.

Table 8.7-2 Cost Estimates for Priority Project

(unit: US$)

Facilities	Priority Project		
	Local	**Foreign**	**Total**
I. Direct Construction Cost			
1. Treatment Plant			
Mohara WTP Expansion Plant, Transmission Pumps	5,535,000	9,633,000	15,168,000
Mohara WTP Rehabilitation Work	355,000	2,275,000	2,630,000
Kalurghat IRP Rehabilitation Work, Reservoir	643,000	1,393,000	2,036,000
2. Distribution Reservoir and BPS			
Khulshi Distribution Reservoir, Pumps, Tank	3,031,000	2,151,000	5,182,000
Patenga Distribution Reservoir	1,381,000	2,331,000	3,712,000
3. Transmission / Distribution Pipeline			
Transmission Pipeline DCIP 900mm x 15,045m	1,049,000	4,224,000	5,273,000
Main Distribution Pipeline	2,315,000	5,584,000	7,899,000
4. Small Size Distribution Pipelines	1,986,000	2,861,000	4,847,000
5. Staff Quarters and Zone Offices	1,480,000	0	1,480,000
Total of Direct Construction cost	**17,775,000**	**30,452,000**	**48,227,000**
II. Overhead and Profit	**791,000**	**10,475,000**	**11,266,000**
III. Procurement of Equipment	**0**	**704,000**	**704,000**
IV. Administration			
1. CWASA Administration Cost	**128,000**	**0**	**128,000**
2. Land Acquisition Cost	**3,370,000**	**0**	**3,370,000**
V. Duties, Taxes, and Charges	**16,316,000**	**0**	**16,316,000**
VI. Engineering Cost			
1. D/D + C/S	782,000	4,022,000	4,804,000
2. VAT for Engineering Cost (5.25%)	252,000	0	252,000
Total of Engineering Cost	**1,034,000**	**4,022,000**	**5,056,000**
VII. Contingencies			
1. Physical Contingency (10% of I+II+III+IV+V+VI)	**3,941,000**	**4,565,000**	**8,506,000**
2. Price Contingency (LCP:0.7%p.a.,FCP:2%p.a.)	**1,376,000**	**4,129,000**	**5,505,000**
VIII. Total Project Cost excluding Price Contingency	**43,355,000**	**50,218,000**	**93,573,000**
Total Project Cost including Price Contingency	**44,731,000**	**54,347,000**	**99,078,000**

Note: Costs for Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Costs for Distribution Pipeline in Kalurghat S.A includes all distribution pipelines outside of Khulshi S.A.

- Madunaghat WTP Phase 1 project and its transmission pipeline
- Battali Hill reservoir rehabilitation work
- Fatehabad IRP project
- Kalurghat IRP groundwater source augmentation project
- NRW reduction program
- Service Connection

8.7.4 Construction Equipment and Materials

Most of the construction materials are imported from adjacent countries, except sand, gravel, concrete pipe etc. Imported materials are available in the local market in Bangladesh. Major mechanical and electrical equipment, however, must be imported from foreign countries by contractors.

In addition to plant machineries and equipment, small size water meters, vehicles, computers will be purchased in the priority project.

Local products and imported materials and equipment are listed below. However, the imported materials for civil work are considered to be procured through sales agents and suppliers in Bangladesh.

(1) Local material

Cement, stone, brick, aggregate, sand, timber, plywood, steel reinforcement bars, structural steel, small PVC Pipe, concrete pipe, steel pipe, road curb, concrete block, brick, AC roof and tiles, fence, road/pedestrian gates, wire nails, gabion mesh, gasoline, diesel, lubricants, admixtures, waterstop, scaffolding, metal forms, guardrail, asphalt, emulsion and other small items.

(2) Imported material

Construction equipment, valves, fittings, ductile iron pipe, truck cranes, vehicles, motorcycles, computers, pumps, motors, transformers, switchgears, disinfection facilities, laboratory equipment, flow meters, and other mechanical and electrical equipment.

8.8 Implementation Schedule

An implementation schedule of the priority project was established to commence the preparation work in 2001 and to complete by the end of 2005, which is the target year of the feasibility study. Thus, the operation of the Mohara WTP Expansion Plant may be started from the beginning of 2006.

However, full operation of the Mohara WTP with a capacity of 40MGD will be materialized in latter half of 2006 because the rehabilitation work of existing Mohara WTP shall be carried out after operation of new plant to secure continuous water supply of 20MGD.

The major activities and its schedule are listed below:

2000	Feasibility Study
2000-01	Preparation and negotiation for financial arrangement Land acquisition (GOB fund)
2002-03	Detailed design and Bidding
2003	Commencement of construction & procurement of equipment
2003-05	Construction (Priority Project) Development of Lateral Pipe and House Connection (GOB fund)
2005	Completion and commissioning of plant
2005-2006	Rehabilitation of existing plant

Bar chart of the implementation activities and annual disbursement schedule are presented in Figure 8.8-1 and Table 8.8-1, respectively.

The required project activities are described below:

(1) Preparation of Project (2000 – 2001)

Preparatory work for the project implementation includes:

- Budgetary arrangements within the Bangladesh Government for land acquisition and institutional development,
- Negotiation of grant/loan with foreign government and lending institution/s,
- Negotiation with landowners for land acquisition of sites, and
- Selection of consultants in accordance with the agreement executed between the foreign lending institution and the executing agency of the Bangladesh Government

This preparatory work shall be commenced by the end of 2000 and completed by the end of 2001.

It should be noted that the institutional development of the executing agency and staffing as required for project implementation are a prerequisite not only to insure the successful achievement of the project objectives, but also to secure the firm commitment of financial assistance from the foreign lending institution/s. Appraisal missions from the institution will focus on the preparedness and maturity of the proposed project as well as the implementing capability of the executing agency, both financially and institutionally.

Figure 8.8-1 Implementation Schedule of Priority Project

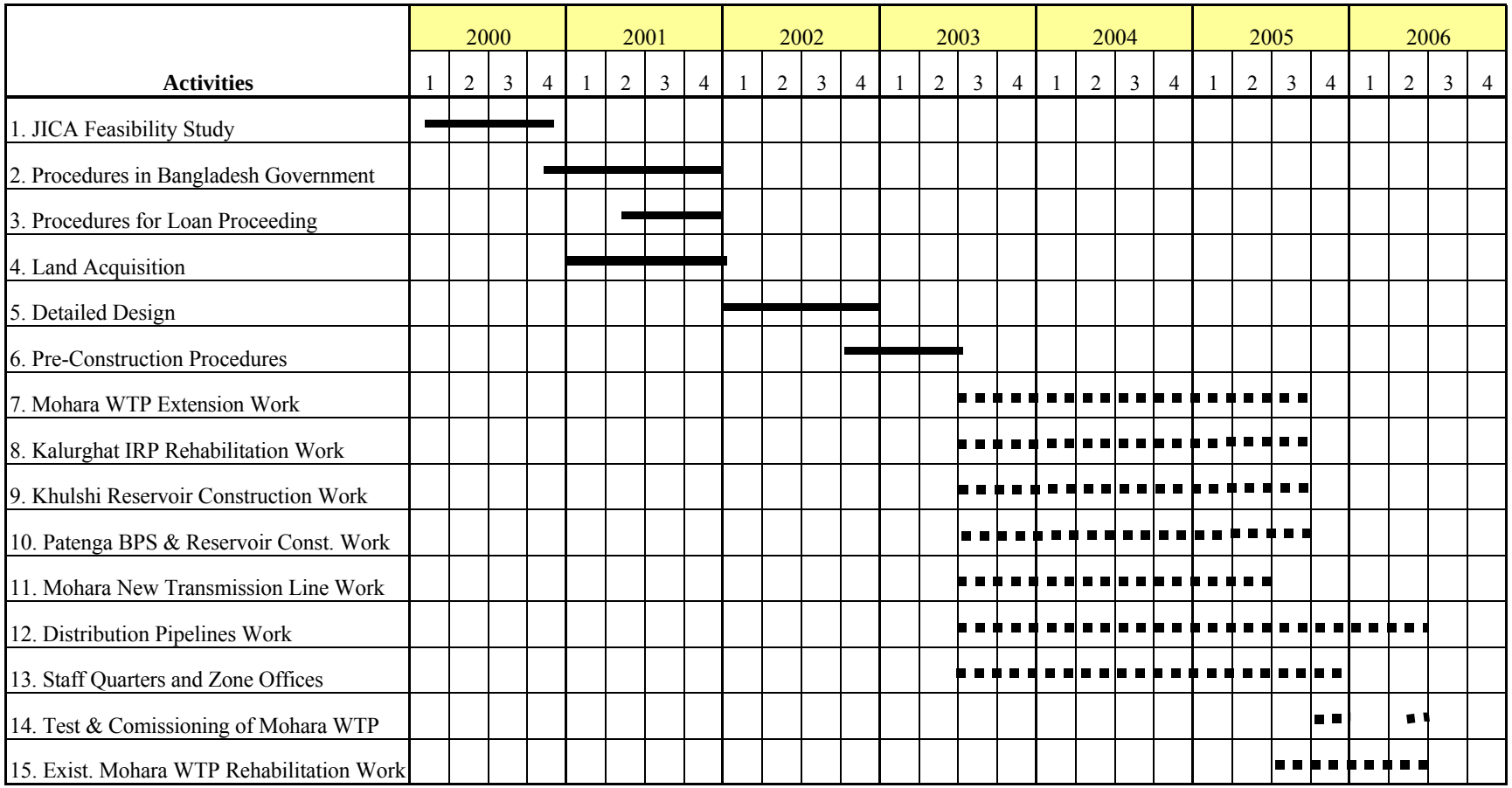


Table 8.8-1 Disbursement Schedule of Priority Project

(unit: US$)

Facilities	Priority Project Total			2001			2002			2003			2004			2005			2006		
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
I. Direct Construction Cost																					
1. Mohara WTP New Plant Service Area																					
WTP Treatment Plant 20MGD, Trans. Pump	5,535,000	9,633,000	15,168,000	0	0	0	0	0	0	1,107,000	1,927,000	3,034,000	2,214,000	3,853,000	6,067,000	2,214,000	3,853,000	6,067,000	0	0	0
Transmission Pipeline DCIP 900mm x 15,045m	1,049,000	4,224,000	5,273,000	0	0	0	0	0	0	210,000	845,000	1,055,000	420,000	1,690,000	2,110,000	420,000	1,689,000	2,109,000	0	0	0
2. Khulshi Distribution Reservoir Service Area																					
Khulshi Distribution Reservoir, Pump, E..Tank	3,031,000	2,151,000	5,182,000	0	0	0	0	0	0	606,000	430,000	1,036,000	1,212,000	860,000	2,072,000	1,212,000	861,000	2,073,000	0	0	0
Distribution Pipeline	1,272,000	2,851,000	4,123,000	0	0	0	0	0	0	127,000	285,000	412,000	509,000	1,140,000	1,649,000	509,000	1,140,000	1,649,000	128,000	286,000	414,000
3. Mohara WTP Old Plant Service Area																					
WTP Rehabilitation Work	355,000	2,275,000	2,630,000	0	0	0	0	0	0	0	0	0	0	0	0	178,000	1,138,000	1,316,000	177,000	1,138,000	1,315,000
Distribution Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Kalurghat BPS Service Area																					
IRP Rehabilitation Work, Clearwater Reservoir	643,000	1,393,000	2,036,000	0	0	0	0	0	0	129,000	279,000	408,000	257,000	557,000	814,000	257,000	557,000	814,000	0	0	0
Distribution Pipeline (outside of Khulshi S.A. *)	1,272,000	2,851,000	4,123,000	0	0	0	0	0	0	127,000	285,000	412,000	509,000	1,140,000	1,649,000	509,000	1,140,000	1,649,000	127,000	286,000	413,000
5. Battali Hill Reservoir Service Area																					
Distribution Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Patenga BPS Service Area																					
Patenga Distribution Reservoir, Pump	1,381,000	2,331,000	3,712,000	0	0	0	0	0	0	276,000	466,000	742,000	552,000	932,000	1,484,000	553,000	933,000	1,486,000	0	0	0
Distribution Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Small Size Distribution Pipelines	1,986,000	2,861,000	4,847,000	0	0	0	0	0	0	199,000	286,000	485,000	794,000	1,144,000	1,938,000	794,000	1,144,000	1,938,000	199,000	287,000	486,000
8. Staff Quarters and Zone Offices	1,480,000	0	1,480,000	0	0	0	0	0	0	592,000	0	592,000	592,000	0	592,000	296,000	0	296,000	0	0	0
Total of Direct Construction Cost	**18,004,000**	**30,570,000**	**48,574,000**	**0**	**0**	**0**	**0**	**0**	**0**	**3,373,000**	**4,803,000**	**8,176,000**	**7,059,000**	**11,316,000**	**18,375,000**	**6,942,000**	**12,455,000**	**19,397,000**	**631,000**	**1,997,000**	**2,628,000**
II. Overhead and Profit																					
1. OH and Profit for ICB (25% of 1, 2, 3, 4, 5 and 6)	0	10,475,000	10,475,000	0	0	0	0	0	0	646,000	1,129,000	1,775,000	1,418,000	2,543,000	3,961,000	1,463,000	2,828,000	4,291,000	108,000	428,000	536,000
2. OH and Profit for LCB (12.5% of 7 and 8)	791,000	0	791,000	0	0	0	0	0	0	99,000	36,000	135,000	173,000	143,000	316,000	136,000	143,000	279,000	24,000	36,000	60,000
Total of Overhead and Profit	**791,000**	**10,475,000**	**11,266,000**	**0**	**0**	**0**	**0**	**0**	**0**	**745,000**	**1,165,000**	**1,910,000**	**1,591,000**	**2,686,000**	**4,277,000**	**1,599,000**	**2,971,000**	**4,570,000**	**132,000**	**464,000**	**596,000**
III. Procurement of Equipment	**0**	**704,000**	**704,000**	**0**	**0**	**0**	**0**	**106,000**	**106,000**	**0**	**598,000**	**598,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
IV. Administration																					
1. CWASA Administration Cost	**128,000**	**0**	**128,000**	**13,000**	**0**	**13,000**	**13,000**	**0**	**13,000**	**26,000**	**0**	**26,000**	**32,000**	**0**	**32,000**	**32,000**	**0**	**32,000**	**12,000**	**0**	**12,000**
2. Land Acquisition Cost	**3,370,000**	**0**	**3,370,000**	**2,696,000**	**0**	**2,696,000**	**674,000**	**0**	**674,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
V. Duties, Taxes, and Charges																					
1. Custom Duty and Other Import Charges	9,907,000	0	9,907,000	0	0	0	52,000	0	52,000	1,061,000	0	1,061,000	2,868,000	0	2,868,000	5,066,000	0	5,066,000	861,000	0	861,000
2. VAT for Civil Work (4.5%)	1,321,000	0	1,321,000	0	0	0	0	0	0	222,000	0	222,000	500,000	0	500,000	528,000	0	528,000	70,000	0	70,000
3. VAT for M&E Equipment (15%)	4,842,000	0	4,842,000	0	0	0	22,000	0	22,000	502,000	0	502,000	1,408,000	0	1,408,000	2,488,000	0	2,488,000	422,000	0	422,000
4. Pre-Shipment Inspection Fee	246,000	0	246,000	0	0	0	1,000	0	1,000	25,000	0	25,000	72,000	0	72,000	127,000	0	127,000	22,000	0	22,000
Total of Duties, Taxes, and Charges	**16,316,000**	**0**	**16,316,000**	**0**	**0**	**0**	**75,000**	**0**	**75,000**	**1,810,000**	**0**	**1,810,000**	**4,848,000**	**0**	**4,848,000**	**8,209,000**	**0**	**8,209,000**	**1,375,000**	**0**	**1,375,000**
VI. Engineering Cost																					
1. D/D + C/S	782,000	4,022,000	4,804,000	0	0	0	321,000	1,782,000	2,103,000	115,000	529,000	644,000	142,000	633,000	775,000	145,000	732,000	877,000	59,000	346,000	405,000
2. VAT for Engineering Cost (5.25%)	252,000	0	252,000	0	0	0	110,000	0	110,000	34,000	0	34,000	41,000	0	41,000	46,000	0	46,000	21,000	0	21,000
Total of Engineering Cost	**1,034,000**	**4,022,000**	**5,056,000**	**0**	**0**	**0**	**431,000**	**1,782,000**	**2,213,000**	**149,000**	**529,000**	**678,000**	**183,000**	**633,000**	**816,000**	**191,000**	**732,000**	**923,000**	**80,000**	**346,000**	**426,000**
VII. Contingencies																					
1. Physical Contingency (10% of I+II+III+IV+V+VI)	**3,941,000**	**4,565,000**	**8,506,000**	**271,000**	**0**	**271,000**	**119,000**	**189,000**	**308,000**	**610,000**	**710,000**	**1,320,000**	**1,371,000**	**1,464,000**	**2,835,000**	**1,697,000**	**1,616,000**	**3,313,000**	**223,000**	**281,000**	**504,000**
2. Price Contingency (LCP:0.7%p.a.,FCP:2%p.a.)	**1,376,000**	**4,129,000**	**5,505,000**	**21,000**	**0**	**21,000**	**18,000**	**84,000**	**102,000**	**142,000**	**478,000**	**620,000**	**427,000**	**1,327,000**	**1,754,000**	**663,000**	**1,850,000**	**2,513,000**	**105,000**	**390,000**	**495,000**
VIII. Total Project Cost excluding Price Contingency	**43,355,000**	**50,218,000**	**93,573,000**	**2,980,000**	**0**	**2,980,000**	**1,312,000**	**2,077,000**	**3,389,000**	**6,713,000**	**7,805,000**	**14,518,000**	**15,084,000**	**16,099,000**	**31,183,000**	**18,670,000**	**17,774,000**	**36,444,000**	**2,453,000**	**3,088,000**	**5,541,000**
Total Project Cost including Price Contingency	**44,731,000**	**54,347,000**	**99,078,000**	**3,001,000**	**0**	**3,001,000**	**1,330,000**	**2,161,000**	**3,491,000**	**6,855,000**	**8,283,000**	**15,138,000**	**15,511,000**	**17,426,000**	**32,937,000**	**19,333,000**	**19,624,000**	**38,957,000**	**2,558,000**	**3,478,000**	**6,036,000**

Note: Costs for Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Costs for Distribution Pipeline in Kalurghat S.A includes all distribution pipelines outside of Khulshi S.A.

(2) Pre-construction stage (2002-2003)

From the beginning of 2002, selected consultants will start the detailed design work. Because of this reason, land acquisition procedure shall be completed by that time. At least approval of landowner for accessing the site for topographic survey and soil investigation shall be secured. The detailed design work will be started with review of F/S to confirm the scope of work of the project. After review work, detailed design work will continue to prepare the bidding documents till the end of 2002. In parallel with detailed design work, pre-qualification procedure of contractors will be conducted for smooth implementation to bidding after detailed design.

After preparation of the bidding documents, bidding for the procurement of maintenance equipment and for the construction of the proposed project will be executed by the middle of 2003.

Other important subjects, such as establishment of a water tariff system for cost recovery, shall also be carried out by the executing agency.

(3) Construction Stage (2003-2006)

Construction work of proposed facilities will start from the middle of 2003. Because of limited time allowance to yearend of 2005, construction work shall be commenced as early as possible after approval of the contract of construction work by the lending institution. Major construction work shall be completed in latter half of 2005 before test operation and commissioning of completed facilities in last few months in 2005, while main distribution pipeline reinforcement work may be extended till the middle of 2006. Since the existing Mohara WTP rehabilitation work shall be carried out after commissioning of the expansion plant, the work will also be continued till the middle of 2006.

In parallel with the above project activities, the executing agency will, in accordance with the detailed design, negotiate with respective landowners and acquire the required land for construction. Other important subjects, such as a tariff system for water supply service for cost recovery, shall also be carried out by the executing agency.

8.9 Considerations for Implementation

Following considerations shall be given for implementation of the project:

(1) Route of Transmission Pipeline

The route of the transmission pipeline from the Mohara WTP expansion plant is desirable to be the CDA Planned Road. Since its implementation has been delayed due to lack of fund, it is expected to be completed by the year 2005, as same as the proposed project. Therefore it was judged that adoption of the CDA road route is difficult from viewpoint of timing. At the time of implementation of pipeline work, if use of the CDA road is possible, it shall be shifted on this route because of less cost and less difficulty in construction work.

(2) Equipment

Mechanical and electrical equipment shall be specified to enable repair work on them in local. They shall be specified to endure local condition of high humid and high temperature. It is desirable to avoid use of complicated mechanical and electrical equipment.

(3) Rehabilitation Work

Rehabilitation works of existing Mohara plant shall be conducted after completion of expansion plant so as to prevent influence on water supply service as far as possible. Rehabilitation works of Kalurghat IRP should also be conducted upon completion of new 5MGD capacity filters, which is expected to be completed by 2002.

(4) New Reservoir

New reservoir for receiving water from the Mohara WTP expansion plant was planned at Khulshi. Land acquisition procedure for the site shall be conducted as soon as possible, as well as for the site of Patenga reservoir. If land acquisition at Khulshi is judged impossible, alternative plan of Nasirabad reservoir is applicable. If land acquisition of it is also difficult, another alternative plan of Battali Hill Head Tank is considerable. In that case, however, it is desirable to re-consider applicability of plans with Battali Hill Reservoir Re-construction to lessen the cost.

(5) Battali Hill Reservoir

The priority project was planned presuming the existing Battali Hill will be used after proper repair work in accordance with the policy of CWASA. If this presumption became in vain after

final decision of CWASA, proposed distribution system shall be re-considered to cope with the final decision. Even in that case, the distribution system in the service block of Khulshi reservoir will be effective, because it is separated from service blocks of existing facilities. However, it is desirable to conduct analysis on whole distribution system to establish an effective and economical distribution system in Chittagong water supply system.

CHAPTER 9

OPERATION AND MAINTENANCE PLAN

CHAPTER 9 OPERATION AND MAINTENACE PLAN

9.1 Proposed Organization for Mohara Treatment Plant

The Mohara water treatment plant has been operated 24-hours mainly by members of CWASA staff. The organization is made up of Executive Engineer, Assistant Engineers, office workers, operators, laborers and securities.

Because of request from central government to reduce number of employees / laborers, three- shift working condition is adopted. Consequently, there are some problems to carry out work in normal rotation due to insufficient number, when operator / office worker require vacation or sick leave as well as a extra day for training of their skill.

The proposed organization structure is shown in Figure 9.1-1, which is divided to tow divisions, the engineers to operate existing plant and to operate new plant will be supervised by the Executive Engineer. The arrangement of staff is also indicated in Table 9.1-1, which requires total of 145 staffs to operate the whole treatment plant including security.

According to staff schedule, 4-Sub Engineers will be allocated for full three shifts, and one Assistant Engineer will always stay in the monitoring room to watch the operation condition over 24 hours, 365 days. They will give advices to operators to control the equipment properly.

Each equipment will be operated by two-men under 3-shifts to avoid from any miss-operation and effective responsiveness to follow the order from the Assistant Engineer in the monitoring room. However, these numbers of operator is not enough when someone requests to take days off or leave. In that case the Executive Engineer will arrange the substitute.

9.2 Work Plan for Operation of Treatment Plant

New water treatment plant will be constructed beside the existing water treatment plant. All information regarding performance of the system will be gathered to monitoring panel in the monitoring room from each measurement devices, such as water level, water flow, operational status of motors, as well as indication of filter backwash status.

Existing water quality analytical room will be moved and integrated to new laboratory room located next to new monitoring room.

9.3 Chemical Dosing Rate

The most important subject for daily maintenance routine work is to predict raw water turbidity of the day to cope with the fluctuating of loading. And then alum-dosing rate is decided for proper coagulation process.

Turbidity of river water vary with little fluctuation during dry season, but during raining season careful continuous attention is required because big and sudden fluctuation occurs due to weather condition in the upstream.

Generally, the Chemical & Quality Control Officer (CQCO) determines alum-feeding rate. The procedure to determine it is as follows:

(1) Check operational condition of the plant by patrol, which especially focuses on observation and confirmation of state of floc formation in the clarifies.
(2) Confirm alum-feeding rate at the chemical dosing facilities.
(3) Conduct a jar test to determine alum-dosing rate.
(4) Examine the operational status at patrol and results of a jar test, and if change of dosing rate at that time is judged to be done, CQCO or its assistant shall inform it to the Executive Engineer, and instruct the operators to do required operation to adjust the dosing rate.
(5) After changing dosing-rate, in charge of the filled operator or its assistant shall feed-back to inform the effect on floc formulation to CQCO.
(6) Above procedure shall be recorded with measured water quality data and observed operational condition to feed back the results on future operation.

Above-mentioned procedure is essential and required to be systemized as a daily routine work. Since the appropriate dosing-rate judged by a jar test sometimes does not result good operational status in the plant, accumulation of data and examination on them to establish the relationship between the laboratory test and actual result are requisite for effective operation.

9.4 Back Washing of Filter

Hydraulically gravity flow with free water board is adopted as structure of the sand filler. Filtration rate is about 250m per day, with which filter layer remove fine floc and suspended substance mixed with the supernatant from the clarifies.

Floc and suspended substance are removed mostly near the surface of the filter layer, if the size of

them is small or fine, they intrude into deeper layer.

If filter back wash system is insufficient, filter problems such as quick rising of water level by clogging of filter bed, and growing of mud-ball will occur, and crack of the filter bed will provide breakthrough of water, then water quality of filtered water will be deteriorated.

Once such problem occurs, back wash process is not functioned well, and filter cleaning is needed to return to normal filter layer condition to maintain porosity of filter bed.

To execute the filter back wash process effectively, the proposed system employs back wash system with pressurized filtered water from other filters and fixed surface wash system with pressurized treated water. The back wash process is started by pressing start button manually, or automatically started by timer or when the water level on filter bed reaches to high level. Backwashing and surface washing periods will be set for about 8 and 15 minutes by timer to secure sufficient wash out effect.

After a long period of operation, filter system may have some problems. For examples, filter layer will be dirty gradually, a part of filter sand will be washed away and layer depth will be decreased, interface between filter sand layer and gravel layer will be irregular, under drain system will be broken, surface wash facility will be broken so on.

To maintain proper effect of back wash it is required that the following operational data and conditions always be monitored:

(1) State of Operation
   1) Initial resistance value (water level) and sand stirring condition during back wash process
   2) Concentration value of suspended substance in back wash wastewater along filtration time
   3) Condition of filter layer surface after back wash process
   4) Coagulation problem at clarifier and carry-over of floc
   5) Variation of water quality at outlet of filter

(2) Filter media
   1) Condition of filter layer surface after back wash process

      A backwash is executed once for 1 to 3 days. After a long operation period, under drain system may be broken. When the system is defect, filter media may fallen down under drain system and surface of filter bed will be irregular.
   2) Condition of filter media

      Check filter media once for 2 to 3 years. Take samples at several places from every 10cm depth of filter media to bottom. Grain size of each sample shall be measured and evaluated. State of dirtiness shall also be examined.

3) Thickness of filter media layer and change of filter layer surface.

(3) Rehabilitation of filter media

Rehabilitation of filter media is needed once in every 7 to 8 years to maintain proper condition.

1) Firstly, take out old filter sand and gravel from filter bed individually and wash them by clean water. Cleansing with sieving is desirable.
2) Secondly, place gravel and sand to original position complying with design specification and criteria.
3) Finally, the rehabilitated filter bed shall be washed by back wash process many times until the back wash water becomes clear.

(4) Determination for backwash

In principle, timing of backwashing will be determined automatically by detecting water level increase to some level or length of filtration period set up beforehand. Condition for start of backwashing shall be decided taking account of following items:

1) It shall be decided so as not to be worse than drinking water standard.
2) It shall be decided so as not exceed 48 hours of filtration period, and so as not to be extremely frequent backwashing.

(5) Determination for rehabilitation / cleaning

After repeat of rehabilitation of filter media by 3 to5 times, filter layer, under drain system and/or clear water pit may be stained or damaged. Consequently, filter will not function properly. The following phenomena indicate the timing of complete rehabilitation of filter bed:

1) Water quality after backwash process is not improved.
2) Aquatic plant or/and organism is found in filter layer.
3) Surface of filter surface is abnormally rough.
4) Irregular flow of backwash water is observed.
5) Cracks or split on the filter bed is observed.

9.5 Production Plan Aiming at Daily Consumption

After completion of new plant, total water supply capacity including being implemented Madunaghat WTP will be increased to about double of present capacity. However, capacity of water distribution system is not sufficient to distribute such volume of water.

Therefore, reinforcement and expansion of small diameter distribution network is requisite, though most of it is out of scope of the project because it requires high cost and long construction period. It is desirable to be implemented in accordance with the progress of the project as far as possible.

For the time being, control of water production is important to meet actual water demand. It is

desirable that operation of the plant be in stable condition to keep proper water quality. For this reason, water production schedule must be established. Methodology of water production control will be presented and trained by Consultants during commissioning period of the new plant.

9.6 Work Items of Maintenance

(1) Inspection and examination of facilities

During long operation period, equipment and facilities have problems, such as deterioration of efficiency, failure of equipment, breakage of facilities, even though they have been functioning at that time. Schedule of repair and rehabilitation shall be planned based on data and observation results obtained through following regular maintenance and inspection work.

1) Daily inspection (about 3 times a day):
   water pressure, water quantity, noise, heat, smell, vibration, lamp test on electrical-monitoring panels, leakage, and so on.
2) Periodical inspection (once a week / a month / 3 months / 6months):
   electrical panels, mixers, pumps, leakage, and so on.
3) Middle-term inspection (once a year):
   performance test of equipment, condition of paintwork, condition of sludge accumulation, calibration of all measurement, and so on.
4) Long-term inspection (once every 3 years or longer interval):
   overhaul check, integrated functional diagnosis of the plant, and so on.
5) Emergency inspection (as needed)
   investigation on major defect and accident, and so on.

(2) Repair and maintenance

1) Daily (about 3 times a day):
   cleaning, check of oil and grease, drain, and so on.
2) Periodical (once a week / a month / 3 months / 6months):
   check and repair of pressure gauge, level meter, sensors of water quality monitoring devices, confirmation of performance of all devices, refilling of oil and grease, screw up loosen bolt and nut, repair of leakage, clean up of premises, and so on.
3) Middle-term (once a year):
   drain work, sludge removal, touch up painting, calibration of instruments, and so on.
4) Long-term (once every 3 years or longer interval):
   overhaul repair, and so on.
5) Emergency (as needed)

repair for major defect and accident, and so on.

(3) Data recording

1) Daily (about 3 times a day):

quantity of intake/supply, pressure gauge and water level, quality of raw water and treated water, amount of chemical feeding and stock volume, status of noise, heat, temperature, smell, and vibration of equipment, particular comments on failure, attendance and performance of staff member, and so on.

2) Periodical (once a week / a month):

quantity of intake/supply water, water quality, water level, weekly average water production/transmission, consumed chemical and power, staff attendance and performance evaluation, expenses, production cost, preparation of weekly/monthly report, and so on.

