CHAPTER 2

EXISTING SEWERAGE FACILITIES

CHAPTER 2 EXISTING SEWERAGE FACILITIES

2.1 General

Compared with the existing sewerage system in South Dhaka, the system within the study area is relatively new. The major parts of sewer system was constructed on 1960s and are still expanding, while only one lift station within the area, Tejigaon L/S was implemented on the year of 1977.

Roughly, the Central Area, corresponding to Gulshan and Banani, is served by sewerage system, while the eastern side of the study area across Gulshan Lake, namely Baridhara and Badda, is served by on-site sanitation facilities.

The study area belongs to MODS Zone V and these facilities are maintained by the Zone Office.

2.2 Sewer System

According to the existing drawing, "Sewerage System, Dhaka WASA Water Supply and Sanitation Urgent Expansion Project, Nov. 1993, scale 1:5,000", the total length of sewers by pipe diameter is as follows:

Pipe Diameter	Total Length
600 mm	1,430 m
450 mm	5,160 m
300 mm	3,805 m
200 mm	48,055 m
Total	58,450 m

Adopted pipe materials are PVC (Polyvinyl Chloride) for pipes with diameters of below 600mm and RC (Reinforced Concrete) for 600 mm pipe.

According to the Executive Officer and Annual O&M Report of Zone V Office, the present status of sewer system is "Good." Although general cleaning of sewer system is carried out once a year by local contractors excluding accidental case, it does not solve the existing chronic poor O&M status.

2.3 Pumping Station

There is one lift station at the south end of the study area, Tejigaon L/S. The existing facilities are as follows:

-	Vacuum Pump	$0.3\ m^3/min$ x 600 mmHg x 0.75 kW x 1 unit	
-	Sump Pump	$0.4\ m^3/min$ x 10 m x 1.5 kW x 1 unit	
-	Inlet Gate	800mm□ x 8.2 mH x 1 unit	
-	Bypass Gate	φ600mm x 8.15 mH x 2 units	
-	Screen	Bar Screen with manual winch 1.5mW x 8.69 mH x 1 unit	
-	Control Panel		
-	Water Level Indicator	Float type with High/Low level switch, 1 unit	
-	Geared Trolley Chain Hoist	Manually operated	0.5 ton x 6.0 mH
-	Vertical Centrifugal Pump	(Pumps No.1&2)	$9.1\ m^3/min$ x 12 m x 22 kW x 2 units
		(Pump No.3)	$6.8\ m^3/min$ x 12 m x 15 kW x 1 unit
		(Pumps No.4&5)	$2.3\ m^3/min$ x 12 m x 11 kW x 2 units

Major facilities are in operational condition excluding the following:

- Vacuum Pump: Due to the lack of spare parts, pump can not be repaired. Pump can not produce vacuum.
- Pump No. 4: Bearing was broken

General layout and structural designs of the Tejgaon L/S are shown in Figure 2.3.1 and 2.3.2, respectively.

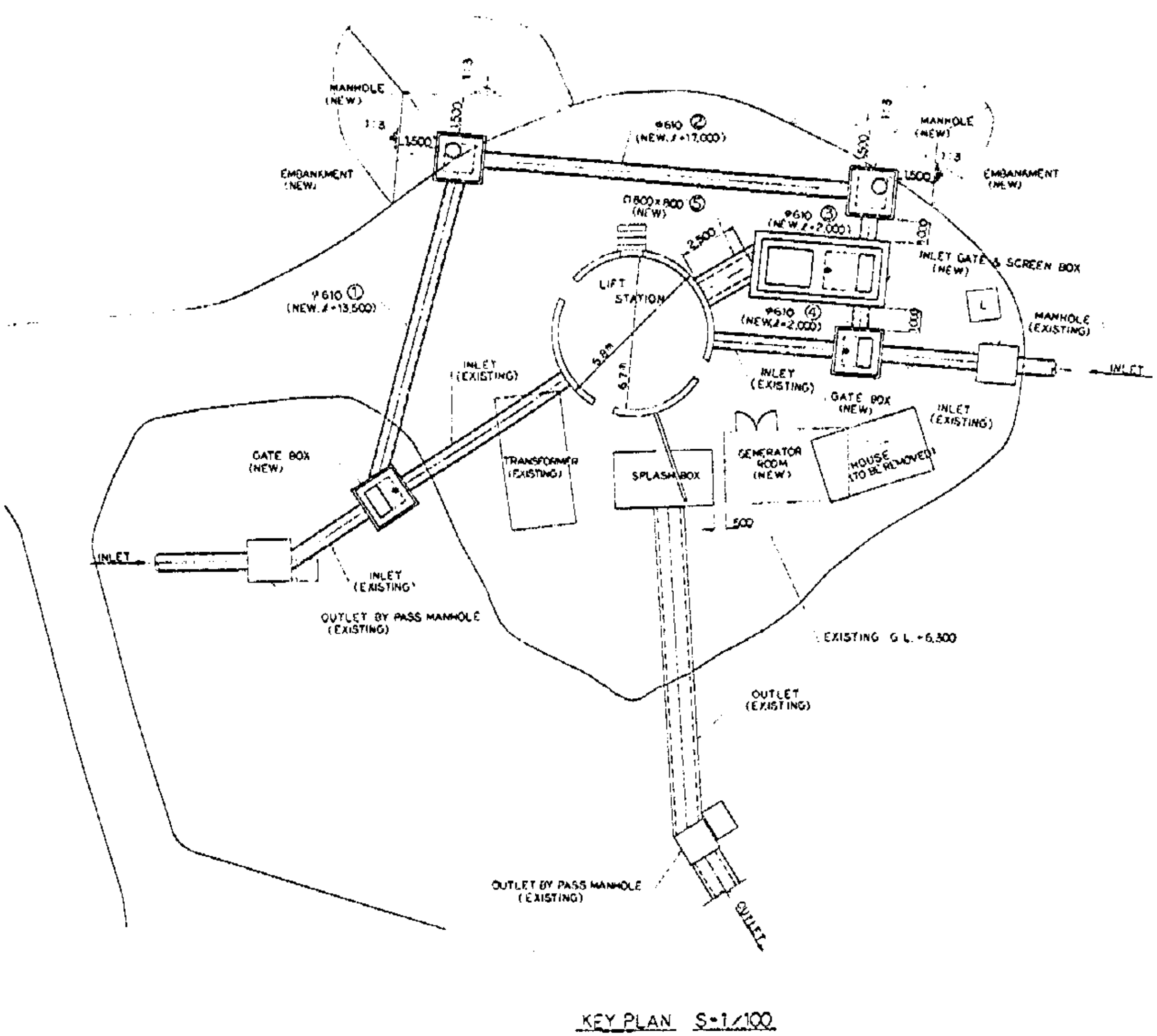


Figure 2.3.1

General Layout of Tejgaon Lift Station

The Study on North Dhaka Sewerage System in North Dhaka

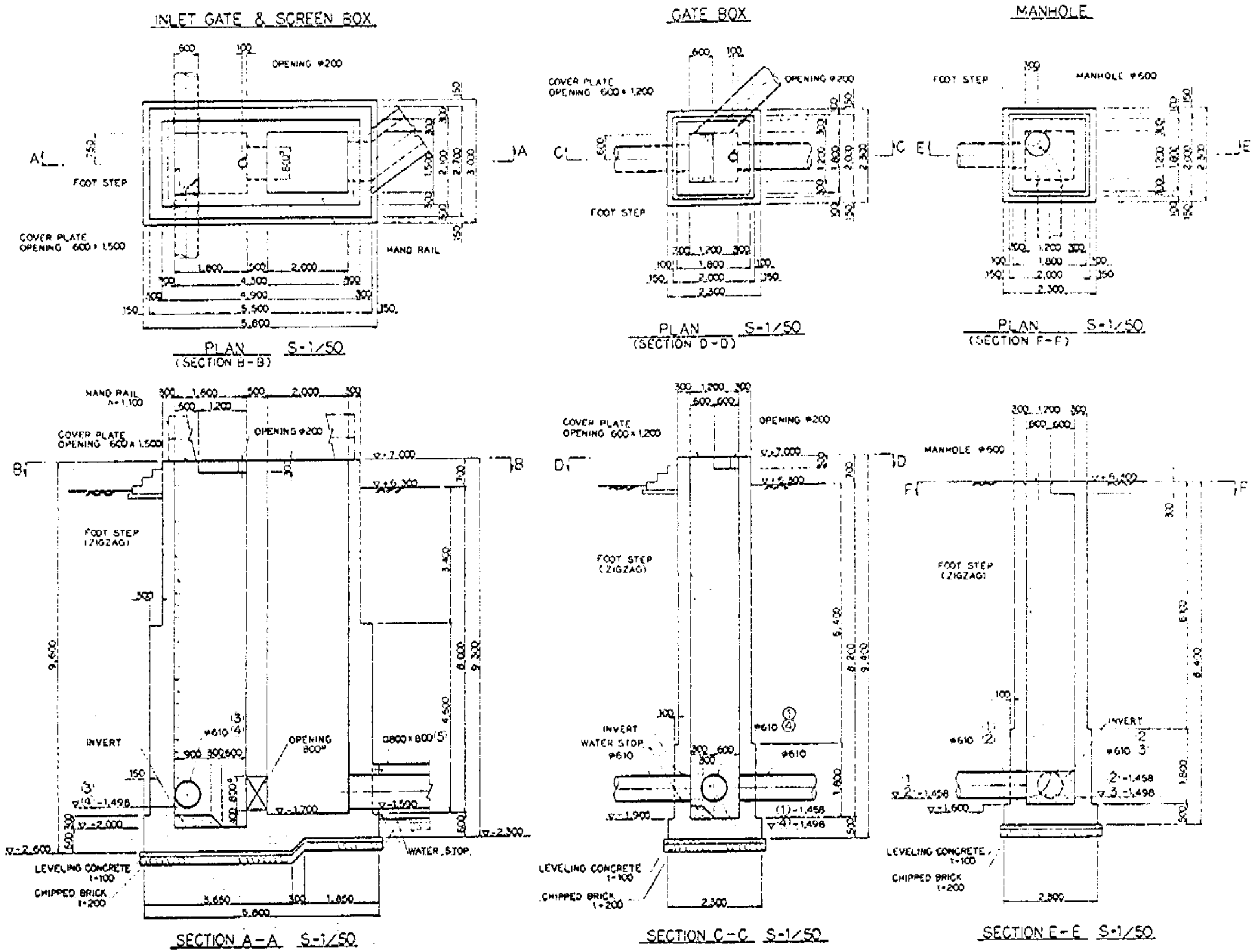


Figure 2.3.2

Structure Drawing of Tejgaon Lift Station (1)

The Study on North Dhaka Sewerage System in North Dhaka

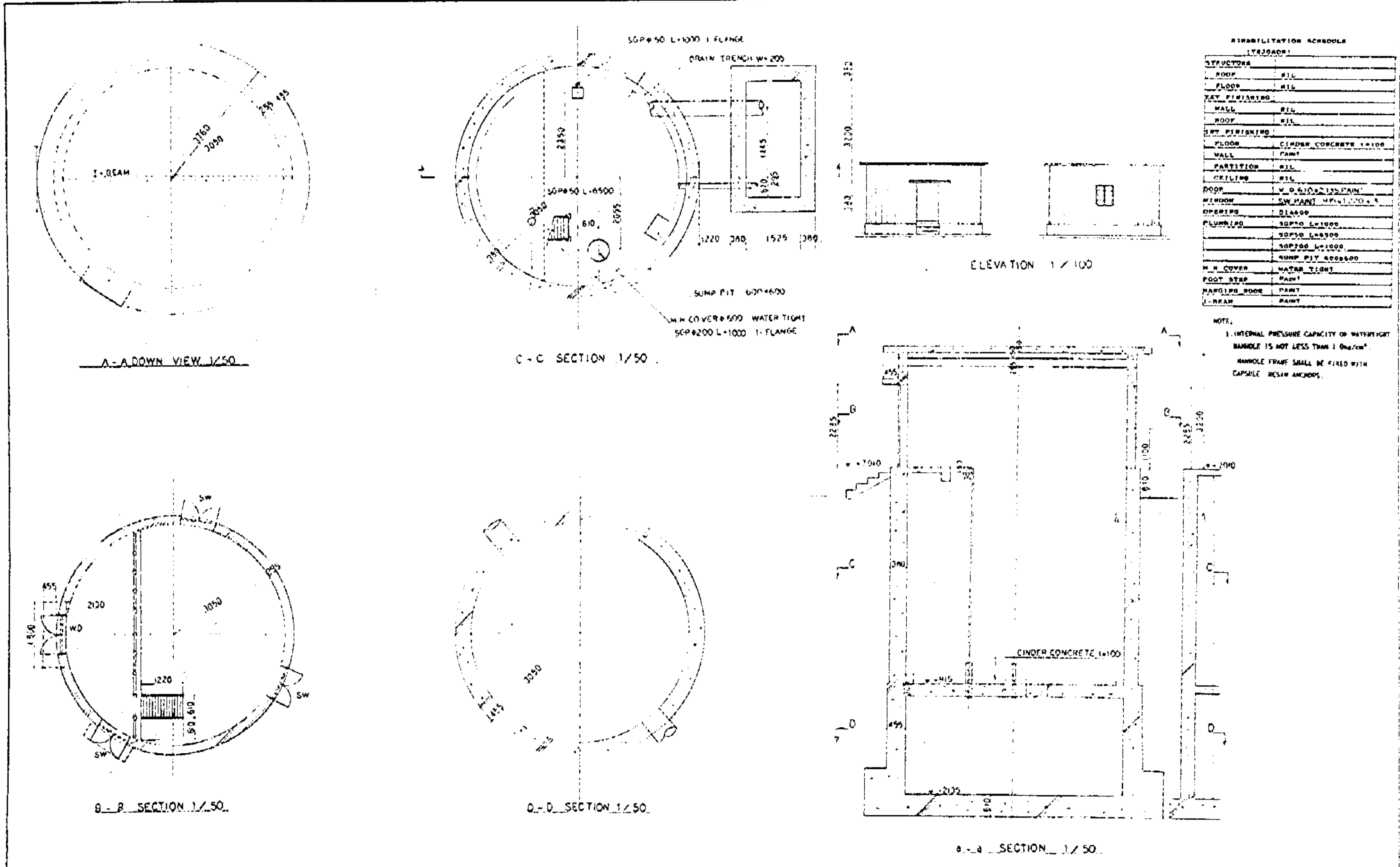


Figure 2.3.2

Structure Drawing of Tejgaon Lift Station (2)

The Study on North Dhaka Sewerage System in North Dhaka

2.4 Existing Design Conditions

Regarding the hydraulic calculation for sewers, Manning Formula is adopted. Flow velocity in sewer network shall be within min. 0.6 m/sec up to max. 2.0 m/sec.
However, DWASA adopts the roughness coefficient of 0.013 even to PVC, it should be corrected as follows;

Roughness Coefficient	Pipe Materials
0.010	PVC
0.013	RC, VC (Vitrified Clay)

DWASA has at present no guideline or manual summarising such design conditions which is indispensable for proper designing of sewerage facilities. It is therefore recommendable to prepare the design manual to be studied by all sewerage engineers involved through the technical seminar for designing, etc.

2.5 Condition of Existing Sewerage Facility

2.5.1 Field Investigation of Existing Sewerage Facilities

Field investigation was carried out on the existing sewerage facilities focusing on the actual pumping volume at the Tejgaon L/S, identification of leakage from the sewer network and the conditions of manholes. The survey results are described below and presented in Figure 2.5.1.

- Operation period of the Tejgaon L/S is not recorded and the present pumping volume is therefore unknown. DWASA staff responded to the inquiries that pumps were operated only a few minutes in every morning due to the quite limited sewage flow to the lift station.

- Field investigation to the existing sewer network revealed that main sewers in Banani area and Mohakhali area had leakage at each one location. These leaking points are located at box culverts (see Photos 1 & 2) across the road along with the Banani Lake and leaked sewage flows into the Banani Lake. These leakages were confirmed by pouring dye into the manholes upstream of the leaking points.

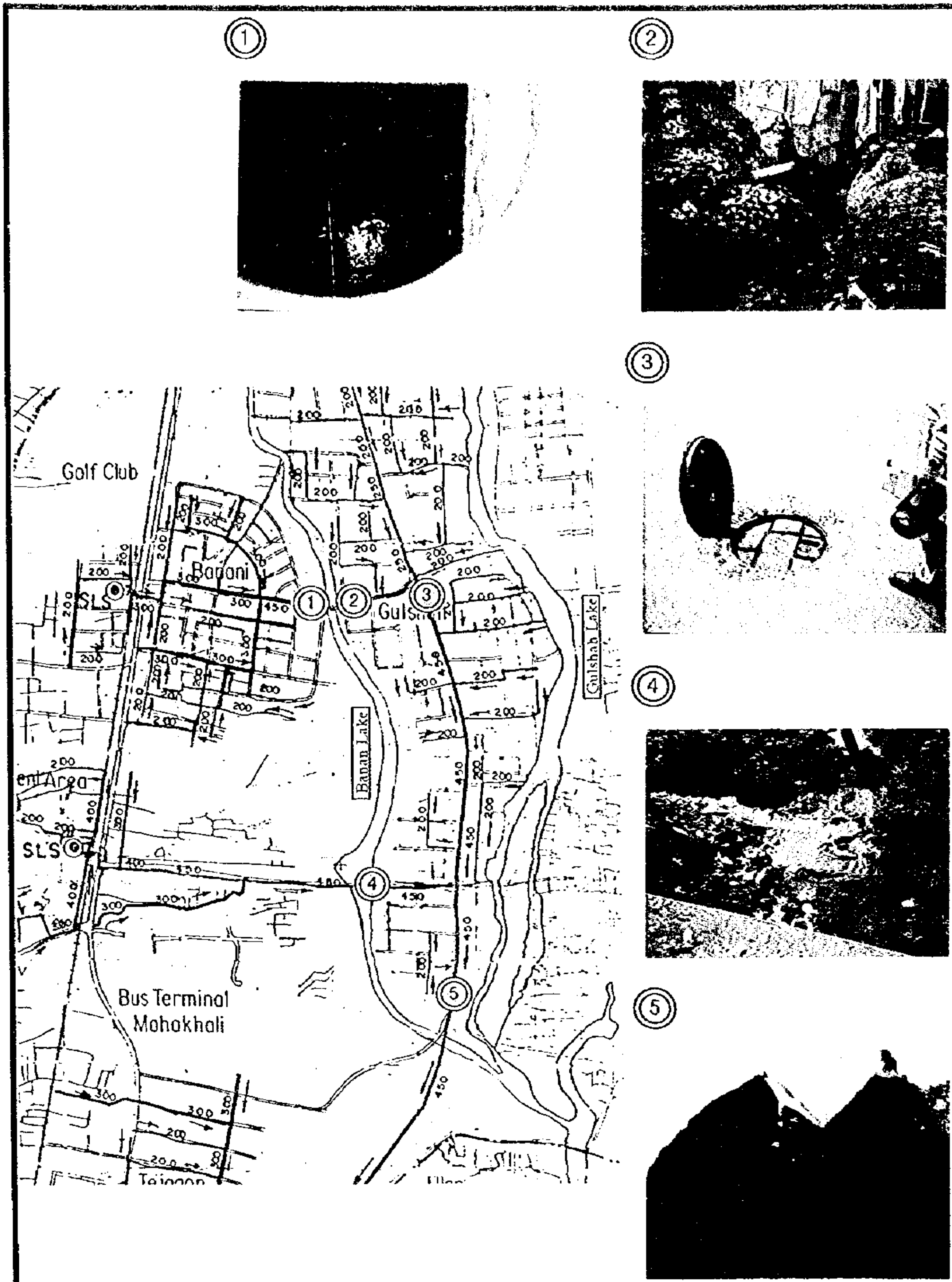


Figure 2.5.1
Results of Existing Sewer Investigation

The Study on the Sewerage System in North Dhaka

- o In Banani and Mohakhali areas, scum was not observed in manholes (see Photo 3) and sewage was flowing smoothly.

