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THE PEOPLE'S REPUBLIC OF BANGLADESH
FLOOD PLAN COORDINATION ORGANIZATION (FPCO)

FEASIBILITY STUDY
ON
GREATER DHAKA PROTECTION PROJECT
(STUDY IN DHAKA METROPOLITAN AREA)
OF
BANGLADESH FLOOD ACTION PLAN NO.8A)

FAP 8A

SUPPORTING REPORT II

JUNE 19[illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY

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FLOOD PLAN COORDINATION ORGANIZATION

FEASIBILITY STUDY ON GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO. 8A

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LIST OF SUPPORTING REPORTS

- SUPPORTING REPORT I -

- SUPPORTING REPORT II -

ABBREVIATIONS

ADB	Asian Development Bank
AIT	Asian Institute of Technology
BBS	Bangladesh Bureau of Statistics
BMD	Bangladesh Meteorological Department
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CAAB	Civil Aviation Authority of Bangladesh
DIT	Dhaka Improvement Trust (now RAJUK)
DMAIUDP	Dhaka Metropolitan Area Integrated Urban Development Plan
DMC	Dhaka Municipal Corporation
DND Triangle	Dhaka - Narayanganj - Demra Triangle
DPHE	Department of Public Health Engineering
DOE	Department of Environment
DWASA	Dhaka Water and Sewerage Authority
ERD	External Resources Division Ministry of Finance
FAP	Flood Action Plan
FPCO	Flood Plan Coordination Organization
GDPP	Greater Dhaka Protection Project
GDFCD Project	Greater Dhaka Flood Control and Drainage Project
GOB	Government of Bangladesh
JICA	Japan International Cooperation Agency
MIWDFC	Ministry of Irrigation, Water Development and Flood Control
MPO	Master Plan Organization
PDB	Power Development Board
PHD	Public Health Department
PWD	Public Works Department
RHD	Roads and Highways Department

RAJUK	Rajdhani Unnayan Katripakkha (Capital Development Authority)
RRI	River Research Institute of the Ministry of Irrigation, Water Development and Flood Control
SOB	Survey of Bangladesh
SWMC	Surface Water Modelling Center
SPARRSO	Space Research and Remote Sensing
UNCHS	United Nations Center for Human Settlements
UNDP	United Nations Development Programme
WAPDA	Water and Power Development Authority
WASA	Water and Sewerage Authority
WMO	World Meteorological Organization

SUPPORTING REPORT F

PRELIMINARY DESIGN OF PROPOSED FACILITIES

Table of Contents

List of Table

Table No.

List of Figures

Fig. No

SUPPORTING REPORT F : PRELIMINARY DESIGN OF PROPOSED FACILITIES

1. Embankment, Road-Cum-Embankment and Sub-Embankment

1.1 Design Condition and Criteria

(1) Topographical Conditions :

The proposed facilities are mostly located in the low-lying flat alluvial plain of which most parts are under water for over half year (Fig. F.1.1 to F.1.3).

(2) Geological Conditions :

The results of the geological survey conducted by the Study team are summarized in Table F.1.1.

Based on these results and the geological data obtained from the other studies, the geological profiles along the proposed alignments are produced and shown in Fig. F.1.1, It shows that a soft soil layer of N-values of less than 4 is developed close to the ground surface.

Relationships between the N-values of the standard penetration tests and the cohesions obtained by the uniaxial compression tests are shown in Fig. F.1.5.

The relationship between the cohesion "C" and the N-value is in general, C=1/8~1/2 N. However the relationship in the range of Depth <10m and N-values <10 which has a tendency to cause sliding, is assumed to be C=0.7xN according to the relationship enveloping the lowest limit of the soil test results.

(3) Embankment Material :

In general, the embankment material should have the following requirements :

- proper workability for compaction
- sufficient shear strength for stability
- low permeability for sufficient seepage resistance

The embankment material should be obtained from nearby the construction site. Thus, soil samples have been taken from the riverside and tested at laboratory. The results were studied and analyzed. The relationship between moisture content, and dry density, compaction density (D-value), triaxial compression test results, and permeability test results are shown in Fig. F.1.6 to Fig. F.1.9.

The soil test results of embankment material revealed the following :

- The cohesion for shear strength can be estimated as 4.0 t/m^2 under the condition of 90% wet side of its maximum dry density.

- The permeability is estimated as 10^{-4} cm/s under the same compaction condition.

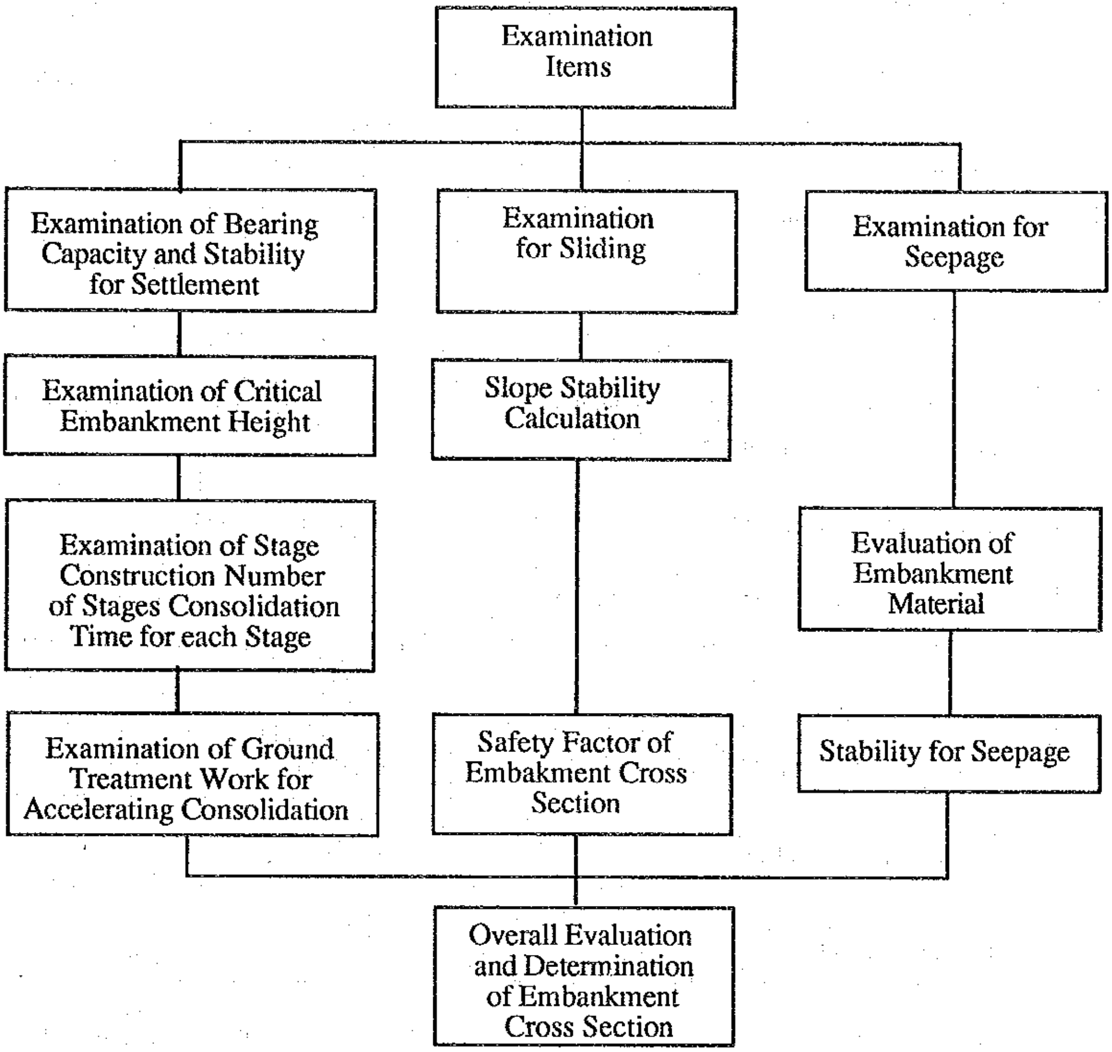
- The natural moisture content is 10~15% under the wet side of its maximum density.

The soil can be used as material for constructing a uniform embankment.

(4) Embankment Stability Analysis

Embankment stability analysis will be conducted according to the following procedures:

Embankment Stability analysis Flow Chart



The stability analyses will be conducted at the following condition :

- Embankment stability after completion (long term)

The safety factor for the embankment stability is to be larger than 1.5 because of :

- As the bearing ground condition in the Project Area is poor because of the soft subsoil layer, the safety factors should have a certain allowance.

- The importance of protection area

5) Construction Period :

The type of foundation treatment work for accelerating the consolidation of soft foundation has a close relationship with the embankment construction period.

The embankment has better to be constructed by a step-by-step construction method according to the progress of the consolidation.

The construction period is determined based on the relationship between the foundation treatment work and the number of stages for embankment construction.

1.2 Standard Cross Sections of the Embankment

1.2.1 Embankment Type and Material :

The embankment type was decided upon based on available material, subsoil conditions, and the design flood water level.

The uniform embankment type was selected for the following reasons:

- Available material at sites is uniform
- As the subsoil is soft, flexible cross section and resistance against ground settlement are required.
- Construction cost is cheaper than other embankment types.

The standard embankment cross sections are shown in Fig. F.1.10.

1.2.2 Foundation Treatment :

There are various foundation treatment methods to be applied according to the construction type, the embankment type, the bearing capacity of the ground, etc. The proposed embankment will partly need to accelerate the subsoil's consolidation by foundation treatments in order to get a required stability.

1) Ground's Bearing Capacity and the Critical Embankment Height

During the field survey period, the following two types of failures were observed at the existing embankments :

- Large settlement occurred when the embankment construction reached a certain height, and
- Sliding failure.

The critical embankment height was assumed by using the Taylor's Stability Analysis Chart as follows :

- Embankment's slope angle : 1:3.0, (B = 18.4°)
- Depth coefficient : nd = (Embankment height + bearing ground depth) ÷ Embankment height = 3.5~6.0
- Stability coefficient : Ns = 5.52 (See Fig. F.1.11)
- Critical embankment height : Hcr=Ns x C÷ rt

Table F.1.3 : Critical Embankment Height

Subsoil Condition		Critical Height : Hcr (m)		
S. P. T. N	Cohesion C=0.7N	Fs=1.0	Fs=1.1	Fs=1.2
1.00	0.70	2.0	1.8	1.7
2.00	1.40	4.0	3.6	3.3
3.00	2.10	5.9	5.4	5.0
4.00	2.80	7.9	7.2	6.6
5.00	3.50	9.9	9.0	8.3
6.00	4.20	11.9	10.8	9.9
7.00	4.90	13.9	12.6	11.6
8.00	5.60	15.9	14.4	13.2
9.00	6.30	17.8	16.2	14.9
10.00	7.00	19.8	18.0	16.5
11.00	7.70	21.8	19.8	18.2
12.00	8.40	23.8	21.6	19.8

Note : Hcr =5.52 x C/r t (m)

According to the above relationship, the ground's bearing strength of the proposed embankment of Greater Dhaka East, having an average N-value 2 to 4, is insufficient in a wide area for supporting the maximum height of 8.5 m and the average height of 5.5 m. If the embankment is constructed up to the design height by a rapid construction method, the embankment would be subject to a sudden settlement or bearing failure.

The ground's bearing strength would increase according to the progress of consolidation by applied loads. If a slow construction method will be applied, the critical height will increase.

In the Study Area, the ground's bearing strength is weak as described above. It would be necessary to construct the embankment by a stage construction method with some foundation treatment.

The embankment sections whose bearing ground must be treated in the Greater Dhaka East and the Narayanganj West are approximately 28.19 km (including 8.52 km of sub-embankments) and 0.80 km respectively and are summarized as follows (For details, see Fig. F.1.12 and Tables F.1.4(1) and (2)).

I. Greater Dhaka East

	Embankment (Total Embankment length)	Station No. From	Station No. To	Distance for Treatment (km)
-	Embankment (27.52km)	E.7	E. 33	10.52
		E. 42+200	E. 59	6.55
		E. 60	E. 64+200	1.80
			Sub-Total =	18.87
-	Sub-embankment (SA) (6.40km)	SA. 5+200	SA. 8+200	1.20
		SA. 10+200	Sa. 12+200	0.80
			Sub-Total =	2.00
-	Sub-embankment (SB) (4.71km)	SB. 0	SB. 7+200	2.96
-	Sub-embankment (SC) (6.31km)	SC. 5+250	SC. 13	3.56
			Total :	28.19 km

II. Narayanganj West

	Station No. From	Station No. To	Distance for Treatment (km)
Embankment (5.70km)	NE. 65	NE. 67	0.40
	NE. 70	NE. 71	0.40
		Sub-Total =	0.80

2) Examination of embankment height by the stage construction by taking into consideration the bearing ground's consolidation.

For normal clay, an increase in the bearing strength by consolidation can be expressed by the following equation :

C = Co+m x 'U' x P

Where, C = ground's cohesion after consolidation (t/m^2)

C_o = strength of original ground (t/m^2)

m = increase rate of strength, approximately 0.3
U = consolidation rate (%)
P = load (t/m^2)

Necessary stage embankment heights by the staged construction for different bearing strengths are shown in Tables F.1.4 (1) - (4).

3) Consolidation Period for a Step Embankment without Foundation Treatment

For the staged embankment construction, it is necessary to leave each embankment step settle for a certain time period until it reaches the required consolidation rate.

For untreated bearing ground, the time periods necessary for obtaining different consolidation rates were calculated as shown in the following Table F.1.5.

Table F.1.5 Consolidation time for Each Embankment Step

Cv (m^2/day	Drain Length (Lm)	95% Consoli-dation Tv	Time (day)	90% Consoli-dation Tv	Time (day)	80% Consoli-dation Tv	Time (day)
0.004	2.50	1.050	1641	0.848	1325	0.567	886
0.004	3.00	1.050	2363	0.848	1908	0.567	1376
0.004	4.00	1.050	4200	0.848	3392	0.567	2268
0.004	5.00	1.050	6563	0.848	5300	0.567	3544
0.004	7.50	1.050	14766	0.848	11925	0.567	7973
0.004	10.00	1.050	26250	0.848	21200	0.567	14175

Note : 1) Consolidation Tv : Coefficient of Consolidation time

According to the table, it will take approximately 10 years to obtain 80% consolidation of untreated soft bearing ground's top 5 m layer which affects the stability of the embankment. Thus, it is evident that adoption of a ground treatment method to accelerate consolidation will be necessary for those embankment sections that require the use of the staged embankment construction method.

4) Foundation Treatment for Accelerating Consolidation

There are the following bearing ground treatment methods :

(a) A consolidation acceleration method to allow step embankment construction;

(b) A bearing ground strengthening method to allow embankment construction on soft ground;

(c) An embanking method using reinforcing materials;

(d) A method for replacing soft top layers :

The characteristics and application of each of the above methods are compared in Table F.1.6.

(1) Selection of Foundation Treatment Method

There are the following three consolidation acceleration methods :

(a) Sand drain-pile method
(b) Geotextile drain-pile method
(c) Sand compaction pile method

Methods (a) and (b) adopt the same vertical draining method and are classified by their material types. Method (c) uses large diameter sand piles only for accelerating consolidation progress. Table F.1.7 lists the necessary features for accomplishing 80% consolidation of the bearing ground in the Study Area for a 7 to 9 month period under the load of an embankment step.

Table F.1.6 Comparison of Bearing Ground Treatment Methods

Method	Principle	Features	Applicability
Consolidation Acceleration Method - Sand Drain - Geotextile Drain (Wick Drain, Etc)	- To accelerate consolidation - To increase ground's own strength	- Widely used - A reliable method to increase entire ground's bearing strength - A slow construction method is adoptable for step embankment construction - A certain amount of consolidation can be accomplished during the construction period	O
Bearing Ground Straighting Method - Sand Compaction	- To forcibly strengthen bearing ground	- Very effective method - Possible to accelerate consolidation	O
Soil Reinforcing Method	- No bearing ground treatment - To reinforce embankment soil	- Reliability of reinforcing soil's strength is required - As bearing ground is untreated, progress of embankment settlement lasts a long period of time - This method is questionable for an embankment's long-term stability in area having a large settlement (use flexible material & variable embankment type)	Δ
Soil Replacement Method	- To replace weak soft soil with strong soil material	- Effective for a thin weak, soft soil layer - Impossible to replace a deep soft soil layer Thus, embankment settlement will be caused by the deep soft soil	Δ

Table F.1.7 Comparison of Accelerating Consolidation Methods

Method	Specifications	Cost per 100m2 (Tk)	Applicability
Sand Drain	ø 400mm sand pile, 2.0m by 2.0m pitch	145,000	O
Geotextile Drain	100mm x 8mm, geotextile Drain 1.25m by 1.25m pitch	113,200	O
Sand Compaction	ø 700mm sand compaction pile, 2.5m by 2.5m pitch	173,000	Δ

The Sand Pile drain and Geotextile drain methods have a following merit and demerit

- Sand Pile Drain

(a) It is rather expensive than Geotextile Drain
(b) It is widely used and practised
(c) Locally available material is usable
(d) When the bearing ground is extremely soft and weak, a sand compaction pile method can be adopted by using the same machinery as for the sand drain pile method.

- Geotextile Drain

(a) It is inexpensive
(b) It is the latest technology
(c) The wick drain is being adopted in the western embankment of FAP-8B Project
(d) The material is not available locally

The above two methods are recommended in this stage.

The final selection should be made after the practice of the Geotextile Drain (wick drain) in the remedial work of western embankment in the FAP-8B Project.

(2) Necessary drain Pile Pitch

The sand drain pile and geotextile drain pitches are calculated by the following equation and conditions.

a) Equation :

$$Th = \frac{Ch.\,t}{de^2}$$

Where,

Th	:	Time factor (%)
Ch	:	Coefficient of consolidation : 0.004 m^2/day
t	:	Consolidation time (day)
de	:	Effective drain pitch (m) (= 1.13 d)
d	:	Drain pitch (m)
dw	:	drain Diameter : Sand pile 0.4^m, Geotext. Drain 0.07^m (Nominal)
n	:	de / dw

b) Drain Pitch

The consolidation time is to be assumed at 7 to 9 months period which coincide with the suspended days of earth work for a year.

Based on the above condition and the relationships between drain pitches and consolidation time, the drain pitches are determined as follows :

- Sand pile drain : 2.00 m
- Geotextile pile drain : 1.25 m.

Table F.1.8 Necessary Sand Drain Pile and Geotextile Drain Pitch

Ch (m2/day)	Drain Pile Dia. (m)	Pitch (m)	Effective Pitch (m)	n	95% Consoli-dation Th	Time (day)	80% Consoli-dation Th	Time (day)
I. Sand Pile Drain								
0.004	0.400	1.00	1.130	2.825	0.200	64	0.100	32
0.004	0.400	1.50	1.695	4.237	0.300	215	0.150	108
0.004	0.400	1.75	1.978	4.944	0.400	391	0.200	196
0.004	0.400	2.00	2.260	5.650	0.500	368	0.200	255
0.004	0.400	2.50	2.825	7.062	0.550	1097	0.250	499
II. Geotextile Pile Drain								
0.004	0.07	0.5	0.57	8.14	0.6	48	0.3	24
0.004	0.07	1.0	1.13	16.14	0.8	255	0.40	128
0.004	0.07	1.25	1.41	20.14	0.9	447	0.45	224
0.004	0.07	1.5	1.70	24.29	1.0	723	0.50	362
0.004	0.07	2.0	2.26	32.3	1.2	867	0.60	434

Note : n, Th : See Fig.F.1.13 (Consolidation Curve and Table)

5) Stability of embankment Cross Section

(1) Stability Against Sliding of Embankment

Stability against sliding of the embankment after completing construction work was examined by using the circular arc sliding method. The results shows that the safety factors of both shallow slope and deep-seated failure stability are 1.61 and 1.64 respectively (See Fig.F.1.14). For the study examination, a representative cross section of the embankment shown in Fig. F.1.10 was analyzed.

By the examination, it was confirmed that the embankment has the required stability (Fs>1.5) to prevent sliding over a long time period for the strength of the bearing ground and the embankment itself.

(2) Stability Against Seepage

Seepage should be examined according to the characteristics of the embankment material and the bearing ground. Soil types of the embankment material and bearing ground in the Study area correspond to the type "ML" of the airfield Classification (Arthur Casagrande) System. The type "ML" soil is a relatively good embankment material. The permeability (K) of the soil material range around 1 x 10^{-4} to 1 x 10^{-5} cm/s on the natural moisture content (See Fig. F.1.8). Based on this soil characteristics and gentle slope of the embankment (1:3), it has been known that the embankment is within the range of safety side against seepage problem.

6) Quality Control of Embankment Material

In Bangladesh, embankment construction is carried out during dry season. Thus, there is a concern that the moisture content of the embankment material might be on the dry side.

In general, the embankment material's compaction density is maintained at more than 90% of the maximum dry density. It is necessary to maintain this density below the wet side in view of maintaining safety against seepage.

7) Land Width for Embankment

The embankment's cross section was decided upon as described in the previous Section. By taking into account the space required for drainage construction space, the land width to be procured for embankment construction was recommended to be the embankment base width plus 30 m (See Fig. F.1.10).

1.3 Associated Structures and Works

1.3.1 Revetment Work

(1) Requirement for the Revetment Work

According to the existing embankment's slope failure conditions, the failures were mainly caused by waves but not the river flow's tractive force. Thus, wind directions are related to the embankment failures.