3) Middle-term (once a year):

preparation of annual report

Figure 9.1-1 MOHARA W.T.P. OPERATION & MAINTENANCE ORGANIZATION

（Total staff: 145; for new plant: 64）

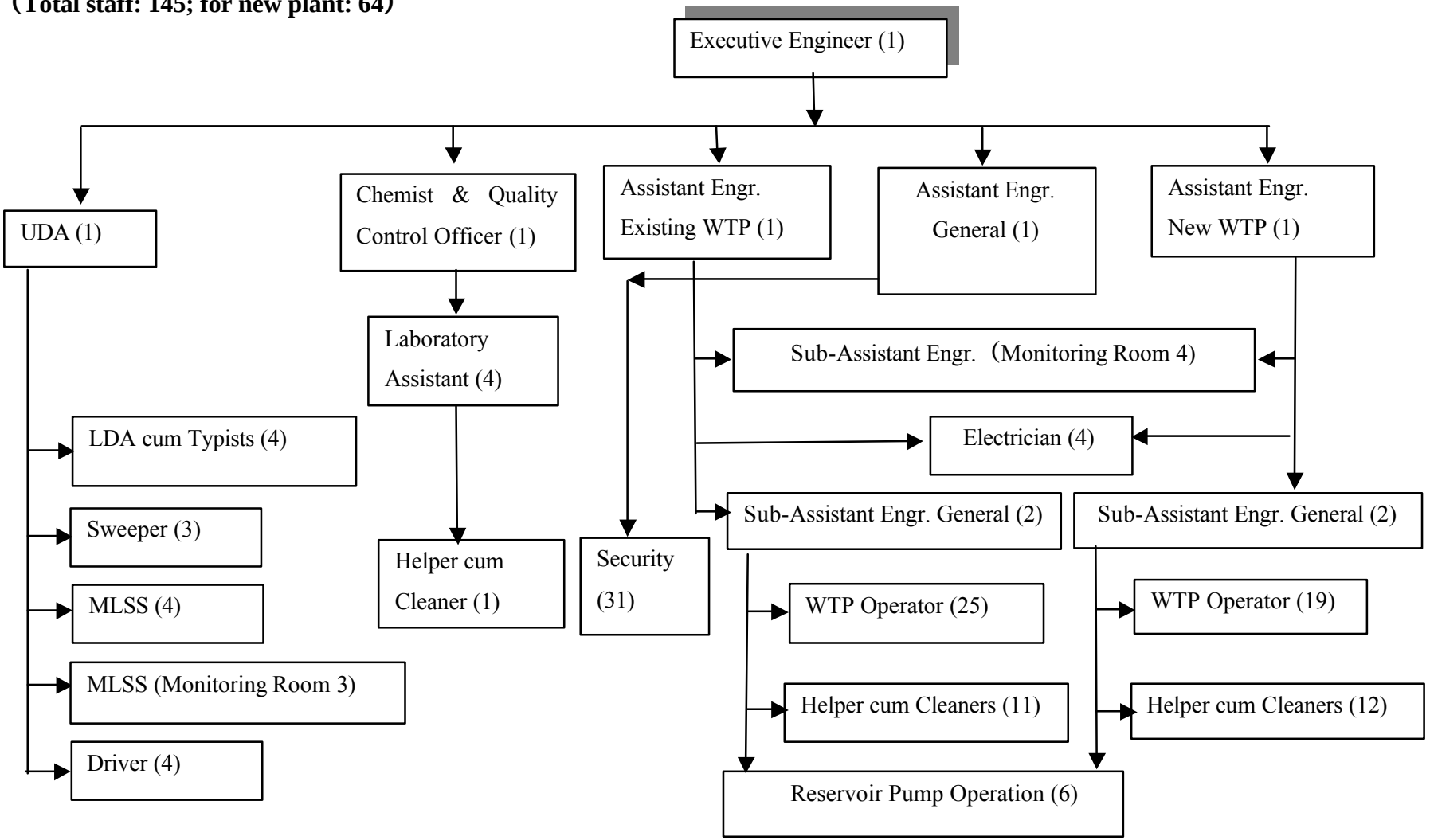


Table 9.1-1 MOHARA W.T.P. Staff Schedule

(**3** -shift : Normal: 9am-5pm / Morning: **6** am-2pm / Evening: 2pm-10pm / Night: 10pm-6am)

No	Unit Name / Designation	Existing					New					Total	Note
		Morning	Evening	Night	Normal	S.T.	Morning	Evening	Night	Normal	S.T.		
I	***Water Treatment Plant***												
1	**Executive Engineer**	-	-	-	1	1	-	-	-	-	0	1	
2	**Chemist & Quality Control Officer**	-	-	-	1	1	-	-	-	1	1	2	
3	**Assistant Engineer**	-	-	-	2	2	-	-	-	1	1	3	
4	**Sub Assistant Engineer General**	-	-	-	2	2	-	-	-	2	2	4	
5	**Sub Assistant Engineer (Monitoring Room)**	1	1	1	1	4	-	-	-	-	0	4	
6	**Operator**												
6-1	High Lift Pumping Station	2	2	2	-	6	2	2	2	-	6	12	
6-2	Raw Water Pumping Station	2	2	2	-	6	-	-	-	-	0	6	
6-3	Chemical Building	2	2	2	-	6	2	2	2	-	6	12	
6-4	Chlorine System	1	1	2	-	4	1	1	2	-	4	8	
6-5	Filter and Clarifier	1	1	1	-	3	1	1	1	-	3	6	
6-6	Electrician	1	1	1	-	3	-	-	-	1	1	4	
6-7	Laboratory Assistant	-	1	1	-	2	1	-	-	1	2	4	
7	**Helper-cum-Cleaner**												
7-1	Chemical feeding	2	2	-	-	4	2	2	-	-	4	8	
7-2	To Work with Operator of filter & Clarifier	1	1	1	-	3	1	1	1	-	3	6	
7-3	For Cleaning of Clarifier	-	-	-	2	2	-	-	-	2	2	4	
7-4	General Purpose	-	-	-	2	2	-	-	-	2	2	4	*
7-5	For Sampling collection	-	-	-	1	1	-	-	-	-	0	1	*:Bar Screen, Desludge, Valve operation, area cleaning
8	**Office Stuff**												
8-1	Upper Division Assistant	-	-	-	1	1	-	-	-	-	0	1	
8-2	Lower Division Assistant cum Typist	-	-	-	2	2	-	-	-	1	1	3	
8-3	Sweeper	-	-	-	2	2	-	-	-	1	1	3	
8-4	MLSS(Monitoring Room)	-	-	-	3	3	-	-	-	1	1	4	
8-5	MLSS(Control room)	-	-	-	-	0	1	1	1	-	3	3	
8-6	Driver	-	-	-	2	2	-	-	-	2	2	4	
9	**Security**												
9-1	Darwan(WASA)	3	3	3	-	9	2	2	2	-	6	15	
9-2	Ansar(Private)	2	2	2	4	10	-	-	-	-	0	10	
	Sub Total					**81**					**51**	**132**	
II	***Reservoir (New KHULSI)***												
10	**Operator**												
10-1	Pump Operator	-	-	-	-	0	2	2	2	2	6	6	
11	**Security**	-	-	-	-	0	2	2	2	-	6	6	
12	**Helper-cum-Cleaner**	-	-	-	-	0	-	-	-	1	1	1	
	Sub Total					**0**					**13**	**13**	
	Grand Total					**81**					**64**	**145**	

CHAPTER 10

FINANCIAL ANALYSIS

CHAPTER 10 FINANCIAL ANALYSIS

Several financial issues must be considered during the course of the project: such as (1) ensuring that there are sufficient funds to carry out the project through project life, (2) recovery of an appropriate portion of the costs from users so as to ease the burden on GOB and implementation agency, and (3) impact of investments on the financial state of the sector and the overall financial considering the Bangladesh government's current financial deficit in the water supply sector.

10.1 Assumed Financial Source

As for the water supply development in Bangladesh, financial aids by the government to CWASA are made in the form of loan from the government; this means that CWASA is responsible to repay loan principal and to pay interest to the government. This method is also applied even in case of foreign financial assistance as a sublease. For example, in case foreign governments or international aid organizations provide funds through the government, the responsibility for repaying the principal and any interest payments to the funding authorities is borne solely by GOB and CWASA shall repay the principal and pay interests to the government just like a loan from the government. In case fund is provided as grant aid assistance to CWASA through the government, the responsibility for repaying the principal and interest to the government is exempted.

Considering the government's continuing serious finance deficit, it would be quite difficult to assume that all investment is financed with internal funds. It would be more appropriate to assume financial assistance from international aid agencies (herein after referred to as "Loan") as well as grant aid from foreign governments (herein after referred to as the "Grant").

Soft loan by the Japan Bank for International Cooperation (JBIC) was assumed as the financial source in this financial study. Conditions of the fund are assumed as shown in Table 10.1-1.

Table 10.1-1 Type of Fund and Condition

Source	Funding Ratio	Assumed Conditions
Local Loan (GOB)	25 %	Period: 30 years Interest rate: 7.5 % Grace period: 10 years
Foreign Loan (JBIC)	75 %	Period: 30 years Interest rate: 1 % (sublease rate: 7.5 %) Grace period: 10 year
Grant	Given a grant for construction of main facility for WTP, transmission pipeline and a reservoir.	

10.2 Financial Analysis

10.2.1 General

The financial profitability of a project is analyzed on the basis of discounted cash flow method, which is essentially aiming to clarify whether the anticipated free cash flows (cash inflows less cash outflows) of the project are reasonably attractive for the investor or not. The discounted cash flow method includes the following three methods prevailingly used for financial analysts and investors.

(1) Net present value method (NPV)

In the net present value method, the basic decision rule is that a project is acceptable if the present value of the free cash flows shall be positive. In order to use this rule, one must estimate: 1) applied discount rate, 2) project economic life, 3) amount of cash inflow in each year, and 4) amount of cash outflow in each year.

(2) Profitability index method (B/C ratio)

Same as the net present value method, the profitability index (benefit/cost ratio) method requires to estimate; 1) discount rate, 2) project economic life, 3) cash inflow, and 4) cash outflow. A project is acceptable if the present value of the cash inflow equals or exceeds to the present value of cash outflow with a designated discount rate.

(3) Financial internal rate of return method (FIRR)

The financial rate of return method finds the rate of return that equates the present value of free cash flows to zero. A project is acceptable if the FIRR equals or exceeds anticipated rate of opportunity cost.

Financial analysis of the project was conducted with following steps:

- Estimation of the revenue (based on production volume, distribution progress, accounted for water, collection efficiency, water tariff)
- Estimation of cost (project cost, O&M cost and preparation of fund source)
- Free cash flow (calculation of FIRR, NPV and B/C ratio)
- Sensitivity analysis and evaluation
- Profit & loss statement analysis
- Net cash position (sources of fund and expenditure)

10.2.2 Assumption for Financial Analysis

Principal assumptions for the financial analysis were as follows:

(1) Cash Receipt

Annual cash receipt was projected using the following formula:

(Annual cash receipt) = (a. Annual production volume of water)
x (b. Accounted For Water)
x (c. Tariff per cubic meter)
x (d. Collection ratio)
x (e. Distribution progress)

The following is the assumption on the each parameter:

1) Production water volume

Production water volume is to be 91,000 m^3/day.

2) Accounted-for Water

Current UFW rate is estimated to be 30 % up to 35 %. UFW should be reduced toward future. Applied UFW was based on the assumption of the Basic Plan in which the UFW will be improved to 25 % in 2005, 22 % in 2010 and 20 % in 2025 gradually. Accounted for water is derived from UFW (1-UFW).

3) Water tariff rate

(a) Tariff level

For simplification, a weighted average unit tariff is applied for the revenue, which is estimated based on shares of domestic use consumption and non-domestic use consumption.

(Weighted average unit Tariff)
= (Tk 4.06/m^3 x 0.74 for domestic) + (Tk 11.35/m^3 x 0.26 for non-domestic)
= Tk 5.96/m^3, say Tk 6.0/m^3

(b) Tariff revision

Past tariff revision is summarized as follows:

- July/1997: up rate 6% (Domestic/Non-domestic)
- Nov./1992: up rate 15% (Domestic/Non-domestic)
- Oct./1990: up rate 10% (Domestic/Non-domestic)
- Nov./1987: up rate 10% (Domestic/Non-domestic)
- Jun/1986: up rate 25% (Domestic/Non-domestic)
- July/1982: up rate Domestic 66%, Non-domestic 40%

The average annual tariff raise from 1982 to 1997 is 6.6 %. Therefore, annual up rate of tariff is to be set at around 6.0 %, if this would be used in the subsequent analysis.

As an alternative analysis, a stepwise progressive tariff structure method will be studied taking

account of the residents' willingness-to-pay.

4) Collection ratio

The present collection ratio is 91 % in average during past five years. For this study, the same ratio is used through the future, because the present consumer ledger book seems to be insufficient in consumer survey and then there is room for improvement certainly.

5) Distribution progress/Increase of consumers

Although it is anticipated that the number of customers will increase annually, due to rise in population density in the present water supply area and expansion of water supply area. The installation cost for improvement/development of existing network is included a part of emergency areas which is not only covered by this particular project but also covered by the existing Mohara W.T.P, Kalurghat I.R.P and also new Madunaghat W.T.P. Water sales ratio against production after completion of the project, which is expected in 2005, was expected to be 70 % in 2005 and increased to 100 % in 2010 provided that extension and expansion of secondary distribution network are carried out on schedule.

(2) Cash Distribution

Cash disbursements consist of:

(For construction and operating phase)

1) Construction cost
2) Operation expenses
3) Personal expenses
4) Repair expenses
5) Depreciation (Financial aspect)

(For replacement phase)

6) Investment for annual replacement of facilities

(For Repayment phase)

7) Interest expenses
8) Repayment of principal

Following assumptions were made for analysis:

1) Construction cost

The sum of construction cost is US$ 96 million[1], which is quoted from Chapter 8.

[1] Some extent of contingencies was deducted for the analysis.

2) Operation expenses

(a) Power cost

It was assumed that power cost for existing wells might be reduced due to shift of water source after completion of the project.

i) Based on the past record of the MWTP in 1999, power cost of the Mohara WTP expansion plant was estimated to be Tk 32,216,090 /year.

ii) Annual power cost for existing wells in MOD-I area was Tk 13,165,928 /year.

Thus, increase of power cost will be:

Tk 32,216,090 /year - Tk 13,165,928 /year = Tk 19,050,162 /year

= US$ 352,780 /year, say US$ 353,000 /year

(b) Chemicals

Based on the past record in 1999, the chemical cost in Mohara WTP was Tk 10,100,000 /year. The chemical cost has been mainly used at Mohara WTP. Therefore, the chemical cost is estimated as follows:

Tk 10,100,000 /year = US$ 187,037 /year, say US$ 187,000 /year

3) Personnel expenses

Based on the past record of the MWTP in 1997, Remuneration of CWASA was Tk 51.28 million /year for its 750 employees, of which 79 persons for Mohara WTP and 183 for MOD-I. As shown in Figure 9.1-1, increase of staff members for the MWTP Expansion plant will be 64, and other operation and maintenance staff is required for distribution facilities. In addition administrative staff should also be enhanced to cope increase of service connection. On the other hand, shift of staff members due to change of water source in the future is also expected. Taking account of those situations, a half number of staff, which is equivalent to 18% of total CWASA's employee, is assumed as the required number of staff members for the operation of facilities constructed in the project. Accordingly, the personal expenses was assumed as follows:

Tk 51,280,000 /year × 0.18 =Tk 9,230,400 /year =US$ 170,933 /year, say US$ 171,000 /year

4) Repair expenses

The cost for repair of equipment is estimated as 0.3 % per year of the invested cost for equipment.

Consequently, O/M cost, which is used in the project analysis, is summarized in Table 10.2-1.

Table 10.2-1 Operation and Maintenance Cost

Item	Cost (US$ per annum)
Power cost	353,000
Chemicals cost	187,000
Personal cost	171,000
Repair cost	54,000
Total	765,000

5) Depreciation (Financial aspect)

Depreciation of fixed assets is assumed using the fixed rate over useful lives of the entities as follows:

(a) Equipment: 15 years (annual depreciation rate: 6.7 %)

(b) Civil constructions and pipes: 50 years (annual depreciation rate: 2 %)

6) Interest expenses/Repayment of principal

The disbursement of interest and principal is included in the annual cash disbursement.

10.2.3 Result of Financial Analysis

Financial analysis was conducted in accordance with following three stages:

Stage 1: Basic Analysis

The basic analysis has been studied on the basis of the assumption stated in preceding sub-section.

(1) Free Cash Flow Analysis

Based on the assumptions stated above, free cash flow was calculated. The results of analysis shows not feasible with following major financial indices:

- Financial Internal Rate of Return (FIRR) = -2.50 %
- Net Present Value (NPV) = US$ -62,690 (at discount rate of 7.5 %)
- Benefit/Cost Ratio (B/C) = 0.26 (at discount rate of 7.5 %)

Calculated FIRR, -2.50 %, is far lower than the expected loan interest of 7.5 %. NPV and B/C Ratio are not sufficient as well. This means that the project is needed to be improved financially.

(2) Sensitivity Analysis

Sensitivity analysis was conducted based on the Free Cash Flow plan. In the analysis, amount of three major items, i.e. capital investment cost, O&M cost, and revenue, were changed in the range of ±10 % respectively as presented in Table 10.2-2. Further, the results of calculation are showed required tariff level for securing FIRR of 7.5%.

As shown in Table 10.2-2, if FIRR of the project shall be kept at 7.5 %, which is equivalent to the interest rate of sublease loan from the government, the revenue shall be secured at 380 % of the one in basic condition. If FIRR is required to be 2.0 or 1.0 %, the revenue shall be raised to 190 or 165 %, respectively.

Table 10.2-2 Sensitivity Analysis

Cost		Revenue	FIRR	NPV (at 7.5%)	B/C Ratio
Capital	O&M		(%)	(US$)	(at 7.5%)
100%	100%	100%	-2.50%	-62,690	0.26
100%	100%	165%	1.02%	-48,129	0.43
100%	100%	190%	2.01%	-42,529	0.50
100%	100%	200%	2.37%	-40,289	0.53
100%	100%	300%	5.46%	-17,888	0.79
100%	**100%**	**380%**	**7.50%**	**32**	**1.00**
100%	90%	380%	7.58%	715	1.01
100%	110%	380%	7.43%	-651	0.99
90%	100%	380%	8.42%	7,858	1.10
110%	100%	380%	6.72%	-7,794	0.92

Note: The 100% presents the basic conditions described in sub-chapter 10.2.1.

(3) Profit & Loss Statement

Based on the previous calculation, a profit & loss statement was calculated. It shows necessity of huge profit in early years of the project period. These deficits in early years shall be compensated with the internal fund or loans. As a result, the profit & loss statement shows the break-even point in the year 2034.

(4) Net Cash Flow/Source of Funds and Expenditure

Net cash flow/Source of funds and expenditure in the course of project implementation are calculated up to the year 2050. The fund flows are in negative net cash position throughout the project period.

Stage 2: Study on Relation between FIRR and Tariff / UFW

Relations between FIRR and water tariff, and between FIRR and Unaccounted-for-water (UFW) were analyzed in this stage.

(1) Sensitivity Analysis between FIRR and Water Tariff

For cash receipt projection, sensitivity analysis was made for change of tariff rate. According to the resident's awareness survey, water tariff seems to be tolerable up to 1.5 times of the present level provided the service level would be improved. With this background, sensitivity analysis was conducted for various weighted average tariff rate ranging from present Tk 6.0/m^3 to Tk 12/m^3 with various annual raise rates. Results of computation are shown in Table 10.2-3 and Figure 10.2-1.

Table 10.2-3 and Figure 10.2-1 show relation between FIRR and Basic Tariff / Annual Raise Rate of Tariff. For instance, when the initial tariff is set at present rate of Tk 6/m^3, tariff should be raised 3 % annually if FIRR is required to be over 2.0 %. When the initial tariff is set at Tk 9/m^3, which is 1.5 times of present rate, tariff should be raised at 2 % annually if FIRR is required to be over 3.0 %.

Table 10.2-3 Relation between FIRR and Water Tariff

Base Tariff (Tk/m^3)		6.0 (100%)	6.6 (110%)	7.2 (120%)	7.8 (130%)	8.4 (140%)	9.0 (150%)	9.6 (160%)	**10.2 (170%)**	10.8 (180%)	11.4 (190%)	12.0 (200%)
Annual Raise Rate (%)	0	-2.50	-1.81	-1.19	-0.63	-0.12	0.36	0.80	**1.23**	1.63	2.01	2.37
	1	-0.76	-0.17	0.37	**0.87**	1.34	1.77	2.19	2.58	2.95	3.31	3.66
	2	**0.70**	1.24	1.74	2.20	2.64	**3.05**	3.44	3.81	4.17	4.51	4.85
	3	**2.00**	2.51	2.98	3.42	3.84	4.24	4.61	4.97	5.32	5.65	5.97
	4	3.20	3.69	4.14	4.57	4.98	5.36	5.73	6.08	6.42	6.74	7.06
	5	4.33	4.81	5.25	5.67	6.07	6.44	6.80	7.15	7.48	7.80	8.11
	6	5.42	5.88	6.32	6.73	7.12	7.49	7.85	8.19	8.52	-	-
	7	6.47	6.93	7.36	7.77	8.15	8.52	-	-	-	-	-
	8	7.49	7.95	8.38	-	-	-	-	-	-	-	-
	9	8.50	-	-	-	-	-	-	-	-	-	-

Base Tariff: Upper; Price, Lower; Ratio of Base Tariff against Present Tariff

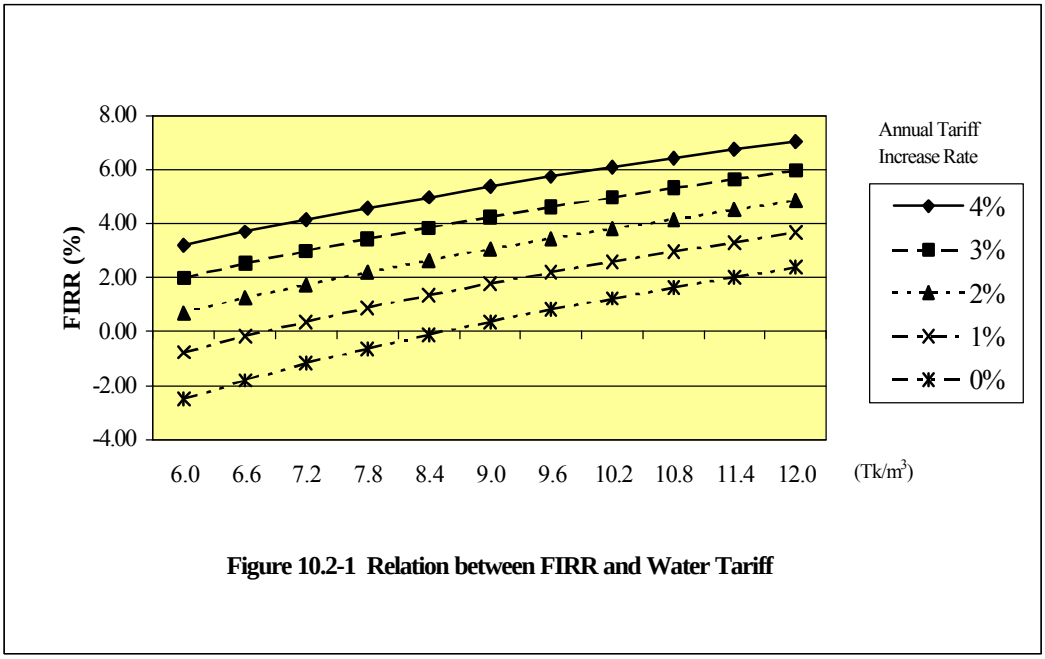


Figure 10.2-1 Relation between FIRR and Water Tariff

(2) Sensitivity analysis between FIRR and UFW

For cash receipt projection, sensitivity analysis was also made for change of un-accounted for water (UFW). According to CWASA's long-term plan for UFW, the present UFW of 34.5 % is assumed to be improved to 25 % and 20 % in 2005 and 2010, respectively. Since the latest data of UFW is estimated at 32 % in 2000, the sensitivity analysis is made for various UFW ratios.

Table 10.2-4 and Figure 10.2-2 show relation between FIRR and UFW ranging from 35 to 15 %.

Table 10.2-4 Relation between FIRR and UFW

Base Tariff (Tk/m^3)		10.2 (170%)	10.8 (180%)	11.4 (190%)	12.0 (200%)
UFW (%)	Base	**1.23**	1.63	2.01	2.37
	35	-0.15	0.24	0.62	**0.98**
	30	0.36	0.76	**1.14**	1.51
	25	0.85	**1.25**	1.63	2.00
	20	1.30	1.71	2.09	2.46
	15	1.73	2.14	2.53	2.91

Note: Base is the case of UFW 25% in 2006, 24% in 2007, 23% in 2008/9, 22% in 2010/13, 21% in 2014/24 and 20% in 2025/50, respectively. UFWs in other cases are fixed through the project life.

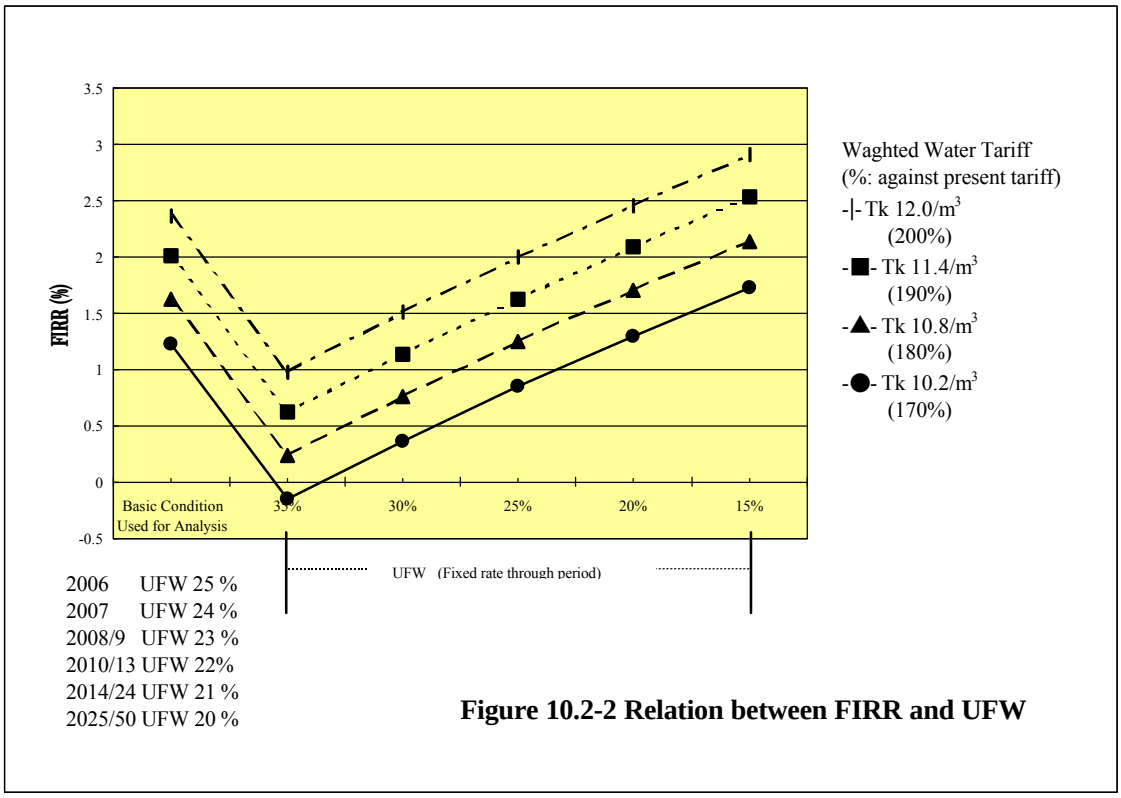


Figure 10.2-2 Relation between FIRR and UFW

Following findings were obtained through Stage 1 and Stage 2:

Case 1 - UFW improvement on schedule (to secure FIRR at 1.0 % at least)

1-a: If tariff is raised within residents' willingness-to-pay,

(i) Tariff should be raised to 170 % (Tk 10.2/m^3) and no annual raise is needed, or as an instance;

(ii) Tariff should be raised to 130 % (Tk 7.8/m^3) and annual raise of around 1.0 % is needed.

1-b: No change on the present tariff level, annual raise of around 2.2 % is needed.

Case 2- UFW improvement not on schedule (to secure FIRR at 1.0 % at least)

2-a: If no improvement of UFW (35 %) is expected,

(i) Tariff should be raised to Tk 12.0 /m^3 and no annual raise is needed, or as an instance;

(ii) Tariff can be kept at present level but annual raise of 3.5 % is needed.

2-b: If UFW is expected to be improved to 30 %,

(i) Tariff should be raised to Tk 11.4 /m^3 and no annual raise is needed, or as an instance;

(ii) Tariff can be kept at present level but annual raise of 3.2 % is needed.

2-c: The UFW is expected to improve by 25 %,

(i) Tariff should be raised to Tk 10.8 /m^3 and no annual raise is needed, or as an instance;

(ii) Tariff can be kept at present level but annual raise of 2.9 % is needed.

Stage 3: Sensitivity analysis on investment cost reduction

In case capital investment cost is reduced to 70 % (assuming 30% of project cost is subsidized by GOB), relation between revenue (tariff level) and FIRR were calculated as shown in Table 10.2-5.

Table 10.2-5 Sensitivity Analysis (30% Cost Reduction)

Cost		Revenue	FIRR	NPV(US$)	B/C Ratio
Capital	O&M	(Present tariff: 100%)	(%)	(Discount Rate)	(Discount Rate)
70%	100%	**152%**	**2.53**	414 (2.5%)	1.00 (2.5%)
70%	100%	**162%**	**3.02**	6,550 (2.5%)	1.07 (2.5%)
70%	100%	200%	4.70	29,869 (2.5%)	1.32 (2.5%)
70%	100%	276%	7.53	76,508 (2.5%)	1.82 (2.5%)

Note: Discount rates for NPV and B/C Ratio are referred to at 2.5% as a weighted actual loan interest.

In order to secure FIRR at 2.53 %, which is the weighted average interest rate (2.5 %) of foreign and local portion of the construction cost estimate (75%: 25%), the revenue level of 152 % (equal to 1.52 times of the present tariff level) is required. If FIRR shall be kept at 3.0%, which is the same interest rate of IDA 1ST Phase, the revenue level of 162 % shall be secured.

In case capital investment cost is reduced to 70 % (assuming 30% of project cost is subsidized by GOB), the Profit & Loss Statement, with the interest rate at 2.5 % and tariff level at 152 %, shows the break-even point in 2016.

Also, in case of interest rate at 3.0 % under the same other conditions, the Profit & Loss Statement shows the break-even point in 2017.

In case capital investment cost is reduced to 70 % (assuming 30% of project cost is subsidized by GOB), the Net Cash Flow under an interest rate at 2.5 % and a tariff level at 152 % is positive throughout the project life. However, in early period, cash is needed as operation fund, which will be provided by

commercial loan. Also, middle period of the project life, expenditure for the principal repayment will increase, and the tariff revision to 152 % of the present tariff in 2006 and 125 % in 2020 will be needed so as to keep positive cash flow.

Also, in case of interest rate at 3.0 %, raise of tariff level to 162 % is needed to maintain the Net Cash Flow positive as same as the above case.

10.2.4 Projection of CWASA Financial Plan up to 2015

Projection of financial plan of CWASA up to 2015 was conducted as shown in Table 10.2-6, in which following considerations were given:

- positive support of the major external financial agencies and the Government (subsidy for the project);
- collection improvement strategies; and
- tariff revision.

As shown the in the table, income/loss from operation in the statement shows negative side in the first five years, from 2001 to 2005, and in the middle three years, from 2011 to 2013. However, it shows positive side in the middle five years, from 2006 to 2010, and in the last two years, from 2014 to 2015. These are mainly due to tariff revision in 2006 and reduction of interest payment in 2014. On the other hand, the projected cash flow will be negative in the first two years, from 2001 to 2002, and in 2004, while another year shows positive side. This means that the internal reserves such as cash deposit need to be allotted.

An alternative plan, of which tariff rate is Tk 6.6 /m^3 (10 % up) from 2001 to 2005, is shown in Table 10.2-7. As shown in this table, the income/loss from operation turns to positive side only in 2003 in comparison with the case of Tk 6.0 /m^3 (see Table 10.2-6). On the other hand, the balance of projected cash flow in those three years with negative side in Table 10.2-6 turns to positive side.

The debt service schedule for the Mohara WTP Expansion Project is shown in Figure 10.2-3. As shown in the figure, the peak of payment including the interest/principal comes in 2016, and the annual amount reaches to Tk 268 million. The interest amount increases from 2004 to 2006, and decreases from 2007 to 2035. The principal payment, required from 2005 to 2035, will be compensated mainly by depreciation.