- o In the northern part of Gulshan, manholes were filled with scum (see Photo 4) and flowing conditions of sewage could not be confirmed by ocular inspection. However, overflow of sewage from several manholes was confirmed at low elevation areas and water level in manholes was assumed to be considerably high.

- o In the southern part of Gulshan, scum was confirmed in manholes, but its volume was comparatively less than that in the northern part of Gulshan. When the bamboo stick was inserted down to the scum, it was felt that there was sewage flow (see Photo 5) in sewer lines.

Based on the above, present conditions of the existing sewer network are summarised as follows:

- o Sewage generated in Banani and Mohakhali areas is mostly leaked from the broken part of sewer lines and flows into the Banani Lake.

- o Sewage discharged from the northern part of Gulshan is stored in the sewer network under stagnant conditions due to clogging of main sewers and causes to generate scum in manholes, and overflow from manholes occurs in the low elevation area..

As a whole, sewage collected in the existing sewer network hardly reaches the Tejgaon L/S and most of sewage assumably flows into the Banani Lake and the Gulshan Lake at present.

2.5.2 Water Quality Examination of Gulshan and Banani Lakes

The existing sewerage service area contained in the proposed North Dhaka East Sewerage Service Area is surrounded by Gulshan and Banani Lakes. Water quality examination to grasp present conditions of aquatic environment was carried out in these lakes. Water samples were obtained from five (5) strategic locations during the field survey in dry season and examined to determine BOD concentration. Sampling locations and water quality analysis results are shown on Figure 2.5.2.

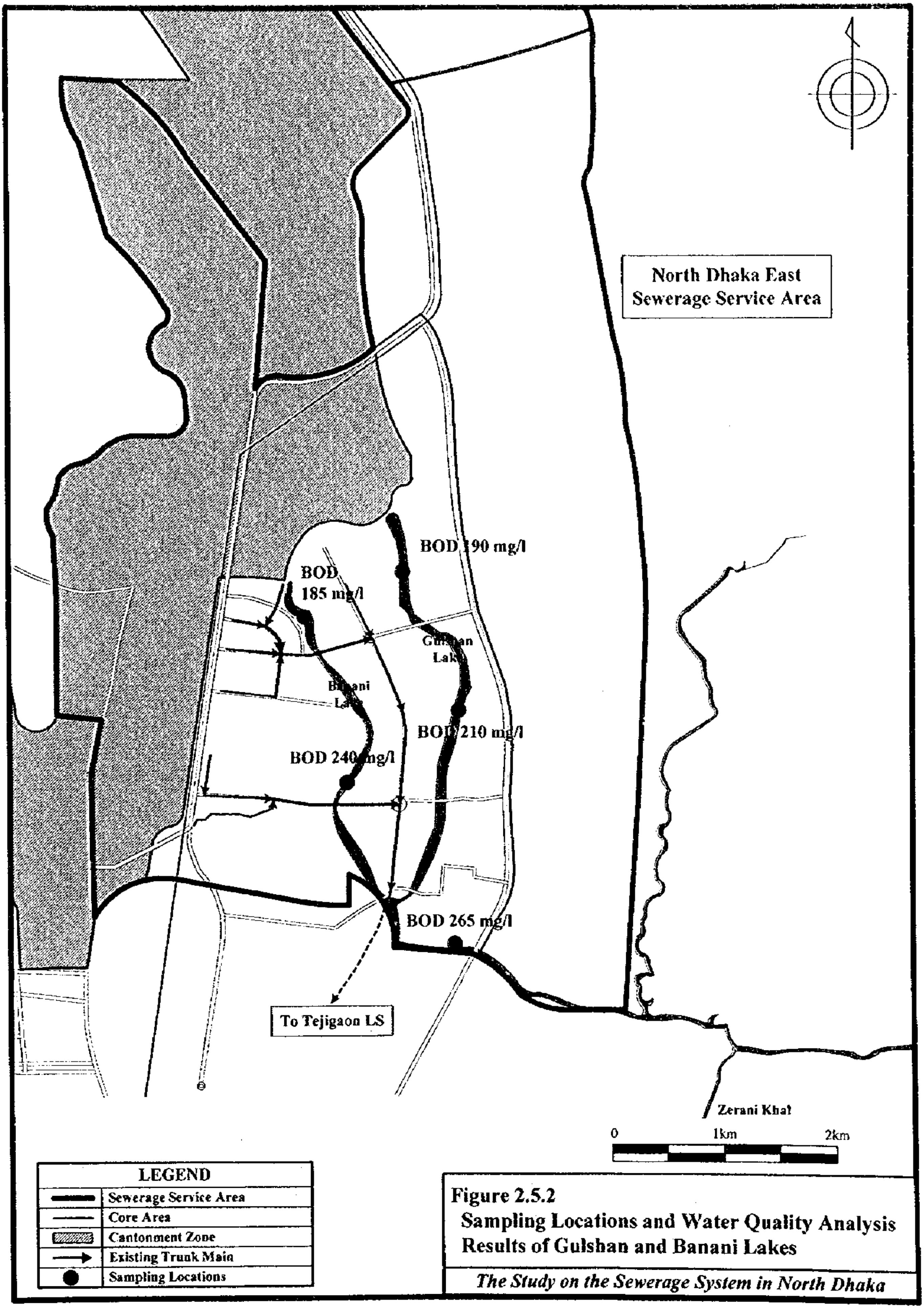


Figure 2.5.2
Sampling Locations and Water Quality Analysis Results of Gulshan and Banani Lakes

The Study on the Sewerage System in North Dhaka

The water quality analysis results revealed the following facts that:

- Water pollution status in Gulshan and Banani Lakes is under serious conditions as BOD values in 5 sampling points are ranging from 185 to 265 mg/l, which is equivalent to the influent quality to the Pagla Sewage Treatment Plant.

- Water quality in downstream (south part) of these two lakes is worse than upstream (north part), which indicates inflow of pollution loads into the lakes.

- Water quality in Banani Lake is far deteriorated than that in Gulshan Lake, which is deemed to be caused by inflow of raw sewage from broken sewer lines laid in Banani area and Mohakhali area.

- Pollution sources of Gulshan Lake are considered to be inflow of overflowing sewage being caused by clogging of sewer line in the north part of Gulshan area, and inflow of raw sewage being discharged in unserved area of sewerage system located at the east bank of Gulshan Lake.

2.5.3 Water Quality Examination of Downstream Rivers

It was found that the water quality of both the Gulshan and Banani Lakes deteriorated and in order to grasp the extent of its influence on the downstream rivers, a water quality examination was carried out. Both Gulshan and Banani Lakes discharge directly into Naral River. Further downstream, Naral River joins Balu River which flows into Lakhya River. Nine strategic locations for collection of samples for water quality examination were chosen along a distance of about 13.5 km between Rumpura Bridge which is at the downstream of both lakes and at the intake point of Saidabab WTP along Lakhya River. The parameters considered for analysis were as follows: pH, COD, SS, NH_4-N and PO_4-P.

The results of the investigation are tabulated in Table 2.5.1 while the location of sampling points and the results of the analysis are shown in Figure 2.5.3.

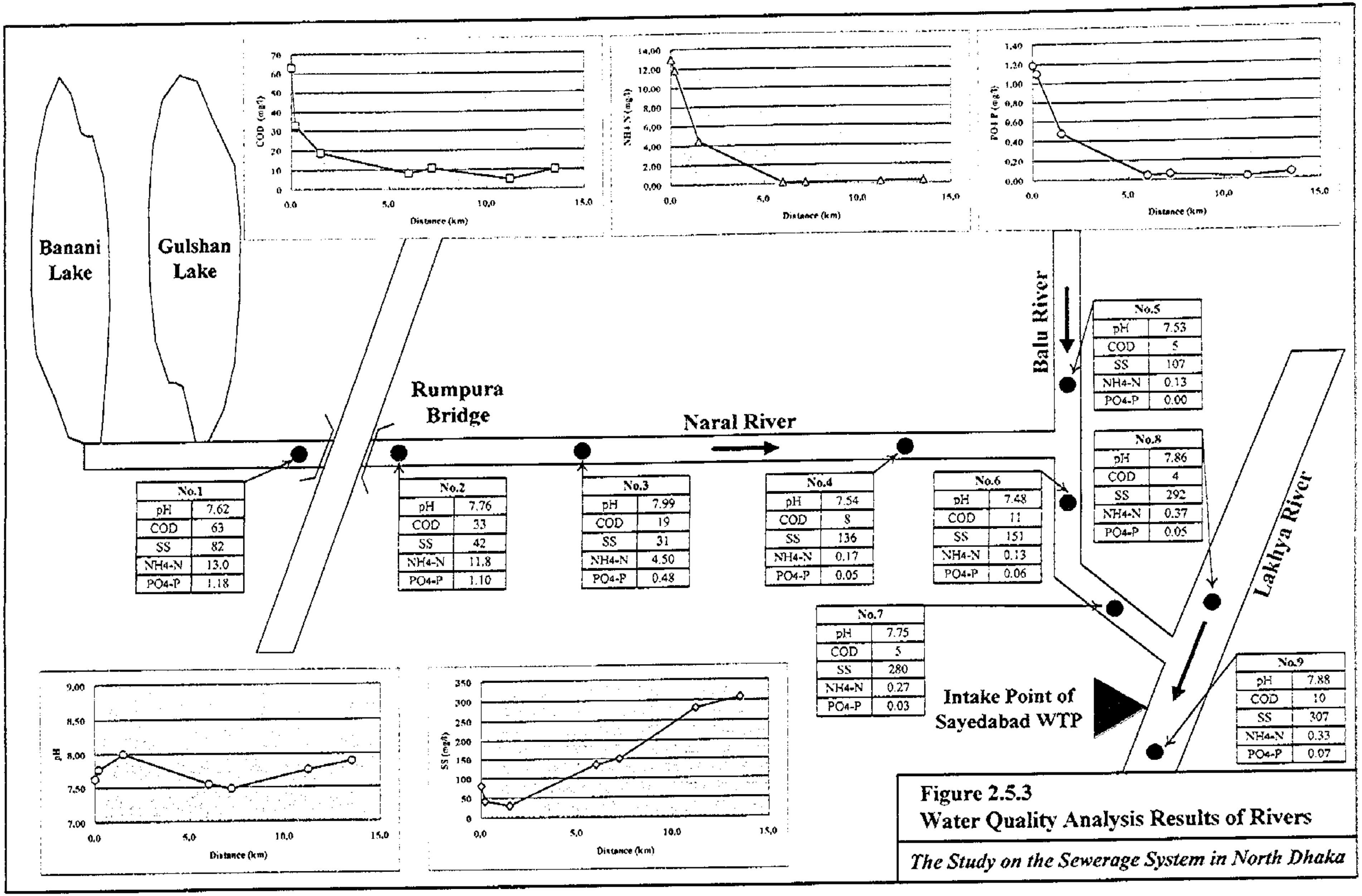
The results of the water quality examination and the influence of the water pollution load from both lakes on the downstream rivers are summarized below:

- In the water quality examination of Gulshan and Banani Lakes during dry season, discussed in the previous section, the BOD content was measured. It was found that at the confluence of both lakes, the BOD concentration was 265 mg/l. At the present examination, measurement of COD content was the main concern and at the same sampling point, a COD concentration of 63 mg/l was determined. Based on these results, it could be interpreted that the concentration of the water pollution was lower than during the dry season due to dilution with rainwater.

- As shown in Figures 2.5.3, the peak of COD, NH4-N and PO4-P concentrations occurred at the confluence of both lakes and the values decreased along downstream direction. Furthermore,SS value is higher in Balu River and Lakhya River than in Naral River which is located directly downstream of the two lakes. However, the observations made on the sediment left undisturbed for a day and a night showed that the components of SS were not organic matter due to pollution but were nearly white silty matter.
- The main difference of the river condition during the wet season water quality examination compared to the dry season was that the low lying areas were almost flooded making it impossible to identify the river banks. Although the pollution load of both lakes was diluted to a great extent, the concentration of each water quality parameter with respect to the downstream distance shown in Figures 3-4 to 3-6 indicated that the influence of the pollution of both lakes could spread up to the midpoint of Naral River even during the rainy season.
- During dry season, dilution with rainwater is impossible to achieve and this can lead to higher concentration at the mouth of both lakes and consequently brings very little reduction in the pollution load further downstream. It is feared that the effect of pollution may spread up to the periphery of water intake of Sayedabab WTP along Lakhya River.

Table 2.5.1 Water Quality Examination Results of Rivers

Sampling Data			Results of Water Quality Examination						Remark
Location	Distance (km)	Time -	Sample Temp. (°C)	pH -	SS (mg/l)	COD (mg/l)	NH_4-N (mg/l)	PO_4-P (mg/l)	
No.1	0	12:10	33.0	7.62	82	63	13.0	1.18	Downstream of Lakes
No.2	0.2	9:20	31.8	7.76	42	33	11.8	1.10	Naral River
No.3	1.5	9:28	31.8	7.99	31	19	4.50	0.48	Naral River
No.4	6.0	9:55	31.8	7.54	136	8	0.17	0.05	Naral River
No.5	-	10:00	31.8	7.53	107	5	0.13	0.00	Balu River
No.6	7.2	10:05	31.8	7.48	151	11	0.13	0.06	Balu River
No.7	11.2	10:28	30.8	7.75	280	5	0.27	0.03	Balu River
No.8	-	10:35	31.0	7.86	292	4	0.37	0.05	Lakhya River
No.9	13.5	10:45	30.8	7.88	307	10	0.33	0.07	Lakhya River



	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9
pH	7.62	7.76	7.99	7.54	7.53	7.48	7.75	7.86	7.88
COD	63	33	19	8	5	11	5	4	10
SS	82	42	31	136	107	151	280	292	307
NH4-N	13.0	11.8	4.50	0.17	0.13	0.13	0.27	0.37	0.33
PO4-P	1.18	1.10	0.48	0.05	0.00	0.06	0.03	0.05	0.07

Figure 2.5.3
Water Quality Analysis Results of Rivers

The Study on the Sewerage System in North Dhaka

CHAPTER 3

WATER QUALITY EXAMINATION

CHAPTER 3 WATER QUALITY EXAMINATION

3.1 General

The 2nd survey on sewage quality and quantity was carried out during the Stage 2 field work to obtain such data in dry season, following the 1st survey conducted in the Stage 1 field work in rainy season in June to July, 1997. The 2nd survey was focused on the domestic sewage, influent and effluent of the Pagla Sewage Treatment Plant, and rivers as public water bodies to receive the treated effluent from the proposed sewage treatment plants.

Water samples were taken during December 1997 to January 1998. Pretreatment and laboratory examination of collected samples were carried out in accordance with "the Standard Method for the Examination of Water and Wastewater" (APHA-AWWA-WPCF).

Water sampling and examination were undertaken by local consultants under the day-to-day supervision of the Study Team.

3.2 Sewage Quantity/Quality Survey

A sewage quantity and quality survey was carried out to grasp the present pollution load and to establish the design sewage quantity and quality. The location of survey points are shown in Figure 3.2.1 to 3.2.2 and a summary of survey results and analysis method is described in Appendix 3.2.1.

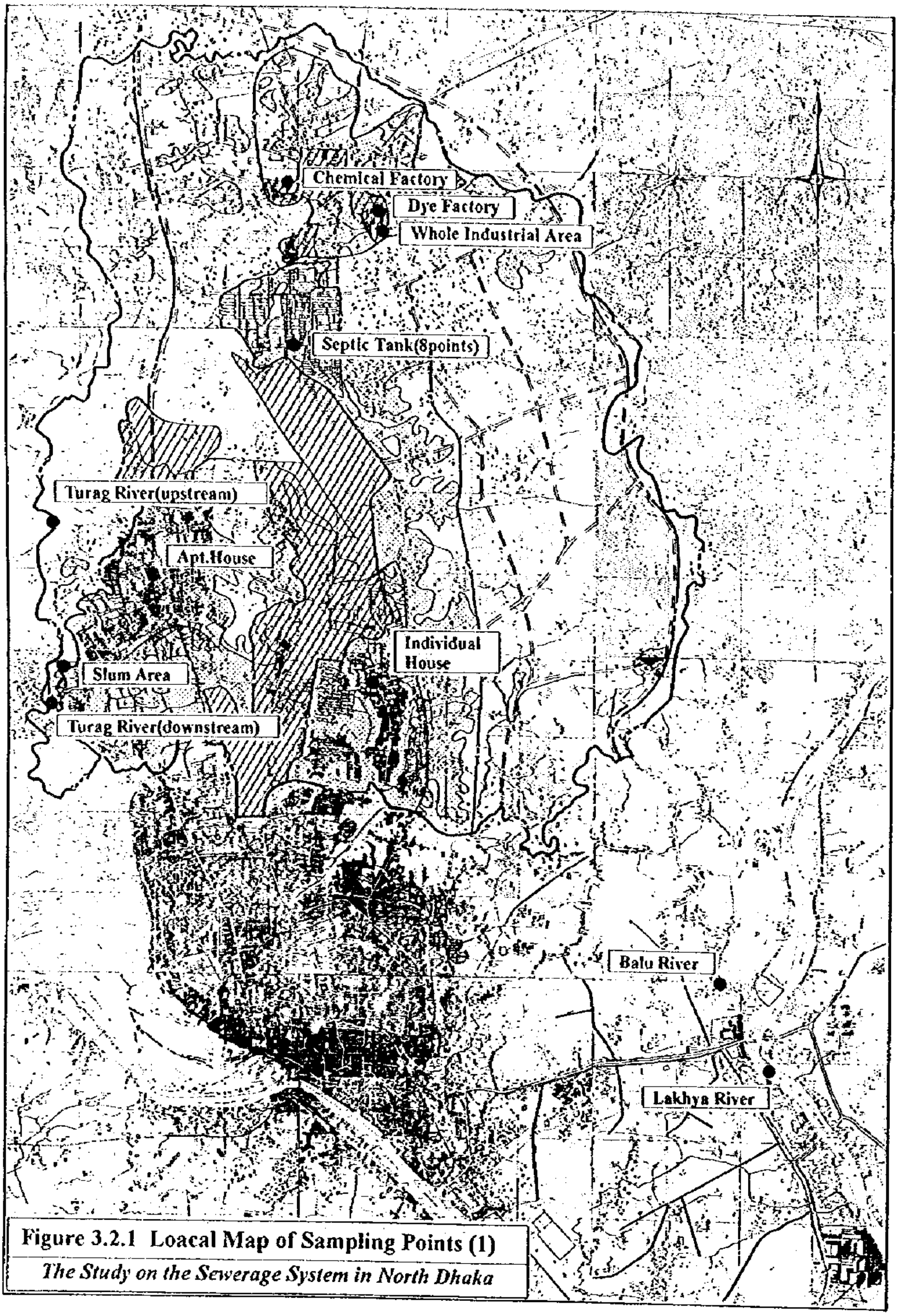


Figure 3.2.1 Loacal Map of Sampling Points (1)