From a fluvial hydraulic viewpoint, the following aspects shall be taken into consideration for designing the revetment work:

a. River Characteristics :

A river's longitudinal character can be specified by dividing the river course into the following three segments :

Segment 1 : alluvial fan area
Segment 2 : Sedimentary dike area
Segment 3 : Delta area

b. Scouring Factors

The Study Area is located in Segment 3 (delta area) and where the flood flow velocity is not great (approximately 1.0 to 1.5 m/s). Thus, its tractive force is not strong. River scouring is mainly to waves caused by wind and by navigating boats.

From a structural viewpoint, revetment work is classified into the following three types according to the locations where the revetment work is placed :

i) High-water revetment :
ii) Low-water channel revetment :
iii) Embankment revetment :

The planned embankment is at least 20 to 30 m away from the low-water river channel. Thus, a high-water revetment is to be adopted.

(2) Reaches of Revetment Works

The revetment covered from foot of high water river bed to top of embankment is designed for the reaches where scouring by waves will be expected.

The high speed wind recorded during the monsoon season came form the North East side.

Based on the above condition, the revetment work is designed for the following reaches:

a. Greater Dhaka East

- Sta. No. E 15 to E 21	:	3.20 km
- Sta. No. E 32 to E 39	:	3.05 km
- Sta. No. E 44 to E 52	:	3.77 km
- Sta. No. E 54 to E 60	:	2.80 km
Total		12.82 km

b. Narayanganj West

- Sta. No. NE 48-(1) R to NE 49	:	2.25 km
- Sta. No. NE 62 A - NE 87	:	6.90 km
Total		9.15 km

The revetment is to be made of concrete block with brick chips and concrete foundation.

1.3.2 Sodding Work

Sodding is provided on the slope of embankment and berm on River side.

1.3.3 Brick Soling for Maintenance Road

The berm on country side of main embankment is used for operation and maintenance. While for sub-embankment, both berms are used for the operation and maintenance. This space is well compacted and paved by brick soiling in order to keep traffic ability in the rainy season. The above items and their work volumes are summarized in Table F.1.9.

2. Flood Wall

2.1 Design Condition and Criteria

1) Topographical and Geological Conditions

Flood walls are basically planned at highly populated areas having relatively higher elevation and good bearing ground conditions.

The bearing capacity at foot portion of flood wall is assumed at more than 5 t/m^2 from boring data.

2) Stability of Flood Wall

- I Type Wall

I type wall is assumed as a sheet pile type structure. This type structure is imprecisely known that when the embeded length is almost same with the free length, the structure is to be stable against over-turning and sliding provided that foot portion is not scoured or disturbed

Accordingly the foot protection is required in order to avoid the disturbance of foot portion of flood wall and enact the passive earth pressure.

Piping is examined by using Lane's approach and concluded satisfaction for the safety.

- T Type Wall

The stability calculation results shows that the typical section of the flood wall satisfy the required safety factors (Fs>1.5) against the stability of overturing, sliding settlement and pumping.

Cut off structure is not required for the prevention of piping.

2.2 Standard Cross Section of the Flood Wall

1) Flood Wall Types and Material

It was decided upon to adopt inverted T-shaped flood walls (T Type Wall) for high wall portion by taking into account the safety. I-shaped flood walls were decided upon for narrow spaced housing areas. All flood walls are of reinforced concrete.

The standard Cross sections of rehabilitation work of existing flood wall and proposed flood wall are shown in Fig. F.2.1 and F.2.2.

2) Foundations

The ground's bearing strength for flood walls were examined. It was found that no special foundations would be required for the flood walls except at some inverted T-shaped sections. The inverted T-shaped flood walls on soft bearing ground will require pile foundations based on the further soil investigation.

3) Proposed Flood Wall Sections

The proposed length and sections of flood wall by area are summarized as follows :

I. Greater Dhaka East :

- New construction (I Type Wall) = 19.62 km (Sta. No. R.0 to R.22)

II. DND :

- New construction (I Type Wall) = 3.38 km

DN = 0.58 km (Sta. No. DN 0, DN 6, DN 22)
DE = 1.05 km (Sta. No. DE 0, DE 13, DE 18, DE 26)
DS = 1.75 km (Sta. No. DS 0 to DS 6)

- Rehabilitation of Flood Wall = 7.60 km

III. Narayanganj West :

- New construction (I Type & T Type Wall) = 11.49 km (St. NE 0 to NE 6, NE 55 to NE 62)

2.3 Stop Log Structure

Stop-log structure is designed at the openings of the flood walls. The location and number are tabulized below, while the general feature of stop-log structure is shown in Fig. F.2.3.

I. DND area : 58 places

II. Narayanganj : 17 places

The above items and their works volumes are summarized in Table F.2.1.

3. Sluice Gate

3.1 Design Condition and Criteria

Sluice gates are planned at crossing points of the existing drainage channels/khals and the proposed pump stations, however small drainage channels are to be combined with others in order to minimize the number of sluice gates.

A sluice gate of Box Culvert type is planned from economic and technical aspects of its lower cost for construction and easy operation and maintenance works.

The flow area of box culvert type of sluice gate is decided based on the design discharge and the design velocity of 2.5 m/s. However the minimum flow area is assumed to be more than 1.0 m^2 by taking account of maintenance work.

3.2 Standard Structure

Total of seven (7) sluice gates are proposed in the Greater Dhaka East. Four (4) sluice gates are attached with pump stations and others are independently allocated along the Balu river and sub-embankment (SA).

For the DND area, one sluice gate attached with pump station is proposed.

For the Narayanganj West area, 14 sluice gates are proposed along the Lakhya river and the Dhaleswari river. Four (4) sluice gates are attached with pump stations (See Fig. F.1.3).

The proposed structural type are basically classified into two types. The one type is constructed at the embankment and others are at flood wall. However the structural shape is not different except operation and maintenance bridge (See Fig.F.3.1 and F.3.2).

The detailed information on the proposed structural features and dimensions of the sluice gates are also shown in Table F.3.1 and F.3.2.

The main features considered in the design are as follows :

1) To protect the gate structures from seepage, a cutoff wall made of steel sheet piles will be provided beneath and at both the sides of the sluice gate, in and outlet.

2) Bearing capacity of subsoils at the proposed locations are assumed to be 5 ~ 10 t/m2 based on soil survey.

   Since the gate structure has a 8 t/m2 (Flood Wall Section) to 14 ton/m2 (Embankment Section) of unit load, some pile foundation is required. The bearing piles shall be driven to soil layers, having more than N-value 30. The pile bearing capacity is calculated at 30 to 50 tons per pile for the embankment section and 20 tons for the flood wall section of Narayanganj West area.

3) The roller type gate is planned taking into account its easy operation and maintenance. The electrical hoisting devices are applied for the big gates which are more than 2 m x 2 m size per gate. While smaller gate is to be operated by manual.

The items and their work volumes are shown in Table F.3.1 and F.3.2.

	Gate No.	Name of Khal	Sta. No.	Design Discharge (m3/s)	FL. of Outlet (m)	Remarks
I.	Dhaka East					
	14	KD-4	E. 68+150	22.57	+ 2.45	-
	15	KD-3	E. 55	37.34	+ 2.45	-
	16	Boalia Khal (KD-1)	E. 43+320	83.18	- 0.7	Pump Station (P5)
	17	Jamair Khal (KD-5)	E. 28+150	114.61	- 1.0	Pump Station (P6)
	18A	Begunbari Khal (KD-11)	E. 11+430	129.49	- 1.3	Pump Station (P7A)
	18B	Dholai Khal	E. 8+90	140.67	- 1.3	Pump Station (P7B)
	Sub-1	(KD-5)	S.A 11+100	83.2	+ 3.92	Sub-Embankment (SA)
II.	DND					
	20	K-4	DE. 10+300	143.5	- 1.4	Pump Station (P11)
III.	N. West					
	21	K-18	NE. 84+120	7.33	3.30	
	22	K-19	NE. 77+160	16.72	0.0	Pump Station (P12)
	23	K-20	NE. 69+100	---	3.21	Pump Station (P13)
	24	K-22	NE. 49+100	21.90	2.63	
	25	K-23	NE. 46+180	10.54	3.12	
	26	K-23	NE. 40+170	10.31	3.11	
	27	K-25	NE. 32	8.83	3.06	
	28	K-26	NE. 26+150	9.18	3.04	
	29	S-1	NE. 19	10.47	3.33	
	30	S-2	NE. 8+50	6.17	3.00	
	31	K-27	NE. 5+70	7.18	2.98	
	32	S-3	NE. 1+150	3.89	3.25	
	33A	K-28	NW. 23	26.97	0.50	Pump Station(NW) (P14A)
	33B	K-30	NW. 14+190	43.15	0.50	Pump Station(NW) (P14B)

4. Pumping Station

4.1 Design Condition and Criteria

4.1.1 Location and Soil Condition

Nine pumping stations, not including the existing Demra pumping station in the DND, are proposed to be constructed for the priority areas i.e, Greater Dhaka East, DND and Narayanganj West. Their locations are shown in Fig. F.4.1 and listed below.

Drainage Area	Sub-Drainage Area	No. of Pumping Station	Station No. of Embankment	Name of Khal
Greater Dhaka East	DC-1	P5	E 43+320	KD-1 (Boalia Khal)
	DC-2	P6	E 28+150	KD-5 (Jamair Khal)
	DC-3	P7A	E 11+340	KD-11(Begunbari Khal)
	DC-4	P7B	E 8+90	KD-14
DND	NA-1	P10(Demra PS)	DE 17+350	KN-1
	NA-2	P11	DE 10+300	KN-4
	NB-1	P12	NE 77+160	KN-19
Narayanganj West	NB-2	P13	NE 69+100	KN-20
	NB-4	P14A	NW 23	KN-28 (Shasongaen Khal)
	NB-5	P14B	NW 14+190	KN-31 (Mondal Para Khal)

Note : 1) Refer Fig. F.4.1

2) P10 is the existing Demra pumping station of BWDB

The soil investigation for the proposed pump stations were conducted by the study team from May to November 1991, the sub-soil conditions of them are summarized below ;

1) Greater Dhaka East (P5, P6, P7A and P7B)

The sub-soil consists of the following three layers :

1) Greater Dhaka East (P5, P6, P7A and P7B)

The sub-soil consists of the following three layers :

Layer	Depth (m)	Thickness (m)	Material	N-Value	Solidity
Upper layer	0 ~ 20	5 ~ 20	Grey silt w /sand or clayey silt w/ sand	0 ~ 3	Very soft
Middle layer	5 ~ 25	5 ~ 7	Grey or brown silt w/ sand, or fine sand w/silt	5 ~ 20	Stiff
Lower layer	below 25	-	Grey or brown sand silt or fine sand	over 20	Very stiff

The lower layer, having N-values of over 20, is presumed to be a suitable soil layer to support the major structures. The suitable soil layers at P5, P6, P7A and P7B sites are presumed to be approx. 22.0, 28.0, 13.0 and 13.0 m in depth respectively. Their ground water levels are relatively high, approximately within 2.5 m deep.

The characteristics of the sub-soil within 10 m in depth are as follows :

- Natural Moisture Content (Wn) : 26.5 ~ 53.7% (37.0%)
- Specific Gravity (Gs) : 2.57 ~ 2.65 (2.61)
- Atterberg Limits : Liquid (Lw) : 37.8 ~ 128.2 (68.3)
  Plastic (Pw) : 21.4 ~ 99.9 (44.5)
- Density : Wet (rt) : 1.70 ~ 2.05 t/m^3 (1.86 t/m^3)
  : Dry (rd) : 1.11 ~ 1.60 (1.37 t/m^3)
- Cohesion (C) : 2.11 ~ 18.52 t/m^2 (7.50 t/m^2)

2) DND (P11)

The sub-soil is basically the same as that of the Greater Dhaka East, however the depth or thickness of each layer is varied. The upper and middle layers are 8.0 and 5.0 m thick respectively. The lower layer which is presumed to be a suitable soil layer for foundation, seems 13.0 m in depth.

The characteristics of the sub-soil within 10 m in depth are as follows :

-	Natural Moisture Content (Wn)	:	25.9 ~ 39.4% (30.8%)
-	Specific Gravity (Gs)	:	2.61 ~ 2.65 (2.63)
-	Atterberg Limits : Liquid (Lw)	:	115.8 ~ 129.0 (122.0)
	: Plastic (Pw)	:	83.1 ~ 102.5 (93.7)
-	Density : Wet (rt)	:	1.86 ~ 2.07 t/m^3 (1.96 t/m^3)
	: Dry (rd)	:	1.33 ~ 1.64 (1.50 t/m^3)
-	Cohesion (C)	:	1.78 ~ 10.37 t/m^2) (6.67 t/m^2)

3) Narayanganj West (P12, P13, P14A and P14B)

The sub-soil is also basically the same as that of the Greater Dhaka East. The suitable soil layer having N-values of over 20, seems 14 m to 16 m in depth.

The characteristics of the sub-soil within 10 m in depth are as follows ;

-	Natural Moisture Content (Wn)	:	22.1 ~ 46.9% (3728.1%)
-	Specific Gravity (Gs)	:	2.58 ~ 2.66 (2.61)
-	Atterberg Limits : Liquid (Lw)	:	37.7 ~ 60.4 (49.7)
	: Plastic (Pw)	:	20.7 ~ 30.8 (25.8)
-	Density : Wet (rt)	:	1.77 ~ 2.08 t/m^3 (1.98 t/m^3)
	: Dry (rd)	:	1.21 ~ 1.67 (1.55 t/m^3)
-	Cohesion (C)	:	4.45 ~ 12.98 t/m^2) (9.23 t/m^2)

The sub-soil condition at each construction site is shown in Figs. F.4.2 (1) and (2).

4.1.2 Design Criteria

The preliminary designs of the proposed nine (9) pumping stations are carried out based on the followings.

1) Pumping Capacity

The design pumping capacities (Q m^3/s)are devided into the following four classes :

Q = 50 m^3/s class : four stations (P6, P7A, P7B, P11)
Q = 25 m^3/s class : one station (P5)
Q = 5 m^3/s class : one station (P14B)
Q = 2 m^3/s class : three stations (P12, P13, P14A)

The detailed pumping capacities are shown in Table F.4.1.

2) Design Water Levels

The design water levels of the river side and the land side are as follows :

- River side (Out side)

H.H.W.L	:	100-year frequency flood water level
H.W.L	:	2 - year frequency flood water level
L.W.L	:	Average water level at the beginning of June.
		3.00 m PWD (P5, P6, P7A, P11 and P14A)
		3.50 m PWD (P13 and P14B)

- Land side (In side)

H.W.L	:	4.00 m PWD (P5, P6, P7A, P7B and P11)
		4.20 m PWD (P12)
		4.60 m PWD (P13, P14A and P14B)
L.W.L	:	3.00 m PWD (P5, P6, P7A, P7B, P11, P12 and P14A)
		3.50 m PWD (P13 and P14B)

3) Pump Head

The static pump head (Hs) is estimated as follows:

Max. static pump head = H.H.W.L (river side) - L.W.L (land side)
Design static pump head = H.W.L (river side) - L.W.L (land side)
Min. static pump head = L.W.L (river side) - L.W.L (land side)

The total pump head (Ht) is estimated as follows :

$$Ht = Hs + Hl$$

Where, Ht : total pump head (m)
Hs : static pump head (m)
Hl : hydraulic losses of pump equipment, valves and sluice way (m)

The hydraulic losses of pump facilities including valves and sluice ways are roughly estimated to be 0.90 m and 0.60 m respectively.

The design static pump head and the total pump head of each station are shown in Table F.4.1.

4) Pump Operation Period

The pump facilities are assumed to be intermittently operated for 5 months at least yearly from June to October, when the river stage is likely higher than 3.00 m PWD (L.W.L) as shown in Fig. E.3.13 in Supporting Report E.

The annual pump discharge volume of each station is estimated as follows :

P5	:	27.2×10^6 m^3	P6	:	59.1×10^6 m^3
P7A	:	27.2×10^6 m^3	P7B	:	51.0×10^6 m^3
P11	:	54.3×10^6 m^3	P12	:	2.1×10^6 m^3
P13	:	2.4×10^6 m^3	P14A	:	2.9×10^6 m^3
P14B	:	5.7×10^6 m^3			

5) Ground Elevation at Pumping Station

The proposed pumping stations are located near the khals crossing the proposed embankments or flood walls, and the existing ground elevations are below the minimum required ground elevation of 4.50 m PWD.

Based on the elevations of the existing roads nearby and the design flood water levels, the design elevation of each pump station yard is planned as follows ;

P5, P6, P7A, P7B and P11 stations : 5.20 m PWD
P12, P13, P14A and P14B stations : 5.80 m PWD

4.2 Major Mechanical and Electric Equipment

4.2.1 Pump Type Alternatives

The conventional pump applied for urban stormwater drainage systems is generally classified as follows:

- Pump
  - (1) Turbo Pump
    - (1) Mixed Flow Pump
    - (2) Axial Flow Pump
    - (3) Centrifugal Flow Pump
  - (2) Others
    - (4) Screw Pump
    - (5) Submersible Pump

Furthermore, mixed, axial and centrifugal flow pumps are devided into volute / diffuser types, single / double section types, and horizontal / vertical types.

Their applicable ranges in total pump head and bore size are summarized below.

Pump Type		Applicable Range in Total Pump Head (m)	Available Pump Dia. (mm)
Mixed Flow Pump	Horizontal	Less than 7 m	Less than ø 2,000
	Vertical	Less than 9 m	Less than ø 4,600
Centrifugal Flow Pump	Horizontal	More than 10 m	Less than ø 1,600
	Vertical	More than 10 m	Less than ø 2,000
Axial Flow Pump	Horizontal	Less than 3 m	Less than ø 2,000
	Vertical	Less than 5 m	Less than ø 4,600
Screw Pump		Less than 8 m	Less than ø 3,500
Submersible Pump		Less than 20 m	Less than ø 1,800

Submersible pump, screw pump and axial flow type pump will not be selected as pump type alternatives taking account of the following reasons :

(1) Submersible pump

- The big bore submersible pump has not yet been used for urban drainage in Bangladesh.

- As the electric motor is installed below the surface of water, strict and high technical operation and maintenance is required. O/M cost will be high.

(2) Screw Pump

- The unit discharge capacity of pump is smaller than that of the other pump. For example, unit discharge capacity of 3,000 mm in dia. is only about 2.5 m^3/s.

- In case of big pumping station, equipment and construction cost is high.

(3) Axial flow type pump

- The axial flow type pump is possible to operate under the design total pump head, however the maximum total pump head must not exceed 1.4 times of the design total pump head because of stall problem.

- The axial flow type is lower in reliability for a wide range of the pump head than the mixed flow type.

In consideration of the above the following three alternative pump types are considered.

- Alternative 1 : Vertical mixed flow pump
- Alternative 2 : Horizontal mixed flow pump
- Alternative 3 : Vertical mixed flow volute pump

For this project, the Alternative 1 'vertical mixed flow pump' is selected. The advantage and disadvantage of each pump type are described below:

(1) Alternative 1 : Vertical mixed flow pump

Advantage :

- It is more reliable over a wide range of flows and its operation and maintenance works are more easy in comparison with the horizontal mixed flow pump.

- The auxiliary equipment is not required much as the horizontal mixed flow pump, so the pump house space is smaller than that of the horizontal type.

- It is not necessary to pay any special attention for protection of motor driving unit from inundation, because it can be installed on the pump unit.

Disadvantage :

- Though compared to the horizontal mixed flow type, this type saves about 10% in mechanical equipment costs, but requires an additional cost for civil works. The total construction cost is likely higher.

(2) Alternative 2 : Horizontal mixed flow pump

Advantage :

- Disassembly of the pump units for inspection and repair is simple and easy

- Required vertical clearance inside the pump house for installation or disassembly of the pump units is small.

- The total cost including equipment and civil works is less than that of the vertical mixed flow type.

Disadvantage :

- Many pre-operational activities are required prior to operate pumps as listed below:

  (a) To start vacuam pump to fill water in intake casing
  (b) To switch on main pump after completion of the above.
  (c) To start discharge valve opening
  (d) To stop vacuam pump operation

  Due to these required pre-operational activities, the operational reliability of this type is lower than that of a vertical flow pump type.

- Inspection of the auxiliary equipment is required more in detail than that of the vertical flow pump type

- Protection of the pump floor from inundation shall be considered because a lot of electrical equipment, are arranged on the pump floor.

(3) Alternative 3 : Vertical mixed flow volute pump

Advantage :

- This type is often available as a medium head pump (total head : 10 m to 20 m)
- Disassembly of the pump rotating parts for inspection or repairs is easy, because the pump casing can be easily lifted up.

Disadvantage :

- The structure of pump pit is more complicated and costly than the other alternatives.
- For pump installation works, the pump floor is necessary to be slightly wider than that of the vertical mixed flow pump.
- The protection works for electrical equipment from inundation, which is arranged outside of pump pit, must be considered.

4.2.2 Number of Pump Unit and Its Bore

In general, by decreasing pump units, the construction cost will become lower, but the rate of risks in pump operation trouble will likely increase.

In this study, pump unit numbers and their bore sizes are planned based on the followings:

- The maximum pumping capacity per unit is decided to be below 10 m^3/s based on the past experience in Bangladesh, considering easiness of operation and maintenance.
- The proposed nine (9) pumping stations are devided into 4 classes by their total pumping capacities. The pump unit numbers of each class are decided to be the same number.
- The pumping capacity per unit for a 25 m^3/s class and a 50 m^3/s class pumping stations is decided to be the same as possible, because of easiness and low costs for operation and maintenance, including of spare parts.

- The pump unit numbers for a 25 m^3/s and a 50 m^3/s classes pumping stations are decided to be more than 3 units based on their 2 to 3 stage implementation and to lower pump operational risks.

- The minimum pump unit numbers are decided to be 2 units.