The integrated debt service schedule of CWASA is shown in Figure 10.2-4. As shown in the figure, the peak of payment including the interest/principal comes in 2016, and the annual amount reaches to Tk

Table 10.2-6 Projection of Financial Plan of CWASA up to 2015

1. Projected income/loss statement

1.1 Estimate of accounted for water (AFW)

Item	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MOD-1	m^3/day	32,000	32,000	32,000	32,000	32,000	0	0	0	0	0	0	0	0	0	0
(Rate of AFW)	(%)	95%	95%	95%	95%	95%										
Sub-total (AFW)	m^3/day	30,400	30,400	30,400	30,400	30,400	0	0	0	0	0	0	0	0	0	0
Kalurghat (inc.3rd Interim)	m^3/day	46,000	46,000	46,000	46,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
Mohara	m^3/day	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
Madunaghat	m^3/day	0	0	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000
New Mohara	m^3/day	0	0	0	0	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
(Rate of AFW)	(%)	68%	70%	73%	74%	75%	75%	76%	77%	77%	78%	78%	78%	78%	79%	79%
Sub-total (AFW)	m^3/day	93,160	95,900	133,590	135,420	222,750	222,750	225,720	228,690	228,690	231,660	231,660	231,660	231,660	234,630	234,630
Total (AFW)	m^3/day	123,560	126,300	163,990	165,820	253,150	222,750	225,720	228,690	228,690	231,660	231,660	231,660	231,660	234,630	234,630
1.2 Estimate of income																
Weighted Average Tariff	(Tk /m^3)	6.0	6.0	6.0	6.0	6.0	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Tariff income	(Tk)	270,596,400	276,597,000	359,138,100	363,145,800	554,398,500	747,994,500	757,967,760	767,941,020	767,941,020	777,914,280	777,914,280	777,914,280	777,914,280	787,887,540	787,887,540
Other income (5%)	(Tk)	13,529,820	13,829,850	17,956,905	18,157,290	27,719,925	37,399,725	37,898,388	38,397,051	38,397,051	38,895,714	38,895,714	38,895,714	38,895,714	39,394,377	39,394,377
Total	(Tk)	284,126,220	290,426,850	377,095,005	381,303,090	582,118,425	785,394,225	795,866,148	806,338,071	806,338,071	816,809,994	816,809,994	816,809,994	816,809,994	827,281,917	827,281,917
1.3 Estimate of expenditure																
O&M cost & Other expenditure	(Tk)	215,070,000	219,010,000	243,020,000	247,590,000	280,230,000	285,670,000	291,260,000	297,010,000	302,940,000	309,040,000	315,320,000	321,800,000	328,480,000	335,370,000	342,480,000
Depreciation	(Tk)	51,620,000	70,940,000	91,250,000	166,480,000	202,190,000	213,460,000	227,920,000	241,460,000	254,840,000	264,930,000	264,930,000	264,930,000	264,930,000	264,930,000	264,930,000
Interest	(Tk)	54,360,000	52,400,000	60,210,000	149,110,000	216,080,000	246,870,000	245,810,000	244,750,000	243,680,000	242,620,000	242,880,000	242,880,000	242,880,000	215,910,000	196,260,000
Total	(Tk)	321,050,000	342,350,000	394,480,000	563,180,000	698,500,000	746,000,000	764,990,000	783,220,000	801,460,000	816,590,000	823,130,000	829,610,000	836,290,000	816,210,000	803,670,000
1.4 Net earning																
Income/loss from operation	(Tk)	-36,923,780	-51,923,150	-17,384,995	-181,876,910	-116,381,575	39,394,225	30,876,148	23,118,071	4,878,071	219,994	-6,320,006	-12,800,006	-19,480,006	11,071,917	23,611,917

2. Projected cash flow

2.1 Sources of fund

Item	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Income/loss from operation	(Tk million)	-36.92	-51.92	-17.38	-181.88	-116.38	39.39	30.88	23.12	4.88	0.22	-6.32	-12.80	-19.48	11.07	23.61
Depreciation	(Tk million)	51.62	70.94	91.25	166.48	202.19	213.46	227.92	241.46	254.84	264.93	264.93	264.93	264.93	264.93	264.93
Loan 1	(Tk million)	264.69	264.69	220.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan 2	(Tk million)	166.68	166.68	138.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan 3	(Tk million)	0.00	0.00	1,209.60	1,239.84	1,276.13	6.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grant	(Tk million)	0.00	0.00	518.40	518.40	518.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total source	(Tk million)	446.07	450.39	2,161.35	1,742.84	1,880.34	258.95	258.80	264.58	259.72	265.15	258.61	252.13	245.45	276.00	288.54
2.2 Application of fund																
Capital expenditure 1	(Tk million)	264.69	264.69	220.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital expenditure 2	(Tk million)	166.68	166.68	138.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital expenditure 3	(Tk million)	0.00	0.00	1,728.00	1,728.00	1,728.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt repayment	(Tk million)	41.77	41.77	41.77	41.77	44.79	51.17	50.79	49.76	48.74	47.71	46.68	32.44	41.44	110.93	193.62
Total disposal	(Tk million)	473.14	473.14	2,129.25	1,769.77	1,772.79	51.17	50.79	49.76	48.74	47.71	46.68	32.44	41.44	110.93	193.62
2.3 Increase/decrease in resources																
Balance (2.1)-(2.2)	(Tk million)	-27.07	-22.75	32.10	-26.93	107.55	207.78	208.01	214.82	210.98	217.44	211.93	219.69	204.01	165.07	94.92

Note: Conditions;

1. Estimate of increasing ratio

	Average Increasing Ratio for Previous 4/5 years	Adopted Increasing Ratio per year
Electricity	0.65%	1%
Consumer Price	5.80%	6%
Real Wage	1.95%	2%

2. Estimate of CWASA's staff number

	Estimate of CWASA's staff number (person)
As of 2001	750
As of 2003	815
As of 2005	946

Source: Statistical Pocketbook of Bangladesh 1998.

3. Unpaid accrued interest/principal are included in this table.

4. Interest/principal payment of the New Mohara Project is calculated with the condition of interest rate 2.5 percent and 70 percent of the project cost assuming 30% of the cost will be granted..

5. Loan 1/Capital expenditure 1 mean the Madunaghat Project. Loan 2/Capital expenditure 2 mean the 3rd Interim Project. Loan 3/Capital expenditure 3 and Grant mean the New Mohara Project.

6. Madunaghat WTP 2nd Phase and Karnaphuli WTP Projects are not included in this financial plan.

7. Water volume produced by the 3rd Interim/Fatehabad IRP Project is counted as 3 MGD from 2005 in Kalurghat (incl. 3rd Interim).

8. Decrease in sources from 2001 to 2002 will be alloted by internal reserve.

Table 10.2-7 Projection of Financial Plan of CWASA up to 2015 (Alternative Plan)

1. Projected income/loss statement

1.1 Estimate of accounted for water (AFW)

Item	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MOD-1	m^3/day	32,000	32,000	32,000	32,000	32,000	0	0	0	0	0	0	0	0	0	0
(Rate of AFW)	(%)	95%	95%	95%	95%	95%										
Sub-total (AFW)	m^3/day	30,400	30,400	30,400	30,400	30,400	0	0	0	0	0	0	0	0	0	0
Kalurghat (inc.3rd Interim)	m^3/day	46,000	46,000	46,000	46,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
Mohara	m^3/day	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
Madunaghat	m^3/day	0	0	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000
New Mohara	m^3/day	0	0	0	0	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
(Rate of AFW)	(%)	68%	70%	73%	74%	75%	75%	76%	77%	77%	78%	78%	78%	78%	79%	79%
Sub-total (AFW)	m^3/day	93,160	95,900	133,590	135,420	222,750	222,750	225,720	228,690	228,690	231,660	231,660	231,660	231,660	234,630	234,630
Total (AFW)	m^3/day	123,560	126,300	163,990	165,820	253,150	222,750	225,720	228,690	228,690	231,660	231,660	231,660	231,660	234,630	234,630
1.2 Estimate of income																
Weighted Average Tariff	(Tk /m^3)	6.6	6.6	6.6	6.6	6.6	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Tariff income	(Tk)	297,656,040	304,256,700	395,051,910	399,460,380	609,838,350	747,994,500	757,967,760	767,941,020	767,941,020	777,914,280	777,914,280	777,914,280	777,914,280	787,887,540	787,887,540
Other income (5%)	(Tk)	14,882,802	15,212,835	19,752,596	19,973,019	30,491,918	37,399,725	37,898,388	38,397,051	38,397,051	38,895,714	38,895,714	38,895,714	38,895,714	39,394,377	39,394,377
Total	(Tk)	312,538,842	319,469,535	414,804,506	419,433,399	640,330,268	785,394,225	795,866,148	806,338,071	806,338,071	816,809,994	816,809,994	816,809,994	816,809,994	827,281,917	827,281,917
1.3 Estimate of expenditure																
O&M cost & Other expenditure	(Tk)	215,070,000	219,010,000	243,020,000	247,590,000	280,230,000	285,670,000	291,260,000	297,010,000	302,940,000	309,040,000	315,320,000	321,800,000	328,480,000	335,370,000	342,480,000
Depreciation	(Tk)	51,620,000	70,940,000	91,250,000	166,480,000	202,190,000	213,460,000	227,920,000	241,460,000	254,840,000	264,930,000	264,930,000	264,930,000	264,930,000	264,930,000	264,930,000
Interest	(Tk)	54,360,000	52,400,000	60,210,000	149,110,000	216,080,000	246,870,000	245,810,000	244,750,000	243,680,000	242,620,000	242,880,000	242,880,000	242,880,000	215,910,000	196,260,000
Total	(Tk)	321,050,000	342,350,000	394,480,000	563,180,000	698,500,000	746,000,000	764,990,000	783,220,000	801,460,000	816,590,000	823,130,000	829,610,000	836,290,000	816,210,000	803,670,000
1.4 Net earning																
Income/loss from operation	(Tk)	-8,511,158	-22,880,465	20,324,506	-143,746,601	-58,169,733	39,394,225	30,876,148	23,118,071	4,878,071	219,994	-6,320,006	-12,800,006	-19,480,006	11,071,917	23,611,917

2. Projected cash flow

2.1 Sources of fund

Item	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Income/loss from operation	(Tk million)	-8.51	-22.88	-20.32	-143.75	-58.17	39.39	30.88	23.12	4.88	0.22	-6.32	-12.80	-19.48	11.07	23.61
Depreciation	(Tk million)	51.62	70.94	91.25	166.48	202.19	213.46	227.92	241.46	254.84	264.93	264.93	264.93	264.93	264.93	264.93
Loan 1	(Tk million)	264.69	264.69	220.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan 2	(Tk million)	166.68	166.68	138.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan 3	(Tk million)	0.00	0.00	1,209.60	1,239.84	1,276.13	6.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grant	(Tk million)	0.00	0.00	518.40	518.40	518.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total source	(Tk million)	474.48	479.43	2,158.41	1,780.97	1,938.55	258.95	258.80	264.58	259.72	265.15	258.61	252.13	245.45	276.00	288.54
2.2 Application of fund																
Capital expenditure 1	(Tk million)	264.69	264.69	220.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital expenditure 2	(Tk million)	166.68	166.68	138.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital expenditure 3	(Tk million)	0.00	0.00	1,728.00	1,728.00	1,728.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt repayment	(Tk million)	41.77	41.77	41.77	41.77	44.79	51.17	50.79	49.76	48.74	47.71	46.68	32.44	41.44	110.93	193.62
Total disposal	(Tk million)	473.14	473.14	2,129.25	1,769.77	1,772.79	51.17	50.79	49.76	48.74	47.71	46.68	32.44	41.44	110.93	193.62
2.3 Increase/decrease in resources																
Balance (2.1)-(2.2)	(Tk million)	1.34	6.29	29.16	11.20	165.76	207.78	208.01	214.82	210.98	217.44	211.93	219.69	204.01	165.07	94.92

Note: Conditions;

1. This is an alternative plan, of which tariff rate is Tk 6.6 /m^3 from 2001 to 2005, Tk 9.2 /m^3 from 2006 to 2015.

2. Estimate of increasing ratio

	Average Increasing Ratio for Previous 4/5 years	Adopted Increasing Ratio per year
Electricity	0.65%	1%
Consumer Price	5.80%	6%
Real Wage	1.95%	2%

3. Estimate of CWASA's staff number

	Estimate of CWASA's staff number (person)
As of 2001	750
As of 2003	815
As of 2005	946

Source: Statistical Pocketbook of Bangladesh 1998.

4. Unpaid accrued interest/principal are included in this table.

5. Interest/principal payment of the New Mohara Project is calculated with the condition of interest rate 2.5 percent and 70 percent of the project cost assuming 30% of the cost will be granted..

6. Loan 1/Capital expenditure 1 mean the Madunaghat Project. Loan 2/Capital expenditure 2 mean the 3rd Interim Project. Loan 3/Capital expenditure 3 and Grant mean the New Mohara Project.

7. Madunaghat WTP 2nd Phase and Karnaphuli WTP Projects are not included in this financial plan.

8. Water volume produced by the 3rd Interim/Fatehabad IRP Project is counted as 3 MGD from 2005 in Kalurghat (incl. 3rd Interim).

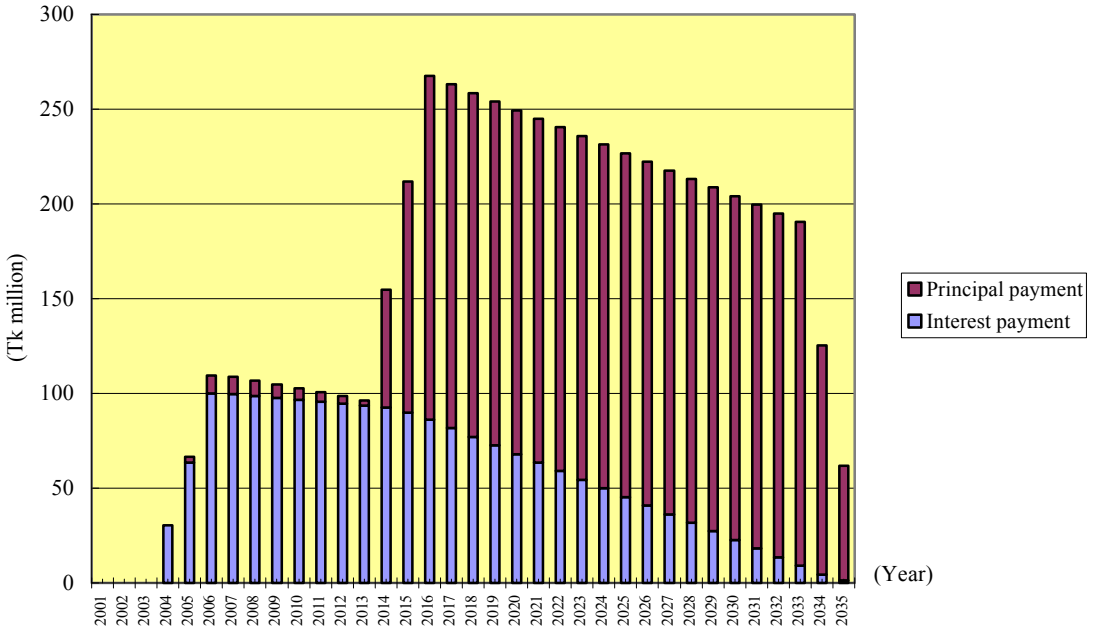


Figure 10.2-3 Debt Service Schedule (Mohara WTP Expansion Project)

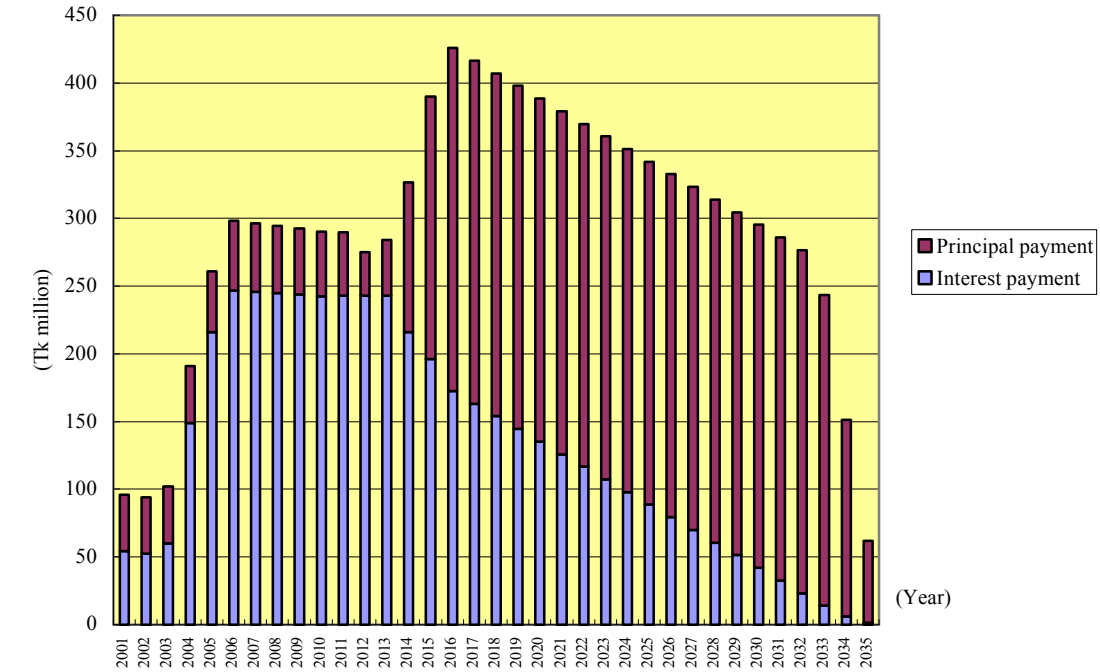


Figure 10.2-4 Debt Service Schedule (CWASA)

426 million. The interest/principal payments of loan for the on-going projects are shown in this figure, which also shows the accrued debt service. As for the Madunaghat and 3rd Interim projects, the interest/principal payments are included from 2003 to 2034 together with the New Mohara project mentioned above. The specific figures of the annual reimbursement schedule of these loans are to be referred to Table 10.2-6.

10.3 Conclusion

To keep this project financially feasible with the FIRR of 7.5 %, which is same to the interest rate of sublease loan through the government, it is necessary to raise the water tariff to around 380 % of the present level, or, as an instance, 200 % up and also annual raise of 4.5 % provided UFW is improved on schedule. If UFW is improved from the present level (34.5 %) up to 30 % only, the water tariff should be raised to 400 % of the present level.

As a result, the intention to collect all investment cost by the water tariff only is unrealistic. Therefore, it is recommended that subsidy from the government to some extent is requisite for the viability of the project. If FIRR is allowed to be 1.0 %, which is same to the condition of foreign government assisted soft loan (e.g. from JBIC) to the government, financial viability of the project will be feasible with affordable tariff raise schedule such as raise to around 170 % of the present level or raise to 130 % and annual raise at 1.0 % as an instance. In this case, CWASA will have a sound business operation provided best effort is made to improve UFW.

10.4 Consideration on Water Tariff

10.4.1 General

As a whole, it is found through the experience of JICA team in South Asia region that there are a few development policy adopted by the governments and waterworks implementation agencies. The basic policy for development of the water supply should be set up into:

"More people less water than some people for their big demand" and

"Larger the consumption, higher the charge"

At present, the water tariffs are fixed by the supplying agency under advise from concerned ministries, which neither reflect the cost structures nor meet the financial requirements of the operating entities. To consider, as to why the central government has to regulate the water tariff, we may surmise:

(1) Non-effective production cost in WASA might be shouldered to users in accordance with the principal "benefit-to-pay";
(2) No sufficient information is supplied about the production cost breakdown for purification of

potable water made to public;

(3) No fair charge against small and large consumers, domestic and non-domestic users would be collected; and

(4) To ensure adequate service and reasonable rates, the followings are mandated by public controls:
   - Appropriateness; The level of planned revenue from water charges should be appropriate.
   - Fairness; Water charges should ensure that the burden is fair to all users, and should be collected from all users depending on their benefit.
   - Clarity; Water rates charged to each user should be clearly shown as a rate or amount.
   - Officially set; Water rates should be officially set in accordance with the rules of supply.
   - Stability; Water rates should be kept stable for a certain period of time.

10.4.2 Comparison of Water Charges with Other Countries

Water charges for domestic use monthly consumption per household being 25 m^3/month in developing countries, which is refereed by a JICA report in 1994[2] and others, are shown below:

Thailand: 4.52 US$/25$m^3$ (GNP per Capita in 1990 US$ 1,402) --- 3.9% of monthly GNP
Philippines: 3.24 US$/25$m^3$ (GNP per Capita in 1992 US$ 750) ----- 5.2% of monthly GNP
Sri Lanka: 1.10 US$/25$m^3$ (GNP per Capita in 1991 US$ 512) ----- 2.6% of monthly GNP
Sri Lanka: 1.39 US$/25$m^3$ (in 2000)
Pakistan: 1.62 US$/25$m^3$ (in 2000)
DWASA: 2.00 US$/25$m^3$ (GNP per Capita in 1991 US$ 190) ---- 12.6% of monthly GNP
DWASA: 1.91 US$/25$m^3$ (in 2000)
CWASA: 1.88 US$/25$m^3$ (in 2000)

As presented above, water charge in South Asian countries are low in comparison with Southeast Asian countries.

10.4.3 Proposed Water Tariff in Future

Unified tariff systems for domestic use and non-domestic use, respectively, are presently employed by CWASA. The present unified tariff system, however, has following problems:

(1) Unit price is too low to recover both of capital cost and O&M cost. However, it is difficult to increase unit price to appropriate level because of affordability of users.

(2) If the unit price is set at suitable level to recover costs, big consumers will enjoy sufficient low cost water, while distressed people should pay high cost for water use comparing with their

[2] The Feasibility Study on the Kalu Ganga Water Supply Project for Greater Colombo, JICA, Main Report p14-30.

affordability to pay.

(3) Redundant water use by rich people will be encouraged if the unit price is set at relatively low level.

Taking account of above characteristics of present unified price system, it is recommendable that following policies for water rates system be employed:

(1) As a public utility charge, the rate shall be set at affordable level for most of residents.
(2) The rate shall be fare for all people, and beneficiary shall shoulder required cost in principle.
(3) Consideration shall be given to distressed people as a public utility charge for basic human needs.

In order to accomplish said antithetic policies, a stepwise progressive water rates system is recommendable as illustrated in Figure 10.4-1 and 10.4-2. It is the tariff structure to ensure poor people can afford their basic water needs and to encourage free water users to switch to direct connections.

In the rate system for domestic use, the unit price of first step is set at the low level lower than the water cost to supply water as a public utility for basic human needs. The second step is set higher than the water cost to recover the required cost for water supply. Unit price at third step is set at higher level to restrict the redundant water use.

In the rate system for non-domestic use, the unit price is set higher than the water cost from first step to recover the required cost for water supply. Unit price at second and third steps are set at higher level to restrict the redundant water use.

Detail trials for making new Tariff Table is discussed in the Supporting Report.

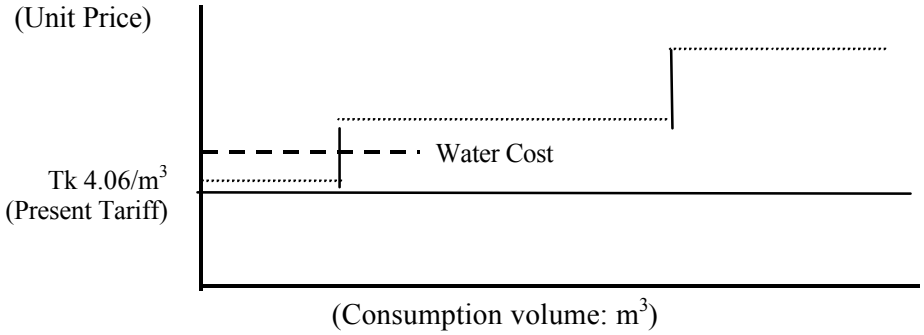


Figure 10.4-1 Tariff Table for Domestic Use

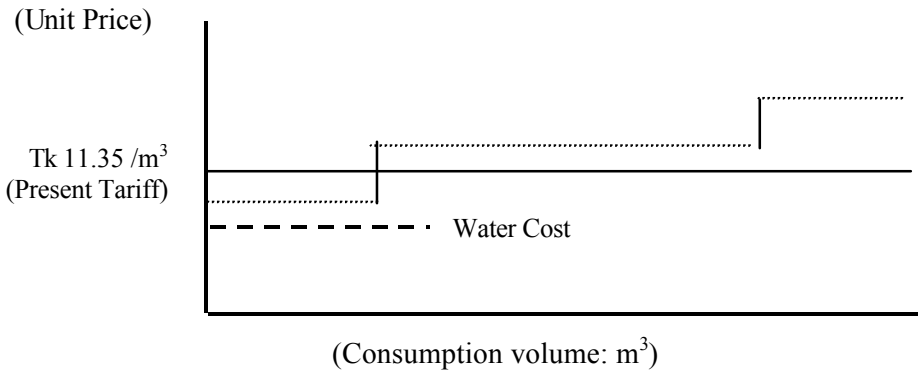


Figure 10.4-2 Tariff Table for Non-domestic Use

CHAPTER 11

INSTITUTIONAL ARRANGEMENT FOR IMPLEMENTATION AND MANPOWER DEVELOPMENT PLAN

CHAPTER 11 INSTITUTIONAL ARRANGEMENT AND MANPOWER DEVELOPMENT PLAN

11.1 Proposed Legislative and Policy Reforms

This project will be implemented by CWASA, which will be accountable and responsible for meeting agreed the Scope of Work (S/W) and operating objectives. With the completion of the Second CWASA Project under IDA assistance in 1987, he has demonstrated his ability to satisfactorily implement medium sized waterworks project.

To the extent possible, this Study has no additional the need for new legislation. However, several policy reforms will have to be enacted by the CWASA Board to ensure the sustainability of the new water supply facilities. These may include;

(i) Water service connection promotion policy: Current experience with water supply project, local and elsewhere, indicates that the high connection costs have tended to discourage potential customer from apply for the service. In the fact that CWASA has not been able to supply water through house connection so easily even being requested from the customers due to absolutely lack of water supply capacity so far.

When this project is completed following to the Madunaghat WTP, the water supply capacity will be remarkably increased. To support ensure the financial viability and raise the utilization rate of the new water supply system, CWASA should change the stance from "demand-driven approach" to "service-driven approach" to sell water. CWASA should set up a task force project team, which will be organized by planning and construction division, procurement section, sales division and billing group, in order to develop/expansion of lateral pipe and house connection works. Additional new house connections of 20,000 units for a couple of years are estimated at the existing and expansion services areas.

At current prices, house connection is estimated to cost about Taka 10,000 per connection including labor, materials, surface restoration and a meter. A policy allowing CWASA to advance a portion (Say 20 % to 30 %) of the service connection costs, to be repaid by the customer over six months - one year, is recommended. Still another variation is to offer service connection discounts out-right for a fixed some period after installation of lateral pipe for the expansion areas. Such policies would, however, have an implication on CWASA's cash flow, which should be assessed, carefully.

11.2 Proposed Human Resource Development Plan

CWASA's water supply capacity will be remarkably extended through construction of the Fatehabad IRP under GOB finance, the Madunaghat WTP under Italian assistance and this particular project when they are implemented. The projected total capacity will be increased around twice from 35.5 MGD to 72MGD.

The proposed program is aiming to not only investigate the present working situation so as to make an improvement plan but also to support for CWASA personal to develop their waking method/manner, time to time through the program. The program will be conducted by the Consultants deeply taking account of current organized practice work/manner, and meanwhile from institutional reform point of view. Therefore, close liaison to ensure consistency with manpower development sector will be maintained. The program shall be contained the through detailed design stage to the construction stage for a period of 15 months. The implementing schedule will be reviewed depending upon the financing source and contract condition.

The supporting program will be consisted of four Key Improvement Program (KIPs), which will bear personnel with clear and challenging work plan. The program will be executed in parallel with each expert in the field of the program.

KIP 1: Operation and Maintenance

The scope of work will include, but not necessarily limited to the following:

(i) Provision of specialist operational support: advice and direction in water treatment and distribution, particular attention being given to operational processes and technology for improvement water quality and distribution control practices for formulation of preventive daily production capacity plan in order to continuously operation of the WTP as much as possible depend on seasonal demand.

(ii) Improvement of yield test method for groundwater resources: advice and direction in introduction of systematic water yield test methods; Step Draw down Test, Continuous Draw down Test and Recovery Test methods, to decide the suitable production capacity of the wells. The operation with the suitable production capacity will ensure the tube wells minimizing from drawdown of the operating water level and then to extend the life circle. Guidelines for preventive maintenance and regeneration of tube wells are prepared and support and advice in the field activities;

(iii) Analysis for distribution network: support, advice and direction in hydraulic analysis for development of the secondary expansion pipe network to be done by CWASA. The program will

be trained intensively to nominated 2 specialists using the CAD equipment transferred through JICA in this Study;

(iv) Provision of preventive maintenance: Advice and direction in preventive maintenance, particular attention being given to the existing facilities including necessity of rehabilitation. Guidelines for preventive maintenance of the water treatment plant including Iron Removal Plant will be provided. Determination the need for rehabilitation, preparation of specifications and procurement of equipment and construction will be included. These rehabilitation selected with a priority would be carried out under this project provided getting concurrence with fund donna to use the budget;

(v) Monitoring indicators: Determination suitable monitoring indicators for use by CWASA to assist in its duties and in general quality control, and in establishing a management information system utilizing these indicators. The proposed monitoring indicators to be developed for the purpose are presented in the succeeding sub-section in this report.

KIP 2: Management and Finance

CWASA's tariffs have been regulated by the Government, and then do not reflect the cost structures to respond in CWASA's financial requirements. This is not only CWASA but also DWASA in the same situation.

Regarding the reason why DWASA's tariffs do not properly reflect the cost of service provided to consumers, the IDA pointed out the following in their report, Fourth Dhaka Water Supply Project, 1996. Those are as follows:

(a) They convey the wrong economic signals, since inefficiencies and distortions (e.g., system losses) are passed on to consumer;
(b) they do not give adequate guidance whether there should be cross-subsidies to the poor;
(c) they do not provide enough justification on the charges being supplied to small, large, domestic or commercial consumers;
(d) they do not reflect externalities (e.g., the cost of treating pollution to the water supply and how this would be reflected in the charge), and
(e) being non-progressive, they encourage wasteful water consumption practices, particularly among upper income and unmetered consumers.

The above-mentioned issues are not properly applied to CWASA. However, it is meaningful to consider the necessity of the institutional reform, loss reduction, efficiency improvement and introduction of commercial business in order to arise institutional performance.

In this course of institutional reform, that is a subject of the S/W in this Study, the current substance of CWASA will have to been requested to present through financial accounting from viewpoint of technical efficiency namely production and selling cost, and financial aspect namely billing and collection and internal management.

With above mentioned background, the scope work under this area will included, but not necessary limited to:

(i) Review of financial accounting systems: from viewpoint of commercial financing/ accounting and advice for improvement.
(ii) Systematic financial management: review and advice the systematic financial management.
(iii) Provide advice on improvement of presentation systems in financial and cost accounting; to be used for budgeting management and improved productivity.
(iv) Review tariff policy and billing system.

Rearrangement of consumer ledger book: review and complication of the existing ledger book and introduce a Task Force for the purpose.

KIP 3: Management Information System (MIS)

The objective of this area is to establish a management information system to assist CWASA in financial and operational decision-making. Activities in this area will include:

(i) Assist in data collection, information generation, survey and analysis so as to provide statistics and reports that determine existing operation and financial conditions. This should include screening useful data/information and requirement data/information in addition;

(ii) Advise on preparation of fundamental data/records, maps, plans for water supply and sewerage and drainage system planning for feature work;

(iii) Provide assistance in the preparation of information and data needed for the decision of annual operation, maintenance and investment programs, and determine the frequency of reporting with management.

(iv) Concentrate the data/information, and statistic and systematic analyze.

(v) Provide assistance on how best to record and analyze for presentation.

KIP 4: Personnel Management and Training

The objection in this area would be to establish a training system in CWASA. There is no training organization and system so for. First of all, therefore, a core of training center should be set up at following steps:

1) Assign a leader who is educated personnel having an enterprising sprit for set up a training center.
2) Preparation of set up program with the consultant assistance to formulate that; but not necessarily limited:
    - to select a target the type of occupation for improvement and reform with respect to working method/manner, systematic management, institutional rationalization in management and financial sections.
    - to select a target the type of engineering for introduction of new technology.
    - to select a target the type of engineering work for improvement of their experience and present routine work; and
    - to select a target the type of job for reform.
3) Selection of urgent items for training in order.
4) Assign educated personnel having rich experience in the field work for training items as to be trainer.
5) Preparation and collection of training text and materials, and discuss and study with the trainers and the consultant exports.
6) Preparation of training program and schedule, and notification to CWASA's employer.

11.3 Public Information and Education Program

CWASA has a responsibility for service connection with meter branching from a nearest lateral pipe, depending on the consumers' offering. A part of consumers have a storage tank in their houses so as to storage water to deal with interrupt or failing water supply. Sometime the consumers are to claim waterworks regarding water quality received. Therefore, CWASA should always educate the consumers to clean the house storage tank and or over head tank of their house frequently due to the tank are in condition being dirty within the water supply processes.