The Study on the Sewerage System in North Dhaka

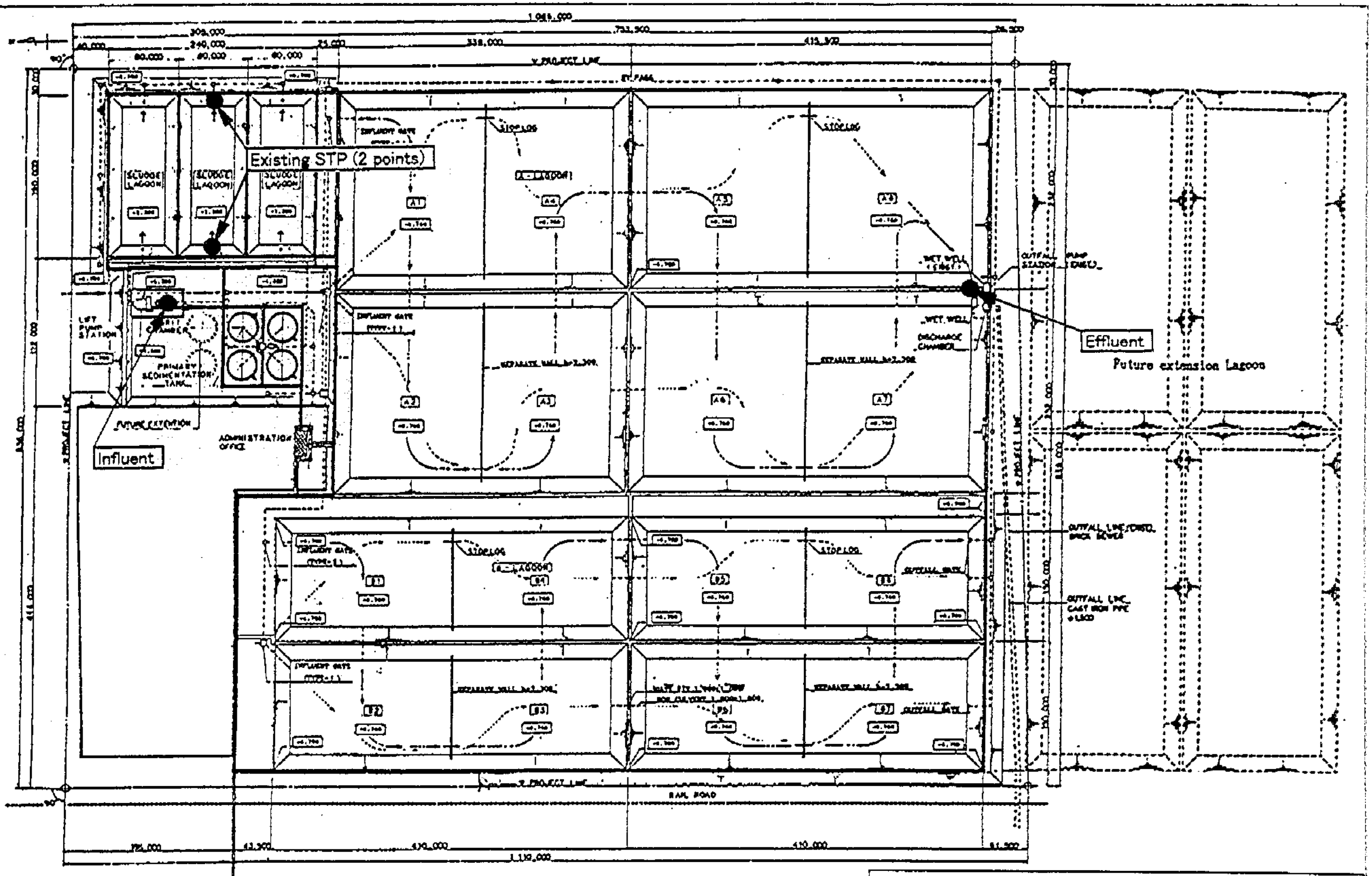


Figure 3.2.2 Loacal Map of Sampling Points (2)

The Study on the Sewerage System in North Dhaka

3.2.1 Contents of the Survey

(1) Domestic sewage quantity/quality survey

1) Survey points

Survey points were selected from three (3) different types of housings namely, detached house, apartment house and slum housings. One (1) point was chosen from each type; thus a total of three (3) points were selected as follows:

- Independent house : Concord, Gulshan-2
- Apartment house : DIT Colony, Uttara
- Slum house : Palpara ghat, Mirpur

Prior to the selection of survey points, the sewer/channel installation status was investigated. Survey points were extracted from the points where the number of houses or population served by the specific sewer/channel could be certified.

2) Survey date

	Rainy Season	Dry Season
Individual house	28,29 Jun., 1997	11,12 Jan., 1998
Apartment house	25,26 Jun., 1997	3, 4 Jan., 1998
Slum housing	29,30 Jun., 1997	2, 3 Jan., 1998

3) Method of sewage flow measurement and sampling

Sewage flow was calculated by measuring the time until specified container was filled up. Collected sewer in the container was utilised for sewage quality survey.

4) Analysis items of sewage quality survey

On-site and laboratory analysis items were as follows:

- On-site : Sewage flow, air temperature, sewage temperature, pH
- Laboratory : DO, BOD, COD, SS, Cl, T-N, T-P, Coliform group bacteria

(2) Domestic sewage quantity/quality survey

1) Type of industrial wastewater and survey point

- Wastewater from textile and dyeing factory : Tongi
- Wastewater from pharmaceutical factory : Tongi
- Mixed wastewater : At the outlet of truck sewer, Tongi

2) Survey date

24 June, 1997

3) Sampling method

Wastewater from textile/dyeing and pharmaceutical factories was taken at the outlet of discharge pipe to the drainage channel. Mixed wastewater was sampled at the drainage main outlet at the Tongi River.

4) Sewage quality analysis items

On-site and laboratory analysis items were as follows:

- On-site : Sewage flow, air temperature, sewage temperature, pH
- Laboratory : DO, BOD, COD, SS, Cl, T-N, T-P, Coliform group bacteria, and heavy metals (Cd, Hg, As, Pb, Cr, Cu, Zn, and Ni)

(3) Sewage quantity/quality survey in the Pagla sewage treatment plant

1) Survey point

- Influent : Grit chamber
- Effluent : Outlet of facultative lagoon

2) Survey date

Rainy season: 26, 27 June 1997

Dry season: 28, 29 December 1997

3) Method of sewage flow measurement and sampling

The sewage flow was calculated by multiplying the velocity and the sectional area of the channel or outlet chamber. Velocity was reckoned by the float method, measuring the time float flows down a certain distance. Sewage sampling was done by ladle.

4) Sewage quality analysis items

The on-site and laboratory analysis items were as follows:

- On-site : Sewage flow, air temperature, sewage temperature, pH
- Laboratory : DO, BOD, COD, SS, Cl, T-N, T-P, Coliform group bacteria, and heavy metals (Cd, Hg, As, Pb, Cr, Cu, Zn, Ni)

(4) Water quality survey for receiving water body

1) Survey point

a. Buriganga River

A water quality survey was carried out in the Buriganga River, the receiving water body of effluent from the Pagla STP. Two (2) survey points were set upstream and downstream of the effluent discharge point of Pagla. The China - Bangladesh Friendship Bridge, 1.5 km away from the discharge point, was selected as the up-stream point, the other point was set 0.5 km downstream of the discharge point.

b. Turag River

Two (2) sampling points near the Mirpur Bridge (downstream) and near the Dhaka Botanical Garden (upstream) of the proposed discharge point for treated effluent from the sewage treatment plant.

c. Balu River

One (1) sampling point, upstream from the confluence point of the Balu River and the Lakhya River.

d. Lakhya River

One (1) sampling point, downstream from the confluence point of the Balu River and the Lakhya River.

2) Survey date

Rainy season:	Buriganga River		26 June 1997
Dry season:	Turag River	Upstream	31 December 1997
		Downstream	30 December 1997
	Balu River		2 January 1998
	Lakhya River		3 January 1998

3) Sampling method

River water was taken by a sampler from the middle of the river.

4) Water quality analysis items

On-site and laboratory analysis items were as follows:

- On-site : Air temperature, water temperature, pH
- Laboratory : DO, BOD, COD, SS, Cl, T-N, T-P, Coliform group bacteria,

and heavy metals (Cd, Hg, As, Pb, Cr, Cu, Zn, and Ni)

(5) Sludge composition analysis

1) Survey point

- Sewage sludge : Sludge lagoon in the Pagla STP, inlet point (1) and farthest point from inlet point (1), total two (2) points
- Septic tank sludge : Eight (8) septic tanks in Uttara area

2) Survey date

- Sewage sludge : 27 June, 1997
- Septic tank sludge : 24 June, 1997

3) Sampling method

- Sewage sludge : Bottom sludge was taken by ladle
- Septic tank sludge : Ditto

4) Sludge analysis items

The analysis items were as follows:

Water content, SS, VSS, heavy metals (Cd, Hg, As, Pb, Cr, Cu, Zn, and Ni)

3.2.2 Results of the Survey and Analysis

(1) Domestic sewage quantity/quality survey

Survey results of domestic sewage quantity/quality are summarised in Table 3.2.1.

Table 3.2.1 **Survey Results of Domestic Sewage Quantity/Quality**

Description			Flow Rate (l/min)	Atom. Temp. (℃)	Water Temp. (℃)	pH (-)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	T-N (mg/l)	T-P (mg/l)	FC (MPN /100ml)	Cl (mg/l)
Rainy Season	Ind. House	Max.	86	31.6	31.1	7.7	4.0	42	115	350	1.6	0.7	1.1×10^6	115
		Min.	38	27.0	26.7	7.4	1.5	2	7	65	0.6	0.5	5.8×10^4	13
		Ave.	58	29.3	28.8	7.6	2.5	21	55	173	0.8	0.6	4.6×10^5	89
	Aprtmt. House	Max.	61	35.5	34.5	8.0	3.0	130	345	110	1.7	0.4	3.3×10^3	42
		Min.	0.5	29.7	29.4	5.2	1.1	10	20	40	0.1	0.1	5.0×10^4	11
		Ave.	38	33.1	32.4	7.1	2.3	40	93	55	0.6	0.3	1.9×10^6	20
	Slum House	Max.	75	33.0	32.0	10.4	3.2	70	195	74	0.5	0.5	2.3×10^6	43
		Min.	12	26.0	26.5	9.8	1.1	4	15	55	0.1	0.4	1.2×10^4	18
		Ave.	50	29.0	29.1	10.0	2.2	29	80	64	0.3	0.5	5.3×10^5	33
Dry Season	Ind. House	Max.	82	20.0	22.5	7.5	1.1	288	578	350	31.6	46.5	1.3×10^7	139
		Min.	7	12.5	14.0	6.8	0.9	31	62	110	19.7	23.1	9.2×10^5	93
		Ave.	50	16.0	18.5	7.1	1.0	191	383	236	27.8	33.6	7.6×10^6	110
	Aprtmt. House	Max.	76	25.0	24.0	8.0	3.6	496	1530	560	26.2	49.1	6.9×10^6	31
		Min.	6	13.0	17.5	7.2	0.8	115	354	70	12.4	14.9	4.5×10^5	22
		Ave.	47	18.0	21.0	7.5	2.3	221	683	258	21.9	32.7	3.0×10^6	25
	Slum House	Max.	160	22.0	24.5	7.5	1.3	394	681	130	26.5	79.7	1.4×10^7	71
		Min.	10	14.0	19.0	7.1	0.8	204	352	50	21.7	22.5	4.6×10^4	28
		Ave.	93	18.5	22.5	7.3	1.1	308	532	93	23.6	46.1	2.9×10^6	53

1) Domestic sewer flow

Survey points were selected from the area where the sewage is composed of domestic miscellaneous sewage, such as kitchen, washing, bathing and shower sewage, or effluent from septic tanks. The sewage flow fluctuations at each survey point are shown in the preceding Figures 3.2.3 and 3.2.4.

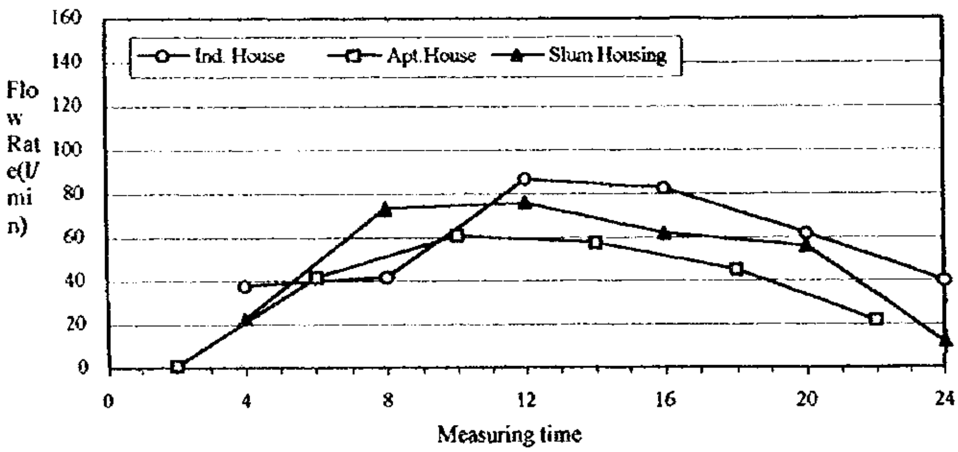


Figure 3.2.3 Fluctuation of Domestic Sewage Flow (Rainy Season)

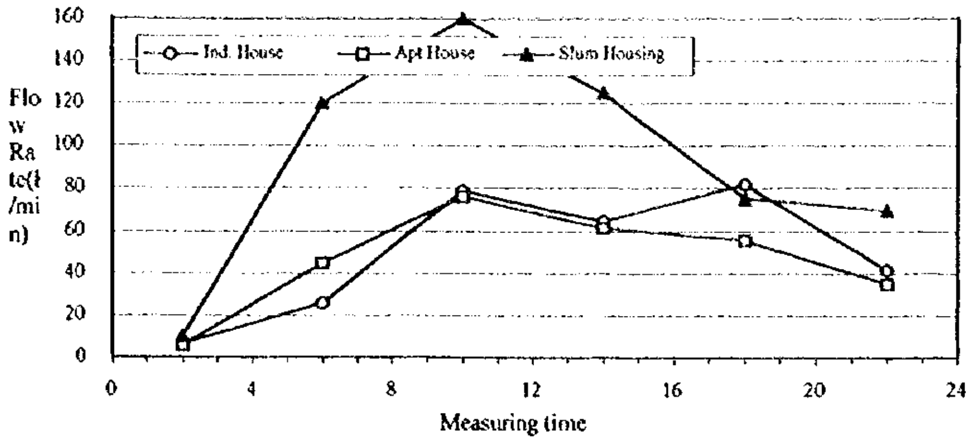


Figure 3.2.4 Fluctuation of Domestic Sewage Flow (Dry Season)

a. Rainy season

Every survey point indicated a majority of sewage flow during the daytime and hourly fluctuations corresponding to lifestyle of the contributing households. During the night time, about 20 to 40 l/min of sewage flow was observed, i.e. 24:00 at independent houses, 06:00 and 22:00 at apartment houses and 04:00 and 22:00 at slum houses; these sewage flows were considered to be caused by the inflow of non-domestic sewage.

Based on the above survey results and actual number of households in the survey area, the per capita sewage flow was estimated at 467 lpcd from independent houses, 249 lpcd from apartment houses, 249 lpcd from slum houses, and an average of 306 lpcd (for details, refer to Appendix 3.2.1). These figures are all larger than the actual water consumption.

b. Dry season

Sewage flow fluctuations in a day show a similar tendency. Although it was anticipated that sewage flow in dry season is less than that in rainy season, only independent houses showed such sewage flow, while apartment houses and slum houses showed larger sewage flow.

Per capita daily sewage flow was estimated based on the above mentioned survey results as follows (for details, refer to Appendix 3.2.2):

- Independent house 400 lpcd
- Apartment house 305 lpcd

- Slum houses 463 lpcd
- Average 397 lpcd

These survey results in both rainy season and dry season are considered to be influenced by inflow of surface/groundwater.

2) Domestic sewage quality

a. Rainy season

The analysis results of domestic sewage quality were evaluated in comparison with examples of Japan, as shown in Table 3.2.2.

Table 3.2.2 Example of Rural Sewage Quality in Japan

Item / Location	pH (-)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	T-N (mg/l)	T-P (mg/l)	FC (MPN /100ml)	Cl (mg/l)
A City	6.9	-	116	55	31	33	3.7	-	105
B City	7.3	-	62	40	19	11	1.2	-	103
C Town	7.5	2.3	46	28	15	10.3	1.6	20,000	92

Table 3.2.2 exhibits example analysis results of wastewater where no sewerage system exists. Water samples were collected from drainage channels wherein domestic sewage and effluent from septic tanks are discharged.

- The high pH values (9.8 to 10.4) measured in the slum house area were not caused by normal daily life patterns and were therefore deemed to be caused by the inflow of wastewater other than domestic sewage.
- BOD, T-N and Chloride are quite low.
- SS and COD were comparatively high, especially the SS of domestic sewage in the independent house area, which had a maximum of 350 mg/l and an average of 173 mg/l. The COD of domestic sewage was examined by means of $KMnO_4$ (potassium permanganate) method in Japan and was about half of the BOD figure. The COD analysis in this Study was conducted by means of $K_2Cr_2O_7$ (potassium dichromate) and generally showed had values approximately double of the BOD figure. The analysis results in this Study showed that COD is higher than the BOD at an average of 2.5 times.

As a whole, the drainage channels receiving domestic sewage and effluent from septic tanks in each survey area were deemed to have inflows of surface water run-off during the rainy season. As a result, some water quality indices were affected in terms of dilution and additional loading of SS occurred.

b. Dry season

All pH values measured in the dry season were within normal limits (7.1 to 8.0). Other water quality indices show relatively higher results than the rainy season; SS was 1.5 to 5 times higher, Cl 1.2 to 1.6 times higher; BOD, COD, T-N and T-P were 5 to 10 times higher. If the sewage flow in the dry season is less than the rainy season, these high values might be interpreted as reasonable. However, the flow rate measurement results at apartment houses and slum houses showed lower volumes than the rainy season and were inconsistent with water the quality analysis results.

Resultant from these survey results, the per capita daily pollution load was estimated at 7.1 gpcd for BOD and 31 gpcd for SS in the rainy season and 100 gpcd for BOD and 74 gpcd for SS in the dry season. These were considered unrealistic values.

(2) Industrial wastewater quality survey

The results of industrial wastewater quality survey are shown in Table 3.2.3.