The proposed pump unit numbers and their pumping capacities and pump bore are as follows :

Pumping Station	Pumping Capacity (m3/s) Total	Unit	Number of unit	Bore of Pump (mm)
P5	25.6	8.53	3	ø 2,000
P6	54.6	9.10	6	ø 2,000
P7A	53.1	8.85	6	ø 2,000
P7B	47.2	7.87	6	ø 2,000
P11	50.2	8.37	6	ø 2,000
P12	2.0	1.00	2	ø 700
P14A	2.7	1.35	2	ø 800
P14B	5.3	2.65	2	ø 1,200

The above pump bore is estimated by the following formula ;

$$D = 1{,}000 \times (0.1 \sim 0.08) \times \sqrt{Q}$$

Where, D : Pump bore (mm)
Q : Unit pumping capacity (m3/)

4.2.3 Power Source of Pump Operation

For pump operation, the diesel engine driven type and the electric motor driven type were studied.

1) Diesel Engine Driven Type

The diesel engine type is able to ensure pump operation in low cost for a limited time duration by supplying diesel fuel and cooling water from fuel and cooling water tanks in its pump yard.

In this project, a diesel engine, of which the capacity is estimated maximum of 770 PS for a 50 m^3/s class pumping station, is to be required to run continously for at least five months yearly during the flood season .

So, the diesel engine driven type requires regular and intensive operation and maintenance works through a year. Operation costs and capital investment costs would be costly.

2) Electric Motor Driven Type

When the electric motor driven type is adopted as the pump power source, the electricity has to be supplied from a 11KV power line. As the existing 11 KV power line by WAPDA, is located within max. 3.0 km from the proposed pump sites.

Considering the annual pump operation hours of 1,300 to 1,600 hr which are estimated at from the current operation records at Narinda and Demra pumping stations, and the maximum pump shaft break power of 580 KW for a 50 m3/s class pumping station, the capital investment costs, operation and maintenance costs of the electric motor driven type will be more economical than those of a diesel engine driven type.

A backup electric power source will, however, need to be provided to handle in case of emergency such emergencies as a power failure.

Taking account of the above, the electric motor driven type is planned as the pump power source. The maximum pump shaft break power of each pump station is estimated to be as follows :

P5	:	560 KW	P6	:	580 KW
P5	:	550 KW	P6	:	490 KW
P5	:	480 KW	P6	:	75 KW
P5	:	132 KW	P6	:	75 KW
P5	:	75 KW			

4.2.4 Gate of Sluice Way

The water gate is planned to be installed at the sluice way outlet in order to shut the culvert in case of emergency or repairing. The requirements for designing a sluice way gate are summarized below :

Pumping Station	Gate Size W (m) x H (m)	Design Water Depth (m) Out side	In side
P5	2.3 x 2.3	6.15	1.00
P6	2.7 x 2.7	5.90	1.00
P7A	2.7 x 2.7	5.60	1.00
P7B	2.5 x 2.5	5.55	1.00
P11	2.5 x 2.0	5.10	1.00
P12	1.0 x 1.0	5.35	1.00
P13	1.0 x 1.0	4.75	1.00
P14A	1.1 x 1.1	5.20	1.10
P14B	1.5 x 1.5	5.10	1.60

Taking account of the above gate requirements, the following types are planned :

- Gates of P5, P6, P7A, P7B and P11
  gate type : steel roller gate
  hoist : pin-jack type with an electric motor

- Gates of P12, P13, P14A and P14B
  gate type : steel sluice gate
  hoist : manual pin-jack type

4.2.5 Other Major Equipment

The other major equipment to be required for the installation, operation and maintenance works of the pumps are summarized as follows :

- Traveling overhead crane

  P5, P6, P7A, P7B and P11 : 40 t electric trolly type crane
  P14B : 13 t electric double rail hoist type crane
  P12, P13 and P14A : 7.5 t manual trolly type crane

- Screen

  P5, P6, P7a, P7B and P11 : automatic raking screen
  P12, P13 and P14A : manual raking screen

- Valve

  In order to prevent flowing backward, a butterfly valve and a flap valve are to be installed at the middle and outlet of the pipe respectively.

4.3 Civil Works

The pumping station consists of intake channel, pump pit / pump house, discharge basin, outlet channel and other related structures. The civil works of these structures are composed of earth work, foundation work, reinforced concrete work, masonry and other works. The general layout of the proposed 9 pumping stations are shown in Figs. F.4.3 (1) to (5).

4.3.1 Intake Channel

The intake channels convey flood water to the pump pits. The intake channel is designed to be a trapezoidal shape with 1:1 slope lined by brick protection as shown in Fig. F.5.1. and the flow velocity is designed to be less than 0.5 m/s at the maximum pump operation. The dimensions of each intake channel are summarized as follows :

Dimension of Intake Channel

No. of Pump Station	Length (m)	Cross Section			Brick Slope Protection (m^2)
		Bottom Width(m)	Top Width(m)	Height (m)	
P5	175.0	21.4	25.8	2.2	1,090
P6	57.0	41.5	46.9	2.7	440
P7A	114.0	41.5	48.5	3.5	1,130
P7B	75.0	41.5	49.1	3.8	810
P11	62.0	41.5	50.1	4.3	760
P12	150.0	6.2	11.6	2.7	1,150
P13	140.0	6.2	9.8	1.8	720
P14A	67.0	6.7	10.3	1.8	350
P14B	135.0	9.2	15.6	3.2	1,230

4.3.2 Pump Pit

The pump pit is a substructure for the pump station, which will be constructed with reinforced concrete. The pump pit is divided into pump cells of rigid frames, of which the width of each is planned to be 3 times of the pump bore. The top elevation of the pump pit (pump floor) is designed to be 10 cm higher than the proposed ground level of pump yard. The bottom elevation of the pump pit is designed to be more than three times deeper of the pump bore from the pump stop level.

As the bearing capacity of sub-soil is not enough for the spread foundation, the pump pit is planned to be supported by piles, of which the section size is 0.4 m x 0.4 m. The allowable bearing capacity per pile, pile length and required number of piles of pump pit at each pumping station are shown in Table F. 4.2.

A typical design of the pump pit is shown in Figs. F.4.4 (1) to (3)

4.3.3 Pump House

The pump house is a superstructure for the pump station, which is to be constructed with reinforced concrete frames and brick walls. The pump house of a 25 m^3/s or a 50 m3/s class pumping station (P5, P6, P7A, P7B and P11) is of two stories and the others (P12, P13, P14A and P14B) are of one story.

The pump house is to have enough spaces and functions for the followings :

- Pump / motor equipment room
- Electrical panel room
- Operation control panel room
- Repair work shop
- Stores for tools, spare parts and others
- Office with toilet including water supply

The pump house should have the spaces and functions above, using the building space efficiently. The pump house projecting beyond the pump pits will be supported by independent footings with reinforced concrete piles.

A typical design of the pump house is shown in Figs. F.4.4 (1) to (3).

In addition, one storied administration building of approx. $100m^2$ is planned for operations and administrative, staff and meeting rooms by taking account of continuous pump operation during the flood season.

4.3.4 Discharge Basin

The discharge basin to where water is pumped out from pump pits, has a function to transmit the pumped water smoothly to sluice ways as surge tanks. The discharge basin is to be constructed with reinforced concrete of which the top elevation is designed to be the same as that of the proposed embankment. The bottom elevation is designed to be able to install the outlet pipe with a flap valve below L.W.L. of the river side. The reinforced concrete pile foundation is planned. Their requirements are shown in Table F. 4.2.

A typical design of the discharge basin is shown in Figs. F. 4.4 (1) to (3).

4.3.5 Sluice Way

The sluice way with a gate leaf at the outlet is planned with a reinforced concrete box culvert type through the flood embankment. As mentioned in section 3 (sluice gate), the maximum velocity, and the maximum size of the culvert are set at 2.5 m/s and 3.0 m x 3.0 m respectively. Accordingly the box culvert will be subdivided into necessary numbers of compartment based on the design pump discharge. The box culvert is also supported by reinforced concrete piles. Their requirements are shown in Table F.4.2.

The dimensions of the designed sluice ways are summarized below :

Dimension of Sluice Ways

No. of Pump Station	Design Discharge (m)	Cross Section			Length (m)
		Width (m)	Height (m)	No. of Compartment	
P5	25.6	2.3	2.3	2	76.7
P6	54.6	2.7	2.7	3	75.2
P7A	53.1	2.7	2.7	3	73.4
P7B	47.2	2.5	2.5	3	73.1
P11	50.2	2.5	2.0	4	61.4
P12	2.0	1.0	1.0	1	60.2
P13	2.2	1.0	1.0	1	56.6
P14A	2.7	1.1	1.1	1	59.3
P14B	5.3	1.5	1.5	1	58.7

Typical design of sluice way is shown in Figs. F.4.5 (1) and (2).

4.3.6 Outlet Channel

The outlet channel is to convey pumped water from the sluice way to the river side. The design cross section is the same as that of the intake channel, which is designed to be a trapezoidal shape with 1:1 slope lined by brick protection as shown in Fig. F. 5.1.

The dimensions of the outlet channels are summarized below:

Dimension of Outlet Channel

No. of Pump Station	Length (m)	Cross Section			Brick Slope Protection (m^2)
		Bottom Width(m)	Top Width(m)	Height (m)	
P5	130.0	16.0	25.0	4.5	1,660
P6	158.0	26.0	30.0	2.0	900
P7A	78.0	17.0	22.6	2.8	620
P7B	125.0	13.0	19.2	3.1	1,100
P11	130.0	9.0	16.2	3.6	1,330
P12	-	-	-	-	-
P13	-	-	-	-	-
P14A	-	-	-	-	-
P14B	-	-	-	-	-

5. Khal Improvement and Trunk Drain

5.1 Khal Section and Slope Protection

The khal improvement is based on the following two types

- Type (1) : Trapezoidal shape with 1:2 slope lined by sodding
- Type (2) : Trapezoidal shape with 1:1 slope lined by brick

Type (1) is applied for the khals situated in agricultural area where land cost is low and land acquisition is comparatively to be easy. Type (2) is proposed for the khals located in existing built-up areas where land acquisition is likely to be difficult.

Operation and maintenance roads with the minimum width of 4.0m, including its shoulders, are planned to the both banks of the khal. The typical cross sections of khal improvements are shown in Fig. F.5.1.

5.2 Bridge

5.2.1 General Features

According to the field investigation by the study team, there are 86 sites at where the khals to be improved are to cross roads, railways and irrigation canals. The locations are shown in Figs. F. 5.2. (1) and (2), summarized below :

Item	No. of Bridge (Place)			
	Greater Dhaka East	DND	Narayanganj West	Total
1. Road Bridge				
- Not to be reconstructed	5	9	4	18
- To be reconstructed	0	28	0	28
- To be newly constructed	12	6	11	29
Sub-Total	17	43	15	75
2. Railway Bridge				
- Not to be reconstructed	-	-	1	1
- To be reconstructed	1	4	0	5
- To be newly constructed	-	-	3	3
Sub-Total	1	4	4	9
3 Aqueduct				
- Not to be reconstructed	-	-	-	-
- To be reconstructed	-	2	-	2
- To be newly constructed	-	-	-	-
Sub-Total	-	2	-	2
Total :	18	49	19	86

Main features of the existing bridges are shown in Tables F. 5.1. (1) to (3).

5.2.2 Design Criteria

The preliminary design of the proposed bridges are based on the following main design criteria :

- Load

  - o for the internal road bridge : H-20
  - o for the highway bridge : H-20-S16
  - o for the railway bridge : M.L.
  - o for the aqueduct : water weight.

- Bridge width

  The bridge width will be designed as the same width as the existing road or railway.

- Allowable reduction of the khal section

  For deciding a bridge span, the allowable maximum reduction rate of the khal cross section is decided at 30% due to the BWDB design criteria.

5.2.3 Road Bridge

The road bridges are classified into the following three types based on their required spans.

- Type (1) : concrete slab bridge (span : below 5 m)
- Type (2) : concrete girder bridge (span: 5 m to 16 m)
- Type (3) : cantilever type concrete girder bridge (span : 16 m to 30 m)

Considering economic efficiency and construction easiness, abutments with wing walls and piers are planned with brick masonry and reinforced concrete respectively. If a spread foundation is not possible, the pile foundation with appropriate wooden or reinforced concrete piles are planned.

The necessary numbers of each type are summarized below :

(Unit : Place)

Bridge Type	Greater Dhaka East	DND	Narayanganj West	Total
Type (1)	-	6	8	14
Type (2)	11	27	3	41
Type (3)	1	1	-	2
Total :	12	34	11	57

Note : The road bridges which are not required to be reconstructed are not included in the table.

The main features of proposed bridges are shown in Tables F. 5.1 (1) to (3). Typical designs of the road bridge are shown in Figs. F.5.3 to F.5.4.

5.2.4 Railway Bridge

Five railway bridges are planned to be reconstructed and three new bridges to be constructed.

A steel girder type bridge is proposed for reconstruction of the existing railway bridge because of the necessity to perform fast and safe construction without stopping trains.

The abutments and piers are planned with the same materials as that of the road bridge. Reinforced concrete piles are used as foundation of abutment or pier, if necessary.

The main features and typical designs of the proposed railway bridges are shown in Table F. 5.1 (1) to (3) and Fig. F.5.3 (2) respectively.

5.2.5 Aqueduct

Only two aqueducts are planned at the khals crossings with the irrigation canals in the DND area. Considering the expected spans of 7 and 15 m in length, reinforced concrete U - type flume bridges are applied. Abutments are planned with brick masonry to economize the construction cost. A pile foundation by wood or reinforced concrete is applied, if necessary.

The main features and typical designs of the proposed aqueduct are shown in Table F. 5.1 (2) and Fig. F.5.4 respectively.

5.3 Trunk Drain

The trunk drain improvements in the Narayanganj town area are based on the following two covered channel types.

- Type (1) : Brick pipe
- Type (2) : Reinforced concrete box culvert

The brick pipe is commonly applied for swerage and drainage in Dhaka because bricks can be supplied in low cost and many skilled masons are available. It is planned that the brick type pipe with a diameter of 1.5 to 3.0 m be used for the improvement of trunk drains.

The drainage pipes of more than 3.0 m in diameter and discharge capacities more than 10 m^3/s, and being under heavy load conditions are planned to use a reinforced concrete box culvert type.

Typical designs of the proposed trunk drains are shown in Fig. F.5.5.

Table F.1.1 LABORATORY TEST DATA OF SOIL INVESTIGATION

	Sampl No.	Depth (m)	Po (t/m2)	SPT N	MOIS.C (Wn)	Gs (t/m3)	Lw	Pw	rt (t/m3)	rd (t/m3)	C (t/m2)	eo	Cc	Cv (cm2/s)
E-1	U-1	3.33	2.66	2.0	75.9	2.59	115.4	54.6	1.56	0.89	1.97	1.92	0.65	4.2 E-04
	U-2	6.33	5.06	2.0	111.1	2.58	111.4	50.0	1.40	0.66	1.48	2.89	1.00	1.5 E-03
	U-3	9.33	7.46	3.0	35.8	2.59	41.8	25.0	1.86	1.37	2.19	0.89	0.15	2.9 E-04
	U-4	12.33	9.86	15.0	21.6	2.60			2.11	1.73	9.78	0.50	0.07	6.9 E-04
	U-5	15.33	12.26	27.0	37.3	2.65	44.6	23.9	1.90	1.38	13.53	0.90	0.15	3.1 E-04
	U-6	18.33	14.66	29.0	26.1	2.65	36.7	22.2	1.96	1.56	12.23	0.70	0.13	6.8 E-04
E-2	U-1	3.33	2.66	2.0	36.7	2.59	47.8	25.9	1.86	1.36	6.45	0.89	0.11	1.7 E-03
	U-2	9.33	7.46	1.0	50.0	2.61	57.7	28.3	1.70	1.13	2.83	1.30	0.58	3.8 E-04
	U-3	12.33	9.86	1.0	52.9	2.63	50.0	27.5	1.70	1.11	3.22	1.37	0.50	3.5 E-04
	U-4	18.33	14.66	3.0	39.7	2.65	50.1	28.2	1.83	1.31	2.93	1.02	0.54	1.6 E-04
	U-5	21.33	17.06	42.0	35.5	2.67	49.3	26.2	1.82	1.35	3.71	0.98	0.24	2.9 E-04
	U-6	24.33	19.46	40.0	26.4	2.65			1.90	1.50	2.70	0.76	0.09	1.1 E-03
E-3	U-1	3.33	2.66	1.0	47.3	2.65	53.4	29.2	1.74	1.18	2.74	1.24	0.31	5 E-04
	U-2	6.33	5.06	1.0	76.7	2.60	119.5	62.5	1.53	0.87	3.29	1.98	0.77	2.1 E-04
	U-3	9.33	7.46	12.0	26.2	2.66			1.91	1.52	2.85	0.75	0.07	2.4 E-04
	U-4	12.33	9.86	12.0	25.6	2.68			1.88	1.49	2.63	0.79	0.06	1.9 E-04
	U-5	15.33	12.26	26.0	20.4	2.67			1.85	1.54	2.96	0.74	0.09	2.9 E-04
	U-6	18.33	14.66	32.0	18.9	2.68			1.81	1.52	2.42	0.77	0.10	1.7 E-04
E-4	U-1	3.33	2.66	2.0	113.2	2.55	119.7	106.2	1.39	0.65	3.37	2.91	0.94	1.5 E-04
	U-2	6.33	5.06	1.0	48.6	2.65	46.8	23.1	1.76	1.19	2.11	1.23	0.28	1.5 E-03
	U-3	9.33	7.46	2.0	53.7	2.63	49.0	25.4	1.71	1.11	2.24	1.35	0.40	2.9 E-04
	U-4	12.33	9.86	1.5	44.2	2.63	43.6	24.4	1.75	1.21	2.47	1.17	0.23	6.2 E-04
	U-5	15.33	12.26	3.0	49.4	2.62	43.3	23.4	1.76	1.18	2.83	1.22	0.24	3.1 E-04
	U-6	18.33	14.66	4.5	29.0	2.65	34.0	19.2	1.83	1.42	4.05	0.87	0.18	9.5 E-04
	U-7	24.33	19.46	13.0	18.8	2.65			2.15	1.81	3.98	0.46	0.11	2.1 E-04
	U-8	27.33	21.86	15.0	22.5	2.67			2.07	1.69	7.88	0.57	0.12	6.2 E-04
E-5	U-1	3.33	2.66	3.0	36.8	2.63	114.9	84.0	1.84	1.35	5.39	0.96	0.19	3 E-03
	U-2	6.33	5.06	2.0	52.5	2.64	109.2	76.6	1.87	1.23	2.69	1.30	0.29	7.2 E-05
	U-3	9.33	7.46	1.5	44.0	2.65	109.9	76.3	1.76	1.22	2.43	1.16	0.25	6.2 E-04
	U-4	12.33	9.86	2.0	39.9	2.66	110.9	79.3	1.78	1.27	2.74	1.10	0.26	1.3 E-03
	U-5	15.33	12.26	1.5	52.9	2.61	106.1	69.4	1.70	1.11	2.22	1.35	0.45	2.8 E-04
	U-6	18.33	14.66	2.0	48.8	2.62	109.2	73.4	1.75	1.18	1.45	1.23	0.33	1.1 E-04
E-6	U-1	3.33	2.66	8.0	30.9	2.57	117.3	89.6	1.88	1.44	14.41	0.80	0.11	1.1 E-03
	U-2	6.33	5.06	13.0	28.3	2.57	128.2	99.9	2.05	1.60	18.52	0.61	0.07	2.6 E-04
	U-3	9.33	7.46	18.0	26.5	2.63	122.4	96.8	1.96	1.55	12.02	0.69	0.10	9 E-04
	U-4	15.33	12.26	24.0	31.6	2.62	123.1	93.5	1.97	1.50	12.45	0.75	0.10	1.5 E-03
	U-5	18.33	14.66	20.0	25.2	2.59	128.2	102.4	2.05	1.64	8.80	0.58	0.32	3 E-05
	U-6	21.33	17.06	21.0	31.8	2.60	121.7	92.4	1.95	1.48	5.94	0.75	0.34	4.5 E-05
	U-7	24.33	19.46	15.0	29.3	2.63	124.9	96.6	2.00	1.55	9.43	0.70	0.18	6.2 E-04
	U-8	27.33	21.86	14.0	71.2	2.54	93.4	57.5	1.58	0.92	16.52	1.75	0.38	8.5 E-04
E-7	U-1	1.33	1.06	3.5	30.2	2.57	59.2	30.4	1.92	1.47	4.96	0.75	0.20	5.1 E-04
	U-2	3.33	2.66	4.5	36.8	2.63	45.0	24.6	1.84	1.35	4.94	0.96	0.24	1.7 E-04
	U-3	6.33	5.06	9.0	36.1	2.65	40.0	23.6	1.84	1.35	5.76	0.95	0.18	4 E-04
	U-4	9.33	7.46	8.0	28.8	2.65	37.8	21.4	1.94	1.51	8.24	0.76	0.14	4.8 E-03
	U-5	12.33	9.86	10.0	31.3	2.66			1.93	1.47	9.43	0.81	0.19	9.5 E-05
	U-6	15.33	12.26	28.0	21.0	2.64	48.1	24.6	2.08	1.72	21.09	0.54	0.12	2.5 E-03
	U-7	18.33	14.66	15.0	28.1	2.63	49.1	24.1	1.98	1.55	4.04	0.69	0.20	4 E-04
E-8	U-1	1.33	1.06	5.0	26.6	2.65	120.2	94.9	1.93	1.52	8.52	0.74	0.12	1 E-02
	U-2	3.33	2.66	5.0	31.1	2.63	123.3	94.1	1.98	1.51	6.00	0.75	0.14	1.1 E-02
	U-3	6.33	5.06	3.5	39.4	2.61	115.8	83.1	1.86	1.33	1.78	0.98	0.29	3.5 E-04
	U-4	9.33	7.46	11.0	25.9	2.62	129.0	102.5	2.07	1.64	10.37	0.60	0.13	1.7 E-03
	U-5	12.33	9.86	15.0	31.8	2.63	121.6	92.0	1.94	1.47	7.68	0.78	0.14	4.9 E-04
	U-6	15.33	12.26	80.0	28.5	2.62	121.6	94.6	1.95	1.52	17.12	0.73	0.13	8.5 E-04
		12.08	9.66	12.00	39.40	2.63	85.90	57.34	1.85	1.36	6.30	1.02	0.26	1.1 E-03
		27.33	21.86	80.00	113.20	2.68	129.00	106.20	2.15	1.81	21.09	2.91	1.00	1.1 E-02
		1.33	1.06	1.00	18.80	2.54	33.96	19.23	1.39	0.65	1.45	0.46	0.06	3 E-05