The tank cleaning should be carried out one time a year in a manner of drain the water and dispose of sedimented sludge in the bottom of the tank, cleaning by hand and water, and finally drain the wastewater in the tank.

The public information and education might be better use a muss media such as newspaper and TV, and or as one idea, delivery/give a leaflet to the students who visit the water treatment plant site as a part of

public education. In the leaflet an importance of tank cleaning should be illustrated to let their family know as well as sanitary conditions. The proposed training center shall be responsible for the purpose in cooperation with the financial budgeting section.

CHAPTER 12

ORGANIZATION PLAN

CHAPTER 12 ORGANIZATION PLAN

12.1 Outline

This particular chapter presents review and suggestion pertaining to new organization and institutional improvement for the autonomous enterprise assuming that the proposed basic plan is carried out in the future.

The detail of the actual organization is mentioned in sub-section 6.2.1, which is managed by a Member of Board that is composed by 4 members included the Chairman, the Administration, the Engineering and the Finance. Six (6) men consists of the Member of Board, Secretary and Commercial Manager are appointed by LGRD.

Practically, Planning & Construction Circle (P&C), Treatment Plant Circle (TP) and Operation & Maintenance Circle (O&M) are supervised by the Member Engineering. The Water Testament division and Operation and Maintenance division have each own site office as well as Water Treatment Plant. Member Finance is classified into Revenue division, Accounts division and Sales division, also, General section and Procurement section are organized under Member Administration.

Development section, under Chairman that is very important section to control all information, evaluate data and preparation of application documents; TAPP, PCP, PP, quarter and yearly reports.

Investigation of more detail actual business activity and quality control in relation to each work or job are not included in this scope of works. We understand that gathering data and information under limited time of the study is insufficient, for which a long-term study is required for suggesting better organization.

Therefore, this chapter prefers suggestion about improvement for the organizational function from operation points of view, which makes no mention of reform or change for each work condition and its responsibility.

As it was found that there is an institutional problem in the existed organization, ”Management and Operational Supporting Program” is proposed at Chapter 11 in this report.

12.2 Size of Organization

To discuss future organization structure, suitable member of staff for organization of water works is

grasped, first.

12.2.1 Number of Staff Members

Magnitude of organization is different depending upon the following conditions such as size of business, type of business, composition of facilities, system of water billing, and scope of internal repairing works. Following is considerable to affect on size of the organization structure.

(1) Size of business
   a) Rationally increase against amount of work in general

(2) Type of business
   a) Both Management water supply and sewerage such as DWASA or
   b) Only water supply management like CWASA

(3) Composition of related facility
   a) Type of water resource (tube well or surface water)
   b) Type of water service (house connection or public tap)

(4) System of water billing
   a) Fixed rate system (without meter)
   b) Commodity charge system (meter system)

(5) Scope of contracted out
   a) Scope of repair of equipment (internal job or contract out)
   b) Meter reading and bill collection (internal job or contract out)

The data of statistics done by Japanese water works association (JWWA) has indicated that the staff number per 1,000-water service population as follows:

a) Waterworks of more than 1,000,000 population served 0.62 (person)
b) Waterworks of 500,000 to 1,000,000 population served 0.54 (person)
c) Waterworks of 250,000 to 500,000 population served 0.56 (person)
d) Waterworks of 100,000 to 250,000 population served 0.51 (person)

The above mentioned suggests even in the fact that if there are the same management and size of business, that staff number is almost equal proportionally to size of business.

12.2.2 Comparison of Staff Number in Similar Countries

The relationship of number of staff as per population served, production and number of connection is compared in relation to the different in relation to the different size of waterworks in the similar countries in Asian Region illustrated in Figure 12.2-1 and Table 12.2-1. Before referring these data,

the following items must be carefully taken into consideration.

1) Not clarify the condition of type of business
   For example, DWASA manages water & sewerage system and the quoted staff number is included both water supply and sewerage section. But CWASA manages only water supply system and the total staff number are existed.

2) The city of Changmai manages only water supply system but the number of full-time is huge. It seems that the number include the city waterworks and district office works owned by the public water supply authority (PWA).

As a result, it is able to presume that the following index would indicate staff number per size of waterworks.

a) Staff number per population served of 1,000 persons 0.70 to 0.85 (person)
b) Staff number per amount of water production of 1,000m^3 3.0 to 4.0 (person)
c) Staff number per water connection of 1,000 pieces 7.0 to 13.0 (person)

It is concluded that present staff number of CWASA is larger than above-mentioned indexes. Especially the staff number per water connection is extremely high. The reason for it may be that the water connection is shared by three to five families with twenty-five persons, and it seems that public hydrant are not included in statistical data.

According to Table 12.2-1, staff numbers per population served and production of water supply of CWASA are larger than DWASA. Above all, the number per population served is 1.5 times as high as DWASA. CWASA's business, however, is smaller than DWASA and no sewerage sector. That means CWASA has room for rationalization of the staff.

Table 12.2-1 Typical City's Water Capacity and Staff Number

	CWASA	DWASA	Cebu	Davao	Ullannbaatar	Bandung	Hanoi	Yangon	Hochiminh	Calcutta	Lahore	Karachi	Manila
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Population Served (x 1,000 ps)	600*	3,780	297	505	695	945	1,257	1,960	2,460	2,904	3,259	8,050	7,108
Daily Production (x 1,000 m^3/d)	145	781	108	128	160	192	360	387	730	1,165	1,270	1,648	2,800
No. of Connection (x 100 Unit)	281	1,640	574	970	18	1,321	1,237	970	2,485	3,360	3,717	10,320	7,794
No. of Stuff (PS)	760	3,033	532	604	1,060	1,022	1,645	1,168	1,590	5,731	2,106	8,679	7,628
Staff per 1,000 Population Served	1.27	0.80	1.79	1.20	1.53	1.08	1.31	0.60	0.65	1.97	0.65	1.08	1.07
Staff per 1,000 Production	5.24	3.88	4.93	4.72	6.63	5.32	4.57	3.02	2.18	4.92	1.66	5.27	2.72
Staff per 100 Connection	2.70	1.85	0.93	0.62	58.89	0.77	1.33	1.20	0.64	1.71	0.57	0.84	0.98

Source: Second Water Utilities Data Book – Asia and Pacific region, Arthur C. Mclntosh, Cesar E. Yniguez, 1997, ADB
*: House Connection only.

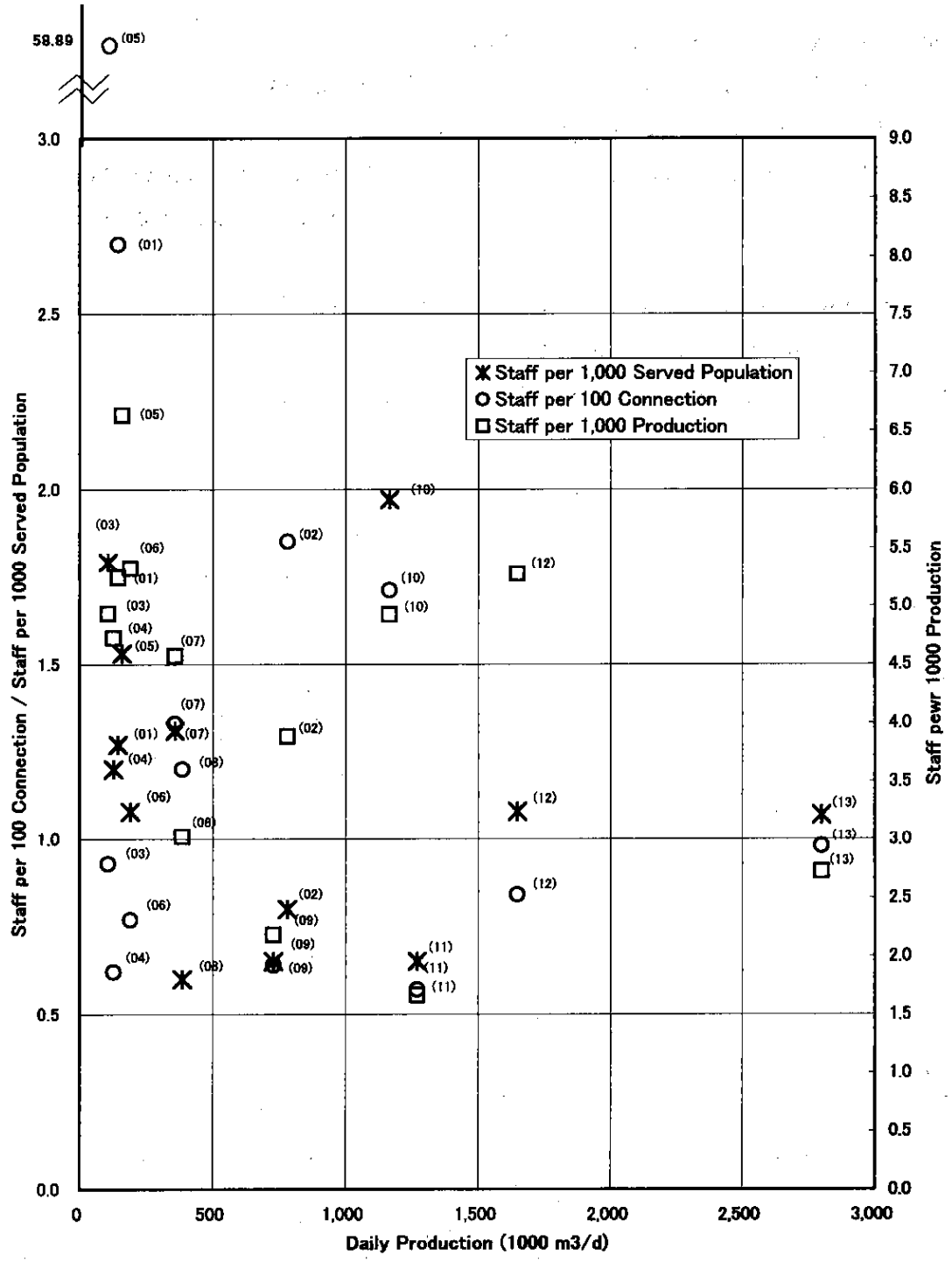


Figure 12.2-1 Staff Number of Water Supply Authorities in Similar Countries

12.2.3 Establishment of Future Organization Structure and Staff

Designed specification for fusibility study is as follows:

a) Planed population served: 3,370,000 (person)

b) Planed amount of water supply: 650,000 (m^3/d)

c) Planed number of water taps: 110,000 pieces for house connections

2,300 pieces for public hydrant

Based on our analysis, staff number is estimated by utilizing above index.

i) By planed Population served:

3.370 (x 10^3ps) x @ 0.70 - 0.85 ＝2,360 - 2,860 (staff number)

ii) By planed amount of water production:

650 (x 10^3.m^3/d) x @ 3.0 - 4.0 ＝1,950 - 2,600 (staff number)

iii) By number of water tap:

113 (x 10^3 pieces) x @ 7 - 13 ＝ 790 - 1,470 (staff number)

From above result, it is estimated that the maximum level of staff number is estimated 2,860 parsons calculated from population served base. As well, 1,950 persons calculated from water production base as minimum level. It is expecting that office automation equipment become more popular and then business reorganization may be accelerated in the future. Therefore, a total number of 1,900 persons, who is given by minimum level from previous calculation, are recommended.

Comparison of staff number between DWASA and CWASA, present and estimated for future plan is shown in Table 12.2-2.

Table 12.2-2 Actual Organization of DWASA/CWASA and Comparison of Future Plan

	DWASA*1	CWASA*2		% of
	At present (a)	1999 year (b)	2010 year (c)%=c/b	CWASA/DWASA (d)=(c)/(a)
1.Population for water supply (person)	4,100,000	1,142,000	3,370,00 (300%)	82
2. Amount of water supply (m^3/d)	930,000	162,500	650,000 (400%)	70
3. Number of water tap (pieces)	180,100	32,000	110,000 (340%)	61
4.Staff number (person)	3,215	750	1,900 (250%)	59
5. Staff number per 1,000 of Population for water supply	0.78	0.66	0.56	72
6. Staff number per 1,000 of amount for water supply (person/m^3/d)	3.5	4.6	2.9	83
7. Staff number per 1,000pieeces of water tap (person)	17.9	23.4	17.3	97

*1： Data referred by World Bank (Ⅳ 1996), *2： Established by this study(2000)

The staff number set forth taken into consideration as follows:

(1) Comparisons of water supply capacity in the future with actual size in CWASA.

i) Population served is to be 300 %, but production is to be 400%. This is fact that water supply level is improved in the future.

ii) Increasing rate of staff number is lower (250%) than increasing rate of population served (300%) and amount of water production (400%).

The expected reasons are as follows:

① Actual staff number is huge against presents business size, which means the organization has to review.

② The staff number will be rationalized due to changing water resource ratio, from tube-wells to more surface water.

③ Staff number will be able to reduce due to less water truck services, except urgent incident.

④ Staff number is able to rationalize due to popularization of office automation equipment.

⑤ Staff will be educated perfectly, which can be adopted accepting the philosophy of corporate management.

(2) Comparison of CWASA with DWASA

i) The production ratio is 70 % but staff ratio is 59 % against DWASA. Because CWASA manages only water supply system but DWASA manages water & sewerage system.

ii) DWASA's 95% of water resource is depended on tube wells that capacity is smaller and then operational effective is lower.

iii) DWASA's water distribution facility is old and leaking rate is high. But CWASA's water facility is comparatively less problem and UFW is expected to be 22%, therefore, staff number is required less.

As a result, it is advisable that the estimated staff number is reasonable to operate water system sufficiently.

12.3 Proposed Organization

New organization structure is needed to establish for adopting the new connect and strategy to improve or reform the current institutional organization.

Taking account of the development of the water supply system and size of the services, the organization structure showing Figure 12.3-1 is recommended.

Key points of the recommended plan are;

(1) To organize a division for each WTP

(2) To change the MOD to MODS (Maintenance-Operation-Distribution-Service), zonal operating unit of CWASA.

MODS 1 manages the Mohara WTP supply area, MODS 2 manages the Karnaphuli IRP supply area, MODS 3 manages the Madunaghat WTP & Fatehabad IRP supply area, and MODS 4 manages the Kalunaphuli WTP supply area, for instance.

(3) In connection to the above, Sales section is struck and the shifted its duty to each MODS.

(4) To reorganize the Procurement from under Secretary to under management of P&C circle.

(5) To change the division name from Development to Planning and Monitoring.

(6) To establish two new divisions, namely Training Center under Secretary, and Task Force for extension and expansion of pipe network (EEP) and house connection as temporally section.

(7) To provide a computer system to section with “circled marks” for management of information.

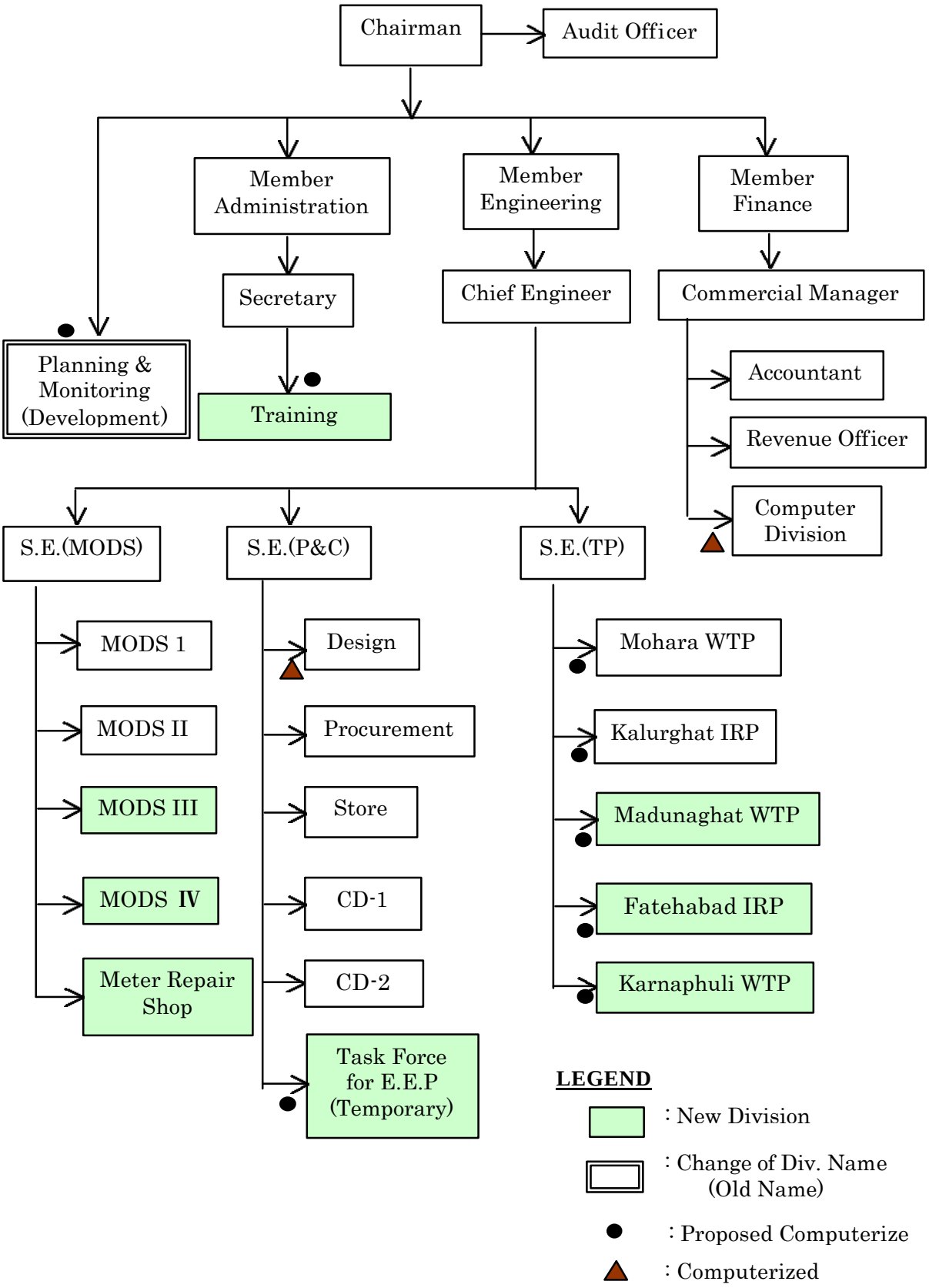


Figure 12.3-1 Recommended CWASA Organization Chart

CHAPTER 13

ENVIRONMENTAL IMPACT ASSESMENT

CHAPTER 13 ENVIRONMENTAL IMPACT ASSESSMENT

13.1 General

13.1.1 Objective Project

The Initial Environmental Examination (IEE) and the Environmental Impact Assessment (EIA) were carried out for the project entitled "Extension and Expansion of Mohara Water Treatment Plant in Chittagong" (the Project).

The JICA Study Team prepared the basic/master plan, in the first phase, for water supply development in Chittagong with the target year of 2010. The objective area (26,913ha in total) covers the whole Municipality of Chittagong and a part of two adjacent Thanas (Hathazari and Sitakunda). The basic plan includes not only the Mohara WTP but also some other water supply development schemes in addition to the existing facilities, such as the Madunaghat WTP project, Kalurghat IRP project, Fatehabad IRP project, and Karnaphuli River WTP project. The study on IEE was carried out for the Mohara WTP Expansion Project during the first phase study, but in consideration of the environmental impact of the basic plan as well.

In the second phase of study, the Team carried out the feasibility study with the target year of 2005 for the expansion & extension of Mohara WTP, as a priority project for urgent implementation. The project contains the following major facilities:

- Extension and Expansion of Mohara WTP (Present 20MGD is doubled to 40MGD after the completion)
- Installation of main transmission pipelines (16.1 km)
- Installation of distribution pipelines (4.7 km)
- Construction of storage reservoirs
- Rehabilitation of existing deteriorated facilities

The details of the project features are to be referred to the other chapters in this report. The objective project for the EIA is thus limited to "the Project " proposed by the feasibility study.

13.1.2 Legislation

The environmental conservation/protection in Bangladesh has to be carried out under the legislation and plans prepared by the government. The legislation and plans related to the environmental study, IEE/EIA, are summarized as follows

(a) The Environmental Conservation Act (ECA), 1995

The ECA is the basic law on the environment and became effective in June 1995. The Environmental Pollution Control Ordinance, 1977 was repealed instead. The Act is composed of 21 articles, which contain the following items:

- Environmental conservation
- Authority to control development and pollution
- Preparation of environmental standards including effluent standards
- Review and approval of environmental impact assessment (EIA)
- Authority of entry for inspection
- Regulation of fine to violation

The Section 12 of this Act stipulates that "No industrial unit or project shall be established or undertaken without obtaining environmental clearance from the Director General of DOE in the manner prescribed by the Rules".

(b) Environment Conservation Rules (ECR), 1997

The ECR has been promulgated, under the ECA, to evaluate and review the environmental impact of various projects and activities. The necessary procedures for environmental approval are also established in this ECA.

Environmental Quality Standards for Bangladesh (EQS) have been set in the ECR to control the ambient environmental quality. The specified limits, which may be damaging to the environment, are shown in the respective standards for the following fields:

- Air quality standards
- Water quality standards (Inland surface water and Potable water)
- Noise quality standards (General)
- Noise quality standards (For Motor vehicle or mechanical vessel)
- Motor vehicle exhaust quality standards
- Quality standards for mechanized vessel exhaust
- Quality standards for Odor
- Sewer discharge quality standards
- Waste discharge quality standards for industrial units and projects
- Gaseous discharge quality standards for industrial units and projects
- Waste emission or discharge quality standards for classified industries (Fertilizer, Integrated textile mill & large processing unit)

(c) EIA Guidelines for Industries

The guidelines for EIA for industries, including development projects, was published in

1997 by DOE. The guideline contains the following items:

- EIA procedures
- Screening
- Application of environmental clearance
- Review of EIA report (by DOE)
- Methodology for the EIA process
- Criteria for locating industrial plants
- Detailed guideline for IEE
- Detailed guideline for EIA

The guidelines of the other sectors are not prepared yet. However, most parts of the guideline (for Industries) may be applicable for the other sectors as well.

(d) National Water Policy (NWP), 1998

The national policies for water resources management and environmental protection are set forth in this NWP, which comprises the following subjects:

- River Basin Management
- Planning and Management of Water Resources
- Water Rights and Allocation
- Public and Private Involvement
- Public Water Investment
- Water Supply and Sanitation
- Water and Agriculture
- Water and Industry
- Water and Fisheries and Wildlife
- Water and Navigation
- Water for Hydropower and Recreation
- Water for the Environment
- Water for Preservation of Haors*, Baors*, and Beels*

  *: Theses are low-lying areas of different types (commonly used in Bangladesh).
- Economic and Financial Management
- Research and Information Management
- Stakeholder Participation

(e) Other Laws /Regulations/Plans Related to Environment

The other laws, regulations or plans related to the environmental study are listed for

reference as follows:

- Factories Act, 1965
- Factory Rules, 1979
- The East Bengal State Acquisition and tenancy Act, 1950
- Acquisition and Requisition of Immovable Property Ordinance, 1982
- The Non-agricultural Tenancy Act, 1947
- Acquisition of Wasteland Act, 1950
- Civil Construction Act, 1984
- Building Construction Laws (Second edition)
- The Embankment Act, 1952
- Antiquities Act, 1968
- The Forest Act, 1982
- East Bengal Protection & Conservation of Fish Act, 1950 (amended 1982)
- Bangladesh Wildlife Preservation Order Amendment Act, 1974
- Wildlife Preservation Order, 1973
- Antiquities Act, 1968
- The Public Health Ordinance, 1944
- Bangladesh National Environment Action Plan, 1995
- Fourth Five Year National Plan (1990-1995)

(f) International Convention

The government of Bangladesh has already ratified (or signed on) the following international conventions/legislation:

- UN Framework Convention on Climate Change (1992): Ratified in 1994
- Convention of Biological Diversity (1992) : Ratified in 1994
- Montreal Protocol (1987) based on Vienna Convention for the Protection of the Ozone layer (1985) : Ratified in 1990
- World Heritage Convention (1972)* : Ratified in 1983
- RAMSAR Convention (1971)* : Ratified in 1992
  (Convention on wetland of international importance especially as waterfowl habitat)
- International Plant Protection Convention Rome (1951) : Ratified in 1978
- Washington Convention (1982): Ratified.
  (Convention on international trading of endangered species of wildlife)
- Convention on International Ocean Law (1982): Signed.

*: No objective locations in and around Chittagong (Project area).

13.1.3 Organization

Ministry of Environment and Forest (MOEF) was established in 1989. The MOEF is the Ministry consolidated into new one of the following two departments:

- Department of Environment Pollution Control
  (Ministry of Local Government and Rural Development)
- Department of Forestry (Ministry of Agriculture)

The present MOEF is, accordingly, composed of the following two departments:

- Department of Environment (DOE)
  Sole governmental organization with authority to control environment in monitoring, management, international convention, nature conservation, etc.
- Department of Forestry (DOF)

The organization of DOE is shown in Figure 13.1-1. The DOE has the Chittagong regional office headed by the DOE director.

13.1.4 Necessity of IEE and EIA

Water supply project is classified as Red category according to the ECR and the EIA guideline. All industries and projects included in Orange/Amber or Red category are required to get the Environmental Clearance from DOE. And the application for the Environmental Clearance needs the IEE Report and EIA Report for a proposed project. That is, without the EIA, the project can not be implemented.

In addition, the JICA Preparatory Study Team, dispatched in October 1999, carried out the preliminary environmental impact assessment. The results confirmed the necessity of IEE and EIA.

13.1.5 Environmental Clearance Certificate

It is necessary for the proposed project to get the official Environmental Clearance Certificate (ECC) for the project implementation. For ECC application, the following documents have to be attached in case of Red Category.

- Feasibility study report
- IEE report/EIA report
- "No Objection Certificate (NOC) " from the local authorities

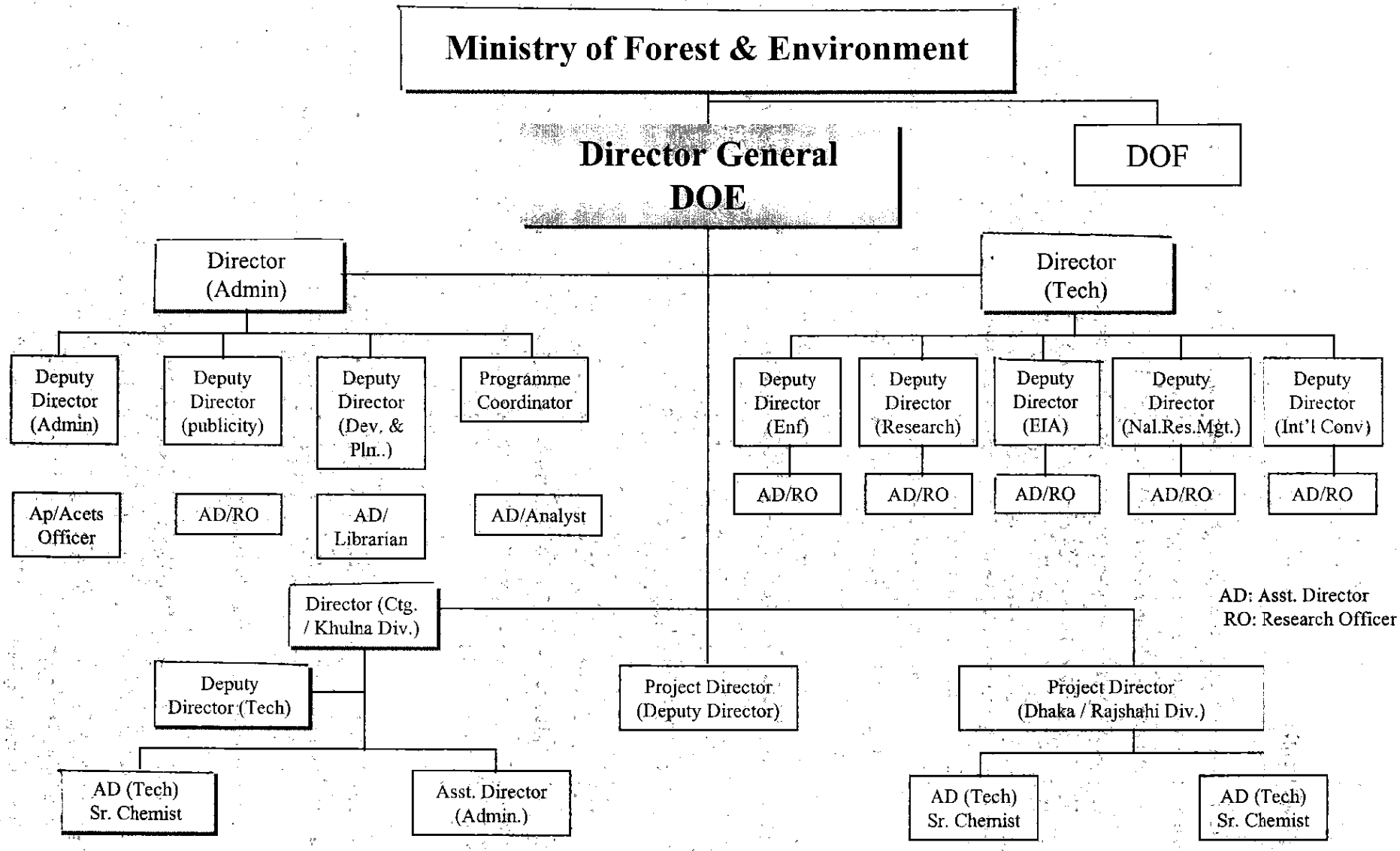


Figure 13.1-1 Organization of DOE

- Pollution minimization plan including emergency plan for mitigation of adverse environmental impacts;
- Outline of relocation plans(where applicable);
- Other information as deemed necessary (where applicable).

The DOE staff and/or the Environmental Assessment Committee (appointed by the government) will review the EIA report in the responsibility of the DOE. The DOE will issue Environmental Clearance to a project, or reject it, or call for some additional information/studies before the clearance is accorded. The details including various cases of the procedure are to be referred to the ECR.

13.1.6 General Procedure of IEE and EIA

The environmental study generally takes the following stages:

- Screening/Scooping (Preliminary EIA)
- IEE
- EIA

Screening examines the potential of adverse impacts for every category of environmental issues and decides whether the IEE and/or EIA process is required or not. The screening often used for site selection as well. Scooping is carried out to evaluate the magnitude of impacts based on preliminary survey and also to identify key issues. The results became the references to define the extent of IEE/EIA studies.

The scope of work and purpose for IEE and EIA is basically not different. The studies are carried out to identify the anticipated environmental impacts and the potential extent and then to propose the mitigation measures as well as the management plan.

The IEE is based on the general survey and the study level is not so in detail. The IEE study is generally carried out at the master plan (or basic plan formulation) stage of a project. The results should be effectively utilized for the feasibility study or the basic design.

The EIA study is a detailed examination of impact including the relevant surveys and monitoring studies with more rigorous impact prediction methods. The EIA study is to be carried out generally during the feasibility study. The detailed EIA survey is conducted for the items selected by IEE and/or in the early stage of EIA, as items with anticipated impact. The results of EIA are to be taken in the detailed design, for ensuring effectiveness of the mitigation and enhancement measures in the construction and O & M stages.

The EIA, after the IEE, was carried out as follows:

- Review of IEE and identification of EIA items
- Data collection and field survey for respective EIA item
- Analyses and evaluation of the EIA survey results
- Study on mitigation measures
- Study on environmental management plan and monitoring program

The monitoring program is generally included in the proposed environmental management plan and be undertaken as follow-up exercise to maintain a certain level of environmental conditions during the project implementation and operation stages.

13.1.7 Sub-contract of IEE and EIA

The EIA as well as IEE was subcontracted to a local consultant company, Bangladesh Engineering & Technological Services (BETS), from the JICA Study Team. The BETS carried out the study from mid February to early April for IEE and from mid-July to mid-October 2000, under the guidance by the JICA Study Team. The major work items for the IEE and the EIA conducted by BETS are respectively listed as follows:

Type (A) for IEE

(a) Collection and review of the existing laws and regulations pertaining to the EIA
(b) Collection and analysis of the existing environmental baseline data and information
(c) Environmental assessment, including the review of previous environmental study, the evaluation of impacts, the preliminary study on the mitigation measures and management plan.
(d) Identification/Confirmation of the need of EIA, to be carried out as a part of feasibility study and presentation of the key issues for the EIA and the feasibility study.
(e) Preparation of IEE report

Type (B) for EIA

(a) Review of the IEE report, the Progress report and the Interim report.
(b) Understanding and confirmation of the objective project in detail.
(c) Study on the project activities.
(d) Collection and study on legal conditions and background for EIA.
(e) Study on the survey area for the data collection as well as for the EIA.
(f) Collection of the environmental baseline data and information.
(g) Field survey to obtain supplementary or detailed data.