Table 3.2.3 Analysis Results of Industrial Wastewater

Factories \ Item	Atmos Temp. (C)	Temp. (C)	pH (-)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	T-N (mg/l)	T-P (mg/l)	FC (MPN /100ml)
Textile/Dyeing	30.5	37.2	10.7	0.6	140	260	227	4.1	0.3	11,000
Pharmaceutical	32.7	31.9	5.6	1.4	200	317	150	1.1	0.6	65,000
Mixed Sewage	32.5	35	10.1	0.5	180	380	298	0.5	0.2	13,000

Factories \ Item	CL (mg/l)	Cd (mg/l)	Hg (mg/l)	As (mg/l)	Pb (mg/l)	Cr (mg/l)	Cu (mg/l)	Zn (mg/l)	Ni (mg/l)
Textile/Dyeing	100	0.02	0.01	<0.05	<0.01	0.025	1.01	0.04	1.5
Pharmaceutical	13	0.02	<0.01	0.05	<0.01	0.020	1.19	0.09	0.04
Mixed Sewage	100	0.03	0.03	0.15	<0.01	0.021	1.17	0.07	2.0

The analysis results of the industrial wastewater and the mixed sample show similar water quality characteristics. A remarkable difference was seen in the pH values from the textile/dyeing samples and the mixed industrial wastewater showed alkaline conditions of pH>10, while pharmaceutical wastewater was acidic at pH 5.6.

The typical industrial wastewater quality of dyeing and pharmaceutical industries in Japan is exhibited in Table 3.2.4. When the survey results and these examples are compared, T-N and T-P are relatively smaller than the Japanese examples, while the rest of the water quality indices were within the normal range.

Table 3.2.4 Typical Industrial Wastewater Quality in Japan

Indices / Factories	pH (-)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	T-N (mg/l)	T-P (mg/l)
Dyeing	3-11	10-350	300	20-250	25	10
Pharmaceutical	2-11	40-2,500	317	200-600	80-100	10-20

These industrial wastewater qualities of BOD, COD and SS were about 10 times greater than that of domestic sewage and the Buriganga River. It was similar to the sewage inflowing at the Pagla STP. Although the national regulation requires the installation of wastewater treatment facilities at factories, there seems to be no particular treatment facilities installed/operated and appropriate measures are required to prevent further environmental pollution in the Tongi River.

When referred to the "Standard Values for Industrial Effluent" of Bangladesh, the analysed industrial wastewater exceeded the standards for pH, DO, BOD, COD, SS and coliform group bacteria.

(3) Sewage quantity/quality survey in the Pagla STP.

The results of sewage quantity/quality survey on influent/effluent of Pagla STP are shown in Tables 3.2.5 and 3.2.6.

1) Inflow sewage volume

The hourly fluctuation of inflow sewage volume measured 6 times a day (4-hour interval) is exhibited in Figure 3.2.5.

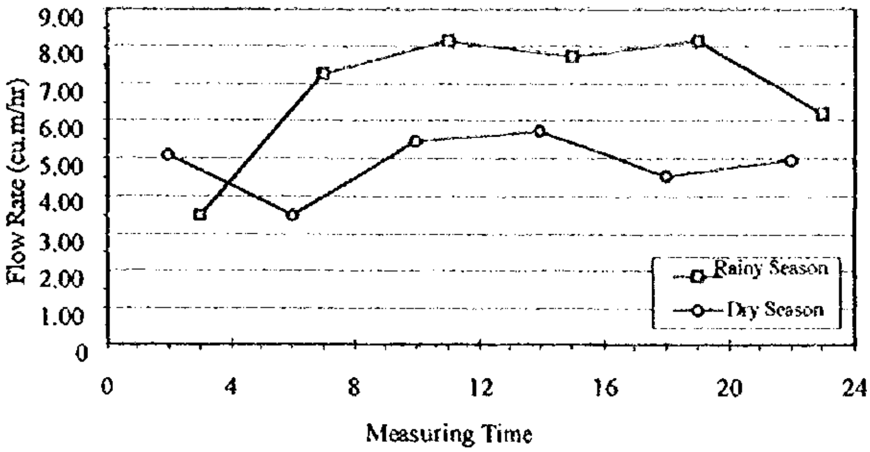


Figure 3.2.5 Hourly Fluctuation of Inflow Sewage Volume at the Pagla STP

Table 3.2.5 Influent and Effluent Quality of Pagla Sewage Treatment Plant in Rainy Season

Item / Sample	Time	Flow Rate (cu.m/hr)	Atom. Temp. (℃)	Water Temp. (℃)	pH (-)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	T-N (mg/l)	T-P (mg/l)
Influent	3:00	3,480	22.5	23.3	8.5	0.20	150	144	370	0.60	0.44
	7:00	7,260	24.5	25.0	8.1	0.40	110	432	180	0.66	0.35
	11:00	8,160	25.5	26.5	8.2	0.33	900	1,368	380	0.47	0.38
	15:00	7,740	25.2	26.5	7.9	0.45	290	504	350	0.32	0.41
	19:00	8,160	24.5	26.0	8.2	0.52	390	720	330	1.00	0.38
	23:00	6,180	24.0	25.5	8.1	0.30	130	288	270	0.30	0.45
	Max.	8,160	25.5	26.5	8.5	0.52	900	1,368	380	1.00	0.45
	Min.	3,480	22.5	23.3	7.9	0.20	110	144	180	0.30	0.35
	Ave.	6,830	24.4	25.5	8.2	0.40	328	576	313	0.56	0.40
Effluent		1,590	25.5	26.0	8.8	0.42	232	576	90	0.15	0.35
Item / Sample	**Time**	**FC (MPN /100ml)**	**Cl (mg/l)**	**Cd (mg/l)**	**Hg (-)**	**As (mg/l)**	**Pb (mg/l)**	**Cr (mg/l)**	**Cu (mg/l)**	**Zn (mg/l)**	**Ni (mg/l)**
Influent	3:00	$8.0x10^4$	70	0.03	0.03	<0.05	<0.01	<0.01	0.37	0.04	0.09
	7:00	$9.5x10^4$	90	0.03	0.02	<0.05	<0.01	0.06	0.53	0.09	1.20
	11:00	$3.5x10^5$	100	0.02	0.02	<0.05	<0.01	0.10	0.32	0.05	1.80
	15:00	$6.0x10^5$	80	0.01	0.02	0.10	<0.01	<0.01	1.33	0.09	0.03
	19:00	$5.2x10^5$	80	0.01	0.02	0.10	<0.01	<0.01	1.54	0.05	1.00
	23:00	$5.0x10^4$	70	0.01	<0.01	<0.05	<0.01	<0.01	2.12	0.07	0.07
	Max.	$6.0x10^5$	100	0.03	0.03	0.10	<0.01	0.10	2.12	0.09	1.80
	Min.	$5.0x10^4$	70	0.01	0.02	<0.05	<0.01	<0.01	0.32	0.04	0.03
	Ave.	$2.8x10^5$	82	0.02	0.02	0.10	<0.01	0.08	1.04	0.07	0.70
Effluent		$4.0x10^4$	80	0.03	0.04	<0.05	<0.01	0.10	0.58	0.04	2.50

Table 3.2.6 **Influent and Effluent Quality of Pagla Sewage Treatment Plant in Dry Season**

Item / Sample	Time	Flow Rate (cu.m/hr)	Atom. Temp. (℃)	Water Temp. (℃)	pH (-)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	T-N (mg/l)	T-P (mg/l)
Influent	3:00	5,080	27.0	26.0	7.1	1.20	136	290	300	58.0	75
	7:00	3,520	28.5	25.5	6.5	0.41	148	539	320	55.1	70
	11:00	5,450	28.0	26.0	6.9	0.56	221	3,520	470	59.3	75
	15:00	5,740	28.0	26.0	6.8	0.69	569	832	960	57.4	65
	19:00	4,520	26.0	24.0	5.9	0.80	210	660	380	48.6	80
	23:00	4,920	26.0	28.0	7.0	0.72	316	1,100	310	43.5	70
	Max.	5,740	28.5	28.0	7.1	1.20	569	3,520	960	59.3	80
	Min.	3,520	26.0	24.0	5.9	0.41	136	290	300	43.5	65
	Ave.	4,872	27.3	25.9	6.7	0.70	267	1,157	457	53.7	73
Effluent (Pump Chamber)	10:00	1,407	26.5	22.0	7.6	2.30	181	196	95	31.3	83
	14:00	1,249	27.0	24.0	7.9	1.10	130	828	180	35.3	75
	18:00	1,317	21.0	22.0	8.2	1.40	124	392	125	30.9	75
Effluent (Fac. Pond)	11:00	-	-	-	7.9	4.10	70	102	42	21.8	12
	11:00	-	-	-	7.9	3.80	66	96	47	26.3	10

Item / Sample	Time	FC (MPN /100ml)	Cl (mg/l)	Cd (mg/l)	Hg (-)	As (mg/l)	Pb (mg/l)	Cr (mg/l)	Cu (mg/l)	Zn (mg/l)	Ni (mg/l)
Influent	3:00	2.7×10^6	131	0.050	0.020	<0.01	0.34	0.02	1.6	1.4	0.25
	7:00	3.0×10^5	125	0.070	0.040	0.02	0.34	<0.01	4.8	0.9	0.06
	11:00	3.1×10^5	116	0.044	0.025	0.01	0.57	<0.01	1.5	1.1	0.12
	15:00	3.3×10^5	127	0.050	0.020	<0.01	0.57	<0.01	3.1	0.9	0.03
	19:00	$3.2\text{-}10 \times 10^5$	142	0.017	0.015	<0.01	0.54	0.01	1.6	1.5	0.04
	23:00	2.9×10^6	122	0.035	0.030	<0.01	0.42	<0.01	2.0	1.3	0.01
	Max.	2.9×10^6	142	0.070	0.040	0.02	0.57	0.02	4.8	1.5	0.25
	Min.	3.0×10^5	116	0.017	0.015	0.01	0.34	0.01	1.5	0.9	0.01
	Ave.	1.1×10^6	127	0.040	0.030	0.02	0.46	0.02	2.4	1.2	0.09
Effluent (Pump Chamber)	10:00	1.5×10^5	133	0.043	0.030	0.01	0.23	0.01	6.2	1.2	0.03
	14:00	2.5×10^5	94	0.045	0.030	<0.01	0.30	0.02	2.1	0.5	0.08
	18:00	2.4×10^5	138	0.048	0.025	<0.01	0.35	0.01	1.9	0.6	0.02

a. Rainy season

The hourly fluctuation of the inflow sewage volume showed that about 8,000 cu.m/hour was seen during daytime, while 3,500 cu.m/hour was recorded at 3:00 of midnight. The hourly average sewage inflow through the day was about 6,830 cu.m/hour, which is equivalent to 164,000 cu.m/day. However, the actual inflow volume in a day was far less than this figure since the operation of the lift pump at the treatment plant was suspended during the night due to the decrease of sewage flow.

b. Dry season

Hourly fluctuation was evident in that the daytime sewage inflow is within the range of 5,000 to 6,000 cu.m/hr, while the night-time flow decreased to 3,500 to 5,000 cu.m/hr.

The average hourly sewage inflow was calculated at 4,870 cu.m/hr, which is about 70% of the inflow of the rainy season. The same tendency was also seen in the actual performance data from 1996. The sewage inflow in December and January was about 60 to 70% of the sewage inflow in June.

2) Inflow sewage quality

a. Rainy season

The highest BOD value of 900 mg/l was observed at 11:00, while the rest of the day showed 110 to 390 mg/l. The overall average of BOD was of 328 mg/l and the average BOD excluding the data at 11:00 was 214 mg/l. COD measured at 11:00 was also as high as 1,368 mg/l.

SS was within the range of 180 to 313 mg/l and average was 313 mg/l, while pH ranged from 7.9 to 8.5 with an average of 8.2 at relatively alkaline side of raw sewage.

T-N was within the range of 0.3 to 1.0 mg/l with an average of 0.56 mg/l. T-N concentration in raw sewage of separate sewer system in Japan is about 30 mg/l and the T-N measured in this Study in about 1/50 of Japan.

T-P was within the range of 0.35 to 0.45 mg/l with an average of 0.40 mg/l. Japanese examples of T-P are few milligrams per litre and T-P measured in this Study is about 1/10 of Japanese examples.

The example data of heavy metals in the influent of sewage treatment plants in Japan are summarised in Table 3.2.7.

Table 3.2.7 Example Data of Heavy Metals of Influent at Sewage Treatment Plants in Japan

Unit: mg/l

Item \ Index	Cd	Hg	As	Pb	Cr	Cu	Zn	Ni
Maximum	0.00222	0.00087	0.0025	0.088	0.0049	0.038	0.290	0.0074
Minimum	0.00010	0.00014	0.0006	0.001	0.0002	0.014	0.100	0.0002
Average	0.00083	0.00045	0.0012	0.014	0.0015	0.023	0.142	0.0029
No. of Data	25	33	25	28	29	28	36	14

Pb and Zn of the analysis results were lower than the above Japanese examples, while other heavy metals were 10 to 100 times higher than the Japanese examples.

With regard to As concentration, four out of the total 6 samples were lower than the minimum limit of examination at 0.05 mg/l, while the remaining two samples showed 0.1 mg/l.

b. Dry season

BOD showed high concentrations in the daytime at 569 mg/l, as experienced in the rainy season. The average BOD was 267 mg/l and the data varied from 136 mg/l to 316 mg/l. Excluding the datum of 569 mg/l, the remaining data showed an average of 206 mg/l, which was almost equivalent to that of the rainy season.

SS was within the range of 300 to 960 mg/l and its average at 457 mg/l was about 1.5 times of the average value in the rainy season.

An average pH was 6.7, which was 1.4 lower than that of rainy season. Measured data varied from 5.9 to 7.9.

T-N values were within the range of 43.5 to 59.3 mg/l and its average was 53.7 mg/l, which was about 100 times higher than the rainy season and similar to the raw sewage of separate sewer systems in Japan.

T-P values varied from 65 to 80 mg/l and showed an average of 73 mg/l. The average value was about 200 times higher than the rainy season and about 10 times higher than the Japanese examples.

Heavy metals showed the following results:

- Pb and Zn in dry season were 10 times larger than that of rainy season which was lower than Japanese example, while Ni was 1/10 of the rainy season.
- Other items in heavy metals were more or less similar results.
- As showed 0.01 and 0.02 mg/l in a total 6 samples.
- As a whole, all items of heavy metals were 10 to 100 times higher than Japanese examples.

Taking into account that the sewage inflow in the dry season was about two-thirds (2/3) of the rainy season, the SS and Cl of the dry season were one and one-half (3/2) times higher than the rainy season. On the other hand, the BOD in the dry season was similar to rainy season and the COD in the dry season was about double the rainy season values. T-N and T-P in the dry season were five (5) times and 200 times higher than that of the rainy season, respectively. However, no particular reason on large difference of T-N and T-P between rainy season and dry season could be found from these survey results.

3) Effluent quality

Effluent quality in rainy season was as follows:

- pH 8.8,
- BOD 232 mg/l,
- COD 576 mg/l, and
- SS 90 mg/l.

Both BOD and COD in the effluent are more or less similar to that of the influent. Even if treatment efficiency is taken into account, the effluent quality is deemed to be high. With regard to SS (90 mg/l in the effluent) showed a 71% removal efficiency over the average figure of the influent (313 mg/l), but it was still considered a high concentration.

The average figures of three samples obtained in the dry season were pH 7.9, BOD 145 mg/l, COD 472 mg/l, and SS 133 mg/l. When compared with the same data of the rainy season, the SS of the dry season is relatively high, while the rest of the water quality indices were low.

The above-mentioned unrealistic results were assumed to be caused by the floatation of sediments from the bottom of the pump pit at the discharge pump station. Especially during the dry season, discharge pumps are operated very seldom and accumulated sediments are floated by the pumps' suction force. In addition, during the operation of discharge pump, the inflow velocity of treated sewage from the facultative pond into the pump pit is quite fast and a considerable amount of sediments from the facultative pond is assumed to be brought into pump pit.

Additional water sampling during the dry season was carried out at the end of the facultative pond, which is the entrance to the pump pit when the pump is not operated. Two additional samples showed 70 and 66 mg/l of BOD, 102 and 96 mg/l of COD, 42 and 47 mg/l of SS, respectively. A visual observation of the collected samples gave the impression of better effluent quality than the said analysis results in terms of turbidity and SS content.

Concentration of heavy metals in effluent varied in comparison to that in influent, but drastic difference was not seen.

(4) Water quality of receiving water body

Water quality analysis results of receiving water body are shown in Table 3.2.8.

Table 3.2.8 Water Quality Analysis Results of Receiving Water Body

Sampling Point \ Item			Atom. Temp. (℃)	Water Temp. (℃)	pH (-)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	T-N (mg/l)	T-P (mg/l)	FC (MPN /100ml)
Buriganga River	Upstream		24.5	24.0	8.8	10.1	18	54	60	0.22	0.22	$2.5x10^4$
	Downstream		24.5	25.0	8.5	9.9	18	52	50	0.80	0.20	$9.0x10^3$
Turag River	Up-stream	10:00	22.0	23.0	8.2	7.5	21	64	65	8.5	3.0	$1.0x10^5$
		14:00	23.0	24.5	8.3	6.8	12	160	70	8.7	2.0	$1.5x10^4$
		18:00	21.0	23.0	8.2	6.3	17	128	65	5.2	2.5	$1.6x10^4$
	Down-stream	10:00	22.0	21.0	8.1	5.0	26	160	90	6.2	2.5	$2.5x10^4$
		14:00	23.0	24.0	8.1	5.7	18	96	105	7.9	3.2	1.1x104
		18:00	20.5	21.5	8.8	5.5	32	140	70	7.3	3.0	$2.3x10^4$
Balu River		10:00	20.5	20.0	8.2	5.9	25	108	210	6.4	7.0	$1.5x10^4$
		14:00	21.0	21.0	8.3	6.2	30	132	120	5.5	6.8	$1.7x10^4$
		18:00	20.0	20.0	8.0	6.0	24	61	110	7.0	6.6	$1.0x10^5$
Lakhya River		10:00	20.0	21.0	8.2	5.8	22	36	140	7.7	3.5	$8.0x10^3$
		14:00	22.0	22.5	8.3	5.4	25	32	280	8.2	4.0	$7.5x10^3$
		18:00	20.0	20.5	8.3	5.7	30	32	90	6.7	3.0	$6.0x10^4$

Table 3.2.8 Water Quality Analysis Results of Receiving Water Body (Continued)

Sampling Point		Item	Cl (mg/l)	Cd (mg/l)	Hg (mg/l)	As (mg/l)	Pb (mg/l)	Cr (mg/l)	Cu (mg/l	Zn (mg/l)	Ni (mg/l)
Buriganga River	Upstream		5.0	0.010	<0.01	<0.01	<0.01	0.10	1.06	0.07	0.10
	Downstream		4.0	0.030	<0.01	<0.01	<0.01	0.10	0.37	0.04	0.03
Turag River	Up-stream	10:00	11.4	0.045	<0.01	<0.01	0.30	<0.01	0.28	0.3	<0.01
		14:00	12.1	0.038	<0.01	<0.01	0.25	<0.01	0.17	0.4	<0.01
		18:00	10.8	0.052	<0.01	<0.01	0.30	<0.01	0.30	0.6	0.01
	Down-stream	10:00	12.6	0.030	<0.01	<0.01	0.28	<0.01	0.30	0.6	0.02
		14:00	11.7	0.052	<0.01	<0.01	0.31	0.01	0.42	0.7	0.04
		18:00	13.8	0.070	<0.01	<0.01	0.30	0.01	0.37	0.5	0.03
Balu River		10:00	8.7	0.076	0.02	<0.01	0.25	0.02	0.25	0.3	0.02
		14:00	7.8	0.070	0.01	<0.01	0.34	0.02	0.15	0.6	<0.01
		18:00	8.9	0.080	0.02	<0.01	0.23	<0.01	0.10	0.9	0.01
Lakhya River		10:00	9.2	0.080	<0.01	<0.01	0.12	<0.01	0.25	0.8	<0.01
		14:00	12.8	0.033	<0.01	<0.01	0.18	<0.01	0.15	0.4	<0.01
		18:00	10.1	0.080	<0.01	<0.01	0.23	<0.01	0.20	0.3	<0.01

1) Buriganga River

Almost no difference was observed in the analysis results between upstream and downstream as shown below.