Table F.1.2 COMPACTION TEST AND MECHANICAL TEST DATA : DHAKA AND NARAYANGANJ WEST

Sampl	RD=95%						RD=95%					
No.	rd	w(%)	rw	c(t/m2)	Ø(deg)	k(cm/s)	rd	w(%)	rw	c(t/m2)	Ø(deg)	k(cm/s)
I.Dhaka East												
E-1-1	1.51	28.80	1.95	7.21	11.75	1.4 E-04	1.43	31.20	1.88	7.91	13.00	6.4 E-05
E-1-2	1.53	31.15	2.03	6.96	11.00	1.3 E-04	1.45	36.00	1.98	7.56	23.50	1.0 E-04
E-2-1	1.46	31.00	1.91	8.61	12.00	1.5 E-05	1.38	34.00	1.85	6.68	16.00	9.2 E-06
E-2-2	1.48	36.25	2.02	5.98	13.50	1.1 E-05	1.41	43.35	2.02	5.80	17.50	1.1 E-05
E-3-1	1.43	32.70	1.89	7.03	5.00	9.1 E-06	1.35	35.60	1.83	5.27	13.00	7.3 E-06
E-3-2	1.45	38.50	2.01	4.39	13.25	7.2 E-06	1.38	46.20	2.01	4.57	13.50	4.2 E-06
E-4-1	1.63	25.75	2.06	6.15	15.00	1.1 E-04	1.55	27.45	1.97	6.68	21.25	1.1 E-04
E-4-2	1.60	28.15	2.06	5.84	13.75	1.1 E-04	1.52	30.55	1.98	8.44	18.25	1.0 E-04
E-5-1	1.56	27.70	2.00	7.66	11.00	2.3 E-04	1.48	30.40	1.93	7.73	23.00	3.0 E-04
E-5-2	1.54	32.15	2.04	6.85	9.50	2.3 E-04	1.46	35.40	1.98	5.62	21.25	2.2 E-04
E-6-1	1.59	24.25	1.98	7.21	18.00	2.5 E-05	1.51	26.65	1.91	4.92	23.75	4.0 E-05
E-6-2	1.63	29.35	2.10	7.00	16.00	4.3 E-05	1.54	32.50	2.04	8.79	19.25	6.7 E-05
E-7-1	1.77	21.25	2.15	5.98	18.00	2.5 E-05	1.68	23.20	2.07	4.92	27.00	3.0 E-05
E-7-2	1.74	19.75	2.09	7.14	13.00	3.0 E-05	1.65	20.70	1.99	5.27	23.25	3.5 E-05
MEAN	1.57	29.13	2.02	6.71	12.91	8.0 E-05	1.49	32.37	1.96	6.44	19.54	7.9 E-05
MIN	1.43	19.75	1.89	4.39	5.00	7.2 E-06	1.35	20.70	1.83	4.57	13.00	4.2 E-06
MAX	1.77	38.50	2.15	8.61	18.00	2.3 E-04	1.68	46.20	2.07	8.79	27.00	3.0 E-04
II. Narayanganj West												
N-1	1.62	22.50	1.99	8.30	31.00	9.6 E-05	1.54	25.30	1.92	11.07	29.00	7.4 E-05
N-2	1.61	25.30	2.02	9.84	33.00	8.4 E-05	1.53	27.00	1.94	7.03	32.50	8.3 E-05
N-3	1.59	25.00	1.99	9.70	29.00	7.4 E-05	1.51	27.50	1.92	8.96	30.00	7.7 E-05
N-4	1.64	25.00	2.05	7.03	31.50	3.7 E-05	1.55	27.50	1.98	4.92	34.00	2.1 E-05
MEAN	1.62	24.40	2.01	8.72	31.13	7.3 E-05	1.53	26.80	1.94	8.00	31.38	6.4 E-05
MIN	1.59	22.50	1.99	7.03	29.00	3.7 E-05	1.51	25.30	1.92	4.92	29.00	2.1 E-05
MAX	1.64	25.30	2.05	9.84	33.00	9.6 E-05	1.55	27.50	1.98	11.07	34.00	8.3 E-05

Table F.1.4(1) : STAGE CONSTRUCTION OF EMBANKMENT : GREATER DHAKA EAST

Each Stage U = 80%

Station No.	Distance (m)	Accumulative Distance(m)	Ground Elevation(m)	Top of Embankment(m)	Embankment Height(m)	Design N	1st Stage(m)	2nd Stage(m)	3rd Stage(m)	Remarks
E - 0	0.0	0.0	5.46	8.60	3.14	7.50	3.14			
1	400.0	400.0	5.46	8.62	3.16	7.50	3.16			
2	400.0	800.0	3.96	8.63	4.67	4.50	4.67			
3	400.0	1,200.0	3.96	8.65	4.69	4.50	4.69			
4	400.0	1,600.0	4.36	8.67	4.31	4.50	4.31			
5	400.0	2,000.0	4.36	8.69	4.33	4.50	4.33			
6	400.0	2,400.0	4.06	8.70	4.64	4.50	4.64			DC-4
7	400.0	2,800.0	4.26	8.72	4.46	4.50	4.46			
8	400.0	3,200.0	3.46	8.74	5.28	2.00	3.67	1.61		
9	400.0	3,600.0	2.96	8.76	5.8	2.00	3.67	2.13		
10	400.0	4,000.0	3.46	8.77	5.31	2.00	3.67	1.64		
11	400.0	4,400.0	3.96	8.79	4.83	2.00	3.67	1.16		
11+150	150.0	4,550.0	3.94	8.80	4.86	2.00	3.67	1.19		
12	250.0	4,800.0	3.92	8.81	4.89	2.00	3.67	1.22		
13	520.0	5,320.0	2.72	8.83	6.11	2.00	3.67	2.44		
14	400.0	5,720.0	2.65	8.85	6.2	2.00	3.67	2.53		
15	400.0	6,120.0	2.55	8.87	6.32	2.00	3.67	2.65		DC-3
16	400.0	6,520.0	3.06	8.88	5.82	2.00	3.67	2.15		
17	400.0	6,920.0	3.11	8.90	5.79	2.00	3.67	2.12		
18	400.0	7,320.0	3.11	8.92	5.81	2.00	3.67	2.14		
18+200	200.0	7,520.0	3.41	8.93	5.53	2.00	3.67	1.86		
19	200.0	7,720.0	3.70	8.94	5.24	2.00	3.67	1.57		
20	400.0	8,120.0	3.02	8.95	5.93	2.00	3.67	2.26		
21	400.0	8,520.0	2.94	8.97	6.03	2.00	3.67	2.36		
22	400.0	8,920.0	2.58	8.99	6.41	2.00	3.67	2.74		
23	400.0	9,320.0	2.48	9.01	6.53	2.00	3.67	2.86		
24	400.0	9,720.0	2.77	9.02	6.25	2.00	3.67	2.58		
25	400.0	10,120.0	2.68	9.04	6.36	2.00	3.67	2.69		
26	400.0	10,520.0	4.88	9.06	4.18	2.00	3.67	0.51		DC-2
27	400.0	10,920.0	5.00	9.08	4.08	2.00	3.67	0.41		
28	400.0	11,320.0	4.93	9.09	4.16	2.00	3.67	0.49		
29	400.0	11,720.0	4.93	9.11	4.18	2.00	3.67	0.51		
30	400.0	12,120.0	1.72	9.13	7.41	2.00	3.67	2.88	3.46	
31	400.0	12,520.0	1.73	9.15	7.42	2.00	3.67	2.88	3.48	
32	400.0	12,920.0	2.04	9.16	7.12	2.00	3.67	2.88	3.49	
33	400.0	13,320.0	4.37	9.18	4.81	2.00	3.67	1.14		
33+200	200.0	13,520.0	5.50	9.19	3.69	3.25	3.12			
34	200.0	13,720.0	6.63	9.20	2.57	4.50	2.57			
35	400.0	14,120.0	7.01	9.22	2.21	4.50	2.21			
36	400.0	14,520.0	4.38	9.23	4.85	4.50	4.85			
37	400.0	14,920.0	1.61	9.25	7.64	4.50	7.64			
38	400.0	15,320.0	2.78	9.27	6.49	4.50	6.49			
39	250.0	15,570.0	6.76	9.28	2.52	4.50	2.52			
40	400.0	15,970.0	6.96	9.30	2.34	4.50	2.34			
41	400.0	16,370.0	4.66	9.31	4.65	4.50	4.65			
42	400.0	16,770.0	5.46	9.33	3.87	4.50	3.87			
43	400.0	17,170.0	2.76	9.35	6.59	2.00	3.67	2.88	3.68	
44	400.0	17,570.0	1.96	9.37	7.41	2.00	3.67	2.88	3.70	
45	400.0	17,970.0	0.86	9.38	8.52	2.00	3.67	2.88	3.71	DC-1
46	400.0	18,370.0	1.06	9.40	8.34	2.00	3.67	2.88	3.73	
47	400.0	18,770.0	1.66	9.42	7.76	2.00	3.67	2.88	3.75	
48	400.0	19,170.0	1.76	9.44	7.68	2.00	3.67	2.88	3.77	
49	400.0	19,570.0	1.46	9.45	7.99	2.00	3.67	2.88	3.78	
50	500.0	20,070.0	2.16	9.48	7.32	2.00	3.67	2.88	3.81	
51	500.0	20,570.0	4.46	9.50	5.04	2.00	3.67	1.37		
52	370.0	20,940.0	3.09	9.51	6.42	2.00	3.67	2.75		
53	400.0	21,340.0	4.59	9.53	4.94	2.00	3.67	1.27		
54	400.0	21,740.0	5.06	9.55	4.49	2.00	3.67	0.82		
55	420.0	22,160.0	2.53	9.57	7.04	2.00	3.67	2.88	3.90	
56	160.0	22,320.0	2.08	9.57	7.49	2.00	3.67	2.88	3.90	
57	400.0	22,720.0	2.39	9.59	7.2	2.00	3.67	2.88	3.92	
58	400.0	23,120.0	2.37	9.61	7.24	2.00	3.67	2.88	3.94	
59	400.0	23,520.0	2.78	9.63	6.85	2.00	3.67	2.88	3.96	
60	400.0	23,920.0	7.26	9.64	2.38	7.50	2.38			
61	400.0	24,320.0	2.38	9.66	7.28	2.00	3.67	2.88	3.99	
62	400.0	24,720.0	4.73	9.68	4.95	2.00	3.67	1.28		
63	400.0	25,120.0	2.50	9.70	7.2	2.00	3.67	2.88	4.03	
64	400.0	25,520.0	2.95	9.71	6.76	2.00	3.67	2.88	4.04	
65	400.0	25,920.0	7.29	9.73	2.44	2.00				
66	400.0	26,320.0	7.55	9.75	2.2	4.50				
67	400.0	26,720.0	6.89	9.77	2.88	4.50				
68	400.0	27,120.0	7.01	9.78	2.77	4.50				
69	400.0	27,520.0	9.80	9.80	0	4.50				
				AVE	5.65	m		18870.0	7520.00	
				MAX	8.52	m		68.6%	27.3%	
				MIN	2.2	m				

Table F.1.4(2) : STAGE CONSTRUCTION OF SUB-EMBANKMENT : GREATER DHAKA EAST

Each Stage U = 80%

Station	Distance	Accumulative Distance	Ground Elevation	Top of Embankment(m)	Embankment Height(m)	Design N	1st Stage(m)	2nd Stage(m)	3rd Stage(m)	Remarks
SA 0	0.0	0.0	6.90	8.62	1.72	4.00	1.72			
1	400.0	400.0	7.61	8.62	1.01	4.00	1.01			
2	400.0	800.0	6.16	8.62	2.46	4.00	2.46			
3	400.0	1,200.0	6.53	8.62	2.09	4.00	2.09			
4	400.0	1,600.0	5.59	8.62	3.03	4.00	3.03			
5	400.0	2,000.0	4.44	8.62	4.18	4.00	4.18			
6	400.0	2,400.0	4.07	8.62	4.55	2.00	3.67	0.88		
7	400.0	2,800.0	4.54	8.62	4.08	2.00	3.67	0.41		
8	400.0	3,200.0	4.26	8.62	4.36	2.00	3.67	0.69		
9	400.0	3,600.0	6.44	8.62	2.18	4.00	2.18			
10	400.0	4,000.0	5.21	8.62	3.41	4.00	3.41			
11	400.0	4,400.0	4.09	8.62	4.53	2.00	3.67	0.86		
12	400.0	4,800.0	4.18	8.62	4.44	2.00	3.67	0.77		
13	400.0	5,200.0	5.63	8.62	2.99	2.00	2.99			
14	400.0	5,600.0	6.64	8.62	1.98	4.00	1.98			
15	400.0	6,000.0	6.35	8.62	2.27	4.00	2.27			
16	400.0	6,400.0	8.12	8.62	0.50	4.00	0.50			
				AVE	3.11	m		2000.0		
				MAX	4.55			0.3		
				MIN	0.50					

Station	Distance	Accumulative Distance	Ground Elevation	Top of Embankment	Embankment Height	Design N	1st Stage	2nd Stage	3rd Stage	
SB 0	0.0	0.0	3.87	8.33	4.46	2.00	3.67	0.79		
1	360.0	400.0	2.51	8.33	5.82	2.00	3.67	2.15		
2	400.0	760.0	2.30	8.33	6.03	2.00	3.67	2.36		
3	400.0	1,160.0	2.55	8.33	5.78	2.00	3.67	2.11		
4	400.0	1,560.0	1.57	8.33	6.76	2.00	3.67	2.88	0.21	
5	400.0	1,960.0	2.95	8.33	5.38	2.00	3.67	1.71		
6	400.0	2,360.0	3.70	8.33	4.63	2.00	3.67	0.96		
7	400.0	2,760.0	4.58	8.33	3.75	2.00	3.67	0.08		
8	350.0	3,160.0	4.91	8.33	3.42	2.00	3.42			
9	400.0	3,510.0	4.65	8.33	3.68	2.00	3.67	0.01		
10	400.0	3,910.0	5.39	8.33	2.94	5.00	2.94			
11	400.0	4,310.0	6.09	8.33	2.24	5.00	2.24			
12	400.0	4,710.0	6.57	8.33	1.76	7.50	1.76			
				AVE	4.72			3335.0	400.00	
				MAX	6.76			0.7	0.1	
				MIN	1.76					

Station	Distance	Accumulative Distance	Ground Elevation	Top of Embankment	Embankment Height	Design N	1st Stage	2nd Stage	3rd Stage	
SC 0	0.0	0.0	3.36	8.21	4.85	4.00	4.85			
1	500.0	500.0	2.76	8.21	5.45	4.00	5.45			
2	500.0	1,000.0	4.53	8.21	3.68	4.00	3.68			
3	500.0	1,500.0	4.09	8.21	4.12	4.00	4.12			
4	500.0	2,000.0	3.94	8.21	4.27	4.00	4.27			
5	500.0	2,500.0	4.29	8.21	3.92	4.00	3.92			
6	500.0	3,000.0	3.12	8.21	5.09	2.00	3.67	1.42		
7	500.0	3,500.0	2.83	8.21	5.38	2.00	3.67	1.71		
8	500.0	4,000.0	2.03	8.21	6.18	2.00	3.67	2.51		
9	500.0	4,500.0	2.58	8.21	5.63	2.00	3.67	1.96		
10	500.0	5,000.0	2.49	8.21	5.72	2.00	3.67	2.05		
11	500.0	5,500.0	2.66	8.21	5.55	2.00	3.67	1.88		
12	500.0	6,000.0	2.10	8.21	6.11	2.00	3.67	2.44		
13	310.0	6,310.0	2.92	8.21	5.29	2.00	3.67	1.62		
				AVE	5.48			3556.0		
				MAX	6.18			0.6		
				MIN	3.68					

Table 1.4 (3) : STAGE CONSTRUCTION OF EMBANKMENT : NARAYANGANJ WEST (NW)

Each Stage U = 80%

Station No.	Distance (m)	Accumulative Distance (m)	Ground Elevation (m)	Top of Embankment (m)	Embankment Height (m)	Design N	1st Stage (m)	2nd Stage	3rd Stage	Remarks
NW 0	0.0	0.0	5.42	7.96	2.54	2.00	2.54			
1	39.0	39.0	6.26	7.96	1.70	2.00	1.70			
2	200.0	239.0	5.36	7.97	2.61	2.00	2.61			
3	200.0	439.0	5.25	7.98	2.73	2.00	2.73			
4	200.0	639.0	5.85	7.99	2.14	2.00	2.14			
5	200.0	839.0	6.51	8.00	1.49	2.00	1.49			
6	200.0	1,039.0	5.75	8.01	2.26	2.00	2.26			
7	200.0	1,239.0	5.49	8.01	2.52	2.00	2.52			
8	200.0	1,439.0	5.06	8.02	2.96	2.00	2.96			
9	200.0	1,639.0	6.91	8.03	1.12	2.00	1.12			
10	200.0	1,839.0	6.03	8.04	2.01	2.00	2.01			
11	200.0	2,039.0	5.09	8.05	2.96	2.00	2.96			
12	200.0	2,239.0	5.07	8.07	3.00	2.00	3.00			
12	200.0	2,439.0	6.75	8.09	1.34	2.00	1.34			
14	200.0	2,639.0	6.29	8.11	1.82	2.00	1.82			
15	200.0	2,839.0	5.02	8.13	3.11	2.00	3.11			
16	200.0	3,039.0	6.06	8.15	2.09	2.00	2.09			
17	200.0	3,239.0	6.31	8.17	1.86	2.00	1.86			
18	200.0	3,439.0	5.30	8.19	2.89	2.00	2.89			
19	200.0	3,639.0	4.77	8.21	3.44	2.00	3.44			
20	200.0	3,839.0	6.45	8.22	1.77	2.00	1.77			
21	200.0	4,039.0	6.55	8.24	1.69	2.00	1.69			
22	200.0	4,239.0	6.67	8.26	1.59	2.00	1.59			
23	200.0	4,439.0	6.09	8.28	2.19	2.00	2.19			
24	200.0	4,639.0	5.20	8.30	3.10	2.00	3.10			
25	200.0	4,839.0	5.27	8.32	3.05	2.00	3.05			
26	200.0	5,039.0	5.12	8.34	3.22	2.00	3.22			
27	200.0	5,239.0	5.22	8.36	3.14	2.00	3.14			
28	200.0	5,439.0	5.79	8.38	2.59	2.00	2.59			
29	200.0	5,639.0	6.86	8.40	1.54	2.00	1.54			
				AVE	2.43					
				MAX	3.44					
				MIN	1.12					

Table F.1.4(4) STAGE CONSTRUCTION OF EMBANKMENT : NARAYANGANJ WEST (NE)

Each Stage U = 80%

Station No.	Distance (m)	Accumulative Distance (m)	Ground Elevation (m)	Top of Embankment (m)	Embankment Height (m)	Design N	1st Stage (m)	2nd Stage (m)	3rd Stage (m)	Remarks
NE 62	0.0	14,430.0	4.52	8.35	3.83	7.50	3.83			
62A	55.0	14,485.0	7.10	8.35	1.25	7.50	1.25			
63	200.0	14,685.0	6.76	8.36	1.60	7.50	1.60			
64	200.0	14,885.0	7.04	8.37	1.33	7.50	1.33			
65	200.0	15,085.0	4.29	8.38	4.09	2.00	3.67	0.42		
66	200.0	15,285.0	4.32	8.39	4.07	2.00	3.67	0.40		
67	200.0	15,485.0	4.79	8.40	3.61	2.00	3.61			
68	200.0	15,685.0	6.12	8.41	2.29	7.50	2.29			
69	200.0	15,885.0	4.86	8.42	3.56	7.50	3.56			
70	200.0	16,085.0	4.21	8.43	4.22	2.00	3.67	0.55		
71	200.0	16,285.0	7.80	8.44	0.64	7.50	0.64			
-(1	179.0	16,464.0	2.70	8.45	5.75	2.00	3.67	2.08		
-1	250.0	16,714.0	5.24	8.45	3.21	7.50	3.21			
-2	250.0	16,964.0	3.91	8.45	4.54	7.50	4.54			
-3	250.0	17,214.0	4.58	8.45	3.87	2.00	3.87			
3	296.0	17,510.0	3.50	8.45	4.95	2.00	4.95			
2	250.0	17,760.0	3.05	8.45	5.40	2.00	5.40			
1	250.0	18,010.0	5.32	8.45	3.13	7.50	3.13			
(1)	250.0	18,260.0	2.50	8.45	5.95	2.00	5.95			
72	69.0	18,329.0	7.44	8.45	1.01	7.50	1.01			
73	201.0	18,530.0	5.31	8.46	3.15	7.50	3.15			
74	200.0	18,730.0	6.35	8.47	2.12	7.50	2.12			
75	200.0	18,930.0	6.27	8.48	2.21	7.50	2.21			
76	200.0	19,130.0	6.57	8.49	1.92	7.50	1.92			
77	200.0	19,330.0	4.72	8.50	3.78	7.50	3.78			
78	200.0	19,530.0	5.47	8.51	3.04	7.50	3.04			
79	200.0	19,730.0	6.19	8.52	2.33	7.50	2.33			
80	200.0	19,930.0	6.15	8.53	2.38	7.50	2.38			
81	200.0	20,130.0	7.16	8.54	1.38	7.50	1.38			
82	200.0	20,330.0	6.41	8.55	2.14	7.50	2.14			
83	200.0	20,530.0	6.18	8.56	2.38	7.50	2.38			
84	200.0	20,730.0	6.54	8.57	2.03	7.50	2.03			
85	200.0	20,930.0	6.83	8.58	1.75	7.50	1.75			
86	200.0	21,130.0	6.91	8.59	1.68	7.50	1.68			
87	200.0	21,330.0	6.90	8.60	1.70	7.50	1.70			
				AVE	2.92			814.50		
				MAX	5.95			14.3%		
				MIN	0.64					