(h) Environmental impact assessment and study on the mitigation measures.(Especially for the selected items categorized as “Anticipated impact” or “Unknown”)
(i) Study on the environmental management plan.
(j) Study on alternatives or options of the proposed project and locations.
(k) Survey of environmental assessment through public hearing.
(l) Occasional reporting on the progress and issues of EIA to the Engineer.
(m) Occasional discussion with relevant agencies concerned, including CWASA, DOE and WARPO, to obtain their opinions and relevant information.
(n) Preparation of the EIA report (Draft and Final).

The EIA Report contains the following in general:

- Baseline studies
- Review of IEE
- Identification and selection of EIA items
- Survey results for EIA
- Evaluation/assessment of impact
- Study of mitigation measures
- Preparation of Environmental Management Program (EMP)
- Preparation of Monitoring Program

13.2 Existing Environmental Baseline Data

13.2.1 Survey Area

Although it may be said that the study/survey area for EIA is the project sites and the surrounding areas, the limit/boundary of the surrounding areas can not be fixed. The boundary of environmental impact study was decided on the basis of individual environmental items and objective facilities/sites. For example, the study on environmental impact of water pollution in a river has to cover nearly all the river systems. And the study on fauna also has to consider the possible moving/active areas as a part of ecological system. In addition, the study area for collecting the environmental baseline will be generally wider than the required locations/areas for environmental impact assessment, depending on the availability of data and some uncertain factors.

However, in general, the survey area is to be classified as follows:

- Type A: Project area (which is the service area by the project)
- Type B: Project site and the surroundings (such as the WTP site, pipeline routes and the reservoir site)
- Type C: Chittagong District/Zila

- Type D: River Basins (of the Halda River and the Karnaphuli River)

The maps of Type A area (including Type B area) and Type C area (including Type D area) are shown respectively in Figures 13.2-1 and 13.2-2.

The selection of area type for data collection and survey was made in consideration of characteristics of each environmental item and the necessity for the environmental assessment.

13.2.2 Social Environment

(1) Administration Division and Population

The objective project area covers the whole Chittagong Municipality and the neighboring areas located on the northern side. The areas and population in the objective area are summarized in Table 13.2-1:

Table 13.2-1 Area and Population in the Project Area

Area Division	Thana	Area (ha)	1991 Pop.	2000 Pop.	2010 Pop.
Chittagong Municipality	Kotwali	625	246,893	352,600	457,500
	Double Mooring	1,500	319,945	537,900	830,200
	Panchlaish	2,601	193,357	309,700	449,000
	Pahartali	4,662	198,894	353,900	576,700
	Chandgaon	3,213	219,641	387,800	632,600
	Chittagong Port	4,463	187,739	364,400	654,900
	Hathazari (a part)	2,938	26,391	45,000	69,900
	Sub-total	20,002	1,392,860	2,350,300	3,670,800
Northern Additional Area	Hathazari (a part)	3,167	73,831	120,300	186,700
	Sitakunda (a part)	3,745	48,655	82,700	134,800
	Sub-total	6,911	12,486	203,000	321,500
Total		26,914	1,515,346	2,553,300	3,992,300

Note: 1991 population is based on the Census.
2000 and 2010 population is projected.

The project area covers 41 wards and 8 unions in 8 Thanas of the Chittagong District/Zila. As seen in the table, the total area is 26,914 ha and the population in 2000 and 2010 is respectively projected at 2,553,300 and 3,992,300. The population density becomes 95 persons/ha in 2000 and 148 persons/ha in 2010.

The average number of family is 5.8 and the number of male is almost 1.4 to 1.5 times more than that of female according to the 1991 census.

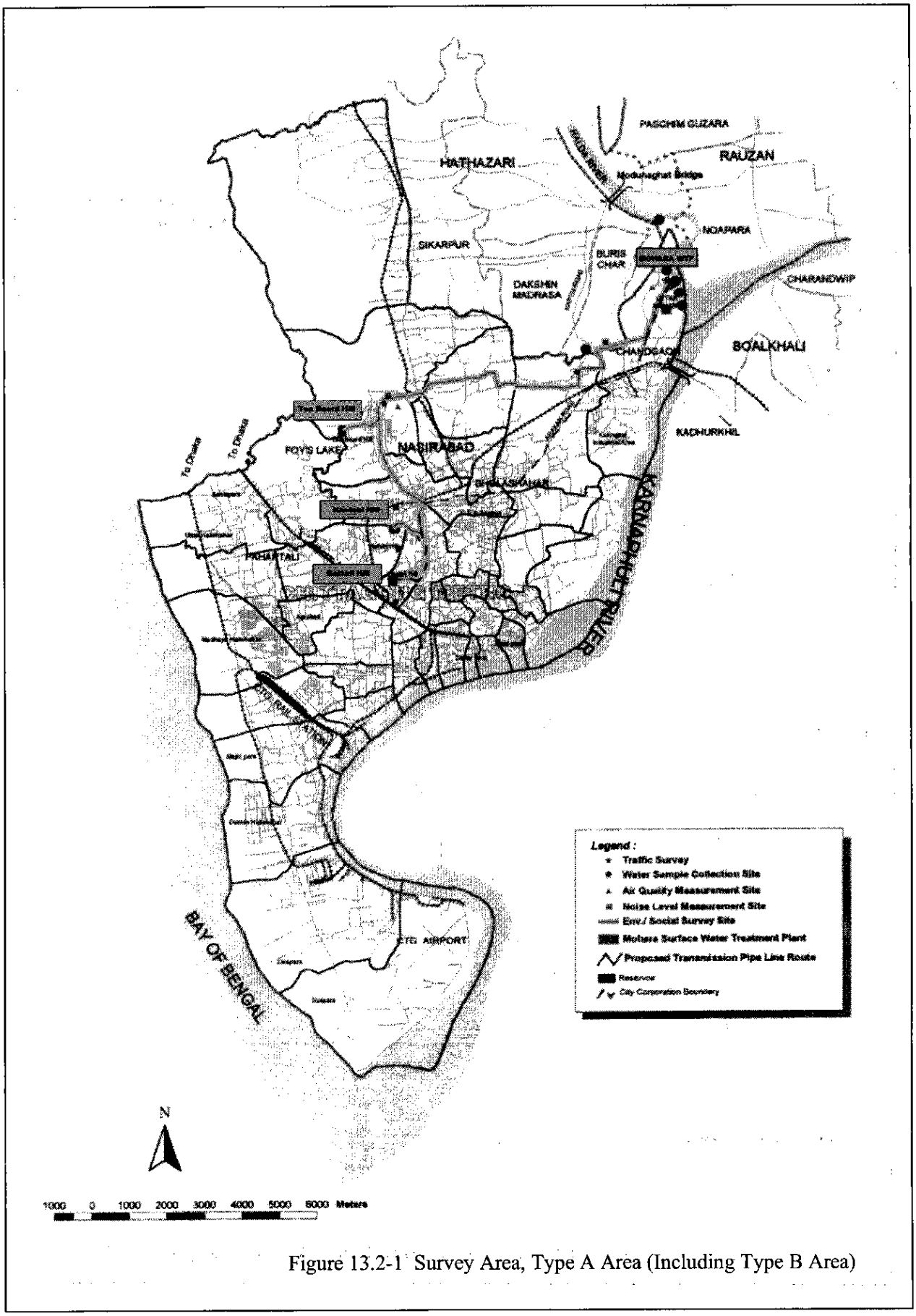


Figure 13.2-1 Survey Area, Type A Area (Including Type B Area)

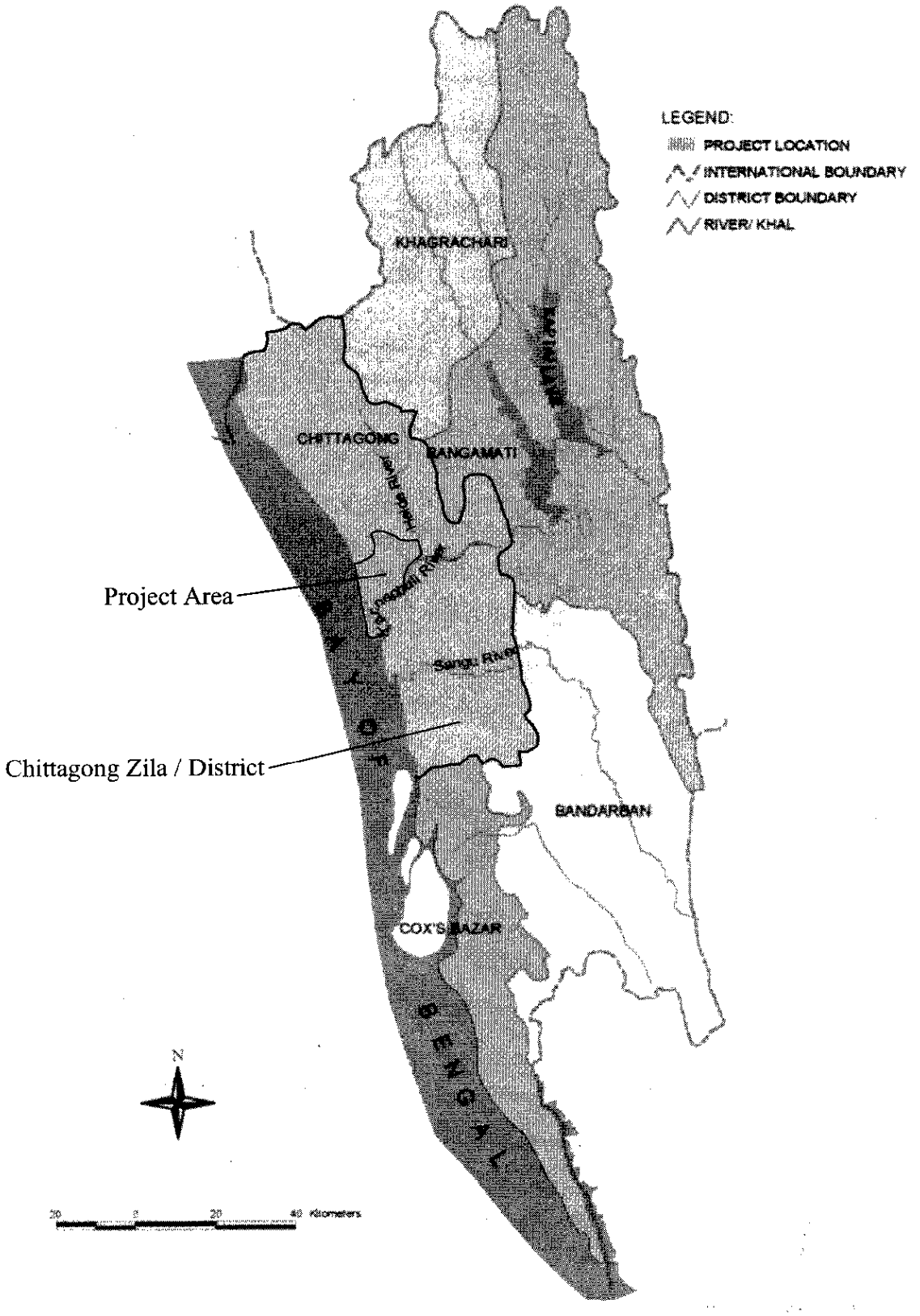


Figure 13.2-2 Survey Area, Type C Area (Including Type D Area)

(2) Income Source and Major Industry

The economic share (GDP) of Chittagong has more than 10 % of the whole Bangladesh. The share of the industry is higher than 30%. The major income sources (major industries) in the project area, Municipality of Chittagong, are classified into the following sectors:

- Commercial sector (Mostly small stores)
- Industry sector (Iron/metal, fertilizer, cement, oil refinery, food/beverage, textile, chemicals, etc. There are some industrial zones including Chittagong Export Processing Zone)
- Agriculture sector (Paddy, vegetable, fruit, etc.)
- Fishery sector (Fish, crab, shrimp, cram, etc.)
- Pubic service sector (Government/Semi-government offices)
- Construction sector (Civil works and architecture)
- Transportation sector (Road, railway, river and air)
- Private service sector (Generally small scale; Restaurant/hotel, consultant, travel agent, etc.)
- Trading sector (Mostly industrial good/product, to and from Chittagong port)

The City of Chittagong is one of two major industrial centers in Bangladesh. The industrial area is generally categorized as follows:

(a) Light industry (Type A1): offices for financial and professional services, light workshops (small furniture makers, tailor's workshops, light metal workshops, small bakeries, car repair shops, handcraft workshops, etc.), etc.

(b) General industry (Type A2): textiles, ready-made garments, food and beverage manufacture, footwear manufacture, wood products, paper products, fabricated metal manufacture, electrical appliances manufacture or assembly, etc.

(c) Heavy industry (Type A3): electrical power producer, ship building, iron and steel mills/foundries, car manufacturing, cement works, rubber products, fertilizer plants, chemical products, petroleum refinery, etc,

(d) Noxious industry (Type A4): animal slaughter-houses bone crushing plants, textile dyeing, leather tanning, manufacture of industrial chemicals, etc.

(e) Mineral workings (Type A5): hill cutting, quarrying, mining, etc.

The city has some industrial areas and the major areas are located as shown in Figure 13.2-3 and listed as follows:

(a) Kalurghat Industrial Area (Type A2 & A3)

(b) Kalurghat Noxious Zone (Type A4)

(c) Nasirabad/Sholashahar Industrial Area (Type A2)

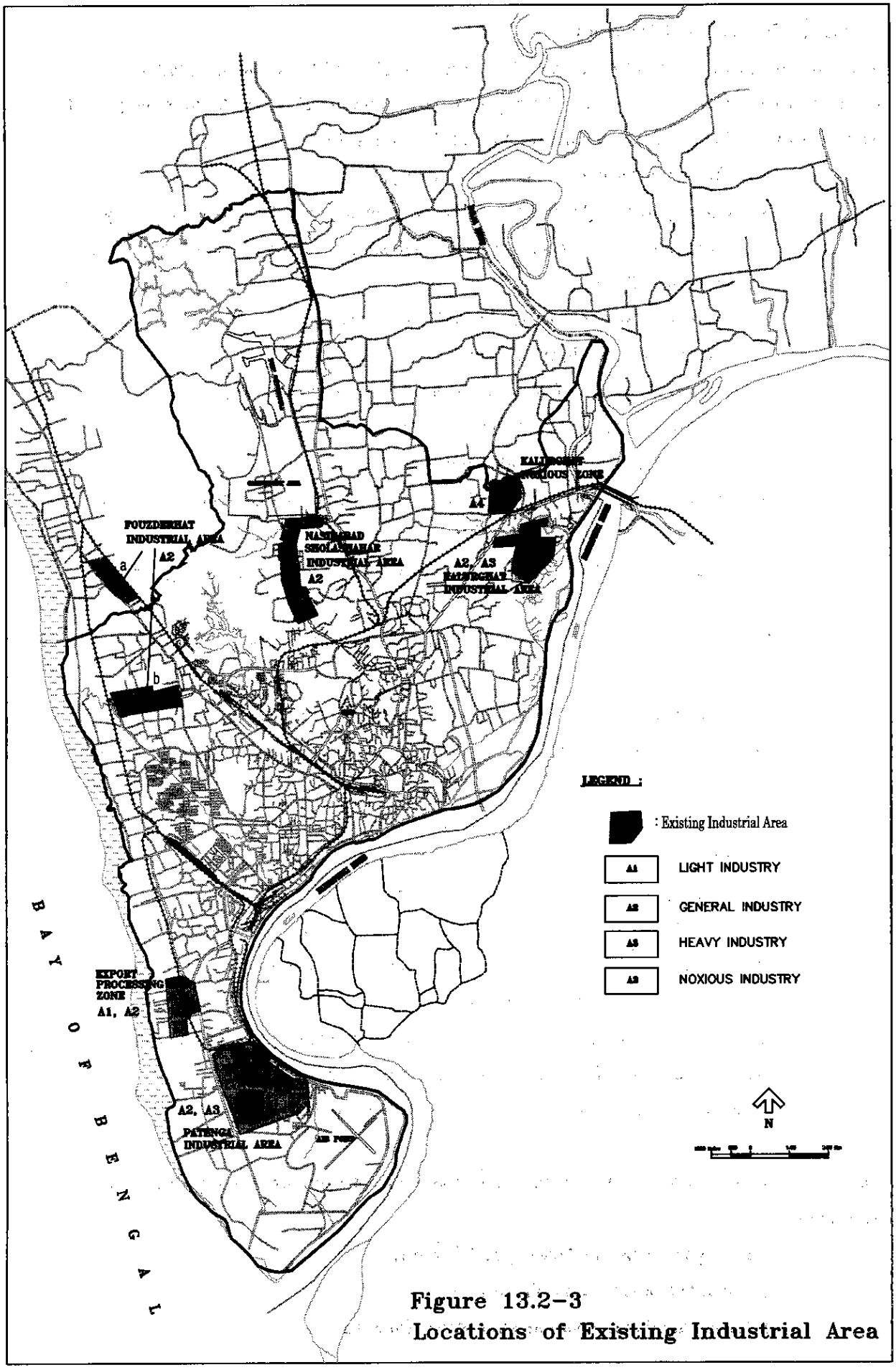


Figure 13.2-3
Locations of Existing Industrial Area

(d) Fouzderhat Industrial Area (Type A2)
(e) Export Processing Zone (Type A1 & A2)
(f) Patenga Industrial Area (Type A2 & A3)

(3) Development Plan

The Chittagong Development Authority (CDA) has prepared " Chittagong Metropolitan Master Plan" in 1995, which comprises two element, a Structure plan and an Urban Development plan. The plan generally contains the policies and methodologies for the development, but it seems to be not definite enough for the actual implementation. It would be necessary to prepare the practical and definite development plan based on the master plan.

(4) Land Use

The objective project area is mostly located in the town area of Chittagong City. That is, a large part is covered with commercial, industrial and residential areas and the agricultural lands are mostly located in the surrounding area. The open spaces, currently not used, are also widely located.

The Mohara expansion WTP site, the main structure of the project, is located on the right-bank of the Halda River, at Mohara Ward of Chittagong Thana. The site was developed by CWASA for the existing Mohara WTP. The WTP site is surrounded by agricultural land with scattered farmers' houses. Some commercial shops are located along the road connected to the WTP entrance gate.

(5) Public Utilities

Most Thanas in the Chittagong Municipality have water supply system. However, only approximately 40% of total household have easy access to water supply system at present.

There is no sewerage system in Chittagong. Approximately 53% of total household have access to sanitary toilet with flushing water. While households of 31 % have other types of toilet and 6% have no toilet facility at all.

The households of approximately 70% have electricity facility in the project area.

The drainage ditches are comparatively developed well in town areas. However, the capacity looks too small in some areas and many ditches are used for dumping places of garbage. The garbage is collected periodically by the city service, but the collecting capacity and the service areas are not sufficient.

(6) Traffic system

The road network is developed widely but the main trunk roads are limited in capacity and in number/length. There are many narrow roads, with irregular alignment and width, extended in every district. Accordingly the roads are usually crowded with mini-auto rickshaws, rickshaws, buses, and people. The transportation for people in the city is mostly by rickshaws (for short distance), mini-auto rickshaws (for middle distance) and public & private buses (for middle to long distance).

There are three lines of railways from Chittagong. The main route is to Dhaka and the other routes are to Farhadabad (to north in Chittagong district) and to Dohazari (to south in Chittagong district).

There is the largest port in Bangladesh on the left bank of the Karnaphuli River. And the Chittagong airport is located in the south of the city.

(7) Historical and Culture Locations

The Municipality of Chittagong and the neighboring areas has some historical/cultural/tourism locations as listed as follows:

- Tomb of Sultan Bayazid Bostami: Situated on a hillock at Nasirabad, about 6 km to the northwest of Chittagong town and has a large pond with several hundred tortoises.
- World War II Cemetery: Located within the city center. In a well-preserved cemetery at a quiet and picturesque place, over 700 soldiers from Britain, Australia, Canada, New Zealand, India, Myanmar, East and West Africa, the Netherlands and Japan who died in the Myanmar front during the World War II are buried for eternal peace.
- Shrine of Shah Amanat: Located in the heart of the town. Place of religious attraction. Hundreds of people visit the shrine everyday for paying homage to the memory of the saint.
- Ethnological Museum: Located in Agrabad.
- Court Building: Situated on the Fairy Hill. The building commands a panoramic bird's eye view of Chittagong. The museum was built for the memory of intense activity during the Independence War in 1971. (The museum was already closed.)
- Foy's Lake: Located approximately 8 km north from the central area of Chittagong. A beautiful man-made lake surrounded by hills and forest is one of major attractive recreational places.

13.2.3 Natural Environment

(1) Location, Topography and Geology

The Municipality of Chittagong is located on the coastal zone facing to the Bengal Bay. The

Karnaphuli River, with the water source in Kaptai Lake, runs down along the southern border of the City. The Halda River, a main tributary, joins to the Karnaphuli River from the right-bank at approximately 20-km from the river mouth. That is, the project area is surrounded by the sea on the west, the Karnaphuli River on the south/southeast, and the Halda River on the east. The project area is flat on the coastal zone but there are many low hills in the inland areas.

The hill ranges, generally 30 - 80 m high, are developed in unconsolidated sands and clays of the Dupi Tila formation. These hills generally take a form of long narrow ranges with steep slopes and there are extensive flat-topped upland areas dissected by steep-sided narrow valleys. But, as seen commonly elsewhere, they generally form irregular hill masses.

The Chittagong area (District) generally consists of substratum of tertiary rocks covered with alluvial deposits. This substratum had a warping movement probably associated with the one that formed the Himalayan chain of mountains, which caused it to buckle up into parallel anticlines running from north to south. The overlying deposit shows that it consists of successive layers of clay and sand. The coastal plains are everywhere underlain by heavy marine or tidal clays, but these have been buried by more sandy or silt deposit near the foot of the hills and the plains.

(2) Meteorological Conditions

Chittagong is situated in the tropical zone. But the temperature is not so high in mid dry season. The annual meteorological conditions mainly based on rainfall are generally divided into the following four seasons:

- December to February: Dry season. Cold and dry
- March to May: Transition season. Hot and occasional rain
- June to September: Rainy/Monsoon season with cyclones. Hot and much rain.
- October and November: Transition season. Occasional rain

The mean monthly minimum and maximum temperature in Chittagong is 19.50 ^{o}C and 27.50 ^{o}C, respectively (in 1996). The average maximum temperature is lowest in December (28.6 ^{o}C) and January (26.2 ^{o}C) and highest from April to July (32.0 ^{o}C ~ 33.3 ^{o}C). The average minimum temperature is lowest in December (16.9 ^{o}C) and January (14.1 ^{o}C) and highest from May to September (25.4 ^{o}C ~ 25.7 ^{o}C). From November to February, the sky is almost cloudless, but humidity is high owing to the proximity of the sea.

The mean annual rainfall is 2,000 ~ 3,000 mm, which varies by a year. The monthly rainfall is high from May to September (250 ~ 700mm) and July is the highest month (700mm). While the monthly rainfall is low from November to March (less than 100 mm) and December and January (10 ~ 20 mm)

are the lowest months.

Humidity variation is not high. The lowest humidity happens in January (75%) and February (72%) and the highest from July to September (85 ~ 88%).

(3) River and River Use

The proposed treatment plant lies at about 1.5 km upstream from its confluence with the Karnaphuli River.

The Halda River is approximately 80km long and has the drainage area of approximately 1,536 km^2. The mainstream of Halda River rises from Badnatali Hill ranges in the Chittagong Hill Tracts and flows southwest and then flows due south until it falls into the Karnaphuli River at Kalurghat. Approximately 30 km from the confluence up to Nazirhat is navigable by big boats throughout the year. In the upper to middle reach, the river is used for local navigation and bamboo rafting. The Halda River collects some streams flowing down from the hill. These streams are used for irrigation at many locations. The river fishery activities are also seen, but it seems to be not for commercial use. The water intake (90,000 m^3/day at present) in the Mohara WTP is the major water consumption from the Halda River. There are also a few irrigation intakes located along the Halda River.

The Karnaphuli River, one of major rivers in Bangladesh, has its water source in the Kaptai Lake. Kaptai Lake is originally a natural lake but now a man-made lake enlarged by a dam for hydro electric-power constructed at the inlet of the Karnaphuli River. The Karnaphuli River flows west with gentle meandering and pours into the Bengal Bay, after collecting some tributaries including the Halda River. From the Karnaphuli River, a large fertilizer company located near the river mouth, takes water at the left-bank of just downstream side of the Kalrugat Bridge. The water is pre-treated there and transported through 29 km pipeline to the factory, which has its own WTP (1,200 m^3/hour in capacity). The Chittagong port, the representative port in Bangladesh, is located on the right-bank side nearly 15 upstream from the river mouth.

(4) River Water Level and Discharge

Both the Karnaphuli River and the Halda River are affected by tide. That is, the surface water level varies according to the tidal movement. And the river occasionally flows to the upstream direction every day, depending on the balance of force between the river flow and tidal flow. The monthly mean high water levels and the low water levels during several months in the Halda River at the intake of Mohara WTP are summarized in Table 13.2-2.

Table 13.2-2 Water Level of Halda River at Mohara WTP

No.	Month	Mean High Water Level (m)	Mean Low Water Level (m)	Range (m)
1	August '99	3.40	1.36	3.0
2	September '99	2.91	0.10	2.8
3	October '99	2.87	0.12	2.75
4	November '99	2.59	-0.41	3.0
5	December '99	2.25	-0.68	2.94
6	January '2000	2.15	-0.60	2.75

Note: Data source from CWASA

There are only two water level gauging stations with discharge measurement in the Halda River, as seen in Figure 13.2-4. One is Paspukuria station and another one is South Sunderpur station. There are some other water level gauges, but without discharge measurement. The annual maximum and minimum discharge records in recent some years at Paspukuria station located approximately 15 km upstream from the Mohara WTP site, which has no tidal affect, are shown in Table 13.2-3.

Table 13.2-3 Discharges of Halda River at Panch Pukuria

Year	Minimum Discharge		Maximum Discharge	
	Discharge (m^3/sec.)	Month	Discharge (m^3/sec.)	Month
1995	0.40	March	195.79	August
1996	1.39	March	195.79	August
1997	2.38	March	244.23	September
1998	2.10	March	386.95	July
1999	8.08	March	548.67	July

The annual mean, maximum and minimum discharge records from the Kaptai dam of recent 10 years are shown in Table 13.2-4.

Table 13.2-4 Discharge from Kaptai Dam

Year	Mean	Maximum	Minimum
1991	49.73	263.82	15.11
1992	27.09	64.00	4.95
1993	51.37	766.23	2.70
1994	23.04	87.47	1.48
1995	26.41	69.49	0.09
1996	34.66	70.85	1.58
1997	34.67	455.45	1.03
1998	47.39	258.41	1.49
1999	46.42	431.89	4.06
Mean/Max. /Mini.	37.86	766.23	0.09

Unit: m^3/sec

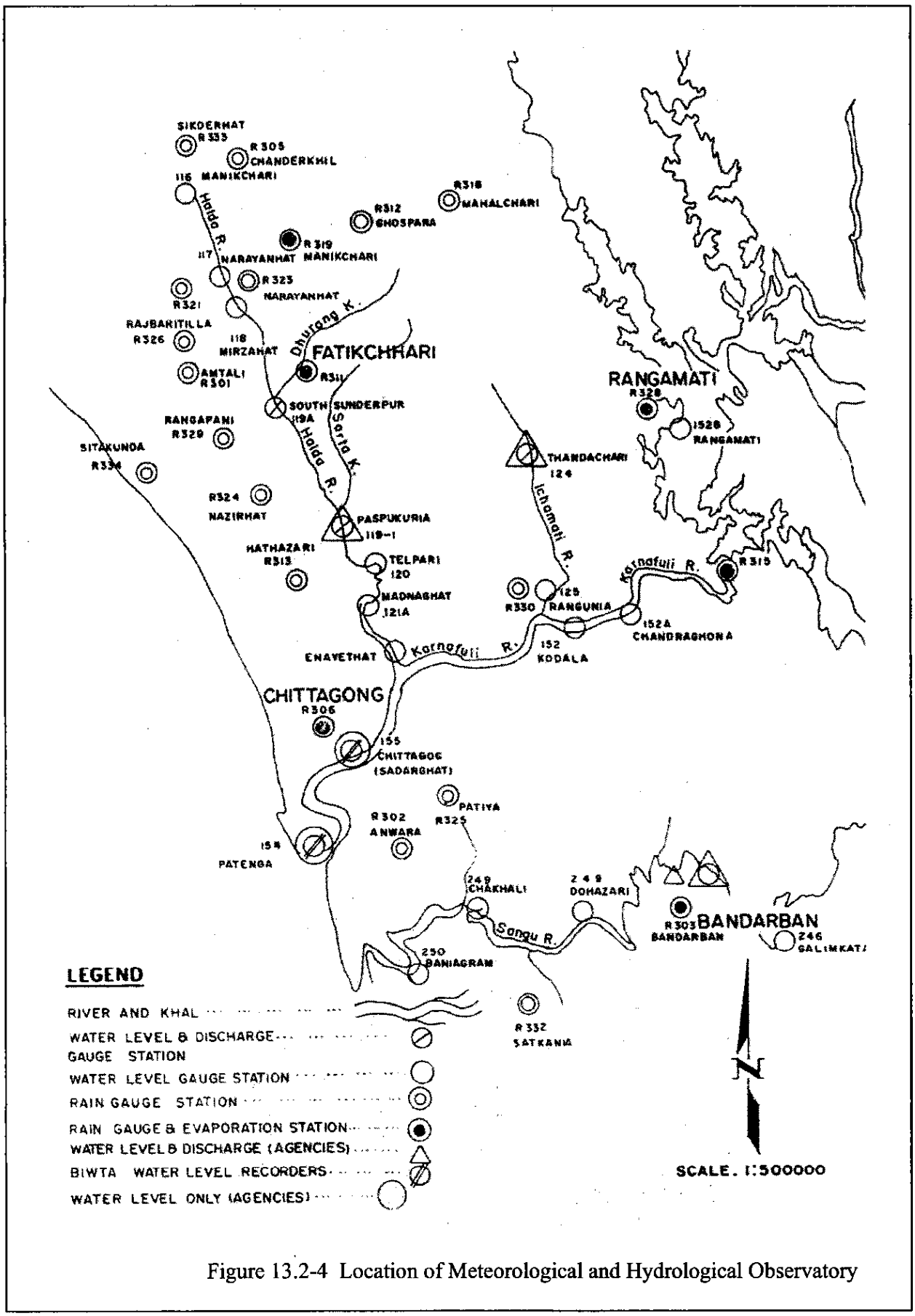


Figure 13.2-4 Location of Meteorological and Hydrological Observatory

(5) Ground water

The ground water exists in confined or unconfined conditions. The confined water is generally located in a range of 60 ~ 200m deep from the ground surface. And the water level of unconfined water has its water surface generally 3 ~ 5 m deep from the ground, although it varies by the season.

(6) Vegetation and Fauna & Flora

Wetland plants/fauna of Bangladesh are characterized by at least 157 macrophytic plants of 48 families. No survey records only for the project area are available. Wetland is very limited in the project area. Only Foy's Lake and few big ponds exist in the city. And they are not natural lake/reservoir. Accordingly the wetland fauna are very common species there.

As it is located in a tropical climate zone with much rainfall, there are many trees and glass lands in Bangladesh. The Chittagong District/Zila is known for its timber-yielding plants such as segun (teak), chambal, gurfan. Besides, there are also many medicinal plants grown there in the forests. However, because of urban area, the vegetation areas are scattered in the project area. Trees are mostly seen on slope of hills, along roadsides or in house yards. Trees commonly seen are Sisoo, Mahogonj, Babla, Neem, Akashmuni, etc. In addition, fruits and horticultural crops are grown in farmlands or homesteads. This includes mango, (mangifera indica) jack fruit, (artocarpus heteraophylla), coconut, cocos nucifera, khoir (treca catcha), bel (aegle marmelos) and etc.