Sampling Point \ Item	BOD (mg/l)	COD (mg/l)	SS (mg/l))
Upstream	18	54	60
Downstream	18	52	50

In other water quality indices, remarkable differences were seen on T-N as 0.22 mg/l in upstream and 0.8 mg/l in downstream and on Cd as 0.01 mg/l in upstream and 0.03 mg/l in downstream, respectively.

Coliform group bacteria, Cu, Zn and Ni in downstream were higher than that in upstream.

Although the effluent quality of the Pagla STP was higher than the water quality in upstream of the Buriganga River, except for T-N and Cu, no significant influence to water quality in downstream was observed, owing to the differences of flow rates between the Buriganga River and the effluent from the Pagla STP.

2) Turag River

Average values of major water quality indices in upstream were 17 mg/l of BOD, 117 mg/l of COD, 67 mg/l of SS and 2.5 mg/l of T-N. Downstream, BOD, COD, SS, T-P and Cl were 1.1 to 1.5 times higher than that of upstream, while T-N was slightly lower than upstream.

Major reason on poorer water quality in downstream is deemed to be caused by discharge of untreated domestic sewage and industrial wastewater from Mirpur area into the Turag River.

3) Balu River

Average figures of three samples were 26 mg/l of BOD, 100 mg/l of COD, 147 mg/l of SS, 6.3 mg/l of T-N and 6.7 mg/l of T-P, respectively. BOD, SS and T-P in the Balu River showed the highest values among the receiving water bodies.

4) Lakhya River

The average figures of three samples were 26 mg/l of BOD, 33 mg/l of COD, 170 mg/l of SS, 7.5 mg/l of T-N and 3.5 mg/l of T-P, respectively.

The "Standard Values for Water" have been established for seven (7) different water uses, i.e. drinking water supply, irrigation, and livestock breeding in Bangladesh. Organic impurities of six (6) sampling points in four (4) rivers exceeded the standard values for these seven purposes.

With regard to heavy metals, Cd, Pb, Cu and Zn in four (4) sampling points in three (3) rivers during the dry season exceeded the standard values, while As at all sampling points was below the standard value.

(5) Sludge composition analysis

Analysis results of sludge composition were shown in Table 3.2.9. Samples from the sludge lagoon at the Pagla STP were collected at the inflow point and the farthest location from the inflow point. Analysis results of these two samples showed remarkable differences on effects of sludge decomposition as follows:

- Inflow point showed high organic content at 92.9% and high water content at 90%.
- The farthest location from inflow point showed low organic content as low as 53.6% and water content at 53.3%.

Although an effect of biological concentration of heavy metals was anticipated, the farthest location from inflow point showed lower values of heavy metals than that the inflow point.

Table 3.2.9 Analysis Results of Sludge Composition

Sampling Point		Item: SS (mg/l)	VSS (%)	T-N (mg/l)	T-P (mg/l)	Heavy Metals (mg/kg): Cd	Hg	As	Pb	Cr	Cu	Zn	Ni
Pagla STP	No. 1*	533,000	53.6	0.062	0.026	0.28	0.43	0.75	54	125	867	2,238	43
	No. 2*	100,000	92.9	0.059	0.031	2.3	5.2	8.00	407	633	11,440	7,060	390
Septic Tank	No. 3	600	-	2.28	0.61	250	33	-	-	-	1,970	80	20
	No. 4	120	-	1.17	0.62	-	167	-	-	83	8,500	250	250
	No. 5	490	-	4.92	0.64	-	41	-	-	41	3,570	90	41
	No. 6	150	-	1.34	0.42	133	200	-	-	67	6,530	270	133
	No. 7	200	-	18.26	0.70	50	100	300	-	150	5,100	150	150
	No. 8	115	-	2.19	0.49	-	87	-	-	174	6,520	220	174
	No. 9	170	-	1.68	0.45	59	118	-	-	-	8,240	290	118
	No. 10	120	-	1.05	0.21	125	83	417	-	167	10,000	290	83

Note: No.1- The farthest location from inflow point of sludge lagoon
No.2- Inflow point of sludge lagoon

As reference information, the above mentioned analysis results were compared with the Japanese technical standards for utilisation of sludge as fertiliser, as shown in Table 3.2.10. As and Cd were below the allowable limits, but Hg was exceeding the allowable limit.

Table 3.2.10 Comparison of Analysis Results and Japanese Standards

Unit: mg/kg-dry sample

Parameter	Allowable Limit for Utilisation as Special Fertiliser	Analysis Results of Sewerage Sludge: No. 1	No. 2
As	< 50	0.75	8.00
Cd	< 5	0.28	2.3
Hg	< 2	0.43	5.2

Note: No.1- The farthest location from inflow point of sludge lagoon
: No.2- Inflow point of sludge lagoon

CHAPTER 4

POSSIBLE RECEIVING WATER BODIES

CHAPTER 4 POSSIBLE RECEIVING WATER BODIES

4.1 Balu River

Compared to the Buriganga River and the Lakhya River, the Balu River is considered to be a small river. The Balu River covers the northeastern periphery of Dhaka City, collects water from the Old Bhrampura River, and empties into the Lakhya River near Demra. The Balu River is also connected to the Tongi River. The Demra area is on the western bank of the Balu River and the Rupgonj is on the eastern bank.

The most important characteristic of the Balu River is tidal; this characteristic becomes dominant throughout the dry season. The tidal effect is felt not only by the upstream rivers but also by the back flow from the downstream rivers and the Bay of Bengal as well. During the dry season, it is only the tidal effect that causes the rivers to flow when the downstream flow is nearly nil. The physical characteristics of the Balu River are shown below.

Table 4.1.1 Characteristics of Balu River

Length Around Dhaka City (km)	Width (m)	Bed Level (m + PWD)	Mean Annual Max. Water Level of Adjacent Flood Plain Area		Mean Annual Mean Water Level of Adjacent Flood Plain Area		Mean Annual Min. Water Level of Adjacent Flood Plain Area	
			WL (m + PWD)	Area (sq.km)	WL (m + PWD)	Area (sq.km)	WL (m + PWD)	Area (sq.km)
22	40-75	0 to -2	5.67	105	2.83	26	0.81	0

4.1.1 Balu River Water Quality

As a preface, it should be noted that most of the water quality studies carried out in Dhaka have concentrated on the major rivers adjacent to the city (i.e. the Buriganga River) and very few studies have been done on the smaller rivers.

The water quality of the Balu River is affected by its location on the periphery of Dhaka City, as a large amount of domestic and industrial wastewater is discharged into the Balu River. During the dry season, the sewage discharge is concentrated due to the reduction in natural flow of the river, accordingly the water quality condition of the river degrades considerably. The tidal nature of the river also contributes to the poor water quality, because the tidal effects can cause the pollutants to be moved upstream as well as downstream. Moreover, as only a very small portion of the pollution load discharged into the rivers of Dhaka City is treated, raw sewage is the norm.

The largest pollutant source to the Balu River is the combined discharge of the Paribagh Khal and the Bengun Baria Khal. These two khals are highly enriched with seriously polluted industrial wastewater from the Tejgaon industrial area as well as domestic sewage. Although the Paribagh and Bengun khals are the largest discharge source, the fact is that nearly all domestic and industrial pollutants of Dhaka City are ultimately discharged into the rivers surrounding the city. A description of the pollutant loading into the Balu River from several drainage channels as well as industrial areas is summarized in Tables 4.1.2.

Table 4.1.2 Discharge Pathways for Drainage Zones

Drainage Zone	Area (sq.km)	Drainage Route
Banabo	7.46	Bengunbari Khal/Nomai Khal/Balu River
Northeast	13.93	Northeastern flood plain/Balu River
Bengunbari Khal	13.70	Paribagh Khal/Begunbari Khal/Nomai Khal/ Balu River
Gulshan Banani	17.64	Gulshan + Mohakhalli/Bengunbari Khal/ Nomai Khal/Balu River

Table 4.1.3 Domestic Pollution Loads by Drainage Zone

Drainage Zone	BOD (ton/day)	TSS (ton/day)	TDS (ton/day)	Flow (cu.m/day)
Banabo	10	10	27	14,000
Northeast	2	2	7	20,000
Bengunbari Khal	26	26	71	37,000
Gulshan Banani	9	9	26	21,000

Source: Browder 1992

A recent water quality analysis of the Balu River 30 feet ahead of the main discharge point of the Tongi Paper & Pulp Mill (approximately 12 km upstream from the North Dhaka East area) by the DOE in October 1997 showed that pH, BOD and COD are 6.7, 2.80 mg/l and 1.98 mg/l, respectively. The water inside the discharge drain had a pH of 6.8, a BOD of 2.90 mg/l and a COD of 7.30 mg/l.

A dissolved oxygen (DO) profile downstream (Chisty & Sohel, 1995) of the Tongi Khal shows that near the Balu River the DO value rise very quickly. It could be surmised that this phenomenon is due to the dilution effect of the Balu River upstream. In this regard, it could also be hoped that the DO level of the Balu River would be better for a significant distance upstream of the confluence with the Tongi Khal.

Downstream of the Balu River however, where the Paribagh Khal is met, the water quality is quite poor. During field visits to the area, it was observed that at the ebb tide period during the dry season (at the point where the Paribagh Khal joins the Balu River), the water quality became so poor that people avoided using the water until the next flood tide would bring "fresh" water from downstream to disperse the polluted water from the Paribagh Khal.

In conclusion, it can be held that the Balu River upstream of the Paribagh Khal up to Lakhya River suffers from high levels of pollutant loading during the dry season as to render the river water unusable for water supply purposes.

4.1.2 Balu River Quantity

The Balu River is hydraulically connected with the larger Sitalokya and Tongi Rivers at their downstream reaches in the Study Area. The Lakhya River and the Tongi River are also inter-related with the Buriganga, Bhrammoputro and the Turag rivers.

The Bangladesh Water Development Board (BWDB) is responsible for measuring the discharge of most of the rivers in Bangladesh. The gauging station of the BWDB measures both water level and discharge for the Balu River and the Turag River and only a water level for the Tongi River (khal). Unfortunately, however, the discharge measurement carried out by the BWDB was only done during non-tidal periods. This ignores the fact that from the water availability point of view, the dry season is the most critical period (during which the rivers are completely tidal).

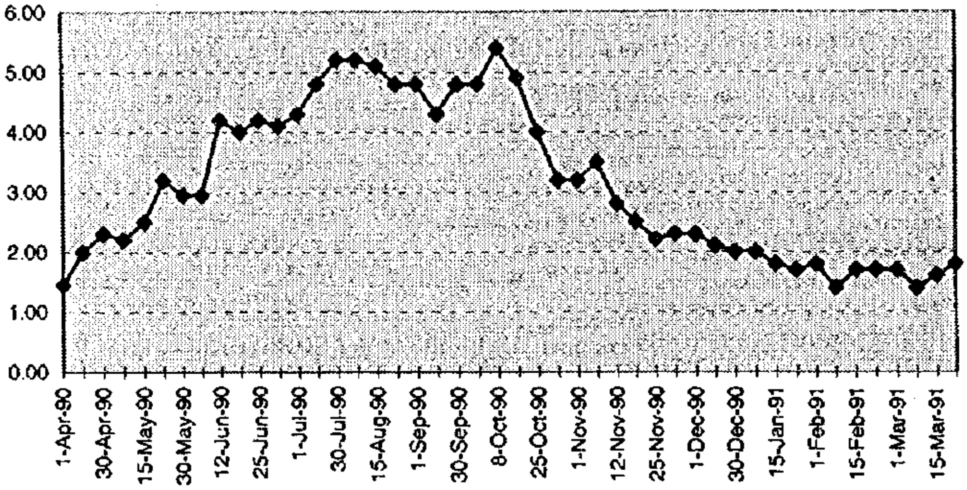
A schematic model analysis of the discharge data has been conducted at some sections of the Balu River for some brief periods. The flow nature of the Balu River is tidal and during the driest periods, the net flow (i.e. the net upstream flow) is almost zero. The details of the flow data for the Balu River are as follows:

Balu River, Branch No. 9

Width:	50 to 75 m
Bottom Level:	-1 to -4 m + PWD
Driest Low Water Level:	0.75 to 1.0 m + PWD
Driest Flood Tide Peak Discharge:	25 to 35 cu.m/sec
Driest Ebb Tide Peak Discharge:	20 to 30 cu.m/sec
Net Flow:	nearly zero

The historical water level of the Balu River (WL9C 7.5 Demra) from 1990 to 1991 is shown below.

Figure 4.1.1 Water Level (in meters) of Balu River from 1990 to 1991



4.1.3 Balu River Water Uses

Like all rivers in Bangladesh, the Balu River is utilized for multiple purposes. In the Study Area, the uses are as detailed below.

- Domestic: bathing, working, drinking (when shallow wells go dry) washing, etc.
- Livestock: often the only source for livestock watering in the project area
- Irrigation: small-scale only
- Industrial: few small-scale enterprises
- Navigation: major transport route for people and goods in Dhaka year-round

4.2 Tongi River (Khal)

The Tongi River is situated along the southern boundary of the Tongi Pourashava. In actuality, the local people call it the Tongi Khal due to the river's small width and length (around 14 km). In fact the river acts as a connecting canal for the Turag River in the west and the Balu River in the east. The characteristics of the Tongi River are as follows:

Table 4.2.1 Characteristics of Tongi River

Length Around Dhaka City (km)	Width (m)	Bed Level (m + PWD)	Mean Annual Max. Water Level of Adjacent Flood Plain Area		Mean Annual Min. Water Level of Adjacent Flood Plain Area
			WL (m + PWD)	WL (m + PWD)	WL (m + PWD)
6	50-75	-1 to -4	5.58	2.59	0.44

4.2.1 Tongi River Quality

An investigation was carried out on the Tongi River in 1995 (during the dry period) by Rezwan and Sohel. The resulting DO profile for the dry period showed that along the entire reach of the Tongi River, the DO value is below critical levels. This is a strong indicator of deteriorating water quality. It can be assumed that this is due to the industrial wastewater being discharged from the Tongi industrial estate.

4.2.2 Tongi River Quantity

The quantity of the Tongi River is nearly zero during the driest periods, as shown in several field experiments done for the Emergency Water Supply Project under the WB. The findings of the study revealed the following:

- Width: 30-75 m
- Bottom Level: 0.2 to -2 + PWD
- Driest Low Water Level: 0.6 to 0.9 m + PWD
- Driest Flood Tide Peak Discharge: 8 to 12 cu.m/sec
- Driest Ebb Tide Peak Discharge; 5 to 10 cu.m/sec
- Net Flow: Nearly zero

4.2.3 Tongi River Water Uses

The Tongi is used for the following uses:

Domestic:	The water use of the Tongi River for domestic purposes is common both during the rainy and dry seasons. These uses are mainly confined to bathing and cleaning work.
Commercial/Industrial:	River water is used for the cleaning of garages, vehicles, etc. and other industrial cleaning work.
Navigation:	A vital role in the transportation network of the area as it is one of the main connecting routes between the eastern and western portions of Dhaka City.
Irrigation	There are no major irrigation projects bordering the Tongi River and small-scale vegetable and rice farms utilize the water from the river however.
Water Supply:	There are currently some proposals to use water from the down-stream of the Tongi River, near the Balu River, as part of a sur-face water supply scheme. The flow and geometry of the river make this feasible only in dire circumstances.

4.3 Turag River

The Turag River has a total length of 75 km and flows near the northwestern boundary of Dhaka City. It collects its water from the Bangshi and ends in the Buriganga. The river flows along the border of the Mohamadpur, Duripur, Digun areas. The characteristics of the Turag River are shown below.

Table 4.3.1 Characteristics of Turag River

Length Around Dhaka City (km)	Width (m)	Bed Level (m + PWD)	Mean Annual Max. Water Level of Adjacent Flood Plain Area		Mean Annual Min. Water Level of Adjacent Flood Plain Area
			WL (m + PWD)	WL (m + PWD)	WL (m + PWD)
20	50-150	-7 to -3	5.67	2.80	0.77

4.3.1 Turag River Quality

The river quality and the circumstances of the Turag River is much the same as found in Section 4.1.1 Balu River Quality. Below are the results of the December 22, 1997 DOE test near the Olympic Textile factory.

pH	EC (μS/cm)	Chloride (mg/l)	TA (mg/l)	Turbid. (JTU/NTU)	SS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Temp. (°C)
7.2	305	13	136	26	-	7.6	1.0	-	-

4.3.2 Turag River Quantity

From the schematic model of the river, analysis has shown that the Turag River's flow is tidal in nature during the dry season and that the net flow has been nearly zero during the 1984-1994 period. The BWDB conducted a study by April 1, 1991 downstream of the Turag near the Mirpur bridge. It was found that the water volumes were 4.2 million cu.m (2.1 + 2.1) during the ebbing periods and 5.1 million cu.m (-2.9 -2.2) during the flooding periods. The net volume upstream was -0.9 million cu.m during a 24 hour period. The mean flow value was calculated at -10.4 cu.m/sec.

Due to the tidal cycle characteristic of the river, the mean water level was found to increase during the measurement period and therefore the progressive storage built up in the river channel can occur only if the flooding volume exceeds the ebbing volume.

The mean value of the oscillating volume during a tidal cycle (12 hours) was assessed in the range of 2 to 2.5 million cu.m and the possible value of the peak discharge are +100 cu.m/sec during the ebbing flow and -150 cu.m/sec during the flooding flow.

4.3.3 Turag River Water Uses

The water uses of the Turag River are much the same as Section 4.1.3 Balu River Water Uses.

4.4 Buriganga River

The Buriganga River encompasses the southwestern periphery of Dhaka City. It originates from the Dhalerwari River north of Dhaka and meets it again south of the city. The Turag River empties into the Buriganga just west of the Dhaka urban area. The upstream area of the Buriganga River, above the confluence with the Turag River, is used to contribute substantially to the flow of the Buriganga. Recently, however, this portion of the river has silted up during the driest months and now the flow of the Turag River is the main source of the Buriganga River.

4.4.1 Buriganga River Water Quality

The quality of the water in the Buriganga River is deteriorating due to the increasing pressures of urbanization and industrialization in the Dhaka area. The river receives the discharge of domestic, industrial, agricultural and other wastewater

One of the major sources for the pollution of the Buriganga River are the large number of tanneries (around 200) located in the Jigkatola area and the Razur Bazar in Dhaka. These tanneries use more than 200 chemicals, including several types of acid, preservative lime, sodium chloride, chromium, etc. The drains, manholes, lakes, canals, etc. have been contaminated by the tanneries' effluent. Effluent discharging into a river has an acceptable limit for BOD of 5 mg/l. Tannery effluent contains BOD levels of between 7 mg/l and 35 mg/l.