Table F.1.9 : MAIN FEATURE OF EMBANKMENT:DHAKA EAST & NARAYANGANJ WEST

	EMBANKMENT LENGTH(KM)	BANKING VOLUME(M3)	FOUNDATION TREATMENT(M2	LAND ACQUISITION(M2)	REVETMENT (M2)	SODDING (M2)	BRICK SOLING(M2)	REMARKS
I.DHAKA EAST A.MAIN EMBANKMENT								
1.DC-1	14.00	1,898,550	458,697	1,067,422	190,276	337,756	70,000	
2.DC-2	6.00	760,123	290,755	484,110	43,325	202,835	30,000	
3.DC-3	2.97	371,481	151,451	247,301	39,270	85,015	14,850	
4.DC-4	4.55	400,032	81,881	323,271		132,521	22,750	
SUB TOTAL	27.52	3,430,186	982,784	2,122,104	272,871	758,127	137,600	
B.SUB-EMBANKMENT								
1.SA	6.40	273,402	70,080	348,860		100,400	38,400	
2.SB	4.71	405,920	145,766	324,481		138,956	28,260	
3.SC	6.31	664,850	189,072	474,322		261,820	37,860	
SUB TOTAL	17.42	1,344,172	404,918	1,147,663		501,176	104,520	
G.TOTAL	44.94	4,774,358	1,387,702	3,269,767	272,871	1,259,303	242,120	
II.NARAYANGANJ.WEST								
1.NW	5.64	161,641		285,839		88,422	19,995	
2.NE	10.35	517,392	48,475	587,107	95,910	118,135	51,750	
G.TOTAL	15.99	679,033	48,475	872,946	95,910	206,557	71,745	

Table F.2.1 MAIN FEATURE OF FLOOD WALL/ WORKS:DHAKA EAST, DND & NARAYANGANJ WEST

	FLOOD WALL LENGTH(KM)	CONCRETE VOLUME(M3)	REHABLITATION WORKS		STOP LOG STRUCTURE(PLS)	REMARKS
			F.WALL RAISING	FOOT PROTECTION		
I.DHAKA EAST A.FLOOD WALL						
1.DC-1	5.85	1,255	-	-	-	
2.DC-2	4.85	1,410	-	-	-	
3.DC-3	2.50	900	-	-	-	
4.DC-4	8.07	1,966	-	-	-	
SUB TOTAL	21.27	5,531	-	-	-	
II.DND						
1.DW	-		-	3.60	14	
2.DN	0.58	206	4.40	5.60	17	
3.DS	1.75	790	-	-	-	
4.DE	1.05	240	3.20	8.40	27	
SUB TOTAL	3.38	1,236	7.60	17.60	58	
III.NARAYANGANJ.WEST						
1.NW			-	-	0	
2.NE	11.48	16,384	-	-	17	
G.TOTAL	11.48	16,384	-	-	17	

Table F.3.1(1): MAIN FEATURE OF SLUICE GATES :DHAKA EAST

No.	Sta. No.	Mark (Khal No.) Q(m3/s)	Dimensions of Culvert B (m)	H (m)	L (m)	N	Inlet B1 (m)	L1 (m)	B2 (m)	Outlet B3 (m)	B4 (m)	B5 (m)	L2 (m)	L3 (m)	O.Bridge L4 (m)	Khal Dimension (b1,b2,h1)	Remarks
I. Greater Dhaka East																	
1	E68 + 150	14	2.20	2.20	36.00	2	5.10	10.00	22.00	5.40	10.20	12.20	12.00	10.00	15.00	2.00	
		(KD-4)														20.20	
		22.57														4.55	
2	E55	15	2.20	2.20	34.00	3	8.00	10.00	25.00	8.60	13.40	15.40	12.00	10.00	15.00	5.00	
		(KD-3)														23.20	
		37.34														4.55	
3	E43 + 320	16	3.00	3.00	45.00	4	14.10	10.00	43.00	15.00	19.80	21.80	12.00	10.00	20.00	20.00	With Pump
		(KD-1)														40.80	P5 : (25.2 M3/s)
		83.18														5.20	
4	E28 + 150	17	2.80	2.80	45.00	6	20.30	10.00	51.20	23.00	28.00	30.00	12.00	10.00	20.00	27.00	Pump
		(KD-5)														49.00	P6 : (54.6 m3/s)
		114.61														5.50	
5	E11 + 340	18A	3.00	3.00	43.50	6	21.80	10.00	54.00	24.20	29.00	31.00	12.00	10.00	19.00	28.50	Pump
		(KD-11)														51.70	P7A : (53.1 m3/s)
		129.49														5.80	
6	E8 + 90	18B	3.00	3.00	43.50	6	21.50	10.00	53.00	23.00	27.50	29.50	12.00	10.00	19.00	27.50	Pump
		(KD-14)														50.70	P7B : (47.2 m3/s)
		140.67														5.80	
7	SA.11+100	Sub-1	3.00	3.00	40.00	4	14.20	4.50	22.00	14.20	16.00	22.00	4.50	10.00	15.00	16.00	Sub Emb.SA
		(KD-5)														31.70	
		83.2														3.92	

Table F.3.1(2) MAIN FEATURE OF SLUICE GATES :DHAKA EAST

Mark	Concrete				Sheet Pile	R.C Pile			Bed.	Excavation	Backfill
(Khal No.)	Inlet	Mainbox	Outlet	Total			Per No.	Total L	Protection		
Q(m3/s)				m3	m2	No	m	m	m2	m3	m3
I. Greater Dhaka East		9.79									
		2.45									
14	132.19	433.44	83.91	649.54	312.60	64	19.0	1216	322	1396	665
(KD-4)											
22.57		9.57									
		2.45									
15	149.99	577.32	106.95	834.26	358.20	95	18.9	1786	384	1670	637
(KD-3)											
37.34		9.35									
		-0.70									
16	259.59	1229.02	156.95	1645.56	506.40	202	19.0	3845	628	7597	2777
(KD-1)											
83.18		9.10									
		-1.00									
17	299.22	1699.50	214.34	2213.06	612.00	292	25.0	7300	792	10181	3024
(KD-5)											
114.61		8.81									
		-1.30									
18A	321.13	1726.75	223.19	2271.07	640.80	304	8.0	2434	830	11022	3193
(KD-11)											
129.49		8.74									
		-1.30									
18B	316.08	1726.02	213.39	2255.49	627.90	299	10.0	2986	805	10919	3193
(KD-14)											
140.67		8.62									
		0.64									
Sub-1	90.46	1082.40	54.33	1227.19	430.20	158	10.0	1585	380	4377	1428
(KD-5)											
83.2											

Table F.3.2(1) : MAIN FEATURE OF SLUICE GATES :DND AND NARAYANGANJWEST

No.	Sta. No.	Mark (Khal No.) Q(m3/s)	Dimensions of Culvert B (m)	H (m)	L (m)	N	Inlet B1 (m)	L1 (m)	Outlet B2 (m)	B3 (m)	B4 (m)	B5 (m)	L2 (m)	L3 (m)	O.Bridge L4 (m)	Khal Dimension (b1,b2,h1)	Remarks
I.DND																	
1	DE.10+300	20 (KN-4) 143.5	3.00	3.00	21.50	6	21.50	10.00	47.00	23.00	27.80	29.80	12.00	10.00	7.00	33.50 45.30 5.90	Pump/Wall P11 : (50.2 m3/s)
2	DE.17+350	19	2.40	2.70	-	2	-	-	-	-	-	-	-	-	-		P 10 (existing Pump.)
II. Narayanganj West																	
1	NE84 + 120	21 (KN-18) 7.23	1.70	1.70	24.00	1	1.70	5.00	11.00	1.70	3.70	5.70	5.00	5.00	7.00	2.00 9.40 3.70	Emb
2	NE 77 + 160	22 (KN-19) 16.72	2.60	2.60	39.30	1	2.60	10.00	23.20	3.30	8.00	10.00	12.00	10.00	15.50	2.00 20.00 4.50	Pump/Emb P12 : (2.0 m3/s)
3	NE69 + 100	23 (KN-20) 20.04	3.00	3.00	38.00	1	3.00	10.00	23.60	3.70	8.00	10.00	11.00	10.00	15.50	2.00 20.00 4.50	Pump/Emb P13 : (2.2 m3/s)
4	NE49 + 100	24 (KN-22) 21.9	2.20	2.20	24.00	2	5.10	5.00	14.00	5.40	7.40	9.40	5.00	5.00	No	4.50 12.24 3.87	Emb
5	NE46 + 180	25 (KN-23) 10.54	2.00	2.00	7.00	1	2.00	1.50	11.00	2.00	3.50	5.50	1.50	5.00	No	2.50 9.26 3.38	F. Wall
6	NE40 + 170	26 (KN-24) 10.31	2.00	2.00	7.00	1	2.00	1.50	11.00	2.00	3.50	5.50	1.50	5.00	No	2.50 9.28 3.39	F. Wall
7	NE32	27 (KN-25) 8.83	2.00	2.00	7.00	1	2.00	1.50	11.00	2.00	3.50	5.50	1.50	5.00	No	2.00 8.88 3.44	F. Wall
8	NE26 + 150	28 (KN-26) 9.18	2.00	2.00	7.00	1	2.00	1.50	11.00	2.00	3.50	5.50	1.50	5.00	No	2.00 8.92 3.46	F. Wall
9	NE19	29 (S-1) 10.47	3.00	3.00	7.00	1	3.00	1.50	5.00	3.00	4.50	6.50	1.50	5.00	No	Box Culvert 3.00 3.0mx3.0m	F. Wall
10	NE8 + 50	30 (S-2) 6.17	2.50	2.50	7.00	1	2.50	1.50	5.00	2.50	4.00	6.00	1.50	5.00	No	Pipe Culvert 2.50 D=2.5m	F. Wall
11	NE5 + 70	31 (KN-27) 7.18	1.70	1.70	7.00	1	1.70	1.50	10.00	1.70	3.20	5.20	1.50	5.00	No	2.00 8.04 3.02	F. Wall
12	NE1 + 150	32 (S-3) 3.89	2.20	2.20	7.00	1	2.20	1.50	4.00	2.20	3.70	5.70	1.50	5.00	No	Pipe Culvert 2.20 D=2.2m	F. Wall
13	NW23	33A (KN-28) 26.97	2.40	2.40	38.00	2	5.80	10.00	16.00	6.60	10.00	12.00	9.00	10.00	15.50	6.00 14.00 4.00	Pump/Emb P14A : (2.7 m3/s)
14	NW14 + 190	33B (KN-30) 43.15	3.00	3.00	29.50	2	7.00	10.00	19.60	7.80	14.00	16.00	15.00	10.00	8.50	9.50 17.50 4.00	Pump/Emb P14B : (5.3 m3/s)

Table 3.2(2) MAIN FEATURE OF SLUICE GATE :DND AND NARAYANGANJ WEST

Mark	Concrete				Sheet Pile	R.C Pile			Bed.	Excavation	Backfill
(Khal No.)	Inlet	Mainbox	Outlet	Total			Per No.	Total L	Protection		
Q(m3/s)				m3	m2	No	m	m	m2	m3	m3
		-1.40									
20	288.18	797.10	214.55	1299.82	580.20	181	8.0	1444	748	6635	1955
(KN-4)											
143.5											
19											
III Narayanganj West		8.58									
		3.30									
21	51.75	145.32	19.35	216.42	193.80	13	13.0	168	147	365	232
(KN-18)											
7.23		8.54									
		0.00									
22	141.89	313.43	70.37	525.69	297.90	37	13.0	485	312	2917	2012
(KN-19)											
16.72		8.47									
		3.21									
23	154.39	324.48	68.07	546.94	312.30	40	13.0	524	316	763	416
(KN-20)											
20.04		8.30									
		2.63									
24	66.02	288.41	31.47	385.90	254.40	38	13.0	491	214	788	369
(KN-22)											
21.9		7.69									
		3.12									
25	28.23	40.00	5.22	73.44	176.70	8	6.4	54	145	126	78
(KN-23)											
10.54		7.65									
		3.11									
26	28.23	39.94	5.22	73.38	176.70	8	6.1	51	145	127	79
(KN-24)											
10.31		7.59									
		3.06									
27	28.23	39.92	5.22	73.36	176.70	8	6.1	51	145	131	81
(KN-25)											
8.83		7.55									
		3.04									
28	28.23	39.88	5.22	73.32	176.70	8	6.1	51	145	133	83
(KN-26)											
9.18		7.52									
		3.33									
29	11.18	51.34	6.58	69.09	182.70	13	6.0	75	95	123	66
(S-1)											
10.47		7.47									
		3.00									
30	11.35	45.85	5.90	63.10	170.70	10	6.0	63	90	145	85
(S-2)											
6.17		7.44									
		2.98									
31	23.85	36.15	4.81	64.81	166.50	7	6.0	43	132	133	86
(KN-27)											
7.18		7.42									
		3.25									
32	8.25	41.62	5.49	55.36	160.50	9	6.0	55	77	118	71
(S-3)											
3.89		8.30									
		0.50									
33A	113.17	484.89	67.69	665.76	306.60	72	16.0	1147	260	3057	1603
(KN-28)											
26.97		8.17									
		0.50									
33B	141.19	441.80	136.36	719.35	324.00	81	11.0	889	336	2930	1418
(KN-30)											
43.15											

TABLE F.4.1 DESIGN CRITERIA OF PUMPING STATION

Item (Drainage Area / Pumping Station)			Greate Dhaka East				DND	Narayanganj West			
			P5	P6	P7A	P7B	P11	P12	P13	P14A	P14B
(1) Pump Drainage Area (km2)			22.11	47.88	46.58	41.34	31.69	1.73	1.92	2.36	4.65
(2) Pump Capacity (m3/s)			25.6	54.6	53.1	47.2	50.2	2.0	2.2	2.7	5.3
(3) Design Water Level (m PWD)	Outer	H.H.W.l. (T = 1/100)	8.15	7.90	7.60	7.55	7.10	7.35	7.25	7.10	7.00
		H.W.L. (T = 1/2)	6.25	6.15	6.05	6.00	5.65	5.80	5.70	5.50	5.45
		L.W.L.	3.00	3.00	3.00	3.00	3.00	3.00	3.50	3.00	3.50
	Inner	H.W.L.	4.00	4.00	4.00	4.00	4.00	4.20	4.60	4.50	4.60
		L.W.L.	3.00	3.00	3.00	3.00	3.00	3.00	3.50	3.00	3.50
(4) Pump Actual Head (m)		Maximum	5.15	4.90	4.60	4.55	4.10	4.35	3.75	4.10	3.50
		Design	3.25	3.15	3.05	3.00	2.65	2.80	2.20	2.50	1.95
		Maximum	0.0	0	0	0	0	0	0	0	0
(5) Pump Total Head (m)		Maximum	6.65	6.40	6.10	6.05	5.60	5.85	5.25	5.60	5.00
		Design	4.75	4.65	4.55	4.50	4.15	4.30	3.70	4.00	3.45
(6) Pump Operating Period			June to October (5 month)								
(7) Ground Elevation at Pump yard (m PWD)		Existing	1.70	2.20	3.00	3.30	4.00	4.50	3.60	3.50	5.20
		Proposed	5.20	5.20	5.20	5.20	5.20	5.80	5.80	5.80	5.80

TABLE F.4.2 FOUNDATION PILE OF PUMPING STATION

Item	Pupping Station	Area of Bottom Slab (m2)	Weight W (t)	Soil Condition: Avg. N-Value of Supporting Layer C (t/m2)	Soil Condition: Avg. N-Value of Middle Layer C (t/m2)	Precast Concrete Pile: Section B1(m)xB2)(m)	Length l (m)	Allowable Bearing Cap. per Pile (t/Pile): Point Resistance	Frictional Force	Total	Required Number of Pile n(nos)	Remarks
Pump Pit Pump Hose	P5	752	11006	16	5	0.4 x 0.4	19	18.4	36.3	54.7	201	
	P6	1246	21191	24	5	0.4 x 0.4	25	28.8	47.9	76.7	276	
	P7A	1246	21154	28	5	0.4 x 0.4	8	32.9	15.7	48.6	435	
	P7B	1246	21010	25	5	0.4 x 0.4	10	29.2	19.5	48.7	431	
	P11	1246	21083	23	5	0.4 x 0.4	8	25.9	13.6	39.5	534	
	P12	209	3073	22	5	0.4 x 0.4	13	25.5	25.2	50.7	61	
	P13	209	3106	18	5	0.4 x 0.4	13	20.8	25.1	45.9	68	
	P14A	223	3331	23	5	0.4 x 0.4	16	26.6	30.9	57.5	58	
	P14B	327	4050	24	5	0.4 x 0.4	11	26.8	21.4	48.2	84	
Discharge Basin	P5	275	2954	16	5	0.4 x 0.4	20	18.3	38.2	56.6	52	
	P6	537	5791	24	5	0.4 x 0.4	26	27.6	49.8	77.4	75	
	P7A	537	5708	28	5	0.4 x 0.4	9	32.8	17.6	50.4	113	
	P7B	537	5694	25	5	0.4 x 0.4	11	29.2	21.4	50.5	113	
	P11	537	5570	23	5	0.4 x 0.4	9	26.9	15.6	42.5	131	
	P12	40	400	22	5	0.4 x 0.4	14	25.5	27.1	52.6	8	
	P13	40	373	18	5	0.4 x 0.4	14	20.8	27.0	47.8	8	
	P14A	44	426	23	5	0.4 x 0.4	17	26.6	32.8	59.4	7	
	P14B	73	675	24	5	0.4 x 0.4	12	27.9	23.3	51.2	13	
Sluice Way	P5	507	7213	16	5	0.4 x 0.4	20	18.3	38.2	56.6	128	
	P6	765	10930	24	5	0.4 x 0.4	26	27.6	49.8	77.4	141	
	P7A	748	10333	28	5	0.4 x 0.4	9	32.8	17.6	50.4	205	
	P7B	703	9844	25	5	0.4 x 0.4	11	29.2	21.4	50.5	195	
	P11	772	7534	23	5	0.4 x 0.4	9	26.9	15.6	42.5	177	
	P12	133	1005	22	5	0.4 x 0.4	14	25.5	27.1	52.6	19	
	P13	121	837	18	5	0.4 x 0.4	14	20.8	27.0	47.8	18	
	P14A	133	1021	23	5	0.4 x 0.4	17	26.6	32.8	59.4	17	
	P14B	218	1336	24	5	0.4 x 0.4	12	27.9	23.3	51.2	26	

TABLE F.5.1(1) KHAL IMPROVEMENT RELATED WORKS (BRIDGE/AQUEDUCT) - GREATER DHAKA EAST

Zone	Khal No.	Bridge No.	Existing		Required	Proposed			Remarks
			Type	Size (m x m)	Size (m x m)	Type	Size (m x m)	Width	
DC-1	KD-1-1	1	Cantilever	17.00 x 4.70	10.43 x 7.70	-	-	-	Road bridge
	KD-1-5	2	Girder bridge	6.58 x 4.70	6.58 x 4.70	-	-	-	" "
	KD-3-1	3	" "	11.50 x 6.50	9.10 x 5.00	-	-	-	" "
	KD-4	4	" "	6.00 x 5.10	7.00 x 5.00	-	-	-	" "
DC-2	KD-5-8	5	Deck-Rly	6.00 x 3.60	9.33 x 4.80	Deck Girder	9.4 x 4.80	1.7	Railway bridge
	KD-10-1	6	-	-	11.11 x 4.90	Girder bridge	11.2 x 4.90	3.66	Road bridge
	"	7	-	-	" "	" "	" "	"	" "
	"	8	-	-	" "	" "	" "	"	" "
	KD-10-2	9	-	-	6.98 x 4.80	" "	7.00 x 4.80	"	" "
	"	10	-	-	" "	" "	" "	"	" "
	"	11	-	-	" "	" "	" "	"	" "
	"	12	-	-	" "	" "	" "	"	" "
	"	13	-	-	" "	" "	" "	"	" "
DC-4	KD-14-2	14	-	-	24.92 x 5.30	Cantilever	25.00 x 5.30	3.66	" "
	KD-14-5	15	Girder bridge	11.00 x 5.30	9.50 5.30	-	-	-	" "
	"	16	-	-	9.88 5.20	Girder bridge	10.00 x 5.20	3.66	" "
	KD-17-2	17	-	-	9.59 5.20	" "	9.60 x 5.20	"	" "
	KD-20-1	18	-	-	8.17 x 5.30	" "	8.20 x 5.30	"	" "