Bangladesh recorded approximately 930 species of vertebrate fauna and categorized as wildlife, although it is said that only 650 species out of these could be seen at present. And approximately 280 (43%) out of the 650 species of wildlife are known as freshwater species. There is no remarkable wildlife in the project area, because of human activities covering the whole area**,** except some common lizards.

A variety of fish and other aquatic animals live in the inland waters of Chittagong District/Zila. Approximately 50 species of fresh water fishes are known to live in this district. Most common fishes are rui, cattla, kalibaush, pabda, pangas and etc. in the rivers, and kechki, puti, khailsha, magur, singh, sarputi, mola, tengra in the pond/lake. Major carps spawn in the Halda River in the beginning of monsoon. In the closed water habitats particularly in ponds, some exotic fishes are reared, which include silver carps, tilapia, pangas and thai magur.

In Chittagong District/Zila, there are some endangered species of fauna and flora recorded in an environmental data book. But, it may be unlikely to find such species in the project area. It is informed that tortoises living in a pond of Sultam Bayezid Bostami shirine are precious/endangered species. But, they live only in the pond, which are taken care by many local inhabitants.

(7) Protected Reserve and National Park

There is no protected area and national park/reserve in and around the project area. However, in and around the Chittagong District, there are reserved areas listed as follows:

(a) National park
- Himchari (in Cox's Bazar)

(b) Wildlife sanctuary/ Game reserve
- Pablakhali
- Chunati
- Teknaf

(c) Proposed wildlife sanctuary
- Pablakhali*
- Rampahar-Sitaphar*
- Bogakine
- Chimbuk
- Sangu-Matamuhari
- Naaf River
- Jinjirawip and Jinjira reef

Among them only two proposed wildlife sanctuaries with * are located in Chittagong Zila/District, but not in or near the proposed area.

13.2.4 Public Nuisance

(1) Air Pollution

Air pollution may be a common issue in most urban areas in Bangladesh. In Chittagong, many old vehicles run without control of exhaust gases and large industries are located in and around the city. Accordingly, gases (SO_X, NO_X, CO, CO_2 and etc.) and suspended particles (smoke, dust, fumes and etc.) should be serious concern. However, because of priority to economic activities, it seems difficult to make effective control to reduce the air pollution at present.

According to the air pollution survey conducted by DOE in 1994, the results show the following conditions:

(a) Residential area along a main road (Sirajudowllah road)
- SPM ranges 450-540 $\mu g/Nm^3$, which is nearly 2.5 times of the standard (200 $\mu g/Nm^3$)
- SOx and NOx ranges 2 – 6 $\mu g/Nm^3$, less than the standard (80 $\mu g/Nm^3$)

(b) Commercial area along a main road (Bahaddarhat road)

- SPM ranges 490-620 μg/Nm^3, which is nearly 1.5 times of the standard (400 μg/Nm^3)
- SOx and NOx ranges 14 – 26 μg/Nm^3, less than the standard (100 μg/Nm^3)

(c) Industrial areas (some locations)

- SPM is nearly 2 - 20 times higher than the standard (500 μg/Nm^3)
- SOx and NOx are less than the standard (100/120 μg/Nm^3)

It is noted that the most people in urban area do no care about the air pollution, as it is already usual conditions.

(2) Water Quality/Pollution

The Halda River is not polluted at present. However, the Halda River receives discharges from non-point pollution sources including engine boats/ships (oil and grease), wastes from human activities, and agricultural activities containing pesticides and chemical fertilizers. Further, some industries are located in the Halda river basin and the effluent discharges into the Halda River through a canal (khal). There are two khals located at 1 - 2 km upstream right-bank of the MWTP site. The Krishuna Khal collects effluent from Nasirabad industrial district and the water contamination in the khal becomes serious in the dry season, according to the information from the inhabitants.

The Karnaphuli River may receive more untreated effluent from Kaurghat and other industrial areas, from human and commercial activities in the urban center, and also from the Chittagong port. However, due to comparatively much flow discharge and effect of tidal water intrusion, the condition of water pollution seems to be not serious yet.

The water quality data of the Halda River at the Mohara intake are shown in Table 13.2-5.

Table 13.2-5 Water Quality of Halda River at Mohara WTP

Parameter	Year							
	1995		1996		1997		1998	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
pH	6.7	7.3	6.8	7.3	6.8	7.4	6.8	7.4
Turbidity, NTU	40	780	20	680	20	68	20	78
Hardness (mg/l as $CaCO_2$)	48	85	55	80	47	185	50	92
Iron (mg/l)	0.2	0.52	0.2	1.2	0.25	0.8	0.35	1.5
Sulphate (mg/l)	0.02	4.0	7.0	10	12	15	20	22
Ammonia (mg/l)	0.18	0.21	0.32	0.40	0.28	0.39	0.38	0.41
Nitrate (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: CWASA

(3) Noise/Vibration/Odor/Waste

The Chittagong is a noisy city because of many kinds of sound, especially from old vehicles. It seems that most people do not care about noise at present. That is, the requirement of environment without noisy sounds is much lower than the development countries, although it may be better for them to get quiet environment.

There are no significant reported concerns for the people to vibration, odor and waste issues at present. It is probable that people are already accustomed to some odor or piled waste, as far as it is within an affordable level. However, during the site reconnaissance, the Japanese Study Team members felt some mal-odor when they passed by in an industrial area. Then, the wastes/garbage are often seen on some roadsides or in some drainage channels, although the scale is not so large in general.

13.3 Results of IEE

13.3.1 Review of Screening and Scoping

The JICA Preparatory Study Team, dispatched to Chittagong in November 1999, carried out the preliminary EIA. The preliminary EIA concluded that the IEE and EIA should be carried out during the master plan / feasibility study stage paying attention to the following items.

- Impact to and reduction of traffic congestion during the construction
- Impact to the river due to additional intake and sludge discharge
- Impact to and reduction of water contamination caused by sludge discharge
- Impact to and reduction of noise/vibration during the construction

The results of review for screening and scoping are respectively summarized in Tables 13.3-1 and 13.3-2. As seen in the tables, the results are not remarkably different, although the results after the review are changed at three items from D (no impact) to C (unknown, need verification) for confirming the specific impacts by the project.

13.3.2 Checklist and Identified Impacts at IEE

There are several methodologies for assessing the environmental impacts of development activities on a project. At the current status of development in Bangladesh, a checklist method is generally adopted and a matrix method is occasionally used. Accordingly, it is decided to use the checklist for this IEE. Although the updating of scoping was already carried out, the checklist for IEE was prepared, as it is common in the IEE stage to study on the impacts at every stage of the project life as listed as follows:

- Pre-construction (Planning, survey, design, etc.) stage

- Construction stage
- Operation & Maintenance (O & M) stage

The end of project life, demolishing stage, is to be not included at the IEE stage, but some considerations are to be made as a matter of O & M stage.

The checklist is prepared as shown in Table 13.3-3, which referred to the results of the scooping for keeping the consistency of the study.

As seen in the results of the checklist, some items are classified as B (slight/minor impact anticipated) or C (Unknown, need further verification). However, no items are classified as A (significant/major impact anticipated).

The descriptions on anticipated impacts on the items/issues classified as B or C are made as follows:

(a) Resettlement/Land acquisition

The detailed plan of the areas to be used for the project is not finalized yet. However, the following land acquisition will be necessary.

- Expansion of the Mohara WTP: If the existing open space is not sufficient for the expansion facilities, some additional areas will be required. But the additional area may not be wide and some paddy fields and unused open spaces will be used. The relocation of houses and facilities/structures may not be required.
- New water supply pipeline: Pipelines are installed mostly along the main roads, so that the land acquisition may not be required. But, it would be necessary to confirm on the basis of the definite plans of pipeline.
- New reservoir (s): There are alternative reservoir sites (hills), proposed at the basic plan stage. These areas, except Battali hill, need land acquisition.

(b) Traffic congestion

Due to the construction works, it will be sure that the traffic is more or less disturbed by the transportation of materials/equipment as well as by the works itself. But, the impacts may be not significant due to the following reasons:

- Temporary work to be completed within a certain period.
- Large-scale works is located in confined areas without public traffic.
- Pipeline installation works is small in scale and temporary.

(c) Water use/right (Halda River)

It is informed that the drinking water has the first priority to use. However, it is necessary to make sure the official and customary water right for water use from the rivers, with

qualitative and quantitative data/background.

(d) Waste disposal

It is anticipated that the waste disposal from the project will be not a significant issue as the quantity of wastes may not be large and no hazardous substances will be included. However, without appropriate control, there is possibility to cause adverse impacts by not only the construction waste but also the waste/sludge during the operation period (and demolition time).

(e) River regime and environment

The impact to the river will be minor, when the scale of rivers and the flow discharge is compared with the discharge volume for intake and effluent discharge at the WTP. However, it would be necessary to confirm the impacts (scouring, water level change, discharge change, etc.) from qualitative and quantitative data/background, especially for the low flow periods.

(f) Water pollution

The water pollution to the Halda River and the Karnaphuli River will be negligible, if the high dilution effect of the effluent from the WTP is considered. The sludge is to be discharged to the Halda River and flows down into the sea through the Karnaphuli River. It would be necessary to confirm the impacts from qualitative and quantitative data/background, especially for the low flow periods.

(g) Noise/vibration

The following noise/vibration sources are considerable:

- Pumping station of WTP
- Construction activities

It will be sure that the project will cause noise nuisance, but the magnitude may not be a serious level for the inhabitants, if the actual present conditions in Chittagong are taken into account.

It is noted that there is an issue at present on "Division of local community at the existing WTP site". The village was divided by the WTP and the village has been asking the short-cut road crossing the conduit pipeline (from the pumping station to the de-silting basin), nevertheless CWASA already constructed the access tunnel but detouring nearly 50 m. This issue is not yet solved; however, it would not be a matter of the proposed expansion project. Such issue will not happen by the new project.

Table 13.3-1 Revised Screening at IEE

Item			Description	Impact		Remarks
				Pre-study	IEE Review	(Reason for impact evaluation at IEE stage)
Social Environment	1	Relocation /Land acquisition	Relocation and/or land acquisition due to project facilities or construction works.	No	Not sure	Possibly no relocation. But, land acquisition will be necessary.
	2	Economic activity	Decrease of production. Change of economic structure.	No	No	No negative impact is considerable. Some positive impacts are expected.
	3	Traffic/Public facilities	Traffic congestion, Accident, Effect on public facilities	Yes	Yes	Possibility of traffic issues during construction.
	4	Division of Communities	Separation of local communities due to blocking of transportation system.	No	No	Not considerable. The existing issue at the WTP is considered as a matter of the existing WTP, but not for the expansion.
	5	Archaeological/Cultural Heritage	Decrease or deterioration of archaeological/cultural sites.	No	No	No such location in the project area.
	6	Vested Right	Right for fishery, water use, logging, etc.	No	Not sure	Possibly no impact. But, better to be confirmed as far as the intake water is increased.
	7	Health and Hygiene	Degradation of hygienic conditions caused by waste disposal and vector insects.	No	No	Rather improved (Positive impact is expected).
	8	Waste Disposal	Construction waste/debris contaminated mud, sludge, general wastes, etc.	No	Not sure	Possibly minor impact. Necessary to study for the treatment method and quantity.
	9	Disaster/Accident	Increase of danger on ground collapse, land sliding, construction accident, etc.	No	No	No such case will happen. But, safety control during construction is necessary.
Natural Environment	10	Topography & Geology	Change of significant landforms and geological features caused by earthwork, etc.	No	No	No remarkable change is considerable.
	11	Soil erosion	Soil erosion originated by runoff through earthworks, logging, etc.	No	No	No remarkable change is considerable.
	12	Ground water	Water contamination or reduction of groundwater caused by excessive pumping, seepage of contaminated water, etc.	No	No	No groundwater is used by the expansion project. The construction works will not make adverse effects on the groundwater.
	13	River & Lake	Change of discharge, velocity, riverbed due to reclamation, new channel construction, etc.	Yes	Yes	Quantity of river water use is not high so that the impacts will be minor, if any. But, it will be necessary to confirm the impact.
	14	Coast	Scouring or sedimentation at coastal area due to change of drifting sands and waves.	No	No	WTP site is located nearly 20 km upstream from the river mouth. No remarkable effect on coastal area is considerable.
	15	Fauna & Flora	Reduction of breeding and extermination of endangered species.	No	No	No endangered species. The project area is located in the town area. But, it will be better to confirm the impact to fauna and flora in the river.
	16	Climate	Climate change arising by implementation of large-scale development of earthworks and structures.	No	No	No impact on climate is considerable.
Pollution	17	Land scape	Change of landscape due to earth works and new structures.	No	No	No remarkable change is considerable.
	18	Air pollution	Air pollution caused by exhaust gas and poisonous gas from vehicles and factories.	No	No	No remarkable air pollution is considerable. Exhaust gas from construction vehicles will be not high in quantity.
	19	Water pollution	Water contamination caused by inflow of soil, chemical substances, oil, etc.	Yes	Yes	Only minor contamination is considered. It will be necessary to study on effluent of sludge from WTP.
	20	Soil contamination	Soil contamination caused by runoff and diffusion of effluent, poisonous substances, etc.	No	No	No remarkable source of soil contamination.
	21	Noise /Vibration	Noise and vibration caused by running vehicle, pumping operation, etc.	Yes	Yes	Possibly minor impact. But, it is necessary to consider the noise from pumping station and also construction works.
	22	Ground Subsidence	Ground surface subsidence caused by change of foundation condition and lowering of ground water level.	No	No	No ground subsidence is considerable. No groundwater is used by the expansion project.
	23	Odor	Occurrence of exhaust gas and odor.	No	No	No odor source in WTP.
			Necessity of EIA	Yes	Yes	Some impacts are anticipated.

Table 13.3-2 Revised Scoping at IEE

Item			Score		Description
			Pre-study	IEE review	
Social Environment	1	Relocation/Land acquisition	D	C	Relocation of residents will be not necessary, but to be confirmed after deciding the final plan of the project.
	2	Economic Activity	D	D	No negative impact is anticipated. The project will rather contribute to enhancement of economy.
	3	Traffic/Public Facilities	B	B	Traffic congestion and disturbance during construction works.
	4	Division of Communities	D	D	No separation of local society is foreseen. The existing issue at the WTP is considered as a matter of the existing WTP, but not for the expansion project.
	5	Archaeological & Cultural Heritage	D	D	No such locations/structures in the proposed project area.
	6	Vested /Water Right	D	C	Possibly no impact. But, necessary to be confirmed
	7	Health and Hygiene	D	D	Hygiene conditions will be improved by the project.
	8	Wastes Disposal	D	C	Sludge from WTP will be discharged to the river
	9	Disaster / Accident	D	D	Construction works is neither a type of large scale nor dangerous one.
Natural Environment	10	Topography & Geology	D	D	No significant change is considerable.
	11	Soil Erosion	D	D	No soil erosion due to the project is considerable.
	12	Groundwater	D	D	No use of groundwater. No seepage of contaminated water to the ground.
	13	River, Lake & Pond	B	B	Minor impact to the river during low water period due to intake water.
	14	Coast & Sea	D	D	Coastal area is located approximately 20 km downstream. No impact is considerable.
	15	Flora & Fauna	D	D	No endangered species identified yet
	16	Climate	D	D	No facility/activity influencing to climate.
	17	Landscape	D	D	No remarkable change of landscape.
Public Nuisance	18	Air Pollution	D	D	No pollution source. But some dust by construction works.
	19	Water Pollution	C	C	Sludge will be discharged to the river.
	20	Soil Contamination	D	D	No remarkable pollution sources considerable.
	21	Noise / Vibration	B	B	Noise from pumping station and from construction works including transportation by heavy vehicles.
	22	Ground Subsidence	D	D	No groundwater use. No deep excavation.
	23	Odor	D	D	No odor from WTP.

Score: A -Significant impact anticipated.
B -Slight impact anticipated
C -Unknown (subject to further verification)
D -Almost no adverse impact is anticipated.

Table 13.3-3 Checklist for IEE

		Item	Magnitude of Impact			Remarks on Impact
			Pre-const. Stage	Const. Stage	O & M stage	
Social Environment	1	Relocation/Land acquisition	C	C	D	Probable Use of private lands for the project site and/or construction works.
	2	Economic activity	D	D	D	No negative impact is considerable. Some positive impacts are expected.
	3	Traffic/Public facilities	D	B	D	Traffic congestion will occur during the construction.
	4	Division of Communities	D	D	D	Separation of local communities due to blocking of transportation system is not considerable. The existing issue at the WTP is considered as a matter of the existing WTP, but not for the expansion project.
	5	Archaeological/Cultural Heritage	D	D	D	No such location affected by the project and the construction.
	6	Vested Right	D	D	C	Possibly minor or no impact. But, better to confirm the water right as far as the intake water is increased.
	7	Health and Hygiene	D	D	D	Rather improved (Positive impact is expected). Degradation of hygienic conditions caused by waste disposal and vector insects is not considerable.
	8	Waste Disposal	D	C	C	Possibly minor impact. Necessary to study the treatment method on construction waste/debris, contaminated mud, sludge, general wastes, etc.
	9	Disaster/Accident	D	D	D	Increase of danger on ground collapse; land sliding, etc. will happen. But, safety control during construction is necessary.
Natural Environment	10	Topography & Geology	D	D	D	No remarkable change of land forms and geological features is considerable.
	11	Soil erosion	D	D	D	No remarkable soil erosion originated by runoff through earthworks, logging, etc. is considerable.
	12	Ground water	D	D	D	No groundwater is used by the expansion project. The construction works will not make adverse effects on the groundwater.
	13	River & Lake	D	D	B	Quantity of river water use is not high so that the impacts will be minor, if any. But, it will be necessary to confirm the impact.
	14	Coast	D	D	D	WTP site is located nearly 20 km upstream from the river mouth. No remarkable effect on coastal area is considerable.
	15	Fauna & Flora	D	D	D	No endangered species. The project area is located in the town area. But, it will be better to confirm the impact to fauna and flora in the river.
	16	Climate	D	D	D	No impact on climate change is considerable.
	17	Land scape	D	D	D	No remarkable change of landscape is considerable.
Pollution	18	Air pollution	D	D	D	No remarkable air pollution is considerable. Exhaust gas from construction vehicles will be not high in quantity comparing with the other sources of vehicles and factories.
	19	Water pollution	D	D	C	Only minor contamination is considered. It will be necessary to study on effluent of sludge from WTP.
	20	Soil contamination	D	D	D	No remarkable source of soil contamination.
	21	Noise/Vibration	D	B	C	Possibly minor impact. But, it is necessary to consider the noise from pumping station and also construction works.
	22	Ground Subsidence	D	D	D	No ground subsidence is considerable. No groundwater is used by the expansion project.
	23	Odor	D	D	D	No odor source in WTP.

Score: A -Significant impact anticipated
B -Slight impact anticipated
C -Unknown (subject to further verification)
D -Almost no adverse impact is anticipated

13.3.3 Preliminary Study on Mitigation Measures and Management Plan

After the identification of significant impacts and issues arising out of them, mitigation measures or project modifications should be proposed. The mitigation measures are to be proposed to all the items with potential negative impact identified by the impact assessment. At the IEE stage, the mitigation measures are not based on the detailed survey or analyses, which should be carried out during the EIA stage.

At the IEE stage, the specific EPM may not be required, as the final project figures/plans are not yet fixed. It is scheduled to carry out the EIA and also in the detailed design stage (for some items). The detailed survey and analyses will be carried out for the EMP based on the selected/final plan of the project.

At the IEE stage, however, the general considerations for the EMP are presented together with the mitigation measures as shown in Table 13.3-4.

13.3.4 Conclusion of IEE

There are some possible adverse impacts anticipated by the IEE, although they may be minor impacts or negligible impacts if any, as listed as follows:

- Resettlement and Land acquisition/compensation for expansion of the WTP, new pipelines and new reservoirs.
- Traffic congestion during the construction works.
- Infringement to water use/right for the other sectors/users.
- Waste disposal during the construction.
- Change of river regime and river environment
- Water pollution due to sludge effluent during low flow in the river.
- Noise and vibration caused by construction works
- Noise caused by the pumping station (WTP)

The significant or major adverse impacts caused by the proposed project are unlikely. Some minor impacts could happen, but be sufficiently reduced by proper mitigation measures and environmental management. It was also recommended to carry out the feasibility study taking account of the results of IEE for minimizing the impacts with earlier countermeasures.

The results of IEE were reviewed at the EIA stage based on the relevant survey and more detailed analyses.

Table 13.3-4 Mitigation and Environmental Management Plan at IEE

Item			Magnitude of Impact			Mitigation Measures	Environmental Management Plan
			Pre-const. Stage	Counts. Stage	O & M stage		
Social Environment	1	Relocation/Land acquisition	C	C	D	Minimize the land acquisition of private lands by alternative study in prior to the final decision on the sites/routes of project facilities. Possibility of land acquisition should be confirmed as early as possible. And the alternative measures are presented, if any difficulty is expected.	Earlier explanation and agreement on the matter to the landowners/inhabitants is desirable. The land acquisition/compensation plans should be established properly.
	3	Traffic/Public facilities	D	B	D	Minimize the traffic congestion by alternative study on the sites/routes selection of project facilities and also on the construction plan/methods.	The construction plans should be prepared in consideration of traffic congestion issues.
	6	Vested/Water Right	D	D	C	For avoiding the troublesome issues in the future, the study on water availability for not only the present users but also anticipated future users is desirable, although the drinking water has the highest propriety to use. That is, it is required to confirm the official and customary water uses at present and in the future in the Halda River and the Karnaphuli River. (User, location, quantity, variation/rule, purpose, required quality, etc.)	Make sure the authority to control the water right. Legal permission should be established. Database of water use should be prepared.
	8	Waste Disposal	D	C	C	Minimize the wastes and also take appropriate measures for waste treatment and disposal for not only the construction period but also the O & M period, although the impacts will not be significant.	The construction plans should be prepared in consideration of waste disposal issues. Monitoring system of sludge discharge and its impacts should be established.
Natural Envi.	13	River & Lake	D	D	B	Confirm definite changes of water level and discharge in the Halda River due to additional water-intake based on the hydrological/hydraulic analysis.	Monitoring and evaluation system of water levels and discharge in the river should be established.
Pollution	19	Water pollution	D	D	C	Confirm the definite impact to the water quality in the Halda River by sludge discharge. Minimize the impacts by sludge discharge in consideration of alternative methods of sludge treatment and discharge.	Monitoring and evaluation system of water quality of the effluent from the WTP and in the river should be established.
	21	Noise/Vibration	D	B	C	Minimize the sound from the pumping station by the design and selection of pumping facilities. And minimize the noisy sound during the construction by the selection of sites/routes and also by the construction methods/plans.	The construction plans should be prepared in consideration of noise issues. Check of sound level from the pumping station and taking countermeasure if necessary.

Score： A -Significant impact anticipated, B -Slight impact anticipated, C -Unknown (subject to further verification), D -Almost no adverse impact is anticipated

13.4 Review of IEE at EIA Stage

In the beginning period of EIA, which started in middle July 2000, the results of IEE were reviewed. It was confirmed that the items with possibility of impact, identified by the IEE, are reasonable. However, after the discussion among the agencies and engineers concerned, it was decided to include the following items for the EIA survey in addition to the items selected by the IEE study:

(a) Water pollution from industrial effluent (Krishuna Khal)

Beside the water pollution caused by sludge discharge from MWTP, the Chittagong office of DOE suggested the survey on the possibility of water contamination caused by the discharge from Krishuna Khal. The Krishuna Khal receives the effluent from a tannery factory in the upstream area.

(b) Air pollution during the construction works

It was informed from a staff of DOE that the air pollution is generally included in one of EIA items in Bangladesh and one of regular concerns by the DOE office. Accordingly, it was decided to include the air pollution item for confirming the impacts during the construction works, which may cause a slight impact due to dust by earth works or exhaust gas from the construction equipment especially in narrow roads.

13.5 Survey Results for EIA

(1) Resettlement and Land Acquisition/Compensation

The extension and expansion works of the Mohara WTP is mostly located within the existing WTP site, which has a large reserved space prepared for the future expansion. Only a very limited part, the northwest corner of approximately 500 m^2, may need the land acquisition from a private owner. This area is currently used for a paddy field. The temporary areas for construction camps and plants may be required in and around the WTP site. The contractor may decide the definite areas.

The transmission pipelines are installed along the existing roads (public property). Accordingly the land acquisition may not be required. However, it may be necessary to use the private lands along the road temporary for the construction works at some sections.

The proposed storage reservoir is located in South Khulshi hill, where the most parts of the whole hill is owned by a private person, who does not have any houses there. Another private person owns a small part of the hill and lives there with his family. Concerning the alternative reservoir sites, the Nasirabad reservoir is located in so-called Tea-board hill and owned by private persons. While, the Battali hill reservoir site is all located in the CWASA property area.

(2) Traffic Congestion

Traffic congestion will happen during the construction works due to the transportation of materials, equipment and heavy vehicles as well as by the works itself.

The construction works of Mohara WTP takes nearly two years. The existing road (called WASA road), connecting the WTP entrance gate and so-called Kaptai road, becomes the main access road to and from the WTP construction site. There are residential houses, shops, ponds, paddy fields, etc. along the road. The road is the major one in this local area and used not only for the daily living activities but also for many kinds of business (activities for income) activities. Although the traffic is not heavy, rickshaws and small vehicles run frequently.

The construction of transmission pipeline may be the most significant parts for traffic congestion. The construction period at each road section may not be so long, possibly within a few months at the longest. However, there are some sections, where the road width is narrow and houses and shops are located densely along the road. And there are some sections, where the road width is wide but the traffic is heavy.

The proposed reservoir site (Khulshi hill) is located beside the Khulshi road, which is one of major roads but generally the traffic is not so heavy there if compared with the other trunk roads.

The traffic survey was carried out at two major roads on August 18 (weekday) as described as follows.

- At Kaptai Road in West Mohara, the number of vehicles (including all types of transportation equipment) during daytime (10 hours from AM8 to PM6) was counted at 5,839 in total, in which Baby taxi was 2,448 (42%) and Rickshaw was 1,420 (24%). There are no remarkable peak hours of traffic volume.
- At Chittagong-Fatikchari Road near Oxygene More, the number of vehicles (including all types of transportation equipment) during daytime (10 hours from AM8 to PM6) was counted at 6,707 in total, in which Rickshaw was 1,956 (29%), Baby taxi was 1,427 (21%) and Tempoo was 613 (9%). Buses and Trucks are counted at 805 and 393 respectively. There are no remarkable changes of traffic volume by hours, although the 12 to PM1 are slightly higher than the other hours.

The transmission pipeline routes are divided into the following eight sections for the convenience of survey as well as for studying the definite mitigation measures:

- Section 1: From Mohara WTP to the Dewan Mohsin road (900m)
- Section 2: From CWASA road to the Kaptai road (1,200m)
- Section 3: From Kaptai road to the Abdl Karim road (2,350m)
- Section 4: Unpaved narrow road in agricultural area (900m)

- Section 5: Road passing the residential area to the Wajeida road (1,300m)
- Section 6: Narrow road passing the rural area and ends at Hathazari cross road (400m)
- Section 7: Road passing rural / housing area and ends at Oxygen mor (1,400m)
- Section 8: Wide main roads (Baijid Bostami road, Asia highway, Zakir Hossain road) to the Khulshi hill (2,950m)

(3) Infringement to water use/right (of the Halda River)

The government has a policy that the ownership of water is not vested in an individual but the state at present. That is, the government reserves the right to allocate water to ensure equitable distribution and efficient development and use. The government agency in charge can redirect its use during periods of droughts, floods, cyclones and other natural and man-made disasters, such as water contamination and ecological emergency.

There is no official water right at present in Bangladesh. However, the priority of water allocation during critical periods will be the following order, in general:

- Domestic and municipal water supply
- Non-consumptive uses for sustenance of the river regime (navigation, fisheries, other wild-life, etc.)
- Other uses such as irrigation, industry, recreation, etc.

In the Halda River, some irrigation intakes are located but, for water supply, no other intakes are located except that of Mohara WTP (2.3 m^3/s after the expansion project). The proposed Madunaghat WTP will have the intake (1.15 m^3/s after the second phase), near the Madunaghat Bridge crossing the Halda River, within some years.

It is predicted that the required intake water from the Halda River may be larger than the river flow during some peak periods of dry season. It may possible to take the required volume in any time due to the effect of tidal water as well as the backwater from the Karnaphuli River. However, the water quality issue, especially saline water intrusion, may become a serious issue in this case.

(4) Waste Disposal

The waste produced during the construction works may become an environmental issue. The major wastes may be classified as follows:

- Excavated earth (soil and gravel)
- Demolished road surface materials (bricks, concrete and asphalt)
- Waste from contractor's camping site

At the Mohara WTP (for desilting basin, receiving well, clear well, clarifiers, flash mixer, transmission pump house, filter, chemical, sludge tank, etc.), the excavation volume is estimated at approximately 72,000m^3 and among them the volume of approximately 47,000 m^3 becomes disposal.

At Khulshi Hill Reservoir (for elevated tank, reservoirs, etc.), the excavation volume is estimated at approximately 15,000m^3 and among them the volume of approximately 8,000 m^3 becomes disposal.
For transmission pipeline of approximately 15 km long, the excavation volume is estimated at approximately 50,000m^3 and among them the volume of approximately 33,000 m^3 becomes disposal.

At Kalurghat rehabilitation, the excavation volume is estimated at approximately 3,000m^3 and among them the volume of approximately 2,000 m^3 becomes disposal.

In addition to the above, various kinds of wastes may be produced at the contractor's camping site due to activities by considerably many workers.

(5) Change of River regime/environment

The water intake volume at Mohara WTP is doubled from the present 1.15 m^3/s to 2.3 m^3/s after the project. Further, in the near future, the Madunaghat WTP project will start to intake water from the Halda River. In addition, it is probable that another irrigation intakes will be constructed in addition to the existing intakes in the future. Accordingly, the natural river flow will be decreased. In this case, slight lowering of water level may happen, but the effect may be negligible, as these additional water intakes is done in the downstream section of the river, where the river water level varies mainly due to changes of the tidal water level.

There is an erosion section of riverbank on the left bank located approximately 0.5 ~ 1-km downstream side of the WTP. As far as seen from the site reconnaissance, the cause may be the flow direction in the river, which may make stronger and deep flow on the right bank side there, possibly due to curving of river course. In addition, the flow from the diverted river course of the Karnaphuli River may directly attack the objective/eroded section during the flood season.

The Halda River is rich in fishes and the lower end section including the WTP site is a good hatchery. Accordingly the riverine fishery is active there.

The saltwater intrusion is one of significant environmental factors for the river. The tidal flow goes up the Halda River everyday. The flow generally reaches to a location upper than 10 km upstream from the confluence with the Karnaphuli River. The past records show the intrusion up to the Sattarghat bridge located nearly 21 km upstream from the confluence. The saline water intrusion depends on some

conditions such as tide water level, discharge of the Halda River, and discharge of the Karnaphuli River. If the discharge of rivers decrease, the saline water may intrude into higher and stronger.

The discharge of the Karnaphuli River is largely controlled by the operation of the Kaptai power station with the reservoir of 750 km^2 in area. It is considered to be necessary to collect the definite data (including the operation rule and the discharge data) of the Kaptai power station, dam and reservoir for the detailed analyses on the effect by the Kaptai dam operation. There is a definite plan of installation of additional generators and turbines within a few years.

(6) Water Pollution due to Sludge Discharge

The water quality sampling (Aug. 16 and 17) and the tests are carried out in the Halda River to observe the effect of sludge effluent at the present condition. The sampling was made at the following four points:

- Point 1: Sludge discharge point in the WTP
- Point 2: Sludge discharge point (outlet point) to the river
- Point 3: 50 m upstream point from the outlet
- Point 4: 50m downstream point from the outlet

The results are shown in Table 13.5-1. As seen in the table, the sludge effluent can be sufficiently diluted after the discharge into the river. For example, Total solid shows 8,100 mg/l at Point 1, 520 mg/l at Point 300 mg/l at Point 3 and 340 mg/l at Point 4. However, the dilution rate may much lower in the dry season. The Bangladesh Standards for inland surface water is shown for the reference in Table 13.5-2.

(7) Water Pollution due to Industrial Effluent

The outlet of Krishuna Khal is located nearly 1.5 km upstream of the WTP site in the Halda River. The water samplings for water quality tests were carried out as follows:

Sampling 1: Halda River (Aug. 16 & 17), to see the normal conditions of the river.

Point 1: In front of the Mohara WTP intake

Point 2: 200 m downstream from the intake

Point 3: 200 m upstream from the intake

Sampling 2: Halda River (July 25), to see the normal conditions of the river including the further upstream (Krishuna Khal).