However, the water quality analyses conducted by the DOE in 1992 found that, in general, the water quality parameters of the Buriganga River were within acceptable levels. In the study conducted on the Buriganga water quality over the period of 1984 to 1992, it was found that the water quality had deteriorated only slightly but that the total solid concentration for both the dry and wet seasons has been steadily increasing. The DOE, for its part, asserts that the capacity of the rivers in Bangladesh to absorb and dilute pollutants is quite large.

The most recent water quality studies conducted to date from 1997. Some representative samples are shown below. Please note that TA represents total alkalinity. Also please note that these samples were taken during the dry season.

Horizontally 35 feet ahead of side point of Buriganga River near Chandnighat at 4 feet depth on September 4, 1997.

pH	EC (μS/cm)	Chloride (mg/l)	TA (mg/l)	Turbid. (JTU/NTU)	SS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Temp. (°C)
6.9	125	5	76	40	0.1	7.0	2.9		30

Horizontally 30 feet ahead of the discharge point for the Pagla STP on September 7, 1997.

pH	EC (μS/cm)	Chloride (mg/l)	TA (mg/l)	Turbid. (JTU/NTU)	SS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Temp. (°C)
6.88	130	14	56	130	0.1	5.5	2.7		29

Main drain of Pagla STP on September 7, 1997.

pH	EC (μS/cm)	Chloride (mg/l)	TA (mg/l)	Turbid. (JTU/NTU)	SS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Temp. (°C)
6.7	140	7	68	115	0.2	0.9	3.60		29

Horizontally 35 feet ahead of Teazaribagh discharge point on October 19, 1997.

pH	EC (μS/cm)	Chloride (mg/l)	TA (mg/l)	Turbid. (JTU/NTU)	SS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Temp. (°C)
7.2	-	8.5	90	28	< 0.1	6.6	3.6		29

Main drain of Teazaribagh Tannery on October 19, 1997

pH	EC (μS/cm)	Chloride (mg/l)	TA (mg/l)	Turbid. (JTU/NTU)	SS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Temp. (°C)
8.4	-	13.0	130	400	50	0	19.0	72.8	30

(Note: Chromium was found at 1.8 mg/l)

The consultant Browder (1992) conducted a water quality survey by choosing seven monitoring stations along the Buriganga River to evaluate. All seven stations were monitored over a one year period. The results are illustrated below.

The figure in this table shows that the Buriganga experiences severe water quality problems during the dry season. During the "lean flow" period (May), the DO is below the generally accepted minimum standard of 4.0 mg/l from Teazaribagh in Pagla. During the "high flow" period (July), the situation is better due to the greater dilution capacity of the rain-swollen river.

Table 4.4.1 **Buriganga Water Quality Summary Data**

Parameters	Locations							Month/ Year
	Mirpur Bridge	Hazaribagh Tannery Area	Chandni Ghat Water Intake Point	Biwta Terminal	Dholai Khal	Friendship Bridge	Pagla STP	
DO (mg/l)	8.0	3.7	2.0	1.0	1.0	-	3.2	May-91
EC (micro-S/cm)	-	425	360	325	325	-	260	
Coliforms (#/100 ml)	-	2,500	12,000	-	95,000	-	6,600	
BOD (mg/l)	-	2.5	10.0	-	-	-	3.5	
DO (mg/l)	6.3	6.4	6.0	6.0	6.0	-	6.0	Jul-91
EC (micro-S/cm)	-	91	93	93	95	-	96	
Coliforms (#/100 ml)	-	240	1500	730	960	-	60	
BOD (mg/l)	-	1.2	1.3	0.9	0.9	-	1.3	
DO (mg/l)	7.6	6.8	6.8	7.1	6.7	6.4	7.0	Oct-91
EC (micro-S/cm)	69	80	83	80	81	89	80	
Coliforms (#/100 ml)	1,400	1,000	6,000	3,000	5,000	2,400	7,000	
BOD (mg/l)	1.6	1.4	1.6	2.0	1.9	1.5	1.3	
SS (mg/l)	15	13	16	16	18	18	20	
TDS (mg/l)	60	63	65	66	66	63	68	
DO (mg/l)	8.5	7.2	6.0	4.6	1.2	3.0	6.6	Feb-92
EC (micro-S/cm)	220	290	300	310	830	300	310	
Coliforms (#/100 ml)	-	-	-	-	-	-	-	
BOD (mg/l)	2.0	4.2	2.7	11.5	77.0	7.0	10.0	
SS (mg/l)	26	29	27	30	192	39	36	
TDS (mg/l)	192	206	212	220	624	210	222	

4.4.2 Buriganga River Quantity

From a hydraulic point of view, the Buriganga is a complex river. It is interconnected with other rivers, including the Balu, the Dhalerwari, the Kaliganga, the Lakhya, the Tongi and the Karanatalia, and also is affected by the tidal effects of the Bay of Bengal during the dry seasons. The Buriganaga River has a total length of 17 km (as measured by a rotameter on a 1:50,000 scale spot image taken on February 27, 1989). Average width of the river around Dhaka City is nearly 500 m.

Generally, the flow of the Buriganga River is non-tidal during the wet season and tidal during the dry season. However, if the back water effect is strong and the upstream flow is small, the Buriganga will occasionally become tidal even during the wet season. The tidal range of the river is not high, with a maximum range of 0.75 m at Millbarak (1992-93). This range varies slightly each year.

A mean monthly flow measurement of the Buriganga River has not been carried out by the BWDB. However, a special investigation was carried out at the Kamreanzin char (island) upstream of the Millbarack gauging station over the period of January 4, 1991 to February 4, 1991. The results are shown below.

- During two ebbing periods, the total volume of water was (4.6 + 4.4) = 9 million cu.m
- Total volume of water during the two flooding periods was (-6.6-6.4) = 13 million cu.m
- Balance of volume (upstream) was -4 million cu.m over 24 hours
- Mean flow value was -46.3 cu.m/sec

The mean value of the oscillating volume during the tidal cycle (12 hours) was assessed to be in the range of 5 to 5.5 million cu.m and the possible value during the ebbing flow and -400 cu.m/sec during the flooding flow. The net flow of the Buriganga River during the investigation period was likely to be zero as it was during the dry season.

The extreme water level recorded of the Buriganga River during the period of 1968 to 1989 was as follows:

- Low flow: 2.42 m PWD at Millbarack
- High flow: 7.36 m PWD at Millbarack (9/89) and 6.82 m PWD at Hariarpara (9.25 km downstream)

4.4.3 Buriganga River Water Uses

The Buriganga has been an important feature in the lives of the people of Dhaka City for many years. The river is used for a wide variety of purposes.

Domestic: The Chandnighat Water Treatment Plant utilizes water from the Buriganga to provide potable water to the older part of Dhaka. The Chandnighat plant began operation in 1878 and has since been periodically upgraded (current treatment capacity is 39.1 million liters per day) as it continues to function. In addition, the Buriganga is used extensively for washing, cleaning, bathing and other related purposes by the poor of Dhaka City. The pollutants found in the river water expose them to health hazards but their available water sources are limited and they often have little choice.

Agricultural: There are no large-scale irrigation projects in the project area, but the river is used for vegetable gardens, etc. which draw water on a limited scale. There are no future irrigation systems reported by the BWDB.

Navigation: The river traffic on the Buriganga is significant. Around 55 cargo vessels of 3-4 m draft and 300 passenger vessels of 2-3 m draft plying the river daily. In order to maintain the river's transport capacity, the Bangladesh Inland Water Transport Authority (BIWTA) carries out dredging work along selected stretches of the river.

4.5 Dholai Khal - Gerani Khal

There are a number of drainage khals (canals) which run through Dhaka City and drain into the rivers that surround the city. Among these, the Dholai Khal is considered one of the main sewage drains of the older and humid part of Dhaka City (the central and eastern part of the city) and drains into the Buriganga River.

The Dholai Khal meets with its two main tributaries, the Gerani Khal and the Debdulal Khal, which originate from the eastern part of the city. The Gerani Khal begins in the northeast part of the city and flows in a southwesterly direction up to the Dayagong railway bridge. The Debdudal Khal begins in the southeast part of the city in Dholaipar and then flows in a northwesterly direction until it meets the Gerani Khal just east of the Dayagong railway bridge. From its confluence point, the Dholai Khal flows in a southwesterly direction until it reaches the Narinda Pumping Station.

Sewage from the older part of Dhaka City (e.g. Nawabpur, Bangshal, Chowk Bazar, Fulbaria and the University) follow a piped drainage system to the Narinda Pumping Station, where the waste is accumulated into a circular pond. The sewage is then pumped into the Dholai Khal during the rainy season and through a sluice gate of the pond during the dry season. The waste water is then conveyed to the Buriganga River by the khal.

The area surrounding the Narinda P/S was dry during the field reconnaissance and was strewn with garbage/refuse. Two of the delivery pipes at the P/S at the discharge point had developed large holes. The circular intake pond at the suction side of the pump house was filled with dried mud and covered by weeds.

Based on a field reconnaissance, the Dholai Khal seems fairly wide at the upstream side, near the old railway bridge, where a gentle flow of shallow blue-gray water could be observed. Both sides of the khal are covered with water hyacinth while the middle portion is free of such growth. Dense undergrowth covers the banks of the khal up to the Dayagong railway bridge. Downstream of the bridge, the wastewater follows a zigzag course due to partial blockage of the khal. Near the railway bridge, the khal is largely free of water hyacinth. The width of the khal varies from 30 to 50 m, while the depth ranges from 5 to 15 m.

4.5.1 Dholai Khal - Gerani Khal Quality

The water of the Dholai Khal is blue-gray with black sludge. The waste mainly contains domestic wastewater, septic sewage, sanitary waste, and industrial waste. Along the embankment of the khal, slum dwellings are common. These dwellings commonly dispose of their liquid and solid wastes into the khal. A water quality analysis performed by the DOE on August 17, 1989 returned the following results:

pH	EC (μS/cm)	Chloride (mg/l)	TA (mg/l)	Turbid. (JTU/NTU)	SS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Temp. (°C)
7.0	650	79.5	236	70	70	0	50.0	0	32/28

During the dry season, the water of the khal is not utilized. During the rainy season, some use might be made of the khal's water on a very limited scale. The polluted nature of the khal means that it is used mainly as a waste receptacle.

4.5.2 Dholai Khal - Gerani Khal Quantity

The length of the Dholai Khal is 4 km, with a total catchment area of around 16.8 sq.km. It is difficult to estimate the discharge of the khal but the flow could be roughly assumed to be 0.2 to 0.3 cu.m/sec at the railway bridge. From the Narinda P/S the khal becomes larger and deeper, with an increased discharge capacity of perhaps 0.5 cu.m/sec.

Retention reservoirs, such as ponds and ditches occupy several hectares in the area of the Dholai Khal. These ponds and ditches are covered with water hyacinth and appear to be shallow (around 1 m); slum dwellings surround these water bodies. Due to the degradation of their storage capacities, such ponds/ditches do not act as storm water reservoirs.

4.5.3 Dholai Khal - Gerani Khal Water Uses

During the wet season the khals are used for many of the same uses as the rivers mentioned above. During the dry season however, the water quality of the khals deteriorates to a level that inhibits the local residents from using the khals for anything other than a convenient waste disposal area.

CHAPTER 5

SEWERAGE SYSTEM PLANNING

CHAPTER 5 SEWERAGE SYSTEM PLANNING

5.1 General

During the previous stage of the Study, the Master Plan for North Dhaka Sewerage System covering the Study Area of 20,850 ha was formulated with a target year of 2020 including the on-site treatment of domestic sewage. Within this context, a sewerage system plan was prepared to cover the total sewerage service area of 6,764 ha consisting of three sewerage service areas, namely Tongi, North Dhaka East and North Dhaka West.

The Priority Project for the subsequent feasibility study was then identified. This priority project would focus on the Core Area of the North Dhaka East Sewerage Zone in the North Dhaka Sewerage Service Area. The target area of the feasibility study was set forth to 2005.

A feasibility study was carried out to develop a readily applicable preliminary engineering design for the financial arrangement of a detailed design and its actual implementation. The sewerage facilities included in the feasibility study were the trunk main and major sewer lines, sewage pump stations and a STP.

5.2 Design Fundamentals

5.2.1 Study Area and Target Year

The composition of area coverage in the North Dhaka East Sewerage Service Area is show in Table 5.2.1. The North Dhaka East Sewerage Service Area consists of two sewerage zones, namely Uttara and North Dhaka East. Each sewerage zone is further divided into the Core Area (for priority implementation of sewerage service) and the Transitional Area (secondary priority to be implemented in the future).

The feasibility study area was then delineated to cover the Core Area (1,958 ha) of the North Dhaka East Sewerage Zone. This study area is composed of 868 ha of built-up area and 1,090 ha of the Cantonment Security Zone. The location of the feasibility study area is shown in Figure 5.2.1.

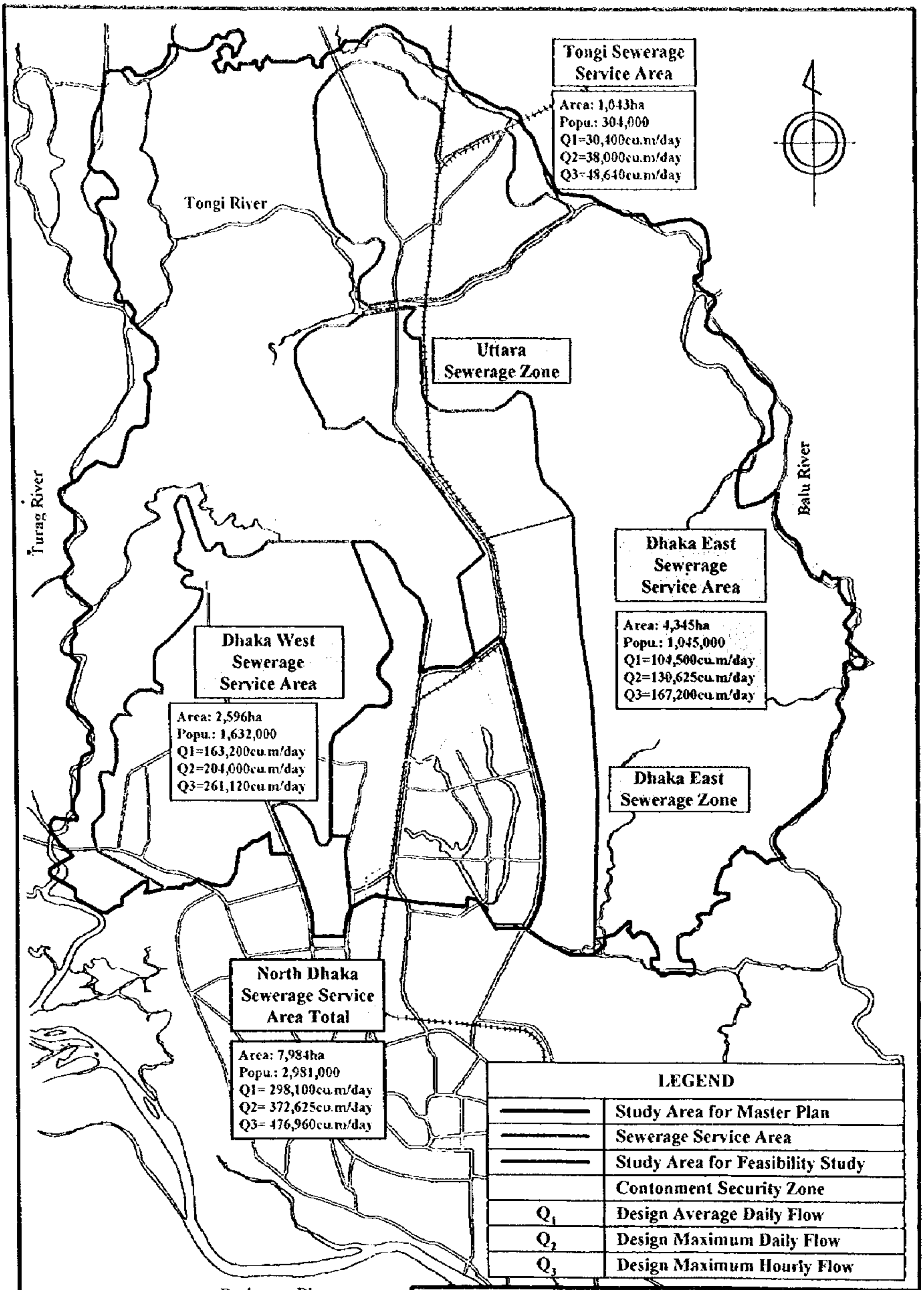


Figure 5.2.1
Location Map of Feasibility Study Area

The Study on the Sewerage System in North Dhaka

Table 5.2.1 Area of North Dhaka Sewerage Service Area

Unit: ha

Sewerage Zone	Core Area			Transitional Area	Total
	Urban Area	Cantonment	Sub-Total		
Uttara	504	0	504	512	1,016
North Dhaka East	868	1,090	1,958	1,371	3,329
Total	1,372	1,090	2,462	1,883	4,345

5.2.2 Design Population

The design population of feasibility study area as adopted in the Master Plan for North Dhaka Sewerage System is shown in Table 5.2.2.

Table 5.2.2 Design Population of North Dhaka Sewerage Service Area

Unit: area in hectare, population in person

Target Year	Sewerage Zone	Item	Core Area			Transitional Area	Total
			Urban Area	Cantonment	Sub-Total		
M/P 2020	Uttara	Area	504	0	504	512	1,016
		Population	86,000	0	86,000	75,000	161,000
	North Dhaka East	Area	868	1,090	1,958	1,371	3,329
		Population	487,000	83,000	570,000	314,000	884,000
	Total	Area	1,372	1,090	2,462	1,883	4,345
		Population	573,000	83,000	656,000	389,000	1,045,000
F/S 2005	Uttara	Area	504	0	504	512	1,016
		Population	80,000	0	80,000	65,000	145,000
	North Dhaka East	Area	868	1,090	1,958	1,371	3,329
		Population	386,000	70,000	456,000	236,000	692,000
	Total	Area	1,372	1,090	2,462	1,883	4,345
		Population	466,000	70,000	536,000	301,000	837,000

5.2.3 Design Sewage Flow

The per capita sewage flow was established in the Master Plan stage to adopt a uniform figure throughout the three Sewerage Service Areas in the North Dhaka based on the current water supply plan. The per capita sewage flow in the target years and their intermediate years is shown in Table 5.2.3.

Table 5.2.3 Per Capita Sewage Flow by Year

Unit: lpcd

Item	2000	F/S 2005	2010	2015	M/P 2020
Design Average Daily Flow	85	95	100	100	100
Design Maximum Daily Flow	105	115	125	125	125
Design Maximum Hourly Flow	135	145	160	160	160

The design sewage flow in the North Dhaka East Sewerage Service Area was estimated as shown in Table 5.2.4. According to this estimation, the design average daily sewage flow in the feasibility study area will be 57,000 cu.m/day in the year 2020 (Master Plan target year) and 43,320 cu.m/day in the year 2005 (Feasibility Study target year). These figures are also illustrated in Figures 5.2.2 and 5.2.3 for the years 2020 and 2005, respectively.