TABLE F.5.1(2) KHAL IMPROVEMENT RELATED WORKS (BRIDGE) - DND

Zone	Khal No.	Bridge No.	Existing		Required	Proposed			Remarks
			Type	Size (m x m)	Size (m x m)	Type	Size (m x m)	Width	
NA-1	KN-1-1	1	Girder bridge	12.50 x 5.00	6.65 x 5.00	-	-	-	Road bridge
	"	2	" "	8.40 x 5.00	6.50 x 5.00	-	-	-	" "
	KN-1-2	3	Box culvert	4.70 x 4.70	15.80 x 5.00	Girder bridge	15.8 x 5.00	40.00	Highway bridge
	KN-1-3	4	Girder bridge	11.00 x 3.00	14.75 x 5.00	" "	14.7 x 5.00	3.66	Road bridge
	KN-1-5	5	Box culvert	4.50 x 4.50	12.60 x 5.00	" "	12.6 x 5.00	40.00	Highway bridge
	KN-1-6	6	Slab bridge	4.85 x 2.30	11.32 x 4.90	" "	11.5 x 4.90	3.66	Road bridge
	KN-1-7	7	Deck-Rly.	11.00 x 4.88	6.26 x 4.88	-	-	-	Railway bridge
	"	8	Girder bridge	8.00 x 4.75	6.47 x 4.75	-	-	-	Road bridge
	NA-2-1	9	Aqueduct	4.00 x 0.61	6.68 x 0.61	Rect. Aqueduct	7.00 x 0.61	"	Rect. Aqueduct
	"	10	Pipe	0.91 x 2.00	6.68 x 4.95	Girder bridge	6.70 x 4.95	"	Road bridge
	"	11	Slab	1.09 x 1.57	6.77 x 4.90	" "	6.80 x 4.90	"	" "
	"	12	Pipe	0.91 x 1.00	6.77 x 4.90	" "	6.80 x 4.90	"	" "
	"	13	Slab	91.00 x 1.35	3.71 x 4.87	Slab bridge	3.80 x 4.87	"	" "
	KN-2-2	14	Pipe	0.91 x 1.00	3.94 x 4.65	" "	4.00 x 4.65	"	" "
	KN-3	15	-	-	6.73 x 4.90	Girder bridge	6.80 x 4.90	"	" "
	KN-13	16	-	-	6.69 x 5.00	" "	6.70 x 5.00	"	" "
	KN-14-3	17	-	-	2.96 x 4.70	Slab bridge	3.00 x 4.70	7.00	" "
	KN-15	18	-	-	4.92 x 4.80	" "	5.00 x 4.80	3.66	" "
NA-2	KN-4-1	19	Deck Rly.	18.3 x 7.00	26.18 x 5.20	Deck Girder	26.10 x 5.20	1.70	Railway bridge
	"	20	Pipe	0.45 x 2.00	29.18 x 5.20	Cantilever	26.10 x 5.20	3.66	Road bridge
	"	21	"	0.91 x 1.00	26.18 x 5.20	Deck Girder	26.10 x 5.20	1.70	Railway bridge
	KN-4-3	22	"	0.91 x 1.00	13.19 x 5.17	Girder bridge	13.20 x 5.20	3.66	Road bridge
	"	23	"	0.61 x 1.00	13.19 x 5.17	" "	13.20 x 5.20	"	" "
	KN-4-4	24	Girder bridge	5.50 x 3.70	9.37 x 5.10	" "	9.40 x 5.10	"	" "
	"	25	Arch bridge	4.50 x 4.85	9.50 x 5.04	" "	9.50 x 5.00	"	" "
	KN-4-5	26	Pipe	0.91 x 1.00	4.95 x 4.85	Slab bridge	5.00 x 4.90	"	" "
	"	27	"	"	5.02 x 4.80	girder bridge	5.10 x 4.80	"	" "
	"	28	"	"	5.09 x 4.75	" "	5.10 x 4.80	"	" "
	"	29	"	"	5.15 x 4.70	" "	5.20 x 4.70	"	" "
	KN-4-6	30	Box culvert	0.70 x 0.80	4.40 x 4.59	Deck Girder	4.40 x 4.60	1.70	Railway bridge
	KN-5-2	31	Girder bridge	13.00 x 5.00	13.30 x 5.00	-	-		Road bridge
	KN-6	32	" "	10.80 x 5.10	6.85 x 5.10	-	-		" "
	"	33	" "	7.00 x 5.20	6.85 x 5.20	-	-		" "
	"	34	" "	10.70 x 5.15	6.85 x 5.15	-	-		" "
	KN-7-1	35	Aqueduct	3.60 x 1.80	14.24 x 1.37	Rect. aqueduct	15.00 x 1.37	0.91	Rect. Aqueduct
	"	36	Slab bridge	2.40 x 2.50	14.24 x 5.17	Girder bridge	14.30 x 5.17	3.66	Road bridge
	KN-7-4	37	Pipe	0.91 x 2.00	5.26 x 5.07	" "	5.30 x 5.07	"	" "
	"	38	Slab bridge	0.95 x 1.65	5.28 x 5.05	" "	5.30 x 5.05	"	" "
	"	39	Pipe	0.61 x 1.00	5.35 x 5.00	" "	5.35 x 5.00	"	" "
	"	40	-	-	5.42 x 4.95	" "	5.45 x 4.95	"	" "
	"	41	Pipe	0.91 x 1.00	5.49 x 4.90	" "	5.50 x 4.90	"	" "
	"	42	Slab bridge	2.30 x 2.00	5.56 x 4.85	" "	5.56 x 4.85	"	" "
	KN-7-5	43	Pipe	0.45 x 1.00	3.47 x 4.72	Deck Girder	3.50 x 4.72	1.70	Railway bridge
	KN-9	44	Slab bridge	3.00 x 1.90	7.05 x 5.10	Girder	7.00 x 5.10	3.66	Road bridge
	"	45	Girder bridge	10.40 x 5.00	7.05 x 5.10	-	-	-	" "
	KN-10	46	Pipe	0.45 x 1.00	6.26 x 4.65	Girder bridge	6.30 x 4.60	3.66	" "
	"	47	"	0.45 x 2.00	6.26 x 4.65	" "	6.30 x 4.65	"	" "
	KN-12	48	Slab bridge	1.70 x 2.25	3.59 x 5.00	Slab bridge	3.60 x 5.00	"	" "
	KN-17	49	-	-	6.14 x 4.50	Girder bridge	6.20 x 4.50	"	" "

TABLE F.5.1(3) KHAL IMPROVEMENT RELATED WORKS (BRIDGE) - NARAYANGANJ WEST

Zone	Khal No.	Bridge No.	Existing Type	Existing Size (m x m)	Required Size (m x m)	Proposed Type	Proposed Size (m x m)	Proposed Width	Remarks
NB-1	KN-19	50	-	-	5.60 x 4.00	Girder bridge	5.6 x 4.00	-	Road bridge
NB-2	KN-21	51	-	-	2.60 x 4.00	Slab bridge	2.7 x 4.00	-	" "
	KN-22	52	-	-	5.25 x 4.00	Girder bridge	5.3 x 4.00	-	" "
	"	53	-	-	5.25 x 4.00	Deck girder	5.3 x 4.00	1.7	Railway bridge
NB-3	KN-23	54	-	-	3.50 x 3.50	" "	3.5 x 3.50	"	" "
	KN-24	55	-	-	3.50 x 3.50	" "	3.5 x 3.50	"	" "
	KN-25	56	Deck-Rly	6.10 x 6.10	3.15 x 3.50	-	-	-	" "
	"	57	Slab bridge	2x4.6 x 5.00	3.15 x 3.50	-	-	-	Roade bridge
	KN-26	58	Box culvert	4.60 x 4.90	3.15 x 3.50	-	-	-	" "
	KN-27	59	Girder bridge	6.00 x 4.70	3.15 x 3.50	-	-	-	" "
NB-4	KN-29	60	-	-	3.50 x 4.00	Slab bridge	3.50 x 4.00	3.66	Road bridge
	"	61	-	-	3.50 x 4.00	" "	3.50 x 4.00	"	" "
NB-5	KN-30-1	62	-	-	8.75 x 4.00	Girder bridge	8.80 x 4.00	"	" "
	KN-30-2	63	Girder bridge	11.80 x 5.10	3.85 x 4.00	-	-	-	" "
	KN-31-1	64	-	-	5.95 x 4.00	Slab bridge	6.00 x 4.00	3.66	Road bridge
	KN-31-2	65	-	-	3.50 x 4.00	" "	3.50 x 4.00	"	" "
	"	66	-	-	3.50 x 4.00	" "	3.50 x 4.00	"	" "
	KN-32	67	-	-	3.85 x 4.00	" "	3.90 x 4.00	"	" "
	"	68	-	-	3.85 x 4.00	" "	3.90 x 4.00	"	

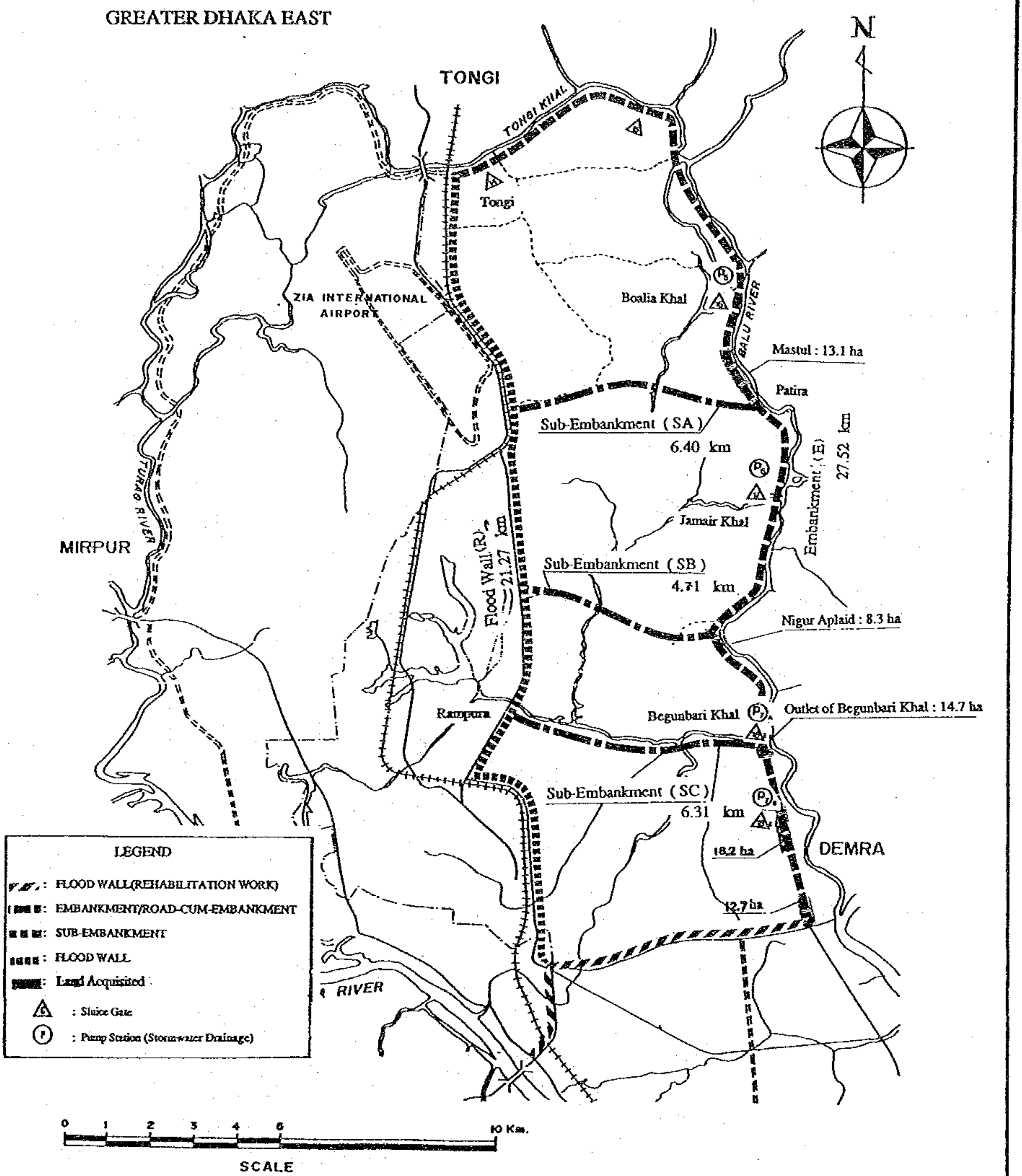


FIG. F.1.1	PROPOSED LAYOUT OF FLOOD MITIGATION FACILITY : GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA

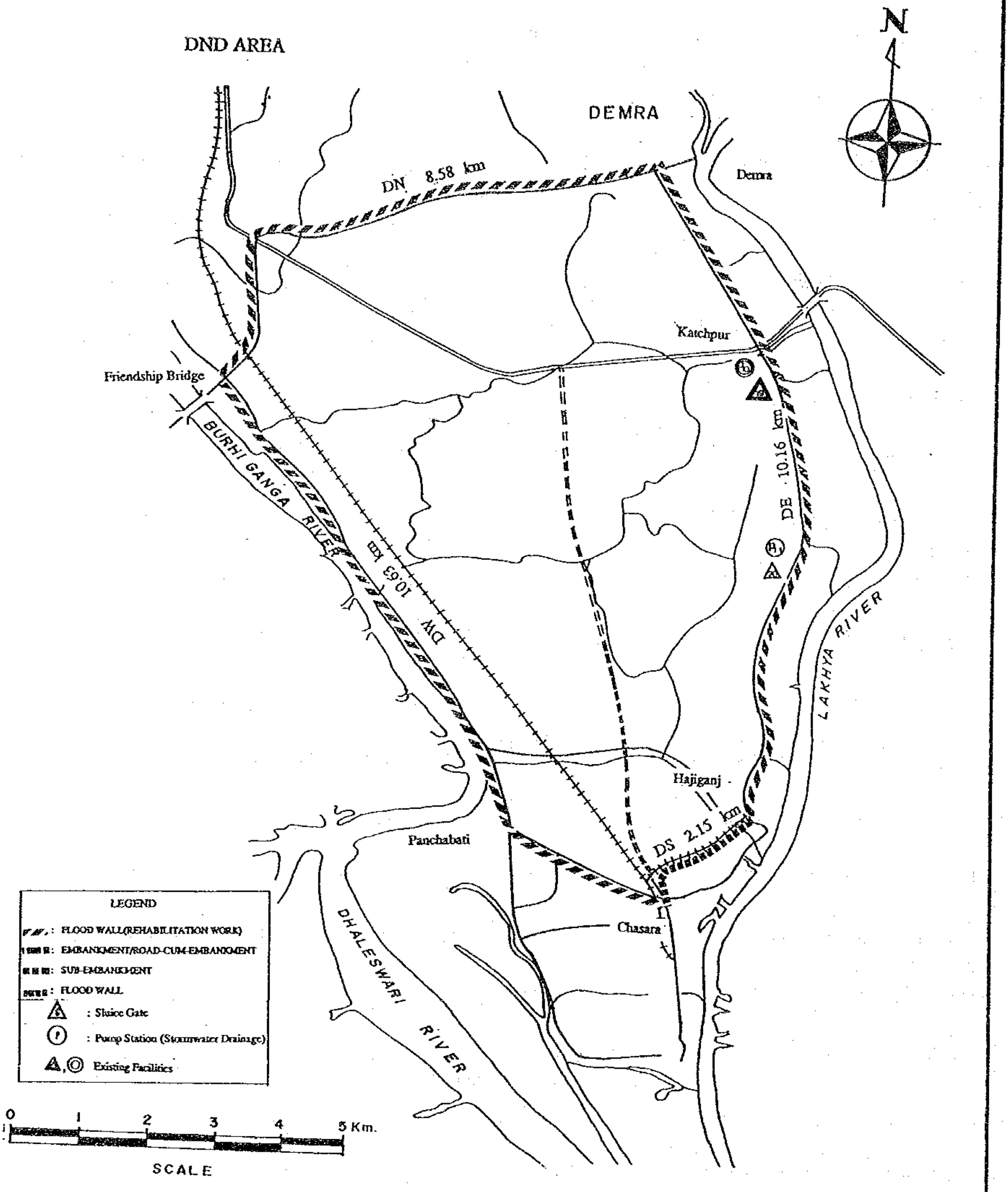


FIG. F.1.2	PROPOSED LAYOUT OF FLOOD MITIGATION FACILITY : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

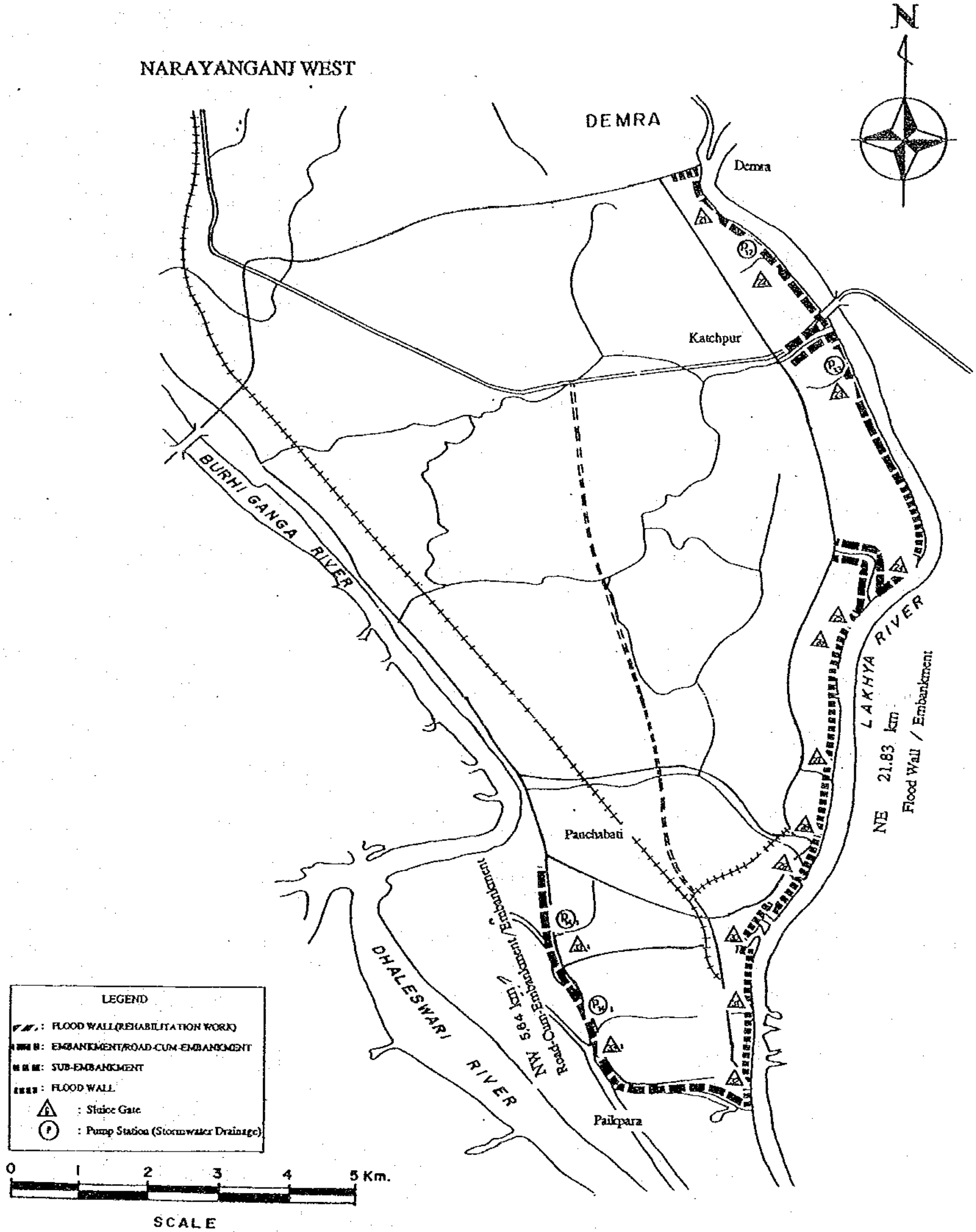
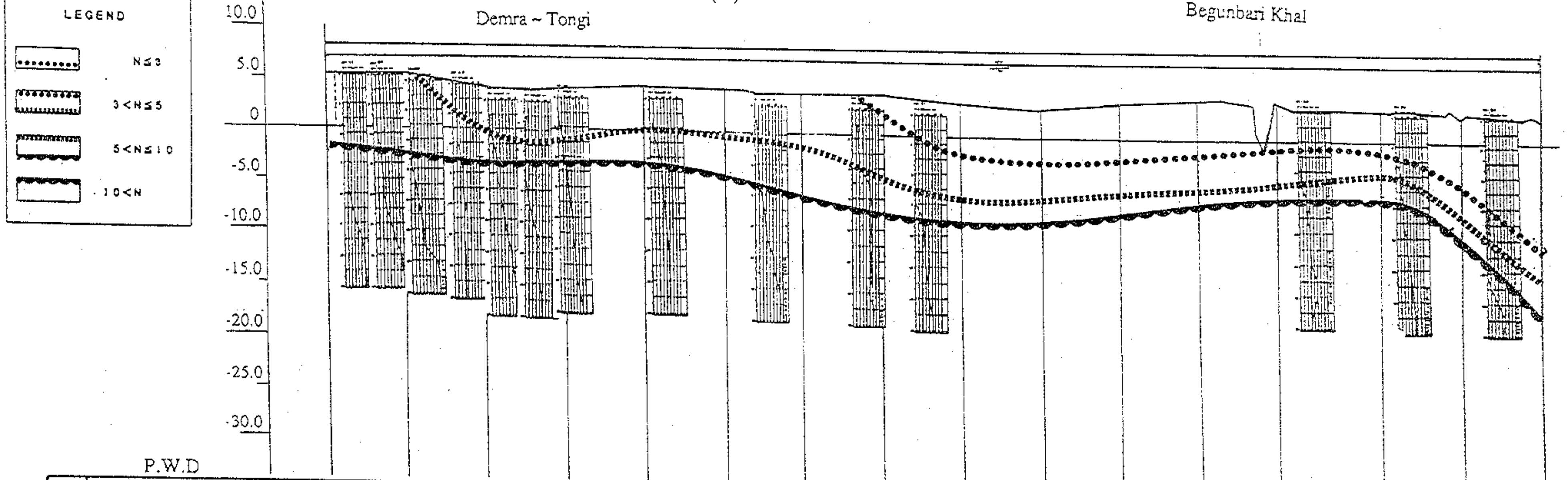