Point 1: In front of the Mohara WTP intake

Point 2: 200 m downstream from the intake

Point 3: 200 m upstream from the intake

Point 4: Outlet of Krishuna Khal (confluence)

Table 13.5-1 Water Quality Test Results, Halda River (for Sludge Discharge)

(Date: August 16 & 17, 2000)

Parameter	Sample Sl-Dis-MWTP	Sample Sl-Dis-Halda	Sample Sl-Dis-50m Upstream	Sample Sl-Dis-50m Downstream
DO	7.2	8.7	8	8.4
BOD	0.5	1	1.1	0.9
COD	9.5	14	11	13
Temperature	23	28	27.5	27.5
Chloride	3.00 mg/L	3.50 mg/L	2.50 mg/L	3.00 mg/L
Chromium	0.00 mg/L	0.00 mg/L	0.00 mg/ L	0.00 mg/ L
Conductivity EC	118 µs / cm	100 µs / cm		81 µs / cm
Nitrate (NO_3)	-	-	0.00 mg/ L	0.00 mg/ L
pH	7.24	7.38	7.58	7.69
Phosphate PO_4	-	-	0.00 mg/ L	0.00 mg/ L
Total Solid (TS)	8100 mg/L	520 mg/L	300 mg/L	340 mg/ L
Turbidity	9500 FTU	238 FTU	200 FTU	215 FTU
Total Coliform	-	-	-	8.0×10^3 MPN / 100ml
Total Dissolved Solid (TDS)	54 mg/L	46 mg/L	32 mg/L	36 mg/ L

Note: Sl-Dis-MWTP: Sludge Discharge point of Mohara WTP
SL-Dis-Halda: Sludge Discharge point of Halda River
Sl-Dis-50m Upstream: 50m Upstream from Sludge Discharge point of the River Halda
Sl-Dis-50m Downstream: 50m Downstream from Sludge Discharge point of the River Halda

Table 13.5-2 Bangladesh Standards for Inland Surface Water Quality

Sl. No.	Designated best use classification	Values			
		pH	BOD (mg/l)	DO (mg/l)	Total coliform (MPN/100ml)
Ka	Drinking water source for supply with disinfecting only	6.5-8.5	2 or less	6 or more	50 or less
Kha	Water used for recreational activities	6.5-8.5	3 or less	5 or more	200 or less
Ga	Drinking water source for supply after conventional treatment	6.5-8.5	3 or less	6 or more	5000 or less
Gha	Water for fisheries	6.5-8.5	6 or less	5 or more	5000 or less
Umma	Industrial water including process and cooling	6.5-8.5	10 or less	5 or more	
Cha	Irrigation water	6.5-8.5	10 or less	5 or more	1000 or less

Note: 1. Limit of ammonia, as N in fishing water is 1.2 mg/l.
2. Values for irrigation water of parameters: Electrical conductivity – 2250 µ mohs/ cm (at a temperature of 25°C), sodium – less than 26%, boron – less than 0.2%

Source: Schedule –3 (part-ka), Rule 13, Environment Conservation Rules 1997, (page 3124 of the Bangladesh Gazette of 28 August 1997). (Own authentic translation from original Bengali).

Sampling 3: Krishuna Khal (Sept. 13), to see the effluent conditions.

Point 1: Near confluence to the Halda River

Point 2: Near pollution source (Tannery factory)

The results are respectively shown in Tables 13.5-3, 14.5-4 and 13.5-5. As seen in the tables, no remarkable points on the effect of effluent were found, possibly due to the survey in the rainy season. However, it is considered that the industrial effluent can be sufficiently diluted at the intake point even in the dry season.

(8) Noise and Vibration by Construction Works

The construction works generally causes the noise and vibration impacts to the inhabitants.

In the Mohara WTP site, the extension works is located on the west of the existing quarter, where only a few farmer houses are located nearby. However, there are houses and shops along the main access road to the WTP, although they are not densely located.

Transmission pipeline route may be the significant locations concerning the noise and vibration as there are some narrow road sections with densely located houses and buildings on both sides.

The proposed reservoir site (Khrushi hill) is a vacant space at present. There is only one house there but it will be removed/relocated before the commencement of works. There are some apartment buildings in the surrounding zone of the hill.

The Chittagong City is very noisy place and the people are accustomed to the environment with considerably noisy sound.

The present noise level was measured at some representative locations in the project area as shown in Table 13.5-6. As seen in the table, the noise level exceeds the acceptable limit of the Environmental Quality Standards shown in Table 13.5-7.

(9) Noise caused by Pumping Station

The noise survey results inside and outside of the pumping station of Mohara WTP are included in Table 13.5-6. The results show 93 dB inside of the pumping house and 87 dB outside but close to the pumping house.

There are only a few small houses located within 20 ~ 30m from the pumping house. At present, no noise-complaint was made from the local people.

After the project, the number of pumping unit becomes double.

Table 13.5-3 Water Quality Test Results, Halda River (Case 1)

(Date : July 25, 2000)

Parameter	Sample 1L	Sample 1H	Sample 2L	Sample 2H	Sample 3L	Sample 3H	Sample 4L	Sample 4H
DO	8.2 mg/ L	8.5 mg/ L	8.3 mg/ L	9.1 mg/ L	8 mg/ L	8.1 mg/ L	7.4 mg/ L	7.9 mg/ L
BOD	1.3 mg/ L	1.1 mg/ L	1.1 mg/ L	1 mg/ L	1.3 mg/ L	1.2 mg/ L	1.5 mg/ L	1.4 mg/ L
COD	8 mg/ L	10 mg/ L	10 mg/ L	9.5 mg/ L	12 mg/ L	9 mg/ L	28 mg/ L	12 mg/ L
Temperature	28 ^oC	28.5 ^oC	28.5 ^oC	28 ^oC	29 ^oC	28 ^oC	29 ^oC	27.5 ^oC
Chloride	1.0 mg/ L	0.50 mg/ L	0.50 mg/ L	0.50 mg/L	0.50 mg/L	0.5 mg/L	0.50 mg/L	0.50 mg/L
Chromium	0.02 mg/ L	0.03 mg/ L	0.02 mg/ L	0.03 mg/L	0.00 mg/L	0.36 mg/L	0.04 mg/L	0.04 mg/L
Conductivity EC	59 µs / cl	71 µs / cm	58 µs / cm	71 µs / cm	59 µs / cm	80 µs / cm	67 µs / cm	60 µs / cm
Nitrate (NO_3)	0.00 mg/ L	0.00 mg/ L	0.00 mg/ L	0.00 mg/L	0.00 mg/L	0.00 mg/L		
pH	7.55	7.87	7.85	7.87	7.75	7.73	7.73	7.75
Phosphate	0.00 mg/ L	0.00 mg/ L	0.00 mg/ L	0.00 mg/L	0.00 mg/L	0.00 mg/L		
Total Solid (TS)	76 mg/ L	73 mg/ L	68 mg/ L	73 mg/L	69 Mg/L	88 mg/L		
Turbidity	733 FTU	274 FTU	452 FTU	274 FTU	453 FTU	278 FTU		
Total Coliform	7.5×10^3 MPN / 100 ml	5.5×10^3 MPN / 100ml	1.5×10^3 MPN / 100ml	9.0×10^3 MPN / 100ml	5.5×10^3 MPN/ 100ml	7.0×10^3 MPN / 100ml		
Total Dissolved Solid (TDS)	29 mg/ L	28 mg/ L	26 mg/ L	28 mg/L	26 mg/L	36 mg/L		

Note: 1--Intake of Mohara WTP, 2 --200m Downstream from Mohara WTP, 3 --200m upstream from Mohara WTP, 4---Confluence of the River Halda and Krishna Khal
L--Low tide, H--High tide

Table 13.5-4 Water Quality Test Results, Halda River (Case 2)

Parameter	Sample 1L	Sample 1H	Sample 2L	Sample 2H	Sample 3L	Sample 3H
DO	7.6 mg/L	8.1 mg/L	7.5 mg/L	8.4 mg/L	8.4 mg/L	7.8 mg/L
BOD	1 mg/L	0.9 mg/L	1.1 mg/L	1 mg/L	0.9 mg/L	1.2 mg/L
COD	10 mg/L	8 mg/L	9 mg/L	12 mg/L	13 mg/L	13.5 mg/L
Temperature	28 °C	26 °C	28 °C	27 °C	27.5 °C	26 °C
Chloride	4.50 mg/L	2.00 mg/ L	3.00 mg/L	1.00 mg/L	3.00 mg/L	1.50 mg/L
Chromium	0.00 mg/ L	0.00 mg/ L	0.00 mg/ L	0.00 mg/L	0.00 mg/L	0.00 mg/L
Conductivity EC	84 µs / cm	94 µs / cm	81 µs / cm	102 µs / cm	298 µs / cm	92 µs / cm
Nitrate (NO_3)	0.00 mg/ L	0.00 mg/ L	0.00 mg/ L	0.00 mg/L	0.00 mg/L	0.00 mg/L
pH	7.42	7.62	7.69	7.64	7.66	7.58
Phosphate PO_4	0.00 mg/ L	0.00 mg/ L	0.00 mg/ L	0.00 mg/L	0.00 mg/L	0.00 mg/L
Total Solid (TS)	37 mg/ L	180 mg/L	340 mg/ L	240 mg/L	340 Mg/L	240 mg/L
Turbidity	296 FTU	188 FTU	215 FTU	137 FTU	198 FTU	158 FTU
Total Coliform	6.0×10^3 MPN/ 100 ml	1.2×10^3 MPN / 100ml	8.0×10^3 MPN / 100ml	2.0×10^3 MPN / 100ml	2.3×10^3 MPN / 100ml	8.0×10^2 MPN / 100ml
Total Dissolved Solid (TDS)	29 mg/ L	42 mg/ L	36 mg/ L	43 mg/L	26 mg/L	42 mg/L

Note: 1 (Intake of Mohara WTP), 2 (200m Downstream from Mohara WTP),
3 (200m upstream from Mohara WTP), L (Low tide), H (High tide)
(Sampling Date: August 16 & 17, 2000)

Table 13.5-5 Water Quality Test Results, Krishuna Khal (for Industrial Effluent)

Parameter	S1	S2
DO	-	-
BOD	-	-
COD	-	-
Temperature	-	-
Chloride	3.50 mg/L	30.50 mg/L
Chromium	0.046 mg/L	0.06 mg/L
Nitrate (NO_3)	1.06 mg/L	0.40 mg/L
pH	7.2	7.17
Phosphate PO_4	1.30 mg/L	1.50 mg/L
Turbidity	156 FTU	1080 FTU
Suspended Solid (SS)	193 mg/L	952 mg/L
Total Coliform*	-	-
Total Dissolved Solid (TDS)	47 mg/L	108 mg/L

Note: S1 Confluence of the river Halda & Krishna Khal
S2 Pollution source of Krishna Khal (near Kaptai road)
(Sampling Date: September 13, 2000)

Table 13.5-6 Results of Noise Level Survey

Sl. No.	Location of the Sampling point	dB
1	Intake point (Pump St.) MWTP	93 (Inside), 87 (Outside)
2	Lift station	91
3	Oxygen Mor (Corner)	85
4	Biozid Bostami Bus stoppage	90
5	2 No gate	105
6	GEC Mor (Corner)	100
7	Dampara (CWASA)	115
8	Ispahani Mor (Corner)	85
9	Kaptai Road A.K. Khan gate	80

Table 13.5-7 Bangladesh Standards for Noise Level

Sl. No.	Area Category	Standards Values (dB)	
		Day	Night
Ka	Silent Zone	45	30
Kha	Residential area	50	40
Ga	Mixed area (Basically residential and together used for commercial and industrial purposes)	60	50
Gha	Commercial area	70	60
Umma	Industrial area	75	70

Note: 1. Day time is reckoned as the time between 6 a.m. to 9 p.m.
2. Night time is reckoned as the time between 9 p.m. to 6 a.m.
3. Silent zones are areas upto a radius of 100 metres around hospitals, educational institutions or special establishments declared or to be declared as such by the Government. Use of vehicular horn, other signals and loudspeakers is prohibited in silent zones.

Source: Schedule 4, Rule-12, Environment Conservation Rules 1997, (Page 3127, Bangladesh Gazette, 28 August 1997). Own authentic translation from original Bengali.

(10) Air Pollution during Construction Works

The air pollution during the construction works may happen in the following cases:

- Dust by earth works
- Exhaust gas from the construction and transportation equipment

The air quality at representative two locations was measured to see the present actual conditions. The results are shown in Table 13.5-8. The air quality standards of Bangladesh are shown in Table 13.5-9. The results can be summarized as follows:

- At a main road, industrial/commercial area, SPM exceeds the standard, even in a rainy day. The values of SO2 and NOx were within the standards but close to the limits.
- At a rural area (Mohara), only STP was measured and confirmed to be lower than the standard.

It is noted that the air quality on many roads in the project area may exceed the standards at present condition.

Table 13.5-8 Results of Air Quality Survey

Date	Location of Sampling point	SPM	SO_2	NOx	Comments
14.08.00	Oxygen Mor (corner)	530	88.12	96.23	It was a rainy day
15.08.00	Mohara WTP site	110	-	-	Rainy day, but not continuous

Table 13.5-9 Bangladesh Standards for Air Quality

Sl. No.	Area	Suspended Particulate Matters (SPM)	Sulfur di-0xide (SO_2)	Carbon Monoxide (CO)	Oxides of Nitrogen (NO_x)
Ka	Industrial and mixed	500	120	5000	100
Kha	Commercial and mixed	400	100	5000	100
Ga	Residential and rural	200	80	2000	80
Gha	Sensitive	100	30	1000	30

(All values in micrograms per cubic meters)

Note: 1. Sensitive area includes national monuments, health resorts, hospitals, archaeological sites, educational institutions and other government designated areas (if any).
2. Any industrial unit located not in a designated industrial area will not discharge such pollutants which may contribute to exceed the ambient air quality above in the surrounding areas of category "Ga" and "Gha".
3. Suspended Particulate Matters (SPM) mean airborne particles of diameter of 10 micron or less.

Source: Schedule 2, Rule-12, Environment Conservation Rules 1997, (Page 3123, Bangladesh Gazette, 28 August 1997). Own authentic translation from original Bengali.

13.6 Mitigation Measures and Environmental Management Plan (EMP)

13.6.1 Public Hearing

The public hearing was carried out for the following purposes:

- To know the people's attention on the project and the environment
- To confirm or identify the predicted impacts
- To find the people's acceptable level of impact
- To get the people's opinions or ideas on the mitigation measures and EMP

The hearing was carried out to 80 households covering all the major construction sites. The questionnaires were prepared for the survey. The questionnaires contain the socio-economic background as well as the respective item of predicted impact. For the impact items, the following common questions were made to the respective respondent.

- Whether there will be any adverse impacts or not?
- Kind of adverse impacts expected.
- Whether the adverse impacts can be accepted by the respondent or not?
- Reasons for not accepting the impacts.
- Considerable/proposed alternatives, mitigation measures, and compensation

It was recognized, from the survey results, that the people's concern is high and they gave considerably useful information and comments to the respective question. The overall appreciation to the project

works was given as summarized in Tables 13.6-1 and 13.6-2.

Table 13.6-1 Overall Appreciation / Comments on the Project / Works

Responses	No. of Responses	%
Project / works favorable	80	100
Not favorable	-	-
Not sure	-	-
Total	80	100

Table 13.6-2 Major Appreciation / Benefits of the Project / Works

Kinds of Benefits	No. of Respondents	% of Total Respondents (80)
Availability of sufficient water	75	94
Availability of clean water	78	97
Reduction of works for transportation of water	38	47
Beneficial for the city people of Chittagong	77	96
Total Respondents	80	-

The results of the public hearing survey were reflected in the study for the mitigation measures as well as for the EMP.

13.6.2 Mitigation Measures

The mitigation measures for reducing and protecting the anticipated impacts were studied for the individual environment item. The effective mitigation measures are selected as listed below. However, these mitigation measures can be applied when the impact over a certain level is anticipated or confirmed. That is, there are two types of mitigation measures. One is taken in any case (from the beginning) and another is taken when the necessity is confirmed by the monitoring.

It is not always necessary to take all the mitigation measures presented below. The selection and combination of measures should be made in accordance with the various actual conditions such as the impact level and the effectiveness of possible measures.

1) Resettlement and Land acquisition/compensation.
   (a) Reasonable amount of compensation.
   (b) Sufficient dialogue and negotiation with the resettling people.
   (c) Preparation of resettlement area/house as early as possible (for convenience of preparation by resettlement family).
   (d) Assistance in employment, if necessary.
   (e) Return of land/houses/facilities in good condition (for temporary uses).
   (f) Provision of water supply to the proposed area by the resettlement family (if not

available at present and if not so costly).

(g) Finding alternative site (of vacant land).

(h) Assistance in settling the problems, if any

2) Traffic congestion

(a) Preparation of bypass.

(b) Provision of sidetracks/foot path.

(c) Construction on a half side.

(d) Traffic flow/safety control and guidance.

(e) Construction works in some limited hours (for example at night).

(f) Sufficient information to the inhabitants and in public.

(g) Early (short time) completion of construction.

(h) Temporary relocation of residential place, if necessary.

3) Infringement to water use/right (of the Halda River)

It may not be possible to present the measures without confirming the adverse impact, as the kind/type and scale of adverse impacts can not be predictable, at least at specific level, for this item. The definite mitigation measures, if necessary, will be proposed from the monitoring results.

However, for example, the following measures are usually considerable:

- Water intake plan in consideration of river maintenance flow and water use by the other users.
- Development of alternative water resources.
- Establishment of regional water resources utilization plan, and Compensation to users if necessary.

4) Waste disposal

For the disposal of waste materials, there are two types of disposal site, a permanent disposal site and a temporary disposal site.

(a) Preparation of appropriate areas for dumping wastes (temporary and permanent) and return of the land with the conditions as it were before (or rather improved) in case of temporary uses. For the permanent disposal site, some ponds may be back-filled, if the owners can accept it. It seems that there are many appropriate disposal sites in and around respective construction site.

(b) Earlier restoration of land after the completion of works (in case of a temporary use).

(c) Earlier transportation of construction wastes from the temporary dumping site.

(d) Provision of sanitary facilities (at major construction site and the camping site).

(e) Prevention of scattered dumping. After completion of final dumping, the site should be neatly land-formed and the effective land-use is also considered.

(f) Appropriate and careful treatment and the management to the wastes generated from construction camps mostly due to daily living/activities of construction workers.

5) Change of River regime/environment

It may not be possible to present the measures without confirming the adverse impact, as the kind/type and scale of adverse impacts can not be predictable, at least at specific level, for this item. The definite mitigation measures, if necessary, will be proposed from the monitoring results.

However, for example, the following measures are usually considerable:

- Water intake plan in consideration of river hydrology.
- Development of other water resources.
- Establishment of comprehensive water resources utilization plan.

6) Water pollution (Sludge effluent)

(a) Extension of outlet of effluent pipe to a deeper location of the river.

(b) Study on the sludge treatment in the WTP site and effective uses of sldges, without discharge into the river, for the future. Although the significant adverse impacts are not predicted at present, it is desirable for the river environment as well as for the inhabitants not to discharge to the river. In addition, approximately 10% of intake water could be saved if not discharged.

7) Water pollution (Industrial effluent)

(a) Intake control (in case the water in the Halda River is polluted higher than the standards for raw water of drinking water).

(b) Strengthening of regulation and guidance to industries (when the effluent is polluted higher than the standards).

(c) Planning and implementation of the sewerage water treatment in the major industry and also the establishment of the sewerage treatment project by the government (in the future), although this matter is one of the whole Chittagong issues.

8) Noise/Vibration (by construction works)

(a) Construction works in some limited hours, which may cause less affect on noise and vibration.

(b) Sufficient information to the inhabitants for the noise and vibration as well as the construction works (location, period, time, etc.).

(c) Compensation to houses with remarkable damage caused by vibration.
(d) Construction methods (including manpower works without machines) with less noise and vibration for critical sections such as narrow roads in residential areas and a location near hospital.
(e) Closure of the construction site by noise-proof walls.
(f) Return of land/houses/facilities in good condition (for temporary uses).

9) Noise (Pump house)
(a) Close the doors of the pumping house at night.
(b) Use of low-sound type for pumping facilities.

10) Air pollution (including dust, by construction works)
(a) Sprinkling of water
(b) Selection of construction methods and construction machines in consideration of reducing air pollution.
(c) Construction works in some limited hours, which may cause less air pollution (exhaust gas and dust).

13.6.3 Environmental Management Plan

The Environmental Management Plan (EMP) was prepared for confirming the necessity of the proposed mitigation measures and also for implementing the measures effectively. The EMP includes various monitoring plans, which may be necessary to confirm the level of impacts or the effectiveness of the mitigation measures.

The EMP was prepared as summarized as follows:

(1) General Plans

(a) Organization and Staffing

The establishment of practical organization for the implementation of the effective and necessary environmental mitigation measures may be the most essential matter.

Although there are some alternative organization considerable, the most reasonable one may be as follows:

- Establishment of Environment department/section in CWASA. The Environmental section is in charge of all the environmental issues and has to prepare the definite/detailed plans for environmental management and monitoring as well as implement these plans effectively. This section also has to be in charge of the legal procedures and the communication matters with people.

- Establishment of cooperative relation with some related government offices/agencies including the Chittagong regional office of DOE.
- Staffing of the section should be minimized in consideration of the budget. However, the experienced and active staff should be assigned and some assistant staff (additional post) also is assigned for strengthening the section activities when required.
- Employment of consultants and survey team may be necessary, if any significant environmental issues happen.
- Budget preparation may be one of difficult matters if the present financial status of CWASA is considered. However, it would be necessary to prepare the budget for the environment as one of priority matters, in consideration of the possible serious and expensive cases caused by the negligence of environmental issues.

(b) Laws, Standards and Regulations

In general, the environmental attention by the Bangladesh Government is high. There is already well established legislation system including ECA, ECA and EIA guidelines. The Bangladesh environment standards cover all the basic items such as water pollution, air pollution, noise, odor, etc. However, it seems that some laws and standards need improvement or more detailed standards are necessary. For example, the effluent standards should be more in detail in consideration of the total pollution load as well as the peak load. And the number of parameters will be also necessary to be increased for the respective standards, especially for the hazardous substances.

In addition, it seems that the regulations to manage and control the problems and issues seem to be not practical enough. More strict and effective regulation should be established. The rules and standards become useless, if the regulation to control the environmental violators is not practically applicable.

(c) People's Participation

The people's participation on the environmental control and management is considered to be an essential matter in these years. It will be effective from various viewpoints such as cost saving, avoiding disputes, enhancement of people's concerns, taking quick measures, etc.

The environment section (to be established) is required to consider the people's participation for preparation of the implementation plan.

The people's participation for the environment can be extended to be one of effective measures to reduce the water system loss (unaccounted), which is over 30% (or 40%?) of the water production at present.

(d) Preparation of Implementation Plan

For implementing the mitigation measures of predicted environmental impacts, the definite implementation plan is required to be prepared. The implementation plan needs to contain the implementation schedule, the organization and staffing, the section/division of objective

sites, the survey and monitoring program, the budget allocation, the facilities & equipment list, etc.

(2) Plans taken at respective project stage

The project composes of the following three stages in general:

- Survey and design stage
- Construction stage
- O & M stage

It is noted that the definite detailed management plan can not be prepared from the beginning, as the necessity and extent of application of mitigation measures is difficult to be confirmed without the results of monitoring.

The proposed management plan based on the monitoring program for the respective environmental item is listed as follows:

1) Resettlement and Land acquisition/compensation
   (a) Preparation of Implementation Plan for the Resettlement and land acquisition/ compensation
      - Detailed survey of the necessity of resettlement and land acquisition/ compensation (including the location, owner and family, existing conditions, properties, legal matters, current prices, etc.)
      - Detailed survey and selection of alternative resettlement sites
      - Preparation of resettlement and land acquisition/compensation schedule
      - Guidance/manual for the communication and negotiation with the owners
      - Estimate of cost and preparation of the budget disbursement schedule
   (b) Monitoring the changes of living conditions (after the resettlement)

2) Traffic Congestion
   (a) Preparation of implementation plan of effective and practicable mitigation measures
   (b) Inspection and identification of actual traffic conditions during construction.
   (c) Hearing from the inhabitants about the differences on traffic/pass before and during the construction works

3) Infringement to water use/right (of the Halda River)
   (a) Establishment of water utilization and management plan for the Halda River (and the Karnaphuli River), including the water-use right and appropriate regulations for the priority use of water for the severe dry season, in consideration of the future increase of water demand and the river maintenance flow (to be established or studied).

(b) Periodical monitoring and review of the water use/demand conditions and water use right. And the estimate of future demand/intake of water from the Halda River.
(c) Monitoring of tidal/saline water intrusion.
(d) Monitoring of stream flow (water level and discharge) in the Halda River and the Karnaphuli River.
(e) Monitoring of water quality of the river.

4) Waste disposal
(a) Preparation of implementation plan of effective and practicable mitigation measures, including the effective uses of disposal land after the completion.
(b) Inspection and identification of actual conditions of waste disposal during the construction works.

5) Change of River regime/environment
(a) Preparation of development and management plan for the Halda River (and the Karnaphuli River), which include the water-use right and appropriate regulations for the priority use of water for the severe dry season, the development of alternative water sources (for the future increase of water demand), the river environmental conservation, and the establishment of river maintenance flow.
(b) Periodical monitoring and review of the water use/demand conditions. And the estimate of future demand/intake of water from the Halda River and the Karnaphuli River.
(c) Monitoring of tidal/saline water intrusion.
(d) Monitoring of stream flow (water level and discharge) in the Halda River and the Karnaphuli River. Discharge conditions/records from the Kaptai Power Station are also included in the monitoring.
(e) Monitoring river conditions (water quality, riverbank erosion, aquatic fauna including fishes & flora, river profile & sections, etc.) and the study on the mitigation measures against the probable changes of river conditions, if necessary.

6) Water pollution (sludge effluent)
(a) Preparation of implementation plan of effective and practicable mitigation measures, if any and necessary
(b) Monitoring of water quality in the river at the outlet of the sludge-pipe and the inspection of sludge dilution without piling during the dry season.
(c) Hearing from the inhabitants about the changes of water conditions (if any) before and during the construction works.

7) Water pollution (industrial effluent)
   (a) Preparation of implementation plan of effective and practicable mitigation measures, if required.
   (b) Periodical water quality survey in the Khal and at the Mohara intake in the Halda River in the dry season.
   (c) Periodical water quality survey of effluent from the industries in Krishuna Khal.

8) Noise/Vibration (construction works)
   (a) Preparation of implementation plan of effective and practicable mitigation measures.
   (b) Inspection and measurement of actual sound and vibration level/conditions during the construction works. Evaluation of noise and vibration by the standards.
   (c) Hearing from the inhabitants about the differences on noise and vibration before and during the construction works.

9) Noise (pump house)
   (a) Preparation of implementation plan of effective and practicable mitigation measures, if required.
   (b) Survey of the conditions of sound after completion of the project.
   (c) Hearing from the inhabitants about the nuisance of sound.

10) Air pollution (construction works)
   (a) Preparation of implementation plan of effective and practicable mitigation measures.
   (b) Inspection and measurement of air pollution level/conditions during the construction works. Evaluation of air pollution by the standards.

It is necessary to include the EMP and monitoring for the construction stage in the specifications of construction contract. The contractor should be in charge of mitigation of adverse environmental impacts, although the inspection and guidance by the government side is also required.

13.7 Summary, Conclusion and Recommendation

As the results of IEE and EIA, it was concluded that the significant or major adverse impacts caused by the proposed project are unlikely.

However, it was predicted that there is possibility of moderate or minor impacts to the following items:

- Item 1: Resettlement and Land acquisition/compensation due to the project implementation
- Item 2: Traffic congestion during the construction works

- Item 3: Infringement to water use/right for the other sectors/users.
- Item 4: Waste disposal during the construction.
- Item 5: Change of river regime and river environment
- Item 6: Water pollution due to sludge discharge during low flow in the river.
- Item 7: Water pollution due to industrial effluent through Krishuna khal
- Item 8: Noise and vibration caused by construction works
- Item 9: Noise caused at the pumping house of the Mohara WTP
- Item10: Air pollution by construction works

The EIA for the items listed above are summarized as shown in Tables 13.7-1 to 13.7-10. The respective table presents the brief descriptions of the following:

(a) Item
(b) Content of item
(c) Cause of impact
(d) Probable impact
(e) Necessary survey for the EIA and study on the mitigation measures
(f) Evaluation of Scale and significance of impact
(g) Proposed mitigation measures
(h) Proposed EMP and monitoring
(i) Remarks, if any

The adverse impact, even if it may happen, could be sufficiently reduced to an environmentally acceptable level by implementation of the Environmental Management Plan (EMP), which includes the execution of proper mitigation measures and monitoring.

Finally, it is recommended to implement the proposed project as follows:

(1) Earlier implementation

The project will contribute a lot for the people in Chittagong City. The project produces not only the social and economic enhancement but also remarkable improvement of sanitary conditions. It is required to realize these positive environmental impacts without delay. The present water supply system has various issues and the level of negative conditions will become more serious in the future, if the project implementation is postponed.

(2) Establishment of the EMP to the Project Implementation

The negative environmental impact is predicted to be not significant and only some minor impacts may happen. However, it is probable that a slight impact may change to a significant one, if the proper environmental management plan (proposed in this EIA study) is not carried out. In addition,

the EMP with execution of appropriate mitigation measures may reduce a moderate/slight impact to a negligible or acceptable level. The first step may be the establishment of an environment section in CWASA, which should have responsibility for the project implementation in harmony with the EMP and the monitoring.

Table 13.7-1 Summary of EIA for Item (1), Resettlement and Land Acquisition

Item : Resettlement and Land Acquisition
Content : Resettlement and Land acquisition/compensation (permanent or temporary) due to project works.
Cause : (1) Land acquisition (without resettlement) of the adjacent area of the existing WTP site for construction of the expansion facilities of WTP. (2) Land acquisition and resettlement for the construction of the proposed transmission main and distribution main (only some limited sections). (3) Land acquisition/resettlement for the construction of the proposed reservoir(s). (Necessity of land acquisition/resettlement depends on the selected site)
Probable Impact (Based on general/preliminary study) : (1) Loss/reduction of income source(s) (2) Nuisance/Uncomforatability/Inconvenience of living in the resettlement site/house.
Necessary survey (for EIA and study on the mitigation measures) : (1) Survey of socio-economic conditions of the inhabitants. (2) Survey of properties (ownership, land use, production, etc.) (3) Hearing from the inhabitants on the probable impacts and the proposed measures. (4) Related laws and regulations for the land acquisition/resettlement/compensation. (5) Investigation of the past examples of similar cases. (6). Survey of available proper site for the resettlement.
Scale /Significance of Impact (Based on the results of EIA survey): (1) At the WTP site, no remarkable adverse impact may happen. But, it will be necessary to confirm the land acquisition of a patch of paddy field. (2) Along the pipeline routes, moderate adverse impact is predicted at some locations, but could be sufficiently accepted by the land-owners/resettles if competent mitigation measures are taken. (3) At the reservoir site, no significant adverse impact may happen, if competent mitigation measures are taken. But, the confirmation may be essential when the project implementation becomes sure.
Proposed Mitigation Measures: (1) Reasonable amount of compensation for the land acquisition. (2) Sufficient dialogue and negotiation with the resettles (without taking forced measures). (3) Preparation of resettlement area/house (acceptable by the resettles). (4) Assistance in employment (if necessary). (5) Return the land/houses/facilities with the conditions as it were before (or rather improved) in case of temporary uses. (6) Provision of water supply to the proposed area by the resettlement family (if not available at present and if not so costly) (7) Finding alternative site (of vacant land) (8) Assistance in settling the problems (relation with neighbors, employment, etc., if any, for at least a year after the resettlement, if any
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities. (2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage) : (1) Preparation of implementation plan for the resettlement and land acquisition/compensation. (2) Monitoring the changes of living conditions for the resettles.
Remarks: (1) It is probable that the reservoir site is changed before the detailed design due to difficulty of land acquisition. (2) The specific locations and areas will be confirmed in the detailed design stage.

Table 13.7-2 Summary of EIA for Item (2), Traffic Congestion

Item : Traffic Congestion
Content : Traffic congestion caused by construction works at the expansion site of WTP, along the transmission mains & distribution mains, and the proposed reservoir site(s).
Cause : (1) Frequent traffic of construction machines and on-site vehicles. (2) Occupancy of roads by construction machines and on-site vehicles.
Probable Impact (Based on general/preliminary study) : (1) Inconveniences of traffic/pass for inhabitants (2) Inconveniences for vehicles passing the roads in the objective site. (3) Economic activities of transportation workers. (4) Danger of traffic accident.
Necessary survey (for EIA and study on the mitigation measures) : (1) Expected traffic congestion in every section of the objective roads and also the other roads indirectly affected. (2) Availability of bypass. (3) Possible areas for sidetrack. (4) Daily/hourly traffic conditions (kinds of vehicles/passengers, volume, and flow). (5) Hearing from the inhabitants and transportation workers including Ricksha workers (significance of impacts, their acceptance, countermeasures, etc.)
Scale /Significance of Impact (Based on the results of EIA survey): (1) At the WTP site, moderate adverse impacts are predicted at the access road (WASA road). (2) Along the pipeline routes, moderate adverse impact is predicted at some locations (at narrow road sections with houses on both sides), but could be sufficiently accepted by the inhabitants if competent mitigation measures are taken. (3) At the reservoir site, moderate adverse impact is predicted, but could be sufficiently accepted by the inhabitants if competent mitigation measures are taken. (4) Some adverse impacts are predicted to transportation business including Ricksha workers, though it will be temporary period. (5) Accident may happen by transportation equipment/vehicle.
Proposed Mitigation Measures: (1) Preparation of bypass (2) Provision of sidetracks/foot path (3) Construction on a half side (4) Traffic flow/safety control and guidance (5) Construction works in some limited hours (for example at night) (6) Sufficient information to the inhabitants and in public (7) Early (short time) completion of construction (8) Temporary relocation of residential place, if necessary
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities. (2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage) : (1) Preparation of implementation plan of effective and practicable mitigation measures. (2) Inspection and identification of actual traffic conditions during the construction works. (3) Hearing from the inhabitants about the differences on traffic/pass before and during the construction works.
Remarks: (1) It is probable that the reservoir site is changed before the detailed design due to the difficulty of land acquisition. (2) The detailed survey will be required for the specific mitigation measures at some narrow and long roads.

Table 13.7-3 Summary of EIA for Item (3), Infringement to Water Use/Right

Item : Infringement to Water Use/Right
Content : Infringement to Water Use/Right in the Halda River
Cause : (1) Increase (100%) of intake water due to the expansion of WTP. (from approx. 1.15 m^3/s at present to 2.3 m^3/s after the project completion)
Probable Impact (Based on general/preliminary study) (1) Reduction of river flow (especially in the dry season). (2) Saline water intrusion to the intake site. (3) Water contamination(in the dry season) (4) Limitation of water uses (such as additional water supply, irrigation, and navigation) for the other purposes (especially in the future).
Necessary survey (for EIA and study on the mitigation measures) : (1) Present water use in the Halda River. (2) Survey/Study of future demand/increase of water use in the Halda River (including the intake water, approximately 1.15 m^3/s after the second Phase, from the proposed Madunaghat WTP). (3) Related laws and regulations for the water right. (4) Hydrological study of the Halda River, including the tidal influences. (5) Present river conditions (water quality, riverbank erosion, aquatic fauna including fishes & flora, river profile & sections, etc.)
Scale /Significance of Impact (Based on the results of EIA survey): (1) Reduction of flow in the dry season will be significant, especially during extreme dry period. However, no adverse impact is predicted for the necessary volume of intake water due to the backwater of the Karnaphuli River. (2) The saline water intrusion to the WTP site will not happen to a significant level, but it is probable that the saline water issue becomes serious in the future, when the water intake volume is remarkably increased from the both rivers.
Proposed Mitigation Measures: (1) It may not be possible to present the measures without confirming the adverse impact, as the kind/type and scale of adverse impacts can not be predictable, at least at specific level, for this item. The definite mitigation measures, if necessary, will be proposed from the monitoring results. (2) Although, for example, the following measures are usually considerable: Water intake plan in consideration of river maintenance flow and water use by the other users, Development of alternative water resources, Establishment of regional water resources utilization plan, and Compensation to users if necessary.
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities. (2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage) : (1) Periodical monitoring and review of the water use/demand conditions and water use right. And the estimate of future demand/intake of water from the Halda River. (2) Monitoring of tidal/saline water intrusion. (3) Monitoring of stream flow (water level and discharge) in the Halda River and the Karnaphuli River. (4) Establishment of water resources development and management planfor the Halda River (and the Karnaphuli River), including the water-use right and appropriate regulations for the priority use of water for the severe dry season, the development of alternative water sources (for the future increase of water demand), and the establishment of river maintenance flow. (5) Monitoring river conditions (water quality, riverbank erosion, aquatic fauna including fishes & flora, river profile & sections, etc.) and the study on the mitigation measures against the probable changes of river conditions, if necessary.
Remarks: (1) The monitoring (water use, hydrological conditions and river environment) and the study (water resources management) will be necessary, although any significant adverse impacts concerning the water right are unlikely at present.

Table 13.7-4 Summary of EIA for Item (4), Waste Disposal

Item : Waste Disposal
Content : Waste Disposal during construction
Cause : (1).Excavated earth (soil and gravel) by construction of the proposed expansion of WTP, transmission main and distribution main, reservoir, etc. (2) Demolished road surface materials (3) Waste from contractor's camp site
Probable Impact (Based on general/preliminary study) : (1) Disturbance of traffic/pass. (2) Deterioration of landscape. (3) Limitation of landaus for other purposes.
Necessary survey (for EIA and study on the mitigation measures) : (1) Volume and content of the waste produced by the construction works. (2) Availability and conditions of temporary dumping locations at the respective site. (3) Availability and conditions of permanent dumping locations and the accessibility.
Scale /Significance of Impact (Based on the results of EIA survey): (1). No remarkable adverse impact is predicted, as far as competent preparation and management for the construction wastes are carried out. Most wastes will be earth materials and others are odd materials used for concrete structures, mechanical facilities and pipes. No toxic and hazardous wastes will be used. (2) The wastes generated from construction camps mostly due to daily living/activities of construction workers may become nuisances for the inhabitants, if any appropriate treatment measures are not carried out.
Proposed Mitigation Measures: (1) Preparation of appropriates areas for dumping wastes (temporary and permanent) and return the land with the conditions as it were before (or rather improved) in case of temporary uses. It seems that there are many appropriate disposal sites in and around respective construction site. For the permanent disposal site, some ponds may be back-filled, if the owners can accept it. (2) Earlier restoration of land after the completion of works (in case of a temporary use) (3) Earlier transportation of construction wastes from the temporary dumping site. (4) Provision of sanitary facilities (at major construction site and the camping site) (5) Prevention of scattered dumping. After completion of final dumping, the site should be neatly land-formed and the effective land-use is also considered. (6) Appropriate and careful treatment and the management to the wastes generated from construction camps mostly due to daily living/activities of construction workers.
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities. (2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage) : (1) Preparation of implementation plan of effective and practicable mitigation measures, including the effective uses of disposal land after the completion. (2) Inspection and identification of actual conditions of waste disposal during the construction works.
Remarks: (1) It will be necessary to review the impact caused by wastes based on the construction plan.

Table 13.7-5 Summary of EIA for Item (5), River Regime/Environment

Item : River Regime/Environment
Content : Change of river regime and environment by water intake
Cause : (1) Increase (100%) of intake water due to the expansion of WTP. (from approx. 1.15 m^3/s at present to 2.3 m^3/s after the project completion)
Probable Impact (Based on general/preliminary study) : (1) Decrease of river flow (2) Change of water level (3) Increase of river bed sediment (4) Change/deterioration of water quality in the river. (5) Change of aquatic ecology (6) Decrease of fish catches (7) Increase of riverbank erosion/scoring. (8) Saline water intrusion to the WTP site.
Necessary survey (for EIA and study on the mitigation measures) : (1) Present water use in the Halda River and the Karnaphuli River. (2) Survey/Study of future demand/increase of water use in the Halda River and the Karnaphuli River (including the intake water, approximately 1.05 m^3/s after the second Phase, from the proposed Madunaghat WTP). (3) Hydrological study of the Halda River and the Karnaphuli River, including the tidal influences and the discharge from the Kaptai dam/power station. Concerning the Kaptai power station, the changes due to future extension plan need to be included in the study. (4) Present river conditions (water quality, riverbank erosion, aquatic fauna including fishes & flora, river profile & sections, etc.)
Scale /Significance of Impact (Based on the results of EIA survey): (1) Reduction of flow in the dry season will be significant, especially during extreme dry period. However, no adverse impact is predicted for the necessary volume of intake water due to the backwater of the Karnaphuli River. The saline water intrusion to the WTP site will not happen to a significant level, but it is probable that the saline water issue becomes serious in the future, when the water intake volume is remarkably increased from the both rivers. (2) Concerning the probable changes of river conditions (water quality, riverbank erosion, aquatic fauna including fishes & flora, river profile & sections, etc.), no significant adverse impacts are predicted due to negligible changes of water level by the backwater of the Karnaphuli River. However, if the saline water intrusion occasionally reaches to the Halda River in the future, some changes of fauna & flora will be seen, although the changes are not always negative side.
Proposed Mitigation Measures: (1) It may not be possible to present the measures without confirming the adverse impact, as the kind/type and scale of adverse impacts cannot be predictable, at least at specific level, for this item. The definite mitigation measures, if necessary, will be proposed from the monitoring results. (2) Although, for example, the following measures are usually considerable: Water intake plan in consideration of river hydrology, Development of other water resources, and Establishment of comprehensive water resources utilization plan.
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities. (2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage) : (1) Establishment of water resources development and management plan for the Halda River (and the Karnaphuli River) , including the water-use right and appropriate regulations for the priority use of water for the severe dry season , the development of alternative water sources (for the future increase of water demand), and the establishment of river maintenance flow . (2) Periodical monitoring and review of the water use/demand conditions. And the estimate of future demand/intake of water from the Halda River and the Karnaphuli River. (3) Monitoring of tidal/saline water intrusion. (4) Monitoring of stream flow (water level and discharge) in the Halda River and the Karnaphuli River. Discharge conditions/records from the Kaptai Power Station are also included in the monitoring. (5) Monitoring river conditions (water quality, riverbank erosion, aquatic fauna including fishes & flora, river profile & sections, etc.) and the study on the mitigation measures against the probable changes of river conditions, if necessary.
Remarks: (1) The monitoring (water use, hydrological conditions and river environment) and the study (water resources management) will be necessary, although any significant adverse impacts concerning the river regime and river environment are unlikely at present. (2) The environmental impacts and the management plan including the monitoring is basically the same as those for the item of wateruse right.

Table 13.7- 6 Summary of EIA for Item (6), Water Pollution (Sludge Discharge)

Item : Water Pollution (by Sludge discharge)
Content : Water pollution of Halda River due to sludge discharge from the Mahara WTP
Cause : (1) Sludge effluent (increased in quantity due to the expansion of WTP)
Probable Impact (Based on general/preliminary study) : (1) Water contamination in the river. (2) Sludge layers left along the riverbank. (Limitation of river-side uses by the inhabitants.)
Necessary survey (for EIA and study on the mitigation measures) : (1) Sludge discharge volume (estimated at approximately 10 % of the intake discharge) and the containment. (2) Water quality changes after dilution in the river. (3) Hearing from the inhabitants on the probable impacts caused by the sludge discharge.
Scale /Significance of Impact (Based on the results of EIA survey): (1) No remarkable adverse impacts are predicted as the sludge is sufficiently/highly diluted in the river (according to the water quality survey conducted in the rainy season) without piling at the outlet area. The content of sludge is mostly particles of sand/silt/clay. Although it also contains Charlene, lime and alum use for the purification of raw water. No toxic and hazardous materials are contained. The inhabitants living around the outlet of sludge discharge pipe do not complain about the sludge.
Proposed Mitigation Measures: (1) Extension of outlet of effluent pipe to a deeper location of the river. (2) Study on the sludge treatment in the WTP site and effective uses of sludge, without discharge into the river, for the future. Although the significant adverse impacts are not predicted at present, it is desirable for the river environment as well as for the inhabitants not to discharge to the river. In addition, approximately 10% of intake water could be saved if not discharged.
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities. (2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage) : (1) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program. (2) Monitoring of water quality in the river at the outlet of the sludge pipe and the confirmation of sludge dilution without piling during the dry season. (3) Study on the sludge treatment in the WTP site and effective uses of sludge, without discharge into the river, for the future. Although the significant adverse impacts are not predicted at present, it is desirable for the river environment as well as for the inhabitants not to discharge to the river. In addition, approximately 10% of intake water could be saved if not discharged.
Remarks: (1) The water pollution caused by the sludge discharge may be negligibly low due to high dilution in the river. However, it is desirable to monitor the conditions during the low tide in the dry season after the completion of expansion works of WTP.

Table 13.7-7 Summary of EIA for Item (7), Water Pollution (Industrial Effluent)

Item : Water Pollution (Industrial Effluent)
Content : Water contamination of the Halda River (at Intake of WTP) due to industrial effluent drained through the Krishuna Khal.
Cause : (1) Contaminated effluent from the industrial area (Tannery factory) through Krishuna Khal.
Probable Impact (Based on general/preliminary study) : (1) Water contamination (inclusion of toxic/hazardous substances) at the intake (during the dry season).
Necessary survey (for EIA and study on the mitigation measures) : (1) Water pollution sources of the Khal. (2) Water quality in the Khal and the outlet in the Halda River (3) Hearing from the inhabitants on the conditions of the Khal in the dry season. (4) Estimate of the affect to the intake water (sufficient dilution) (5) Effluent from the industrial area, discharged to the Khal.
Proposed Mitigation Measures: (1) Intake control (in case the water in the Halda River is polluted higher than the standards for raw water of drinking water). (2) Strengthening of regulation and guidance to industries (when the effluent is polluted higher than the standards). (3) Planning and implementation of the sewerage water treatment in the major industry and also the establishment of the sewerage treatment project by the government (in the future), although this matter is one of the whole Chittagong issues.
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities.
(2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage) : (1) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program. (2) Periodical water quality survey in the Khal in the dry season. (3) Periodical survey of effluent from the industries. If the effluent quality exceeds the standard, immediate countermeasures have to taken for reducing the contamination. (4) Guidance to construct the sewerage water treatment in the major industry and also the establishment of the sewerage treatment project by the government (in the future), although this matter is one of the whole Chittagong issues.
Remarks: (1) The necessity of survey on this item was instructed from the Chittagong DOE office to BETS (Subcontractor for EIA) (2) This item may not be the usual EIA item of the project, as the project does not influence to the water contamination of the Khal. However, if the contaminated water coming out of the Khal reaches to the WTP site, the sanitation problem may happen. Accordingly, it is considered that this item is also one of EIA items.

Table 13.7-8 Summary of EIA for Item (8), Noise/Vibration (Construction Works)

Item : Noise/Vibration (Construction Works)
Content : Noise/Vibration caused by construction works around the proposed WTP site, along the transmission mains & distribution mains, and the proposed reservoir site(s).
Cause : (1) Construction machines at the construction site. (2) Transportation vehicles
Probable Impact (Based on general/preliminary study) : (1) Inconveniences and nuisance for inhabitants (2) Damage to houses (vibration)
Necessary survey (for EIA and study on the mitigation measures) : (1) Land use around the construction sites (2) Soil and geological/foundation conditions (3) Hearing from the inhabitants about the significance of impacts, their acceptance, possible countermeasures, etc.
Scale /Significance of Impact (Based on the results of EIA survey): (1) At the WTP site, no significant adverse impacts are predicted due to some distance between the houses and the construction site (but a few houses are located nearby). (2) Along the pipeline routes, moderate adverse impact is predicted at some locations (at narrow road sections with houses on both sides) , but could be sufficiently accepted by the inhabitants due to the necessity of works and the temporary nuisance. (3) At the reservoir site, moderate adverse impact is predicted, but could be sufficiently accepted by the inhabitants.
Proposed Mitigation Measures: (1) Construction works in some limited hours, which may cause less affect on noise and vibration. (2) Sufficient information to the inhabitants for the noise and vibration as well as the construction works (location, period, time, etc.). (3) Compensation to houses with remarkable damage caused by vibration. (4) Construction methods (including manpower works without machines) with less noise and vibration for critical sections such as narrow roads in residential areas and a location near hospital. (5) Closure of the construction site by noise-proof walls. (6) Return of land/houses/facilities in good condition (for temporary uses)
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities. (2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage): (1) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program. (2) Inspection and measurement of actual sound and vibration level/conditions during the construction works. (3) Immediate and competent countermeasures to mitigate the adverse impacts, when the noise and vibration cause to serious nuisance for the inhabitants at and around the construction sites. (4) Hearing from the inhabitants about the differences on noise and vibration before and during the construction works. (5) Standard/regulation of noise, if any
Remarks: (1) Mitigation measures with high cost can not be applicable in Bangladesh (2) The detailed survey will be required for the specific mitigation measures at some narrow and long roads.

Table 13.7-9 Summary of EIA for Item (9), Noise (Pumping House)

Item : Noise/Vibration (Pumping House)
Content : Noise from the pumping house in the WTP site.
Cause : (1) Increase of the pumping capacity (Installation of additional unit)
Probable Impact (Based on general/preliminary study) : (1) Uncomfortable feeling by noise for inhabitants especially at night.
Necessary survey (for EIA and study on the mitigation measures) : (1) Survey of the present conditions of sound. (2) Estimate of the increase of noise. (3) Hearing from the inhabitants about the nuisance of sound. (4) Standard/regulation of noise, if any
Scale /Significance of Impact (Based on the results of EIA survey): (1) No significant adverse impact is predicted, due to some distance between the pumping house and the residential houses. There are already the existing pumping stations and the inhabitants have made no claims to the sound. The increase of pumps will no make remarkable increase of noise, although the monitoring and confirmation will be required.
Proposed Mitigation Measures: (1) Close the doors of the pumping house at night. (2) Use of low-sound type for pumping facilities
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities. (2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage): (1) Preparation of implementation plan of effective and practicable mitigation measures, if required. (2) Monitoring the noise level after completion of the project. (3) Hearing from the inhabitants about the nuisance of sound.
Remarks: (1) The inhabitants may be more or less sensitive to the environmental impact in consideration of the case that a part of the access road (with pipelines underneath) to the pumping station has to be opened for free crossing/passing by the inhabitants without fences (for security purpose) due to the claim from the inhabitants about the detouring route connecting both sides of the access road at the existing WTP.

Table 13.7-10 Summary of EIA for Item (10), Air Pollution (Construction Works)

Item : Air Pollution (Construction Works)
Content : Air pollution (including dust) caused by construction works around the proposed WTP site, along the transmission mains & distribution mains, and the proposed reservoir site(s).
Cause : (1) Construction machines at the construction site. (2) Transportation vehicles
Probable Impact (Based on general/preliminary study) : (1) Nuisance for inhabitants (2) Health problem for inhabitants
Necessary survey (for EIA and study on the mitigation measures) : (1) Land use around the construction sites (2) Soil and geological/foundation conditions (3) Hearing from the inhabitants about the significance of impacts, their acceptance, possible countermeasures, etc.
Scale /Significance of Impact (Based on the results of EIA survey): (1) At the WTP site, no significant adverse impacts are predicted due to some distance between the houses and the construction site (but a few small houses are located nearby). (2) Along the pipeline routes, moderate adverse impact is predicted at some locations (at narrow road sections with houses on both sides). But it is only during the construction hours (temporary nuisance). (3) At the reservoir site, no significant adverse impacts are predicted due to some distance between the houses and the construction site.
Proposed Mitigation Measures: (1) Sprinkling of water for dusty earth works. (2) Selection of construction methods and construction machines in consideration of reducing air pollution (dust and exhaust gas). (3) Construction works in some limited hours, which may cause less air pollution (exhaust gas and dust)
Proposed EMP and monitoring (Common/general plan): (1) Establishment of an environmental section in CWASA, coordination with the other related agencies (DOE, etc.), assignment of experienced staffs and budgets preparation for the activities. (2) Improvement and strengthening of existing laws, rules, standards and regulations for effective environmental management and control. (3) Enhancement of people's participation for environmental management and control. (4) Preparation of implementation plan for the effective mitigation measures and EMP including the monitoring program.
Proposed EMP and monitoring (Plans taken at respective project stage) : (1) Preparation of implementation plan of effective and practicable mitigation measures. (2) Inspection and measurement of air pollution level/conditions during the construction works. (3) Evaluation of air pollution by the standards.
Remarks: (1) Mitigation measures with high cost can not be applicable in Bangladesh. (2) The detailed survey will be required for the specific mitigation measures at some narrow and long roads.

CHAPTER 14

PROJECT EVALUATION

CHAPTER 14 PROJECT EVALUATION

14.1 General

The proposed project for the Extension and Expansion of Mohara Water Treatment Plant in Chittagong was evaluated from viewpoints of expected benefits and appropriateness/feasibility. Composition of the evaluation items adopted was technical aspects, financial aspects, environmental aspects, and social and economic aspects.

Since the water supply are one of the major urban infrastructures, associated legislative and institutional arrangements including community participation for improvement and maintenance of urban living circumstance are indispensable to maximize the overall benefits of the project. In this report, comments and recommendations relevant to extension of the water supply system are also identified and incorporated.

14.2 Benefit and Justification of the Project

The principle objections of water supply system development and its operation are (1) to always supply water with safety and cheapest and (2) to help human health and hygiene for improvement of living level.

The existing water supply system of Chittagong City was transferred from the City Corporation in 1963 and has been extended under the assistance of IDA mainly.

The present population of Chittagong City is estimated at 3.0 million and projected at 3.7 million in 2010. The present supply capacity of the CWASA is 161,500 m^3/day. The coverage rate is only 45 percent, which is very low level at the big city and representative of the country. The current water supply situation in the City is of service for 15 hours a day or one day for two or three days, depending on the location and area.

On the other hand, blessing the location of land, a greater emphasis on industrial sector development in the Chittagong seaport, which has a share of 80 percents of import and export trading of the country.

According to the economic development, the city population has been remarkable increased and hence the water supply service level has trained toward decrease. Resultant from this, service problem of the city has been caused due to lack of water supply ability.

As for an emergency countermeasure CWASA has planned to extend the Kalurghat Iron Removal Plant having a capacity of 22,500 m^3/day under the fund of GOB, and also to constant new water treatment plant at Madunaghat having a capacity of 45,500 m^3/day under the assistance of Italian Government.

Showing the present and water supply situation by means of the unit water supply rate (supply volume per person per day), the present in rate is 140 lpcd. Even though completion of two projects planned by CWASA, excluding Mohara expansion project, the unit rate in 2005, will be at 120 lpcd, which is low level against the present services. That means no improvement of the service level. Taking account of level-up of the peoples' standard of living and increase of water demand for industrial, the service level is rather decline than the present, and hence the city economy activities will be constrain.

If CWASA would have an intention to maintain the planned water supply target level in 2005, no more house connection is allowed. In that case, water supply coverage rate would be lower level than the present, which resulting serious socio-economic problems will be caused.

This particular project is to extend the existing Mohara Water Treatment Plant and to supply the water to the areas to be increased population density in the city and new supply areas to be expanded and also to industrial zones. When the project is implemented, the water coverage rate is to be 50%, and the unit in rate is expected to be 178 lpcd.

14.3 Project Evaluation

14.3.1 Technical Evaluation

Project evaluation from technical viewpoint is carried out as described below:

1) According to the extension of existing Mohara Water Treatment Plant under the proposed project, the water service conditions in water quality and quantity will be considerable improved.
2) Since the proposed water treatment plant is adopted at the same type of treatment method/type with the present system, no special technical operator is required.
3) The distribution system is changed from directly pumped transmission and distribution method/system up to natural flow-down through a reservoir. According to the change of distribution system; (1) the users will be served safety water "any time when they needed at stable water pressure"; (2) the operation are required no valves and pumps control for arrangement of water supply areas. As "one water reservoir covers one supply area", the operation and maintenance work are to be simple and easy.

14.3.2 Financial Evaluation

To keep this water supply project financially sustainable on the long run, it is important to secure stable and long-term financial resources to recover all disbursements made for operating and maintenance, replacement of fully depreciated assets, and initial investments.

For instance, if the water works fails to secure financial resources required for operating and circumstance disbursements, certain services will not be provided satisfactorily, and in the worst case, the entire water supply system will cease its function. As for the shortage of replacement disbursements, the water works will face difficulties as a part of the machinery works has been left out-of use. As for the shortage of financial disbursements, the situation might not have impacts on users as serious as in preceding cases.

As result of the financial analysis, the following are observed:

1) When the rate of return is to set at 7.5 percent, which is the loan condition of the government financial aid, the present weighted average tariff (6 Tk/m^3) should rise at 3.8 times, or as an instance, rise at twice and also annual rise of 4.5 percent is needed. This is unrealistic.
2) If the rate of return is to set at 1.0 percent, which is the loan condition of the foreign financial aid, the present tariff should rise at 1.7 times, or as an instance, rise at 1.3 times and also annual rise of 1 percent is needed. This will be meeting the inhabitants' willingness to pay.

As a result, the implementation of the project is needed to be complemented by an appropriate government financial subsidy.

14.3.3 Socio-economic Evaluation

Safe drinking water and the sanitary dispose of waste have long been recognized as basic needs of society, as both of them function to safeguard human health and enable a more productive life. Health and environmental problems caused by inadequate water supply and poor waste disposal have been exacerbated by continued population growth and the high concentration of that population in urban areas.

In economic term, indirect benefits are called external economic, even those who are not paying for the water services directory. The following are examples such benefit:

1) Improvement of public health regardless of whether or not they have house connections.
   Improved public health is a community benefit, which contributes to all peoples of the community. Improvement of awareness on public health and environmental condition of the

inhabitants will be expected.

2) Cost saving in health care cost and in auxiliary health and sanitation cost
   A concrete example of benefit of improved overall community health is decrease of social costs. Improvement of sanitation condition will bring decrease in health care costs and in auxiliary health and sanitation costs.
3) Infrastructure as a basis for economic development Investment in a water supply lays a positive base for economic development, both through the employment generated through the actual building of the system and through contributing to overall public welfare, which in turn can used to induce investment into Chittagong's private sector by both domestic and foreign enterprises.
4) Construction's long-term effects on the local economy Even after construction has been completed, an expanded water supply system will have a positive effect on local employment by absorbing a part of the labor force as maintenance workers. The consequent increase in income will serve to increase effective demand, which will in turn contribute to economic growth, as will the derived demand from the project's maintenance activities.

   Of course, construction's short-term effect on the local economy during the duration of construction is expected by increasing district output.

   As explained above, economic benefits of expanding the water supply system are not limited to individual users, but rather are spread over society as a whole, as well as industries. Some of the EPZA and other firms are awaiting stability water supply with sufficient water quality and quantity. They have direct effects on the enterprise and broaden the economic development to the entire country.

   However, in actuality it is quite difficult to spread the costs of the project over the various indirect beneficiates of the complete project. As a result, portions of public expenditures, which are not attributable to the individual user, are not fairly to other possible beneficiaries. Thus, when may not be an appropriate index for gauging the overall economic meaning of the water supply project.

14.3.4 Environmental Evaluation

Environmental Impact Assessment (EIA) of the proposed project was carried out during the course of the study.

As the results of EIA study, the overall evaluation concluded as follows:

The significant or major adverse impacts caused by the proposed project are unlikely. Some minor impacts could happen, but could be sufficiently reduced to an environmentally acceptable level by implementation of the Environmental Management Plan (EMP), which includes proper mitigation measures.

The mitigation measures for reducing and protecting the anticipated impacts were studied for the individual environment item. Then, the Environmental Management Plan (EMP) was prepared for confirming the necessity of the proposed mitigation measures and also for implementing the measures effectively. The EMP includes various monitoring plans, which may be necessary to con0irm the level of impacts or the effectiveness of the mitigation measures.

14.3.5 Emergency Project and Hidden Costs

The project proposed as the emergency countermeasures is designed to solve the present critical water service in the City. Development of the project will be a further extension toward the basic plan. The hydraulic analysis for distribution network, however, was executed aiming at the water demand in the F/S, target year of 2005.

From development of the water supply point of new, this particular project is not completed itself. The project is planned to meet water demand in F/S target year on premise of the implementation of the CWASA's on-going projects, namely Madunaghat WTP and the 3rd Kalurghat IRP. However, these CWASA's on going projects are designed to increase the production capacity only, and not included the implementation or extension and expansion of the distribution main and network. Accordingly, this particular project covers a part of the improvement of distribution main pipe entire service area and in the project implementation cost as an emergency countermeasure.

In additions to the project cost, therefore, there are extra hidden costs so as to complete the overall projects, which might sum up as follows:

(1) Extension and expansion of supply network in a part of the project.
(2) Construction of household connections, which will be mainly, bore by the user.
(3) As for no immediate connection, cost of industrial wastewater treatment, should be treated for discharge at their own cost in accordance with the regulation.

CHAPTER 15

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 15 CONCLUSIONS AND RECOMMENDATIONS

15.1 Conclusions

Owing to remarkably development of the industrial sector in the Chittagong City and its suburban area, the population of the City has been remarkably increased for this decade.

The present water supply situation of the City is summarized that water served population is 1.14 million, water coverage ratio is 45 percent, and water supply volume per capita per day (unit rate) is 142 lpcd. These figures in the basic plan target year of 2010 are estimated at 3.37 million, 84 percent, and 193 lpcd, respectively. The new water source for the proposed water treatment plant for the improvement/expansion of the water supply system in the Chittagong City is to be the Karnaphuli River, besides the planned the expansion of Mohara and Madunighat WTPs and others. Availability of the raw water was confirmed on water quality and quantity for treatment plant of the potable water.

To solve the current critical water supply situation, the expansion project of Mohara WTP, which is also included in the basic plan, was formulated as a priority. The planned target year for the F/S project is 2005 as emergency one. After completion of the project, the present water supply conditions will be improved so that served population will be 1.58 million and unit rate will be 173 lpcd.

It shall be noted that the proposed expansion project of Mohara WTP meets with the national policy for infrastructure development stipulated in the Annual Development Program 2000-2001 being adopted by the Government of Bangladesh.

Likewise, the necessary and appropriateness as well as urgency of the proposed project has been substantially acknowledged and justified for betterment of critical water shortage, public hygiene and environmental conservation in Chittagong City and urban infrastructure as well.

According to the financial analysis, in order to recover all cost of this project entirely by the water tariffs, it will be necessary to raise the tariff to 3.8 times of the present weighted average tariff. This amount equivalents to 2.5 times upper than limit of the general inhabitants' willingness-to-pay. As a result, the intention to collect all costs by the water tariffs only is unrealistic. The implementation of the project should be complemented by an appropriate government financial subsidy.

Here, being the study more for financial analysis, (1) Assuming that 30% out of total project cost of US $ 96 million is assisted from the government as a financial subsidy, it is needed to rise up at 2.7 times of the present tariff. (2) Assuming that the rate of return for payment to the government is 1% which is

equivalent to the rate of JBIC, it is needed to rise up at 1.7 times of the present tariff, and (3) Assuming that 30% out of total project costs of US $ 96 million is subsidized from the government financial subsidy, and also the rate of return for payment to the government is 2.5% which is a weighted average rate based on the foreign and local potions (75%: 25%) of the project cost estimate, it is needed to rise at 1.5 times of the present tariff. As a result, the cases of (2) and (3) only mentioned the above are feasibility for the project implementation.

Overall Conclusion

(1) Based on this study, it may be concluded that the scale and scope of investment of the project appear appropriate, and the effects of the investment, which seem satisfactory. Management Systems necessary for the project operation are considered to be sufficient.
(2) However, it is difficult to fully recover costs of the investment without substantial financial complements by the government financial subsidies. As a result, special considerations should be made for a financial scheme, which can fully fund the project.

15.2 Recommendations

The following recommendations are presented in accordance with their importance and priority.

(1) Establishment of measures to secure project fund,
(2) Negotiation with landowners for land acquisition,
(3) Preparation and submittal an application of change the tariffs to the government for their approval,
(4) Consideration to introduce the slab tariffs structure for close-subsidy between consumers so as to help the law income group, and
(5) The proposed project is designed to construct Mohara WTP extension plant, transmission pipe, reservoirs, and distribution main, and install a part of main connection pipe in the existing supply areas so as to form a certain network to distribute but water from the existing system. Therefore, secondary distribution pipeline and house-connection, which are out of scope of the implementation cost estimate, should be installed in parallel with the progress of the proposed project.