Table 5.2.4 Design Sewerage Flow of North Dhaka East Sewerage Service Area

Phase	Target Year	Sewerage Zone	Item	Unit	Core Area	Cantonment	Sub-Total	Transitional Area	Total
M/P	2020	Uttara	Area	ha	504	0	504	512	1,016
			Population	person	86,000	0	86,000	75,000	161,000
			Q1	cu.m/day	8,600	0	8,600	7,500	16,100
			Q2	cu.m/day	10,750	0	10,750	9,375	20,125
			Q3	cu.m/day	13,760	0	13,760	12,000	25,760
		North Dhaka East	Area	ha	868	1,090	1,958	1,371	3,329
			Population	person	487,000	83,000	570,000	314,000	884,000
			Q1	cu.m/day	48,700	8,300	57,000	31,400	88,400
			Q2	cu.m/day	60,875	10,375	71,250	39,250	110,500
			Q3	cu.m/day	77,920	13,280	91,200	50,240	141,440
		Total	Area	ha	1,372	1,090	2,462	1,883	4,345
			Population	person	573,000	83,000	656,000	389,000	1,045,000
			Q1	cu.m/day	57,300	8,300	65,600	38,900	104,500
			Q2	cu.m/day	71,625	10,375	82,000	48,625	130,625
			Q3	cu.m/day	91,680	13,280	104,960	62,240	167,200
F/S	2005	Uttara	Area	ha	504	0	504	512	1,016
			Population	person	80,000	0	80,000	65,000	145,000
			Q1	cu.m/day	7,600	0	7,600	6,175	13,775
			Q2	cu.m/day	9,200	0	9,200	7,475	16,675
			Q3	cu.m/day	11,600	0	11,600	9,425	21,025
		North Dhaka East	Area	ha	868	1,090	1,958	1,371	3,329
			Population	person	386,000	70,000	456,000	236,000	692,000
			Q1	cu.m/day	36,670	6,650	43,320	22,420	65,740
			Q2	cu.m/day	44,390	8,050	52,440	27,140	79,580
			Q3	cu.m/day	55,970	10,150	66,120	34,220	100,340
		Total	Area	ha	1,372	1,090	2,462	1,883	4,345
			Population	person	466,000	70,000	536,000	301,000	837,000
			Q1	cu.m/day	44,270	6,650	50,920	28,595	79,515
			Q2	cu.m/day	53,590	8,050	61,640	34,615	96,255
			Q3	cu.m/day	67,570	10,150	77,720	43,645	121,365

Note: Q1: Average Daily Flow
Q2: Maximum Daily Flow
Q3: Maximum Hourly Flow

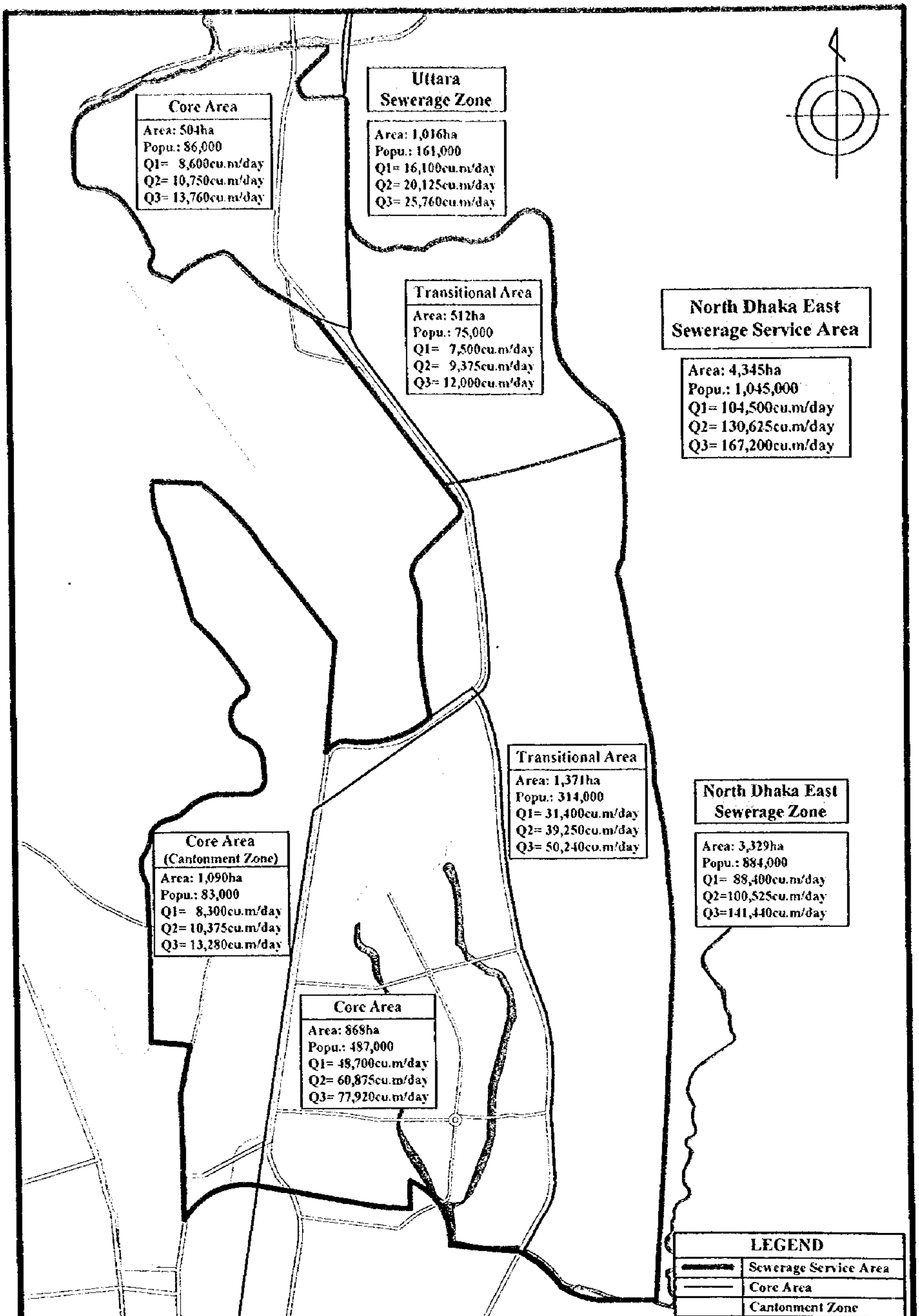


Figure 5.2.2
Design Sewage Flow of North Dhaka East Sewerage Service Area (Year 2020)

The Study on the Sewerage System in North Dhaka

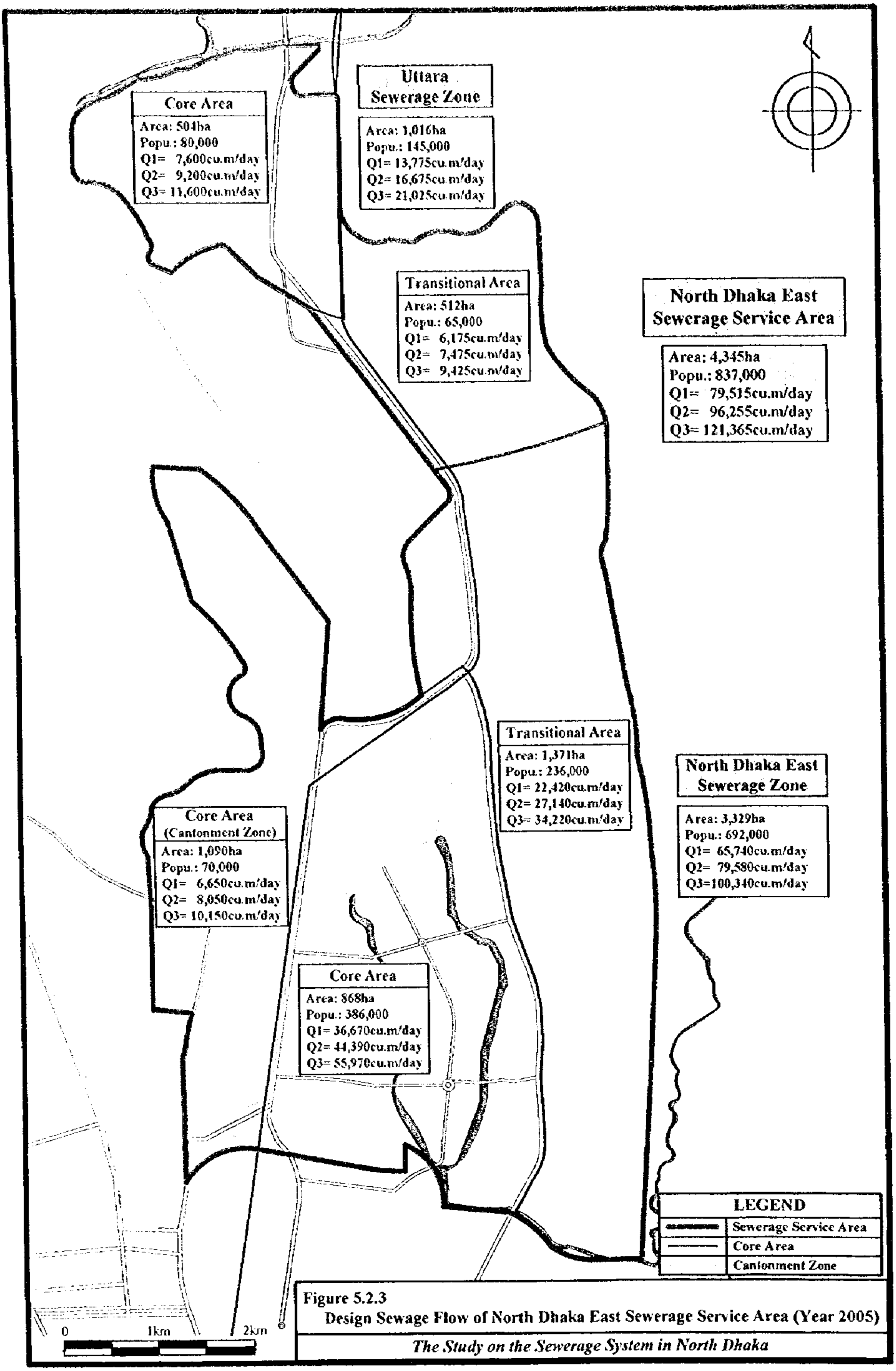


Figure 5.2.3
Design Sewage Flow of North Dhaka East Sewerage Service Area (Year 2005)

The Study on the Sewerage System in North Dhaka

5.3 Conditions and Design Criteria

5.3.1 Conditions for Sewerage Facility Planning

Prior to proceeding with the sewerage facility planning, the following conditions were predetermined as planning fundamentals in the feasibility study:

(1) The Feasibility Study shall be limited within the Study Area of the Master Plan as determined in the Scope of Work for the Study. The relevant matters regarding to the South Dhaka Sewerage System, such as the effective utilisation of the existing sewerage system, would therefore taken up in Chapter 14 Emergency Project for North Dhaka East.

(2) The feasibility study area, the Core Area of the North Dhaka East Sewerage Zone, includes the Cantonment Security Zone (1,090 ha). Owing to the nature of this restricted military establishment, it was assumed that the sewerage facility plan and its implementation be undertaken by the military authorities and would be excluded from public investments. Acceptance of domestic sewage from the residential areas within the Cantonment Security Zone was, however, considered at two (2) connection points of the main sewers in the course of the Feasibility Study.

(3) The Core Area of the North Dhaka Sewerage Zone has an existing sewer network (654 ha). The facility plan of this particular area shall be prepared on the basis to provide supplementary pipes to augment the existing main sewers to cope with the planned sewage flow in the year 2020 (Master Plan target year).

(4) The facility plan in the feasibility study would be carried out in due consideration of the overall plan presented in the Master Plan:
- to accommodate the design sewage flow of the Master Plan for sewer lines, and
- to meet with the design sewage flow of the feasibility study for pump stations and STP.

(5) The secondary main sewers in the feasibility study would be defined as sanitary sewers under gravity flow having diameters of 300 mm or larger and their layout indicated in the facility plan.

(6) Pump stations were also planned at locations that would be connected with main sewers (diameters of 300 mm or larger).

5.3.2 Design Criteria

(1) Sewer

Refer to Chapter 8.3.2 of the Master Plan.

(2) Pump station

Refer to Chapter 8.3.2 of the Master Plan.

(3) Sewage treatment plant

1) Treatment method

The optimum sewage treatment method was identified to be the stabilisation pond method during the course of the Master Plan preparation. A commonly applied sequence of this treatment method is illustrated below.

Anaerobic Pond → Facultative Pond → Maturation Pond

A description of each treatment facility in stabilisation pond method is given below:

- Anaerobic pond

  Raw sewage will pass slowly in this pond, which is quite deep. Most of the suspended materials will be settled in this pond. Organic substances in the sewage and settled materials will be converted at near the bottom layer into inorganic substances through anaerobic decomposition processes and further concentrated.

  Depending on water temperature and retention time, about 40% to 60% of the BOD loading in raw sewage will be removed at this stage.

  Generally, the effective depth of the pond ranges from 2.5 m to 5.0 m, while the retention time ranges from one (1) day to five (5) days.

- Facultative pond

  A facultative pond is, in contrast to an anaerobic pond, shallow to allow photosynthesis by algae and to treat organic substances in sewage by aerobic decomposition.

  The common effective depth is 1.5 m to 2.0 m.

- Maturation pond

  A maturation pond is mainly used to remove pathogenic germs. The removal of such micro-organisms takes place through a combination of several natural conditions in the maturation pond, such as sedimentation, a shortage of nutrients, ultraviolet radiation (sunlight), high temperature, high pH, pathogens and antibiotics to be generated and disposed by some living organisms, and death by life-cycle.

  Retention time is generally three (3) days to 10 days, depending on the number of micro-organisms in the inflow sewage and treated sewage and on the temperature, etc.

In the application of stabilisation pond method to the feasibility study, the common sequence of treatment process was modified upon evaluation of the actual performance at the Pagla STP that:

- The anaerobic pond for sedimentation and anaerobic treatment was replaced with a primary sedimentation tank, and
- The maturation pond for disinfection was replaced by the application of a chlorine disinfection tank.

The following treatment process was then introduced for the North Dhaka East STP:

Primary Sedimentation Tank → Facultative Pond → Chlorine Disinfection Tank

The reasons for the above-mentioned modification are described hereunder.

- Primary sedimentation tank

  The required surface area will be significantly reduced and retention time will be shortened to about 2 hours from 1 to 5 days, although the primary sedimentation tank will require mechanical and electrical equipment for the sludge scraper and the sludge draining pump.

  The actual performance at the Pagla STP shows the following facts:

  - The primary sedimentation tank is deemed not to create any problematic O&M practices.
  - The primary sedimentation tank can remove about 60% of SS and 45% of BOD, which is an acceptable grade of treatment performance, although anaerobic treatment effect cannot be expected.

- Chlorine disinfection tank

DWASA has enough experience to handle chlorine disinfection system, not only at the Pagla STP, but also at water treatment plants and no significant problems in terms of the procurement and usage of liquefied chlorine has been observed. Thus, the application of chlorine disinfection tank can minimise the surface area and attain higher treatment efficiency than the maturation pond.

2) Design criteria

The design criteria of stabilisation pond is shown in Table 5.3.1, while the flow sheet the of treatment process is shown in Figure 5.3.1.

Table 5.3.1 Design Criteria for Sewerage Treatment Plant

Items	Unit	Value	Remark
1) Primary Sedimentation Tank			
Overflow Rate	cu.m/sq.m/day	35.0	for Daily Max.
Effective Water Depth	m	3.0	Ditto
Weir Loading	cu.m/m/day	250	Ditto
BOD Removal Rate	%	40.0	Ditto
SS Removal Rate	%	60.0	Ditto
2) Facultative Pond			
BOD Areal Load	kg/ha/day	60.3×1.0993^{T}	for Daily Average
Safety Factor	--	1.5	–
Water Depth	M	1.5 - 2.0	--
BOD Removal Rate	%	33.3	Ditto
SS Removal Rate	%	37.5	Ditto
3) Disinfection Tank			
Retention Time	Min	15	for Daily Average
Depth	M	2.0	--
4) Sludge Lagoon			
SS Areal Load	kg/sq.m/year	35	for Daily Average
Retention Day	Day	90	Ditto

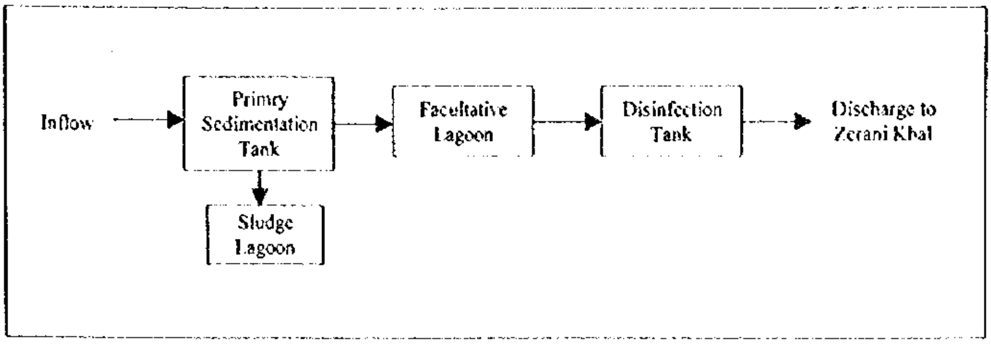


Figure 5.3.1 Flow Sheet of Stabilisation Pond Treatment Method

Considerations given to establish the design criteria are as follows:

a. Primary sedimentation tank

i. Water surface area load

The removal efficiency of SS by sedimentation is directly proportional to the water surface area and the settling velocity of particles, and inversely proportional to the flow rate. In this respect, the water surface area load is considered the key design criteria and is given as the flow rate divided by the water surface area. The water surface area load is generally defined to be 35 to 70 cu.m/sq.m/day against the maximum daily sewage flow.

In this Feasibility Study, 35 cu.m/sq.m/day was adopted, which is same as the Pagla STP, to attain a satisfactory level of SS removal in order to lessen loading to the succeeding facultative pond.

ii. Effective water depth

It is generally known that sedimentation efficiency depends on the surface area of a sedimentation tank and water depth is not such a great concern. However, too shallow a depth in the sedimentation tank causes poor efficiency owing to the floatation of settled particles because of the unstable flow and the movement of the scraper, as well as the negative effects of temperature and wind.

The standard figures of effective water depth range from 2.5 to 4.0 m. In this feasibility study, the effective water depth was set at 3.0 m, which is same as the Pagla STP.

iii. Weir load

A large overflow rate at the unit length of a weir causes an increase of flow velocity at an adjoining area of the weir and leads to the floatation of settled particles. In this regard, reduction of weir load by extending the length of weir is required to attain required sedimentation efficiency.

Generally, the weir load is set at 250 cu.m/m/day as standard design criteria. In addition, it is desirable to allow the whole length of the circumference be a weir when a circular-shaped sedimentation tank is introduced.

Considering the above, the weir load is intended to maintain the said 250 cu.m/m/day in the facility design of this feasibility study.

b. Facultative pond

i. BOD area load

Many formula exist for determining the surface area, depth and retention time to design facultative ponds and each shows a different performance in the actual facilities. The "Application Guideline of Urban Sewerage and Wastewater Treatment Technology in Developing Countries (Draft)" (Ministry of Construction, Japan, 1993) recommends the application of the "BOD Area Load Formula" as shown below, which was developed through a regression analysis of actual performance data from various treatment plants.

Ls (kg-BOD/ha/day) = 60.3×1.0993^{T}

Safety Factor: 1.5

Where, Ls: BOD Area Load

T: Average Minimum Atmospheric Temperature

In this feasibility study, the aforementioned formula was applied to determine the water surface area of the facultative pond.

ii. Effective water depth

It is commonly said that the effective water depth in a faculative pond is limited by the penetrative depth of sunlight, since the majority of oxygen is supplied by the photosynthesis of algae in facultative pond and the transparency of the water significantly decreases corresponding to its depth. On the other hand, too shallow a depth will cause excessive transparency and restrict the growth of algae, because of the higher water temperatures in the summer season.

The effective depth shall also be determined in due consideration of the negative influence of settled particles and algae on the water quality in the surface layer.

The effective depth of facultative pond is recommended to be 1.5 to 2.0 m in the aforementioned Application Guideline and 0.6 to 1.5 m in the United States. In this regard, the effective depth is set at 1.5 m.

c. Chlorine disinfection tank

Retention time

To obtain effective disinfection of the treated effluent, chlorine shall be mixed and contacted with the effluent for the minimum of 15 minutes.

In this facility plan, retention time in the chlorine disinfection tank is determined to be 15 minutes, although some additional time may be expected during the flow period from the disinfection tank to the discharge point at the receiving river.

d. Sludge lagoon

The function of a sludge lagoon is to decompose deposited sludge into inorganic substances under anaerobic conditions and to reduce the sludge volume. By this process, the characteristics of sludge develop favourable conditions for easy thickening. Upon sufficient decomposition to an inorganic state and a reduction of sludge volume, the supernatant will be discharged and the remaining sludge will be sun-dried and then carried out for final disposal by land filling. In this respect, the sludge lagoon shall maintain enough retention time to allow for the decomposition of organic substances and enough surface area for sun-drying.

In the application of the facility planning in this feasibility study, the design criteria of sludge lagoon were set forth as shown below, taking into account the atmospheric temperature and relative humidity in Dhaka:

- SS Area Load: 35 kg/sq.m/year
- Retention Time: 90 days

The details of this setting up are shown in Appendix 5.5.8.

5.4 Receiving Water Body of Effluent from Sewage Treatment Plant

5.4.1 Approach to Determine Receiving Water Body

The receiving water body of the effluent from the North Dhaka STP was determined after a comprehensive evaluation of 1) water course alignment and embankment conditions of rivers and canals around the proposed STP, 2) present and future prospect of water use, 3) possible influent to the high water level of rivers and canals during rainy season, etc.

5.4.2 Alternative Plans of Receiving Water Body

The following three prospective receiving water bodies were identified as alternatives in consideration of the distance from the proposed site of STP and the actual flow conditions:

Alternative 1: Discharge to the Naral River
Alternative 2: Discharge to the Gerani Khal
Alternative 3: Discharge to the Buriganga River through discharge pipe

The present situation of the above-mentioned alternatives is summarised in Table 5.4.1 and exhibited in Figure 5.4.1, respectively. The required facilities to discharge treated effluent and the construction costs of each alternative were estimated as shown in Table 5.4.2.

The Balu River and the Lakhya River were the potential receiving water bodies, but were not taken up in the evaluation of alternatives for the following reasons:

* These rivers are designated as the River Pollution Control Area to conserve surface water as drinking water sources under the DMDP of RAJUK which is referred as the supreme urban development plan.
* The surface water intake facility for the Saidabad Water Treatment Plant Project is under construction near the Meghna Bridge, which is just downstream from the confluence point of two rivers at the time of this feasibility study.
* No suitable road exists to lay the effluent trunk main from the STP to the discharge point.

Table 5.4.1 Situation of Receiving Water Body by Alternatives

Alternative No.	Alternative 1	Alternative 2	Alternative 3
Name of Receiving Water Body	**Naral River**	**Zerani Khal**	**Buriganga River**
Type of Receiving Water Body	River	Drainage Canal	River
Administrative Agency	MWR[1)]	DCC[2)]	MWR
Flow Route	Naral River -> Balu River -> Lakhya River (-> Buriganga River)	Zerani Khal -> Dholai Khal -> Buriganga River	-> Buriganga River
Water Quality[3)]	Balu River: BOD - 26 mg/l SS - 150 mg/l COD - 100 mg/l Lakhya River: BOD - 26 mg/l SS - 170 mg/l COD - 33 mg/l	Buriganga River: BOD - 18 mg/l SS - 60 mg/l COD - 54 mg/l	Buriganga River: BOD - 18 mg/l SS - 60 mg/l COD - 54 mg/l
Water Use of Receiving Water Body	None	None	None
Water Use in Downstream	Lakhya River: Water Supply Source (Saidabad WTP)	Buriganga River: Water Supply Source (Friendship Bridge WTP)	None

Note: 1) MWR: Ministry of Water Resources (Bangladesh Water Development Board)
2) DCC: Dhaka City Corporation
Source: JICA Study Team for the Sewerage System in North Dhaka

Table 5.4.2 Construction Cost of Additional Facility for Sewage Effluent by Alternatives

Alternative No.	Alternative 1	Alternative 2	Alternative 3
Conveyance System	By Gravity	By Gravity	By Pumping
Required Facility to Discharge Treated Effluent	None	Inverted Siphon to cross Naral River L=20m	Discharge Pump Discharge Pipe (Pressure Pipe) 1,100mm×2 lines L=10km
Construction Cost	0 Tk	8,445,000 Tk	1,158,506,000Tk

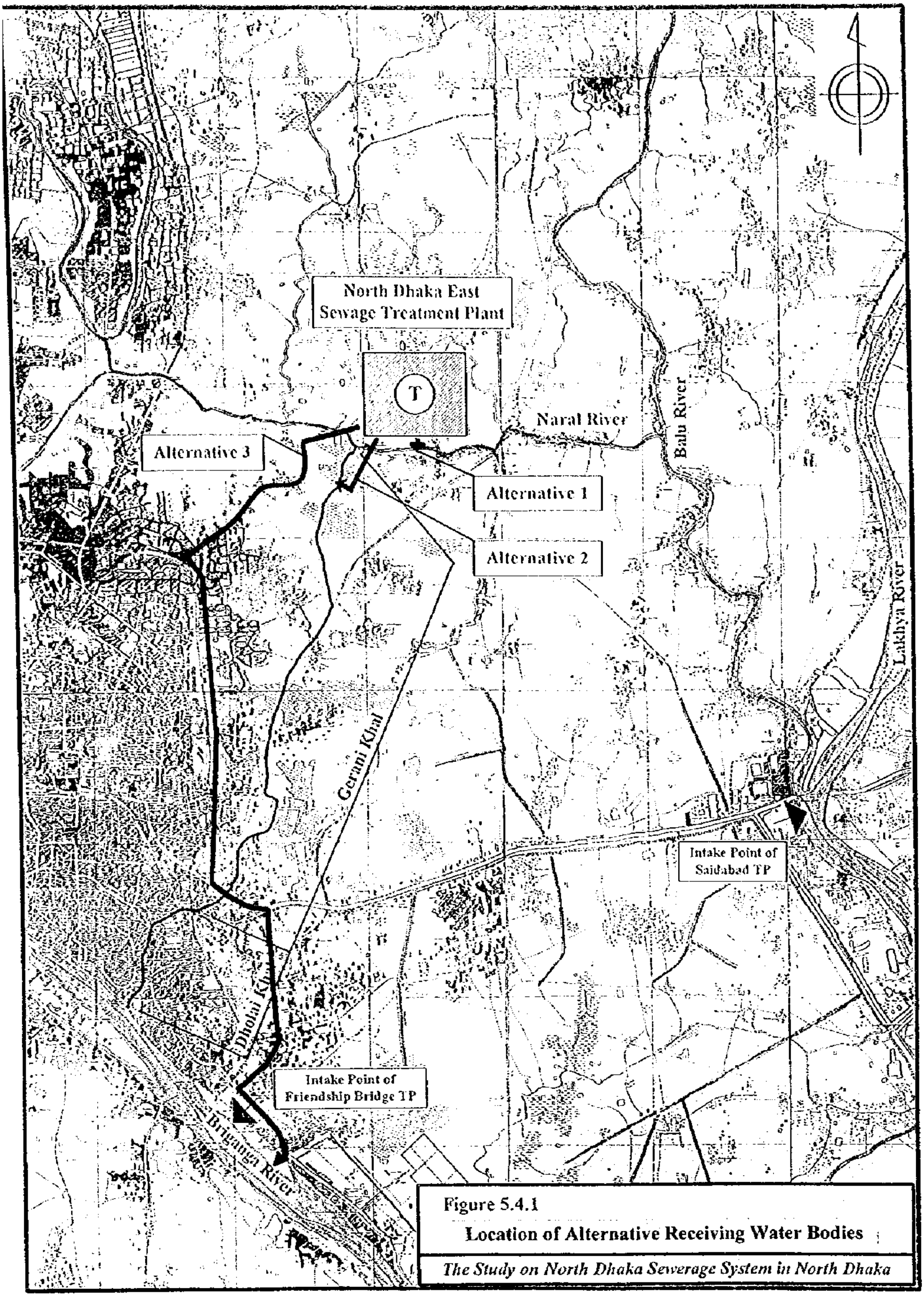


Figure 5.4.1

Location of Alternative Receiving Water Bodies

The Study on North Dhaka Sewerage System in North Dhaka

5.4.3 Selection of Receiving Water Body

The optimum receiving water body was selected based on the previously mentioned approach. A comparative evaluation of the alternatives was made for the individual subjects as described below.

(1) Water use in receiving water body and its down stream

All of three alternatives do not pose any interference to water use, since the water at proposed discharge points are not utilised for any specific purpose, such as irrigation.

However, there are planned water uses downstream of the receiving water bodies:

1) In the Lakhya River, the construction of a surface water intake facility is currently underway for the Saidabad Water Treatment Plant with World Bank financial assistance.

2) In the Buriganga River, there is also a plan to locate a surface intake facility and water treatment plant near the Friendship Bridge. This plan is however, subject to review and re-evaluation in the course of comprehensive study for water supply and sewerage services in Metropolitan Dhaka.

Judging from the above-mentioned situation, the Lakhya River has a potential concern in its water use downstream and Alternative 1 therefore would have a large influence in terms of water quality conservation. Alternative 1 would also have an indisputable conflict with the DMDP in that disposal of the treated effluent would be a new pollution source upstream, while there will be a new water intake facility in downstream wherein this water body is designated as a River Pollution Control Area.

(2) Water quality downstream

The North Dhaka East STP has a principal role as strategic urban infrastructure to decrease pollution loads in the Balu River and the Lakhya River. However, the proposed STP may become an new pollution source to the receiving water body, since the design effluent quality for BOD and SS are set at 40 mg/l and 50 mg/l, respectively; the alternative receiving water bodies have water quality levels equivalent to or better than the design effluent quality.

It is therefore deemed indispensable to avoid the discharge of treated effluent into water bodies having important water uses. In this respect, Alternative 1 has a potential influence on the water quality downstream of the receiving water body and hence, should be avoided in this Feasibility Study.

(3) Required facility to discharge treated effluent

Alternative 3 is considered inappropriate in terms of the required facility to discharge treated effluent based on the following reasons:

* Alternative 3 requires the largest construction cost and implementation period among three alternatives.

* Its long disposal pipe (about 10 km) requires a large-capacity discharge pump, with high electricity costs, to dispose of the treated effluent regardless of the season.

* O&M of discharge force main becomes difficult due to its long distance.

Prior to adopting Alternative 3, it is a prerequisite to establish an overall sewerage master plan, including the South Dhaka Sewerage System. This should be done in reference to the outcome of the North Dhaka Sewerage Master Plan, and to review the role of the Pagla STP and the possible integration or realignment of the sewerage service zones between North Dhaka and South Dhaka.

The other alternatives were considered to have no noteworthy problems.

(4) Influence of effluent disposal to high water level in receiving water body in rainy season

1) Alternative 1

Alternative 1 is not favourable since the discharged effluent will remain under stagnant conditions until the water level in the Naral River decreases. This owes to the inter-linked flow of the Naral River, the Balu River and the Lakhya River, as they are tidal rivers.

However, after the construction of a stormwater pumping station at the confluence point of the Naral River and the Balu River, in accordance with the "Greater Dhaka Flood Control and Drainage (GDFCD) Project", the above-mentioned hydraulic problem will be solved in the future.

2) Alternative 2

The Gerani Khal and the Dholai Khal were designated as urban drainage channels in the "Updating Study on Storm Water Drainage System Improvement Project in Dhaka City" (implemented by JICA in 1990). This study established the stormwater drainage plans of the khals, which have a total drainage area of 2,562 ha. The stormwater drainage plan of the study is shown in Figure 5.4.2.

In the said drainage plans, an implementation plan was established. The implementation plan has a "First Priority Area" for zones B and C, which have a total drainage area of 1,816 ha and includes the whole length of the Dholai Khal (about 1,700 m) and the Gerani Khal (about 2,900 m).

During the course of the Study for North Dhaka Area, the "Dholai Khal Rehabilitation and Area Development Project" has been implemented for zone B (6.40 sq.km) of the said First Priority Area with the financial assistance from the UNDP/UNCHS. The project scope is described below.

- Construction of a new pumping station with a capacity of 80,000 cu.m/hour at the confluence with the Buriganga River,
- Improvement of Dholai Khal by covered types (box culvert) from the Dayagonji Railway Bridge up to the Sutrapur Iron Bridge (length: approx. 1.4 km),
- Improvement of Dholai Khal by open lined section from the Sutrapur Iron Bridge up to the Buriganga River (length: approx. 0.3 km),
- Improvement of the Gerani and Debdulai Khals by an open-lined section from the confluence with both khals up to their uppermost points (length: approx. 1.1 km and 1.25 km respectively),
- Construction or expansion of three (3) retention basins with a combined capacity of 220,000 cu.m
- Construction of a small pumping station at the largest retention basin (Narinda) which would serve to empty the lower part of the retention basin

The operation of the Dholai Khal Storm Drainage Pump Station has commenced during the rainy season (from May to November); this enables the discharge of stormwater into the Buriganga River, despite its having a higher water level than the Dholai Khal. This pump station has a discharge capacity of 22.22 cu.m/sec.

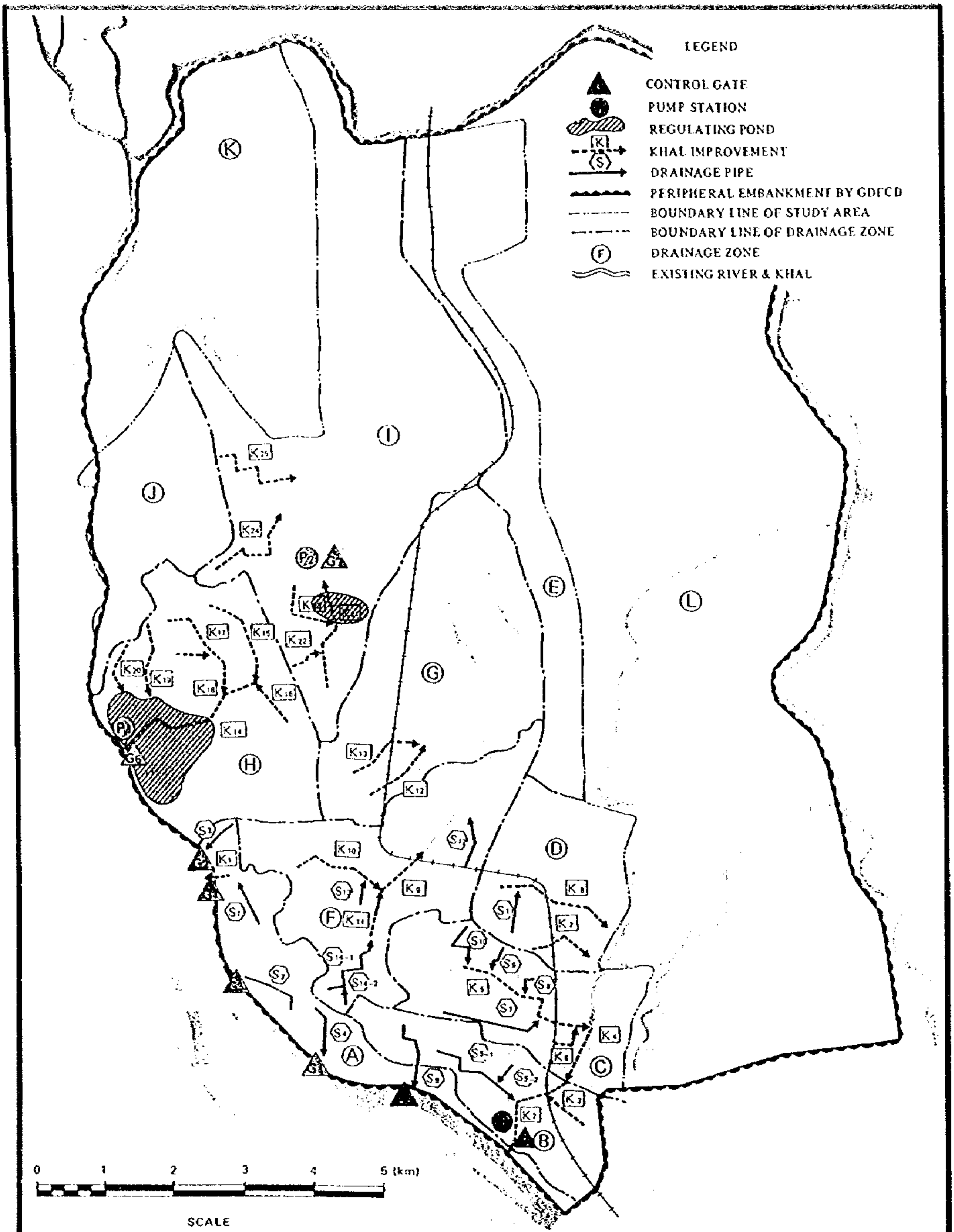


Figure 5.4.2
Proposed Facilities of Updating Study on Storm Water Drainage System Improvement Project in Dhaka City

The Study on the Sewerage System in North Dhaka

In contrast to the above-mentioned pump capacity, the design average daily flow of the North Dhaka East STP is only 1.21 cu.m/sec (Master Plan) and is equivalent to about 5% of the said pump capacity. Taking into account the presence of the retention basin, which has a total capacity of 220,000 cu.m, the disposal of treated effluent will not have any significant influence on the planned operation of the said pump station.

It shall be noted that the disposal of effluent would commence upon the completion of the rehabilitation/improvement of the Gerani Khal and the Dholai Khal in their up-stream reaches, since these channels are not yet implemented.

3) Alternative 3

Alternative 3 does not pose any problem since the treated effluent is to be discharged into the Buriganga River via discharge pump.

Through the above-mentioned evaluation of each alternative, it is determined that Alternative 2 is the optimum plan for effluent disposal from the viewpoint of safeguarding the water use downstream and the smooth discharge of treated effluent during the rainy seasons' high water levels in the receiving water bodies.

The usage of the Gerani Khal and the Dholai Khal for receiving water bodies requires, however, close co-ordination and co-operation between DWASA (sewerage system) and the DCC (stormwater disposal) in its realisation, since these khals have to be rehabilitated/improved in connection with the implementation of the sewerage system.

If the rehabilitation/improvement of the Gerani Khal and the Dholai Khal is not completed in time to commence the operation of the North Dhaka East STP, the treated effluent may be disposed into the Naral River as temporary measure. In this case, the negative influence on water quality is considered to be small, since during the initial operation period of the STP receives a limited amount of sewage inflow until the completion of the sewer network installation and the service connections.