FIG. F.1.3 PROPOSED LAYOUT OF FLOOD MITIGATION FACILITY : NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

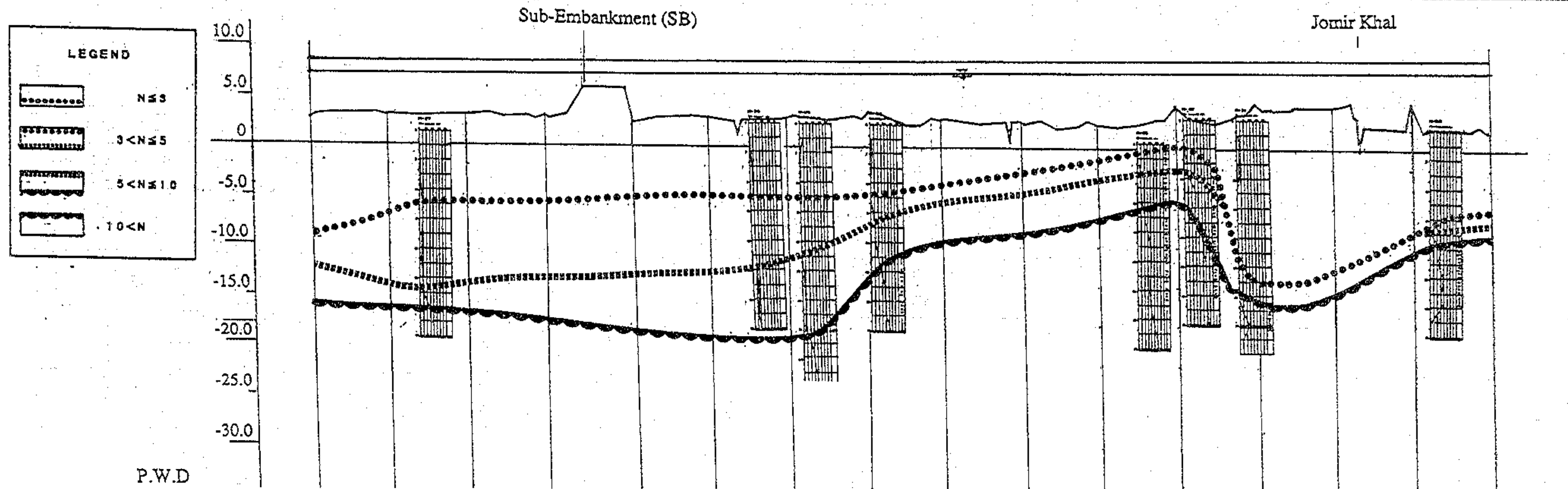
Greater Dhaka East : Embankment (E)



		E. 0	E. 1	E. 2	E. 3	E. 4	E. 5	E. 6	E. 7	E. 8	E. 9	E. 10	E. 11	E. 12	E. 13	E. 14	E. 15
DESIGNED	GRADIENT	i = 1/22,930															
DESIGNED	TOP OF EMBANKMENT	8.60	8.62	8.63	8.65	8.67	8.69	8.70	8.72	8.74	8.76	8.77	8.79	8.81	8.83	8.85	8.87
DESIGNED	H.W.L	7.40	7.42	7.43	7.45	7.47	7.49	7.50	7.52	7.54	7.56	7.57	7.59	7.61	7.63	7.65	7.67
GROUND ELEVATION		5.46	5.46	3.96	3.96	4.36	4.46	4.06	4.26	3.46	2.96	3.46	3.96	3.92	2.72	2.65	2.55
DISTANCE (M)		0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	520.0	400.0	400.0
ACCUMULATED DISTANCE(M)		0	400.0	800.0	1200.0	1600.0	2000.0	2400.0	2800.0	3200.0	3600.0	4000.0	4400.0	4800.0	5320.0	5720.0	6120.0
STATION NO.		E. 0	E. 1	E. 2	E. 3	E. 4	E. 5	E. 6	E. 7	E. 8	E. 9	E. 10	E. 11	E. 12	E. 13	E. 14	E. 15

FIG. F.1.4(1) GEOLOGICAL PROFILES ALONG THE PROPOSED EMBANKMENT (E) (1) (GREATER DHAKA EAST)

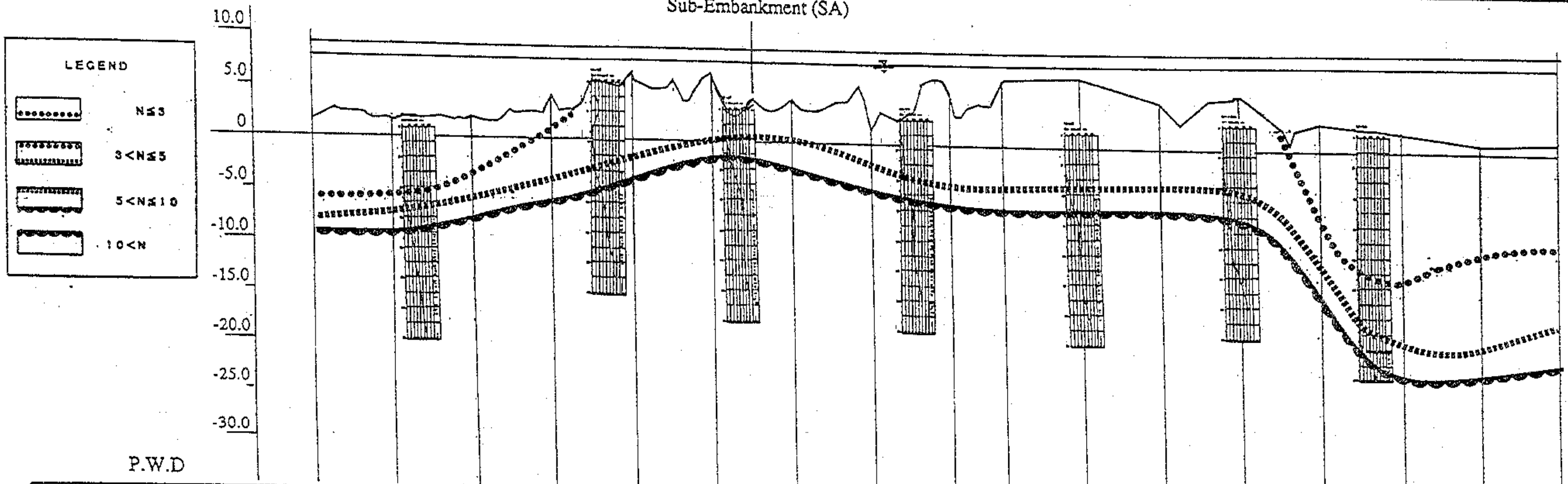
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



		E.15	E.16	E.17	E.18	E.19	E.20	E.21	E.22	E.23	E.24	E.25	E.26	E.27	E.28	E.29	E.30
DESIGNED	GRADIENT	1 = 1/22,930															
	TOP OF EMBANKMENT	8.87	6.88	8.90	8.92	8.94	8.95	8.97	8.99	9.01	9.02	9.04	9.06	9.08	9.09	9.11	9.13
	H.W.L.	7.67	7.68	7.70	7.72	7.74	7.75	7.77	7.79	7.81	7.82	7.84	7.86	7.88	7.89	7.91	7.93
GROUND ELEVATION		2.55	3.06	3.11	3.11	5.96	3.02	2.94	2.58	2.48	2.77	2.68	4.88	5.00	4.93	4.93	1.72
DISTANCE (M)		400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0
ACCUMULATED DISTANCE (M)		6120.0	6520.0	6920.0	7320.0	7720.0	8120.0	8520.0	8920.0	9320.0	9720.0	10120.0	10520.0	10920.0	11320.0	11720.0	12120.0
STATION NO.		E.15	E.16	E.17	E.18	E.19	E.20	E.21	E.22	E.23	E.24	E.25	E.26	E.27	E.28	E.29	E.30

FIG. F.1.4(2) GEOLOGICAL PROFILES ALONG THE PROPOSED EMBANKMENT (E) (2) (GREATER DHAKA EAST)

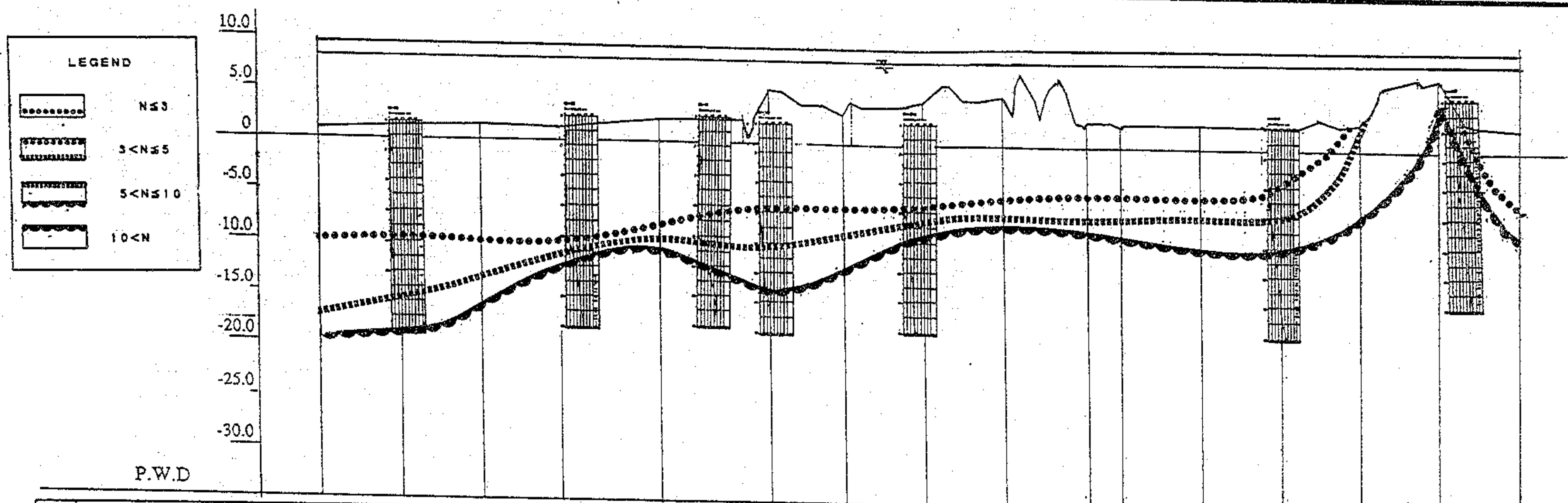
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



		E.30	E.31	E.32	E.33	E.34	E.35	E.36	E.37	E.38	E.39	E.40	E.41	E.42	E.43	E.44	E.45	E.46
DESIGNED	GRADIENT	I= 1/22,930																
	TOP OF EMBANKMENT	9.13	9.15	9.16	9.18	9.20	9.22	9.23	9.25	9.27	9.28	9.30	9.31	9.33	9.35	9.37	9.38	9.40
	H.W.L	7.93	7.95	7.96	7.98	8.00	8.02	8.03	8.05	8.07	8.08	8.10	8.11	8.13	8.15	8.17	8.18	8.20
GROUND ELEVATION		1.72	1.73	2.04	4.37	6.83	7.01	400.0	1.61	2.78	6.76	6.96	4.66	5.46	2.76	1.96	0.86	1.06
DISTANCE (M)		400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	250.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0
ACCUMULATED DISTANCE (M)		12120.0	12520.0	12920.0	13320.0	13720.0	14120.0	14520.0	14920.0	15320.0	15570.0	15970.0	16370.0	16770.0	17170.0	17570.0	17970.0	18370.0
STATION NO.		E.30	E.31	E.32	E.33	E.34	E.35	E.36	E.37	E.38	E.39	E.40	E.41	E.42	E.43	E.44	E.45	E.46

FIG. F.1.4(3) GEOLOGICAL PROFILES ALONG THE PROPOSED EMBANKMENT (E) (3) (GREATER DHAKA EAST)

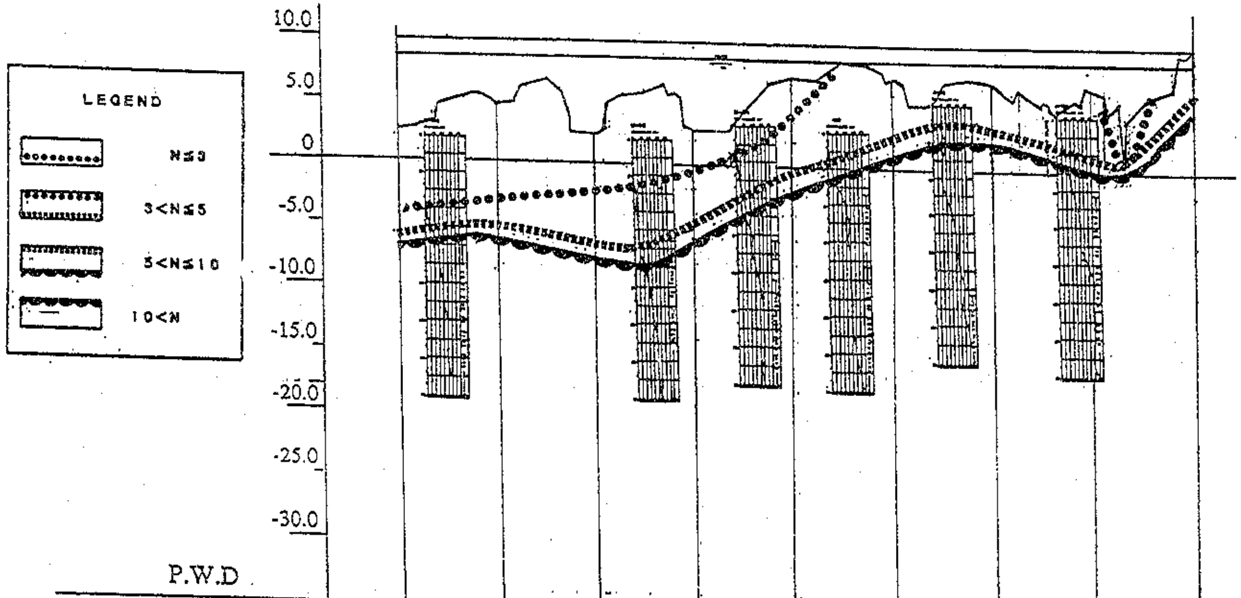
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



DESIGNED	GRADIENT	i = 1/22,930															
DESIGNED	TOP OF EMBANKMENT	9.40	9.42	9.44	9.45	9.48	9.50	9.51	9.53	9.55	9.57	9.57	9.59	9.61	9.63	9.64	9.66
DESIGNED	H.W.L	8.20	8.22	8.24	8.25	8.28	8.30	8.31	8.33	8.35	8.37	8.37	8.39	8.41	8.43	8.44	8.46
GROUND ELEVATION		1.06	1.66	1.76	1.46	2.16	4.46	3.09	4.59	5.08	2.53	2.08	2.39	2.37	2.78	7.26	2.38
DISTANCE (M)		400.0	400.0	400.0	400.0	500.0	500.0	370.0	400.0	400.0	420.0	160.0	400.0	400.0	400.0	400.0	400.0
ACCUMULATED DISTANCE (M)		18370.0	18770.0	19170.0	19570.0	20070.0	20570.0	20940.0	21340.0	21740.0	22160.0	22320.0	22720.0	23120.0	23520.0	23920.0	24320.0
STATION NO.		E.46	E.47	E.48	E.49	E.50	E.51	E.52	E.53	E.54	E.55	E.56	E.57	E.58	E.59	E.60	E.61

FIG. F.1.4(4) GEOLOGICAL PROFILES ALONG THE PROPOSED EMBANKMENT (E) (4) (GREATER DHAKA EAST)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



DESIGNED	GRADIENT	I= 1/22,930								
DESIGNED	TOP OF EMBANKMENT	9.66	9.68	9.70	9.71	9.73	9.75	9.77	9.78	9.80
DESIGNED	H.W.L	8.46	8.48	8.50	8.51	8.53	8.55	8.57	8.58	8.60
GROUND ELEVATION		2.38	4.73	2.50	2.95	7.29	7.55	6.89	7.01	10.76
DISTANCE (M)		400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0
ACCUMULATED DISTANCE(M)		24320.0	24720.0	25120.0	25520.0	25920.0	26320.0	26720.0	27120.0	27520.0
STATION NO.		E.61	E.62	E.63	E.64	E.65	E.66	E.67	E.68	E.69

FIG. F.1.4(5) GEOLOGICAL PROFILES ALONG THE PROPOSED EMBANKMENT (E) (5) (GREATER DHAKA EAST)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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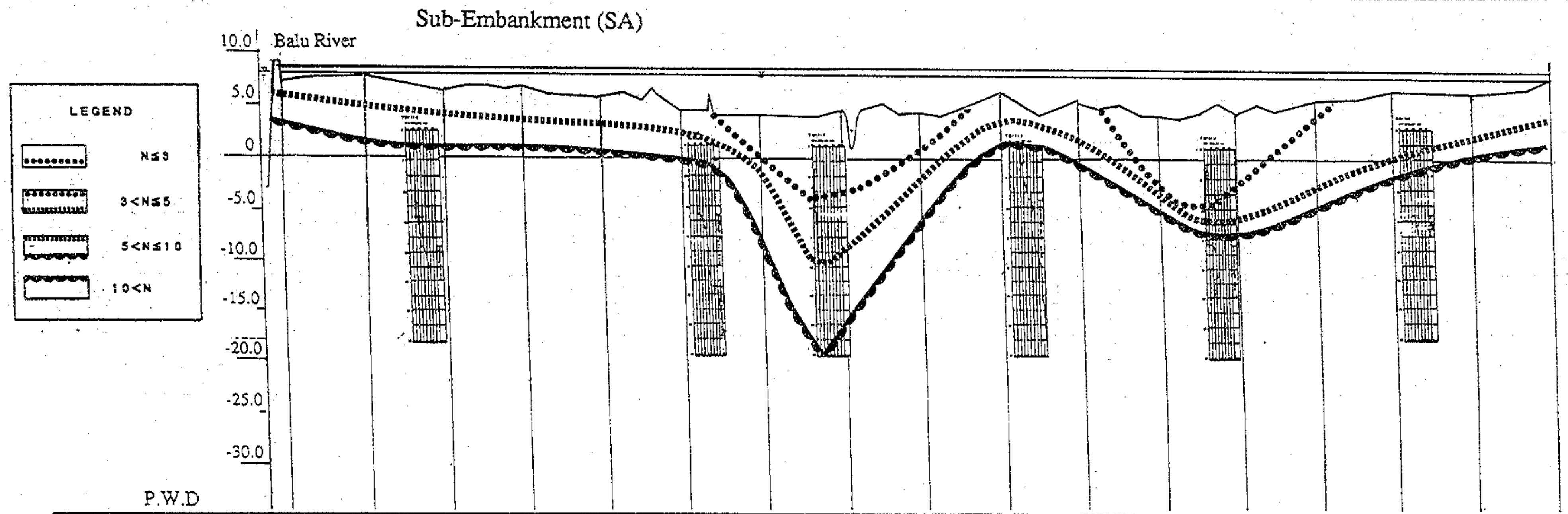
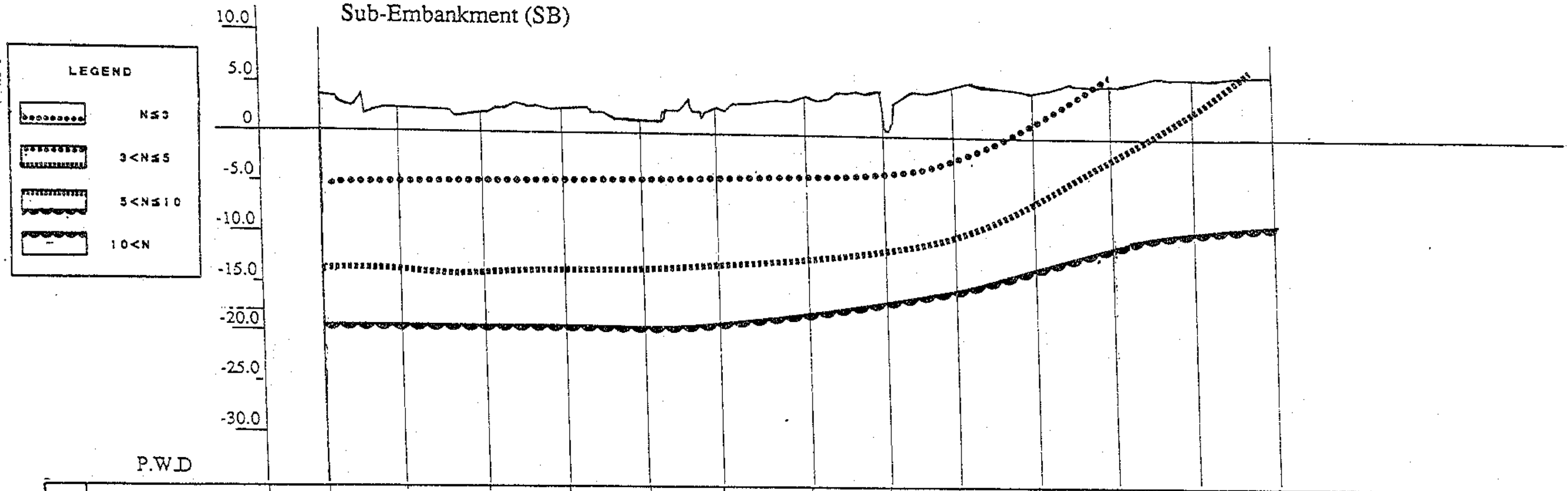


DESIGNED	GRADIENT	LEVEL																
	TOP OF FLOOD WALL /EMBANKMENT	8.62 m.																
	H.W.L	8.02 m.																
GROUND ELEVATION		6.90	7.61	6.16	6.53	5.59	4.44	4.07	4.54	4.26	6.44	5.21	4.09	4.18	5.63	6.64	6.36	8.12
DISTANCE (M)		0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0
ACCUMULATED DISTANCE (M)		0	400.0	800.0	1200.0	1600.0	2000.0	2400.0	2800.0	3200.0	3600.0	4000.0	4400.0	4800.0	5200.0	5600.0	6000.0	6400.0
STATION NO.		SA.0	SA.1	SA.2	SA.3	SA.4	SA.5	SA.6	SA.7	SA.8	SA.9	SA.10	SA.11	SA.12	SA.13	SA.14	SA.15	SA.16

FIG. F.1.4(6) GEOLOGICAL PROFILES ALONG THE PROPOSED SUB-EMBANKMENT (SA) (GREATER DHAKA EAST)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

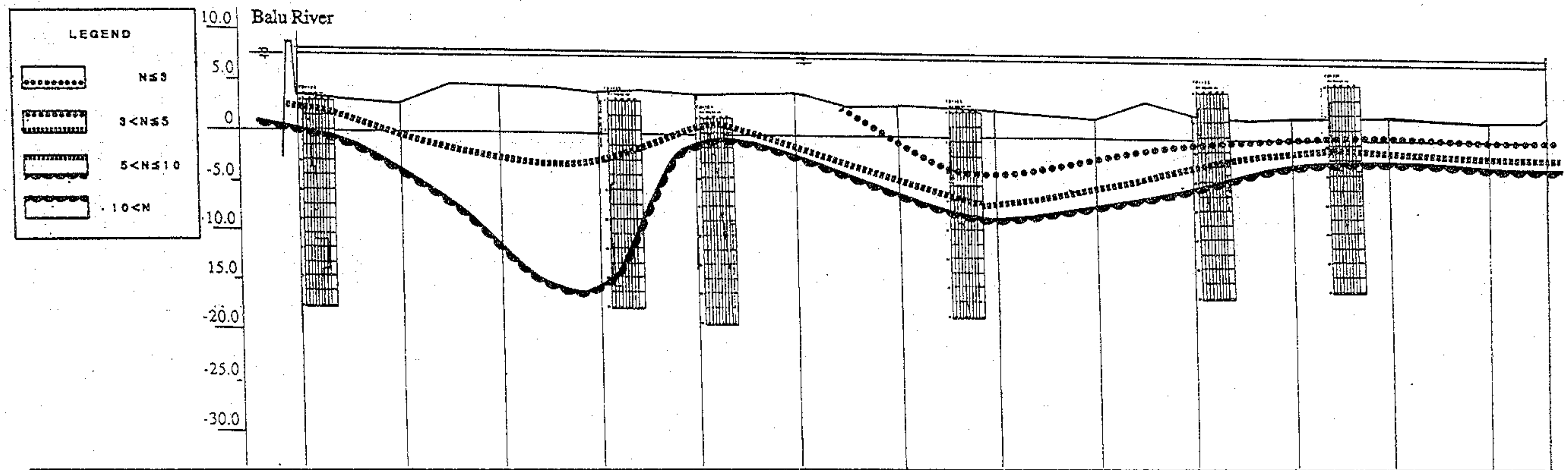


		SB.0		SB.1	SB.2	SB.3	SB.4	SB.5	SB.6	SB.7	SB.8	SB.9	SB.10	SB.11	SB.12
DESIGNED	GRADIENT	LEVEL													
DESIGNED	TOP OF FLOOD WALL /EMBANKMENT	8.33													8.33
DESIGNED	H.W.L	7.73													7.73
GROUND ELEVATION		1.16	3.87	2.51	2.30	2.55	1.57	2.95	3.70	4.58	4.91	4.65	5.39	6.09	6.57
DISTANCE (M)		0.0	10.0	350.0	400.0	400.0	400.0	400.0	400.0	400.0	350.0	400.0	400.0	400.0	400.0
ACCUMULATED DISTANCE (M)		0.0	10.0	360.0	760.0	1160.0	1560.0	1960.0	2360.0	2760.0	3110.0	3510.0	3910.0	4310.0	4710.0
STATION NO.		SB.0		SB.1	SB.2	SB.3	SB.4	SB.5	SB.6	SB.7	SB.8	SB.9	SB.10	SB.11	SB.12

FIG. F.1.4(7) GEOLOGICAL PROFILES ALONG THE PROPOSED SUB-EMBANKMENT (SB) (GREATER DHAKA EAST)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

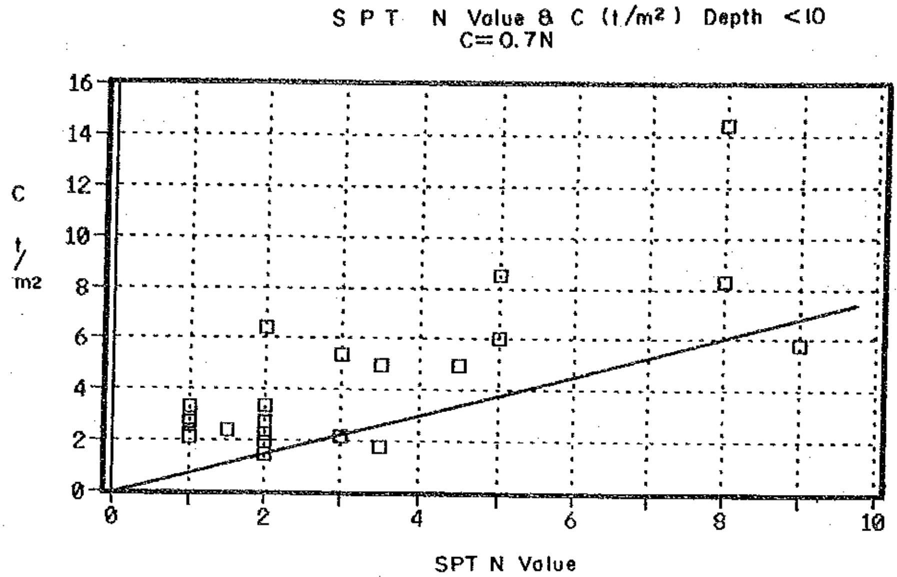
Sub-Embankment (SC)



DESIGNED: GRADIENT	LEVEL													
DESIGNED: TOP OF FLOOD WALL /EMBANKMENT	8.21 m.													
DESIGNED: H.W.L	7.61m.													
GROUND ELEVATION	3.36	2.76	4.53	4.09	3.94	4.29	3.12	2.83	2.03	2.58	2.49	2.66	2.10	2.91
DISTANCE (M)	0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	310.0
ACCUMULATED DISTANCE(M)	0	500.0	1000.0	1500.0	2000.0	2500.0	3000.0	3500.0	4000.0	4500.0	5000.0	5500.0	6000.0	6310.0
STATION NO.	SC.0	SC.1	SC.2	SC.3	SC.4	SC.5	SC.6	SC.7	SC.8	SC.9	SC.10	SC.11	SC.12	SC.13

FIG. F.1.4(8) GEOLOGICAL PROFILES ALONG THE PROPOSED SUB-EMBANKMENT (SC) (GREATER DHAKA EAST)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



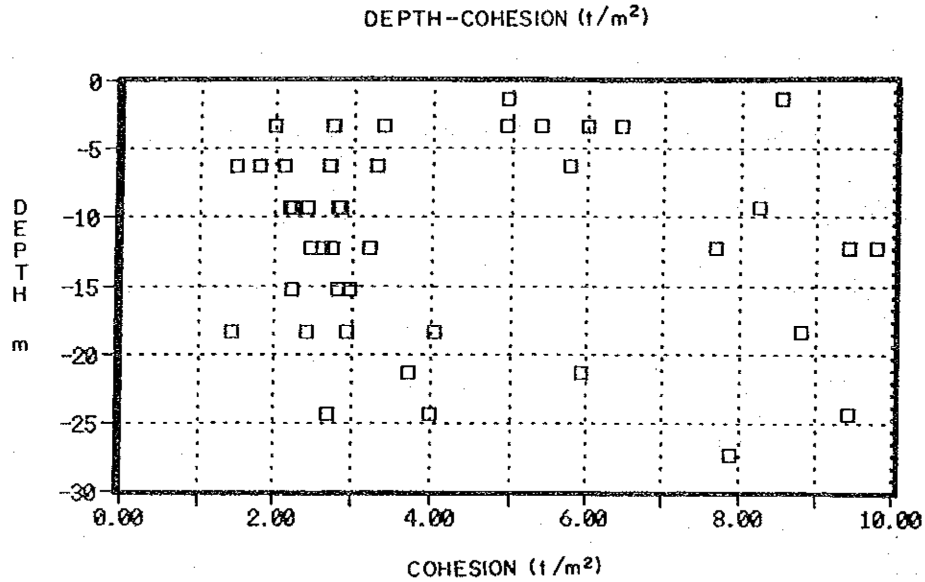


FIG. F.1.5 RELATIONSHIPS BETWEEN N-VALUES AND COHESION

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA

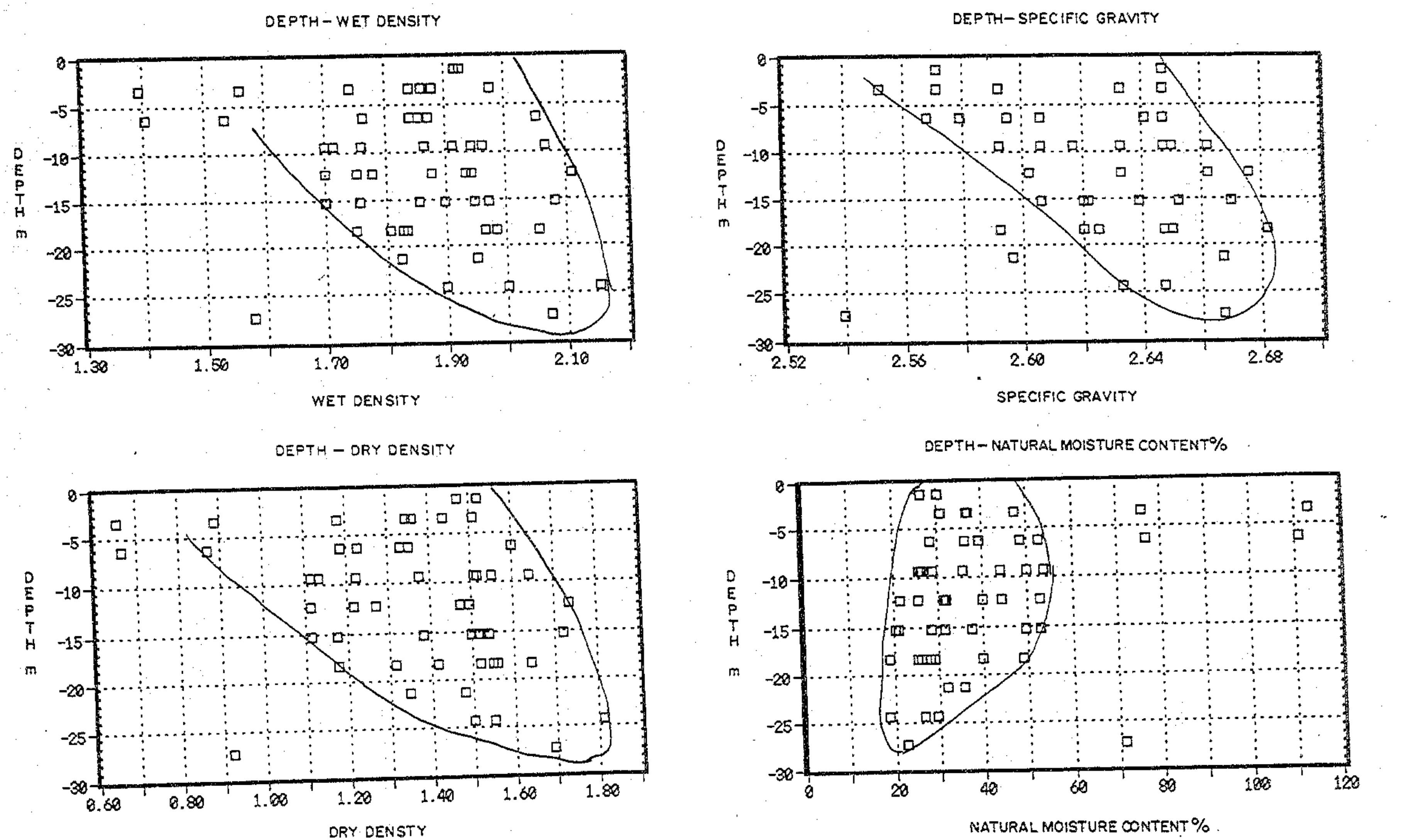
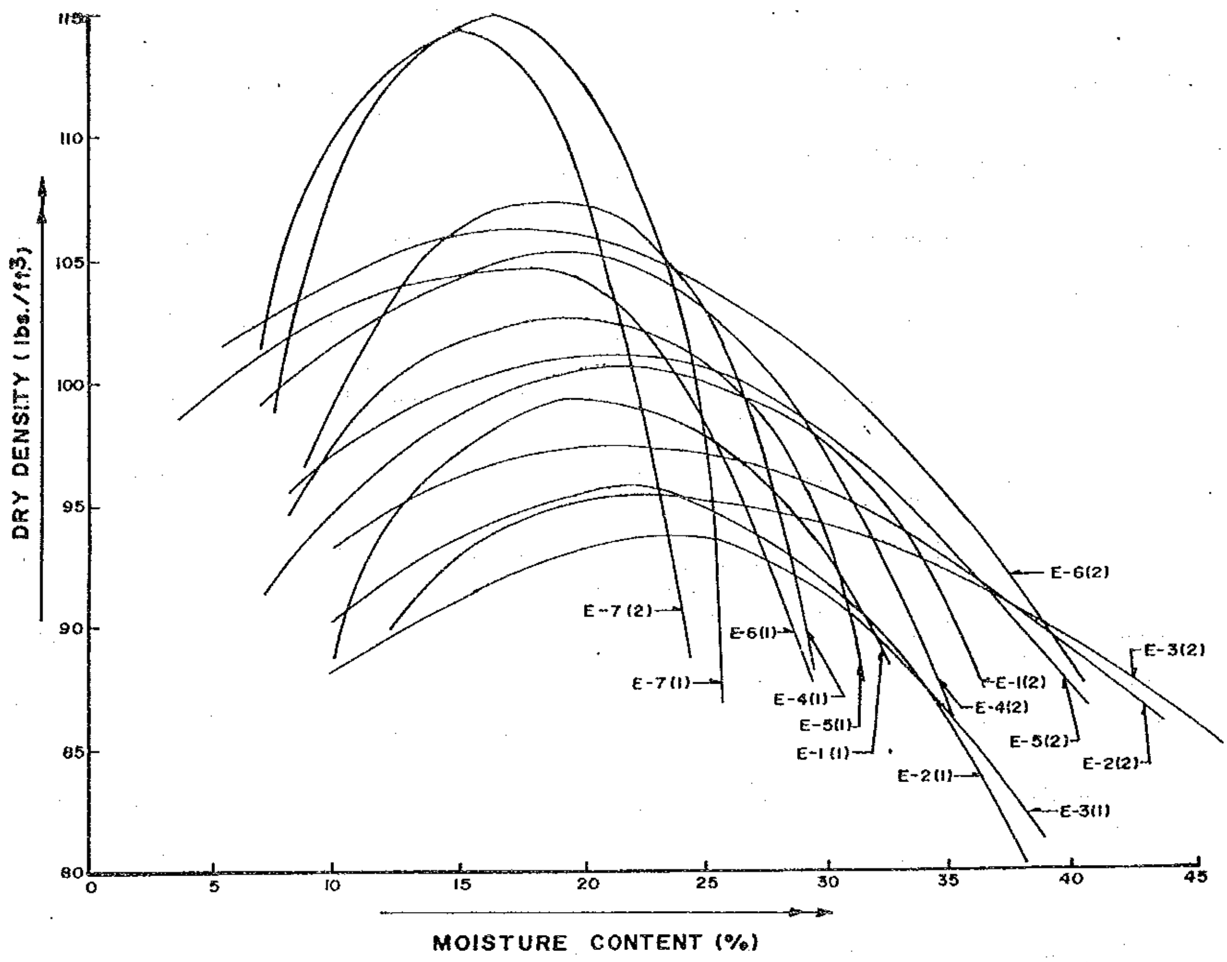


FIG. F.1.6	RELATIONSHIPS BETWEEN DEPTH AND SOIL FACTORS

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



Compaction Curve of Embankment Material

FIG. F.1.7	COMPACTION CURVE OF EMBANKMENT MATERIAL

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

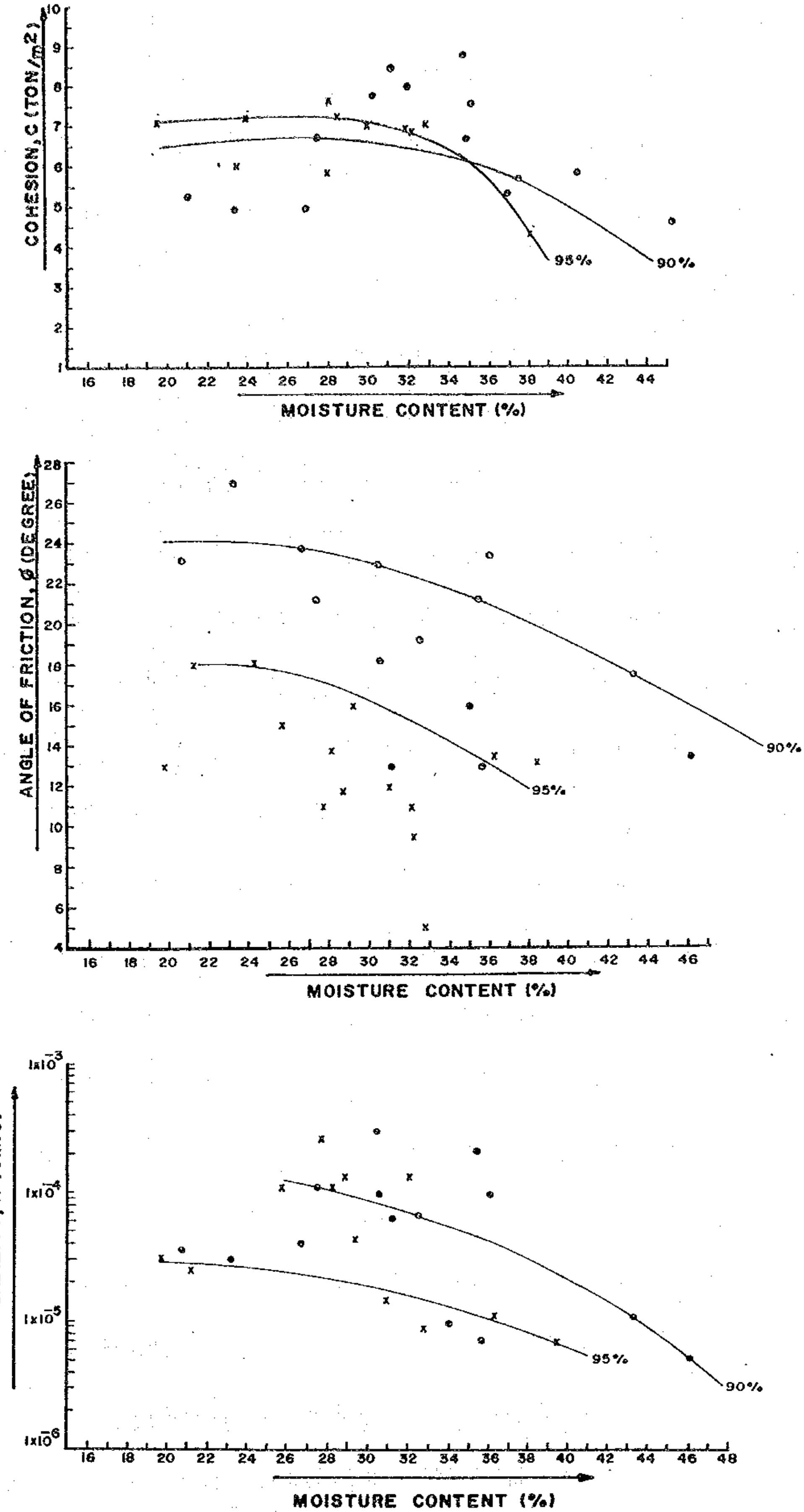


FIG. F.1.8 RELATIONSHIPS BETWEEN MOISTURE CONTENT AND MECHANICAL SOIL ELEMENTS (C, Ø AND K)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH