United Nations Development Programme
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Ministry of Irrigation, Water Development and Flood Control
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South East Region
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BGD/86/037

Noakhali North Drainage and Irrigation Project
Feasibility Study
Volume 8 - Annex I
Engineering

October, 1993

Sir M MacDonald and Partners Limited, UK
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2

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FEASIBILITY STUDY

ANNEX I - ENGINEERING

CONTENTS

Page Nr.

Page Nr.

TABLES

After Page Nr.

FIGURES

APPENDICES

9

CHAPTER I.1

DATA, SURVEYS AND FIELD INVESTIGATIONS

I.1.1 Topography

I.1.1.1 Available Topographic Data

The following topographic survey data is available associated with the project area:

(i) 4 inch to 1 mile (1 in 15 840) Water Development Maps. These maps were prepared from 1963 or 1967 aerial photography, verified in the field between 1966 and 1969. Spot levels are generally shown on a 100 m x 300 m approx. grid, with 1 foot interval contours. Coverage of the project area is incomplete, as shown on Figure I.1.1, but this can mostly be made up by the older Dakatia Basin Irrigation Survey Maps.

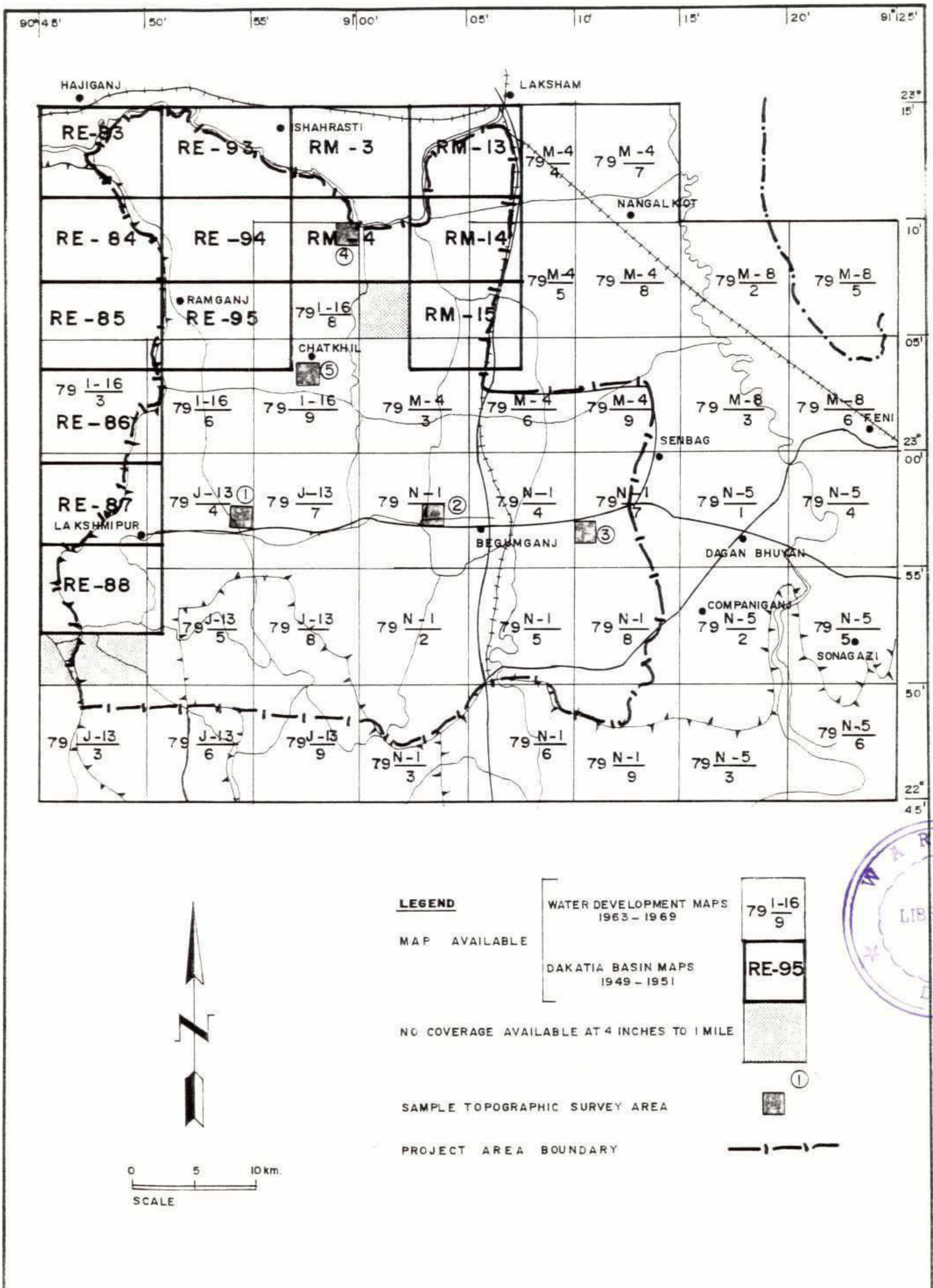
(ii) 4 inch to 1 mile (1 in 15 840) Dakatia Basin Irrigation Survey Maps. These maps were prepared from 1949 aerial photography, with field survey in 1951. Spot levels are shown on a 650 m x 650 m approx. grid, with 1 foot interval contours. Figure I.1.1 shows those sheets which are available to fill gaps in the coverage of the Water Development Maps.

(iii) 1 in 40 000 Irrigation Planning Maps. These maps were prepared from 1942 or 1953 aerial photography, with field survey in some cases originating in 1905, but generally 1931 to 1932, and verification 1956 to 1957. Spot levels are shown on a grid of between 650 m and 800 m approx. square, with 5 feet interval contours.

(iv) 1 in 50 000 Third/Fourth Edition Maps. These maps were prepared from 1974/75 aerial photography, with field verification in 1983/84. Sparsely scattered spot heights are shown, and no contours. The whole project area is covered by four sheets.

(v) 1 in 30 000 nominal scale black and white aerial photography covering most of the project area (see Appendix I.1). This photography was prepared for the whole Bangladesh coastal zone in early 1990 by FINNMAP Oy on behalf of BIWTA. It had at one stage been anticipated that the 1 in 10 000 scale topographic mapping to be prepared from this photography would be available to the present study, but it is now understood that this will not be ready before 1994. Requests were also made for prints of the 1 in 10 000 rectified photomosaics, prepared as an intermediate stage in the mapping process, but these also were not received. Enlargements of the basic aerial photography to 1 in 5 000 nominal scale were however obtained for the five 2 km approx. square sample areas shown in Figure I.1.1 and discussed in Section I.1.1.3 below.

Figure I.1.1
Index of 4 inch to 1 mile Maps



(vi) 1 in 50 000 multispectral SPOT satellite imagery with 20 m resolution, dated early 1989. The whole project area is covered by four sheets, coinciding with the 1 in 50 000 Third/Fourth Edition Maps described above.

(vii) Some 127 channel cross-sections within the project area, incorporated in the South East Regional Model (SERM) by the Surface Water Modelling Centre (SWMC).

(viii) Four Survey of Bangladesh (SOB) maintained bench-marks.

Further details of this data are given in Appendix I.I to this annex.

Elevations on the Water Development Maps, and those assigned to the SOB bench-marks, are all to the Survey of Bangladesh (or its precursor the Survey of Pakistan) datum. The channel cross-sections, as well as all BWDB and SWMC water level gauge records and simulated water levels, are to the Bangladesh Public Works Datum (PWD). To convert an elevation based upon the SOB datum to PWD, 0.46 m must be added. In accordance with standard BWDB practice, all elevations on drawings etc for this study are quoted to PWD datum unless otherwise stated.

I.1.1.2 Land Level Database

Inundation analysis has been carried out, as described in Annex B (Hydrology and Modelling), by relating water levels simulated using the Mike11 South East Regional Model (SERM), developed by the Surface Water Modelling Centre (SWMC), to a land level database prepared from the 4 inch to 1 mile Water Development Maps. The inundation analysis relates only to the net cultivable arable land, since it is to this that the agricultural benefits relate. Therefore settlement, orchard and other non-arable areas have been omitted from the database, along with the elevations associated with them. To do this, an existing land use map, distinguishing arable and non-arable land, was prepared at 1 in 50 000 scale from the 1990 aerial photography. This map (in seven sheets, including part of the Little Feni Basin) is presented in reduced form in Appendix I.II to this Annex. To fill in gaps in the coverage, the 1989 SPOT imagery and the 1 in 50 000 Third/Fourth Edition Maps also had to be used. The non-arable areas were then measured from the land use map by one minute square. The elevations to be omitted were identified solely with reference to the Water Development Maps.

It is recognised that there may be some locational mismatch between the Water Development Map elevation data of 1966 to 1969 and the land use data of 1990, but it is considered that this approach has made the best possible use of the available data. Availability of the new 1 in 10 000 mapping, or even just the the 1 in 10 000 rectified photomosaics, would have considerably expedited preparation of the database, and made it more truly representative of existing conditions. Nevertheless, the checks on topography in the sample areas and on bench-mark datum consistency described in the sections which follow, in conjunction with the good correlations obtained between the results of the inundation analysis and actual field conditions, lead to the conclusion that the land level database is fully adequate for the purposes of the present study.

In areas where Water Development Map elevations were not available, the 1 in 40 000 Irrigation Planning Maps were used, giving a much sparser density of spot levels. In general, the the level information on the latter maps was common with that on the Dakatia Basin Irrigation Survey Maps, at least for the areas of interest. It was noticed that in some other areas the spot levels on the Water Development Maps were sparser than usual, and common with those on the two older map series. The quoted heights appeared however to relate to pillar tops rather than ground level, with a systematic increase of 0.8 feet compared with those on the Irrigation Planning Maps. In such areas the Irrigation Planning Maps were again used.

The database includes a separate file for each map sheet (45 in all, including part of the Little Feni River basin to the east). Within each file the data is separated into a list of spot levels for each of the 25 Nr one minute squares within the sheet, with each list preceded by the square number, the gross area, the net cultivable arable area and the number of spots. The whole file is headed by the map sheet number and the grid reference of the north-west corner. The spot levels have all been converted to metres above Public Works Datum.

Individual minute squares falling outside the area of coverage of the database have a single zero elevation entry. In general, the project area and its various subdivisions are defined for the purposes of inundation analysis in terms of the nearest whole square. However at the periphery of the database, where elevation data is available for only a part of a square, either because of a lack of data or because the boundary is marked by a major river, the gross area of the minute square was reduced by an appropriate amount in the database. Otherwise, the gross area of each one minute square was taken as 311 ha.

I.1.1.3 Checking Topography in Sample Areas

Five 2 km square sample areas, indicated in Figure I.1.1, were selected for detailed topographic survey, as representative of the topography, inundation conditions etc found within the project area. The topographic survey work described in this and subsequent sections was carried out under a sub-contract awarded to Messrs International Survey Company. Each sample area is centred on a 1 minute map grid square (actually 1.69 km by 1.84 km), and may therefore be directly related to the corresponding square within the land level database. The purpose of these surveys was as follows:

(i) To assess whether the Water Development Maps adequately represent the topography for the purpose of inundation analysis, from the point of view both of correctness and frequency of spot levels.

(ii) To check whether the estimate of net cultivable arable area incorporated in the land level database is reasonable.

(iii) To enable the elevations of selected plots to be determined, and hence the inundation from simulated or observed water levels. This information was then to be used in conjunction with the plot agricultural surveys, to assist in confirming the relationships between cropping and flood characteristics.

(iv) To assess the typical proportion of the non-arable area devoted to ponds.

Water levels were also monitored at points within each sample area throughout the 1992 monsoon season, as discussed in Section I.1.2 below.

For each sample minute square, the area-elevation curve for the net cultivable arable area (NCA) was prepared from the survey data, and compared with that extracted from the land level database. In each case it was assumed (as in the use of the land level database for inundation analysis) that each spot level was representative of a fixed proportion of the total NCA. The 1 in 5 000 surveys were sufficiently detailed to permit separate measurement of homestead/orchard and pond areas, and these were both deducted in arriving at the net cultivable arable area. The results are presented in Figures I.1.2 to I.1.6. Reduced copies of the maps for each square are presented in Appendix I.III to this annex.

The following observations are made:

(i) The correspondence between the area-elevation curves from the land level database and the sample area survey is generally reasonable, although in the case of Areas 2 and 4 there is an elevation shift of up to about 0.2 m. Since in the case of Area 2 the land level database is higher, whilst in Area 4 it is the sample area survey which is higher, this discrepancy does not indicate an overall datum shift, and must reflect only local variations.

(ii) The discrepancies between the net cultivable arable areas from the land level database and the sample area surveys are as follows:

Area 1	-	+8%
Area 2	-	-1%
Area 3	-	-16%
Area 4	-	+11%
Area 5	-	+20%
Weighted Mean	-	+4%

Although a closer correspondence would have been desirable in some cases, the difficulties of interpretation from the 1 in 30 000 scale aerial photography means that these results are hardly surprising. The overall discrepancy of +4% could reasonably be attributed to growth in settlements between the date of the photography (1990) and that of the sample area surveys (1993). It therefore seems likely that on average, over extensive areas, the land level database gives a good representation of the net cultivable arable area. Adjustment of the NCA in the case of Area 3 would also greatly improve the correspondence between the two area-elevation curves.

(iii) Figure I.1.7 gives the combined area-elevation curves for the five sample areas. In this case the discrepancy between the curves ranges from about -0.1 m to +0.1 m (together with the 4% difference in NCA already referred to), confirming that the land level database represents very well the topography of a number of squares taken together, as is the case in the inundation analysis under the present study. It should be noted that even quite substantial discrepancies would not totally invalidate the analysis of benefits, since these are in effect determined from the *change* in inundation between the without and with project situations.

Figure I. 1.2

Comparison of Area-Elevation Curves
Sample Area 1

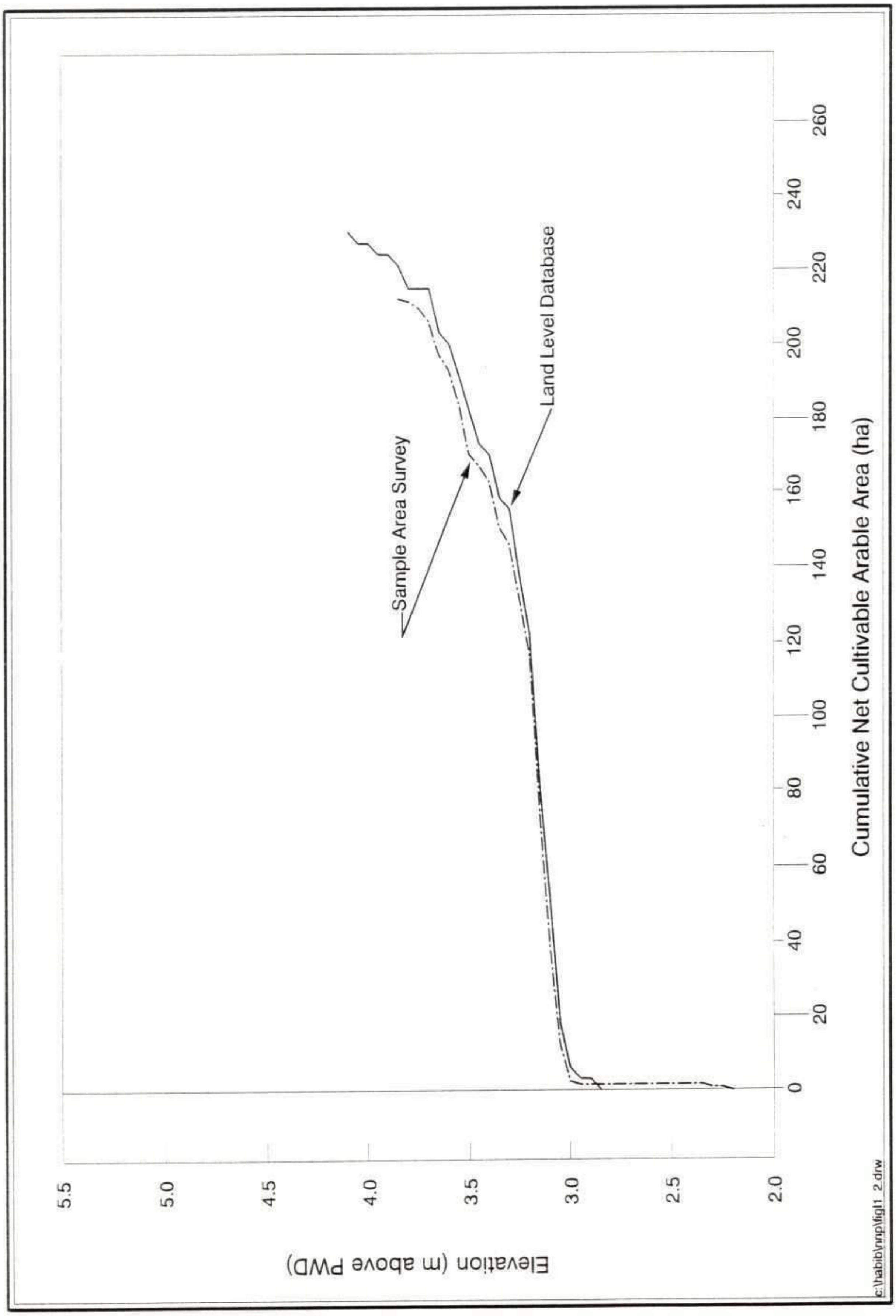


Figure I.1.3

Comparison of Area-Elevation Curves
Sample Area 2

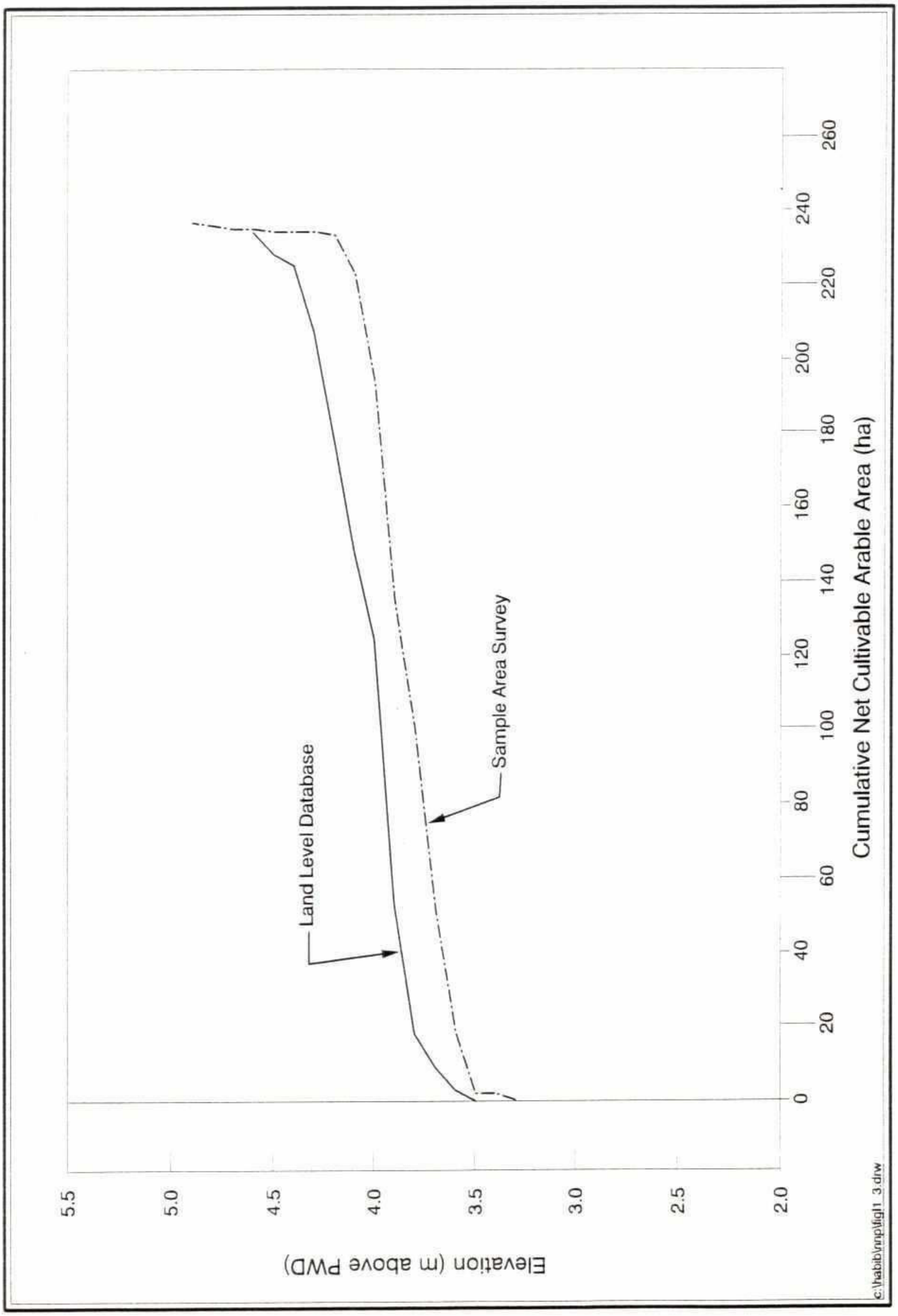


Figure I. 1.4

Comparison of Area-Elevation Curves
Sample Area 3

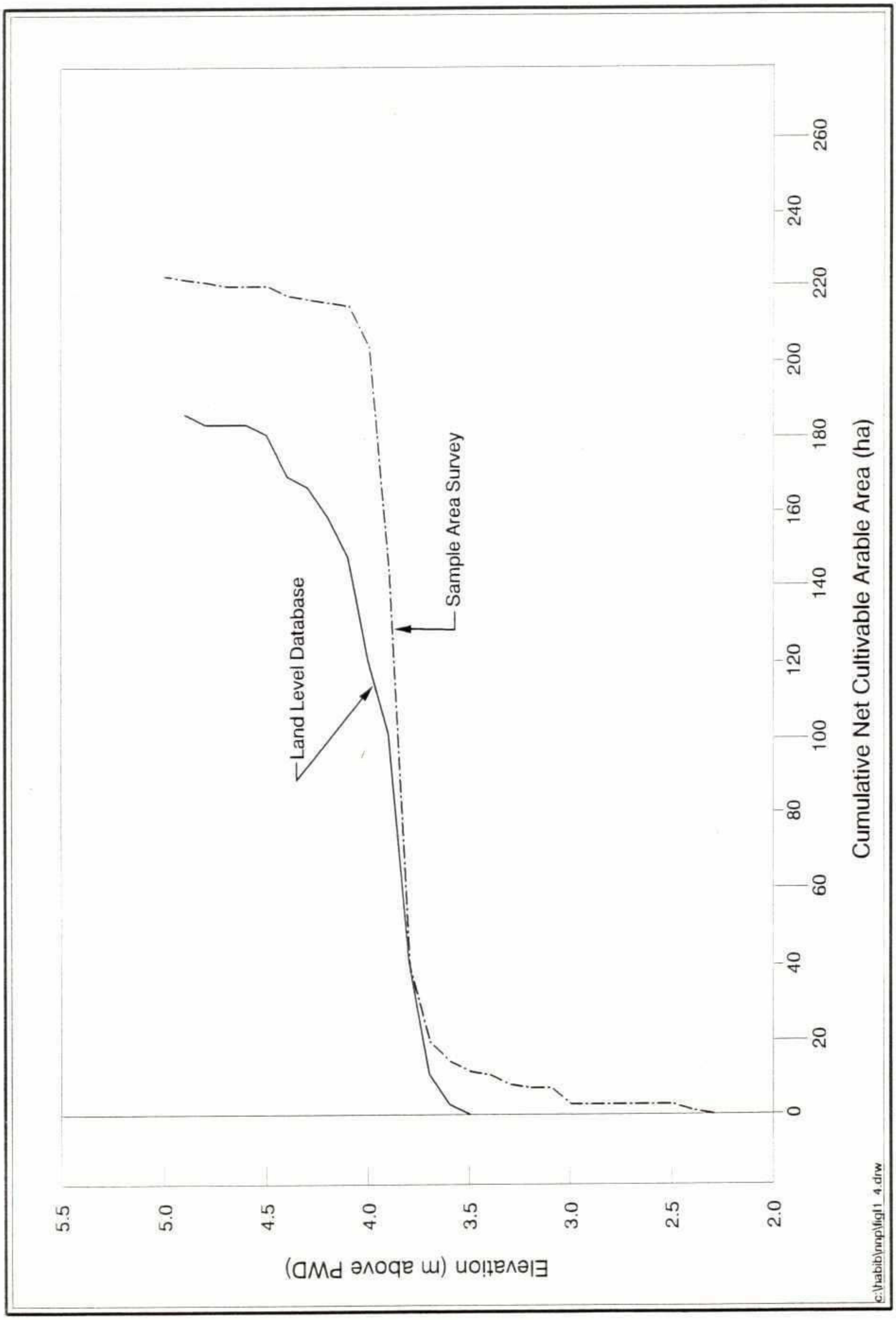


Figure I. 1.5

Comparison of Area-Elevation Curves
Sample Area 4

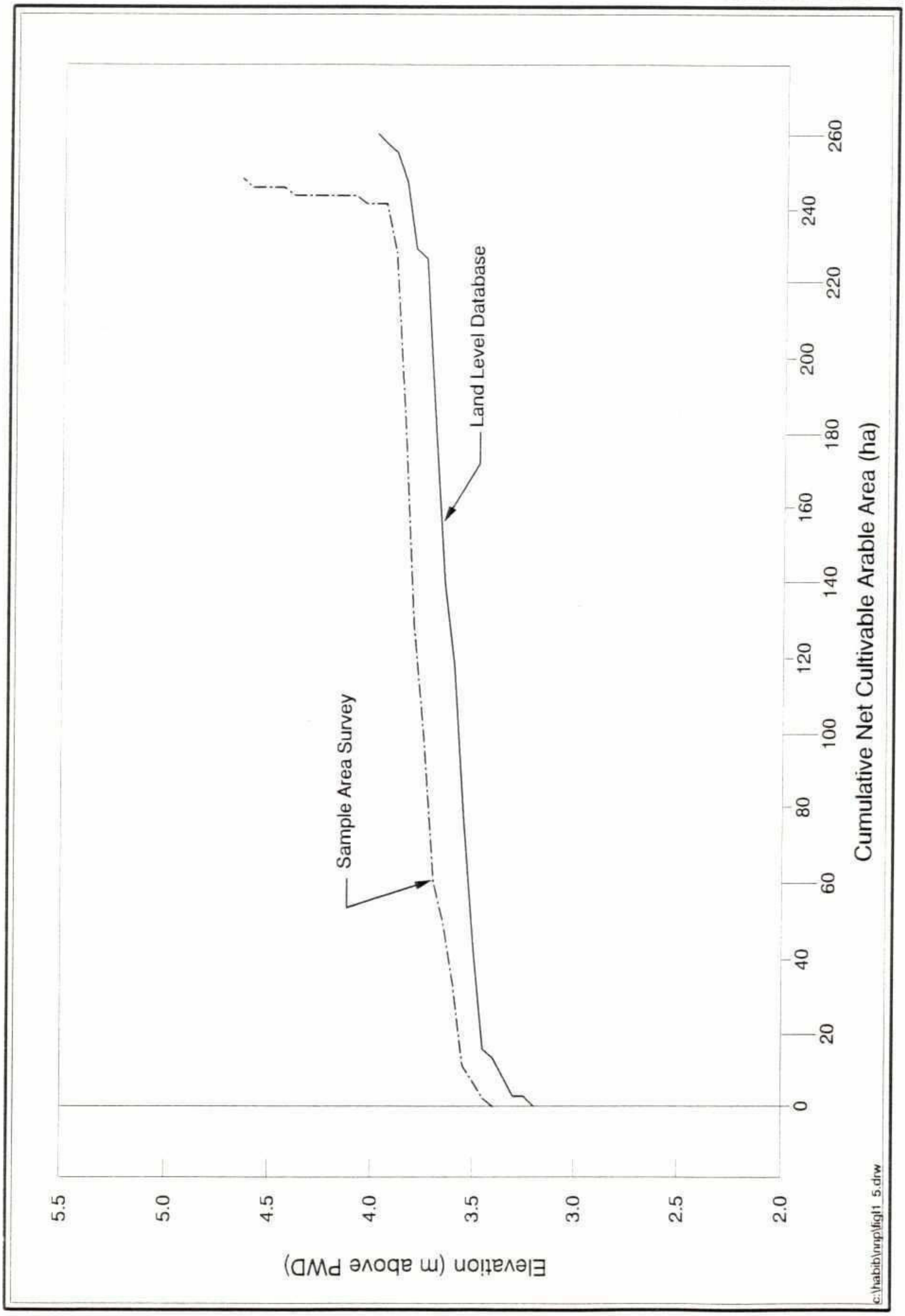


Figure I. 1.6

Comparison of Area-Elevation Curves
Sample Area 5

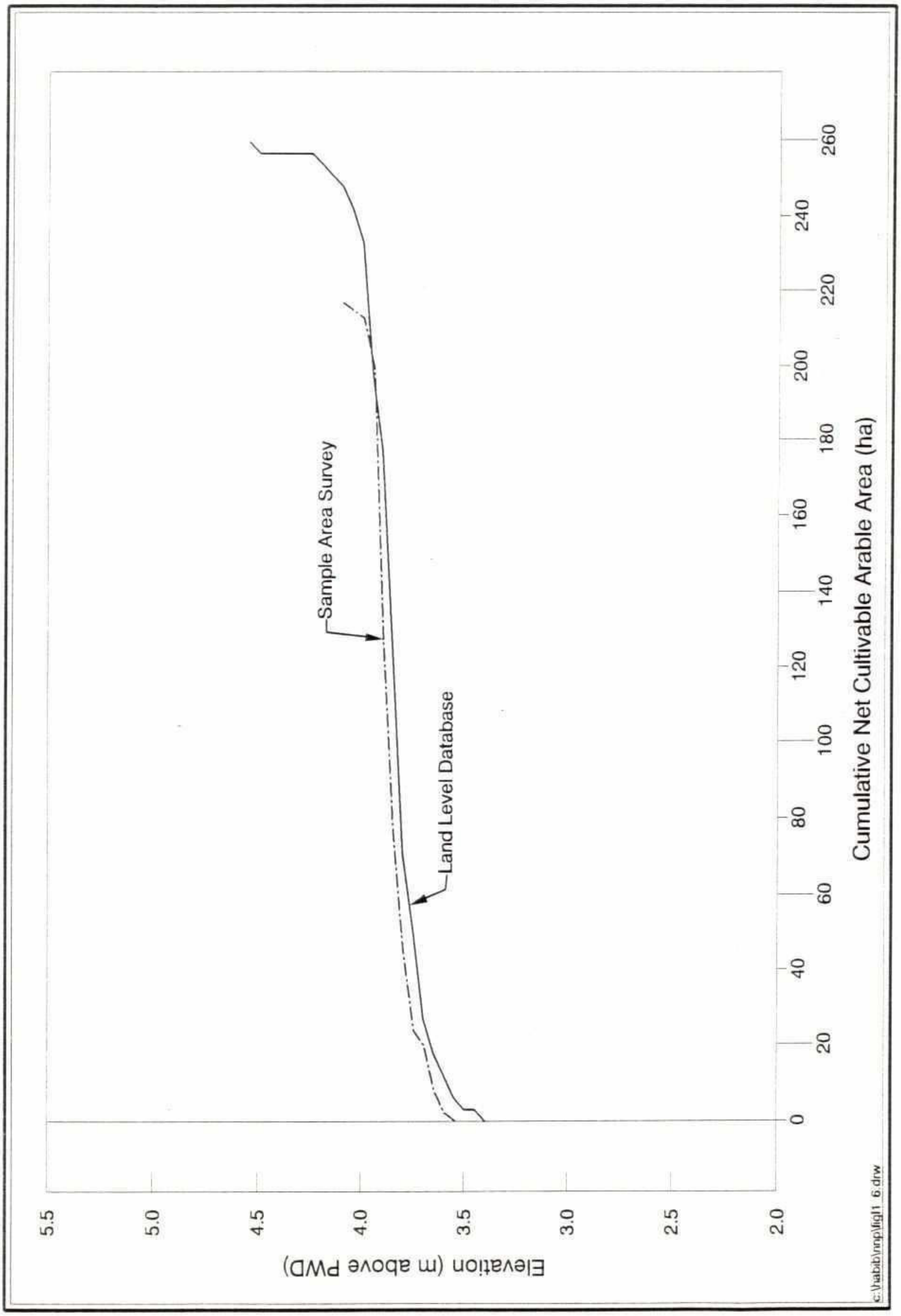
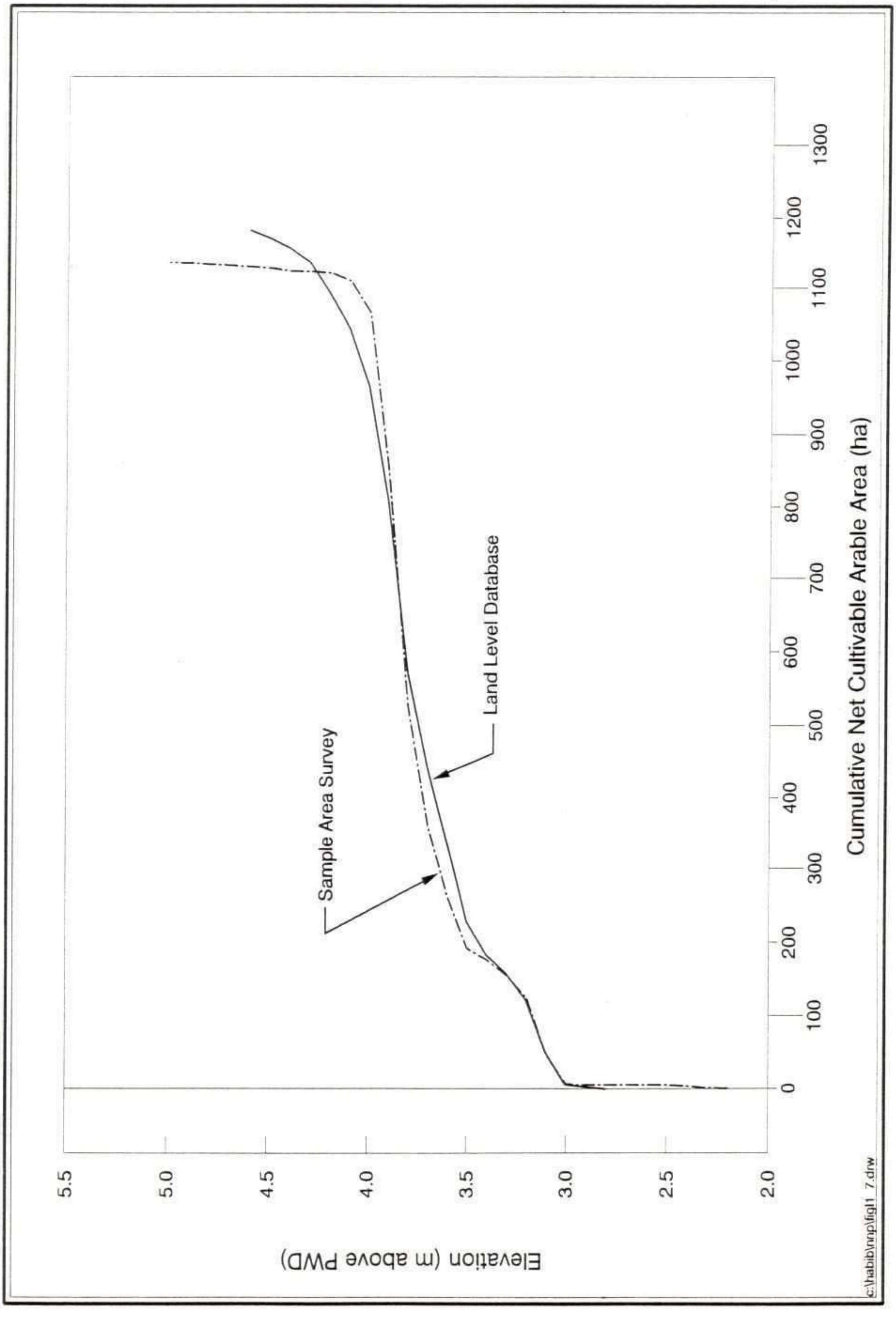


Figure I. 1.7

Comparison of Area-Elevation Curves
Combination of Five Sample Areas



(iv) The breakdown of the non-arable land use within each sample square between homesteads/orchards and ponds is given in Table I.1.1. The pond area has been expressed as a percentage of the total non-arable area, to give an idea of the variation in density of ponds throughout the project area.

TABLE I.1.1

Non-arable Land Use by Sample Area

Sample Area	Gross Area (ha)	NCA (ha)	Homestead/ Orchards (ha)	Ponds	
				(ha)	% of non-arable area
1	311	212.5	90.4	8.1	8.2%
2	311	236.4	53.0	21.6	29.0%
2	311	222.6	73.9	14.5	16.4%
4	311	248.0	47.5	15.5	24.6%
5	311	216.6	75.4	19.0	20.1%
AVERAGE	311	227.2	68.0	15.7	18.7%

I.1.1.4 Checking Bench-marks and Gauge Zeros

In order to have confidence in inundation analysis based upon the land level database and water levels simulated using the SERM, it was necessary to ensure that all are related to a consistent elevation datum. Although all elevations have been nominally expressed in relation to the Public Works datum, there was concern that some discrepancies may have crept in, between the SERM and the Water Development Maps, and perhaps even between individual map sheets. The elevation data used in the SERM is comprised of the following:

- channel cross-sections,
- water level boundary conditions derived from gauge station records, and
- water level records from other gauge stations used in calibration.

It is known that before the SERM was developed, considerable effort was put into checking the bench-mark network, and it has therefore been assumed that if the gauge station bench-marks used for the model can be shown to be consistent, then the channel cross-section data will also be correct to the same datum.

Using the four SOB maintained bench-marks as a starting point, a network of levelling was executed throughout the project area, and in some cases beyond its boundaries, to establish the following elevations:

- 28 Nr water level gauge station zeros and/or associated bench-mark elevations, including some BWDB stations not used in the SERM. Also included were the BIWTA Chitalkhali gauge station at Char Abdullah (Ramgati thana) and the BWDB station at Chandpur, to assist in deriving/verifying 25 years of boundary condition data at the Lower Meghna (see Annex B, Hydrology and Modelling).

- 4 Nr bench-marks identified, with elevations, on the Water Development Maps, and found surviving in the field,

- 20 Nr bench-marks installed in 1991 by FINNMAP Oy, in connection with the 1 in 10 000 mapping referred to in Section I.1.1.1(v) above. These bench-marks have not yet been officially assigned elevations, but once these are known, including the effect of any regional level datum correction, the whole project topographic database could then be adjusted to the corrected national datum if desired, and

- 11 Nr new bench-marks to assist in Sample Area Surveys, and the Khal and Structure Site Surveys (see below).

The detailed results are presented in Appendix I.IV to this Annex. The datum consistency was found to be generally satisfactory, but discrepancies in excess of 0.1 m were found at three of the gauge stations. In one of these cases there was probably a confusion over bench-mark descriptions, whilst in another the gauge record was not used in the model. Overall, no correction was considered justified. One of the SOB maintained bench-marks was found to be inconsistent with the other three, perhaps again due to confusion over bench-mark descriptions. The consistency of the four Water Development Map bench-marks was very satisfactory, confirming that the land level database is compatible with the SERM, with no significant datum shift over the last 25 years.

It has not been possible conclusively to check the datum for each individual Water Development Map sheet, because relatively few surviving bench-marks could be found. However, when ground levels from the khal surveys discussed in Section I.1.1.5 below were compared with nearby spot levels on selected map sheets, there appeared to be no cause for concern. In the case of map sheet Nr 79 N-1/2 which, unlike all the others, stated in the legend that elevations were to Public Works rather than SOB datum, it was possible using this method to deduce that the legend was incorrect, and that adjustment from SOB to PWD was required.

I.1.1.5 Khal Surveys

Although channel cross-sections are available within the SERM, it was considered necessary to take additional sections for the following purposes:

- to increase the frequency of cross sections in the SERM at some critical locations, particularly on WAPDA/Rahmatkhali Khal, to improve model representation.

- to check the significance of other channels identified on the aerial photography and SPOT imagery, to see whether they warranted incorporation within the SERM,

- to assist in deciding which channels should be excavated under the project proposals and to what design profile, and

- for the calculation of excavation quantities for cost estimation.

Details of the channels concerned and the locations of cross sections are given in Appendix I.IV to this annex. The results were plotted in both longitudinal and cross section form.

I.1.1.6 Structure Site Surveys

A detailed topographic survey was carried out at Rahmatkhali Regulator, including the site of the proposed new regulator, covering an area of 10 ha. A further 1 ha survey was carried out at the point where Musar Khal leaves the project area south-east of Rahmatkhali Regulator, but in the event no structure was proposed here. Another 10 ha survey was performed at the site of Kazirhat Regulator on the Little Feni River, in case it was found that a satisfactory integrated approach to the drainage of the sub-region required an intervention here. However, the Noakhali North area was found to be substantially independent of the Little Feni basin, and interventions for the latter are dealt with under the Regional Plan. Locations of the site surveys are indicated on the Bench-mark Location Map presented in Appendix I.IV to this annex.

I.1.2 Water Level Monitoring

I.1.2.1 Sample Area Water Level Monitoring

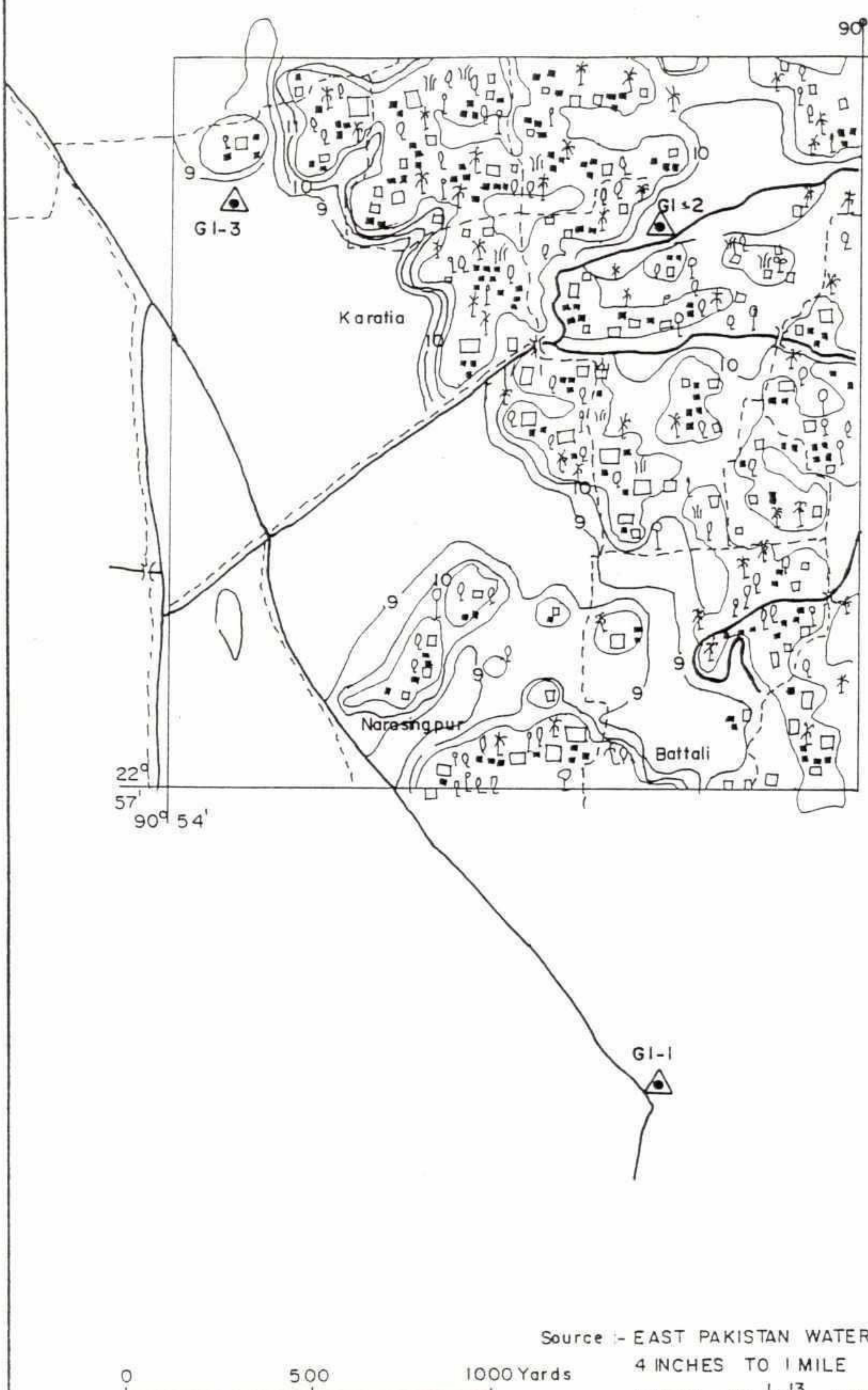
Temporary gauges were established in each of the sample survey areas described in Section I.1.1.3 above, to monitor flood levels during the 1992 late monsoon season, from the end of August to 15 October. In the case of Areas 1, 2, 3 and 5, two gauges were installed in paddy fields within the area and another within the adjacent modelled khal which was considered to reflect or control flooding within the square. In the case of Area 4, on the south bank of the Dakatia River at Chitoshi, water levels have been taken from the SWMC gauge station Nr G-22 at Chitoshi for the third reading. The gauge locations are indicated in Figures I.1.8 to I.1.12.

The objectives of monitoring water levels were as follows:

- to check actual flood depths within the sample area, and
- to test the validity of the assumption that flooding within a one minute square (and indeed in a group of one minute squares) can adequately be represented by a single water level. This assumption is implicit in the use of simulated water levels at selected model nodes for inundation analysis.

Figure I.1.8

Location of Water Level Gauge Sample Area 1



Source :- EAST PAKISTAN WATER DEVELOPMENT MAP
4 INCHES TO 1 MILE
SHEET 79 $\frac{J-13}{4}$, 1970.

Figure I.1.9
Location of Water Level Gauge
Sample Area 2

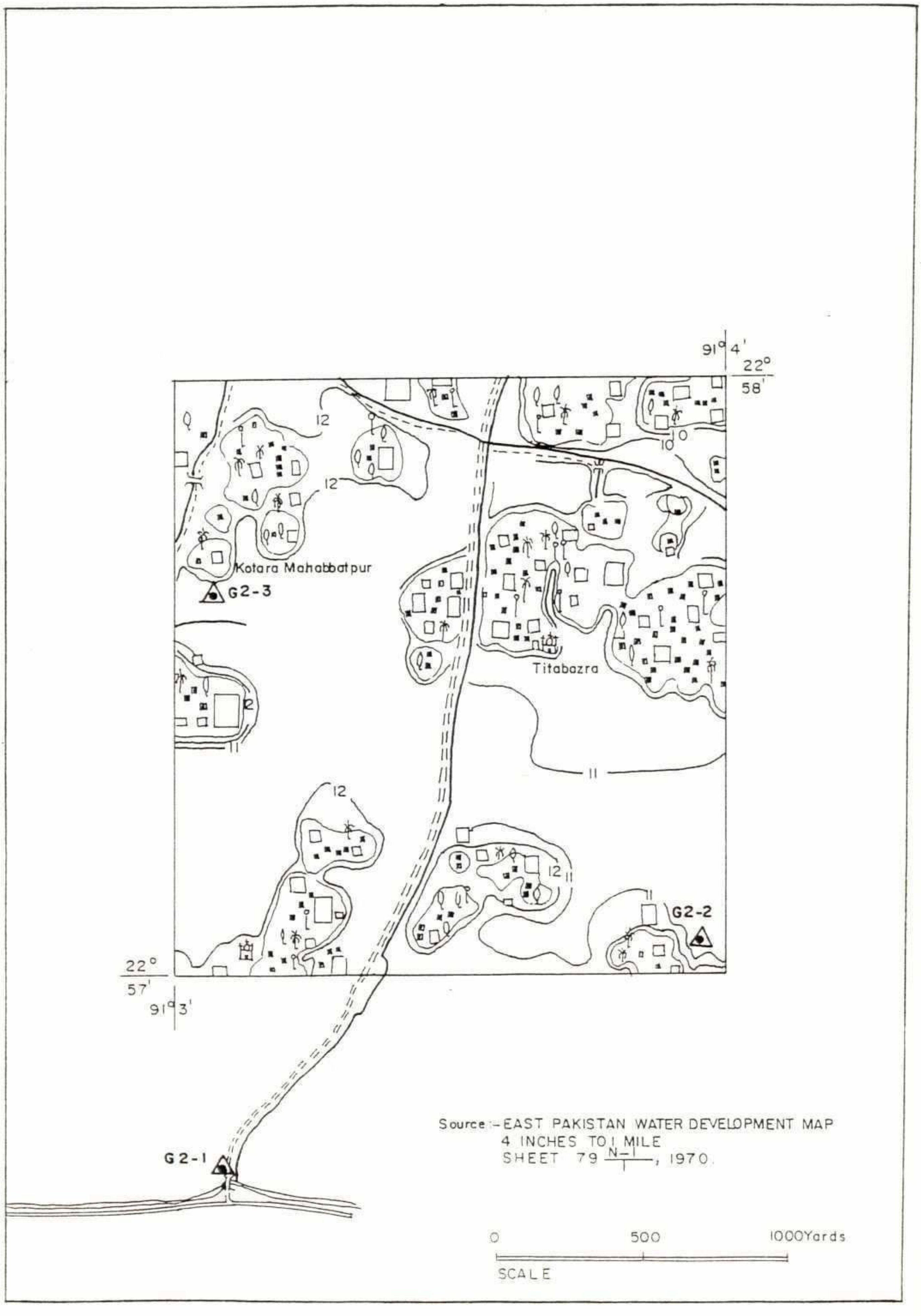
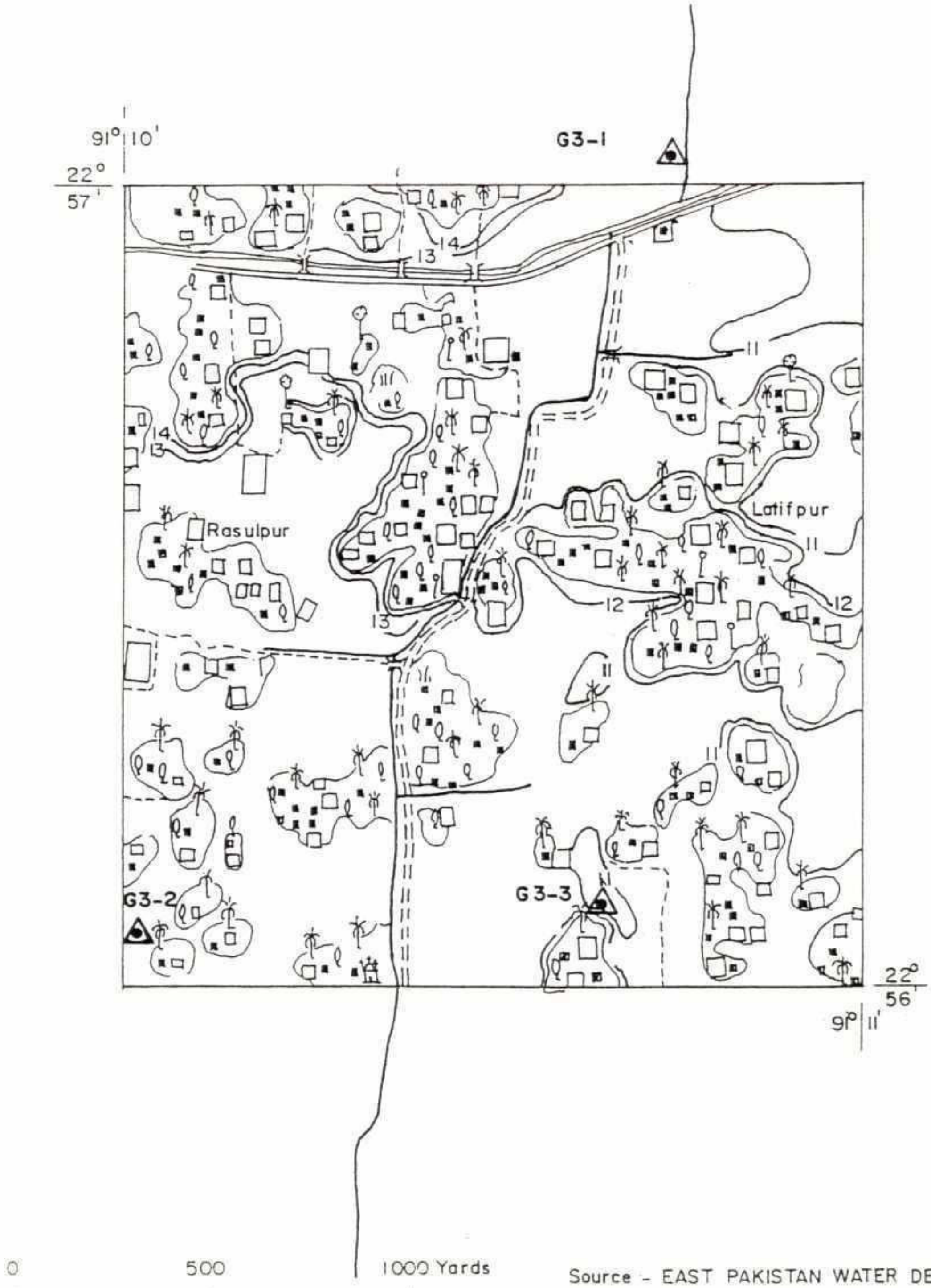


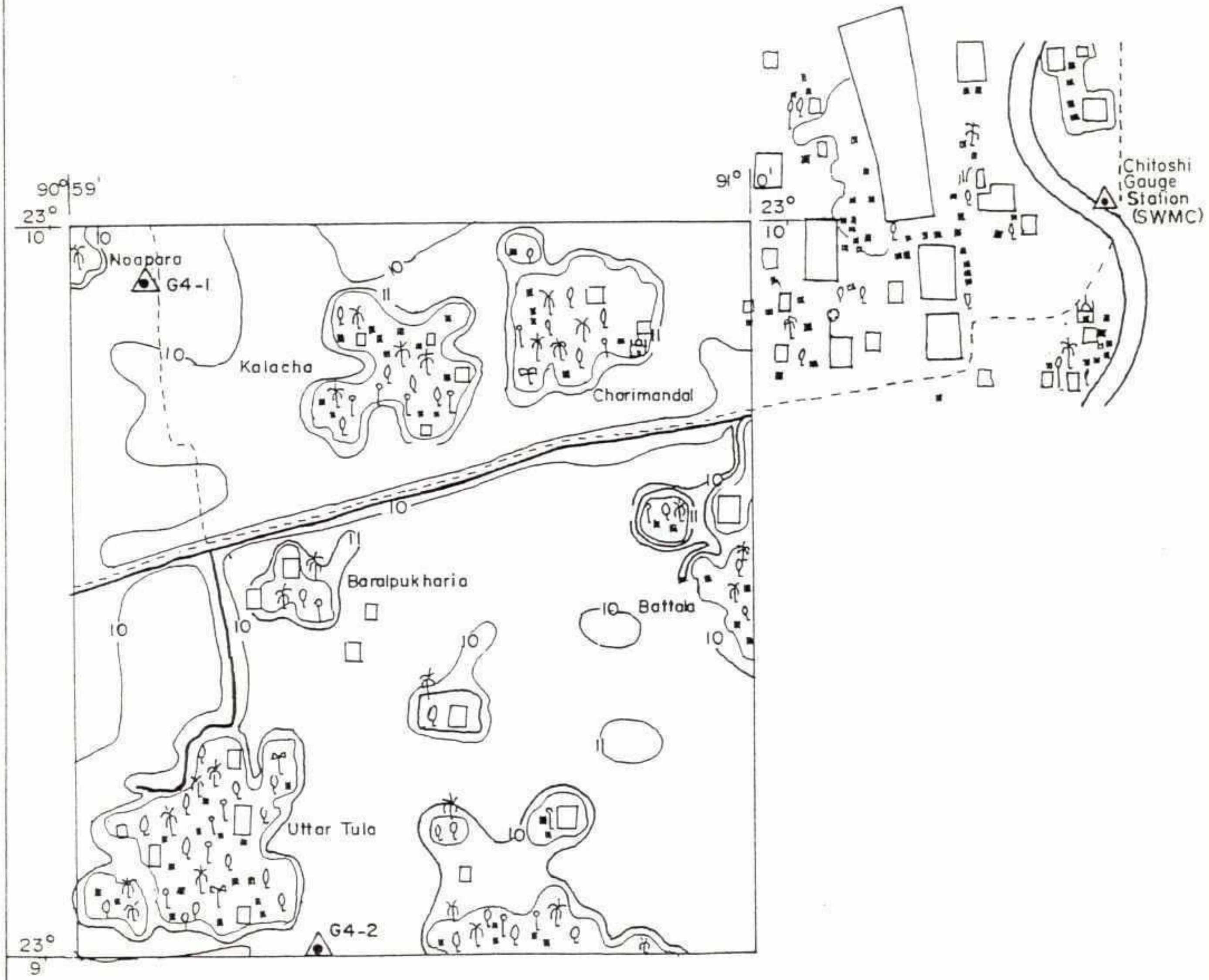
Figure I.1.10
Location of Water Level Gauge
Sample Area 3



Source - EAST PAKISTAN WATER DEVELOPMENT MAP
4 INCHES TO 1 MILE
SHEET 79 $\frac{N-1}{7}$, 1970.

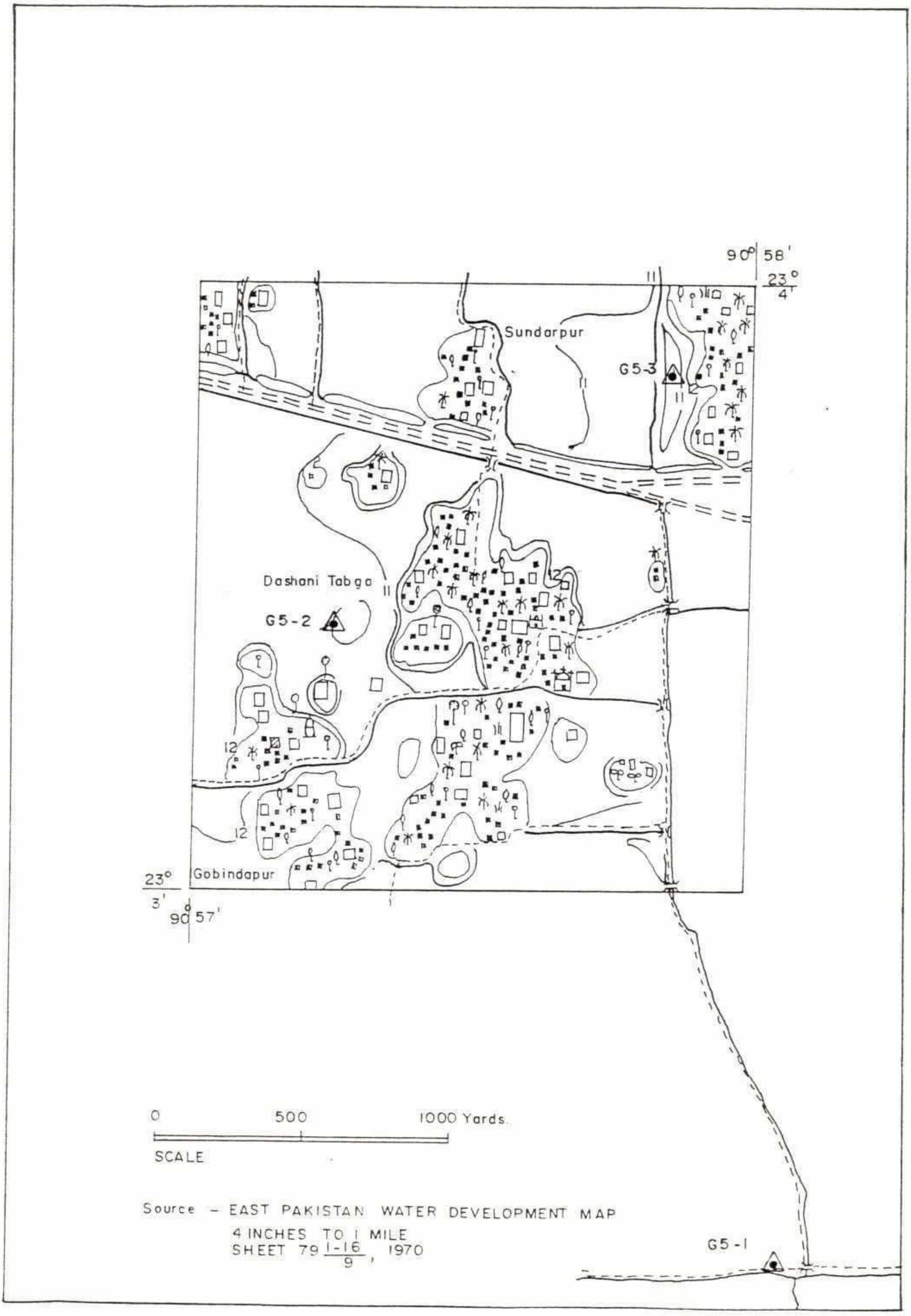
Figure I.1.11

Location of Water Level Gauge
Sample Area 4



Source :- BANGLADESH WATER DEVELOPMENT MAP
4 INCHES TO 1 MILE
SHEET 79 I-16/8, 1972.

Figure I.1.12
Location of Water Level Gauge
Sample Area 5



Local people were employed to take gauge readings three times a day (06.00, 12.00 and 18.00 hours), and the gauge zero elevations were subsequently determined in the course of the sample area survey work.

In the event, the 1992 monsoon season was unusually dry, and except for Area 3, at the eastern end of the Begumganj depression, none of the gauges within the fields recorded a water depth in excess of about 20 to 35 cm. The results are presented in Figures I.1.13 to I.1.17. Since the season was so atypical, it is not possible to draw any conclusions as to normal flood depths, but the following observations may be made:

(i) In Areas 1 and 2 (Figures I.1.13 and I.1.14) the khal water levels remain below the zero marks (corresponding with ground level) of the gauges in the fields. The water on the fields (10 to 25 cm) represents accumulated rainwater retained by the field bunds, although there was no aman crop around the gauges in any of the sample areas.

(ii) In Area 3 (Figure I.1.15), the depth of water on the fields is about 75 cm at the end of August, reflecting the khal water level. As the recession continues, the field levels appear more or less isolated from the direct effect of the khal water level, which is falling faster. This could be explained by the deliberate bunding of fields in order to retain water for the subsequent boro season, but the implied bund height does seem surprising. The oscillation of the khal water level in the second half of the period could be due to the successive construction and breaching of cross-bunds, again for the retention of irrigation water.

(iii) In Area 4 the Dakatia water level, as recorded by the Chitoshi gauge station, dominates initially, but on the recession a little water hangs in the fields until they eventually become dry.

(iv) In Area 5, the gauge reader responsible for the gauge in the khal was replaced mid-way through the period, as he was found to be unable to read the gauge reliably. However, even discounting the first half of the record, it is difficult to account for the oscillating water level in the khal, rising well above that in the fields, one of which stands more or less dry. Nevertheless, it is known from the public participation meetings that farmers in this area go to great lengths to retain water on their land for the boro season, and it may be that the explanation is the same as that for Area 3. In this case however, the high bunds constructed around the fields have had the effect of excluding the water stored in the khal, whereas perhaps in a normal year they might be intended to hold water at a higher level. The rate of fall of the water levels in the fields (6 to 8 mm/day) is consistent with evaporation and percolation, in the absence of further rainfall, without any drainage.

Because of the absence of deep flooding during 1992 at the locations monitored, it was not possible to verify entirely the approach to inundation analysis. As water levels rise, one would expect discrete water bodies within the depressions to combine into a more or less level sheet. As drainage takes place, some areas would lag behind others because of obstructions etc, returning to a situation of discrete water bodies with differing levels. The only area demonstrating this behaviour was Area 4, and to a lesser extent Area 3. It does appear that the analysis method may be somewhat imprecise in distinguishing between F0 (less than 0.3 m flood depth) and F1 (0.3 m to 0.9 m flood depth), particularly because of artificial interference with the flooding and drainage

Figure I.1.13

Water Level Monitoring - 1992
Sample Area 1

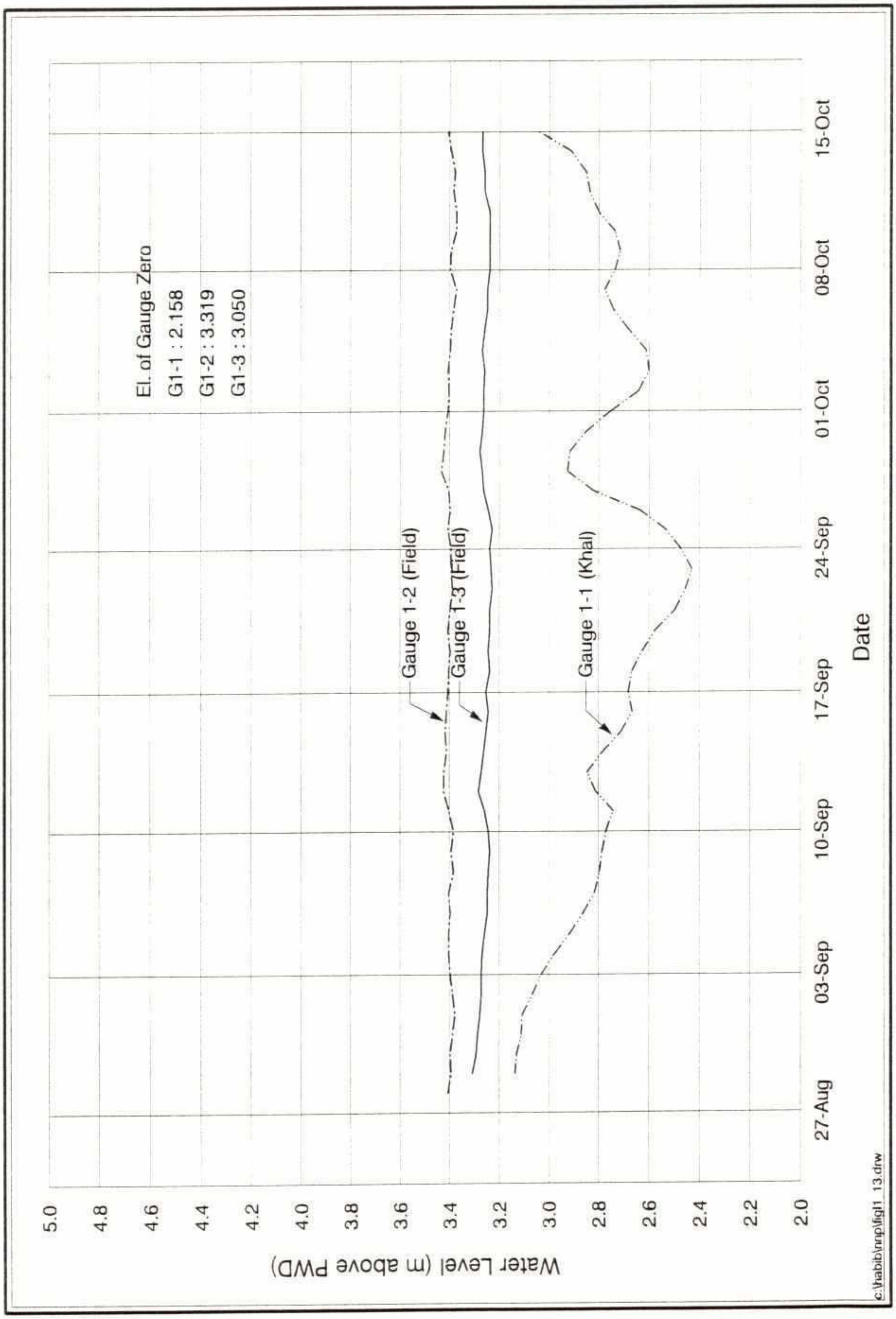


Figure I.1.14

Water Level Monitoring - 1992
Sample Area 2

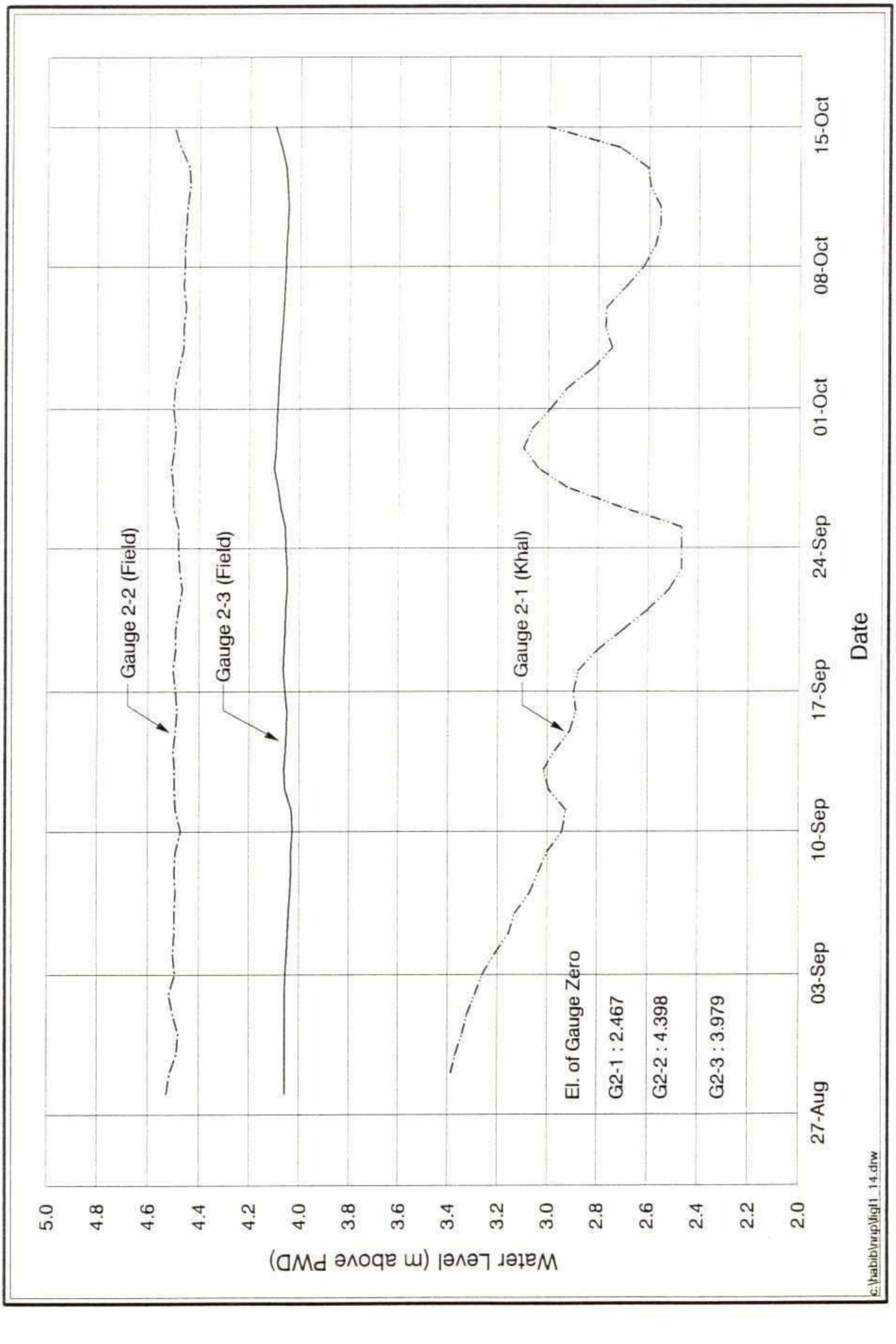


Figure I.1.15

Water Level Monitoring - 1992
Sample Area 3

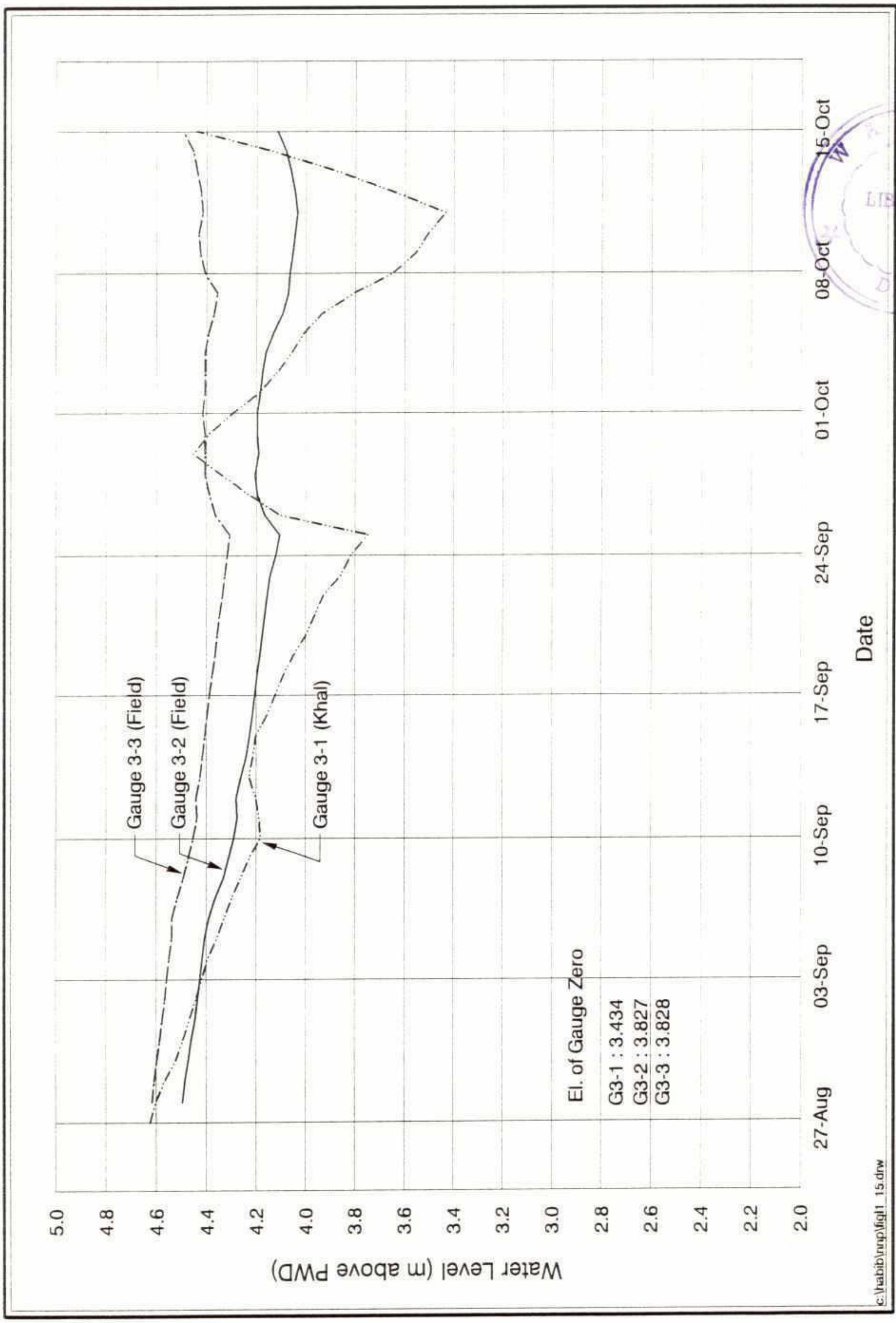


Figure I. 1. 16

Water Level Monitoring - 1992
Sample Area 4

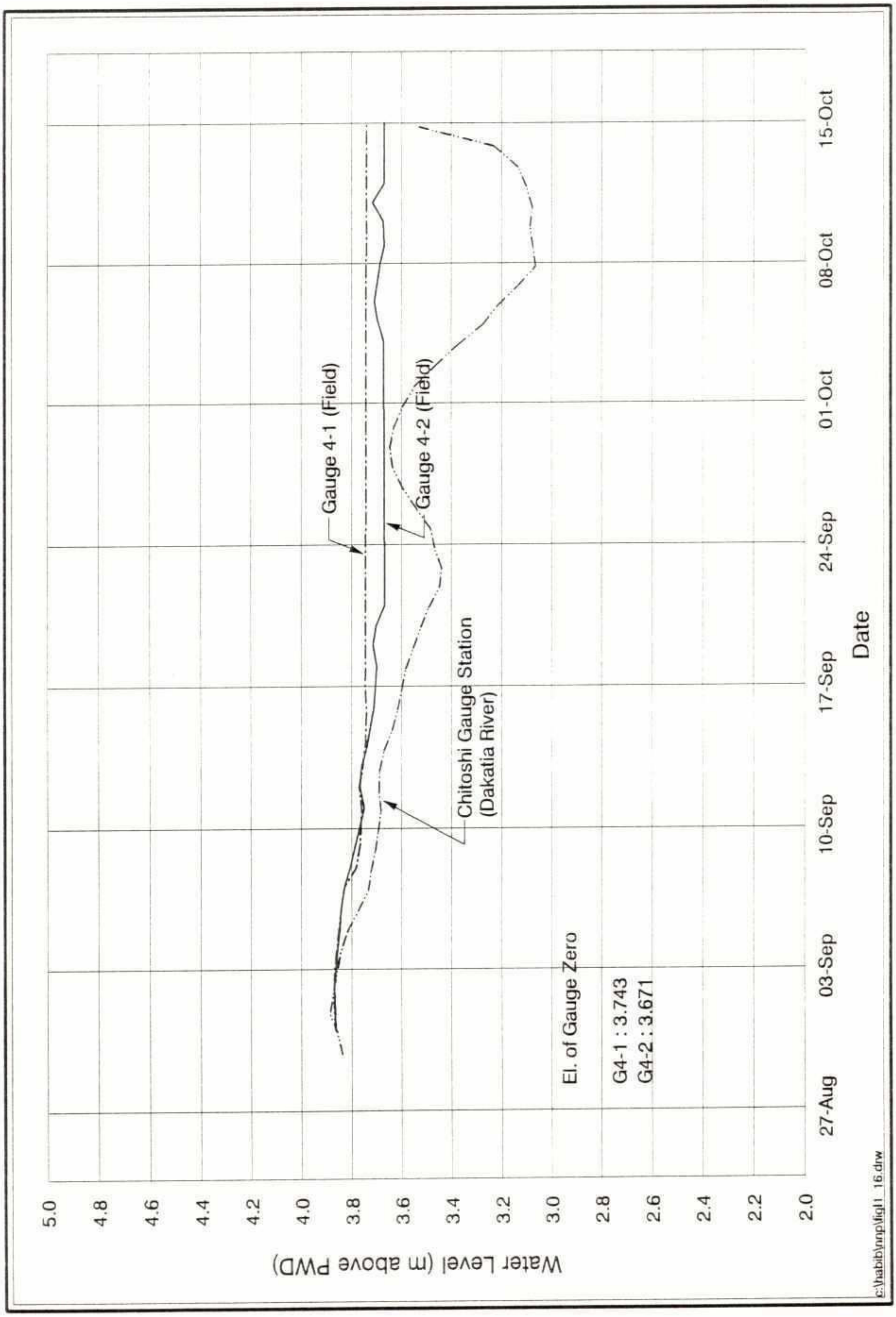
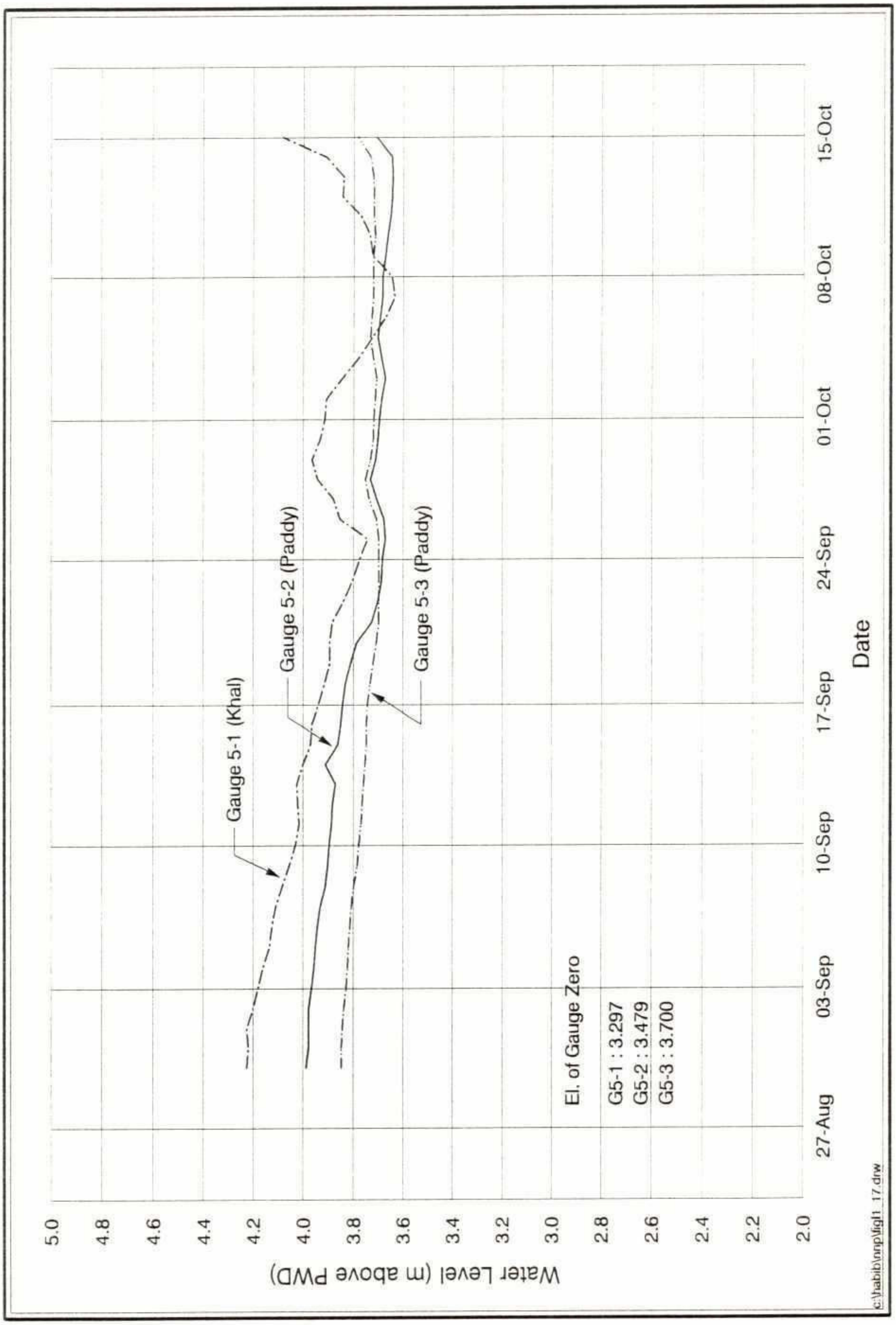


Figure I.1.17

Water Level Monitoring - 1992
Sample Area 5



processes. However, it is anticipated that the much more critical boundary (from the point of view of agricultural benefits) between F1 and F2 (0.9 m to 1.8 m flood depth) would not be significantly affected by such interference, and will be distinguished with greater accuracy.

I.1.2.2 Water Level Monitoring at Rahmatkhali Regulator

Water levels were monitored downstream of Rahmatkhali Regulator at hourly intervals between 0600 hrs ad 1800 hrs every day from 3 to 18 February 1993. These readings were used to assist in the development of tidal boundary conditions downstream of the regulator for use in the SERM runs, as described in Annex B (Hydrology and Hydraulic Modelling). The data collected is presented in Appendix I.V to this Annex.

I.1.3 Morphology

I.1.3.1 Lower Meghna Erosion

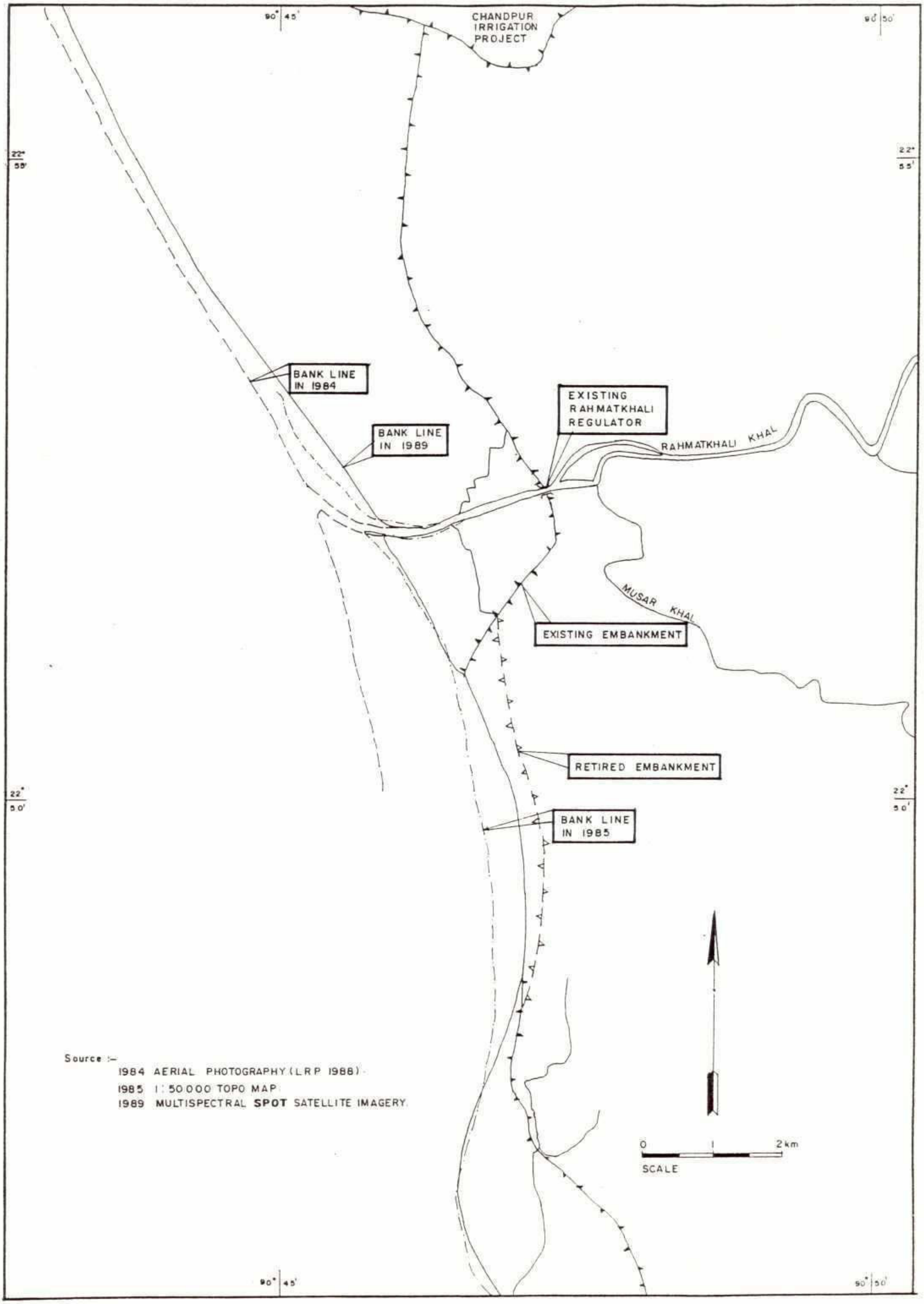
Any development of the Noakhali North project area must take account of possible shifting of the existing bank line of the Lower Meghna, particularly in determining any vulnerability of the Rahmatkhali Regulator.

FAP 9B (Meghna Bank Protection) and BWDB reports relating to erosion problems along the Lower Meghna were reviewed, and field visits undertaken to the area near the regulator and the nature and extent of erosion along the bank line studied. Available aerial photography, SPOT satellite imagery and maps from 1963 to 1990 were also studied. Subsequently a series of LANDSAT images (December 1973 - January 1993) covering part of the area also became available. Lastly the distance from the regulator to the main channel was measured in March 1993.

There are severe erosion problems at Chandpur town and along the north western portion of the Chandpur Irrigation Project (CIP) embankment. Both the town and the CIP have suffered damage in the past and remain under threat of erosion from the Lower Meghna as this huge river turns through almost a right angle bend at the junction of the Padma and Upper Meghna. This problem is discussed in the South East Regional Plan report and a proposal had been made by FAP 9B for a hard point at Chandpur which the Regional Plan supports. However, for the purposes of this report and the Noakhali North Project, the erosion at these locations poses no threat, since the CIP eastern embankment remains as a second line of defence.

The principal concern for the project is the stability of the river section at and near the Rahmatkhali regulator. Previous reports have suggested very rapid erosion at this location and one report (LRP 1988) suggested that the regulator could be under threat by the year 2003. However a review of the satellite imagery between 1973 and 1993 does not seem to support this and although a char opposite the Rahmatkhali Khal mouth disappeared and there was some erosion, the gross erosion rates reported were not of the main left bank. Figure I.1.18 compares the Meghna bank line in 1984 (from an aerial photograph presented with the LRP report), 1985 (presumed date of field revisions on Third Edition 1 in 50 000 map) and 1989 (SPOT imagery). In each case the alignment would represent the dry season conditions. In 1984, the bank was 3 250 m from the regulator along the line of the outfall channel, whilst a year later in 1985 it had reduced to only about 2 600 m.

Figure I.1.18
Lower Meghna Erosion Near Rahmatkhali Regulator



However, by 1989 the distance was still 2 400 m, and in 1990 perhaps 100 m less as assessed from the aerial photography of that year, although precise measurement from an unrectified image is difficult. A physical measurement, undertaken during this study in March 1993, produced a distance of 2 287 m. Thus it would seem that the last major erosion took place during the 1984 flood season, which was estimated to be a 1 in 5 year flood, based upon water levels at Chandpur, and since then the rate has been quite modest, even during the 1987 and 1988 floods, and for the last year or two more or less stable. The LRP report mentioned above foresaw the possible stabilisation of the erosion rate as the meander moved downstream.

Examination of the LANDSAT images (1973-1993) indicate that the meanders of the Lower Meghna are gradually moving downstream, as might be expected, and that the left bank at Rahmatkhali is safe for the foreseeable future. Indeed the recent imagery shows some accretion just to the north.

The substantial flows from Rahmatkhali Khal have always kept the mouth of the Khal clear and with the proposed increased discharges in the Khal this is expected to continue.

I.1.3.2 The Noakhali Khal

Historically the Noakhali Khal has been a principal drainage channel from what is now called the Begumganj depression. After the construction of the cross-dams 1 and 2, in 1959 and 1964 respectively huge areas of land were accreted to the south of the old coastal embankment.

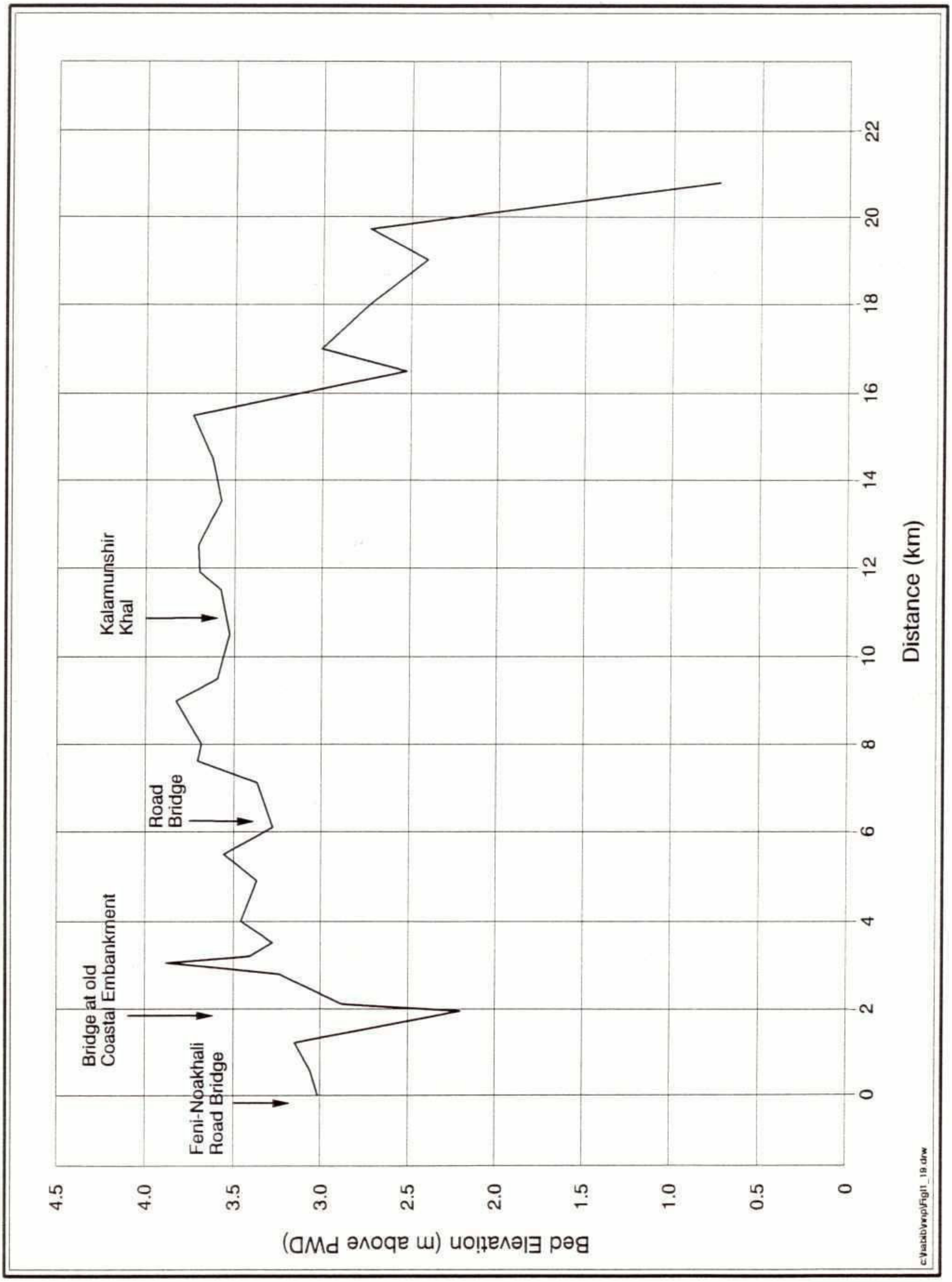
Water level records began to be collected for the Noakhali Khal at a station near Noakhali in the mid 1960's. These records are shown in detail in Annex B. The records indicate that from the time records started (1967) until 1974 there was a definite increasing trend in peak monsoon water levels and over the same period there was a substantial decrease in the tidal range. It was over this period that most of the land accretion occurred and, although this has continued, the hydraulic condition of Noakhali khal, at the southern embankment, stabilized at that time and has been largely constant since. Despite several attempts to improve drainage, through re-excavation, the khal has remained ineffective as a drain throughout the last 20 years. The distance from the junction of WAPDA Khal and Noakhali Khal to the sea has increased to 50 km which is further than the distance from the same junction to Rahmatkhali Regulator. The accretion at the mouth of Noakhali Khal is still occurring.

It is clear, therefore, that there would be severe problems in making Noakhali Khal into an effective drain since to do this would require major re-excavation over a very long distance and the construction of a large regulator at a site where accretion is continuing. This would present severe obstacles to sustaining a silt free outlet.

The LRP report of 1988 also identified the siltation problems of Noakhali Khal and further suggested that the mouth of the khal would continue to move east by up to 20 kms, particularly if additional cross-dams are built to accrete further land. The present study has included a resurvey of the Noakhali Khal which shows nearly 20 km with a bed level above +3.00m PWD. The longitudinal section is given in Figure I.1.19. This confirms the LRP analysis. The LRP report suggested that during the early monsoon period (April-June) spring tides bring flows into the Begumganj depression. This situation in fact occurs throughout the dry season and since these flows are partly saline the local population tends to construct cross dams in the khal to keep them out. The

Figure I. 1. 19

Longitudinal Section of Noakhali Khal South of Old Coastal Embankment



reverse flows are not large in quantity and therefore do not contribute greatly to flooding but the proposed drainage improvements could draw more water into the system. For these reasons a regulator on the khal has been included in the plan for the proposed project.

I.1.3.3 Sedimentation in the Internal Khals

Sediment deposition from rivers rising in the Tripura Hills is a problem in several areas of the Little Feni and the upper reaches of the Dakatia. There are, however, very few sediment data available for the project area. There is no routine sediment or water quality sampling at any location. The Land Reclamation Project (LRP 1988) recorded sediment concentrations downstream of Rahmatkhali Regulator in 1987, and these are presented in Figure I.1.20. The Surface Water Modelling Centre (SWMC) also recorded sediment concentrations at Chandraganj, midway along the Rahmatkhali/WAPDA Khal system, on a few occasions during 1990 and 1991, and these are presented in Figure I.1.21. These, and especially the Chandraganj data, suggest that suspended sediment concentrations within the internal channels are quite low.

This is as expected, since the water is mainly run-off from direct rainfall on the project area and its immediate surroundings. Almost all the sediment arriving from the Tripura hills is deposited in the Little Feni catchment and the upper reaches of the Dakatia. As the land in the project area is very flat, criss-crossed by a large number of existing embankments which inhibit widespread sheet erosion, the runoff will be almost clear, whilst nowhere within the catchment are there steep channels with high velocities. For similar reasons, bed loads also are likely to be very small.

As also expected, the material which is found in suspension is very fine (median grain size 0.01 to 0.02 mm according to sampling by SWMC), and most of this will remain as washload, to be flushed out through Rahmatkhali Regulator rather than being deposited elsewhere in the system. The situation is unlikely to change in the with project situation; although flow velocities have been shown by the SERM to be lower, this cannot lead to significantly increased deposition if very liitle material ever enters suspension, and should, in conjunction with the generally flatter side slopes (1 in 2), result in improved channel stability.

Sedimentation in the main khals has been relatively slow over the years, and some of this has been caused by excavated material being washed back into the khal during rainstorms. In the Begumganj depression, where flow velocities are very low, the siltation of the bed might be expected to be at its highest, and yet no re-excavation of this section has occurred in the last 20 years and the bed has silted by less than 1.0m in this period. Further downstream there is no evidence of accretion and problems are more concerned with erosion. The low levels of sediment found by LRP and SWMC are entirely consistent with the perceived rate of sedimentation in the khals of about 0.05 m/yr.

Amost no sediment from Meghna overspill is deposited in the project area. The SERM clearly shows that in most years all the floodwater is derived from stored rainfall and there is no net inflow from the Meghna. Even in the peak of the monsoon season in high flood years the quantities of inflow are for short durations only and there is net outflow every day. Virtually all tidal effects in the Dakatia are attenuated in the reach below Hajiganj and inflows above Hajiganj are almost non-existent.

Figure I. 1.20

1987 Suspended Sediment Concentration D/S of Rahmatkhali Regulator

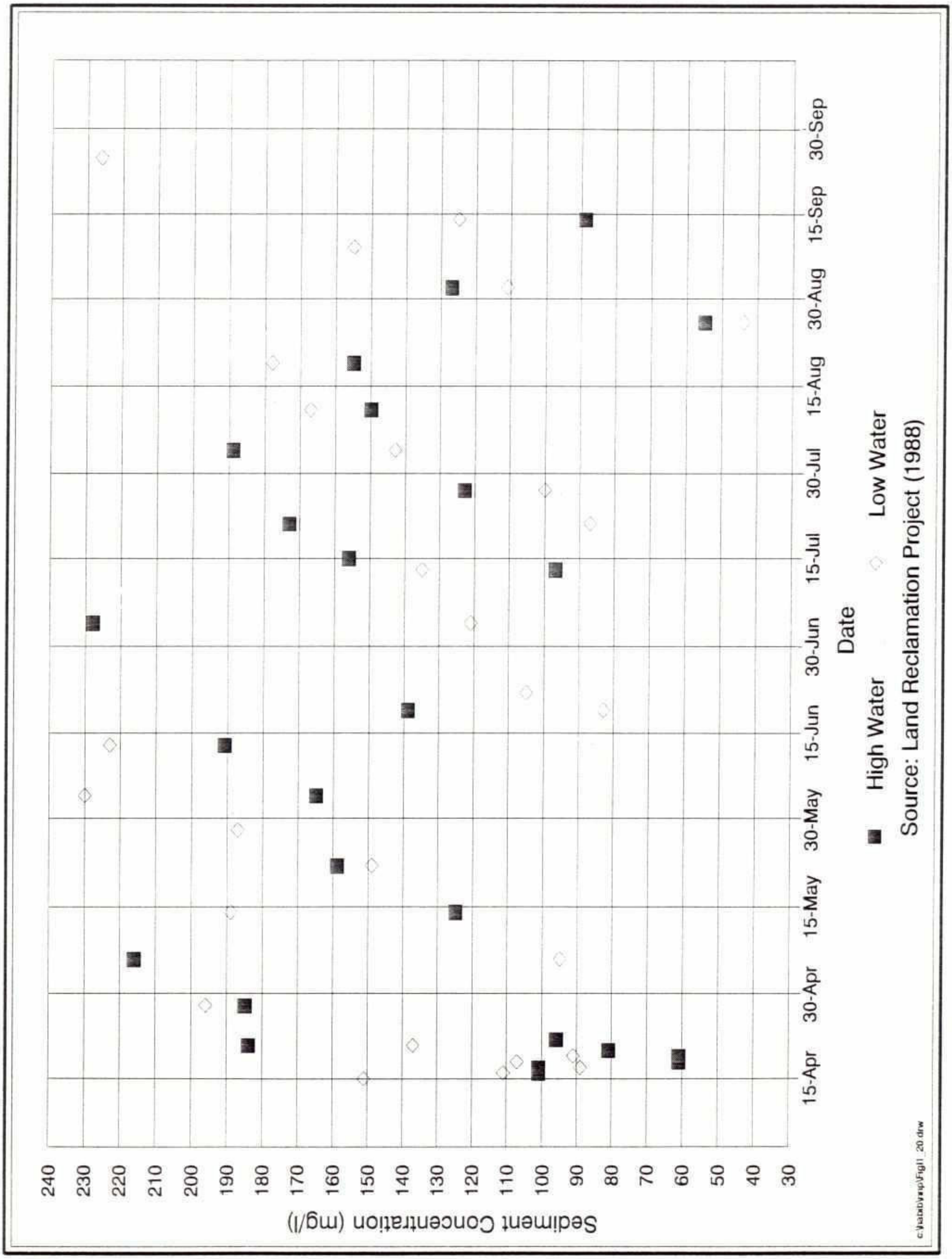
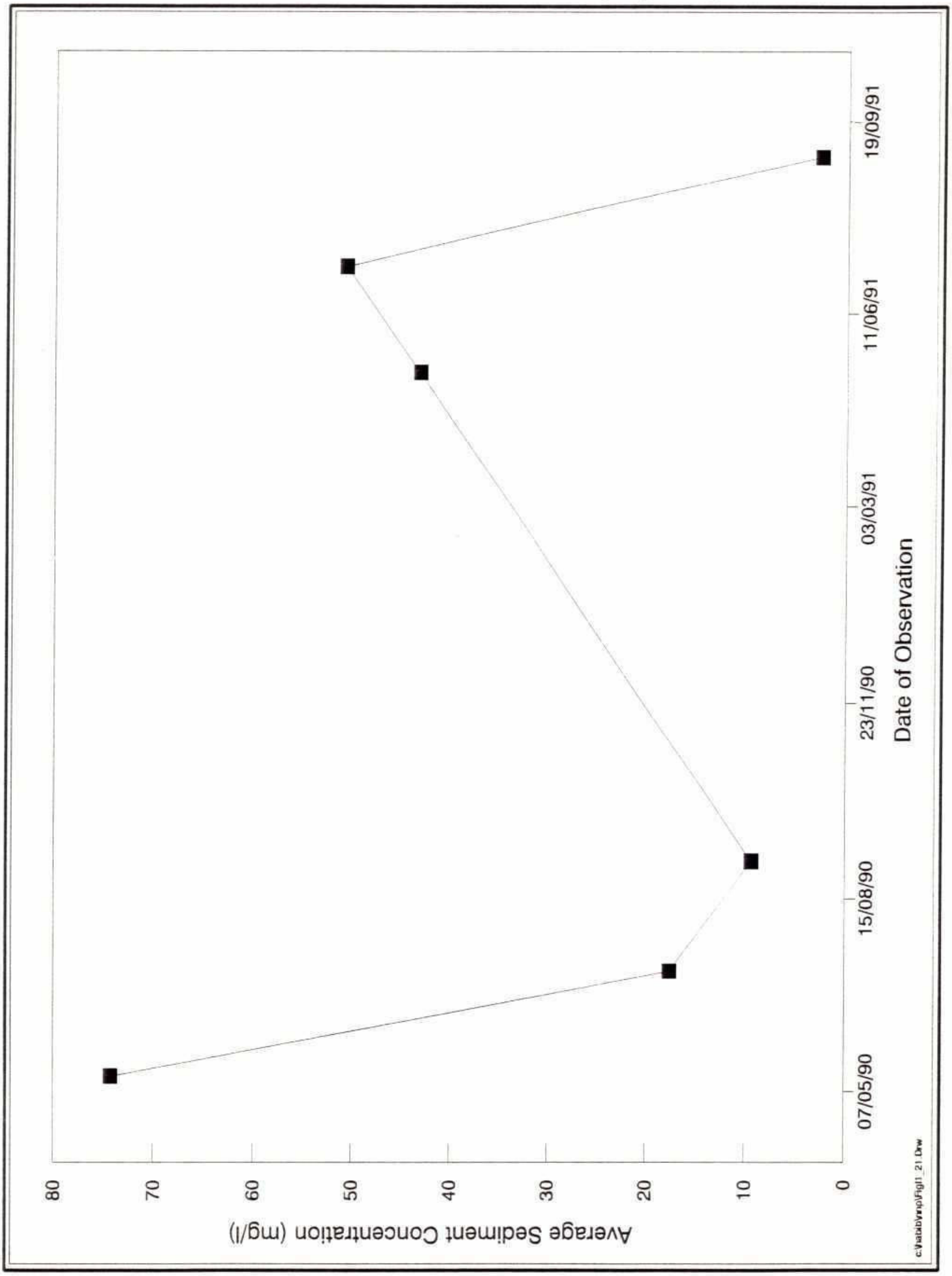


Figure I.1.21

Sediment Concentrations in WAPDA Khal Chandraganj Gauge Station (SWMC)



Nevertheless, the proposed admission of Lower Meghna water into the khal system for irrigation could imply the admission also of additional sediment. If one assumes the application of about 1 350 mm of irrigation water per season with a sediment concentration of 100 mg/l (ie typical April concentration downstream of Rahmatkhali Regulator, from Figure I.1.20) over an area of 30 000 ha, this is equivalent to letting in 40 500 tonnes of sediment per year, or about 30 000 cubic metres. Much of this sediment will end up on the fields, but even if all of it is assumed to be deposited in the channel system of superficial area say 3 000 000 million square metres, it would result in an annual depth of deposition of only 10 mm.

It is therefore concluded that sediment deposition within the Rahmatkhali/WAPDA Khal drainage system has not been a major problem in the past, and is unlikely to become so under the proposed project.

I.1.3.4 Sea Level Rise

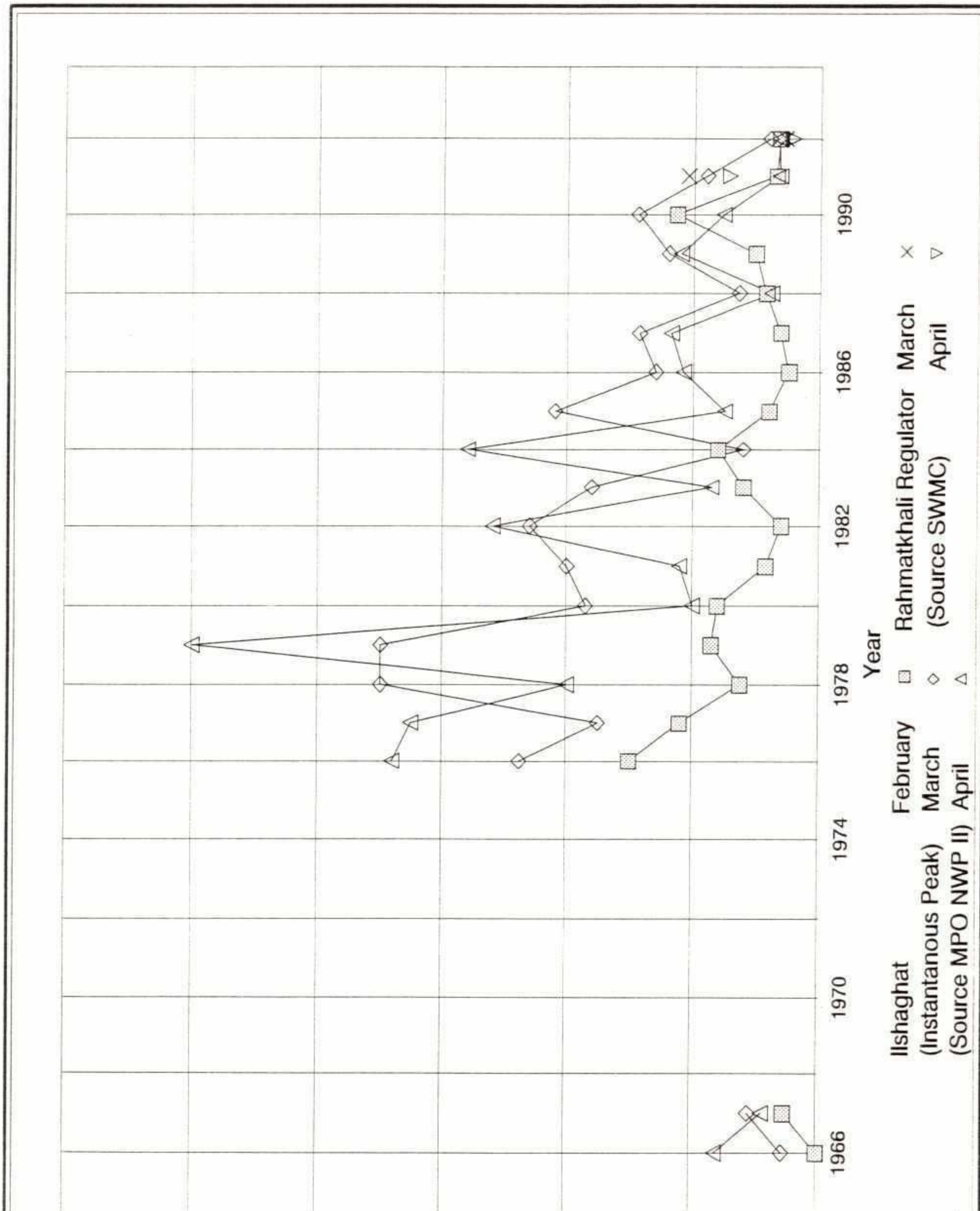
It has been postulated that a rise in sea level as a result of global warming would severely affect large parts of Bangladesh including the project area. The consultants are indebted to Dr. Robert Kay of the University of Waikato, New Zealand, who provided recent data on this issue. This data, presented in Appendix I.VI to this annex, shows that progressive revisions of the International Panel on Climate Change (IPCC) best estimates have produced lower values for expected sea level rise. With revised models based on recent IPCC (1992) findings the projected rise for the year 2100 is 0.48m. However, if the project life of 30 years is considered the projected rise is only 0.10m. This would not significantly affect duration of discharges through the regulator. It should also be noted that recent analysis of available data in Bangladesh has been unable to identify any reliable evidence of even relative sea level rise to date. This suggests that for the purposes of this study sea level rise may be considered to be a very minor factor in terms of project viability. In the very long term, if significant sea level rise were to occur, the provision of some additional gated width would provide much longer term sustainability of the tidal drainage system.

I.1.4 Lower Meghna Salinity

There is very little salinity data available for the Meghna River. However the data used in the National Water Plan Phases I and II (Ilshaghat, at the northern tip of Bhola Island, more or less opposite Rahmatkhali Regulator outfall) has been updated and supplemented by data collected by the Surface Water Modelling Centre (1991-1992) downstream of Rahmatkhali regulator. The data have been plotted as series of monthly maximum salinity readings for February, March and April (ie the critical part of the boro irrigation season), for the period from 1966 to 1992, and the results are presented in Figure I.1.22. It should be noted that the Rahmatkhali Regulator readings were taken only occasionally, and therefore probably do not represent instantaneous peaks. This shows a clearly declining trend in salinity levels during the dry season.

The main reason for this decline is considered to be the progressive elongation of the Meghna estuary as the accretion of new lands to the south continues. This means that the saline water is driven further out into the Bay of Bengal during the monsoon season and therefore returns to a lower point of the river in the dry season. This trend is expected to continue.

Figure I.1.22
Lower Meghna Salinity



The plotted results show that only twice in the last ten years has a result been obtained in excess of 2 000 μS/cm during the irrigation season. Unless this level became a common value rather than a very rare peak there would be no adverse effect on irrigated rice. The limit of 2 000 μS/cm for the salinity of irrigation water has been adopted as this is the threshhold for the salinity of the soil saturation extract at the transplanting stage for zero yield loss. The saturation extract salinity can rise much higher thereafter without damage. Under arid conditions there is a danger of a build-up of soil salinity if irrigation water at the threshhold salinity value is continually applied, but in the Bangladesh context, where huge quantities of fresh water arrive every monsoon season, far exceeding the annual irrigation application, there is no such danger. This assertion is confirmed by experience in the coastal regions which are vulnerable to periodic inundation by seawater, but usually recover their productive capacity by the following season.

The Land Reclamation Project recorded salinities at high tide and low tide between April and November 1987 downstream of Rahmatkhali Regulator, and obtained a peak April value of 340 μS/cm at low water (LRP 1988). The annual peak was 1000 μS/cm in June, well clear of the irrigation season, also at low water. These results are reproduced in Figure I.1.23. Although this record does not agree well with that for Ilshaghat, which peaked in March in 1987, it does imply that salinities at the regulator site tend to be lower than at Ilshaghat, but this situation may change once significant volumes of irrigation water are taken in. The fact that at least in some years (from both Figures I.1.22 and I.1.23) salinities continue to rise into April and beyond, even though the river discharge has started to rise, does imply that the position of the saline front in the estuary is not simply determined by a steady state equilibrium of incoming tide against outgoing dry season flow. Instead, it supports the suggestion already made above that saline water is driven out into the Bay of Bengal during the monsoon and progressively works its way back during the low flow season, until eventually reversed again. Thus the upstream limit of the saline front may depend upon the intensity of the preceding monsoon season as much as upon the current dry season discharge. Figure I.1.22 tends to support this argument, although not conclusively, with relatively low peak February salinities in 1978, 1981, 1985 and 1988, following higher than average floods in 1977, 1980, 1984 and 1987 repectively.

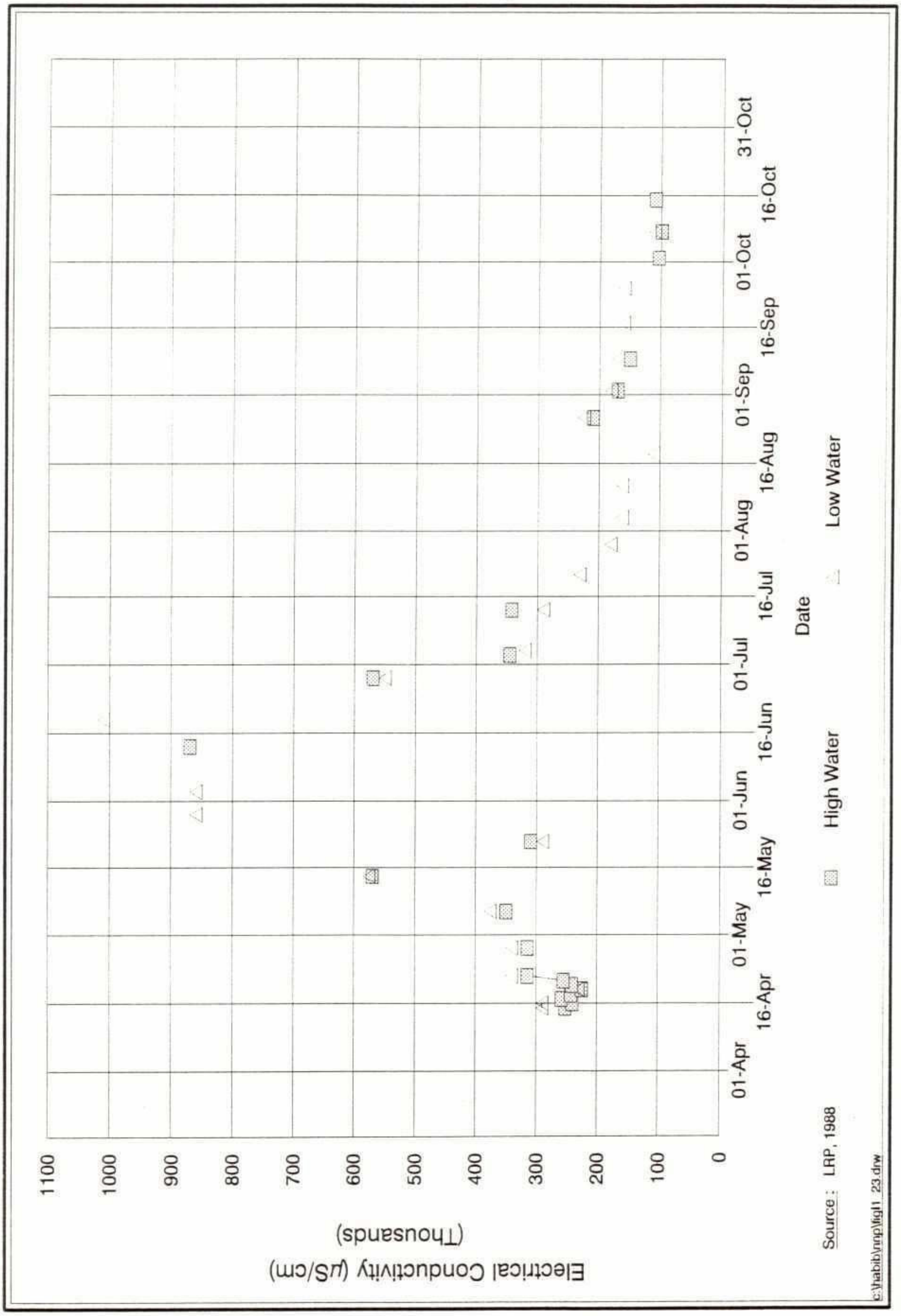
From all of the foregoing, this study supports and reinforces the NWP II contention that even with forecast upstream development, water quality at Ilshaghat and therefore at Rahmatkhali would remain suitable for irrigation.

In the long term the possible construction of a Jamuna barrage with large scale diversions of water elsewhere could affect the situation, but in this case not only might Rahmatkhali be affected but Bhola island and other schemes in the south west would be affected even more. In the absence of detailed knowledge of how such a barrage might be operated if it were ever to be constructed the consultants have assumed that the operating rules would continue to allow flows similar to those provided for in the NWP II. As stated above, under these conditions the trend in salinity levels should continue to decline and salinity poses no problems for the proposed project.

The interaction between salinity in the shallow groundwater and the water within the internal khal system is discussed in Annex C (Groundwater).

Figure I.1.23

1987 Salinity D/S of Rahmatkhali Regulator



I.1.5 Shallow Borehole Soil Investigations

I.1.5.1 General

Twelve exploratory shallow boreholes were sunk at various locations along the khal system to investigate the properties of the soil which would be excavated as part of the project proposals. The locations are shown in Figure I.1.24. The boreholes were sunk in conjunction with hand tubewells which were used for testing the shallow groundwater, as discussed in Annex C. The detailed site locations and borehole logs, together with grain size and chemical analysis results on the soil samples are presented in Appendix I.VII to this annex.

I.1.5.2 Soil Chemical Analysis

The highest electrical conductivity of soil water extract was 810 μS/cm, found at an elevation of about -1.5 m (PWD) at borehole Nr 2, just west of Begumganj on WAPDA Khal. This is well within the acceptable limit for rice, and there is no sign of any salinity build up in the soil (see Section I.1.4 above). The elevation of -1.5 m is almost 1 m below the proposed excavated bed level. The pH, percentages of organic carbon and organic matter together with the phosphorus content were also measured, as indicated in Appendix I.VII, and none of these characteristics were in any way abnormal. It has thus been concluded that from the point of view of salinity and chemistry, there should be no agricultural problems associated with the disposal of spoil from khal excavation

I.1.5.3 Soil Texture

The soil texture is of much more concern than its chemistry, in the context of spoil disposal. Sand contents in excess of 70% were found in boreholes as shown in Table I.1.2. Full details are available in Appendix I.VII to this annex. The sandy material appears to be concentrated in the south and west of the proposed khal excavation area. In these areas it is unlikely to be acceptable for the spoil from khal excavation simply to be disposed of by spreading on agricultural land, and alternative methods of disposal have to be considered as discussed in Section I.4.7 below. The present investigations, although identifying the problem, are not adequate to quantify the exact extent of the sandy material, and more detailed surveys will be required at the detailed design stage.

Figure I.1.24
Location of Exploratory Boreholes

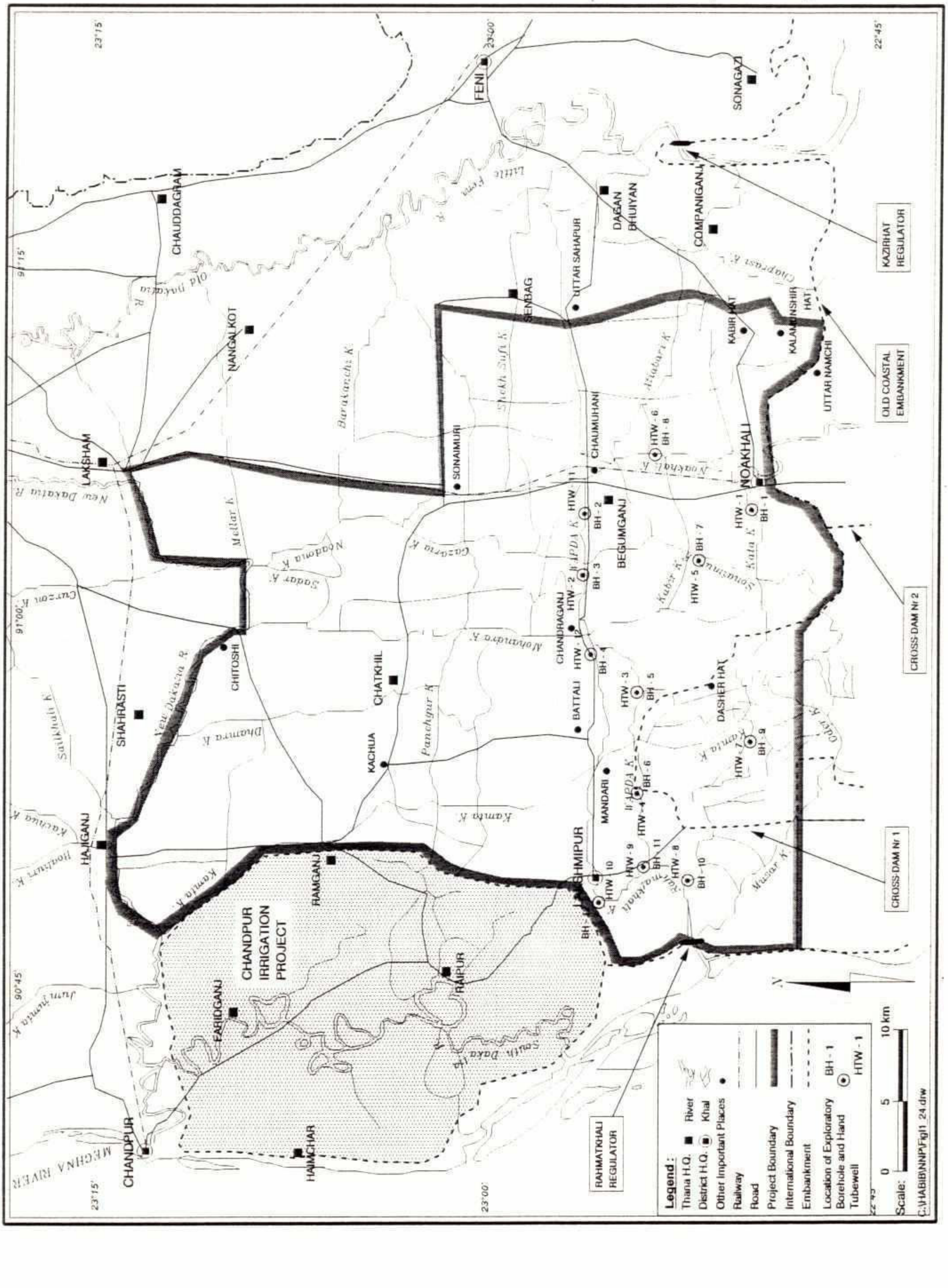


TABLE I.1.2

Sandy Soil Detected in Exploratory Boreholes

Borehole Nr	Elevation (m, PWD) From	To	% Sand	Borehole Location
5	0.3	-1.0	82.1	WAPDA Khal SW of Chandraganj
9	2.4	1.9	92.06	Honrakhali Khal
10	-1.1	-	92.22	Rahmatkhali Khal near Bhawaniganj
11	Throughout		71.87	WAPDA Khal at Piarapur

I.1.6 Existing Infrastructure

I.1.6.1 Roads and Road Structures

The principal roads within and adjacent to the project area, together with railways, are shown in Figure I.1.25. The major routes under the responsibility of the Roads and Highways Department (RHD) are:

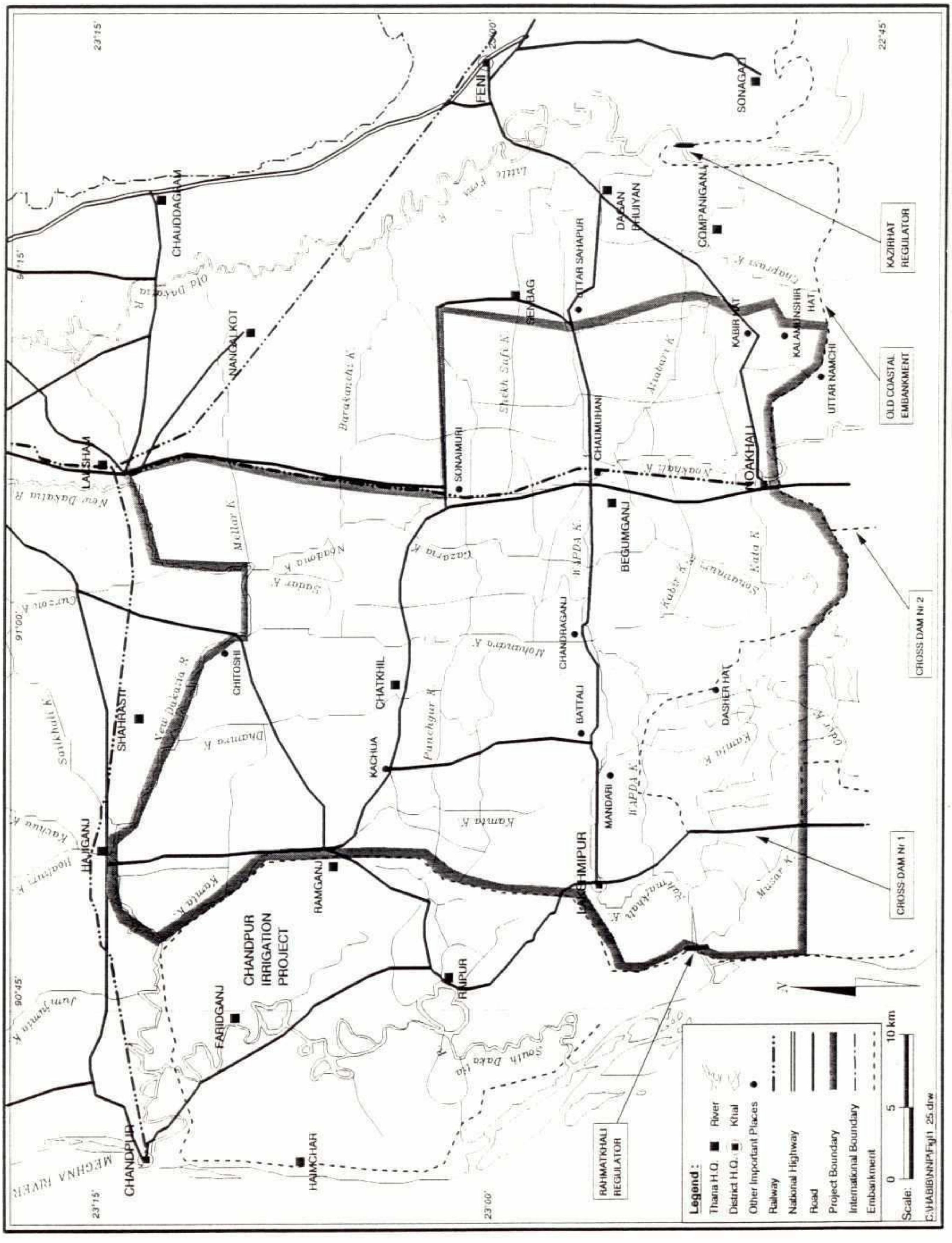
- Dhaka-Comilla-Chittagong National Highway
- Comilla-Chandpur
- Comilla-Laksham-Sonaimuri-Begumganj-Noakhali
- Feni-Begumganj-Lakshmipur-Raipur
- Sonaimuri-Chatkhil-Ramganj
- Ramganj-Hajiganj (to be upgraded)
- Lakshmipur-Ramgati
- Ramganj - Chitoshi.

This is a substantial network and several works are ongoing or in the pipe line. The Sonaimuri-Chatkhil-Ramganj road is currently being upgraded with new bridges over all the major khals. A new road has recently started, which will provide a new access route from Lakshmipur to Mazimiarhat (Rahmatkhali regulator). This is expected to be completed by 1995 and this 12 feet (3.65 m) wide road will therefore meet the requirement of the residents of Zone A who request navigation facilities at the regulator; with the road in place such facilities will not be required.

In addition, the Ramganj-Hajiganj road is to be upgraded as a regional road although it is not clear if a bridge is to be provided over the Dakatia.

The RHD also informed the team that they propose to construct several new cross-drainage structures on the Laksham-Begumganj road similar to those currently under construction on the Ramganj-Sonaimuri section which are quite adequate in respect of drainage capacity.

Figure I. 1.25
Transport Networks



The Local Government Engineering Department (LGED) is responsible for many roads. An LGED/ILO project is in the process of producing excellent thana maps showing locations of all roads and embankments and the existing cross-drainage structures. Unfortunately only two of these maps were currently available to this study in their final form, but some others were available in draft (for details see Appendix I.I to this annex). However the complete set should be obtained for the final design work. A list of roads and structures under the responsibility of LGED is presented in Appendix I.VIII to this annex.

A survey was performed of all road structures which might be affected by the project proposals and information was sought from the local, regional and Dhaka offices of the LGED, particularly on depth and type of foundations. For all except the newest bridges details were unavailable, and information then had to be sought by field inspection and local enquiry. Details are presented in Appendix I.VIII to this annex.

I.1.6.2 Hydraulic Structures

The only major hydraulic structure within the project area of direct relevance to the project proposals is the existing Rahmatkhali Regulator, of which details are given in Chapter I.4. There are however nine water retention structures constructed primarily on minor khals under the Noakhali Integrated Rural Development Project, Phase I (DANIDA). Their locations are shown in Figure I.1.26. Their original purpose was apparently in expectation of an earlier proposed Noakhali Irrigation Project based upon pumping water from the Dakatia River, for which they were to serve as irrigation check structures. Unfortunately, under the present proposals, they will probably have no role, although some may be useful as checks within the tertiary distribution system. It appears that all of the fall boards which were originally provided have been lost or damaged, and in some cases farmers are constructing temporary earth bunds in preference to using the structures as intended. Such earth bunds within channels are encountered throughout the project area, presumably for irrigation water retention.

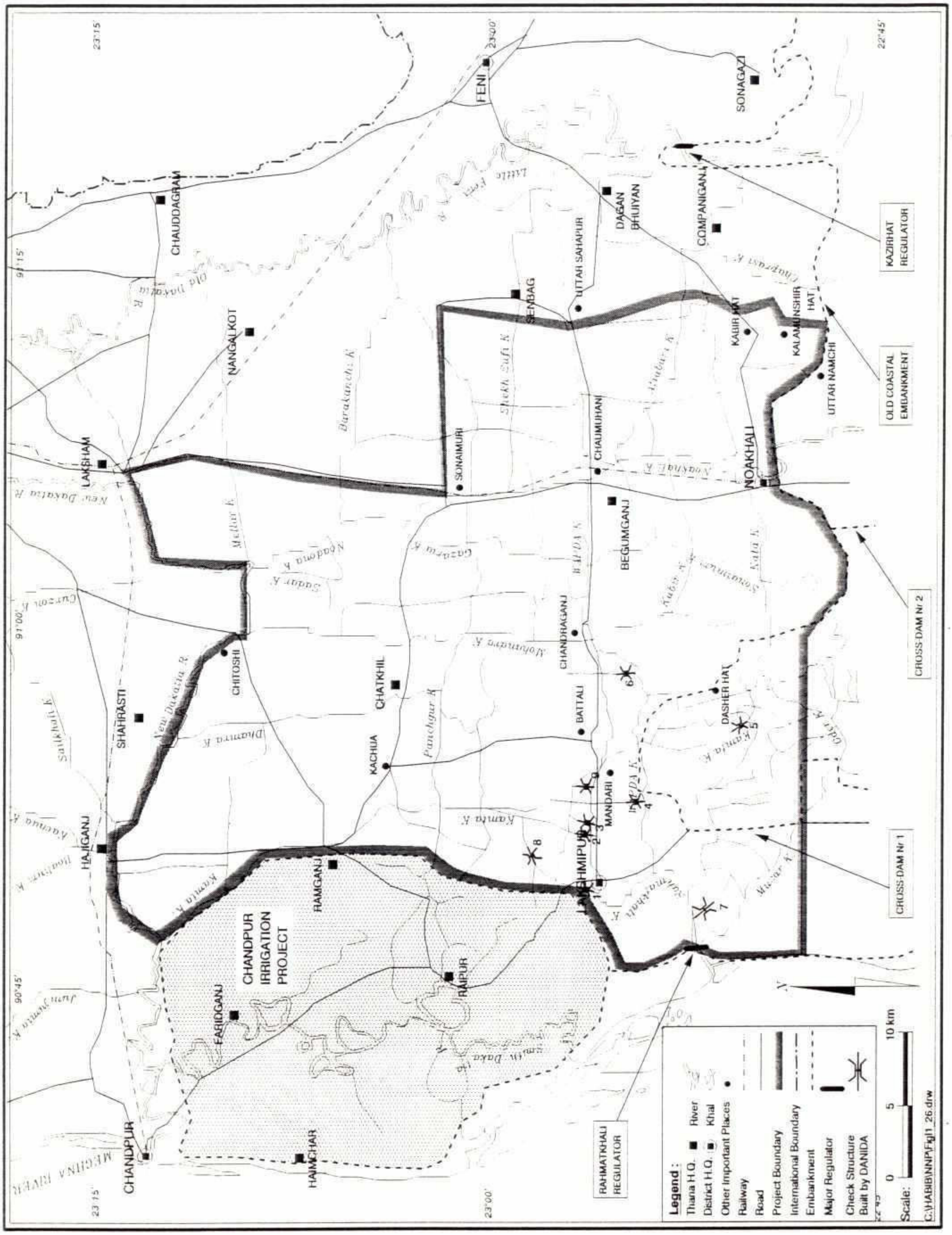
I.1.6.3 Navigation

As already mentioned above, the only issue in this respect which was mentioned during the public participation programme was the possibility of incorporating navigation facilities in the Rahmatkhali regulator. The provision of the new road eliminates this requirement. It should be pointed out that there is considerable water borne traffic up to the regulator from the Meghna River, but since the internal khal system is not suitable for year round transport it is more appropriate for the regulator to be the terminus and onward transport to be by an adequate road.

The existing traffic was reported to include approximately 100 private country boats per day from Chandpur, Bhola and Chittagong. Also a new passenger service has started.

The only other significant navigation route within the project area is the Dakatia river along its northern boundary. Since no proposals for the Dakatia are now incorporated in the recommended development no changes are necessary.

Figure I. 1.26
Location of Existing Hydraulic Structures



Within the project area, the widening and deepening of khals may permit wider use of small boats but it is not anticipated that this will be significant. The proposals will not adversely affect water bome transport at any location, except perhaps the free-ranging of very small craft during the flood season.

I.1.6.4 Electricity Supply

The Power Development Board (PDB) provides power supplies in Lakshmipur Pourashava, Bhawaniganj Bazar, Rakhalia Bazar and textile area, Mandari Bazar, Hajirpara Bazar, Chandraganj, Begumganj, Laksham, Sonaimuri, Chaumahani and Noakhali urban areas.

A map of the existing distribution system and development under way for Bangladesh as a whole (33 kV to 230 kV) and for the Comilla, Chandpur, Lakshmipur and Noakhali districts (11 kV to 230 kV) was made available to the consultants. There is a 33 kV line connecting Chandpur, Lakshmipur, and Begumganj towns, and a 132 kV line is under construction between Chaumuhani and Feni.

According to government policy, the responsibility for power supply in all areas other than municipal and major industrial areas is being transferred to the Rural Electrification Board (REB). The REB is active in most of the thanas within the project area. An REB zone draws power from the PDB network, and has its own 33 kV and/or 11 kV distribution system ('backbone line'), with sub-stations as required. Power is then supplied to individual samities or co-operatives. Connections to new samities will be provided if the estimated annual revenue will exceed Tk 30 000 per mile of new line required. Thana headquarters are automatically provided with connections, and it is understood that irrigation pumping is also given priority. In Lakshmipur there are existing connections to 74 LLPs, 3 DTWs and one STW and there are plans for an additional 300 connections. REB also provides electricity at favourable rates for agricultural uses and no payment is required for transmission lines. The present status of REB activities within the project area is given in Table I.1.3.

TABLE I.1.3

Rural Electrification in the Project Area

Thana	Area Served sq.km	PDB 33 kV Line (km) Existing	PDB 33 kV Line (km) Handed Over	REB 11 kV Backbone Line (km)	Total Distribution Line (km) Planned	Total Distribution Line (km) Constructed
Begumganj	500	122	-	50	900	750
Senbag	150	47	-	14	260	182
Chatkhil	126	55	-	-	263	160
Lakshmipur	538	-	-	66	426	213
Raipur	264	-	-	11	187	41
Ramganj	178	-	-	15	134	24
Hajiganj	190	70	49	30	314	232
Shahrasti	155	60	60	10	255	167
Laksham	15	39	-	-	19	14

Source: REB Dhaka

1.1.6.5 Gas

There is an existing gas supply by 10" diameter pipe from Feni along the shoulder of the roads and branched via a regulator system to Senbagh, Chaumuhani (east), Chaumuhani (West) and Begumganj. This is planned to be extended to Lakshmipur. It is normal practice to lay the pipeline 5 to 6 feet below the existing khal bed level at crossings.

1.1.6.6 Flood Protection Infrastructure

The project area is surrounded by either high ground (east) or by existing embankment. To the south the old coastal embankment originally protected the area from the sea. This embankment is now largely redundant and the existing structures are largely ineffective. The south western boundary comprises the main Meghna left embankment and contains the existing Rahmatkhali Regulator. The embankment condition is generally adequate and the regulator structure has maintained its structural integrity over the last 20 years despite its excessive overloading. As reported elsewhere the overloading has caused severe erosion downstream, and some upstream, of the regulator, both of the channel sides and of the bed. BWDB are currently undertaking some remedial measures to the sides of the channel and the development proposals include additional recommendations to prevent further erosion.

The main embankment has not suffered from public cuts and appears to be accepted by the local population. Further north the western boundary comprises the CIP eastern embankment so that the project area has a double line of defence against either flooding or erosion from the Meghna.

Just to the north of the project boundary the existing Chandpur to Comilla road and railway embankment provide major obstacles to movement of flood water. The combined effects of all these embankments both protect the area from severe inundation from the Meghna during high tides and they also in some cases contribute to the area's inadequate drainage.

The largely man made khal system was mostly constructed when the area was nearer to the coast, and the improvements made in the early 1970's have proved inadequate in the face of increasingly difficult drainage to the south.

CHAPTER I.2

MINOR IRRIGATION

I.2.1 Existing Situation

All existing irrigation within the project area comes under the category of minor irrigation; that is to say that there are no schemes involving major pump stations and/or extensive gravity distribution. The CIDA funded Bangladesh-Canada Agriculture Sector Team (AST), in its Census of Lift Irrigation, categorises minor irrigation modes as follows:

- Low Lift Pumps (LLP)
- Deep Tubewells (DTW)
- Shallow Tubewells (STW)
- Deep Set Shallow Tubewells (DSSTW)
- Hand Tubewells (HTW)
- Traditional Methods

The AST has been collecting data on numbers of LLP and STW since 1986 (excluding 1990 and 1992). For 1991 it included DTW, HTW and traditional methods in its census. Data are collected by Department of Agricultural Extension (DAE) block supervisors for their individual block, collated by the thana agricultural officers and forwarded to the AST in Dhaka for processing and quality control. The AST census is generally accepted as the most reliable national database of minor irrigation.

Table I.2.1 gives an inventory of the minor irrigation by mode and by thana within the project area, from the AST data for 1991 (the latest year for which data was available at the time of analysis). The full data by DAE block are presented in Appendix I.IX to this annex. It is known that since 1991 several new DTW have been installed in Begumganj, Chatkhil, Ramganj and Lakshmipur thanas, and the 1991 data have accordingly been updated in Table I.2.2. Figure I.2.1 shows the distribution of groundwater and surface water irrigated area by DAE block within the project area in 1991, whilst Figure I.2.2 shows the distribution of STW units.

Figures I.2.3 to I.2.5 show the trends in DTW, STW and LLP development since 1986 for Lakshmipur and Begumganj combined, as these thanas represent the bulk of the area which will receive irrigation benefits under the project proposals. The contribution from STWs is apparently in steep decline (although this is based upon only one year's data), but a very steep growth in DTW development has occurred since 1989. Meanwhile LLP development appears more or less to have stabilised, perhaps on reaching the limit of surface water availability. It is apparent from Table I.2.2 that LLP is by far the dominant irrigation mode.

As described in the agriculture and economics annexes, there is some disagreement between the AST data and the areas of reported boro cropping by BBS, DAE and the project farmer surveys. The reason for these sometimes significant differences was not obvious but by evaluation of other supporting data it has been possible to make some adjustments to the AST data.

TABLE I.2.1
Inventory of Minor Irrigation in the Noakhali North Area

Thana	DTW	STW	MTW	LLP <1 cs	LLP 1 cs	LLP 2 cs	LLP 3-5 cs	DTW	STW	MTW	LLP <1 cs	LLP 1 cs	LLP 2 cs	LLP 3-5 cs	Tradit- -ional	Total Irrigation	Surface Water	Groundwater (suction)	Groundwater (Total)
	nr	nr	nr	nr	nr	nr	nr	he	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
Noakhali	0	0	21	84	46	6	1	0	0	17	1,469	1,286	271	73	1,591	4,707	4,690	17	17
Begumganj	1	52	20	549	192	55	1	28	397	49	2,199	1,418	762	51	4,219	9,123	8,649	446	474
Chatkhil	0	0	4	428	24	2	0	0	0	1	1,915	153	14	0	157	2,240	2,239	1	1
Senbag	14	70	2	74	11	2	0	384	453	1	258	89	31	0	296	1,512	674	454	838
Laksam	0	22	1	311	99	63	0	0	63	0.2	1,522	736	1,327	0	1,019	4,667	4,604	63	63
Hajiganj	7	1	0	9	52	73	0	174	4	0	61	645	2,032	0	168	3,084	2,906	4	178
Shahrasti	9	0	0	45	55	22	1	196	0	0	211	544	384	1	117	1,453	1,257	0	196
Faridganj	0	9	0	0	15	45	0	0	61	0	0	125	656	0	22	864	803	61	61
Ramganj	0	4	4	301	131	41	0	0	14	1	924	869	536	0	250	2,594	2,579	15	15
Laksmipur	14	18	3	211	171	413	0	342	101	0.4	773	1,519	6,490	0	1,064	10,289	9,846	101	443
Ramgati	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	45	176	55	2,012	796	722	3	1,124	1,093	70	9,332	7,384	12,503	125	8,903	40,534	38,247	1,163	2,287

Source : AST/CIDA (1991), WITHOUT DTW UPDATE

TABLE I.2.2
Estimated Current Irrigation Coverage

Thana	DTW Command	Revised DTW Nrs	Estimated DTW Irri. ha	Estimated Groundwater ha	Estimated Irrigation ha
Noakhali		0	0	17	4,707
Begumganj	28.0	3	76	522	9,171
Chatkhil		20	506	507	2,746
Senbag	27.4	14	354	808	1,482
Laksam		0	0	63	4,667
Hajiganj	24.9	7	177	181	3,087
Shahrasti	21.8	9	228	228	1,485
Faridganj		0	0	61	864
Ramganj		3	76	91	2,670
Laksmipur	24.4	25	632	734	10,580
Ramgati		0	0	0	0
Total	25.3	81	2,049	3,212	41,459

Table assumes 1991 (AST) irrigation plus revised DTW Numbers, with 1991 average DTW command area.

Figure I.2.1

Distribution of Minor Irrigation in 1991

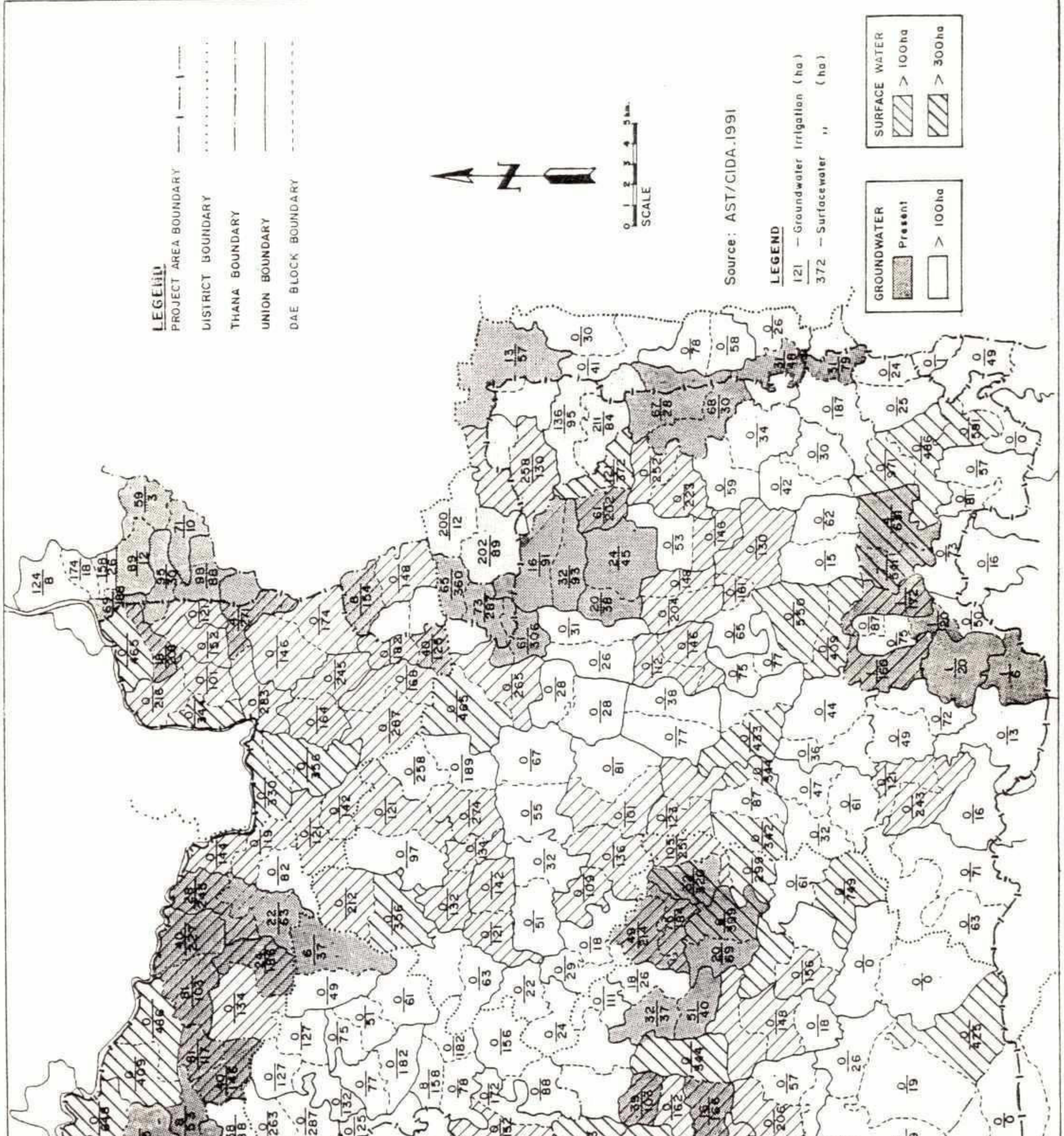


Figure I.2.2

Distribution of STWs in 1991

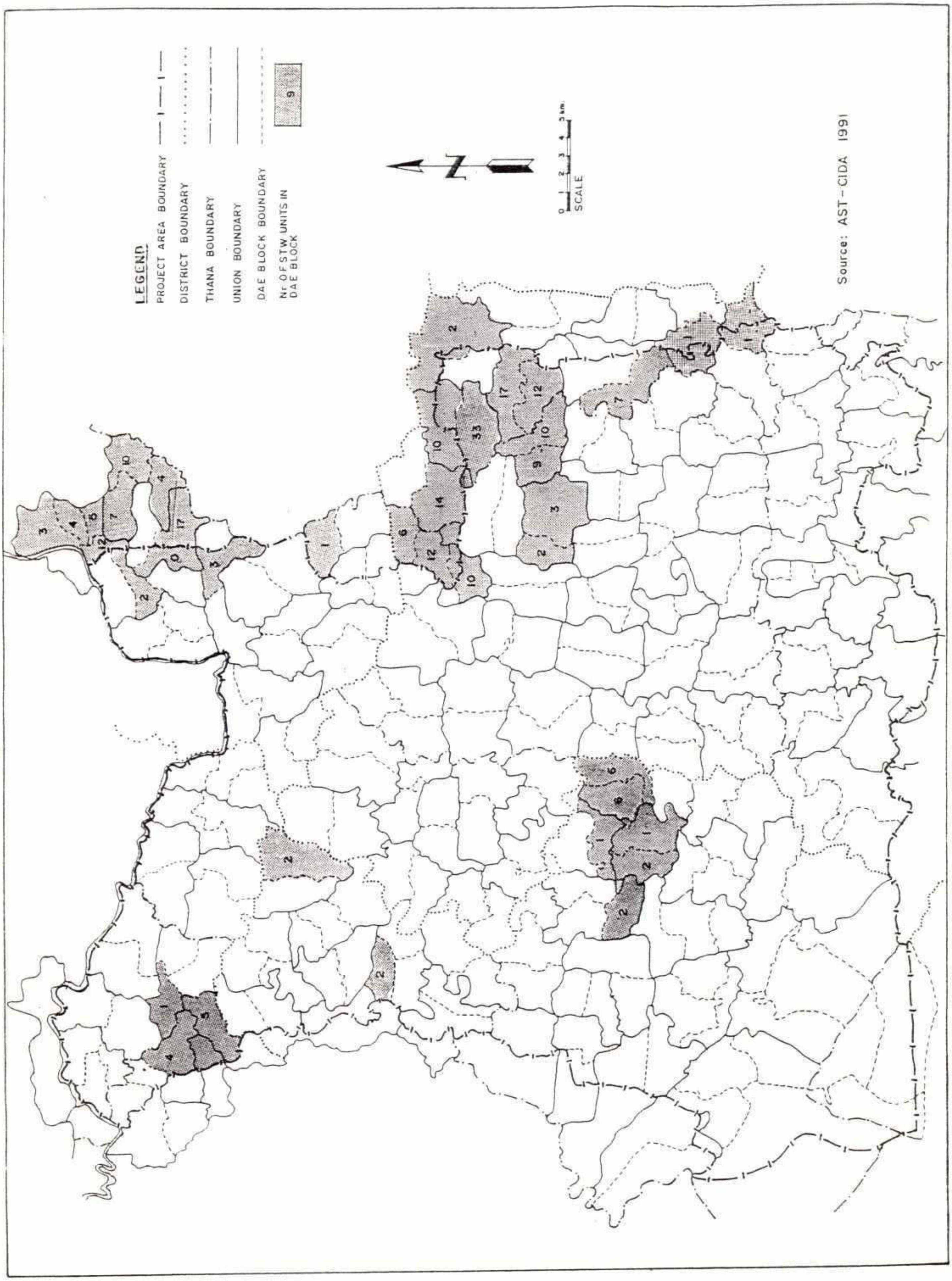


Figure I.2.3

Deep Tubewell Development since 1986
Lakshmipur and Begumganj Thanas

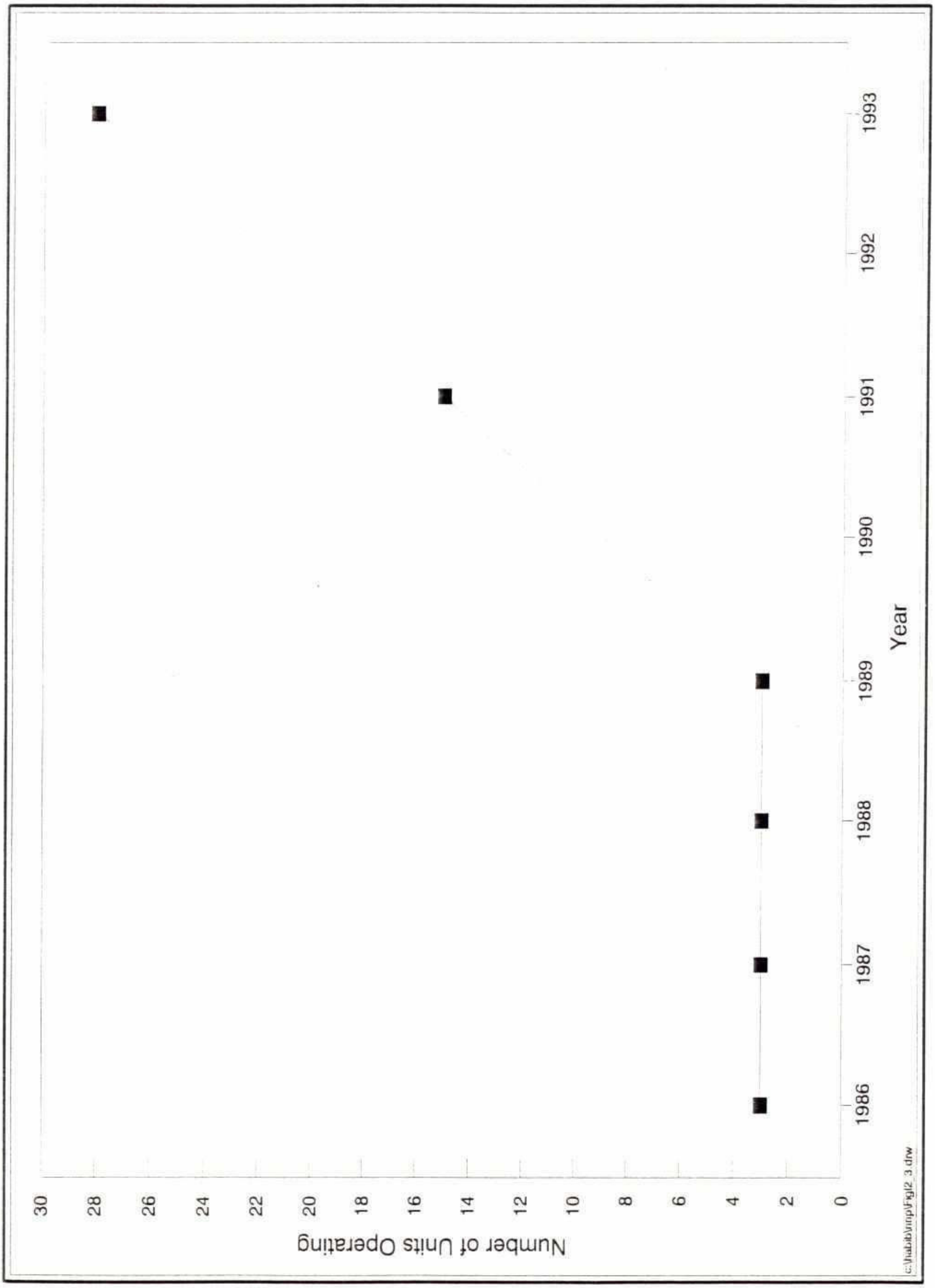


Figure I.2.4

Shallow Tubewell Development since 1986
Lakshmipur and Begumganj Thanas

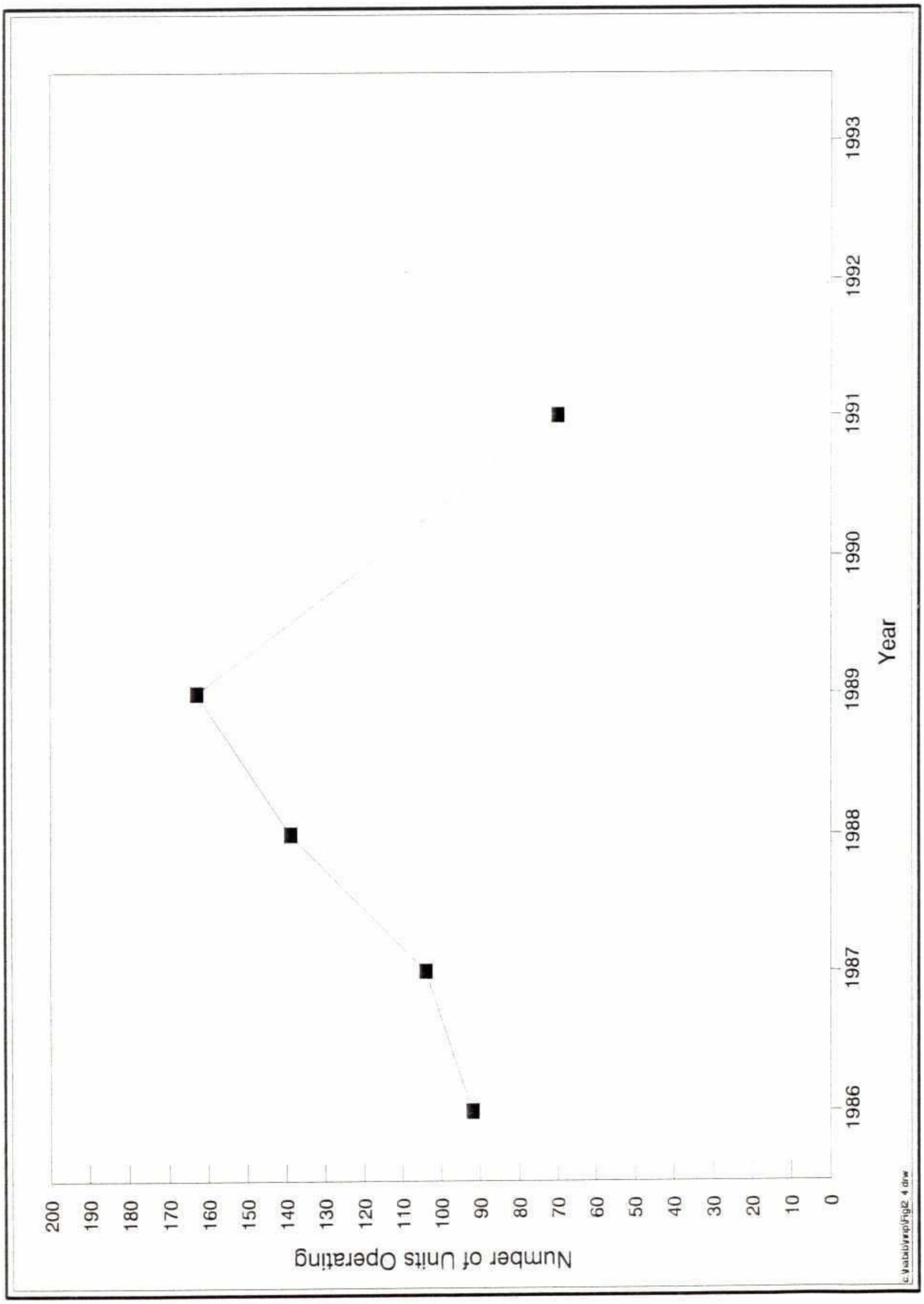
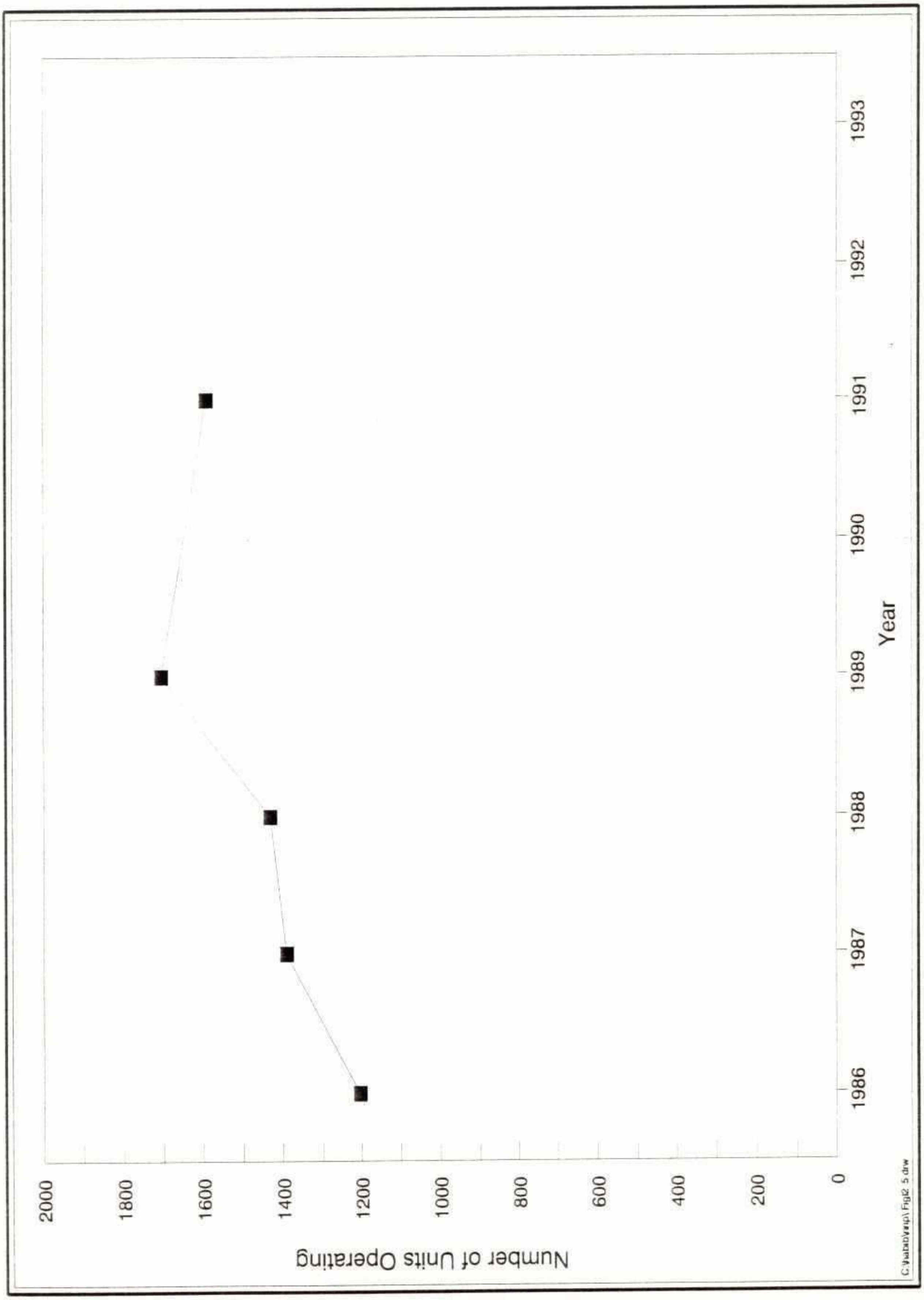


Figure I.2.5

Low Lift Pump Development since 1986
Lakshmipur and Begumganj Thanas



Firstly this study has undertaken a survey of pump operators, the detailed results of which are tabulated in Appendix I.X to this annex. This survey indicated that a substantial proportion of LLP operators move pumps from place to place irrigating more that one area with the same unit. This dual usage of pumps is not identified in the AST data.

Secondly the AST data was compiled in 1991 and the farmer surveys and BBS data are for 1992. It is reasonable to assume that there was some growth during 1991/1992, particularly since, as can be seen from Figure I.2.5, LLP numbers fell back between 1989 and 1991. This growth has been assumed at 5%. Thirdly there are very substantial differences of areas per LLP unit between one thana and another as reported by AST data. It is interesting for example that the area per unit in Noakhali is much higher than in the neighbouring Begumganj thana whereas conversely the area of traditional irrigation reported in Begumganj is much higher than that in Noakhali. It is quite possible that much of the traditional irrigation reported in Begumganj is in fact supplied by LLP. This would tie in with the data from the farmer surveys where very little traditional irrigation was reported.

Table I.2.3 shows the AST data with the two adjustments discussed above. The adjusted areas are very close to those used in the economic analysis which were based on an average of the unadjusted AST data and the farmer surveys.

Fortunately the remaining variations between the adjusted AST data and the farmer survey data are small when the areas specified for new irrigation supplies are considered. This is because most of the newly irrigated areas are in Zones A and C where the adjusted AST data and the farmer surveys produce quite similar answers.

Table I.2.4 presents the adjusted irrigated areas from Table I.2.3, broken down by mode and zone. LLPs account for over 75% of all the irrigation in the project area. As described above even this may be an underestimate, since much of the land recorded as served by traditional irrigation takes water which was originally lifted by LLP.

TABLE I.2.3

Adjusted Irrigated Areas by Zone

Zone	AST 1991 Irrigated Area (ha)	Increase in LLP Area with Dual use (ha)	Assumed Increase in Area 1991-992	Adjusted AST Irrigated Area (1992) (ha)
A	3,557	508	203	4,268
B	7,994	1,042	452	9,488
C	8,799	1,929	535	11,265
D	18,744	4,462	1,160	24,366
Total	39,094	7,941	2,350	49,387

61

TABLE I.2.4

Irrigation by Mode and Zone

Zone	DTW	STW	MTW	Traditional	LLP	Total
A	345	0	0	188	3735	4268
B	13	3	18	3984	5470	9488
C	804	874	53	2108	7427	11265
D	936	194	1	2487	20748	24366
Total	2097	1072	72	8766	37380	49387

I.2.2 Low Lift Pump Practices and Problems

It is noticeable that there are very large differences in the AST data in the areas served per LLP unit. During the topographical survey the surveyors were asked to obtain details for all the pump units they observed along the khals during their surveys. These khals were of course, the larger khals in the network. Unfortunately not all the survey parties followed these instructions but the results obtained are nevertheless valuable and they confirm random field interviews along the major khals. The number of pumps for which details were obtained was 56 and the power of the engines varied from 3 hp to 25 hp. The largest unit was an electric powered pump near Lakshmipur commanding 40 ha where REB are now offering cheap power rates for such units. Only five units were serving less then 10 ha and the average command area was 21.5 ha. The detailed information is presented in Appendix I.X to this annex.

Discussion with farmers and villagers at typical pump locations on the large khals yielded similar results to those given above and typical tertiary channel lengths quoted were from 1.0 to 1.5 km and exceptionally 2.4 km. These results tend to confirm that where there are more reliable sources of water farmers manage to organise quite large units for distribution and will take water quite long distances. If this had not been the case it would be quite impossible for the areas reported to be growing boro rice.

There are of course very large numbers of smaller pump units serving very small areas and it is these that tend to be moved from place to place. The pump operator survey consequently showed the overall average area per pump to be only 8.2 ha. Nevertheless on the banks of the Dakatia there are two or three substantial floating pump stations which supply up to 1000 ha. The largest unit, in fact, supplies areas on the north side of the Dakatia which is outside the project boundary but it serves to illustrate that very substantial private initiatives are undertaken where a reliable source of supply is available.

A number of installations were visited in the field and it is clear that farmer groups are adopting sensible and practicable methods to achieve good distribution. However the pump operator survey showed that the most common limitation on command area was the supply of water in the khal (72%) of responses. Only in Zone A was this not the primary problem. In Zone A the major problem is stated to be transmission difficulties (54.2% in Zone A and 32.3% overall). The only other significant problem recorded was "competition from other pumps" which could also be directly connected with water availability.

Figure I.2.6 shows two types of existing arrangement for tertiary canals. Type (a) shows a channel cut into the top of an existing road embankment. The particular system seen commenced at Rahmatkhali Khal with a proper discharge box, a culvert under the main Begumganj-Lakshmipur Road and then a plastic lined channel. This was stated to be 1.5 miles (2.4km) long and to be commanding 65 acres (26.3 ha).

The more common type (b) shows a channel using an existing small khal adjacent to a village road or track, with a small bank on the other side using material excavated from the khal. This small bank would be broken in the monsoon to allow drainage. In this type the pump is mounted on a temporary cross dam at the small khal's outfall to the main khal. Again in the monsoon season the pump is removed and the cross dam demolished to allow drainage. There are many such khals and embankments available in the area. These systems are simple, cheap and effective and it is anticipated that these types of systems would be typical in the future.

The farmers of the area have shown considerable ingenuity and it is anticipated that any water which can be made available will be taken up. Demand, at present, far exceeds supply and this is likely to remain the case in future.

I.2.3 Expected Future Groundwater Development

(a) Shallow Aquifer

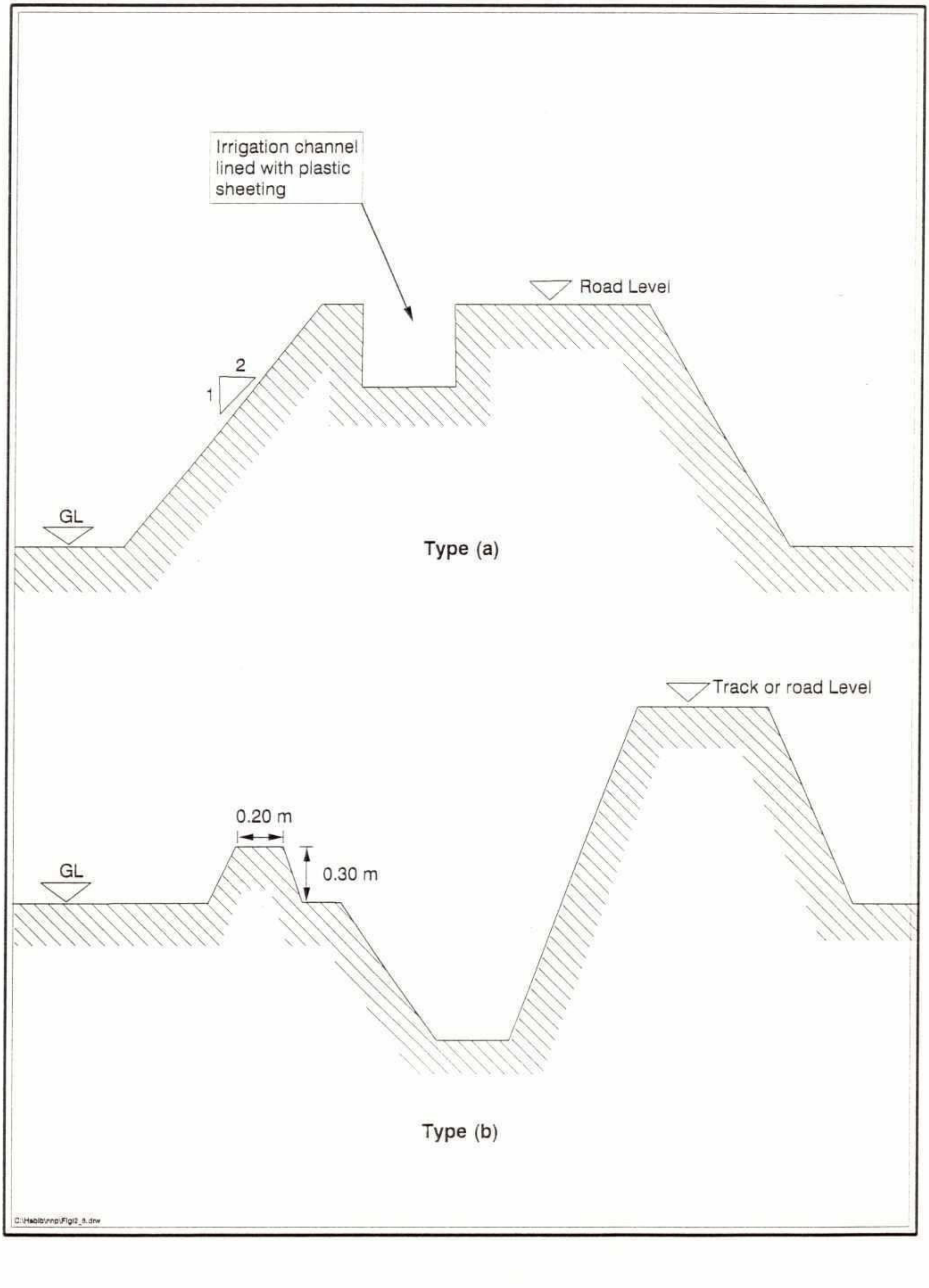
There will always be difficulties in development of the shallow aquifer because of the need for careful settings of screened casing to avoid the entry of saline water. Also in the areas to the east of the Begumganj depression (eg Senbag) conventional STW technology has difficulty in maintaining suction during the dry season as water levels fall and sometimes there are gas-related problems.

Both these problems could sometimes be overcome by the use of Shallow Force Mode Tubewells (SFMTWs) and as these become more widely known there will be some scope for further development of the shallow aquifer. However it is considered unlikely that the development will be significant and only in areas away from locations where surface water may be obtained. SFMTWs are discussed in more detail in Annex C (Groundwater).

b) Deep Aquifers

Much of the project area is underlain by the Dupi Tila formation which contains a deeper fresh water aquifer generally below 130m. The recent exploitation of this aquifer in Lakshmipur and Chatkhil Thanas may be expected to continue whilst BADC equipment stocks last. It is interesting to note that most of the recently developed wells are outside the zones where the Noakhali North Project expects to increase surface irrigation. This report has assumed that future development of this aquifer will be limited to about a further 1000 ha in the project area using existing BADC stocks. Thereafter it is anticipated that the cost of deep tubewell technology will restrict development to areas where there is no alternative source of supply. This is discussed in the South East Regional Plan where recommendations concerning investigation and development of this aquifer suggest that priority should be given to other areas for utilisation of this resource.

Figure I.2.6
Typical Tertiary Irrigation Channels



In any case extensive development of the aquifer cannot be recommended until proper investigations are completed to confirm its extent and recharge and to ensure that it is sufficiently confined to prevent leakage of saline water from above. Monitoring of the existing wells combined with a well managed investigation through trial holes and piezometers could yield urgently needed data to confirm the sustainable development which could be achieved.

I.2.4 Typical Command Areas

Assumed irrigation command areas for the various types of irrigation equipment at present in use are given in Table I.2.5. Additional details including the capital and operating costs associated with the pumping and distribution systems are presented in Annex J (Financial and Economic Analysis). The National Minor Irrigation Development Project is planned to develop several modified groundwater technologies, using small force mode pumps to overcome the problems of gas and underlying salinity in shallow aquifers. Cheaper versions of the existing DTW, including one having a 1 cusec (28 l/s) capacity are also to be developed. These new technologies may find application within the project area, but are unproven as yet.

TABLE I.2.5

Capacities and Command Areas of Pumping Equipment

Description	Capacity (l/s)	Command Area (ha)
Low Lift Pump (LLP 1)	20	10
Low Lift Pump (LLP 2)	56	20
Shallow Tubewell (STW)	8	4.5
Deep Set Shallow Tubewell (DSSTW)	8	4.5
Deep Tubewell (DTW)	60	22

I.2.5 Irrigation Water Requirements

Irrigation water requirements have been assessed in accordance with the methodologies developed for the CROPWAT computer programme (Manual and Guidelines for CROPWAT, FAO, Rome 1991). These requirements have been calculated for use in the irrigation model runs described in Annex B (Hydrology and Hydraulic Modelling) to assess the irrigation benefits available from inflows at Rahmatkhali Regulator. The basic assumptions made are as follows:

(i) Irrigated boro dominates all other crops, and the water requirements have therefore been calculated for this crop alone. The crop growth stages, their lengths (rounded to whole decad periods) and the values of the crop coefficients associated with each, derived from the Deep Tubewell II Project Final Report (Supporting Volume 2.1 - Natural Resources, Mott MacDonald/ODA, 1992), are shown in Table I.2.6. It has been assumed that boro is transplanted between the 1 January and the 10 February, giving a total stagger in the crop calendar of 40 days.

65

TABLE I.2.6

Crop Growth Stages and Crop Coefficients for Boro

Growth Stage	Length (days)	Crop Coefficient (Kc)	Remarks
Nursery	30	1.2	10% of transplanted area
Land Preparation	10	-	150 mm application
Initial and Development	40	1.1	
Mid-season	40	1.05	
Late Season	30	0.8	

(ii) Reference evapotranspiration values have been taken for Noakhali, since this is the nearest climatic station collecting sufficient data for application of the modified Penman formula. The average monthly reference evapotranspiration (ET_o) for Noakhali for the years 1965 to 1980, calculated by the modified Penman method using the CROPWAT programme is given in Table I.2.7. Decad values for calculating water requirements on a 10-day basis were interpolated by drawing a smooth curve.

(iii) The rainfall station used for the calculations is Sonaimuri, with records available since 1962. The CROPWAT method derives an estimate of the 80% dependable decad rainfall by factoring the average decad rainfall by the ratio of the 80% dependable annual rainfall to the average annual rainfall. A range of options is available for converting the result to effective rainfall (ie allowing for that which is lost to percolation and runoff), but for the present analysis the CROPWAT Option 1 has been taken, with 80% being assumed effective, falling to 70% for monthly rainfall values in excess of 100 mm. The calculation of effective 80% dependable rainfall is presented in Table I.2.8. for the boro season (December to May).

TABLE I.2.7

Average Monthly Reference Evapotranspiration (ET_o, mm/day) at Noakhali

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3.31	4.39	5.45	6.10	5.91	4.49	4.52	4.51	4.46	4.24	3.61	3.10

Source: South East Regional Study Consultant's calculations

TABLE I.2.8

Calculation of 80% Dependable Effective Rainfall at Sonaimuri, Station R-377

Average Annual Rainfall - 3 198 mm   80% Dependable Annual Rainfall - 2 864 mm   Ratio - 0.896

Month	December			January			February			March			April			May		
Decad Nr	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Average	0	0	0	0	1	3	4	4	6	6	7	10	32	54	64	70	75	80
80% Dep	0	0	0	0	1	3	4	4	5	5	6	9	29	48	57	63	67	72
Effective	0	0	0	0	1	2	3	3	4	4	5	7	29	34	40	44	47	50

All units in mm

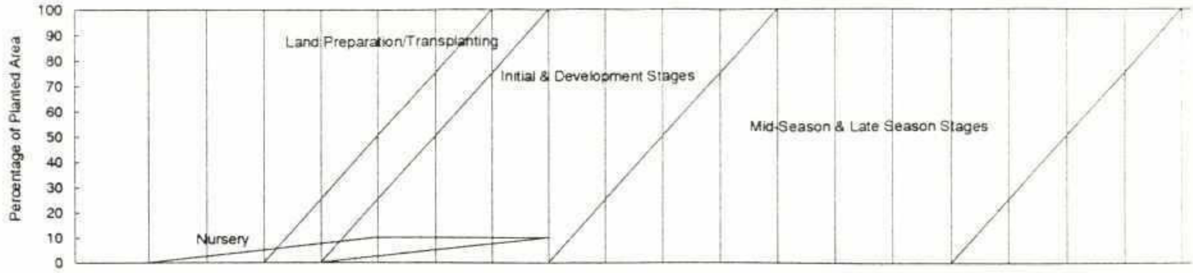
(iv) A deep percolation rate of 4.5 mm/day has been adopted for the present study, which is appropriate for the fairly light soils found within the area to be provided with irrigation, although probably a little conservative within the Begumganj depression.

(v) An overall transmission efficiency of 80% has been adopted in determining the water duty for the required inflow at Rahmatkhali Regulator. This fairly high figure has been adopted because existing khals are used as the main distribution channels, and water levels will be well below ground level. Furthermore, a substantial degree of re-use is anticipated, since any surplus runoff will find its way back into the distribution system.

The calculation of the irrigation water requirement is set out in Figure I.2.7. The peak 24 hour continuous water duty was found to be nearly 1.5 l/s/ha at the end of January, with a second peak of 1.4 l/s/ha during March.

Figure I.2.7

Calculation of Irrigation Water Requirement



Month		December			January			February			March			April			May	
Decad (end of)	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Reference Evapotranspiration																		
ETo (Noakhali) (mm)	32	31	30	30	32	37	41	44	47	51	55	58	60	61	62	62	60	55
Effective Rainfall (mm)	0	0	0	0	1	2	3	3	4	4	5	7	20	34	40	44	47	50
Nursery																		
% of area entered nursery stage	3	5	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
% of area left nursery stage			0	3	5	8	10	10	10	10	10	10	10	10	10	10	10	10
% of area at nursery stage	3	5	8	8	5	3	0	0	0	0	0	0	0	0	0	0	0	0
Crop Coefficient Kc	1.2	1.2	1.2	1.2	1.2	1.2												
Evapotranspiration ET (mm)	38	37	36	36	39	44												
Deep Percolation (mm)	45	45	45	45	45	45												
Net Irrigation Requirement (mm)																		
- over area at nursery stage	83	82	81	81	83	87												
- equivalent over whole area	2	4	6	6	4	2												
Land Preparation/Transplanting																		
% of area entered LP/T stage		0	25	50	75	100	100	100	100	100	100	100	100	100	100	100	100	100
% of area left LP/T stage		0	0	25	50	75	100	100	100	100	100	100	100	100	100	100	100	100
% of area at LP/T stage		0	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0
Land Preparation Application (mm)			150	150	150	150												
Net Irrigation Requirement (mm)																		
- over area at LP/T stage			150	150	149	148												
- equivalent over whole area			38	38	37	37												
Initial & Development Stages																		
% of area entered I & D stage			0	25	50	75	100	100	100	100	100	100	100	100	100	100	100	100
% of area left I & D stage							0	25	50	75	100	100	100	100	100	100	100	100
% of area at I & D stage			0	25	50	75	100	75	50	25	0	0	0	0	0	0	0	0
Crop Coefficient Kc				1.1	1.1	1.1	1.1	1.1	1.1	1.1								
Evapotranspiration ET (mm)				33	36	41	45	48	52	56								
Deep Percolation (mm)				45	45	45	45	45	45	45								
Net Irrigation Requirement (mm)																		
- over area at I & D stage				78	80	84	87	90	93	97								
- equivalent over whole area				20	40	63	87	68	46	24								
Mid-Season Stage																		
% of area entered M-S stage							0	25	50	75	100	100	100	100	100	100	100	100
% of area left M-S stage											0	25	50	75	100	100	100	100
% of area at M-S stage							0	25	50	75	100	75	50	25	0	0	0	0
Crop Coefficient Kc								1.05	1.05	1.05	1.05	1.05	1.05	1.05				
Evapotranspiration ET (mm)								46	49	54	57	61	63	64				
Deep Percolation (mm)								45	45	45	45	45	45	45				
Net Irrigation Requirement (mm)																		
- over area at M-S stage								88	90	95	97	99	88	75				
- equivalent over whole area								22	45	71	97	74	44	19				
Late Season Stage																		
% of area entered L S stage											0	25	50	75	100	100	100	100
% of area left L S stage (ie harvested)														0	25	50	75	100
% of area at L S stage											0	25	50	75	75	50	25	0
Crop Coefficient Kc												0.8	0.8	0.8	0.8	0.8	0.8	
Evapotranspiration ET (mm)												46	48	49	50	50	48	
Deep Percolation (mm)												45	45	45	45	45	45	
Net Irrigation Requirement (mm)																		
- over area at L S stage												84	73	60	55	51	46	
- equivalent over whole area												21	37	45	41	25	12	
Total Requirement over Whole Area (mm)	2	4	44	63	81	102	87	90	92	95	97	95	81	64	41	25	12	0
Overall Transmission Efficiency (%)	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Irrigation Diversion Requirement (mm)	3	5	54	79	101	127	109	112	114	119	122	119	101	80	51	32	14	0
24 hr Continuous Water Duty (l/s/ha)	0.03	0.05	0.63	0.91	1.17	1.47	1.26	1.29	1.32	1.37	1.40	1.37	1.16	0.92	0.59	0.36	0.16	0

CHAPTER I.3

ENGINEERING COSTS

I.3.1 Basis of Costing

This chapter sets out the basis of the engineering cost estimates which were prepared for each of the development options analysed. Rates and costs have been prepared at 1992 financial prices as per FPCO Guidelines. In general, rates for the various work items have been derived from an analysis of the operations and materials etc involved, and then compared with those available from the following sources, and adjusted if appropriate:

- Schedule of Rates for Comilla O & M Circle, 1992, BWDB, Comilla.
- Schedule of Rates for Muhuri O & M Circle, 1992, BWDB, Feni.
- Schedule of Rates collected from local contractors working in BWDB projects.
- Schedule of Rates for Road & Bridge Works, 1990, RHD, Dhaka Zone.
- Schedule of Rates prepared by World Bank Resident Mission in Bangladesh, Sept. 1991.
- FAP 2 reports (1992), FAP 8A reports (1991), FAP 21/22 reports (1992)

It is anticipated that most of the work will be constructed under contracts awarded on the basis of local competitive bidding, but it is also hoped to involve landless contracting societies in the manual earthworks operations. Accordingly, the rates for these operations have been prepared with reference to information supplied by Comilla Proshika.

I.3.2 Earthworks

Earthworks constitute the major component of the proposals, and special attention has therefore been given to deriving as realistic rates as possible for this part of the works. Various combinations of manual and mechanical methods have been investigated, in order to arrive at the most effective approach for any given circumstances. It has been concluded that manual excavation is best employed in all locations except where the depth of water makes it difficult or impossible. Under these conditions mini-dredgers have been adopted. Full-sized dredgers as presently used in Bangladesh were also investigated, but found to be more expensive and less appropriate for the works envisaged. The spoil would be pumped as a slurry and retained within small bunds to the required depth. The basic delivery pipe length is assumed to be 500 m, giving an effective transport distance of about 300 m.

Considerable attention has also been paid to the matter of spoil disposal. The system eventually most favoured has been to spread the material on adjacent land, and pay the farmers compensation for the loss of a season's production. Compensation for the loss of one season's cropping was set at Tk 15 000 per hectare, plus an additional Tk 1 000 per hectare for fertiliser for the next season. This approach appears preferable to acquiring land for spoil disposal, as it minimises both the loss of land for agriculture and the displacement of people. Consultations in the field suggested that although many people supported this approach, it was not universally acceptable, and the alternative of acquiring land for disposal was also costed. In practice, a mixture of the two approaches is likely. A separate item has also been included for the stripping, storage and replacement of topsoil in places where the spoil material is too sandy to be spread directly onto agricultural land.

69

I.3.3 Unit Rates

Unit rates were derived on the basis of the unit labour costs, materials costs and construction equipment charge rates presented in Tables I.3.1, I.3.2 and I.3.3 respectively. In each of the tables, rates and costs from various sources are compared, with the value adopted for the present analysis shown in the final column. Table I.3.4 presents the build-up of the rate for each item of work from the information in the preceding tables and assumptions about production rates etc. Table I.3.5 gives rates for the various sizes and types of gate used in the proposals.

The financial costs of land acquisition have been taken as Tk 500 000 per hectare for agricultural land (including a 50% premium on the value of typical registered transactions) and Tk 1 620 000 per hectare for homestead areas, including an allowance for replacement housing.

I.3.4 Calculation of Capital Costs

The capital costs were calculated for each intervention by applying the derived unit rates to the work quantities measured from drawings etc. In accordance with the FPCO Guidelines for Project Assessment, the following additions were made, to arrive at the total project cost:

- 15% of the total cost of work items, to cover unforeseen physical contingencies, and

- 12% of the total cost of work items plus physical contingencies to cover engineering services, made up as follows:

-	survey and investigation	2%
-	detailed design and preparation of tender documents	3%
-	supervision of construction	5%
-	administration costs	2%

I.3.5 Operation and Maintenance (O&M) Costs

Operation and maintenance costs have been assumed in accordance with the FPCO Guidelines for Project Assessment as follows:

Embankments	6%
Khal Excavation	6%
Irrigation and Drainage Structures and Bridges	3%
Bank Protection	10%
Pump Stations (Civil & Electrical & Mechanical Works)	2%
Buildings	6%
Vehicles	4%
Equipment	4%

TABLE I.3.1

Daily Labour Rates

Taka per 8 hour day

Type of Labour	BWDB Comilla 1992	BWDB Muhuri,Feni 1992	World Bank 1990	FAP8A 1991	FAP2 1992	FAP 21/22 1992	R & HD 1990	Adopted for Present Study
1 Foreman	–	–	–	225	170	190	–	225
2 Skilled labour	60	50	70	–	75	160	65	75
3 Common labour	45	40	60	80	55	70	50	60
4 Operator	60	65	–	270	85	170	–	100
5 Driver	60	65	–	150	85	220	–	125
6 Mechanic	–	100	–	210	100	–	–	125
7 Welder	–	90	–	200	85	–	–	125
8 Electrician	60	80	150	210	85	–	–	125
9 Concrete worker	–	–	–	120	75	–	–	75
10 Carpenter	70	80	130	175	110	–	110	100
11 Mason/Plasterer	70	100	130	175	110	–	110	100
12 Steel worker	75	80	–	145	110	–	–	100
13 Painter	70	85	130	140	110	–	110	110
14 Plumber	75	80	150	230	110	–	–	110
15 Pavement worker	–	–	–	130	110	–	110	110
16 Surveyor	55	70	–	260	115	–	–	170

Sources:

- Schedule of rates for Comilla O & M Circle (1992) and Muhuri O & M Circle(1992), BWDB.
- Schedule of rates for road & bridge works (R&HD, 1990)
- Schedule of rates prepared by World Bank resident mission in Bangladesh (Sept.'90).
- FAP 2 (1992), FAP 8A (1991), and average rate of FAP 21/22 (1992)

TABLE I.3.2

Unit Rates of Principal Construction Materials

Tk (including Taxes)

Item	Unit	Comilla 1992	R&HD 1990	World Bank 1991	Soiltech 1992	Engineers 1992	FAP 21/22 1992	Muhuri, Feni 1992	FAP8A 1991	FAP2 1992	Adopted for Present Study
1. Cement, aggregates & bricks											
Portland cement	kg	4.1	4.2	4.5	5.2	4.5	4.4	4.1	5.0	5.0	4.5
Sand	cu.m	450	450	390	450	550	235	550	500	450	450
Gravel / Boulder	cu.m	1,129	1,050	850	800	900	1,800	1,275	1,200	1,050	1,100
Stone Chips	cu.m	–	–	–	–	–	–	–	–	–	1,450
Bricks (Including carriage)	1000 Nr	2,300	2,100	2,400	2,500	2,600	2,100	2,200	3,100	2,100	2,200
Brick chips	cu.m	960	630	–	850	880	1,000	750	1,200	750	800
2. Steel materials											
Reinforcement bar (Torsteel)	ton	–	–	–	25,000	26,000	25,000	24,000	31,000	26,000	24,000
Reinforcement bar (round)	ton	23,400	24,500	24,000	20,000	23,000	20,000	25,000	–	26,000	23,400
Structural steel	ton	22,400	–	22,000	–	32,000	–	25,000	26,000	32,000	24,000
Steel sheet pile	ton	40,000	–	–	35,000	46,000	30,000	–	31,000	40,000	40,000
3. Concrete products											
R.C.pile (250mmx250mm)	lin.m	–	–	–	–	–	–	–	–	780	780
R.C.pile (300mmx300mm)	lin.m	–	–	–	–	–	–	–	–	1,040	1,040
R.C.pile (400mm dia.)	lin.m	–	–	–	–	–	–	–	–	–	1,500
4. Others											
Wooden pile (d=100mm)	lin.m	75	–	–	–	–	–	–	–	200	–
Timber (class–a)	cu.m	18,000	–	23,000	21,000	25,000	24,500	17,650	25,000	25,000	20,000
Timber (class–b)	cu.m	10,500	–	14,800	14,000	15,000	–	11,475	15,000	15,000	15,000
Wood for shuttering	cu.m	–	–	–	–	–	–	8,850	–	3,600	9,000
Sand bag	Nr	10	–	–	6	7	22	7	–	7	7
Bamboo	Nr	65	–	–	100	120	90	60	–	100	10
Gasoline	litre	–	–	–	15	15	16	–	15	15	15
Diesel oil	litre	–	–	–	14	14	15	–	14.5	14.5	15

Source:

- Schedule of rates for Comilla O&M Circle (1992) and Muhuri O&M Circle, Feni (1992), BWDB.
- Schedule of rates for road & bridge works (RHD, 1990)
- Schedule of rates prepared by WB resident mission in Bangladesh (Sept. 1991)
- FAP8A report (1991), FAP2, FAP 9A, FAP 21/22 reports (1992).

TABLE I.3.3

Unit Charge Rates for Construction Equipments

Equipment	Capacity	Capital cost at site (000 Tk)	Life year	Operation of equip. (hr/yr)	Operation of equip. (day/yr)	Depreciation (Tk/hr)	Maintenance & repair (%)	Maintenance & repair (Tk/hr)	Management (%)	Management (Tk/hr)	Total Cost (Tk/hr) Foreign Currency	Total Cost (Tk/hr) Local Currency	Total Cost (Tk/hr) Total (Tk./hr.)	FAP21/22 (Tk./hr.)	Adopted for Present Study (Tk./hr.)
Mini dredger 8"	65 m3/hr.	19 000	3	3 750	250	1 520	65	1 098	7	355	2 398	574	2 972	–	3 000
Bulldozer	11 t	4 748	6	975	150	730	65	528	7	341	1 153	446	1 599	562	1 600
Bulldozer	15 t	6 045	6	975	150	930	65	672	7	434	1 467	568	2 036	750	2 000
Bulldozer	21 t	9 389	6	975	150	1 444	65	1 043	7	674	2 279	883	3 162	1 125	3 200
Backhoe/Dragline	0.35 cu.m	3 627	5	1 365	210	478	50	266	7	186	691	239	930	750	1 000
Backhoe/Dragline	0.6 cu.m	5 991	5	1 365	210	790	50	439	7	307	1 141	395	1 536	875	1 600
Dump truck	11 t	4 251	4	1 365	210	701	60	467	10	311	1 074	405	1 479	500	1 500
Ordinary truck	6t	2 191	4	1 365	210	361	55	221	10	161	538	205	742	470	750
Compaction roller	10 t	3 013	6	975	150	464	50	258	7	216	670	268	937	1 500	950
Crawler crane	30 t	10 360	7	975	150	1 366	70	1 063	7	744	2 216	956	3 173	500	3 200
Truck crane	10 t	6 084	7	1 365	210	573	35	223	7	312	751	357	1 108	–	1 100
Crawler pile driver	35 t	20 567	5	1 365	210	2 712	50	1 507	7	1 055	3 918	1 356	5 274	–	5 300
Diesel pile hammer	3.5 t	3 740	4	975	150	863	60	575	7	269	1 323	384	1 707	–	1 700
Vibration hammer	30 kw	1 643	4	975	150	379	60	253	7	118	581	169	750	–	750
Water pump	200m3/hr	–	–	–	–	–	–	–	–	–	–	–	–	–	250
Submersible pump	4 in.	69	5	1 365	210	9	110	11	5	3	18	5	23	–	25
Vibration compactor	80 kg	65	3	1 365	210	14	45	7	5	2	20	4	24	–	25
Concrete mixer	0.5 cu.m	811	5	1 365	210	107	70	83	5	30	173	46	220	250	250
Concrete vibrator	45 mm	48	3	1 365	210	11	35	4	5	2	14	3	16	–	20
Diesel generator	125 kVA	1 531	6	1 365	210	168	35	65	5	56	221	69	290	375	300
Diesel generator	30 kVA	690	6	1 365	210	76	35	29	5	25	99	31	131	250	150

Note: –

1. Rates include depreciation, operation cost, fuel cost and taxes.
2. Data or Capital cost, Operation, Maintenance and Management from FAP 2 Final Report, (1992).

72

TABLE I.3.4

Unit Rates for Civil Engineering Construction

	Work Item	Remarks	Unit	LABOUR: Foreman		Mason/ Carpenter etc.		Skilled Labour		Common Labour		MATERIALS: Cement		Sand		Chips Tk 800/cum (Brick)		Shuttering	EQUIPMENT	UNIT COST
	Daily wages rates, unit rates (Refer to Table - 1.2)			Tk. 225/day		Tk. 100/day		Tk. 75/day		Tk. 60/day		Tk. 4.5/kg		Tk. 450/cum		Tk 1450/cum (Stone)			Operation Cost	
				Requirement per unit	Cost Tk./unit	Requirement per unit	Cost Tk./unit	Requirement per unit	Cost Tk./unit	Requirement per unit	Cost per unit	Requirement per unit (kg)	Cost Tk./unit	Requirement per unit (cum)	Cost Tk./unit	Requirement per unit (cum)	Cost Tk./unit		Tk./Unit	Tk.
1	Strip topsoil, store and respread	manual	ha	1/450	0.50					1/20	3.00									3.50
2	Channel excav. & spreading spoils (trans. L=50m)	manual	cu.m	1/225	1.00					1/2	30.00									31.00
3	Channel excavation (transport. L = 100m)	manual	cu.m	1/150	1.50					1/1.6	38.00									39.50
4	Channel excavation (transport. L = 50m)	manual (transport.)/ mecha. (excv.)	cu.m	1/450	0.50					1/5.5	11.00								dragline/ backhoe=37.00	48.50
	Channel excavation (transport. L = 100m)	manual (transport.)/ mecha. (excv.)	cu.m	1/225	1.00					3/10	18.00								bulldozer=37.00	56.00
6	Channel excavation (transport. L = 200m)	manual (transport.)/ mecha. (excv.)	cu.m	1/225	1.00					2/5	24.00								backhoe=37.00	62.00
7	Channel excavation (transport. L = 500m)	mechanical	cu.m	1/225	1.00					1/10	6.00								backhoe=37.00, dumptruck=92.00	136.00
8	Channel excavation (transport. L = 300m)	mini dredger	cu.m	1/450	0.50					1/20	3.00								dredger = 46.50	50.00
9	Channel excavation & formation of embankment.	mechanical excv./manual	cu.m	1/450	0.50					1/3	20.00								backhoe/ dragline=37.00	57.50
10	Channel excavation and formation of embankment	manual excv. /mechanical	cu.m	1/450	0.50					1/5	12.00								bulldozer=31.50	44.00
11	Construction of embkt. (excavation, compaction & shaping)	manual	cu.m	1/225	1.00					1/1.5	40.00									41.00
12	Embankment (compaction & shaping)	manual	cu.m	1/450	0.50					1/6	10.00									10.50
13	Embankment (compaction & shaping)	mechanical	cu.m	1/450	0.50					1/20	3.00								bulldozer=22.00	25.50
14	Turfing	manual	sq.m	1/450	0.50					1/20	3.00									3.50
15	Structural excavation (transport. L = 50m)	manual	cu.m	1/225	1.00			1/11	7.00	1/2	30.00									38.00
16	Structural excavation (transport. L = 100m)	manual	cu.m	1/225	1.00			1/11	7.00	1/1.8	33.50									41.50
17	Structural excavation (transport. L = 100m)	manual (transport.)/mecha.	cu.m	1/225	1.00					3/10	18.00								backhoe=37.00	56.00
18	Backfilling of structure by local earth	manual (filling)/mechanical	cu.m	1/450	0.50			1/45	2	1/10	6.00								comp.roller=19.00	27.50
19	Backfilling of structure by local earth	mechanical	cu.m	1/450	0.50					1/25	2.50								bulldozer=31.50	34.50
20	Dewatering	per pump with 100 nos. well point	day																	3600.00
21	Boulder dumping (300 mm min.) complete.		cu.m																	2250.00
22	Steel Sheet Pile (10 mm) installed		ton																	34000.00
23	Slope protection, concrete blocks, (1:3:6)	300x300x300, manual	cu.m	1/28	8.00	1/5	20.0	3.2	240.0			212	954.00	0.47	211.00	0.94 (Brick)	752.00	94.00	vibrator=9.0 mixer=114.0	2402.00
24	Bank Protection (Figure I.4.11) Complete	See Appendix I.XIII	m																	18000.00
25	Structural concrete (210 kg/sq.cm)	incl. scaffold, support & form	cu.m	1/28	8.00	1/5	20.0	3.5	263.0			397	1788.00	0.42	190.00	0.84 (Stone)	1218.00	165.00	vibrator=9.0 mixer=114.0	3775.00
26	Lean concrete (1:3:6)	manual	cu.m	1/38	6.00	1/6	16.0	3.2	240.0			212	954.00	0.47	211.00	0.94 (Brick)	752.00		vibrator=9.0 mixer=114.0	2302.00
27	Reinforcement bar (including fabrication)	manual	ton	4/3	300.00	8	800.0	10	750.0							rebar=24000.00				25850.00
28	Construction of Building	Complete	sq.m																	6500.00

Note: Labour and material requirements derived from BWDB Schedule of Rates for Comilla O&M Circle (1992) and Muhuri O&M Circle (1992)

B Tab13.4.wk1

TABLE I.3.5

Unit Rates for Gates

Item	Description	Unit	Unit rate Tk 000
1	2.8 m x 3.0 m balanced flap gate, embedded parts and hand hoist	Nr	160
2	3.0 m x 3.0 m unbalanced flap gate, embedded parts and hoist	Nr	160
3	3.0 m x 3.0 m balanced flap gate, embedded parts and hand hoist	Nr	183
4	1.5 m x 3.0 m slide gate with embedded parts and hand hoist	Nr	100

In addition to the percentage allowance for vehicles, running costs (driver, fuel, lubricants etc) of Tk 70 000 per vehicle per year have been allocated. The 1 Nr truck, 2 Nr pickups and 10 Nr motor cycles proposed for the project have been taken as equivalent to 7 Nr vehicles for purposes of running costs. O&M requirements generally are discussed in Chapter I.5 of this annex.

CHAPTER I.4

ENGINEERING PROPOSALS

I.4.1 Project Concept

The project has the twin objectives of alleviating the two most frequently articulated water related problems of the local population, namely:

- Congested drainage
- Shortage of water for irrigation

The project aims to achieve these objectives by improving the existing infrastructure of the Noakhali Comprehensive Drainage Project which was constructed in the early 1970s, and by substantially revising its function. The existing scheme consists of the 14 vent Rahmatkhali Regulator outfalling to the River Meghna, and the associated Rahmatkhali and WAPDA Khal drainage system extending eastwards as far as Noakhali Khal at Chaumuhoni, as shown in the Base Map (Figure I.4.1). It is understood that one of the principal intended functions of the regulator was the exclusion of saline Meghna water from the internal channel system, and there was no question originally of the admission of water for irrigation. As already discussed in Section I.1.4, the water quality in the Lower Meghna at the outfall has improved significantly in recent years, probably as a result of land accretion to the south and, far from wishing for it to be excluded, farmers are even now trying to make arrangements for water to be admitted for dry season irrigation.

It is therefore proposed both to improve the original drainage function and to introduce a surface water irrigation function through a major upgrading of the existing Rahmatkhali Regulator and khal network. Full use is to be made of the tidal range (up to about 2.3 m during February 1993), by means of automatic counterweighted flap gates, to expedite both the evacuation of drainage water in the monsoon season and the admission of irrigation water during the boro season.

The approach to project development is based on a number of concepts which have been kept in mind throughout the study. These concepts are as follows:

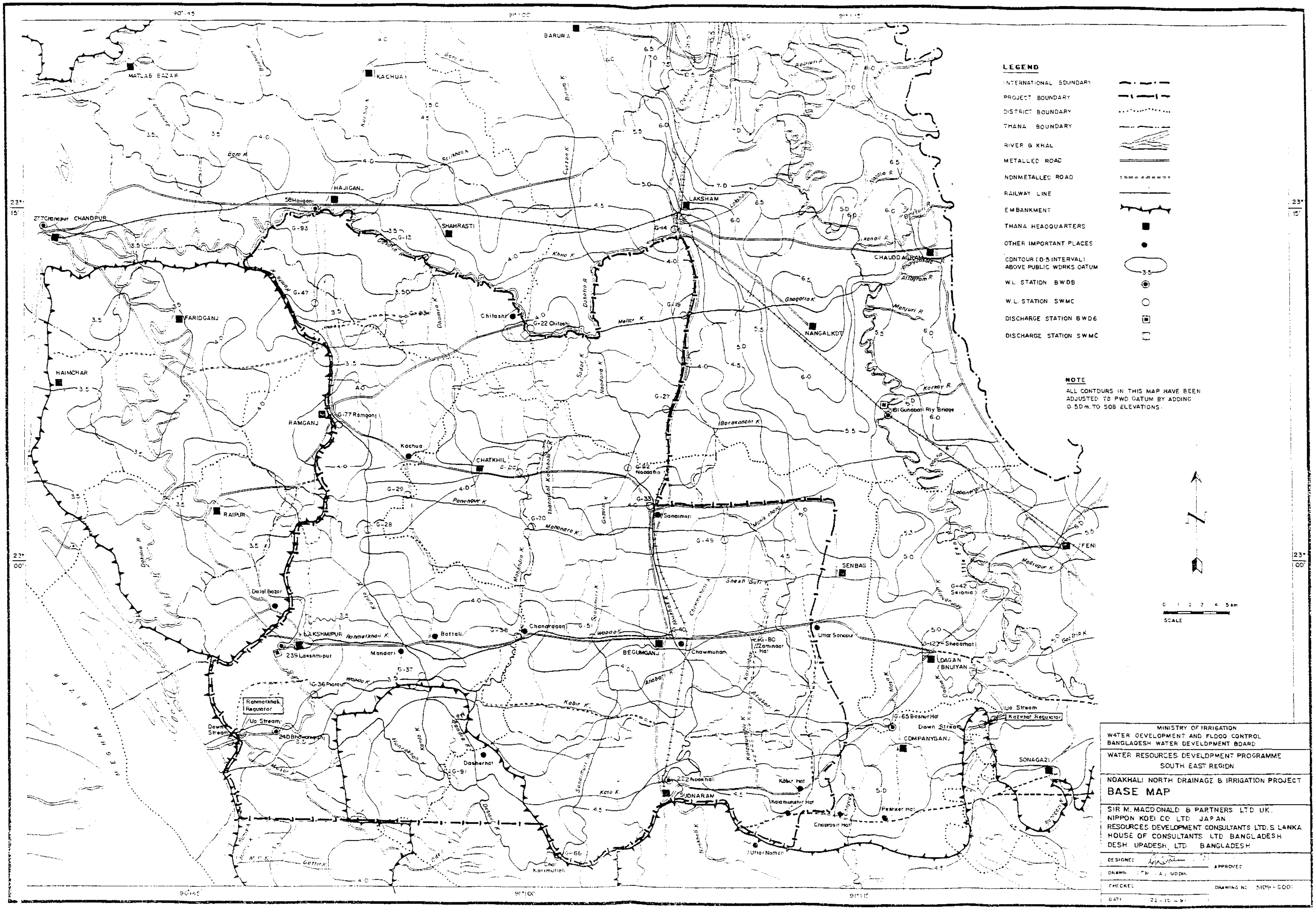
- the proposals should not create "insider/outsider" perceptions. In other words no one should feel excluded.

- the operation of the scheme should be as simple as possible with minimum interventions required by project staff for satisfactory functionality.

- following directly from above there should be the minimum number of structures which can be interfered with by vested interests.

- by making the same infrastructure serve both drainage and irrigation needs all zones of the project will receive some benefit and none will have reason to frustrate it.

Figure I.4.1



LEGEND
INTERNATIONAL BOUNDARY
PROJECT BOUNDARY
DISTRICT BOUNDARY
THANA BOUNDARY
RIVER & KHAL
METALLED ROAD
NONMETALLED ROAD
RAILWAY LINE
EMBANKMENT
THANA HEADQUARTERS
OTHER IMPORTANT PLACES
CONTOUR (0.5 INTERVAL) ABOVE PUBLIC WORKS DATUM
W.L. STATION BWDB
W.L. STATION SWMC
DISCHARGE STATION BWDB
DISCHARGE STATION SWMC
NOTE
ALL CONTOURS IN THIS MAP HAVE BEEN ADJUSTED TO PWD DATUM BY ADDING 0.50m. TO SOB ELEVATIONS.
SCALE
MATLAB BAZAR
KACHUA
BARURA
HAJIGANJ
LAKSHAM
CHANDPUR
SHAHRASTI
CHAUDDAGRAM
FARIDGANJ
NANGALKOT
HAIMCHAR
RAMGANJ
CHATKHIL
RAIPUR
SENBAG
FENI
LAKSHMIPUR
BEGUMGANJ
DAGAN BHUIYAN
COMPANYGANJ
SONAGAZI
SUDHARAM
MEGHNA RIVER
Rahmatkhali Regulator
Kazirhat Regulator
MINISTRY OF IRRIGATION
WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD
WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION
NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
BASE MAP
SIR M. MACDONALD & PARTNERS LTD UK.
NIPPON KOEI CO LTD JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. S LANKA
HOUSE OF CONSULTANTS LTD BANGLADESH
DESH UPADESH LTD BANGLADESH
DESIGNED
APPROVED
DRAWN
CHECKED
DRAWING No 5109-G001
DATE

- land acquisition should be kept to a minimum.

The first of these concepts requires the abandonment of the approach of complete protection by means of a full flood control polder. Instead, the project area is viewed as part of a sub-regional drainage scheme which has no fixed boundaries. The studies are aimed at proving that this concept can produce useful benefits at reasonable cost to produce a viable project. The possibility of turning part of the scheme into a polder was considered but it would require many additional structures requiring a very sophisticated level of management, and even more seriously could easily be frustrated by the local population who were on the "outside" of the polder. Therefore this approach was not pursued.

A further consequence of the approach outlined above is that it is not possible to design the project using conventional or traditional hydrological parameters because the project boundaries are unknown and the areas draining to each of the outlets varies during the season. It is therefore necessary to design the system using hydrodynamic modelling techniques. These techniques have been recently developed in Bangladesh to a degree of accuracy which now allows a reasonable evaluation of the Noakhali North project area by this method. As explained elsewhere the model can and should be progressively improved but its present accuracy in this area leads us to the view that it can be relied on sufficiently for feasibility study evaluation.

At the recently held "Third Conference on the Flood Action Plan" (Dhaka, May 17th-19th 1993) the consultants were asked why they had not considered compartmentalisation for this area. Apart from the fact that in this large area this would pose the same problems as the polder approach discussed above there is a more important factor. The flooding in this area is not caused by main river flooding. The principal cause is sub-regional (local) rainfall collecting at a faster rate than the drainage system can accommodate. Thus one cannot develop rules which allow exclusion of main river flows to protect prescribed areas and even less can one predict when such systems will need to be operated. The rainfalls have a much less regular pattern than main river levels. Compartmentalisation could interfere with the "natural" drainage system proposed and this is considered unsuitable in this particular situation. The project aims instead to remove large quantities of the stored rainfall from the area so that a substantial part of the resident population can once again practise monsoon season cultivation as they were able to do in the early 1960s and before.

I.4.2 Drainage

The first objective of improving the severe drainage congestion of the area must be dependent on utilisation of the low tide periods effectively since at high tides, unless preventive measures are taken, water will flow into the project area.

At the present time the existing infrastructure drains the area near the Rahmatkhali regulator very effectively (Zone A) but further away water levels gradually build up to levels which produce deep and prolonged flooding in what is commonly known as the Begumganj depression and further north.

In order to alleviate this situation a number of improvements are necessary as follows:

- Lower water levels at all points in the system (the project must not increase levels anywhere).

- to achieve this it is necessary to flatten gradients across the area. Since levels at the outfall are controlled by the tide, only small improvements at this location will be possible.

- to achieve flatter gradients it is necessary to have lower velocities in the main channels. This will also help in reducing erosion problems.

Therefore in selecting the design option great care has been taken to ensure that all three of these objectives are met. The only method which can achieve these objectives is a balanced improvement of the main structure and the main channels by increasing their capacity.

Local people have expressed a preference for deepening rather than widening the channels, and this has been done to the maximum extent possible since this also keeps land acquisition to a minimum. However it is important that the channels are kept to a minimum stable width to prevent erosion and meandering.

I.4.3 Irrigation

As discussed in Chapter I.2, there is very limited potential for groundwater development for irrigation in the project area and yet there is abundant evidence that there is a pent up demand for irrigation facilities. At the present time there are large areas already irrigating from sources which are extremely unreliable and although the year of survey (1992) showed good yields, there are reports of failures the previous year since in many areas farmers are still partially dependent on rainfall. Also the rates currently charged by LLP operators suggest a "scarcity premium" on water. Almost 75% of respondents to the pump operator survey complained of inadequate water supply as the limiting factor affecting cropping in the boro season. At public participation meetings irrigation was the most commonly mentioned "demand" of the people.

It was therefore, decided at an early stage of the studies that the project should incorporate proposals which could substantially increase the area of irrigation in the project area. As the studies progressed it became apparent that it was unlikely that taken separately either drainage or irrigation development of the existing system would prove economically viable. This leads to the inevitable conclusion that it is essential to develop an infrastructure which is truly dual purpose so that all the investment serves both irrigation and drainage objectives.

Thus the irrigation network is the khal system itself, which as it is enlarged provides better drainage and at the same time more storage for irrigation water.

In exactly the same way as low tides are used to achieve drainage in the monsoon season so high tides are used twice daily to recharge the khal system for irrigation, and the entire khal system acts as a night/tidal storage system. Once again for maximum effectiveness this requires automatic functioning of the control structure.

I.4.4 Selection of Recommended Option

The selection of the recommended option was based on a series of tests carried out on the hydrodynamic model as described in Annex B (Hydrology and Hydraulic Modelling). After preliminary runs aimed at identifying the impact of the major changes proposed, various tests were carried out to evaluate the influence of other possible interventions as follows:-

- the construction of a new regulator downstream of Kazirhat on the Little Feni River,
- the construction of a regulator on the Dakatia River upstream of Chabagadi Pump Station (Chandpur Irrigation Project),
- the effects of upstream projects, and
- the effect of a pump station at Rahmatkhali to supplement the inflow available under tidal influence.

None of these possibilities was found to have a significant effect on the expected benefits, since the changes in water levels at the critical points in the system were negligible. Thus the selected option is insensitive to outside influences as tested.

The option of an embankment on the South side of the Dakatia upstream of Chitoshi was abandoned once the early monsoon benefits of the proposed scheme were identified.

The general layout of the selected option is shown in Figure 1.4.2 and its principal features are described below.

1.4.5 Rahmatkhali Regulator

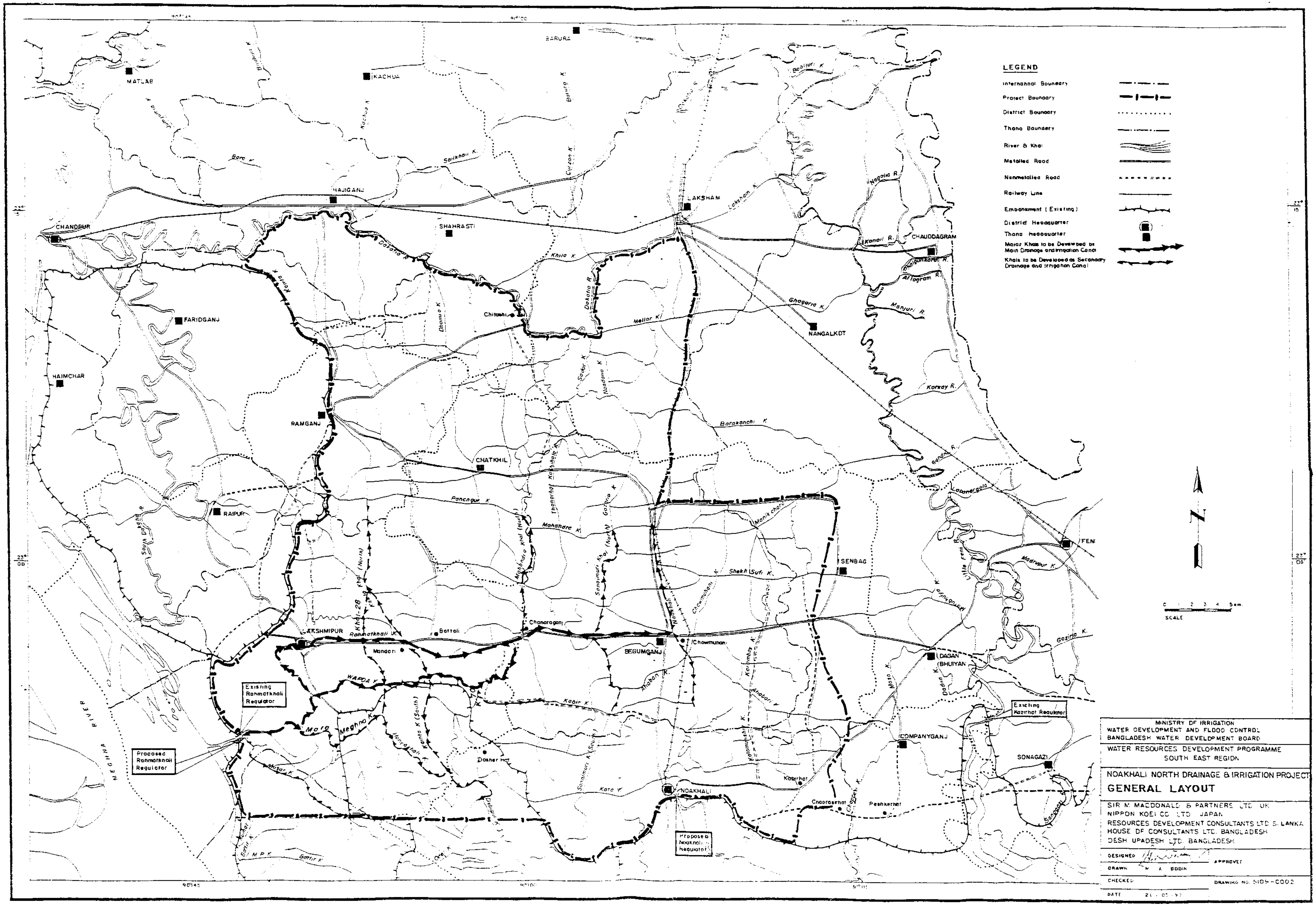
It had been widely supposed that the existing regulator was the currently limiting constraint to improved drainage. However, this has been shown not to be the case, and indeed the flooding patterns also confirm this. The existing regulator has been tested on the model in a number of configurations (various sill levels) to try to improve the hydraulics through the structure. Raising the sill also prevents excessive draw down upstream and therefore limits upstream velocities at low tide, and it achieves this without reducing the volumes of flow through the regulator and without increasing the peak water levels. This is achieved because weir flow conditions obtain for a larger proportion of time.

Having achieved this, the provision of an additional, parallel structure to increase discharges was tested in various combinations with increased khal sizes. All these options, assumed similar sized gates and the same sill levels as on the existing regulator. A refinement which could be tested at design stage would be to enlarge the gates on the new structure by deepening them by say 0.5 m and at the same time lowering the sill level below that of the existing structure. This could have the effect of reducing the maximum discharge through the existing structure whilst maintaining the total discharge capacity. This could further improve the hydraulics of the existing structure, improving energy dissipation in the stilling basin, which ideally should be lowered, but for practical reasons cannot be.

Both structures would take the form of dual opposed flap gated regulators, and would be operated in a similar manner. The upstream flaps would be hoisted clear in the monsoon season allowing the downstream flaps to operate as in a conventional flap-gated outfall regulator, whilst during the dry season the downstream flaps would be hoisted clear, allowing Meghna water to enter under tidal influence and be retained for irrigation by the upstream flaps. It is anticipated that for significant periods, perhaps from April to May/June, it should be

80

Figure I.4.2



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GENERAL LAYOUT

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possible to keep both sets of gates in the raised position without loss of benefit, allowing free access to fish etc and easy clearance of floating debris and water hyacinth.

The proposed site layout for the improved existing and new structures is given in Figure I.4.3. Details of the structures themselves are discussed in the sections which follow.

(i) Modifications to the Existing Rahmatkhali Regulator I

The existing regulator has 14 Nr 10 foot (3.05 m) square vents, fitted with heavy steel flap gates on the Meghna side and upstream facing sector gates on the country side. The proposed modifications to the structure are shown in Figures I.4.4 and I.4.5, and are outlined below:

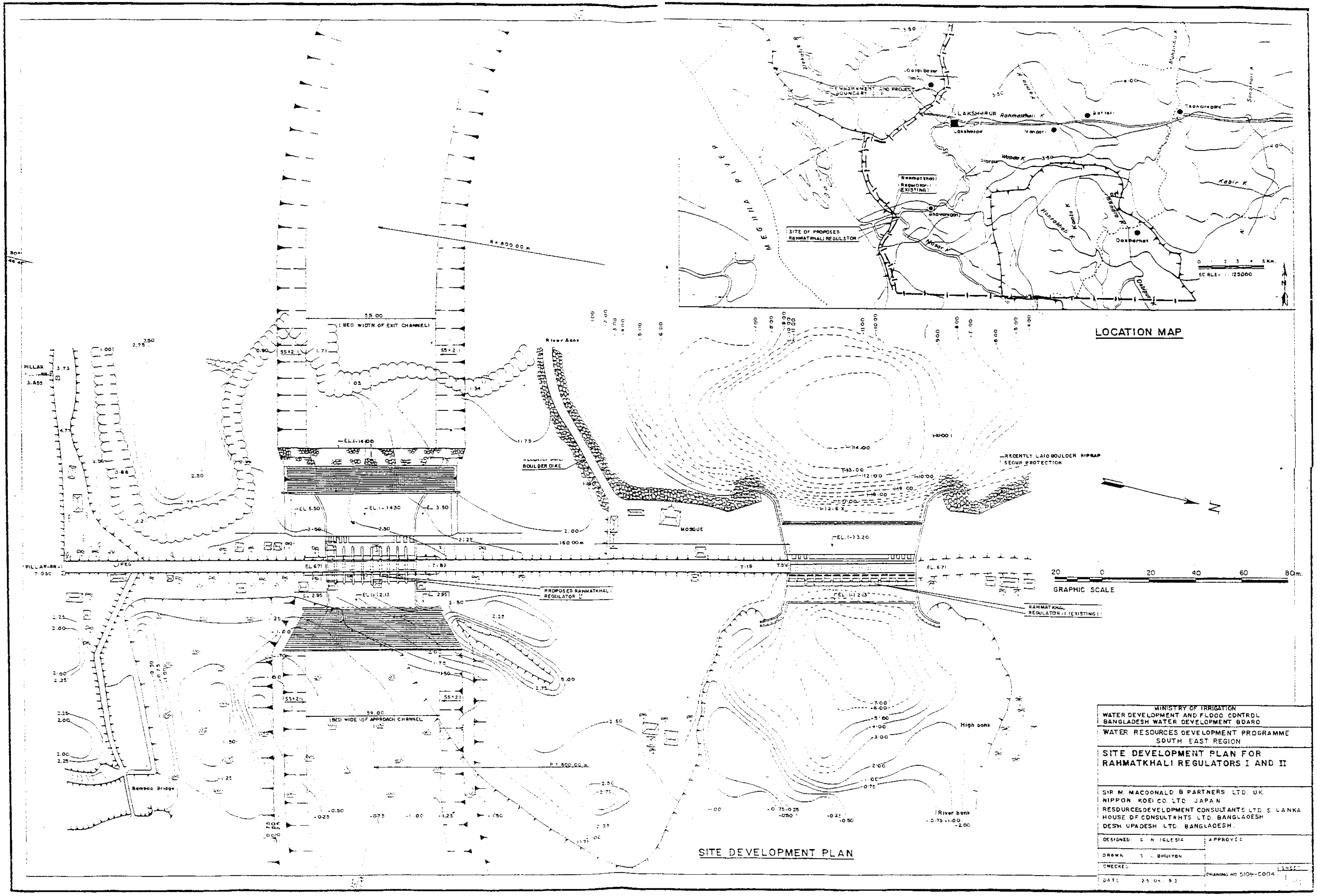
- (a) Raising the sill level of the existing structure by approximately 1.00 m.
- (b) Replacing the single hinged existing flap gates with double hinged flap gates and adding a simple hoist mechanism for raising the gates in the dry season. Although counterbalancing would have been desirable, this would have necessitated more radical alteration of the existing structure.
- (c) Replacement of the existing sector gates with counterweighted flap gates set to open inwards (towards the khal) to allow inflow at high-tides during the dry season and to close when inflow ceases.
- (d) Additional downstream (river side) protection works to the bed of the channel to reduce scour problems.

The 1993 site survey shows that a scour hole of about 150 m across and extending down to 14 m below PWD has formed on the Meghna side of the regulator. On the upstream side, a similar but smaller hole about 80 m across and down to 7 m below PWD has also formed. Both holes may be seen in Figure I.4.3. A downstream scour hole is to be expected, particularly since the existing regulator is known to be substantially overloaded, but the very large size of the hole is indicative of the high erodibility of the bed material. Problems may have been somewhat worsened through use of a restricted number of bays of the regulator, for instance because of the breakage of hoisting ropes. It is proposed to dump large boulders in this hole, immediately downstream of the remaining original concrete block protection, to form a stable slope of about 1 in 3.

The upstream scour hole may have been caused by existing informal arrangements for the admission of irrigation water, by removing or propping up a few of the flap gates to admit water at high tide; indeed, the orientation of the hole in Figure I.4.3 does suggest such a cause. In the with project condition some scour may continue to occur, but the discharge intensity will then be fairly low since all the vents will be operational, and no additional upstream protection is anticipated at this stage.

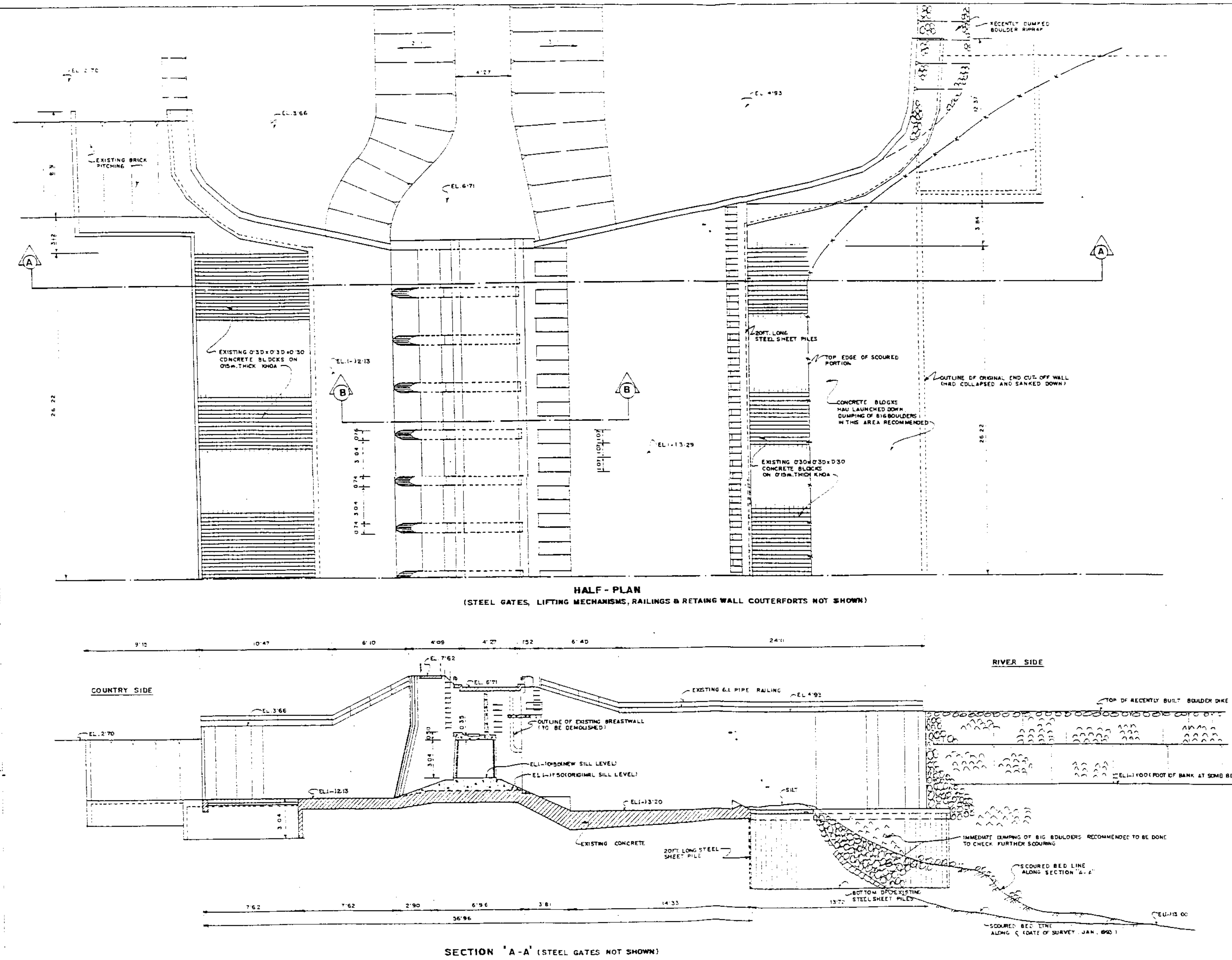
The existing sill of the regulator is being raised by about 1 m to elevation 0.5 below PWD, as discussed above. It is believed from the 1993 survey work that the existing regulator may have been constructed 0.14 m higher than indicated on the original design drawings, and the sill may thus need raising by correspondingly less in order to replicate the modelled configuration.

82 Figure I.4.3



83

Figure I.4.4



NOTES

1. ALL CONCRET SHALL BE CLASS 'A' UNLESS OTHERWISE SPECIFIED
2. ALL DIMENSIONS UNLESS OTHERWISE SHOWN, ARE IN METERS.
3. STRUCTURE LEVELS(EL.) ARE IN METERS (PWD) ADJUSTED IN - ACCORDANCE WITH 1993 SURVEY RESULTS (+ 0.14m)

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RAHMATKHALI REGULATOR I IMPROVEMENT PLAN AND SECTION.

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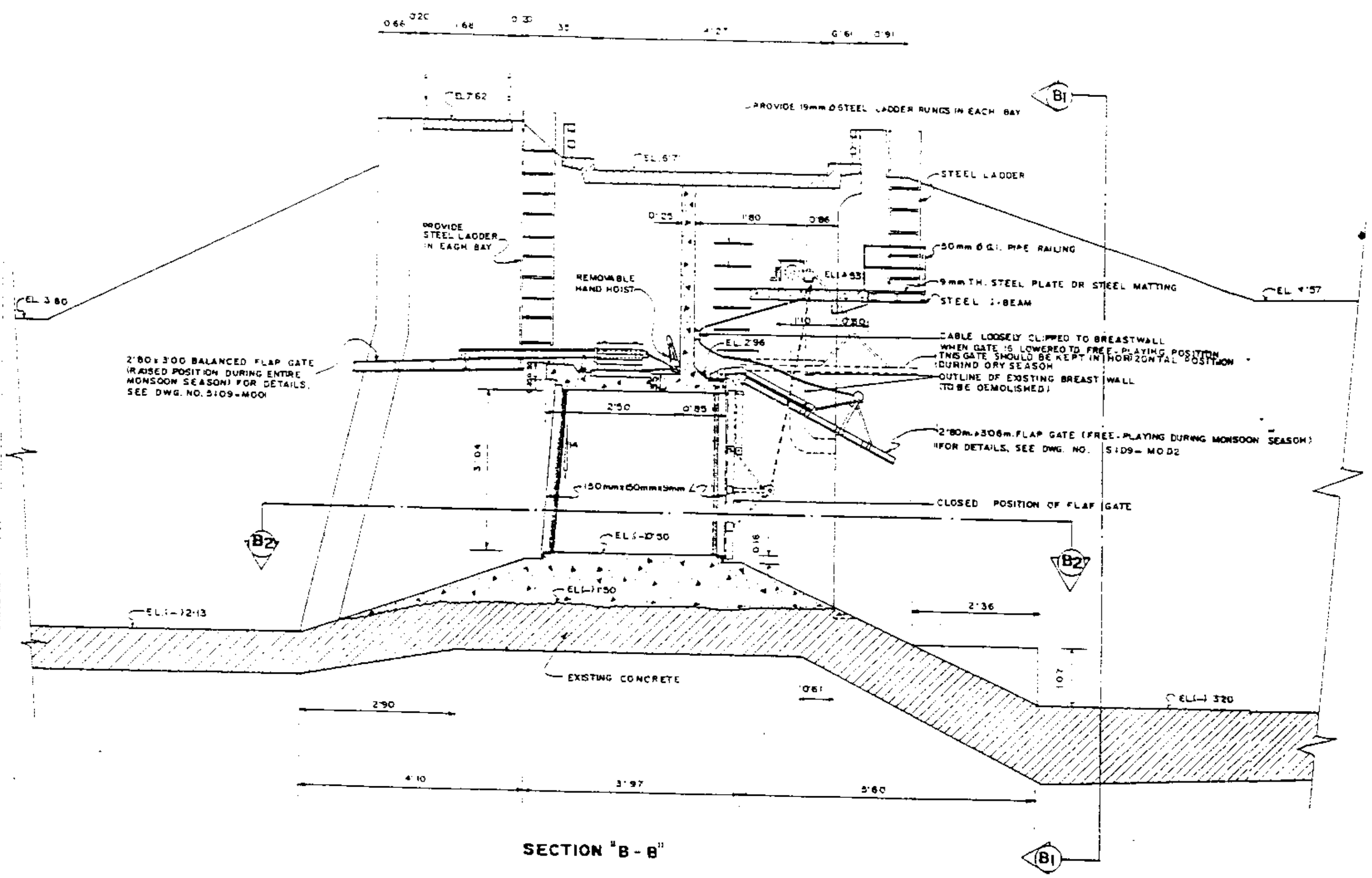
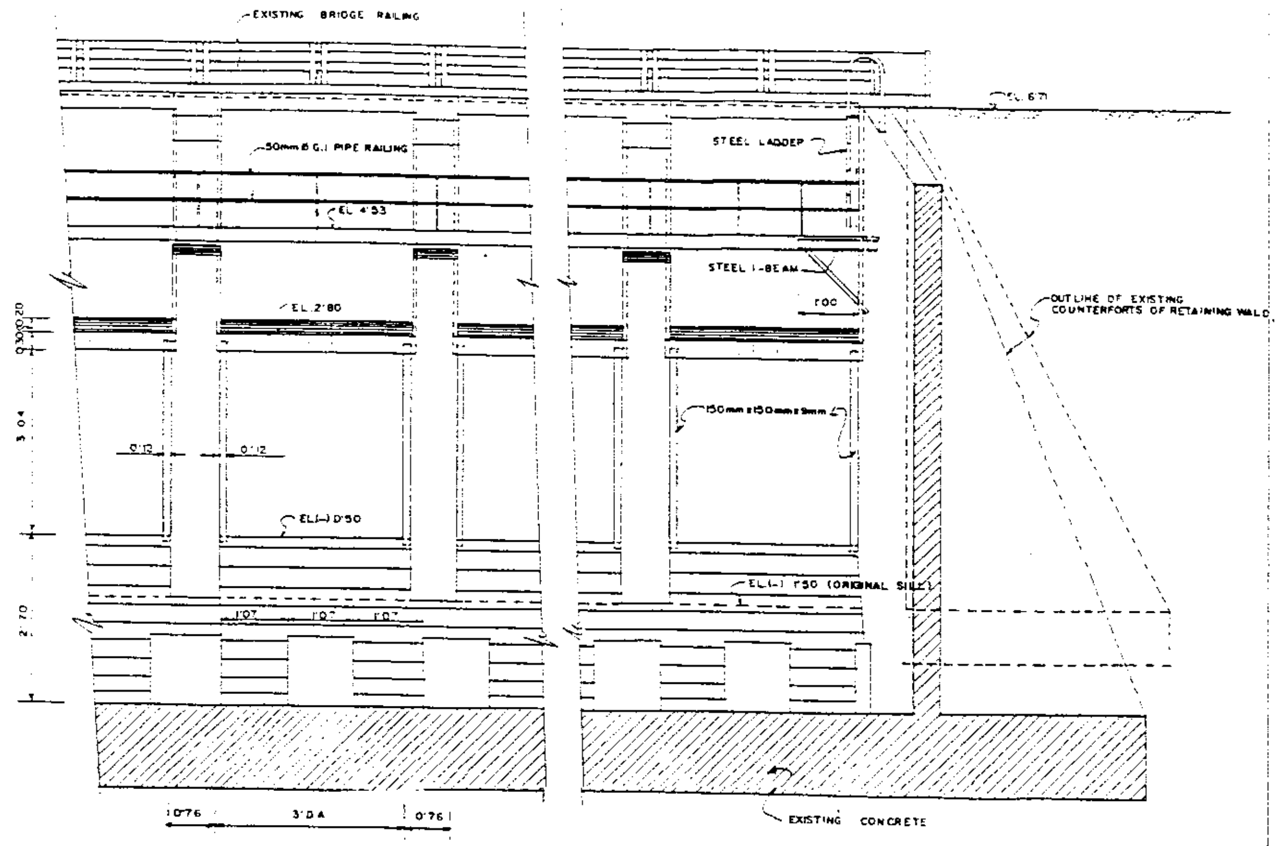
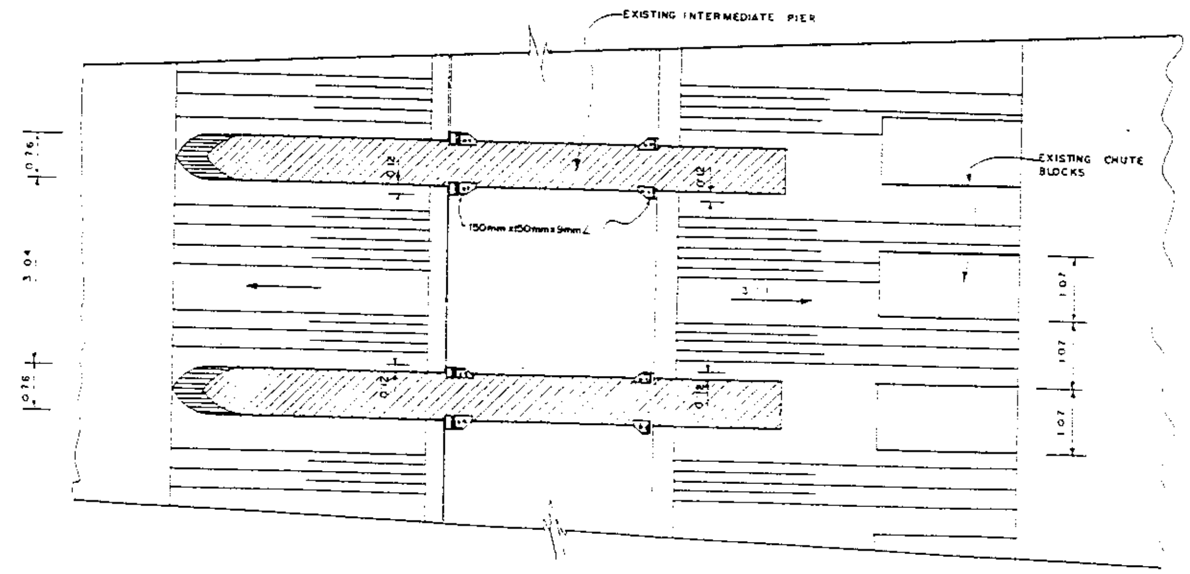
Figure I.4.5



SECTION "B - B"



SECTION "B1 - B1" (STEEL FLAP GATES NOT SHOWN)



SECTION 'B2 - B2'

NOTES

1. ALL CONCRETE SHALL BE CLASS 'A' UNLESS OTHERWISE SPECIFIED
2. ALL DIMENSIONS, UNLESS OTHERWISE SHOWN, ARE IN METERS
3. ALL ELEVATIONS (EL) ARE IN METERS (PWD)
4. ALL EXISTING RADIAL GATES AND FLAP GATES SHALL BE REMOVED AND REPLACED BY NEW BALANCED FLAP GATES AND UNBALANCED FLAP GATES AS SHOWN.

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SECTIONS AND DETAILS.

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The existing sector gates are reported to require 6 people to raise them by the hoisting mechanism available, whilst the downstream flap gates are badly rusted, and the single central pivot arrangement is subject to frequent failure. It is understood that the flap gates are currently in the process of being replaced, although the single pivot arrangement is being retained. If their condition permits, it may be possible to make economies by modifying them rather than again replacing them completely. The sector gates are to be replaced entirely by new counterweighted flap gates. Details of the proposed gates are given in Appendix I.XI to this annex.

(ii) The Proposed New Regulator II

Details of the proposed new regulator are given in Figures I.4.6 and I.4.7. It would be constructed along the alignment of the original khal, which was diverted when the existing regulator was commissioned. This regulator would have 10 Nr 3 m square vents, incorporating the following principal features:

(a) Sill level at the same level as the revised level of the existing structure.
(b) Double hinged counterweighted flap gates downstream (river side) for drainage.
(c) Similar double hinged counterweighted flap gates mounted in the reverse direction upstream (khal side) in exactly the same manner as described in (i) above for the existing regulator.

Notwithstanding (a) above, there may be some benefit, as discussed earlier, in lowering the sill of the new regulator.

The downstream stilling basin floor of the new regulator is dropped down to 4.5 m below PWD in order to achieve a Froude Number approaching 4.5, which is considered to produce a steady hydraulic jump. The basin flares at the downstream end to give an exit velocity not exceeding 1.2 m/s. Downstream of the stilling basin, flexible protection is provided in the form of a 12 m length of concrete block protection followed by a 10 m length of boulder filled gabion mattressing. The latter should be able to accommodate itself to any scour hole which may form, without losing its integrity or effectiveness. An 18 m length of concrete block protection alone is provided at the upstream end.

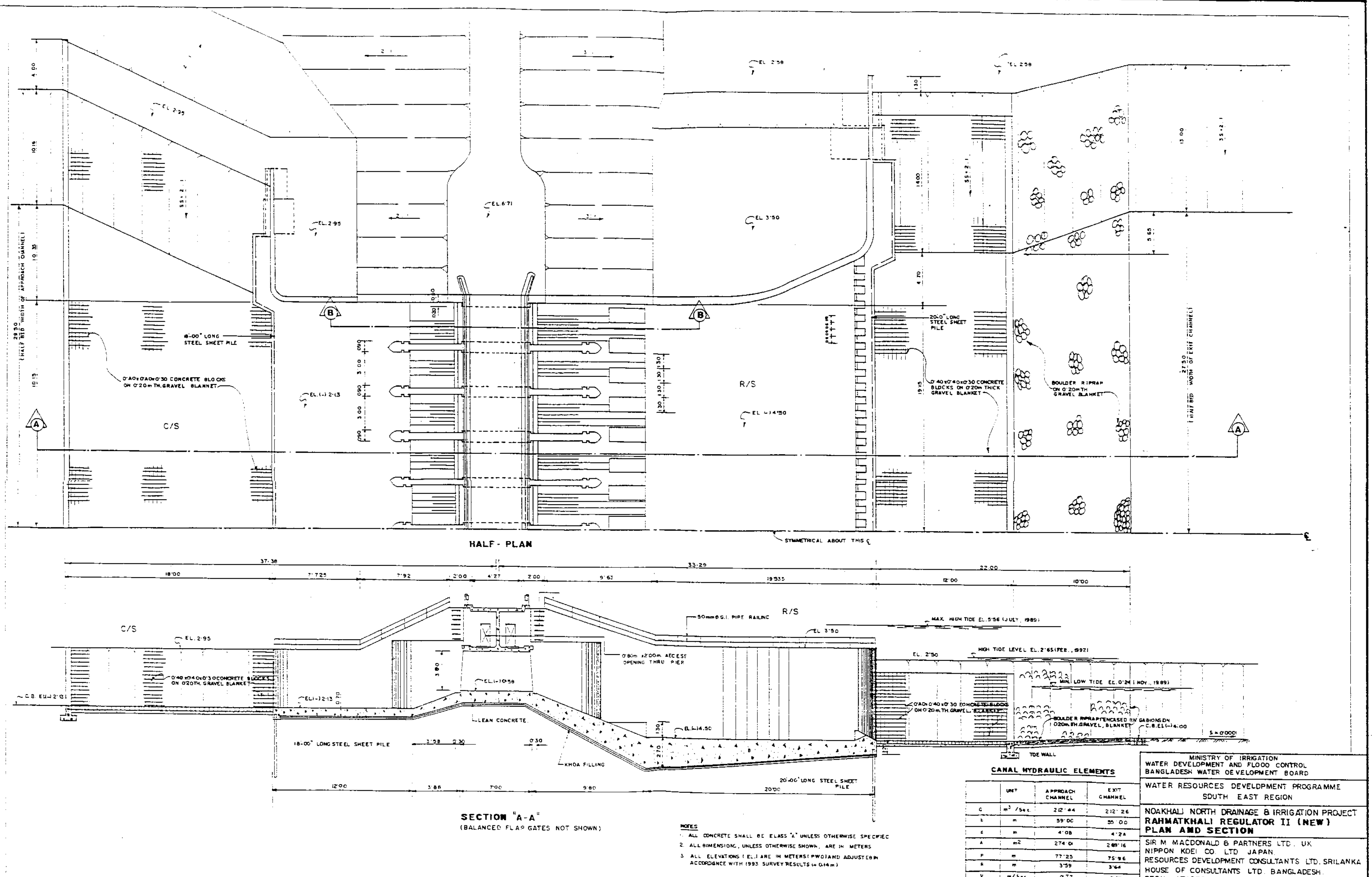
The depth of the upstream and downstream sheet pile cut-offs was determined using Lacey's scour depth formula, applying safety factors of 1.5 and 1.25 at the downstream and upstream ends respectively. Floor thicknesses were determined by finding the uplift pressures from both Khosla's Method of Independent Variables and Lane's Weighted Creep theory, and designing against the greater of the two results.

Again, details of the proposed gates are given in Appendix I.XI to this annex.

Problems are frequently encountered at outfall regulators in Bangladesh with a build-up of water hyacinth and other floating debris on the upstream side, and measures for dealing with it are necessary. It is particularly important that debris does not enter the vents of the structure during the monsoon season (which it may well do when the upstream flap gates are hoisted clear of the water) and then interfere with the closure of the downstream flaps when the tide rises. One possible solution would be the use of floating booms held at a distance from the upstream pier ends by hinged stays about 4 m in length. Two or three of the gates could be designated for the flushing of debris, and the booms removed periodically, after manually raising the downstream flaps under conditions of lower downstream water level. Floating debris may then be guided to

86

Figure I.4.6



CANAL HYDRAULIC ELEMENTS

	UNIT	APPROACH CHANNEL	EXIT CHANNEL
Q	m³/Sec.	212·44	212·26
b	m	59·00	55·00
d	m	4·08	4·24
A	m²	274·01	269·16
P	m	77·25	75·96
R	m	3·59	3·64
V	m/Sec.	0·77	0·79
SS		2:1	2:1
n		0·03	0·03
S		0·0001	0·0001
DESIGN W.S. EL	m, PWD	1·95	0·24
C.B. EL	m, PWD	(-) 2·13	(-) 4·00

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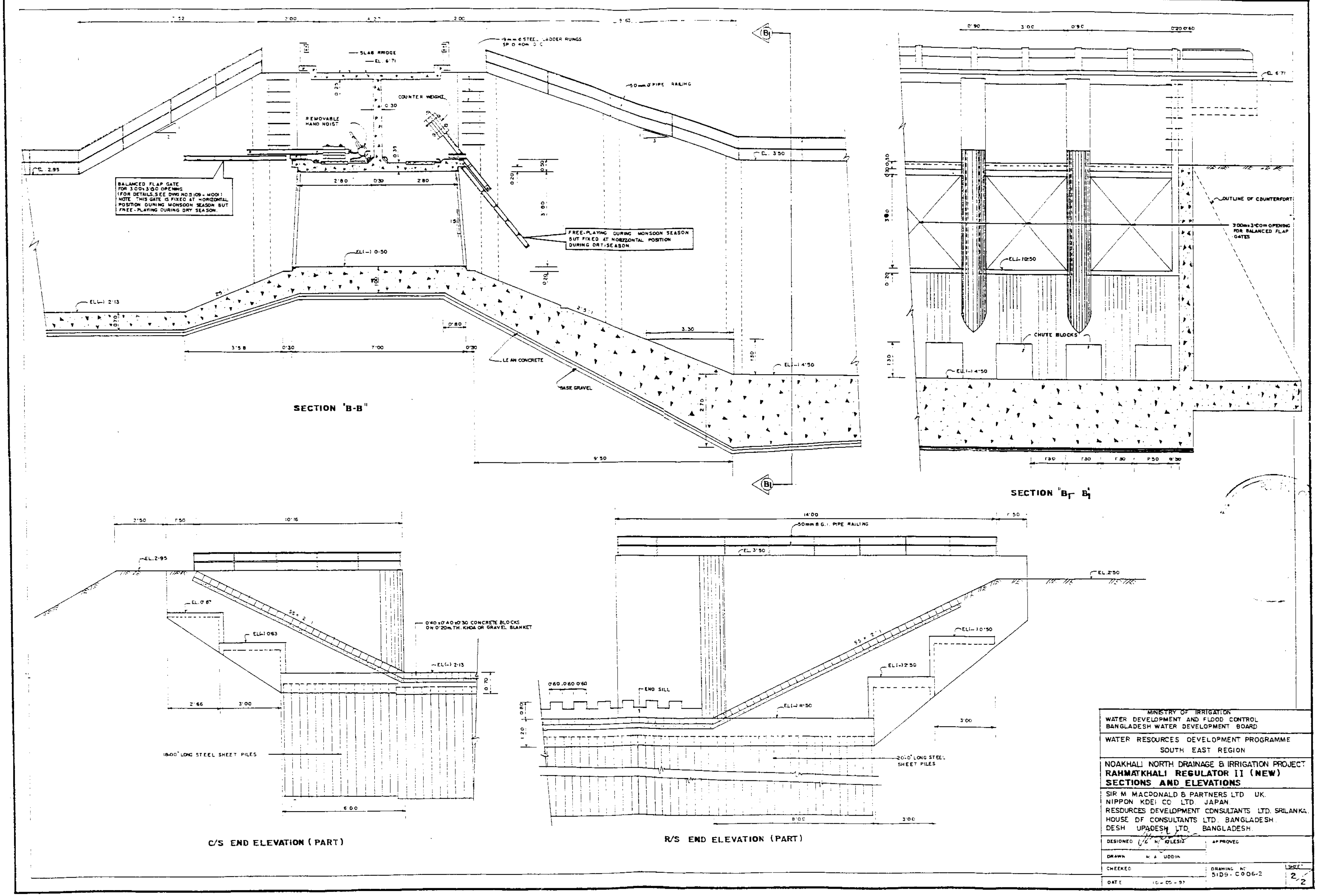
Figure I.4.7



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these vents and float cleanly through the structure without any obstruction. It may be desirable to instal a floating boom upstream of the modified existing regulator to divert all debris to the new regulator, since the procedure described above would be much more difficult to carry out in the absence of counterbalancing to the downstream flap gates.

I.4.6 The WAPDA and Rahmatkhali Khals

As already discussed, it is the khal system which presently limits the drainage capacity from the project area. The without project water profiles and the seasonal build up of water levels suggest that this limitation applies throughout the monsoon season and not only at peak storm periods, which is why the peak water levels occur much later than the peak rainfall periods. The approach to khal improvement was to test various sizes of channel, gradually increasing the dimensions and plotting the improvements in water levels achieved for the design year (1983). This design year was selected from the results of the "without project" 25 year simulation run as it gave close to 1 in 5 year conditions for almost all flood durations at a selection of locations throughout the project area.

The first enlargement tested utilized the existing top width and maximum channel depths as far as possible except in a 10 km reach at the upstream and of WAPDA Khal where the existing channel is seen to be very small; here some widening was incorporated even in this first option. Successive widening of the channel was considered in combination with some further deepening until sharply diminishing returns in terms of improved (lower) peak water levels were seen. A fuller discussion is presented in Annex B (Hydrology and Hydraulic Modelling).

The recommended option involves substantially less widening compared with that foreseen at the time of the pre-feasibility study. This has been achieved by some further deepening at the downstream end of WAPDA and Rahmatkhali Khals. It is also a reflection of the more accurate analysis possible with a calibrated tidal model.

The principal features of the proposed works are:

(a) Widening and deepening WAPDA Khal
(b) Deepening Rahmatkhali Khal within the width of its existing section and embankments (where present).
(c) Bed protection to and modification of existing bridges as necessary to accommodate the enlarged channel sections.
(d) Some loop-cuts to straighten out the khal alignment where possible.
(e) Where loop-cuts would be very difficult or expensive, proposals for a total of 1 850 m of bank protection works are incorporated to prevent erosion on the outside of sharp bends.

The selected design option sections provide both flatter water gradients and slower channel velocities when compared with the existing channels, even though discharges are greatly increased. The maximum hourly velocity identified at peak 1 in 5 year discharges anywhere in the system is approximately 0.80 m/s. This may be compared with velocities of upto 1.25 m/s at various points of the existing system. The combination of reduced velocities, loop-cutting and bank protection are designed to eliminate the current erosion/ bank stability problems. The proposed realignment/loop-cuts on WAPDA Khal and the downstream portion of Rahmatkhali

Khal are shown in Figures I.4.8 to I.4.10. No such works are anticipated on the remainder of Rahmatkhali Khal. The complete longitudinal profiles for the two channels are presented in Appendix I.XII to this annex.

Bank protection has been costed on the basis of concrete cubes laid on a bed of crushed brick (khoa), with a geotextile filter beneath, as shown in Figure I.4.11. An alternative arrangement which might also be considered at the detailed design stage is the provision of brick-filled gabion mattressing, also placed on a crushed brick and geotextile filter layer.

It should be noted that in the interpretation of modelling results and the presentation of channel longitudinal profiles and cross-sections, for consistency with the chainage system incorporated in the South East Regional Model (SERM) by the SWMC, Rahmatkhali Khal has been taken as extending from the River Meghna downstream of Rahmatkhali Regulator via Lakshmipur all the way to the junction with Noakhali Khal at Begumganj. The name 'WAPDA Khal' has thus been used solely for the reach parallel to Rahmatkhali Khal west of Chandraganj (see Figure I.4.2). Elsewhere in this report the more conventional terminology has been used, with the head of Rahmatkhali Khal at Chandraganj, and the reach from Chandraganj to Noakhali Khal regarded as the upstream reach of WAPDA Khal.

I.4.7 Secondary Khals

The WAPDA and Rahmatkhali Khals provide the main drainage routes to the downstream control structure. In order for the drainage flows to reach these khals there is a need for a secondary feeder khal system. This system already exists but is often substantially silted. This is often because excavated material has been piled immediately next to the top of the bank with the result that it is washed back into the channel during the monsoon. Many complaints were heard in the field concerning bank instability, although it appears that problems are often due to attempts to raise road embankments beside the khals using excavated material, without taking more agricultural land; inevitably, side slopes become steeper and collapse occurs. Over the years the policy has been to use a design bed level of about +0.91 m PWD (+3.00 ft PWD), which is generally too shallow for the admission of tidal water.

The extensive data collected from the topographic surveys carried out for the study were reviewed and it was observed that the principal secondary khals (including Kamta, Mohendra, Sonaimuri and Noakhali) usually had top widths close to or more than 20 m. It is also apparent that the natural side slopes are about 1:2 or steeper. As discussed in Section I.1.5, it is known that many of the soils are very sandy, and for this study a 1:2 side slope has been used to ensure stability with the increased depths proposed, compared with the general practice of the BWDB of using side slopes of 2:3.

The ground levels in the area suggest that if top widths of 17-20 m are used then a bed level of -0.50 m could be achieved with 1:2 side slopes and a minimum bed width of 1.0 m. This section was chosen to test both drainage and irrigation conditions. For drainage conditions the bed levels and widths are not critical but for irrigation it was perceived that the maximum depth possible should be obtained. In both cases the overriding consideration was to ensure that the section could be accommodated with minimal land acquisition. The analysis of the surveyed sections suggest that less than 1 ha of land acquisition would be required for the 114 km of secondary khal proposed for deepening in the selected option.

Figure I.4.8

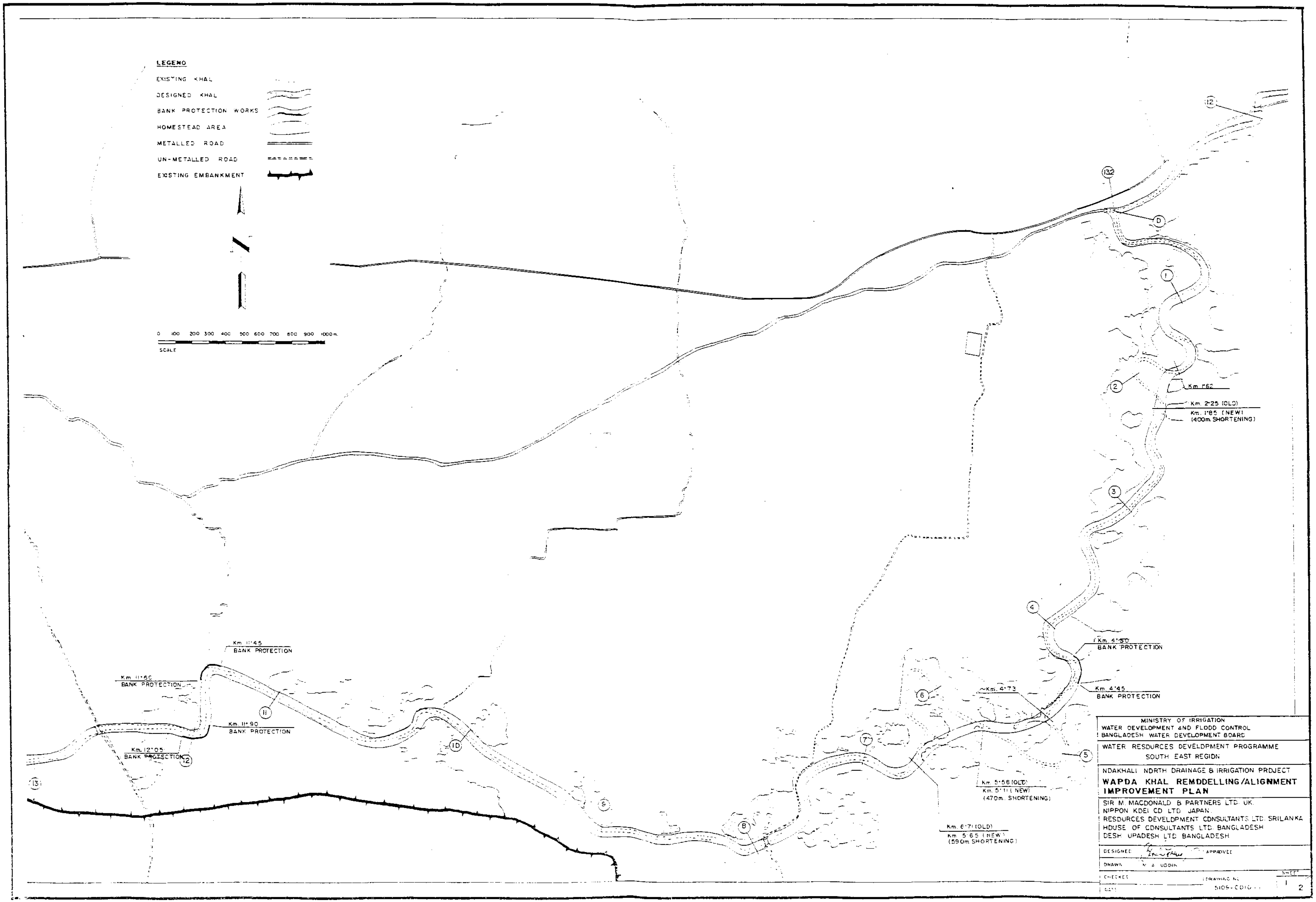
LEGEND
EXISTING KHAL
DESIGNED KHAL
BANK PROTECTION WORKS
HOMESTEAD AREA
METALLED ROAD
UN-METALLED ROAD
EXISTING EMBANKMENT
0 100 200 300 400 500 600 700 800 900 1000m.
SCALE
Km. 1·62
Km. 2·25 (OLD)
Km. 1·85 (NEW)
(400m SHORTENING)
Km. 4·50
BANK PROTECTION
Km. 4·45
BANK PROTECTION
Km. 4·73
Km. 5·58 (OLD)
Km. 5·11 (NEW)
(470m. SHORTENING)
Km. 6·71 (OLD)
Km. 5·65 (NEW)
(590m SHORTENING)
Km. 11·45
BANK PROTECTION
Km. 11·60
BANK PROTECTION
Km. 11·90
BANK PROTECTION
Km. 12·05
BANK PROTECTION
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Figure I.4.9

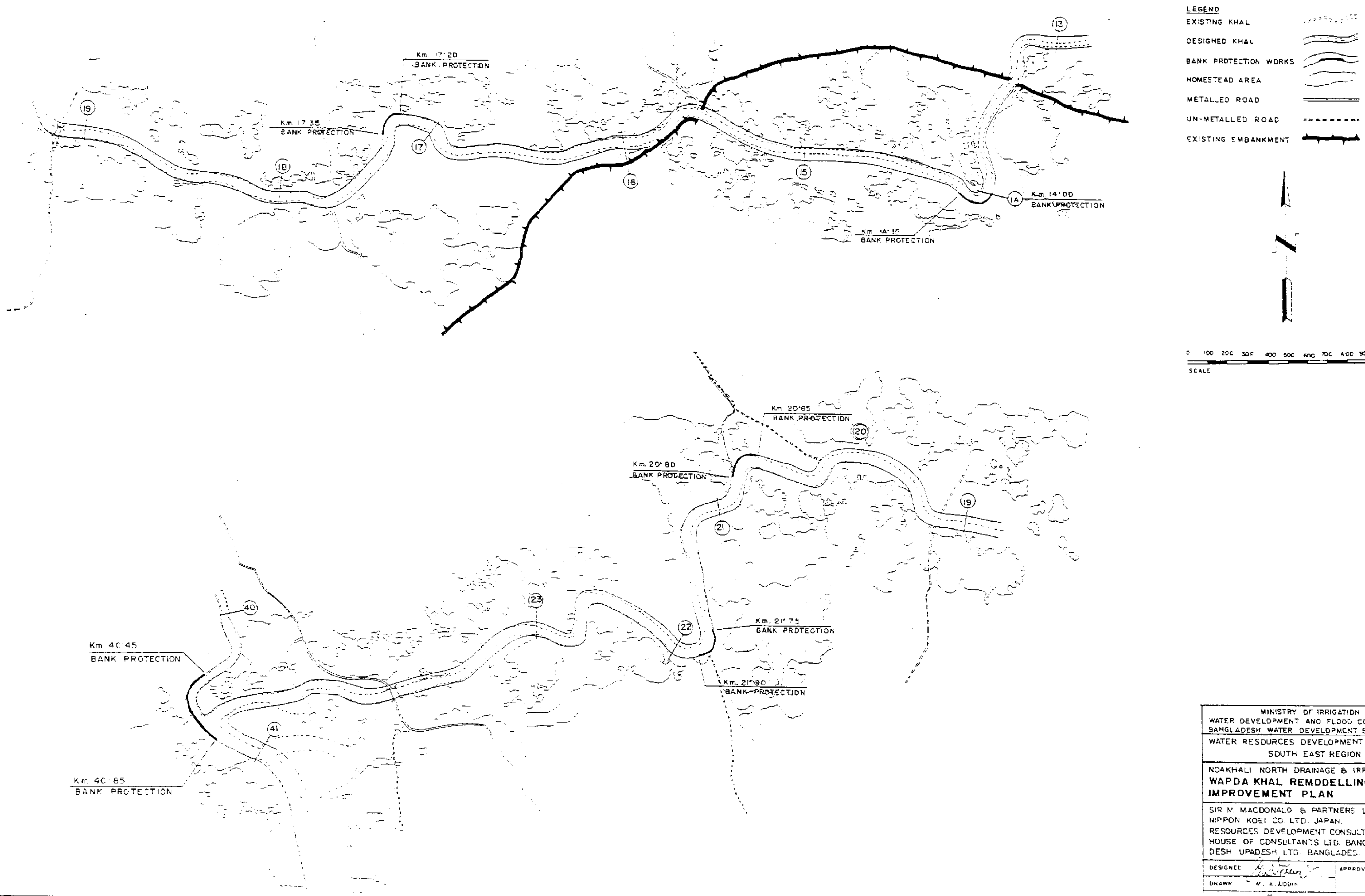

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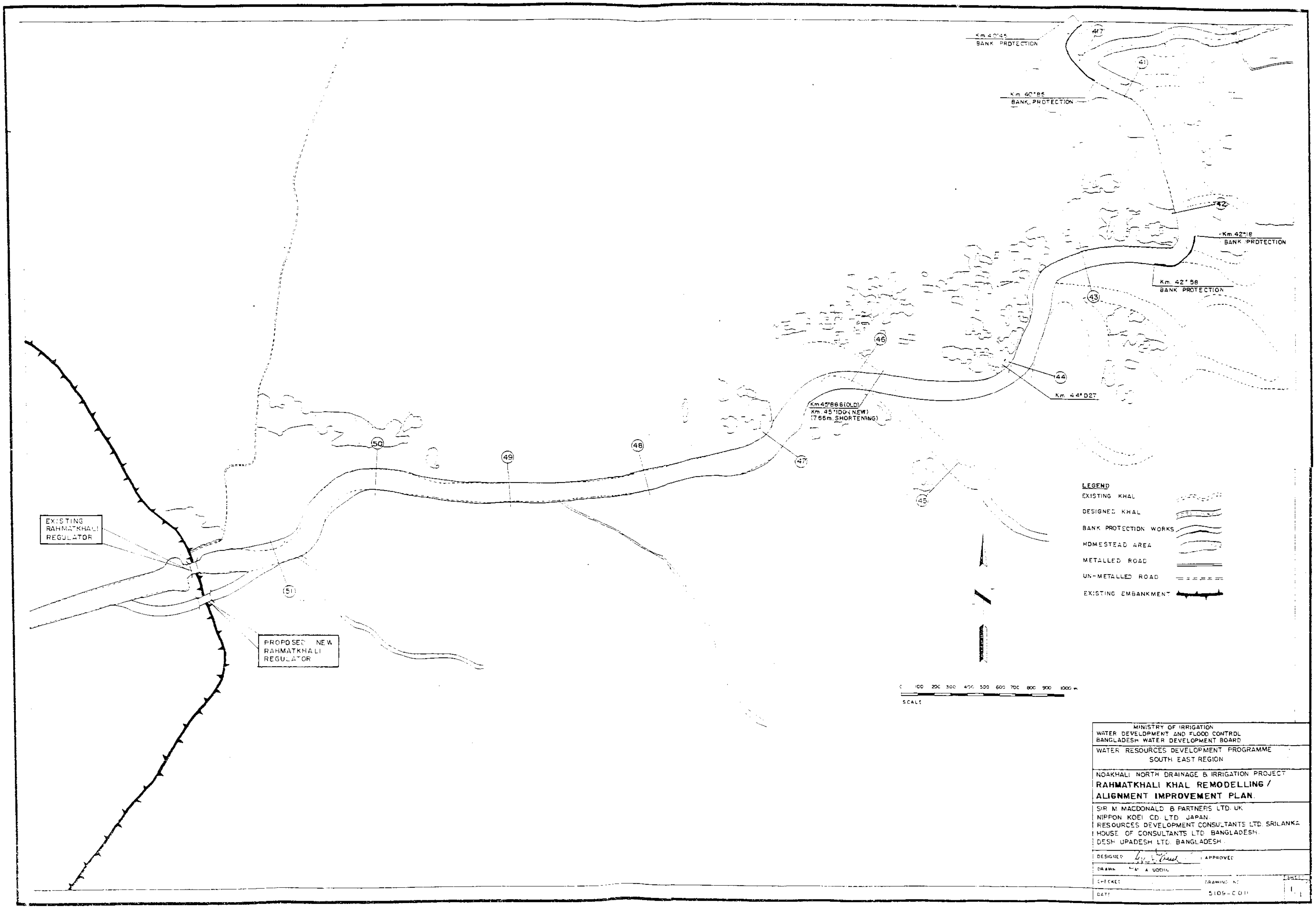
Figure I.4.10



Km 40+45
BANK PROTECTION
Km 40+85
BANK PROTECTION
Km 42+18
BANK PROTECTION
Km 42+58
BANK PROTECTION
Km 44+027
Km 45+866 (OLD)
Km 45+100 (NEW)
(766m SHORTENING)
EXISTING RAHMATKHALI REGULATOR
PROPOSED NEW RAHMATKHALI REGULATOR
41
42
43
44
45
46
47
48
49
50
51
LEGEND
EXISTING KHAL
DESIGNED KHAL
BANK PROTECTION WORKS
HOMESTEAD AREA
METALLED ROAD
UN-METALLED ROAD
EXISTING EMBANKMENT
0 100 200 300 400 500 600 700 800 900 1000 m
SCALE
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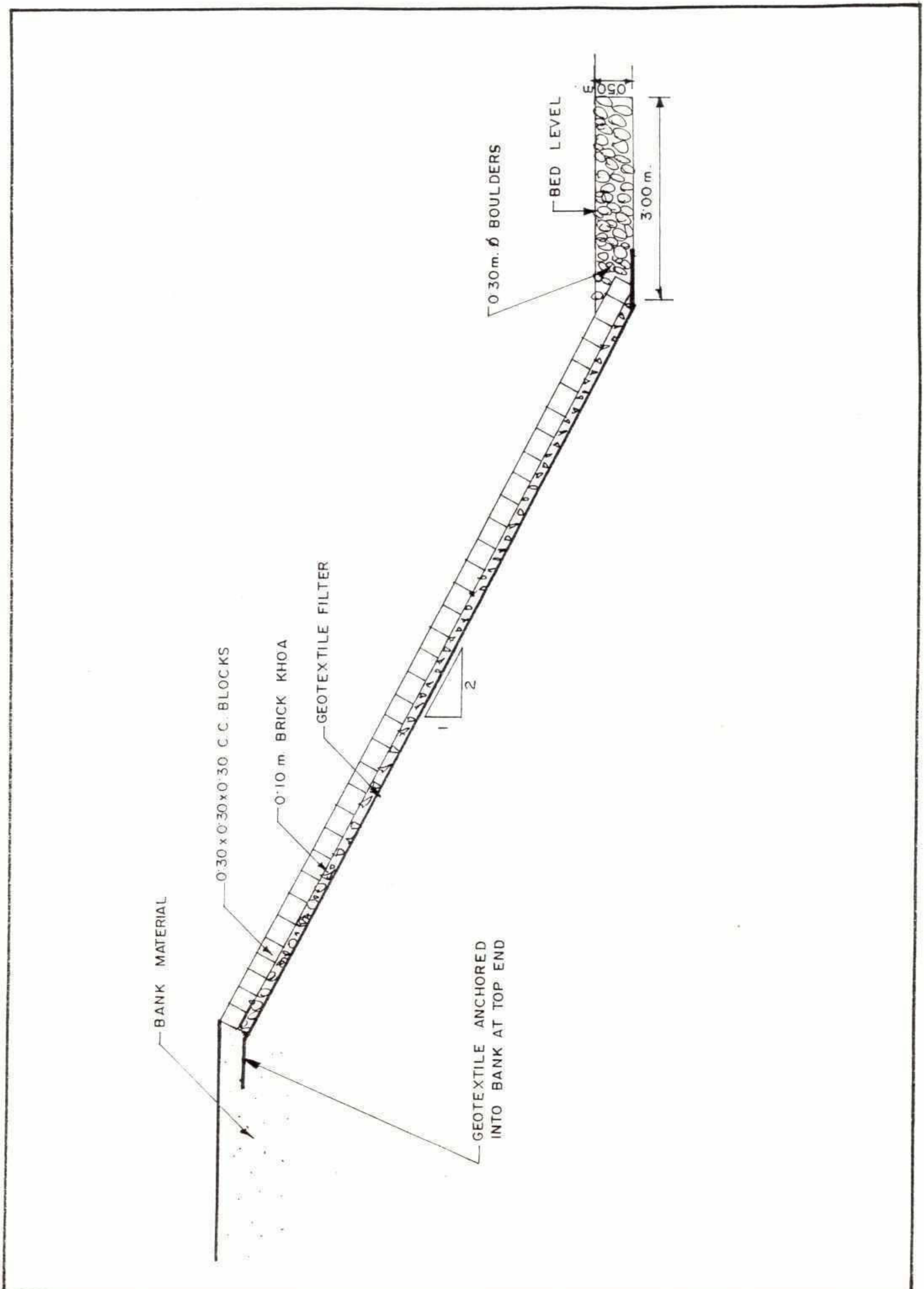
Figure I.4.11

Typical Detail of Bank Protection



The longitudinal profiles for the khals proposed for excavation are presented in Appendix I.XII to this annex.

I.4.8 Other Works

(a) Noakhali Regulator

A four vent regulator with vertical lifting gates is proposed for Noakhali Khal at the point where it flows through the old coastal embankment. The proposed structure is shown in Figure I.4.12. It is to be located approximately at the point where Noakhali Khal passes through the old coastal embankment, as shown in Figure I.4.1, and would be tied into that embankment. There is a newly constructed bridge at this point, and the possibility of effecting economies by incorporating the regulator with that could be investigated at the detailed design stage. It is intended that during the monsoon season the regulator should be kept open (May to October) to allow free drainage from the project area as required (subject to the limitations of downstream channel siltation as discussed in Section I.1.3.2 above). The regulator's designed capacity is similar to the maximum simulated values from the hydrodynamic model results so that drainage will be unaffected. However it is proposed that during the dry season the gates are closed to prevent ingress of saline water during peak high tides. This will ensure that the irrigation water in the khals remains fresh and it will also remove the need for construction of cross dams as occurs at the present time. These are constructed too late to be totally effective since saline water apparently enters the system before they are completed.

(b) Modifications to Existing Bridges

The proposed khal excavation will necessitate modifications to many of the existing bridges, because of either inadequate span or depth of foundation. As already discussed in Section I.1.6.1, information on foundations is unavailable in most cases but, from field investigation and local enquiry, it has been found that pile cap tops are generally 1.5 m to 1.8 m below the existing channel bed. Where wooden piles have been used, these are typically 4.5 m long and RCC piles 7.5 m long. Foundations to trussed pier type bridges are generally at 4.5 m below existing bed level. On the basis of information which could be gleaned, provisional proposals have been made for the required works, as indicated in Appendix I.VIII to this annex. These works fall into the following categories:

- scour protection to piers/abutments. Where the foundations will not be exposed by the excavation itself, but the pile cap, especially of timber piled bridges, could be undermined by scour, brick mattress scour protection is proposed. A typical detail is included in Figure I.XII.3 in Appendix I.XII to this annex,.

- deepening of pier foundations on multi-span bridges. Where pier pile caps would be exposed by the proposed excavation, the deck is to be propped and the pier demolished and reconstructed with a deeper foundation,

- provision of additional spans. In some cases on Rahmatkhali and WAPDA Khals, additional spans are required to accommodate the widened channel, and

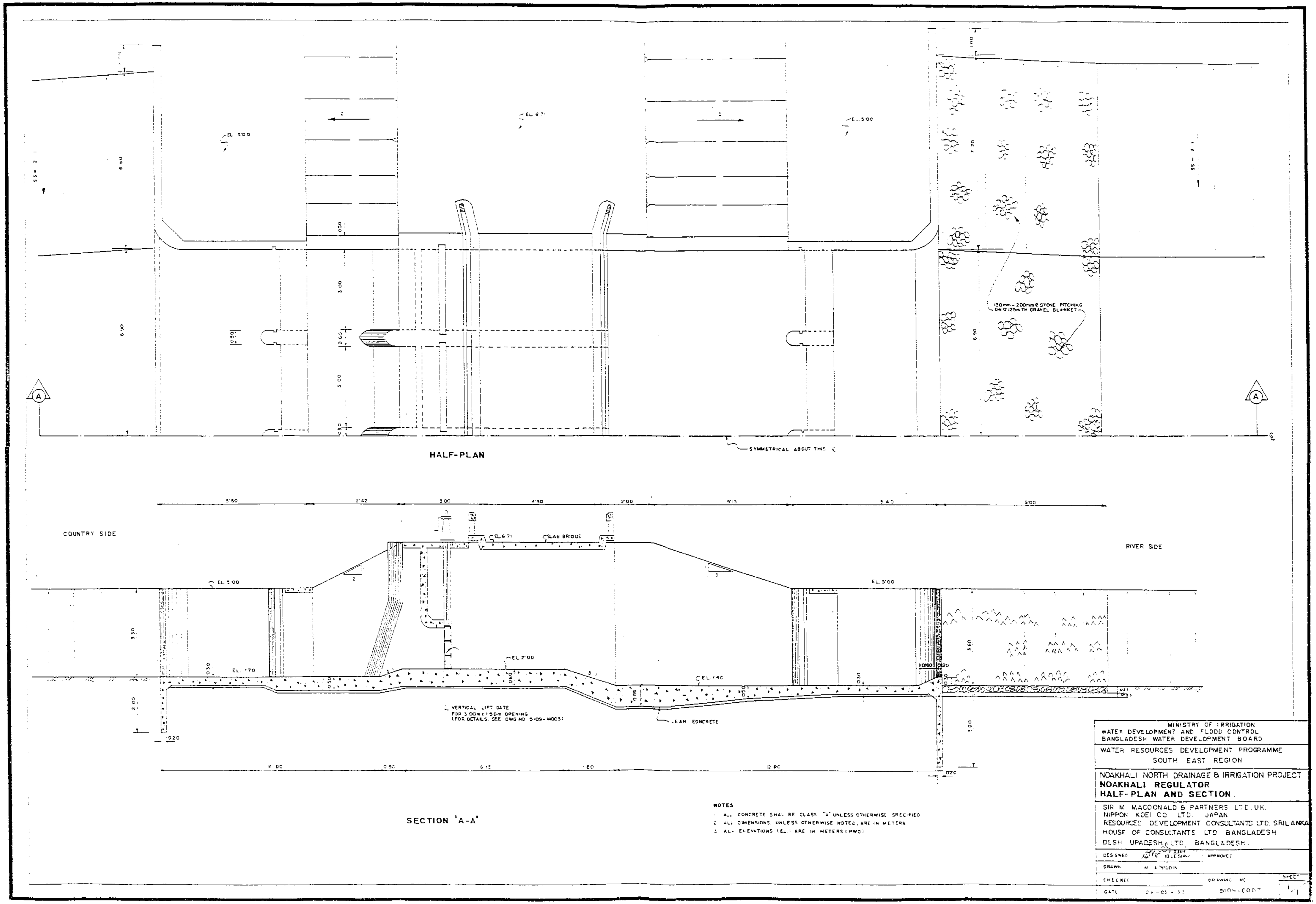

HALF-PLAN
SYMMETRICAL ABOUT THIS ℄
150mm - 200mm ⌀ STONE PITCHING ON 0.125m TH GRAVEL BLANKET
EL. 5.00
EL. 6.71
SECTION "A-A"
COUNTRY SIDE
RIVER SIDE
SLAB BRIDGE
EL. 2.00
EL. 1.70
EL. 1.40
LEAN CONCRETE
VERTICAL LIFT GATE FOR 3.00m x 1.50m OPENING (FOR DETAILS, SEE DWG NO 5109-M003)
NOTES
1. ALL CONCRETE SHAL BE CLASS "A" UNLESS OTHERWISE SPECIFIED
2. ALL DIMENSIONS, UNLESS OTHERWISE NOTED, ARE IN METERS
3. ALL ELEVATIONS (EL.) ARE IN METERS (PWD)
MINISTRY OF IRRIGATION
WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD
WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION
NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
NOAKHALI REGULATOR
HALF-PLAN AND SECTION.
SIR M. MACDONALD & PARTNERS LTD. UK.
NIPPON KOEI CO. LTD. JAPAN
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH
DESH UPADESH LTD. BANGLADESH.
DESIGNED
APPROVED
DRAWN
CHECKED
DRAWING NO
5109-C007
DATE
SHEET

Figure I.4.12

- demolition and replacement. This is required in the case of two single span bridges on secondary khals, which are very narrow between abutments.

In general, an absolute minimum bed width of 1 m has been assumed beneath bridges on secondary khals in determining the need for structural modification, allowing a slight constriction compared with the upstream and downstream bed width if necessary.

(c) Office Refurbishment

It is proposed to refurbish and reequip the BWDB offices at Lakshmipur, Noakhali and Feni so that they can function efficiently with a suitably enlarged staff for the supervision of construction stage and thereafter for operation and maintenance of the scheme. This item has not been costed in detail, but a provisional amount has been allowed in the overall estimate.

I.4.9 Land Acquisition and Spoil Disposal

The issue of land acquisition is always contentious and for this reason the consultants have taken great care in the evaluation of what might be required and in devising options which could reduce the amount required to the absolute minimum.

In the consultant's view this is likely to be the single most important element in terms of effective project implementation.

It is for this reason that the consultants have gone to some considerable effort to obtain as much information as possible concerning land values, present ownership, and the local populations' views concerning various methods of implementation.

There are two separate elements in terms of land acquisition as follows:

(i) Land required to achieve the proposed sections of the khals.
(ii) Land for depositing spoil excavated from khals.

The different aspects of these two elements are discussed below:

(a) Land Required for Excavation of Khals

This cannot be avoided if the scheme is to be effective. The total amount of area to be acquired including loop-cut areas and the Rahmatkhali regulator amounts to 76 ha. Out of this, the areas of the loops themselves could be filled with excavated spoil and reclaimed to provide homesteads and farmland of area at least as great as that taken by the new cuts and probably more. Thus no net land loss need be accounted for by these loop cuts and this reduces the net area of land to be acquired by 19 ha. This reduction has not been deducted from project costs. Of the remaining 57 ha a large proportion is believed to be already owned by BWDB because a wide strip of land was purchased during the construction of WAPDA Khal in the early 1970's. The study team obtained copies of the old land acquisition plans and in general the widths then acquired are more than adequate to accommodate the new proposed sections. However it is not possible to identify where the existing khal lies within the acquired limit, and in some cases the existing khal line appears to be outside the acquired areas. Therefore a completely new survey will be required, and no allowance for BWDB owned land has been made in the project estimates, with all land costed at full value including a premium on land values for compulsory purchase in accordance with recent policy.

Thus the project has assumed full compensation for all land to be taken for construction of the enlarged khals.

(b) Land Required for Disposal of Excavated Spoil

When WAPDA Khal was built in the early 1970's land was acquired for spoil banks and some remnants of these banks are still visible. However in most cases the material has long since been removed. The material has been used for a variety of purposes but most of it has been spread over the farmland, and the bank areas reclaimed for farming. Members of the study team have also witnessed the spreading of dredged spoil over farmland in the Gumti area and the use of excavated material (from khal beds) for raising land for planting orchards (this was near Ramganj in Noakhali North Project area). The team's sociologists were requested to question local groups in informal discussions concerning what should be done with the large quantities of earth which require disposal and what methods should be used. All suggestions considered come from the local people and these included:

- Embankments at edge of khal
- Road Embankments
- Homesteads and Markets
- Spreading Spoil

Although the use of spoil for road embankments and homesteads is entirely practical it could not account for more than a small proportion of the volume to be disposed of. The study has therefore costed both the other suggested alternatives as follows:

(i) Embankments or Spoil Heaps

These are assumed to be 2.5 m high and could be arranged either as intermittent embankments, to allow drainage, or as more concentrated areas as potential orchard or homestead areas. The method would be to strip topsoil, dump the spoil and respread the topsoil, leaving areas ready for development. This method requires the purchase of the land and, allowing for some disposal in the cut-off lengths near loop-cuts, it is estimated that the amount of land required would be 456 ha.

(ii) Spreading Spoil

This has been costed by assuming that all the spoil would be spread over farmland at a depth of 0.30 m. Although this method was acceptable to a majority of people interviewed it was not accepted by all and several expressed doubts as to the quality of the material whereas others thought it would be good.

98

As discussed in Section 1.1.5.3 above, soil sampling has indicated that a substantial proportion of the spoil may be too sandy to be acceptable for spreading on agricultural land. For areas where spoil is of unacceptable quality the proposed method would be to strip the existing top soil, store it, spread the excavated material and replace the top soil. For costing purposes half of the spreading area has been assumed to require this treatment. It would be possible to spread spoil to a greater depth when using this method, thus requiring less area, but this has not been allowed for in the estimates.

The costing of this method has also allowed for full compensation of the farmers whilst the process is completed. The entire process should be completed within one cropping season on any particular piece of land and compensation could be either in cash or kind (crop) equivalent to the net return the farmer could expect. This has been set at an average 15 000 Tk/ha. In addition the farmer would be given fertilizer sufficient for the following crop valued at 1 000 Tk/ha. The total area affected if this method were applied everywhere would amount to 3 633 ha (if the depth of spoil were increased the area would correspondingly reduce).

The economic analysis suggests that there is little difference between these methods in terms of EIRR but clearly there may be a difference in terms of acceptability to the population. It is considered that the alternative approaches need to be taken to the people and if necessary a combination of the two methods could be applied.

There is one further method which would involve the removal of all the material for disposal in the Meghna or wherever the contractor could make suitable arrangements. It has been estimated that such an operation could increase the overall project cost by up to 25 %.

The solution of using embankments is not favoured since it encourages the practice of piling earth on the edges of the cut sections thereby increasing the likelihood of its being washed back into the excavated section. Also, more significantly, the acquisition of such a large area (456 ha) could prove socially disturbing. However it should be borne in mind that these raised areas could potentially be considered an asset as orchards or homestead areas.

1.4.10 Quantities and Costs

Quantities of all the significant work items have been measured from the drawings and other design details to arrive at cost estimates. The khal excavation quantities have been calculated by comparing the design and existing cross-section at every surveyed cross-section location. For costing purposes, it has been assumed that the lower reach of Rahmatkhali Khal (downstream of the point where it is rejoined by WAPDA Khal) and the whole of WAPDA Khal (west of Chandraganj) will be excavated by mini-dredger. All other excavation is to be by hand. In practice the excavation method will probably not adhere precisely to this pattern, but it is considered to give a realistic division of the quantities for feasibility study purposes. The engineering quantities have been extended at the unit rates derived in Chapter 1.3 to this annex. Detailed costs and quantities are presented in Appendix 1.XIII to this annex.

Two alternative summaries of the project costs for complete implementation, including engineering surveys, design and construction, are presented in Tables 1.4.1 and 1.4.2. The estimated breakdown of costs on a year by year basis is also given. Table 1.4.1 assumes that all excavated spoil is to be placed in embankments or

TABLE I.4.1

Bill of Quantities for Noakhali North Project
Land Acquisition for Disposal of Spoil

Sl No	Description	Unit	Rate	Quantity	Amount (Tk. Mil.)	Implementation Year 1	2	3	4	5
1	Modification of Existing	Nr	L.S.	1	20.50	–	5.00	10.00	5.50	–
	14 Vent Rahmatkhali Regulator									
2	New 10 Vent Rahmatkhali Regulator	Nr	L.S.	1	69.20	–	15.00	35.00	19.20	–
3	New 4 Vent Noakhali regulator	Nr	L.S.	1	5.92	–	–	5.92		–
4	Modification of Existing Bridges									
	a) Modification of Structures	Nr	L.S.	1	7.49	–	–	3.74	3.75	–
	on WAPDA/Rahmatkhali Khal									
	b) Scour Protection of Bridge Piers	Nr	L.S.	1	3.30	–	–	1.65	1.65	–
	c) Modification/Reconstruction									
	of Bridges on Minor Khals	Nr	L.S.	1	7.14	–	–	3.57	3.57	–
5	Dredging Rahmatkhali & WAPDA Khal	cu.m	50.0	7388393	369.42	–	36.82	138.80	138.80	55.00
6	Manual Excavation Rahmatkhali	cu.m	39.5	2340206	92.44	–	–	–	46.22	46.22
	& WAPDA Khal									
7	Khal Bank Protection	m	18000.0	1850	33.30	–	–	–	16.00	17.30
8	Manual Excavation of Minor Khals									
	(115 Km)									
	a) Noakhali Khal	cu.m	31.0	229026	7.10	–	–	–	3.00	4.10
	b) Sonaimuri Khal	cu.m	31.0	631608	19.58	–	–	–	10.00	9.58
	c) Mohandra Khal	cu.m	31.0	509238	15.79	–	–	5.79	5.00	5.00
	d) Honrakhali Khal	cu.m	31.0	195411	6.06	–	–	3.06	3.00	–
	e) Marameghna Khal	cu.m	31.0	169795	5.26	–	–	2.00	3.26	–
	f) Khal No 28	cu.m	31.0	99154	3.07	–	–	3.07	–	–
	g) Kamta Khal	cu.m	31.0	406035	12.59	–	–	6.59	6.00	–
	h) Kabir Khal	cu.m	31.0	210972	6.54	–	–	3.00	3.54	–
	i) Musar Khal	cu.m	31.0	164614	5.10	–	–	5.10	–	–
9	a) Strip topsoil, Store,	ha	85000	19.01	1.62	–	–	0.81	0.81	–
	and Respread (Loop Cutting)									
	b) Strip topsoil, Store,	ha	85000	456.80	38.83		4.45	12.94	12.94	8.50
	and Respread (Spoil Heaps)									
10	Buildings and Equipment									
	a) Refurbishment of BWDB offices at	Nr	L.S.	600000	0.60	–	0.60	–	–	–
	Lakshmipur, Noakhali and Feni									
	b) Computers, Generator									
	and Survey Equipment	Nr	L.S.	850000	0.85	–	0.85	–	–	–
11	Vehicles	Nr	L.S.	2100000	2.10	–	2.10	–	–	–
	(1 No Truck, 2 No pickup, 10 Motorcycle)									
12	Land Acquisition									
	a) Regulator Site	ha	500000.0	10.000	5.00	–	5.00	–	–	–
	b) WAPDA/Rahmatkhali Khal (Agricultural)	ha	500000.0	61.000	30.50	–	18.30	12.20	–	–
	c) WAPDA/Rahmatkhali Khal(Homestead)	ha	1620000.0	5.000	8.10		4.86	3.24	–	–
13	Land Acquisition for Spoil Heaps	ha	500000.0	456.800	228.40	–	114.20	114.20	–	–
	(Spoil Dump 2.5 m High)									
14	NGO's Cost	Nr	L.S.	28250000.0	28.25	3.53	7.06	7.06	7.06	3.54
	Sub-Total of Direct Construction Cost = A				1034.04	3.53	214.24	377.74	289.30	149.24
	Physical Contingencies 15% of (A) = B				155.11	0.53	32.14	56.66	43.40	22.39
	Sub-Total (A) + (B) = C				**1189.15**	**4.06**	**246.38**	**434.40**	**332.70**	**156.80**
	Engineering Service Cost 12% of C				142.70	28.00	28.00	33.00	33.00	20.70
	Total Project Cost (Tk. mil.)(A)+(B)+(C)=				**1331.85**	**32.06**	**274.38**	**467.40**	**365.70**	**192.32**

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TABLE I.4.2

Bill of Quantities for Noakhali North Project
Land Renting for Disposal of Spoil

Sl No	Description	Unit	Rate	Quantity	Amount (Tk. Mil.)	Implementation Year 1	2	3	4	5
1	Modification of Existing	Nr	L.S.	1	20.50	–	5.00	10.00	5.50	–
	14 Vent Rahmatkhali Regulator									
2	New 10 Vent Rahmatkhali Regulator	Nr	L.S.	1	69.20	–	15.00	35.00	19.20	–
3	New 4 Vent Noakhali regulator	Nr	L.S.	1	5.92	–	–	5.92		–
4	Modification of Existing Bridges									
	a) Modification of Structures	Nr	L.S.	1	7.49	–	–	3.74	3.75	–
	on WAPDA/Rahmatkhali Khal									
	b) Scour Protection of Bridge Piers	Nr	L.S.	1	3.30	–	–	1.65	1.65	–
	c) Modification/Reconstruction									
	of Bridges on Minor Khals	Nr	L.S.	1	7.14	–	–	3.57	3.57	–
5	Dredging Rahmatkhali & WAPDA Khal	cu.m	50	7388393	369.42	–	36.82	138.80	138.80	55.00
6	Manual Excavation Rahmatkhali	cu.m	39.5	2340206	92.44	–	–	–	46.22	46.22
	& WAPDA Khal									
7	Khal Bank Protection	m	18000	1850	33.30	–	–	–	16.00	17.30
8	Manual Excavation of Minor Khals									
	(115 Km)									
	a) Noakhali Khal	cu.m	31	229026	7.10	–	–	–	3.00	4.10
	b) Sonaimuri Khal	cu.m	31	631608	19.58	–	–	–	10.00	9.58
	c) Mohandra Khal	cu.m	31	509238	15.79	–	–	5.79	5.00	5.00
	d) Honrakhali Khal	cu.m	31	195411	6.06	–	–	3.06	3.00	–
	e) Marameghna Khal	cu.m	31	169795	5.26	–	–	2.00	3.26	–
	f) Khal No 28	cu.m	31	99154	3.07	–	–	3.07	–	–
	g) Kamta Khal	cu.m	31	406035	12.59	–	–	6.59	6.00	–
	h) Kabir Khal	cu.m	31	210972	6.54	–	–	3.00	3.54	–
	i) Musar Khal	cu.m	31	164614	5.10	–	–	5.10	–	–
9	Strip topsoil, Store, and Respread									–
	a)Loop Cuts	ha	85000	19.01	1.62	–	–	0.81	0.81	–
	b)Soil spreading areas	ha	85000	1816	154.36	–	15.44	51.20	51.20	36.52
10	Buildings and Equipment									
	a) Refurbishment of BWDB offices at	Nr	L.S.	600000	0.60	–	0.60	–	–	–
	Lakshmipur, Noakhali and Feni									
	b) Computers, Generator									
	and Survey Equipment	Nr	L.S.	850000	0.85	–	0.85	–	–	–
11	Vehicles	Nr	L.S.	2100000	2.10	–	2.10	–	–	–
	(1 No Truck, 2 No pickup, 10 Motorcycle)									
12	Land Acquisition									
	a) Regulator Site	ha	500000	10	5.00	–	5.00	–	–	–
	b) WAPDA/Rahmatkhali Khal(Agricultural)	ha	500000	61	30.50	–	18.30	12.20	–	–
	c) WAPDA/Rahmatkhali Khal(Homestead)		1620000	5	8.10		4.86	3.24	–	–
13	Land Compensation	ha	16000	3633	58.13	–	5.80	20.23	30.00	2.10
	(Soil Spreading, 0.3 m depth)									
14	NGO's Cost	Nr	L.S.	3E+07	28.25	3.53	7.06	7.06	7.06	3.54
	Sub–Total of Direct Construction Cost = A				**979.30**	**3.53**	**116.83**	**322.03**	**357.56**	**179.36**
	Physical Contingencies 15% of (A) = B				146.90	0.53	17.52	48.30	53.63	26.90
	Sub–Total (A) + (B) = C				1126.20	4.06	134.35	370.33	411.19	206.26
	Engineering Service Cost 12% of C				135.14	26.50	26.50	31.00	31.00	20.14
	Total Project Cost (Tk. mil.)(A)+(B)+(C)=				**1261.34**	**30.56**	**160.85**	**401.33**	**442.19**	**226.41**

raised areas (2.5 m high), as discussed in Section I.4.9 above, on land acquired in accordance with FAP 15 recommendations and government regulations. Allowance is made for stripping topsoil from the whole area acquired, and replacing it after dumping.

The alternative costed proposal shown in Table I.4.2 assumes that all excavated spoil will be spread over farm land and that appropriate compensation will be paid as also described in Section I.4.9. Allowance has been made for stripping topsoil and replacing after spoil spreading over half the area affected.

The difference in capital costs in financial terms is less than 6 % and the difference in economic terms is also small (see Annex J). The consultants recommend the cheaper but less economic solution of paying compensation for spreading, since it would seem less disruptive in the long term. However it may be that in practice a mixture of the two approaches may prove to be the locally preferred solution with some areas opting for the one approach and others for the other.

I.4.11 Benefits of the Selected Option

The detailed benefits are discussed in the Agriculture and Economics annexes (Annexes E and J), whilst the inundation and irrigation model analyses are presented in Annex B (Hydrology and Hydraulic Modelling). Fisheries and environmental implications are discussed in Annexes F and H respectively.

The discussion of benefits in this annex is limited to the impacts upon irrigation and drainage.

(i) Irrigation

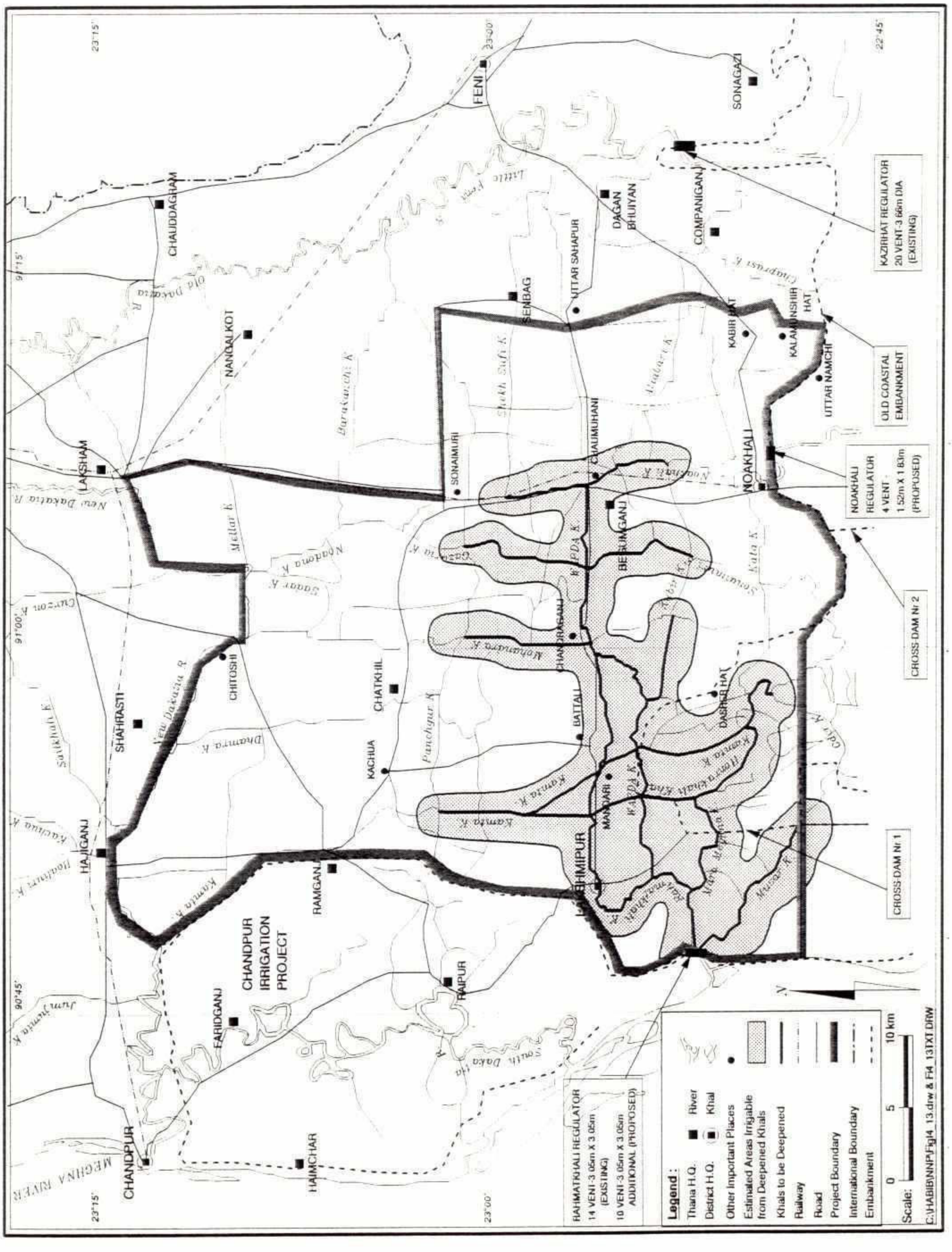
The area benefiting from irrigation is shown in Figure I.4.13. It is assumed that LLPs can command a strip of width 1.3 km each side of the deepened khals. The gross benefited area has been measured as 40 180 ha. On the basis of the gross (GA) and net cultivable arable (NCA) areas by one minute square in the land level database (see Section I.1.1.2), the ratio of NCA to GA within the benefited area was calculated to be 69.3%, giving an NCA of 27 845 ha. The existing irrigated area by mode within the benefited area, calculated from the unadjusted 1990 AST data (see Chapter I.2 and Appendix I.IX to this annex) on the basis of the proportion of each DAE block falling within the area of interest, is as follows:

DTW	-	102 ha
STW/DSSTW/MTW	-	55 ha
Traditional	-	1 889 ha
LLP	-	5 402 ha
TOTAL	-	7 449 ha

As discussed in Chapter I.2, the existing irrigated area is for various reasons considered to be somewhat higher than that given by the 1990 AST data, and for the purposes of analysis a figure of 9 336 ha has been used, giving a potential additional irrigated area of 18 509 ha. The total area of surface water irrigation to be served by water admitted by Rahmatkhali Regulator includes the existing surface water irrigation, and is thus about

Figure I.4.13

Area Benefiting from Irrigation



28 000 ha, with a peak water requirement of 42 m^3/s assuming a peak water duty of 1.5 l/s/ha (see Chapter I.2). It has been shown in Annex B (Hydrology and Hydraulic Modelling) that the regulator can in fact admit sufficient water for an area of 30 000 ha.

It should be noted that much of the existing irrigated area has an unreliable water supply, which should be significantly improved by the project, although this benefit has not been quantified in the economic analysis.

(ii) Drainage

A discussion of the changes in water levels and flood phasing throughout the monsoon season is presented in Annex B (Hydrology and Hydraulic Modelling) but the benefits in terms of peak flood depths are clearly illustrated by Figures I.4.14 to I.4.16. Figure I.4.14 shows the percentage of the NCA within each one minute square (1.7 km by 1.85 km) experiencing peak four day duration flood depths in a 1 in 5 wet year of greater than or less than 0.9 m (ie the threshold between flood phases F1 and F2). Figure I.4.15 shows the corresponding position in the with project situation. It can be observed that the Begumganj depression has been substantially eliminated as a deeply flooded area, and significant benefits are experienced even adjacent to the Dakatia River. Figure I.4.16 shows the change between the without and with project situations. This figure shows up to 70% to 80% of the NCA within the depression area shifting from F2 or deeper to F1 or shallower.

These reductions in depths of inundation translate into:

(a) Substantial improvements to monsoon season cropping potential in Zones B and C and more limited improvement in the southern parts of Zone D.

(b) Improved protection for boro crops by the reduction of early monsoon water levels (May). This will be of benefit principally in Zone D.

(c) Reduced crop and non-agricultural (housing, fish ponds roads and other infrastructure) damage in Zones B and C owing to the substantially reduced water levels even in exceptional years. For example in the Begumganj depression the water levels in year 1987 and 1988 in the with project situation would be reduced to well below those of a 1:2 year event in the without project situation. Even in the most extreme year recorded (1974, approximately a 1 in 50 year event) the levels would be reduced to those presently occurring 1 year in 2, which produces no damage.

Figure I.4.14

Without Project 1 in 5 Year Peak Flood Phasing

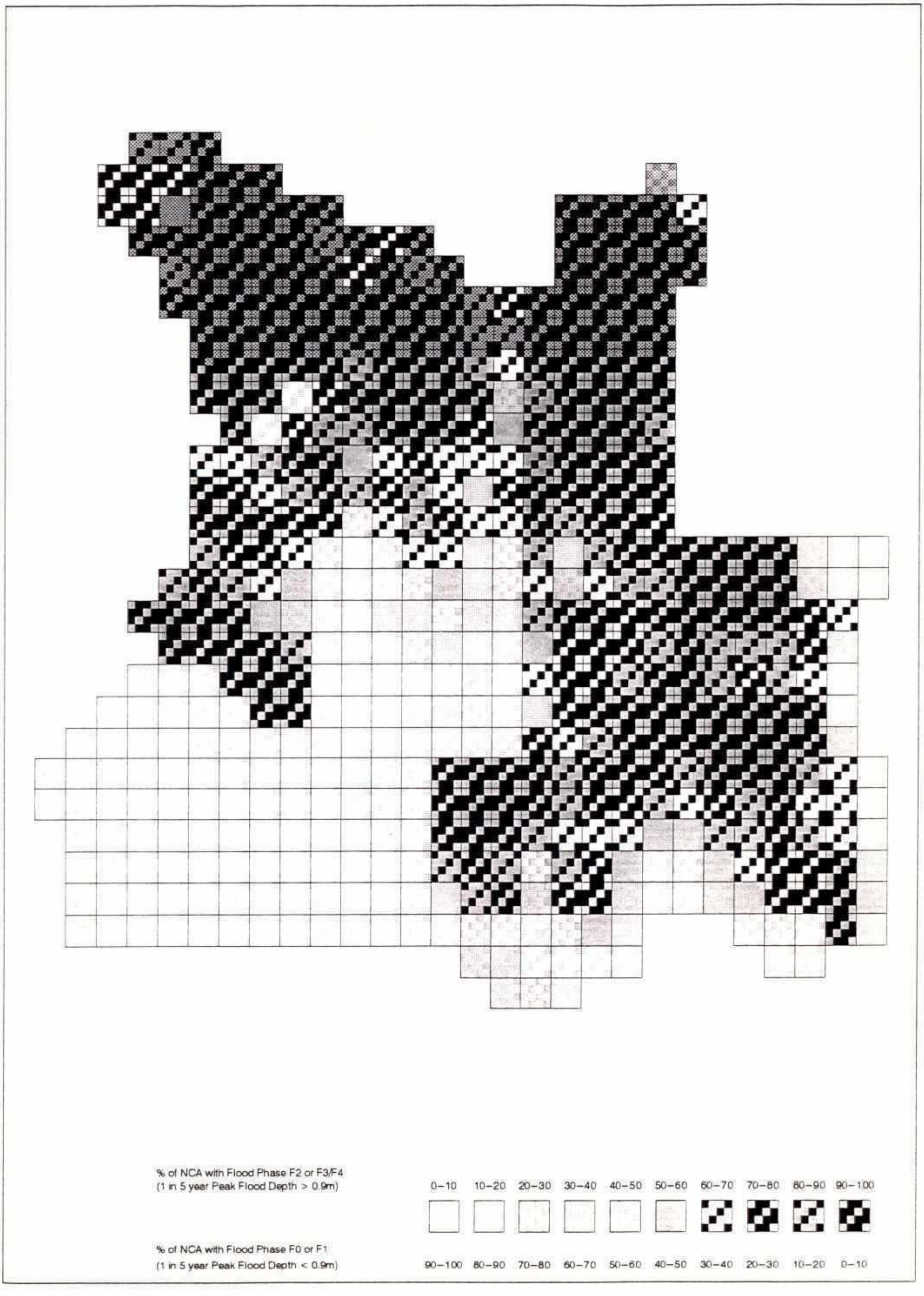


Figure I.4.15

With Project 1 in 5 Year Peak Flood Phasing

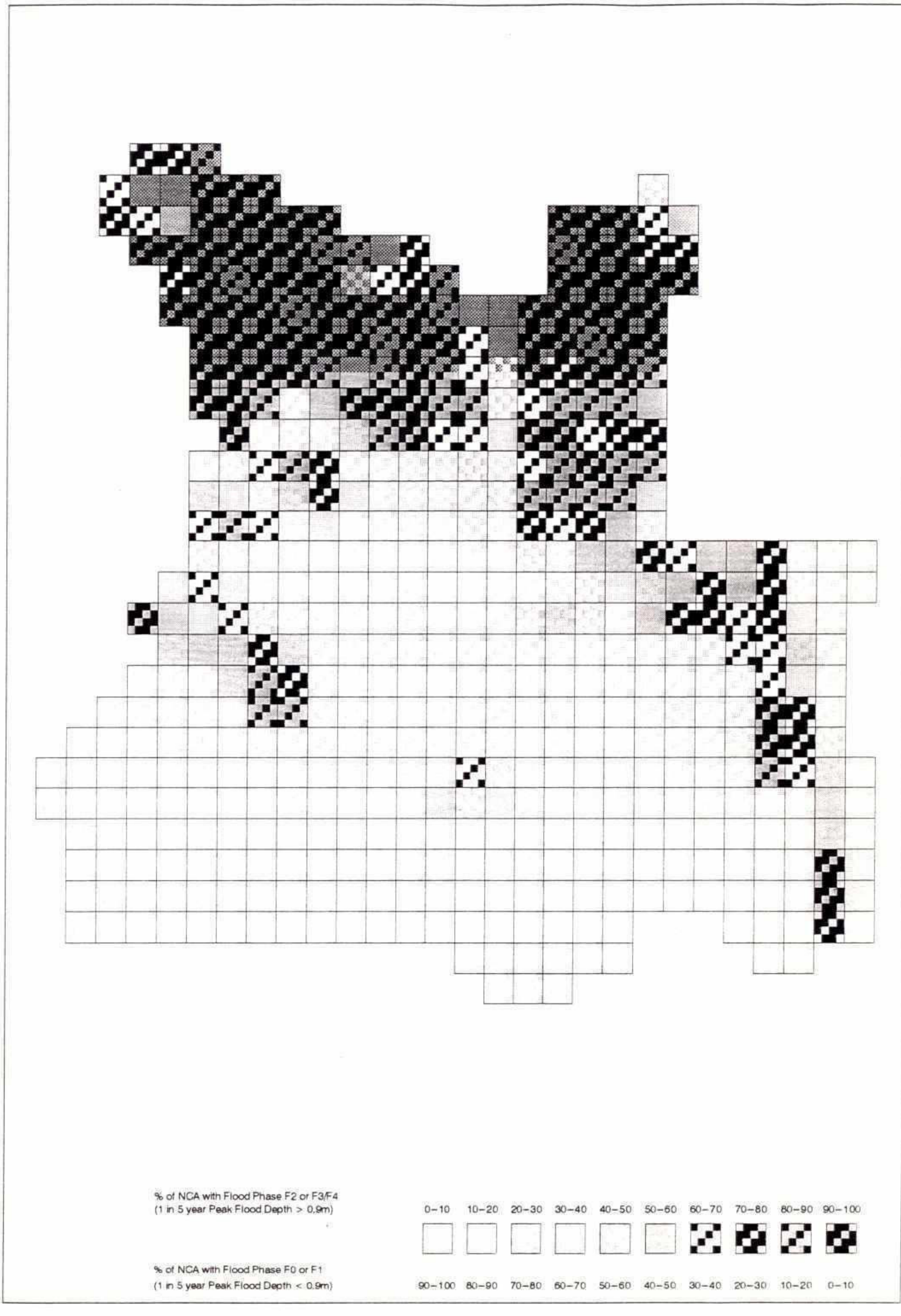
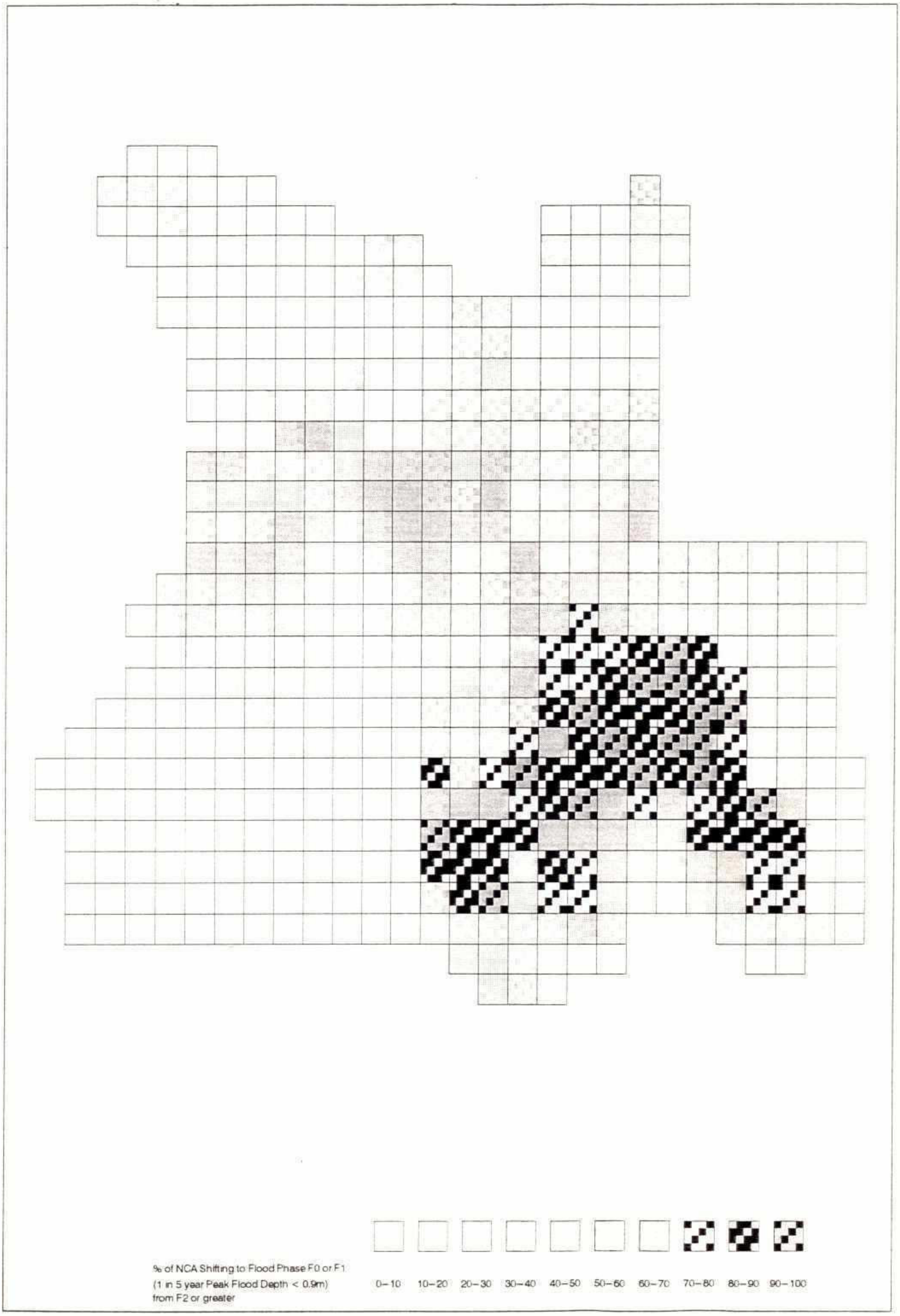


Figure I.4.16

With vs Without Changes in 1 in 5 Year Peak Flood Phasing



CHAPTER I.5

IMPLEMENTATION AND OPERATION & MAINTENANCE

I.5.1 Institutional Arrangements

It is vitally important that the institutional arrangements are established as soon as a decision is made to proceed with the project and that the core elements of these arrangements provide good continuity throughout all development stages.

The public participation guidelines issued by FPCO indicate that at the design stage a Project Coordination Committee (PCC) should be established by the implementing agency. This agency will be the Bangladesh Water Development Board (BWDB).

It is recommended that this committee be established initially to monitor the preliminary studies which are needed before the design starts and that this is then continued through all stages through to Operation and Maintenance (O&M).

In the past many projects have been monitored by Project Implementation Committees (PICs) but from the public participation programme it would seem that these committees are not held in high esteem owing to their having been dominated by local elites and vested interests. Thus the PCC must be clearly seen to operate in a different manner.

The PCC should allow representation from the concerned central government and local government agencies and their officials, and also from elected public representatives (eg MPs and/or Union Council Chairman) and also most importantly from representatives of potentially disadvantaged groups. (eg fishermen, landless people and those who will lose land through acquisition).

As a result of the participation programme undertaken at the feasibility study stage it is proposed that consultants be appointed for the predesign and design stages to ensure that the identified vulnerable groups are properly represented through the efforts of selected NGO's who would be sub-contracted to the consultants and could directly assist the representation of the design team and the vulnerable groups at the PCC meetings as described in the following sections.

I.5.2 Pre-Design Phase

A number of additional studies are needed to allow finalisation of the design and to ensure that adversely affected groups are adequately compensated. Those relating to fisheries and the environment are discussed in Annexes F and H. Details of engineering and cadastral surveys are given in Appendix I.XIV to this annex and summarised below:

(a) Detailed topographic/cadastral mapping to provide:

(i) Cross-section data on all khals proposed for re-excavation for detailed design/quantities.

108

ii) Accurate cadastral maps for identification of land-holdings, their ownership and occupation, leading to detailed recommendations and schedules for a land compensation/resettlement plan.

(b) Geotechnical Surveys to identify:

(i) Foundation conditions at the site of the new Rahmatkhali Regulator.

(ii) More detailed information on the distribution of sandy soils in the khals to identify areas requiring special attention for spoil disposal.

(iii) Foundation survey of existing bridges.

I.5.3 Design Phase

I.5.3.1 Requirements

The contract for scheme design would be tendered by BWDB. The TOR would include provisions for the consultant to employ an NGO to assist in ensuring proper public participation.

The consultants should be ready to start work as soon as the results of the topographic and geotechnical surveys are available. It is suggested that tendering for both surveys and consultants could start at the same time.

Additional computer modelling will be required at the design stage and it is suggested that the following information should be available to the design team:-

- 1:10 000 photomosaics of the area based on 1990 photographs. This data set was not available to the feasibility study.

- 1:10 000 mapping (FINNMAP-BIWTA) with updated land level database. These maps were originally to be available for the feasibility study but are now much delayed.

- The new thana maps prepared by the LGED/ILO project, showing road embankments and cross-drainage structures.

This mapping would allow an improved model re-calibration and the compilation of a complete GIS based on the FAP 19 system which would allow spatial identification of benefitted areas.

I.5.3.2 Design Procedures

As already discussed, it is envisaged that design consultants would be appointed so that they would be in place by the time the required topographic and geotechnical surveys were completed. Indeed it may be appropriate if the same team were to be involved in the required additional studies, so that good understanding and continuity is maintained and consistent advice can be given to the BWDB and to the PCC. The PCC's role at this stage would largely be to coordinate the activities of the design team, the NGO (participatory activities), the other ministries and local government agencies. These latter will include:-

- BWDB (design section, consultants etc.)
- BARDC (DAE) (Minor irrigation - NMIDP),
- R&H (bridge modifications),
- DOF (Fisheries mitigation measures),
- LGED (bridge modifications and local drainage programmes),
- Forest Department (New homestead areas).

The continued involvement of the elected representatives of the affected areas will also be essential.

I.5.4 Implementation Phase

I.5.4.1 Management Structure

The implementing agency, BWDB, will be responsible for the tendering, award and supervision of the various contracts needed to complete the project works. To achieve effective and timely completion they will require the cooperation and assistance of many other organisations and groups.

The vehicle for this cooperation will, once again, be the PCC. The public participation guidelines, FAP 15, SRP and others have already made many recommendations as to how projects would proceed. There is a common theme to these proposals but all have differences which are appropriate to their own views and the needs of their types of project. For this particular project it is considered that it would be most appropriate for both the design consultants and their corresponding NGO(s) to assist the BWDB both in ensuring maximum involvement and cooperation of the people and in translating the agreed designs into a finished product according to a predetermined timetable.

I.5.4.2 Contract Implementation Procedures

(a) Rahmatkhali Regulator

It is recommended that one contractor be appointed both for the modification of the existing regulator and the construction of the new regulator. These structures' close proximity and the need to complete the works within two dry seasons could lead to difficulties in site access arrangements if separate contractors were used.

Work on the remodelling of the existing regulator would be restricted to the dry season (November-April/May) to ensure that the existing drainage capacity is maintained in the wet seasons during construction.

The same contractor could also be responsible for the associated inlet and outlet channel earthworks.

110

(b) Main Khal Widening and Deepening

The major earthworks are programmed to be done by a fleet of mini-dredgers. This is because where much of the excavation is to be done under water it is unsuitable for hand excavation. Additionally the volumes required would involve large scale import of labour and the programme would be substantially extended, whereas the dredgers can work throughout the year. It is envisaged that the dredging work would be let as one or two contracts of 3 years duration, so that the cost of the dredgers can be fully recovered by the contractor over the period of the contract.

The dredgers to be used are substantially smaller than those currently in use in Bangladesh since the dredging depth and power required for this work is less than normal. Also these smaller units can be more easily mobilised and assembled in the khal system and moved from place to place. Also because of their lower power requirements they are cheaper to operate.

However, for a substantial part of the Rahmatkhali Khal, which currently has little or no water in the dry season, it has been assumed that hand excavation methods could be employed using LCS supervised by BRDB, LGED or NGO in a similar system to that used for the Systems Rehabilitation Project.

Both methods allow for stripping of topsoil, where the spoil material is too sandy to permit spreading directly onto the fields, and respreading as necessary (all to be done by hand labour). This work also provides the compartments for the dredged material.

(c) Excavation of Secondary Khals

All this work is scheduled as hand labour to be executed in the dry seasons using LCS groups in exactly the same manner as in (b) above. Again topsoil stripping and respreading may be required in some locations but most of this excavation is relatively shallow where better soils are encountered.

(d) Land Acquisition/Compensation

It is very important that compensation is agreed prior to execution of the works. The NGO(s) will be most important in ensuring that disputes (inevitable) are brought to the attention of BWDB and the PCC in a timely manner to prevent/minimise disturbance to the implementation programme.

(e) Other Works

(i) Khal bank Protection should immediately follow the completion of earthwork at the appropriate locations. This work lies entirely within the reaches which it is anticipated would be enlarged by dredging, and it might therefore best be performed by the respective dredging contractors.

(ii) Construction of Noakhali Regulator could appropriately be constructed under a separate small contract, although there is no reason why it should not be incorporated in the same contract package as the Rahmatkhali Regulator works, subject to the contractor's capacity. Noakhali Regulator should be constructed before the excavation of Noakhali Khal (or at least a temporary closure embankment in place) since, although the khal enlargement does not extend to the regulator site, there is still a danger of increased intrusion of seawater into the deepened channel network.

(iii) Refurbishment/Equipment of BWDB facilities should be completed in year 1 of the programme so that supervision facilities are in place for the major works.

I.5.4.3 Implementation Schedule

Figure I.5.1 shows the provisional implementation schedule including all studies and designs as well as construction works. Each year is a calendar year starting in April.

Generally the principal for programming construction is to use the monsoon season for tendering and award procedures and the dry season for construction, particularly for manual works.

The progression of works has been assumed to start at the downstream end of the system, so that as soon as an area is finished it can benefit from both improved drainage and irrigation potential. Thus it is estimated that the first irrigation benefits will be available in year 4 (second half) after completion of the main regulators and the first tranche of secondary khals. The first drainage benefits will be felt in the first half of year 5.

It has been assumed that the fisheries and environmental studies could be let as one package or separately, with the results of the surveys available to the design team at least six months before the end of the design period so that any necessary physical mitigation measures can be incorporated in the designs.

The NGO design activities are scheduled to start six months after the design consultants start work. This allows the design team to review the proposals and produce a revised khal alignment based on the results of the topographic and geotechnical engineering surveys.

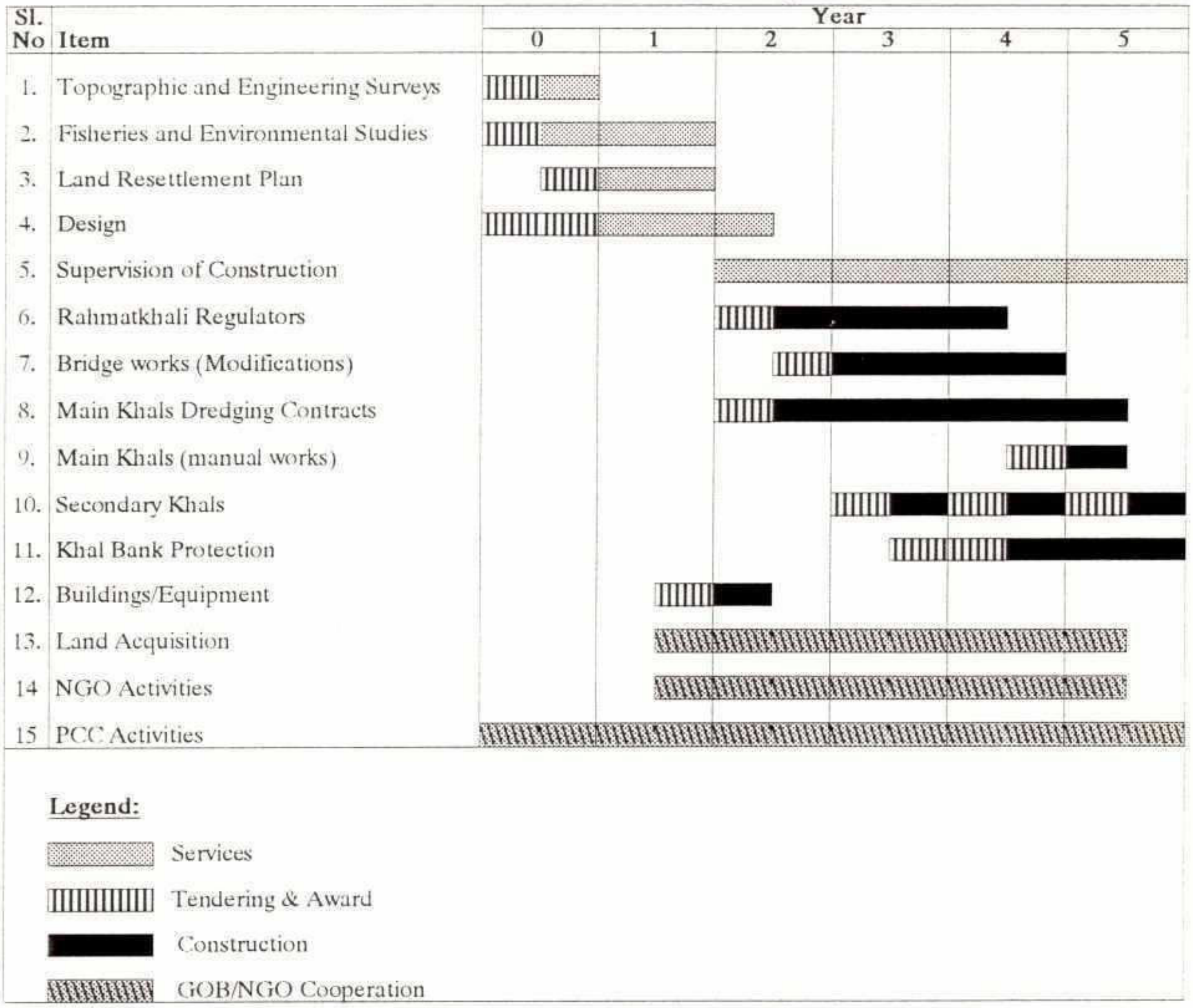
I.5.5 Operation & Maintenance

I.5.5.1 General

There are a number of recently completed, ongoing and planned projects which have studied, are studying or will study various aspects of this element of successful scheme development. These studies include FAP 13 (and the forthcoming FAP 13A), Systems Rehabilitation Project, the National Minor Irrigation Development Project and the forthcoming FAP 26 which may affect institutional arrangements.

The consultants team have discussed aspects of O & M with both SRP and FAP 13 personnel and also with various BWDB officials. These consultations and the perceptions of local people have helped to frame the recommendations set out in this section.

Figure I.5.1
Implementation Schedule



There are many problems related to O & M but the two principal areas of concern for this particular project are firstly adequate provision of regular funding for maintenance and secondly the involvement of the local people to ensure their continued interest and support for the project and its objectives.

The following sections set out what needs to be done, how it could be arranged and how it could be funded.

I.5.5.2 Operation

The project as conceived is exceptionally simple in terms of operation but must nevertheless be staffed and equipped to fulfil the required tasks in an effective, efficient manner.

(a) The Rahmatkhali Regulators.

The two regulator structures are the only major control mechanism on the entire project and on their effective operation depend the whole of the benefits. The chosen design means that on a day to day basis no structure operations are required but seasonal operations and occasional emergency operations will be required.

The operating rules will be closely defined at the design stage but in outline they are as follows:-

(i) Monsoon Season

As soon as water levels in the Meghna river rise such that levels at Piarapur reach + 3.00 m PWD the downstream (riverside) tidal flaps should be lowered into their operating positions. These gates will then operate in a similar manner to the existing gates except that they will open wider under much lower heads and velocities allowing improved access for some fish species.

The gates will remain in their operating mode until the water levels in the khal system are well below ground level at Piarapur, Begumganj and Chandraganj, so ensuring that drainage of the area is largely completed. It is suggested that a level at Chandraganj of + 2.3 m PWD would provide an effective measure to trigger the lifting of the flood protection gates. However an additional rule would include the maximum spring tide level of the Meghna at the regulator which should be below +3.00 m PWD.

When these two conditions are met the flood protection gates should be lifted clear of the water and fastened in the horizontal position. This is likely to occur during November but will vary from year to year.

It will be necessary at intervals during the monsoon season to flush through the regulator any water hyacinth and other floating debris accumulating upstream. As discussed in Section I.4.5(ii) above, it is anticipated that two or three of the vents in the new regulator would be designated for this purpose. All debris arriving upstream of the regulators would be directed to these by means of floating booms, assisted manually using long poles etc from the top of the regulator structure and/or from securely tethered boats. It is essential that the downstream flap gates on the bays concerned are raised clear of the water before the upstream booms are removed to commence flushing.

114

(ii) Irrigation Season

As soon as the downstream flood gates have been raised, the upstream irrigation gates should be lowered into their operating positions so that when Meghna river levels are higher than those inside they will open to admit water for irrigation but when Meghna water levels fall (to those inside or lower) then the gates will close and will retain the water admitted during high tide. These gates will remain in the operating mode at least until the end of March. At this time the storage of water for irrigation becomes less important as the Meghna river level is already increasing and sufficient water should be available in the khal system for the reduced irrigation requirement at this time without the need for gate regulation.

It is therefore proposed that the irrigation gates are lifted clear of the water at the beginning of April and fastened in their horizontal position.

For the months of April and May in most years it will be possible to keep the vents completely open providing unrestricted access for all spawn, fry and fish until the Meghna river achieves a level requiring flood protection as described in section (i) above.

(iii) Emergency Operation

This area is prone to cyclones and these most often occur in April or May, and can sometimes produce a substantial tidal surge in the Meghna. This last occurred in 1991 and caused considerable damage to the hoisting mechanisms on the existing regulator and resulted in severe flooding in the areas upstream of the regulator (see calibration records for 1991 in Annex B). It is therefore recommended that the flood gates be lowered when a severe cyclone is forecast to hit this area so as to prevent flood damage to boro crops and flooding of homestead areas as occurred in 1991.

(b) Irrigation Channel System

It is envisaged that the BWDB operating staff would spend much of their time, particularly during the dry season, surveying and monitoring the status of the khal system to ensure that its condition is satisfactory for irrigation purposes. Also it is at this time that effective monitoring and control of irrigation abstractions is required so as to ensure that all units are receiving water according to their established rights.

I.5.5.3 Maintenance

The requirements for maintenance of the project are again relatively simple to describe but implementation could be a problem unless proper preparations and organisations are put in place and these are described later in this chapter. The sub-sections below describe the maintenance activities required.

(a) The Rahamatkhali Regulators

The gates will require regular painting and the gate seals will need adjustment and occasional repair or replacement. Also the hinge mechanisms will require regular greasing. Periodic monitoring and adjustments to the counterweights will be required to ensure their continued effective operation. This is most sensibly done during the seasons when each set of gates is not required for operation.

Regular monitoring of the upstream and downstream protection works and channels should be done and any remedial works required carried out as soon as operating conditions permit. The best period would be during April and May when neither drainage nor irrigation operations are necessary and flows through the structure should be at a minimum.

(b) Khal System

The primary consideration here is likely to be the possibility of siltation or in places erosion. In both cases the prerequisite of good maintenance will be regular inspection and survey of the system to identify problems before they become severe.

The design at this stage has provided for the improvement of the khal to reduce or eliminate erosion, but the effectiveness of this will require frequent inspection and prompt remedial measures where problems occur, whether at locations where protection is provided and is under attack or at locations where it was not anticipated.

Siltation of khals could occur in three ways as follows:-

- collapse of embankment owing to instability, overloading of the embankment or pore pressures in the slopes, or
- material washed into the khals during the monsoon season.
- clogging through accumulation of water hyacinth and other floating debris.

The sediment studies described in Section 1.1.3.3 show low concentrations of sediment and the bed materials of the main khals show little evidence of sedimentation. However the tributary khals generally have bed levels substantially above those of the main khals and above the level generally adopted by BWDB when carrying out khal deepening (+ 0.91 m PWD). It is not entirely clear to what bed level the WAPDA khal was originally excavated since the drawings could not be obtained. However it appears that little maintenance work has been undertaken on the main khals and yet they are still substantial channels suggesting little siltation has occurred (indeed erosion is the main problem).

The provisions for earthworks maintenance contained in the FPCO guidelines require 6% of the capital cost to be provided for maintenance on an annual basis. This is equivalent to a volume of over 600 000 m^3/annum for the proposed project and this in turn is equivalent to an annual deposition of over 0.15 m of silt over the entire surface area of the khal system. Siltation on this scale is most unlikely although the cost estimates do allow for this percentage. The consultants would expect siltation to occur at not more than a third of this rate, bearing in mind that no Meghna water is involved and that all sediments from the Tripura hills are deposited in the Little Feni catchment. It is suggested that the operation and maintenance staff of the project collect data annually to monitor performance of the system and adjust the O & M budget accordingly, in agreement with the system beneficiaries.

U6

I.5.5.4 O & M Costs

The estimated O & M costs have been prepared in accordance with the FPCO guidelines. As stated above in the case of earthworks these provisions may be excessive but the economic viability of the project is not affected by this factor and therefore for costing purposes the guidelines have been followed. In terms of financial viability and costs justification and recovery, the monitoring and adjustment of maintenance budgets is recommended.

The costs are estimated to include:

- technical and administration staff,
- labour and materials for minor works,
- contracted maintenance works,
- vehicles, survey and other equipment,
- periodic painting and maintenance of gates, hoist mechanisms, hinges etc,
- monitoring of soil structure and chemistry in the principal I&D improvement areas,
- supervision, monitoring and control of irrigation pump operators, and
- cooperation with water user associations to identify and remedy operational problems.

The operation and maintenance costs of the proposed works as described above are set out in Table I.5.1.

TABLE I.5.1

Annual Operation and Maintenance Costs

Sl No.	Description	Capital Cost (Tk. million)	Annual O&M %	O&M Cost (Tk. million)
1.	Modified Existing Regulator	20.50	3	0.615
2.	New 10 Vent Regulator	69.20	3	2.076
3.	New 4 Vent Regulator	5.92	3	0.178
4.	Modifications to Bridges	17.93	3	0.538
5.	Dredged Channels	369.42	6	22.165
6.	Manual Excavation	173.53	6	10.41
7.	Khal Bank Protection	33.30	10	3.330
8.	Buildings	0.60	6	0.036
9.	Equipment	0.85	4	0.034
10.	Vehicles (* 4% + 70,000x7)	2.10	*	0.574
	Total	-	-	39.956

I.5.5.5 Public Participation in O & M

The sustainability of projects like the Noakhali North Drainage and Irrigation Project is likely to substantially depend on the continued interest and support of the beneficiaries who are primarily the farming community. Additionally all the project works will directly benefit all those living and working near or adjacent to the enlarged khals both through irrigation and improved drainage.

It is important that these people understand and accept that the maintenance of the system is in their own interests and that as the principal beneficiaries they should contribute to maintenance.

Possible funding arrangements are discussed in Section I.5.5.8, but the method of involving the people in maintenance needs to be developed taking funding into account as the issues are interrelated.

The Systems Rehabilitation Project (SRP) has pioneered new ways of involving people in maintenance activities and these initiatives should be incorporated in the proposed project. Also the Muhuri irrigation project has developed a system whereby there is dialogue with water users associations which implicity acknowledges an interdependence between the managers (BWDB) and the users.

I.5.5.6 Beneficiary Organisations and their Formation

As already identified by other projects the most obvious beneficiary groups are those concerned with irrigation facilities. There will be approximately 30000 ha of irrigation benefitting from the proposed project and it is recommended that the NGO which has developed relationships with the people along all the khals at the design stage incorporates in its messages that the project is a package requiring not only land at construction stage but also support at the O & M stage in return for which the project will provide irrigation benefits.

The message to farmers should be that the formation of WUAs would not only bring responsibilities in terms of costs but would also bring rights as follows:-

(i) The right to an assured irrigation supply.

(ii) Power to negotiate reasonable water rates with the pump operator

(iii) The right to consultation and information concerning the O & M needs and costs.

The encouragement and formation of WUAs based on LLP command areas should be a primary function of the NGO activities. Also the formation of confederations of WUAs into larger units, could be promoted for representation on the PCC.

Once again at the O&M stage the PCC would be the coordinator bringing together the scheme managers, the users and the benefitting communities to arbitrate and resolve disputes and recommend improvements as necessary.

118

1.5.5.7 Participation and O & M Works

Much of the maintenance work will involve the need for hand labour for desalting the secondary khals. It is recommended that this be undertaken by LCS groups comprising both male and female groups. This suggests that these works should in fact not be carried out by direct beneficiaries but by the less fortunate in society, thus spreading the benefits. Rather the principal beneficiaries would be providing the means for this further dispersion of benefits to the disadvantaged.

It is recommended that Canal Maintenance Groups (CMG) are formed in a similar manner to those currently undertaking embankment maintenance under SRP. The groups must be recognised and registered by an organisation (eg BRDB or an NGO) which will both stand as guarantor and assist with processing of payments. These groups will require training and supervision. Since they will come from the same communities as those of the beneficiaries who are indirectly financing them there will be incentives for the work to be executed properly.

1.5.5.8 Funding of O & M

The issue of O & M cost recovery is always difficult but in this case as already stated the most obviously benefitting members of the community are those people who will benefit from irrigation. It is proposed therefore, that a substantial proportion of the O & M costs could be recovered from the WUAs through an irrigation fee arrangement. This could either be collected directly by BWDB from the WUA or through an operating licence fee for an LLP. If the latter were the case then the BWDB management could both monitor and control the operators through the licensing system and could also ensure through contact with the WUA that the operators are not overcharging. This is an example of how the rights and responsibilities of WUA's can be balanced through the negotiation of these levels of charges.

At the present time it appears that LLP operators are charging farmers a premium for water scarcity since charges are much higher in Noakhali than in the Gumti Phase II project area, according to the surveys undertaken in both areas. It is suggested that the existing levels of charges could still give operators a good return and could provide sufficient funds for O & M. If 30 000 ha of irrigation contributes Tk 1 000/ha/yr as an irrigation fee this would represent Tk 30 million for O & M.

The expected net benefit from a hectare of boro is about Tk 10 000/ha in financial prices after including family labour and Tk 6 710 irrigation charges in the costs. If the Tk 1 000/ha/yr irrigation fee referred to above is deducted from this irrigation charge, this would still leave the pump operator with Tk 5 700/ha/yr for operating the pump, which is more than the total charge currently quoted in the Gumti area. Clearly this level of irrigation fee could not be considered excessive.

The above suggestions should not be regarded as firm recommendations, since it is important that this project should not be radically different from others and therefore the recommendations and national policy which finally emerge from the initiatives and pilot projects of SRP and FAP 13.1A should be applied in an appropriate manner to the Noakhali North Project. However the above discussion serves to demonstrate that O & M cost recovery could be largely or completely achieved through irrigation charges.

The O & M costs may well be substantially lower than those quoted in Table I.5.1 for reasons already explained, and it is important that whatever system is implemented it should be transparent and that most of the funds are retained at the local level, managed and accounted for by the local managers to the WUAs and their representatives. Accountability is an important requirement for the success of any charging system.

If national policy requires that part of the O & M costs are recovered from drainage beneficiaries on a wider scale then again the results of the SRP initiatives should be awaited. Options for such charges could include:

- tax on farm inputs,
- land drainage rates,
- fuel tax, and
- local VAT

The most rational basis would be a land drainage rate, but this is extremely difficult to arrange and administer since every land holder will benefit differently, some substantially and some not at all (eg those already having FO land and those remaining on F2 land). This aspect must be arranged through national policy.

Once all O & M costs can be recovered through such charges as those considered above consideration could be given to recovery of capital costs. This is also a question for national policy and SRP/NMIDP/FAP 13A will need to address such issues since all tertiary irrigation is now in the private sector.

I.5.5.9 O & M Management

The BWDB is expected to be responsible for O & M of the completed scheme using a similar organisational structure as presently existing. The Executive engineer, O & M will remain the executive officer of the project and he and his staff would report regularly to the PCC on all matters relating to the scheme. The PCC will ensure that any disputes between BWDB, the LLP operators and or WUAs are resolved through discussion with WUA representatives. SRP has recommended units of 20 LLPs. In this case this would result in up to 75 such units who could ask to have matters discussed by the PCC. Thus, for a scheme of this size it may be that sub-committees will need to be formed.

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APPPENDIX I.I

MAPS, AERIAL PHOTOGRAPHY AND SATELLITE IMAGERY

TABLE I.I.1

Topographic Mapping, Aerial Photography and Satellite Imagery

Sl.Nr.	Description	Coverage	Scale	Date	Source	Comments
1.	Topographic Map	Nation	1:50 000	1985	SOB	Surveys 1983-84/ aerial photos 1974-75. 3rd/4th Edition.
2.	Irrigation Planning Map	Nation	1:40 000	1958	SOP	Surveys 1956-57 / aerial photos, 1942/53
3.	Water Development Maps	Nation	1:15 840	1968	BWDB/SOP	Surveys 1966-69 / aerial photos 1963-67 See Fig I.1.1.
4.	Dakatia Basin Irrigation Map	Dakatia Basin	1:15 840	1951	BWDB/SOP	Surveys 1951 / aerial photos 1949 See Fig I.1.1
5.	Soil Associations Map	Nation	1:125 000	1990	MPO/SRDI	Draft
6	Planning Map	Nation	1:125 000	1990	MPO	Draft
7	Black & White Aerial Photography	Coastal Zone	1:30 000	1990	BIWTA/ FINNMAP	See Figure I.I.1
8	Multispectral SPOT Satellite Imagery	South East Region	1:50 000	1989 (Jan/ Feb)	FPCO/France	20 m x 20 m resolution
9	LANDSAT MSS Image Print	South East Region (Part)	1:250 000	5 Dec. 1973	FAP 19	80 m x 80 m resolution

SOB - Survey of Bangladesh
SOP - Survey of Pakistan
SRDI - Soil Resources Development Institute
MPO - Master Plan Organisation (now Water Resources Planning Organisation)
BIWTA - Bangladesh Inland Water Transport Authority
FPCO - Flood Plan Coordination Organisation

Figure I.I. 1

Available Coverage of 1990 Aerial Photography within the Project Area

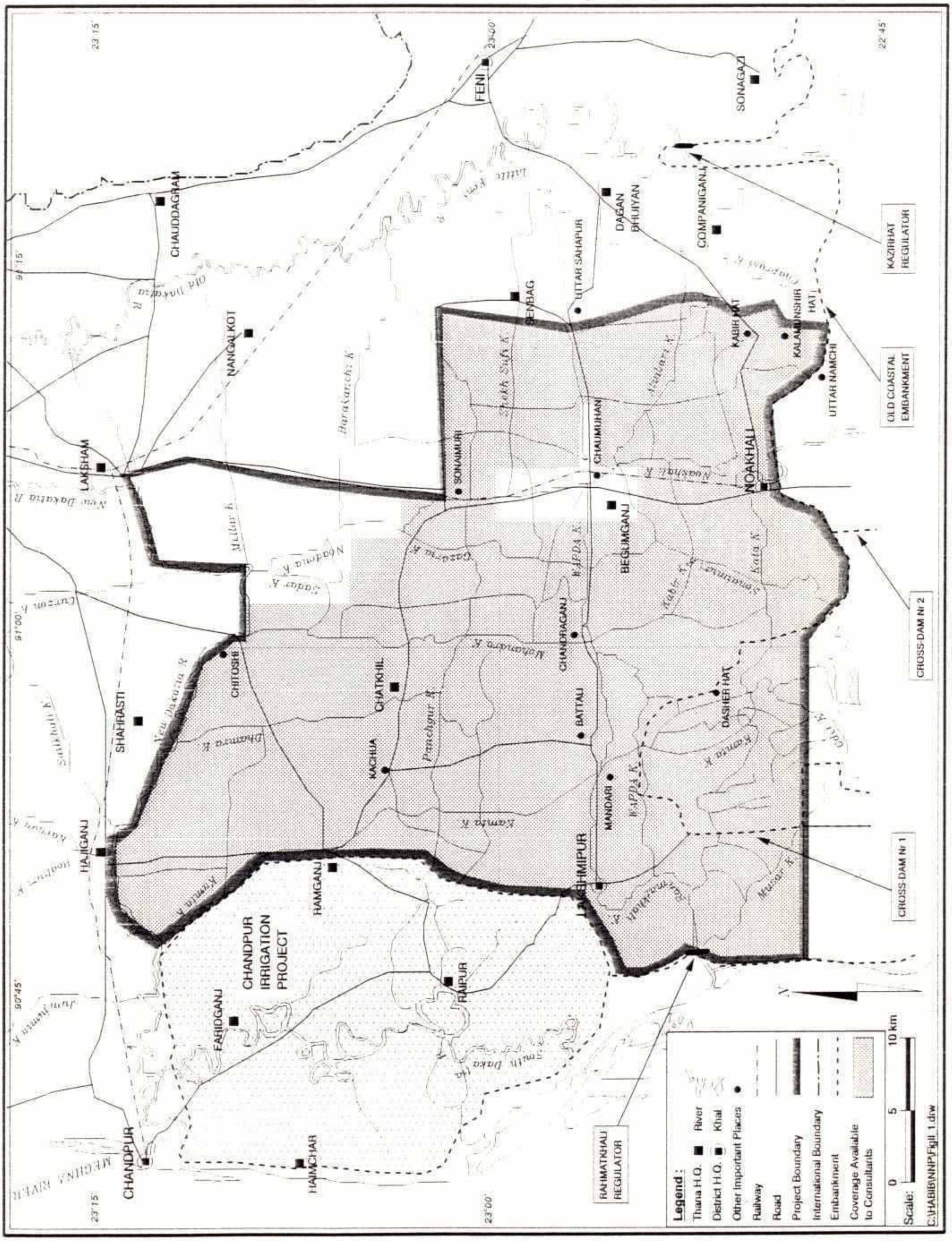


TABLE I.I.2

Infrastructure Development and Agricultural Extension Maps

Sl.Nr.	Description	Scale	Date	Source	Comments
A. Thana Base Maps (LGED)					
1	Lakshmipur	1:50 000	1992	LGED	Draft
2	Chatkhil	1:50 000	1992	"	Colour Print (UNDP/ILO Project
3	Ramganj	1:50 000	1992	"	Colour print (UNDP/ILO Project)
4	Ramgati	1:50 000	1992	"	Draft
5	Sudharam	1:50 000	1992	"	Draft
Thana Road Maps (LGED)					
1	Lakshmipur	1:50 000	1992	LGED	Draft
2	Chatkhil	"	"	"	"
3	Ramganj	"	"	"	"
4	Ramgati	"	"	"	"
5	Sudharam	"	"	"	"
Thana Drainage Embankment Maps (LGED)					
1	Lakshmipur	1:50 000	1992	LGED	Draft
2	Chatkhil	"	"	"	"
3	Ramganj	"	"	"	"
4	Ramgati	"	"	"	"
5	Sudharam	"	"	"	"
	Thana Land Use / Water Use Maps (LGED)				
1	Lakshmipur	1:50 000	1992	LGED	Draft
2	Chatkhil	"	"	"	"
3	Ramganj	"	"	"	"
4	Ramgati	"	"	"	"
5	Sudharam	"	"	"	"

125

TABLE I.I.2 (Contd.)

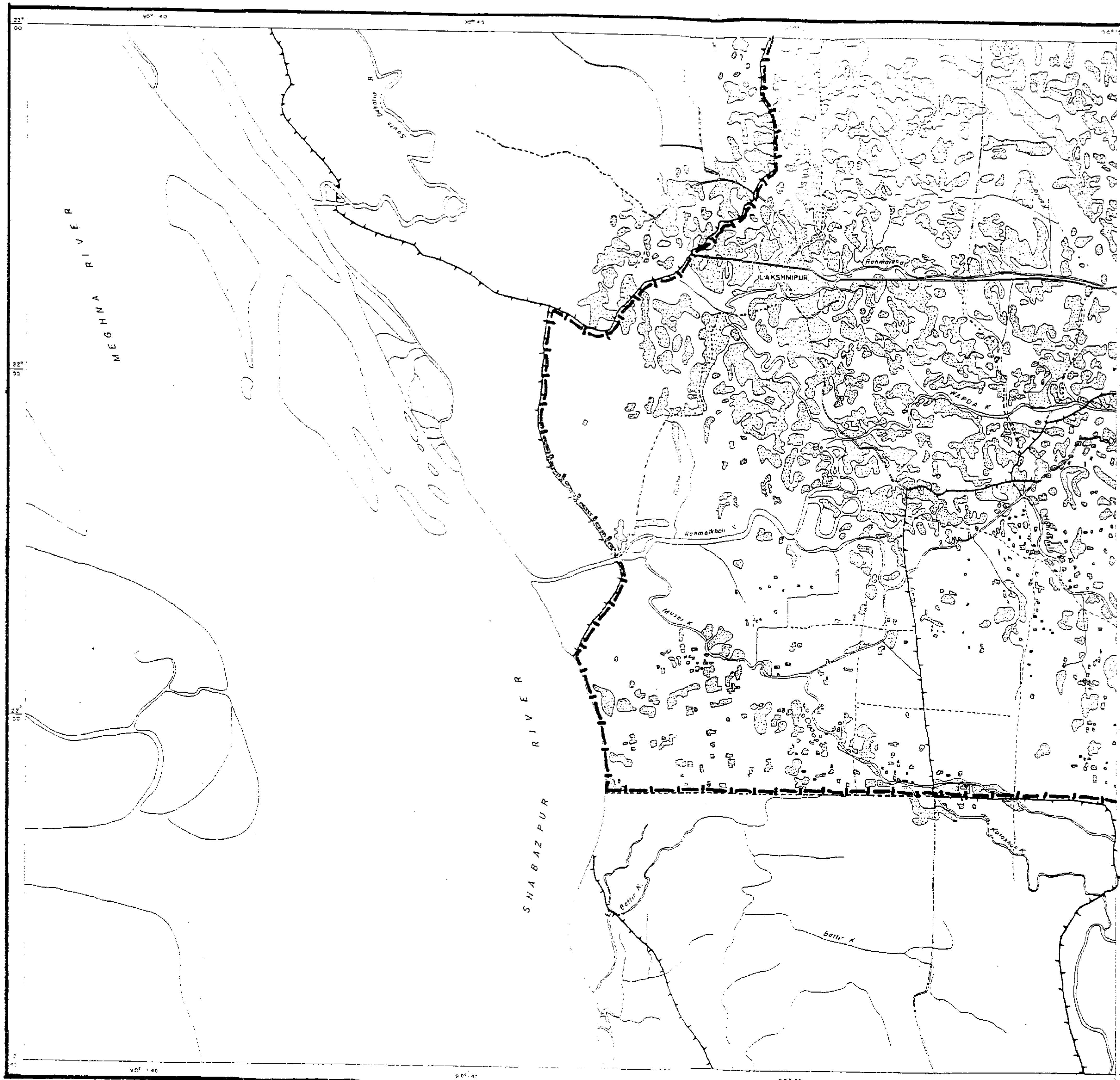
Infrastructure Development and Agricultural Extension Maps

Thana Irrigation Maps (LGED)					
1	Lakshmipur	1:50 000	1992	LGED	Draft
2	Chatkhil	"	"	"	"
3	Ramganj	"	"	"	"
4	Ramgati	"	"	"	"
5	Sudharam	"	"	"	"
B. Transmission Line Maps					
1	Lakshmipur Zila (33 KV)	1:253 440	-	PDB	Draft
2	Noakhali Zila (132 kV, 33 kV)	"	-	"	"
3	Bangladesh (230 kV, 132 kV, 33 kV)	-	-	"	"
C Agricultural Extension Block Boundary					
1	Begumganj Thana	-	1992	Thana Parishad	Draft
2	Senbag "	1:12 000	-	"	"
3	Chatkhil "	-	-	"	"
4	Faridganj "	1:75 000	-	"	"
5	Shahrasti "	1:60 000	-	"	"
6	Sudharam "	-	-	"	"
7	Ramgati "	1:125 000	-	"	"
8	Ramganj "	1:120 000	-	"	"
9	Lakshmipur "	1:60 000	-	"	"
10	Hajiganj	-	-	"	"
11	Laksham	-	-	"	"

APPENDIX I.II

LAND USE MAPS SHOWING ARABLE AND NON-ARABLE AREAS

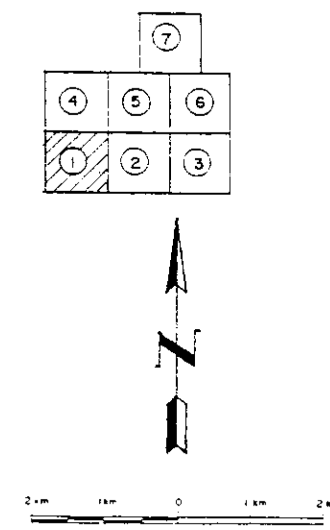
Figure I.II.1



LEGEND

Project Boundary
Thana Headquarter
River & Khal
Metalled Road
Un-Metalled Road
Cart - Track
Existing Embankment
Railway Line
Non-Arable Area (Village, Orchard etc)

Note
Homestead / Orchard, Areas interpreted from 1990 aerial photography, except areas enclosed by chain dotted line —·— which are interpreted from 1989 SPOT Satellite imagery.



MINISTRY OF IRRIGATION
WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

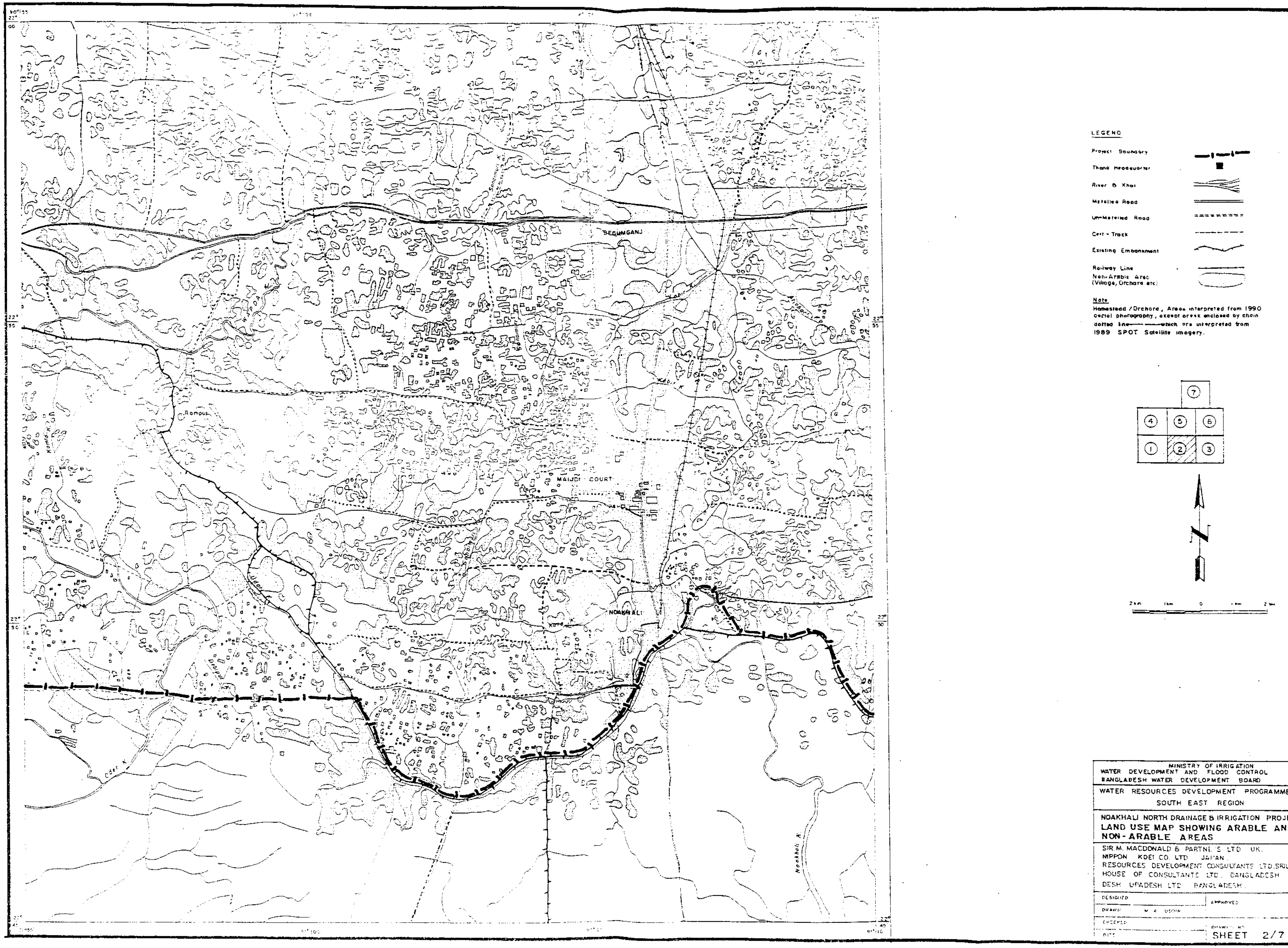
NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
LAND USE MAP SHOWING ARABLE AND NON-ARABLE AREAS

SIR M MACDONALD & PARTNERS LTD UK
NIPPON KOEI CO LTD JAPAN
RESOURCES DEVELOPMENT CONSULTANTS LTD, SRILANKA
HOUSE OF CONSULTANTS LTD BANGLADESH
DESH UPADESH LTD BANGLADESH

DESIGNED	APPROVED
DRAWN M A UDDIN	
CHECKED	DRAWING NO
DATE	SHEET 1/7

128 | 122

Figure I.II.2



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BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
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NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
LAND USE MAP SHOWING ARABLE AND NON-ARABLE AREAS

SIR M. MACDONALD & PARTNERS LTD UK.
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RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH
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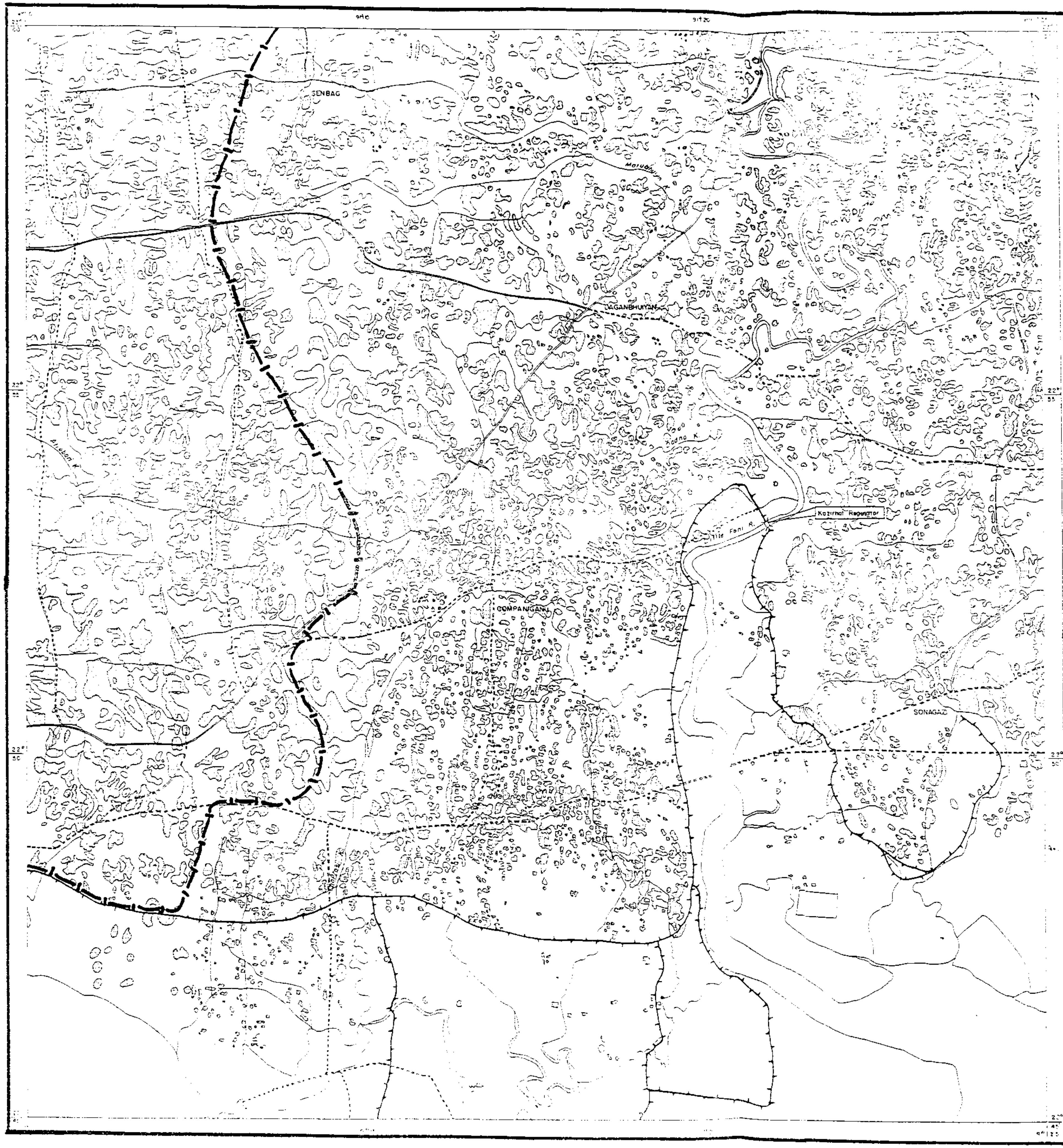
Figure I.II.3

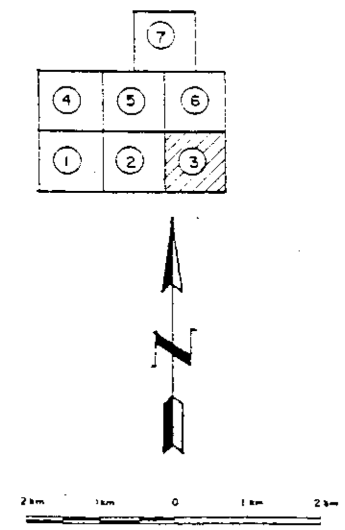


LEGEND

Project Boundary	
Thana Headquarter	
River & Khal	
Metalled Road	
Un-Metalled Road	
Cart - Track	
Existing Embankment	
Railway Line	
Non-Arable Area (Village, Orchard etc.	

Note

Homestead / Orchard , Areas interpreted from 1990 aerial photography , except areas enclosed by chain dotted line ——— which are interpreted from 1989 SPOT Satellite imagery.



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BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT

LAND USE MAP SHOWING ARABLE AND NON-ARABLE AREAS

SIR M. MACDONALD & PARTNERS LTD. UK.
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DESH UPADESH LTD. BANGLADESH.

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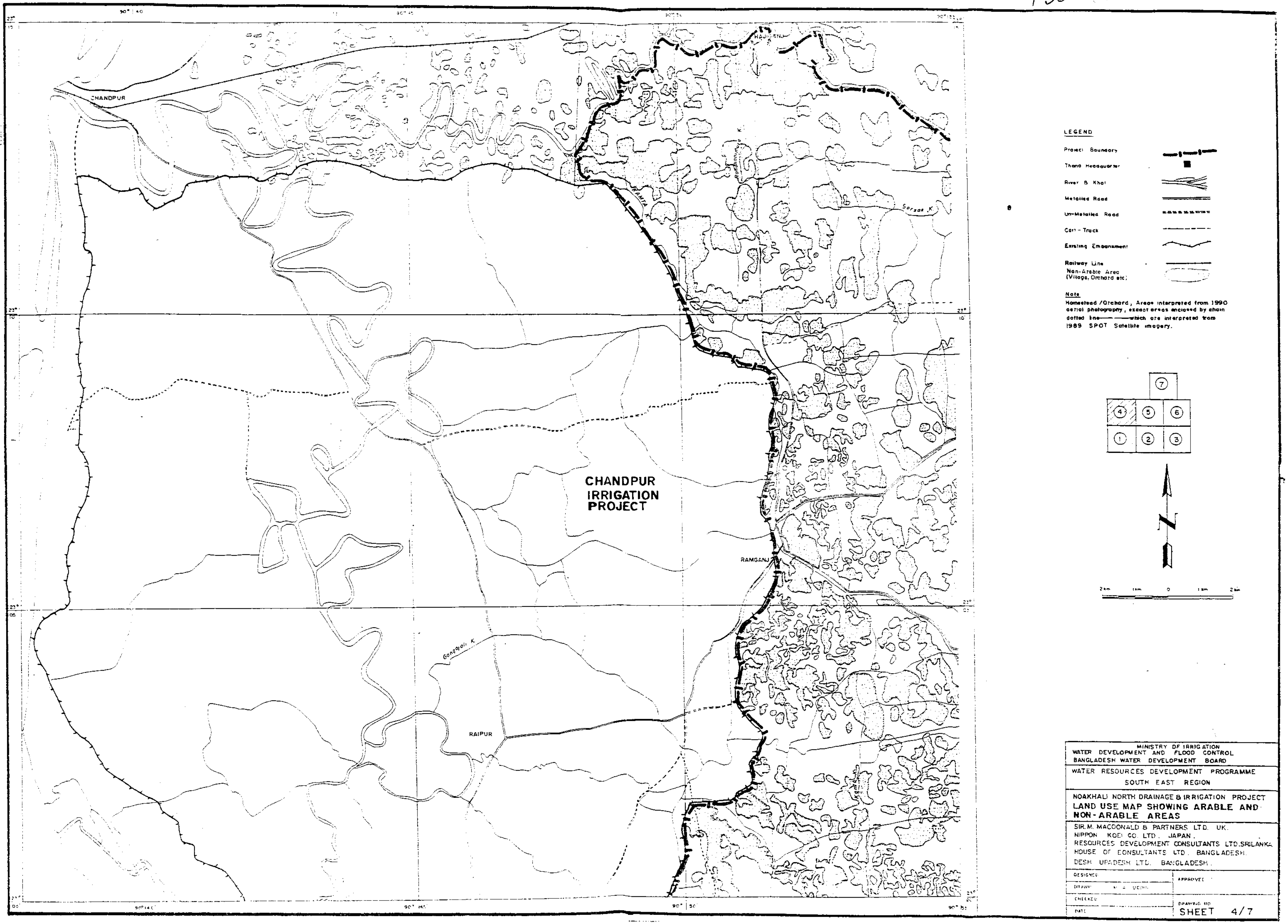
Figure I.II.4



MINISTRY OF IRRIGATION
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BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
LAND USE MAP SHOWING ARABLE AND NON-ARABLE AREAS

SIR M. MACDONALD & PARTNERS LTD. UK.
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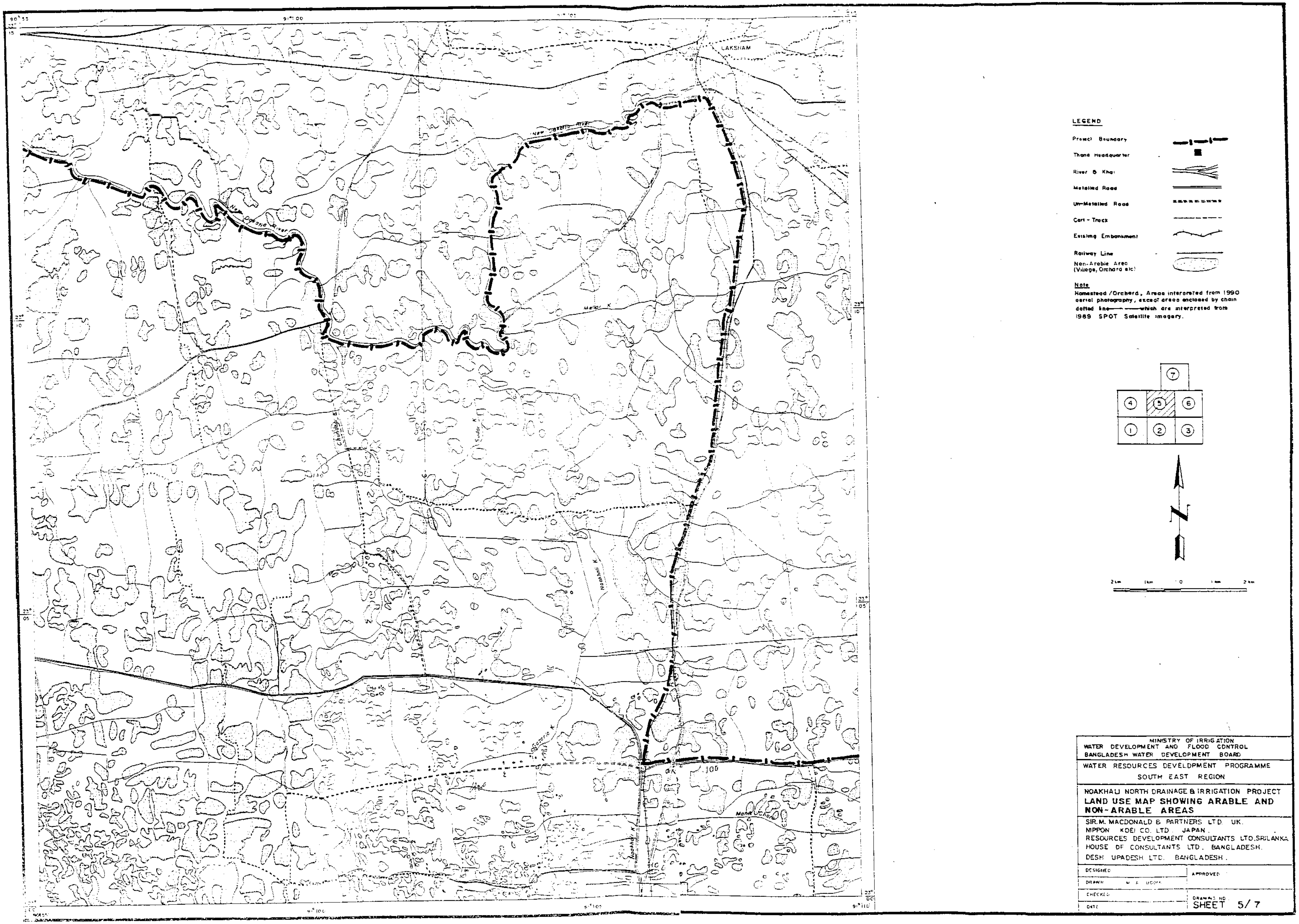
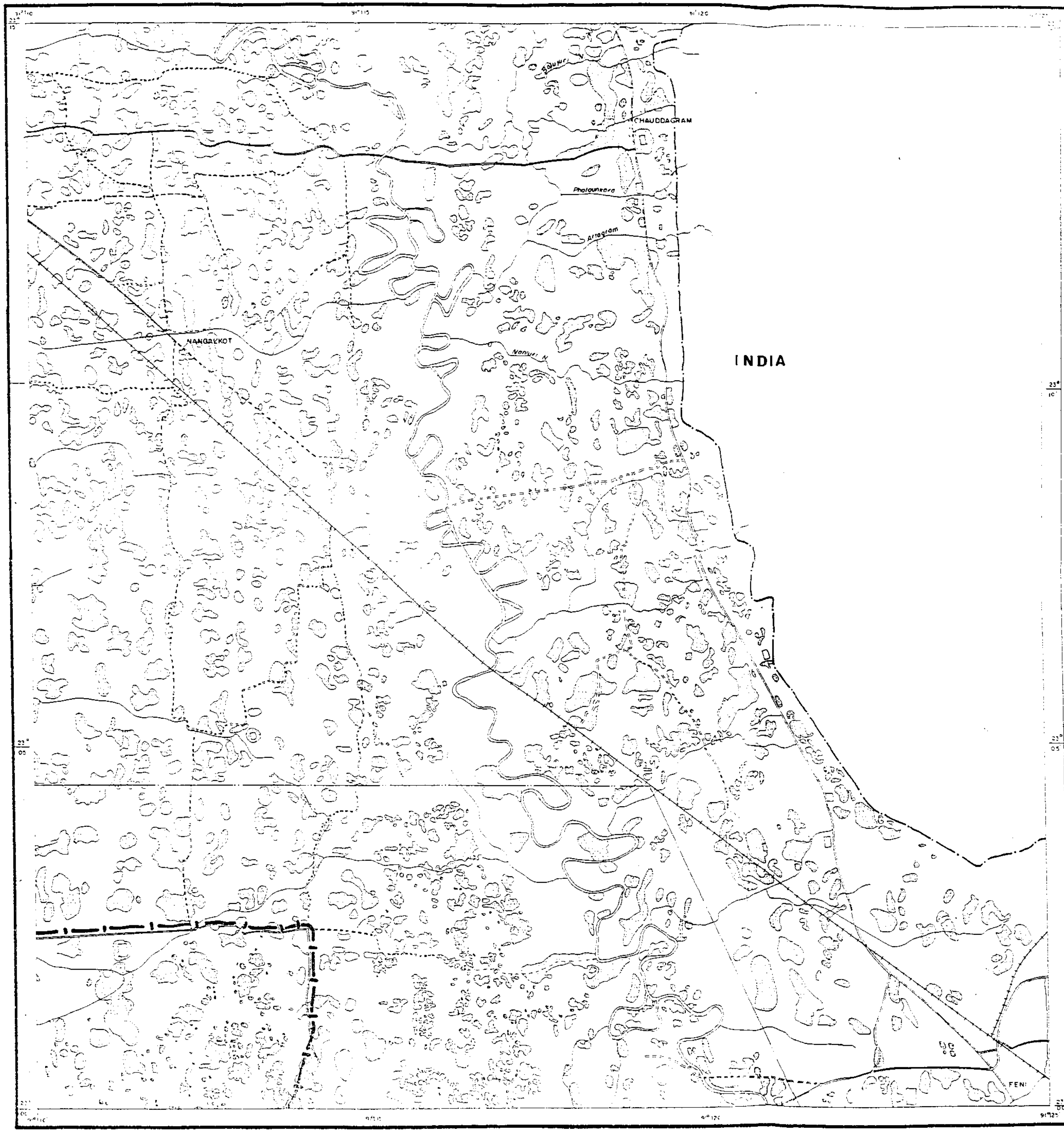
CHECKED	DRAWING NO.
DATE	SHEET 4/7

131 131

Figure I.II.5



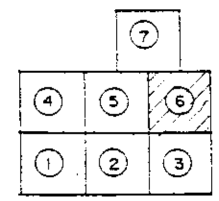
132 | 32 **Figure I.II.6**



LEGEND

- Project Boundary
- Thana Headquarter
- River & Khal
- Metalled Road
- Un-Metalled Road
- Cart - Track
- Existing Embankment
- Railway Line
- Non-Arable Area (Village, Orchard etc)

Note
Homestead /Orchard, Areas interpreted from 1990 aerial photography, except areas enclosed by chain dotted line —— which are interpreted from 1989 SPOT Satellite imagery.



N

2 km 1 km 0 1 km 2 km

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BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
LAND USE MAP SHOWING ARABLE AND NON-ARABLE AREAS

SIR M. MACDONALD & PARTNERS LTD. UK.
NIPPON KOEI CO. LTD. JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH.
DESH UPADESH LTD. BANGLADESH.

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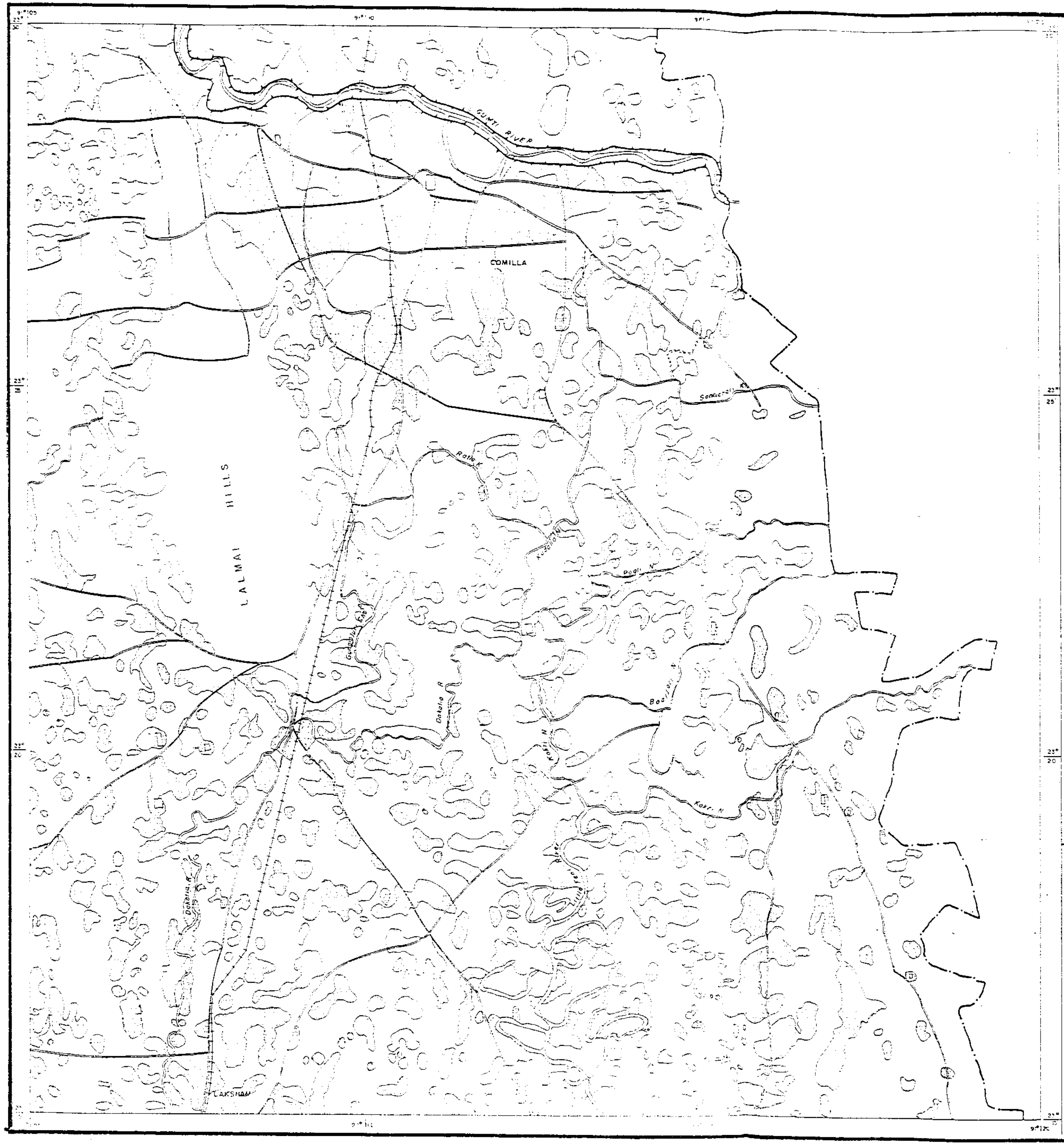
Figure I.II.7

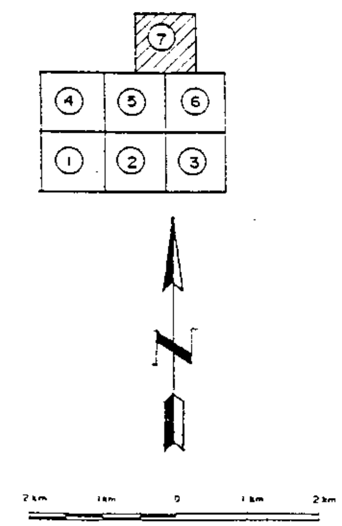


LEGEND

Project Boundary
Thana Headquarter
River & Khal
Metalled Road
Un-Metalled Road
Cart - Track
Existing Embankment
Railway Line
Non-Arable Area (Village, Orchard etc)

Note

Homestead / Orchard, Areas interpreted from 1990 aerial photography, except areas enclosed by chain dotted line ——— which are interpreted from 1989 SPOT Satellite imagery.



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BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
LAND USE MAP SHOWING ARABLE AND NON-ARABLE AREAS

SIR M MACDONALD & PARTNERS LTD. UK.
NIPPON KOEI CO. LTD. JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA.
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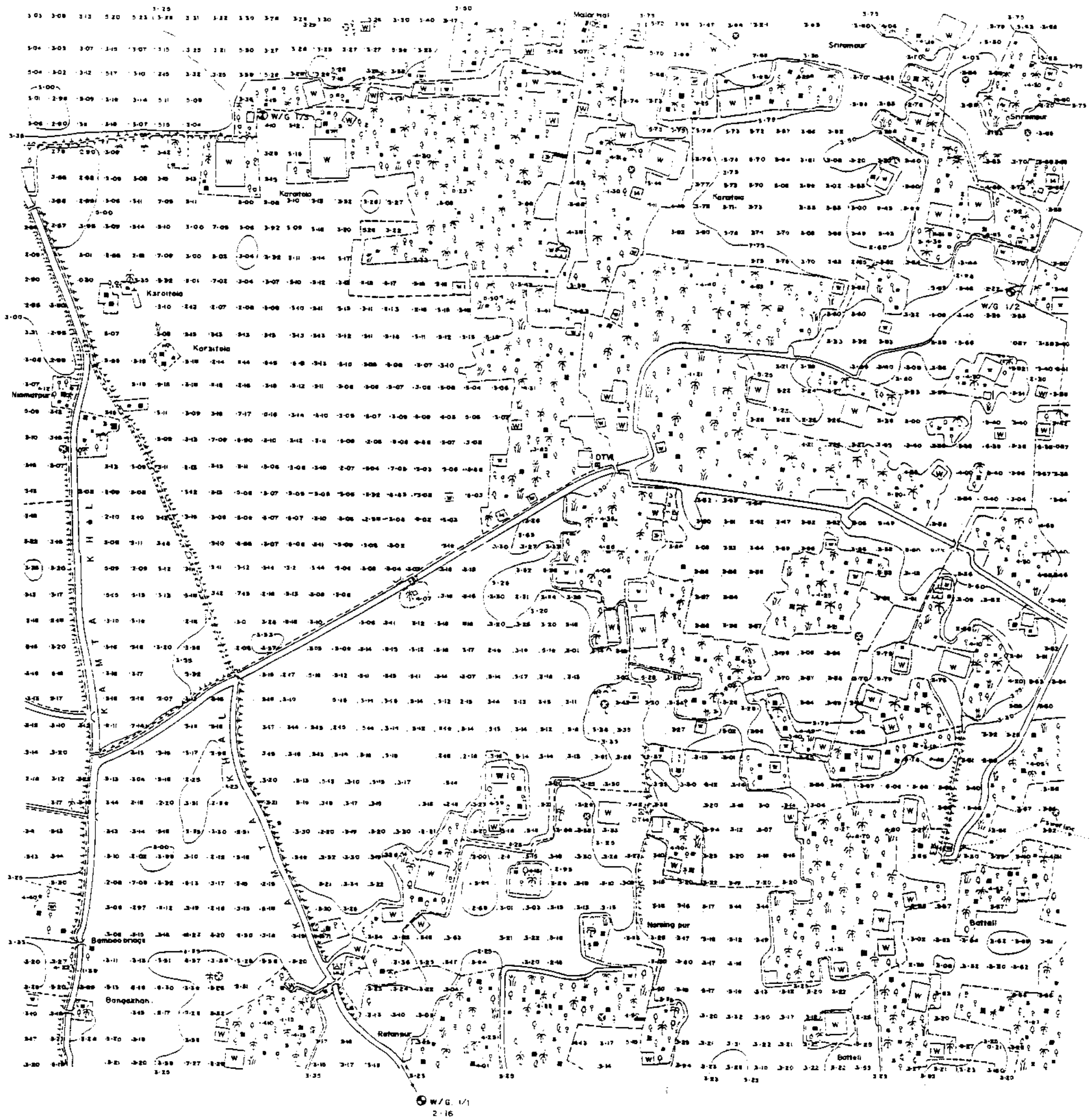
APPENDIX I.III

SAMPLE AREA TOPOGRAPHIC MAPS

Figure I.III.1



LEGEND

Metalled, Non Metalled & Brick Road

Cart-track with bridge, Foot path

River bank with water gauge, Khals

Canal, Embankment with sluice regulator

Pond, Water tank Ditch or Borrow pit

Broken ground, Marsh, Mud

Electric main power line

Telephone line

Homestead, Huts, Tomb

Mosque, Idgah, Church, Temple

Tree: Prominent surveyed, Cultivation limit, Graves

Betelnut, Coconut, Bamboo, Other trees

Grass, Cane, Palm tree, Scrub

Boundary: District; Thana

Bench-mark, Levelled spot height — 26·23, ·25·3

Temporary Water Level Gauge — W/G.

Deep Tube Well — B DTW

Note:-

- Contour Intervals 0.25 metres
- Contours have been shown by interpolation between levelled spot heights.
- All heights appearing in this sheet are in terms of PWD datum. To bring these heights in terms of SOB datum subtract 0·46 metre.
- Zero Value of Gauge I/1, I/2 & I/3 are 2·16m 3·32m and 3·05m

Scale 1:500

NO	DATE	DESCRIPTION
REVISION		

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BANGLADESH WATER DEVELOPMENT BOARD

SOUTH EAST REGION
WATER RESOURCES DEVELOPMENT PROGRAMME

NOAKHALI NORTH PROJECT FEASIBILITY STUDY
TOPOGRAPHICAL SURVEY MAP OF SAMPLE AREA NO-1

SIR M. MACDONALD & PARTNERS LTD. UK.
NIPPON KOEI CO. LTD. JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. S. LANKA
HOUSE OF CONSULTANTS LTD BANGLADESH
DESH UPODESH LTD. BANGLADESH

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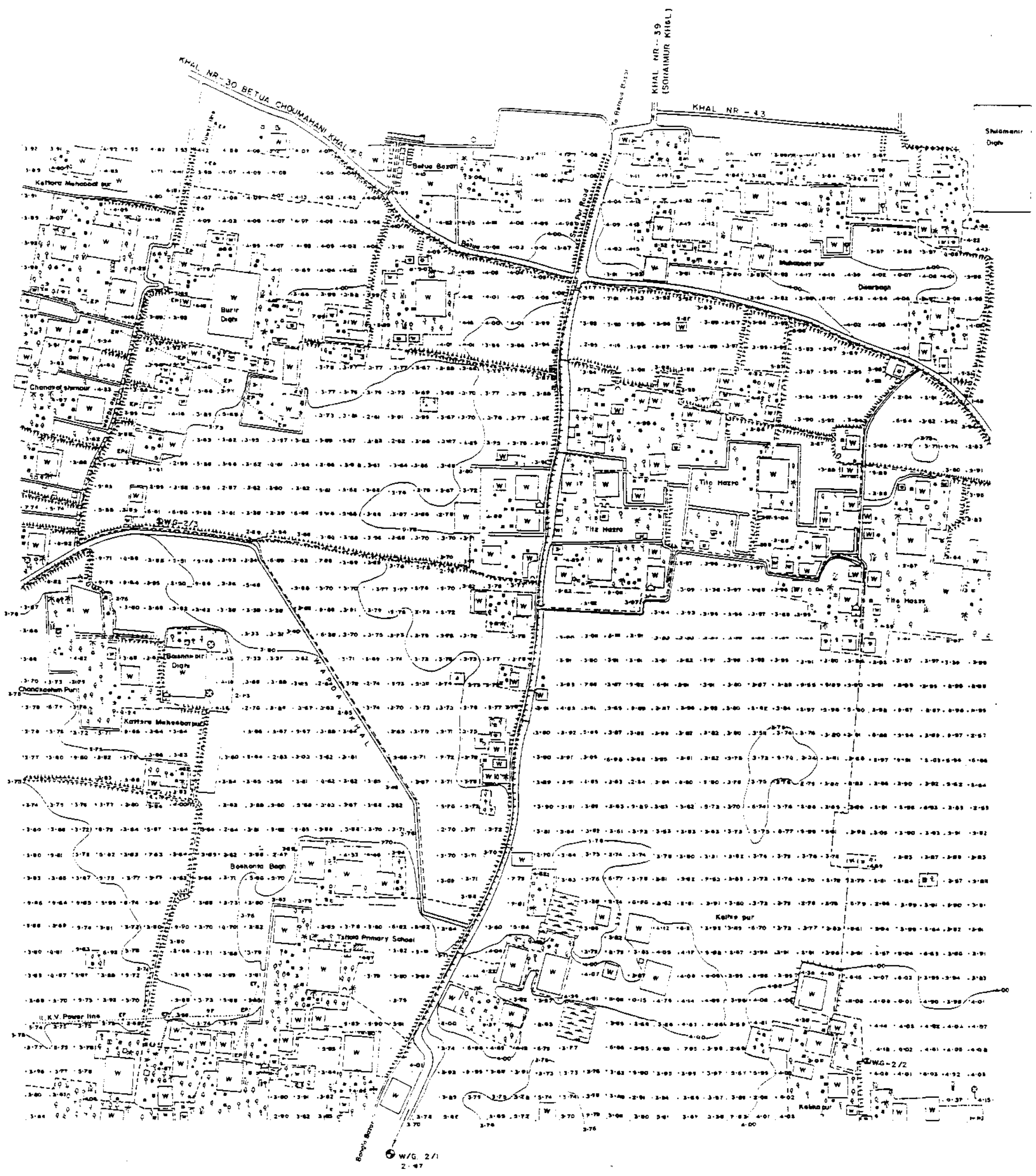
Figure I.III.2



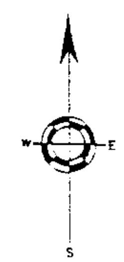
LEGEND

Metalled, Non Metalled & Brick Road
Cart-track with Wide Foot path
Ar-a- bank with water gauge, Khals
Canal, Embankment with sluice regulator
Pond, Water tank, Ditch or Borrow pit
Broken ground, Marsh, Mud
Electric main power line
Telephone line
Homestead, Huts, Tomb
Mosque, Idgah, Church, Temple
Tree: Prominent surveyed, Cultivation bank, Graves
Betelnut, Coconut, Bamboo, Other trees
Grass, Cane, Palm tree, Scurb
Boundary; District; Thana
Bench-mark, Levelled spot height ... 26·23 ... 23·7
Temporary Water Level Gauge ... W/G

Note:-

- Contour intervals 0.25 metres
- Contours have been shown by interpolation between levelled spot heights.
- All heights appearing in this sheet are in terms of PWD datum. To bring these heights in terms of SOB datum subtract 0·46 metre.
- Zero Value of Gauge 2/1, 2/2 & 2/3 are 2·47m, 4·40m & 3·98m.

Scale 1:500



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BANGLADESH WATER DEVELOPMENT BOARD

SOUTH EAST REGION
WATER RESOURCES DEVELOPMENT PROGRAMME

NOAKHALI NORTH PROJECT FEASIBILITY STUDY
TOPOGRAPHICAL SURVEY MAP OF SAMPLE AREA NO-2

SIR M. MACDONALD & PARTNERS LTD. UK.
NIPPON KOEI CO. LTD. JAPAN
RESOURCES DEVELOPMENT CONSULTANTS LTD. S. LANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH
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DATE	CHECKED
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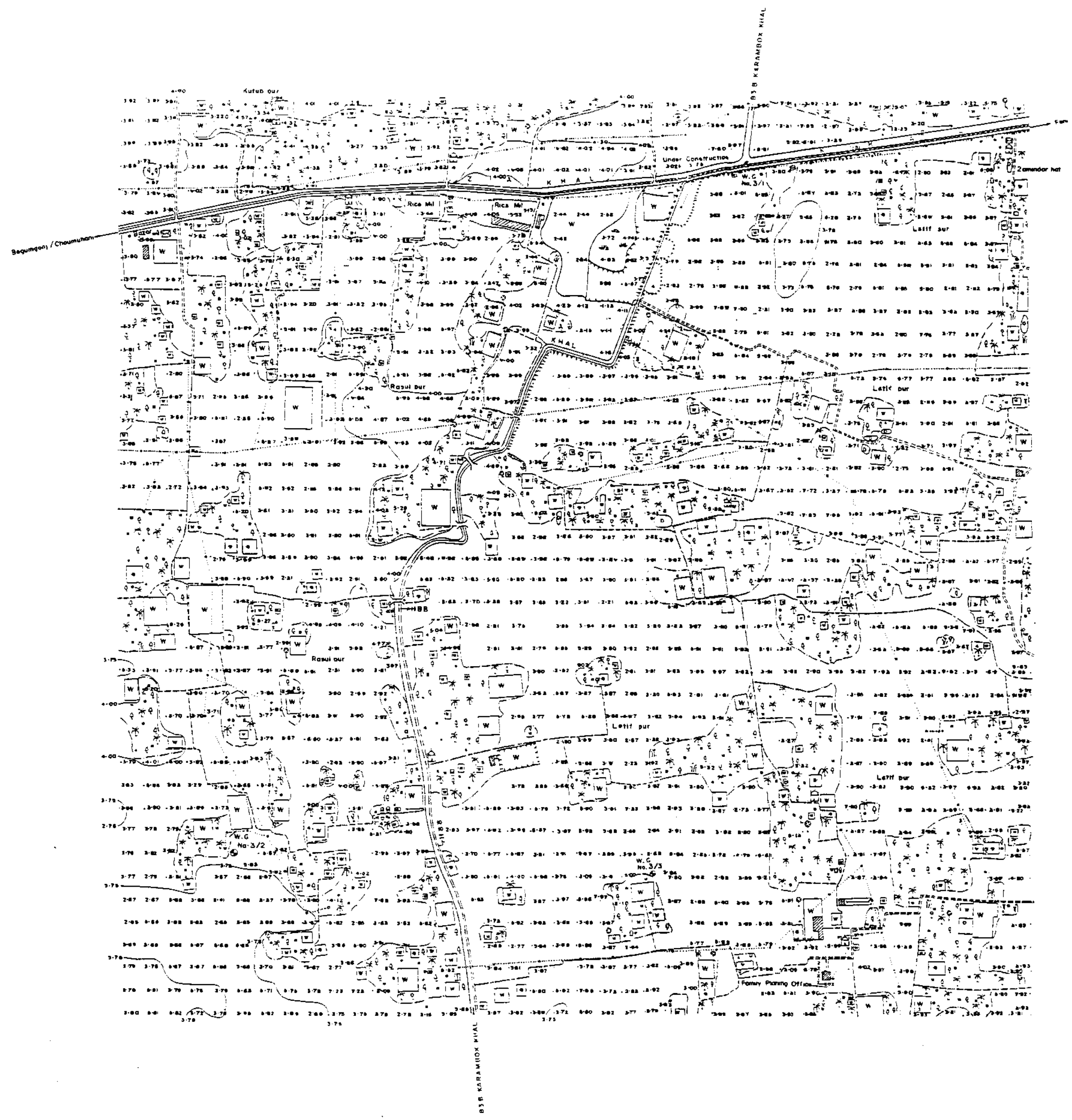
Figure I.III.3



LEGEND

Metalled, Non Metalled & Brick Road
Cart-Track with bridge, Foot path
River bank with water gauge, Khals
Canal, Embankment with sluice regulator
Pond, Water tank, Ditch or Borrow pit
Broken ground, Marsh, Mud
Electric main power line
Telephone line
Homestead, Huts, Tomb
Mosque, Idgah, Church, Temple
Tree: Prominent surveyed, Cultivation limit, Groves
Betelnut, Coconut, Bamboo, Other trees
Grass, Cane, Palm tree, Scrub
Boundary: District; Thana
Bench-mark, Levelled spot height — 26·23, ·22·3
Temporary Water Level Gauge — W/6.

Note:-

- Contour Intervals 0.25 metres
- Contours have been shown by interpolation between levelled spot heights.
- All heights appearing at this sheet are in terms of PWD datum. To bring these heights in terms of SOB datum subtract 0·46 metre.
- Zero Value of Gauge 3/1, 3/2 and 3/3 are 3·43m, 3·83m, 3·43m

Scale 1:500

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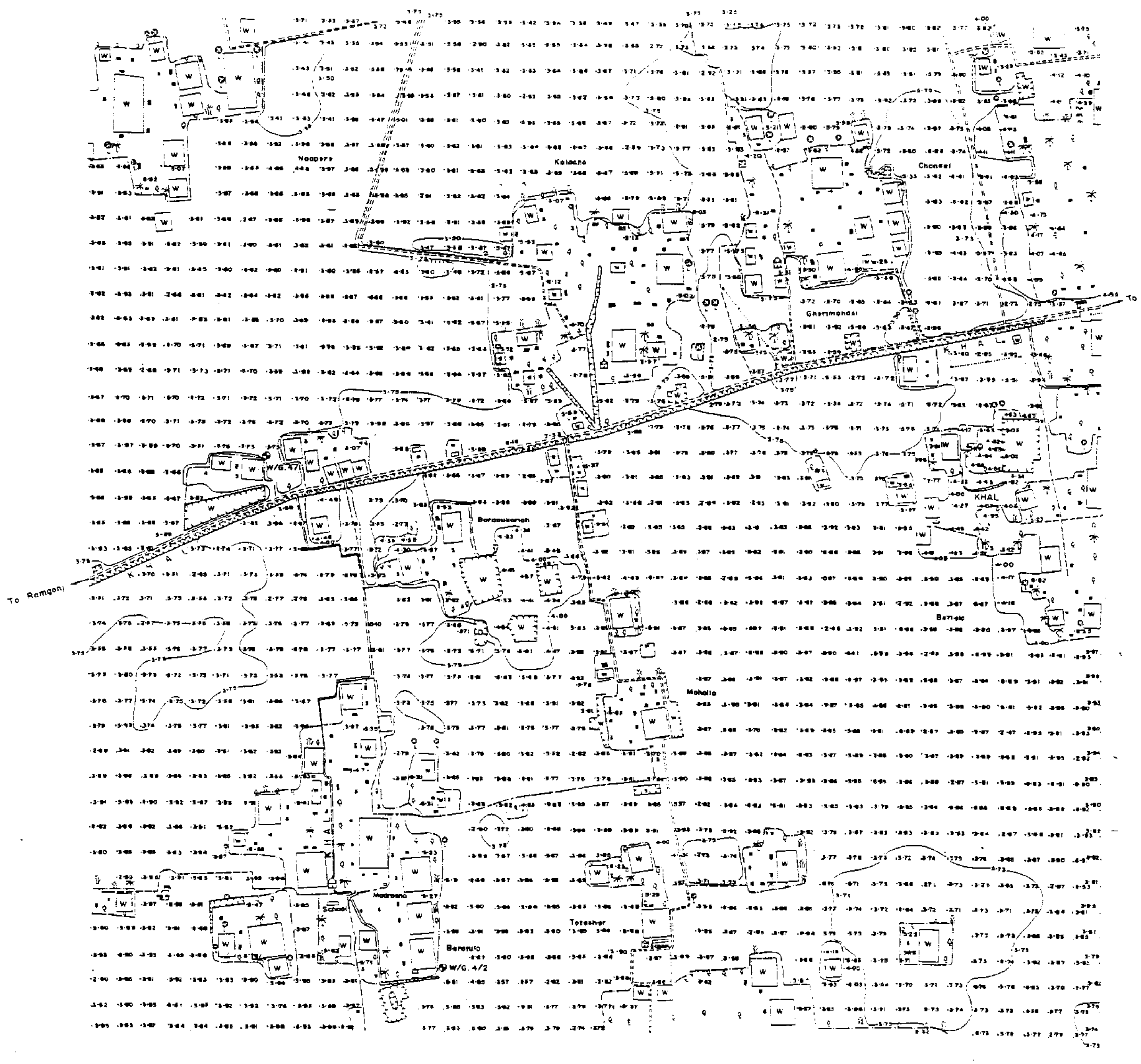
NOAKHALI NORTH PROJECT FEASIBILITY STUDY
TOPOGRAPHICAL SURVEY MAP OF SAMPLE AREA NO-3

SIR M. MACDONALD & PARTNERS LTD. UK.
NIPPON KOEI CO. LTD. JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. S. LANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH
DESH UPODESH LTD. BANGLADESH

DATE | CHECKED
DRAWN MD. ANAMUL HOQUE | APPROVED

SURVEYED BY
INTERNATIONAL SURVEY COMPANY | DRAWING NO. 5109/
626, EAST JURAIN, DHAKA

Figure I.III.4



LEGEND

- Metalled, Non Metalled & Brick Road
- Cart-track with bridge, Foot path
- River bank with water gauge, Khals
- Canal, Embankment with sluice regulator
- Pond, Water tank, Ditch or Borrow pit
- Broken ground, Marsh, Mud
- Electric main power line
- Telephone line
- Homestead, Huts, Tomb
- Mosque, Idgah, Church, Temple
- Tree: Prominent surveyed, Cultivation limit, Graves
- Betelnut, Coconut, Bamboo, Other trees
- Grass, Cane, Palm tree, Sauro
- Boundary: District; Thana
- Bench-mark, Levelled spot height — 26·23
- Temporary Water Level Gauge — W/G.

Note:-

- Contour intervals 0.25 metres
- Contours have been shown by interpolation between levelled spot heights.
- All heights appearing in this sheet are in terms of PWD datum. To bring these heights in terms of SOB datum substract 0·46 metre.
- Zero Value of Gauge 4/1 and 4/2 are 3·7m & 3·67m.

Scale 1:500

NO	DATE	DESCRIPTION
REVISION		

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BANGLADESH WATER DEVELOPMENT BOARD

SOUTH EAST REGION
WATER RESOURCES DEVELOPMENT PROGRAMME

NOAKHALI NORTH PROJECT FEASIBILITY STUDY
TOPOGRAPHICAL SURVEY MAP OF SAMPLE AREA NO-4

SIR M. MACDONALD & PARTNERS LTD. UK.
NIPPON KOEI CO. LTD. JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. S. LANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH
DESH UPDOESH LTD. BANGLADESH

DATE	CHECKED
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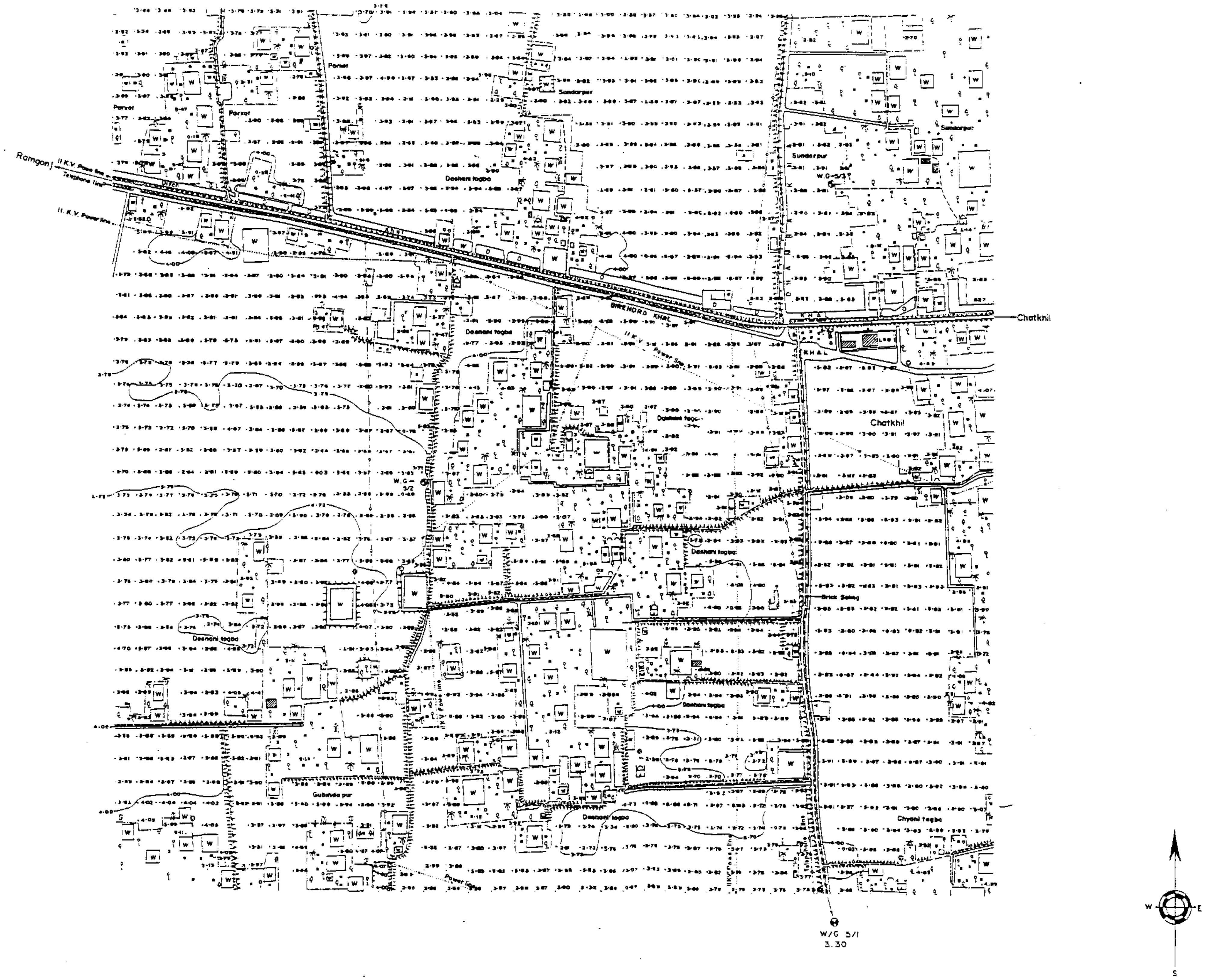
SURVEYED BY
INTERNATIONAL SURVEY COMPANY | DRAWING NO. 5109/
626, EAST JURAIN, DHAKA

Figure I.III.5



LEGEND

Metalled, Non Metalled & Brick Road
Cart-track with bridge. Foot path
River bank with water gauge. Khals
Canal. Embankment with sluice regulator
Pond. Water tank. Ditch or Borrowpit
Broken ground. Marsh. Mud
Electric main power line
Telephone line
Homestead, Huts. Tomb
Mosque. Idgah. Church. Temple
Tree: Prominent surveyed. Cultivation limit. Groves
Betelnut. Coconut. Bamboo. Other trees
Grass. Cane. Palm tree. Scrub
Boundary: District; Thana
Bench mark. Levelled spot height — 26·23
Temporary Water Level Gauge — W/G.

Note:-

- Contour intervals 0.25 metres
- Contours have been shown by interpolation between levelled spot heights.
- All heights appearing in the sheet are in terms of PWD datum. To bring these heights in terms of SOB datum subtract 0·46 metre.
- Zero value of Gauge 5/1, 5/2 and 5/3 are 3·30 m, 3·48 m and 3·70 m.

100 0 100 200 300 400 metres

Scale 1:500

NO.	DATE	DESCRIPTION
REVISION		

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WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

SOUTH EAST REGION
WATER RESOURCES DEVELOPMENT PROGRAMME

NOAKHALI NORTH PROJECT FEASIBILITY STUDY
TOPOGRAPHICAL SURVEY MAP OF SAMPLE AREA NO-5

SIR M. MACDONALD & PARTNERS LTD. UK.
NIPPON KOEI CO. LTD. JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. S. LANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH
DESH UPODESH LTD. BANGLADESH

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APPENDIX I.IV

BENCH-MARKS AND CHANNEL CROSS-SECTION LOCATIONS

LIST OF BENCH-MARKS CHECKED

A. Bench-Marks Used to Establish Water Level Gauge Zeros

Gauge Number	Gauge Location	Bench-Mark Description	B.M. Established by	SWMC/BWDB Elevation (m PWD)	1993 Elevation (m PWD)	Remarks
G-14	Laksham	B.M. kept on top of S.E. corner of bridge abutment near Daulatgonj Rly. station at Laksham.	SWMC/ BWDB	7.657	7.857	
G-19	Poloya	B.M. kept on N.E. corner of bridge 14/1 (Floor level) at Poloya, near Khila Bazar.	SWMC/ BWDB	8.064	8.044	
G-22	Chitoshi	B.M. kept on B.M. pillar situated on the bank of the River Dakatia near Kheya ghat at Santir Bazar behind shops.	SWMC/ BWDB	5.284	5.291	
G-23	Narimpur	B.M. kept on R.C.C. pillar to the south of the mosque at Narimpur Bazar.	SWMC/ BWDB	5.335	5.364	
G-26	Kacharia Bazar	B.M. (BWDB) kept at Kacharia Bazar near G-26, on the N-W corner of a bridge slab on the road towards the village.	SWMC/ BWDB	5.820	7.845	Presumed discrepancy in Bench-Mark description.
G-27	Barakanchi	B.M. kept on N.E corner of culvert slab at Barakanchi, culvert Nr.20/1, between 6 km and 7 km from Sonaimuri.	SWMC/ BWDB	7.365	7.387	
G-36	Piarapur	B.M. kept on top of the north-east corner of the abutment of R & H bridge over WAPDA Khal on the Lakshmipur-Ramgati road at Piarapur.	SWMC/ BWDB	7.341	7.279	
G-37	Mandari	B.M. kept on top of the lower most railing of Mandari R & H bridge on the Lakshmipur-Chandraganj Road.	SWMC/ BWDB	8.415	-	B.M. Not found.

Gauge Number	Gauge Location	Bench-Mark Description	B.M. Established by	SWMC/BWDB Elevation (m PWD)	1993 Elevation (m PWD)	Remarks
G-38	Chandraganj	B.M. kept on top of the north-east corner of the guard wall of Chandraganj R & H bridge Nr. 7/2	SWMC/ BWDB	8.883	8.857	
G-40	Begumganj	B.M. kept on R.C.C pillar fixed at the south of the office of the SDE (BWDB) at Begumganj, near bridge Nr. 1/1	SWMC/ BWDB	6.093	6.087	
G-42	Selonia	B.M. kept on R.C.C pillar (BM) fixed near N-W. side of the Selonia R & H Bridge and about 12 m west from the road edge.	SWMC/ BWDB	5.228	5.262	
G-49	Chatterpaiya Bazar	B.M. kept on top R.C.C pillar within the compound of Mr. Kalikumar's house about 175 m south of bazar and 33 m west of road at Chatterpaiya Bazar	SWMC/ BWDB	5.457	5.474	
G-51	Bangla Bazar	SOB Bench-Mark Nr. N98 is used for this gauge station	SWMC/ BWDB	7.088	7.083	
G-65	Basurhat Bazar	B.M. kept on S-E corner of the south footpath of the culvert at Basurhat Bazar.	SWMC/ BWDB	8.388	8.370	
G-68	Char Karimullah	B.M. kept on northern side of the veranda floor of Sluice Operator's house situated N-E of the Sluice at Char Karimullah.	SWMC/ BWDB	5.695	5.630	
G-77	Ramganj	B.M. kept on top of N-E corner of verandah floor of L.S.D godown-building near to the pond at Ramganj.	SWMC/ BWDB	5.005	-	Damaged
G-8	Zamindarhat	B.M. kept on the west end of the south parapet of bridge Nr.6/1 on the Chowmuhani-Feni Road east of Zamindar Hat Bazar.	SWMC/ BWDB	7.142	7.157	
G-91	Dasherhat	B.M. kept on top of bridge slab (N-E corner) at Dasherhat.	SWMC/ BWDB	7.150	7.069	

Gauge Number	Gauge Location	Bench-Mark Description	B.M. Established by	SWMC/BWDB Elevation (m PWD)	1993 Elevation (m PWD)	Remarks
G-92	Naodona	B.M. kept on top of steel cap of concrete pillar (BWDB permanent BM) situated north of bailey bridge at Naodona.	SWMC/ BWDB	5.439	5.122	
G-127	Shebarhat	B.M. kept on S.E corner of side bridge of Feni-Chowmuhani road about 50 m east of Shebarhat Bazar.	SWMC/ BWDB	6.176	6.205	
-	Kazirhat Regulator	B.M. kept on top of the upstream head wall of Kazirhat Regulator.	BWDB	5.486	5.435	
-	Rahmatkhali Regulator	B.M. kept on top of S-E corner of operating platform of Rahmatkhali Regulator at Mouzzarhat.	BWDB	7.767	7.762	
181	Gunabati Railway Bridge	B.M. on the southern side of the Feni-Laksham railway line, about 50m east of Gunabati railway bridge.	BWDB	8.020	8.014	
182	Companiganj	B.M. above the gauge on the head wall of sluice gate Nr. 11 at South Musapur.	BWDB	5.325	5.337	
222	Sonapur	B.M. is situated on an iron-capped pillar 28 feet south-east of railway telegraph post Nr. 109/17 on the west side of the railway and the right bank of Noakhali Khal at the house of Badiur Rahman Sareng in Shahpur village, about 0.5 km from the office of S.O, BWDB, Sonapur.	BWDB	5.523	5.496	Damaged
239	Lakshmipur	B.M. is situated on the first step of the western guard shed of the food depot, about 50 feet north of the LSD godown on the Lakshmipur-Rahmatkhali Regulator road.	BWDB	4.620	4.555	
58	Hajiganj	WAPDA B.M. to the west of the jute godown owned by Mr. A.M. Matin MP for Hajiganj, at Toragar, Hajiganj Bazar.	BWDB	4.907	3.867	

144

Gauge Number	Gauge Location	Bench-Mark Description	B.M. Established by	SWMC/BWDB Elevation (m PWD)	1993 Elevation (m PWD)	Remarks
240	Bhawaniganj	B.M. on pucca platform 300m west of Bhawaniganj Bazar	BWDB	3.487	3.775	Not used by SWMC
227	Chandpur	B.M. on the base of the lamp post about 60 m west of the Chandpur BWDB gauge station.	BWDB	5.410	5.329	
-	Chitalkhali	Chitalkhali IWTA BM at Char Abullah near IWTA Gauge Station	IWTA	5.096 (m CD)	3.672	IWTA Gauge Station CD = Chart Datum

B. Other Bench Marks.

Water Development Map Sheet Number	Bench-Mark Ref. Nr.	Bench-Mark Description	B.M. Established by	Elevation Stated on Map (m PWD) (ft SOB)	1993 Elevation (m PWD)	Remarks
9I/16/6	WD1	On the north-east corner of the bridge slab at Bijoy Nagar in front of Mr. Sekander Master's house (house name Farazi Bari)	SOB/BWDB	5.631 16.97	5.613	
9J/13/4	WD2	On the top step of the eastern parapet to the steps leading down from the cemented bench to the pond at Mr. Jahiruddin Paluan's Mosque on the South side of the Begumganj - Lakshmipur road at Atiatali.	SOB/BWDB	4.637 13.71	4.594	
79j/13/7	WD4	On the centre of the south guard wallof a culvert over a khal at Bat-tali on the Begumganj-Lakshmipur road ,near the junction with the road to Ramganj.	SOB/BWDB	7.524 23.18	7.516	
79J/13/7	WD5	On top the east end of the south parapet wall of the R&H bridge on the Begumganj-Lakshmipur Road at Uttar Chandrapur.	SOB/BWDB	6.412 19.63	6.439	

Water Development Map Sheet Number	Bench-Mark Ref. Nr.	Bench-Mark Description	B.M. Established by	1993 Elevation (m PWD)	Remarks
79J/13/4	FM 102	Finnmap BM pillar south of Lakshmipur at Shanserabad on road to Ramgati.	FINNMAP	4.829	FINNMAP Official elevations are not yet assigned.
79J/13/7	FM 1203	Finnmap BM pillar on west side of Battali-Kachua road at Kashipur, at the north-est corner of the pond at the crossing point of the channel beside the road from Kachua to Ruhith Khali via Dattapur.	FINNMAP	6.271	FINNMAP Official elevations are not yet assigned.
79I/16/9	FM 1205	Finnmap BM pillar on the west side of the Battali - Kachua road on the south side of Shahapur Bazar.	FINNMAP	5.571	FINNMAP Official elevations are not yet assigned.
79I/16/9	FM 1206	Finnmap BM pillar on the west side of the Battali - Kachua road 1 000 feet south of Kachua Bazar and 500 feet south of Kachua bridge.	FINNMAP	5.917	FINNMAP Official elevations are not yet assigned.
79I/16/5	FM 1207	Finnmap BM pillar north-west of Kachua beside the road to Ramganj.	FINNMAP	6.244	FINNMAP Official elevations are not yet assigned.
79J/13/4	FM 4412	Finnmap BM pillar at the south-east corner of the compound of Forkania Madrasha, adjacent to the house of Kabir Bari on the north side of the Begumganj - Lakshmipur road at Atiatali.	FINNMAP	4.576	FINNMAP Official elevations are not yet assigned.

Water Development Map Sheet Number	Bench-Mark Ref. Nr.	Bench-Mark Description	B.M. Established by	1993 Elevation (m PWD)	Remarks
79J/13/4	FM 4413	Finnmap BM pillar near the house of Mansinga Bari in the village of Jadia west of a bridge on the Begumganj - Lakshmipur road.	FINNMAP	5.305	FINNMAP Official elevations are not yet assigned.
79J/13/4	FM 4414	Finnmap BM pillar beneath a tong shop about 500 feet east of Mandari R & H bridge on the Begumganj - Lakshmipur road, at the junction with the road to Mandaribazar.	FINNMAP	4.940	FINNMAP Official elevations are not yet assigned.
79J/13/7	FM 4415	Finnmap BM pillar on the south-east corner of Hazipara High School compound/field on the north side of the Begumganj - Lakshmipur road.	FINNMAP	5.187	FINNMAP Official elevations are not yet assigned.
79J/13/7	FM 0909	Finnmap BM pillar on the north side of the Begumganj - Lakshmipur road at the crossing of the Shaderghar - Kamarerhat road.	FINNMAP	5.357	FINNMAP Official elevations are not yet assigned.
79J/13/7	FM 4416	Finnmap BM pillar south of the mosque at Deopara on the north side of the Begumganj - Lakshmipur road west of Chandraganj Bazar.	FINNMAP	5.662	FINNMAP Official elevations are not yet assigned.
79N/1/1	FM 4417	Finnmap BM pillar about 200 feet east of Poluanbaria Bazar between Lakuria Kandi and Sujatpur on the Begumganj - Lakshmipur road.	FINNMAP	5.480	FINNMAP Official elevations are not yet assigned.
79N/1/1	FM 4418	Finnmap BM pillar in front of campus of Gafur Company (brick manufacturers) on the south side of the Begumganj - Lakshmipur road near Banglabazar.	FINNMAP	5.525	FINNMAP Official elevations are not yet assigned.

Water Development Map Sheet Number	Bench-Mark Ref. Nr.	Bench-Mark Description	B.M. Established by	1993 Elevation (m PWD)	Remarks
79N/1/1	FM 4419	Finnmap BM pillar 500 feet west of Kendurbagh Bazar and 200 feet west of kilometre post 3 from Begumganj, on the north side of the Begumganj-Lakshmipur road.	FINNMAP	5.719	FINNMAP Official elevations are not yet assigned.
79N/1/4	FM 4420	Finnmap BM pillar in Begumganj in front of the BADC oil tank on the south side of the Feni - Lakshmipur road, near the north-east corner of the Police Station.	FINNMAP	5.657	FINNMAP Official elevations are not yet assigned.
79N/1/4	FM 4421	Finnmap BM pillar at Lakshminarayanpur on the Feni - Begumganj road, on the east side of Surbapool bridge at the north-west corner of a tank.	FINNMAP	5.704	FINNMAP Official elevations are not yet assigned.
79N/1/3	FM 0903	FM BM situated at village Kaladarap and about 10m. south from center line of Dighali-Sudharam Embankment.	FINNMAP	5.724	FINNMAP Official elevations are not yet assigned.
79N/1/6	FM 118	FM BM situated at Ansar Company Bazar and about 3.5 km. from sonapur and south side of sonapur-Atkopalia Road.	FINNMAP	7.022	FINNMAP Official elevations are not yet assigned.
79N/1/8	FM 123	FM BM situated in the village Sundalpur, North side of Kabirhat-Sonapur road and north side of water tank.	FINNMAP	6.331	FINNMAP Official elevations are not yet assigned.
79N/1/8	FM 125	FM BM situated in front of Kefayet Ullah's shop on Harishchandra Bhuiyan's hat.	FINNMAP	6.433	FINNMAP Official elevations are not yet assigned.

148

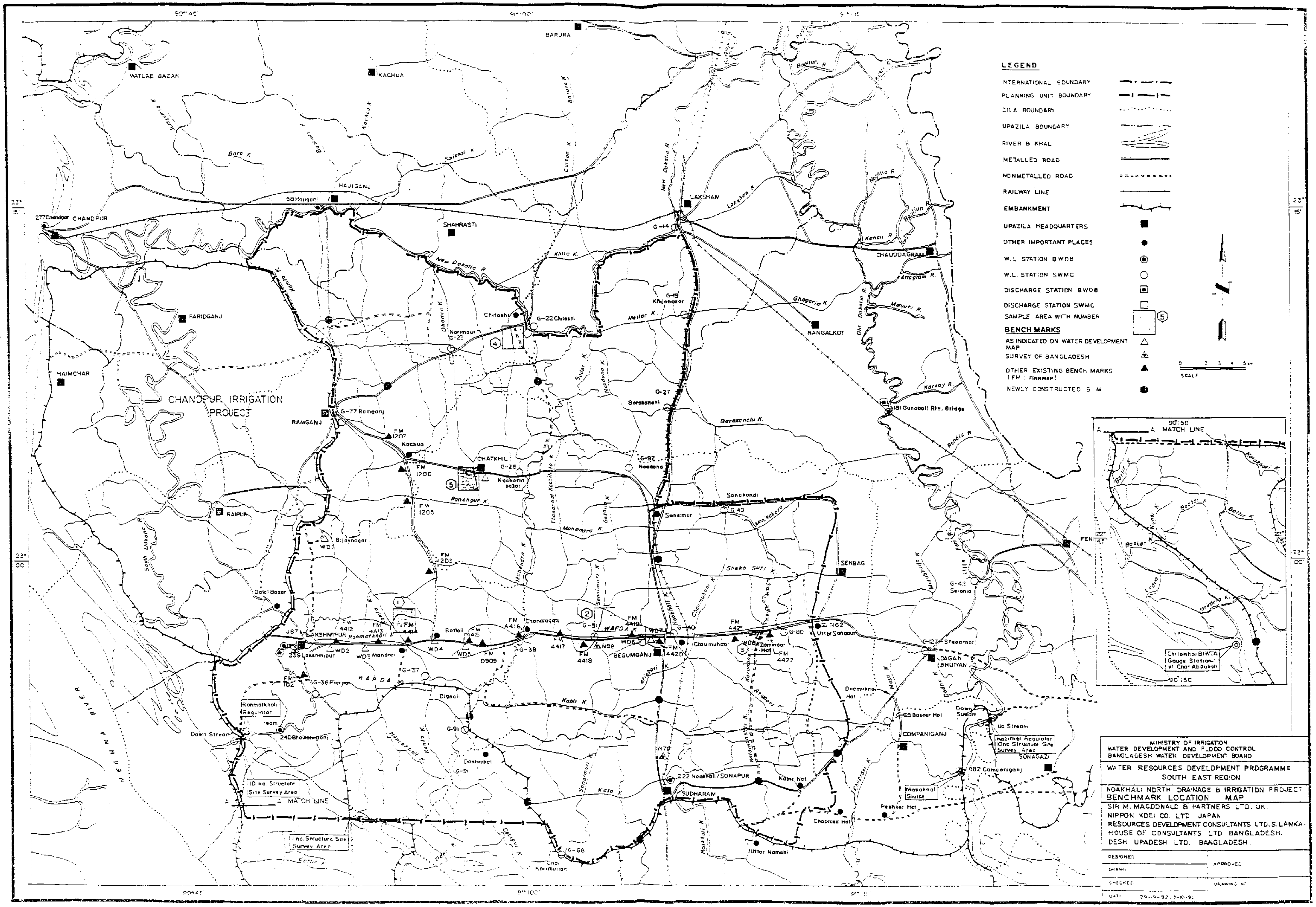
C. Bench Marks Maintained by Survey of Bangladesh

Water Development Map Sheet Number	Bench-Mark Ref. Nr.	Bench-Mark Description	B.M. Established by	Elevation given by SOB (m PWD) / (ft, SOB)	1993 Elevation (m PWD)	Remarks
79J/13/1	J87	At the west end of the first step from the bottom of the steps to the front (south) verandah of Lakshmipur Police Station.	SOB	4.778 14.171	4.546	1993 elevation adopted.
79N/1/1	N98	Engraved on top the north-west wingwall of bridge Nr.4/1 at Banglabazar on the Chaumuhani - Lakshmipur road.	SOB	7.082 21.729	7.083	
79N/1/5	N79	Engraved on the north-west corner of the cemented flooring of the east verandah of Maijdi Court Railway Station.	SOB	6.290 19.133	6.292	
79N/1/7	N62	Engraved on the western bottom of the south parapet of the bridge on the Feni- Lakshmipur Road, 150 feet east of the junction with the road from Senbagh Police Station.	SOB	7.697 23.745	7.697	

Note: For bench-mark locations see Bench-Mark Location Map (Figure I.IV.1)

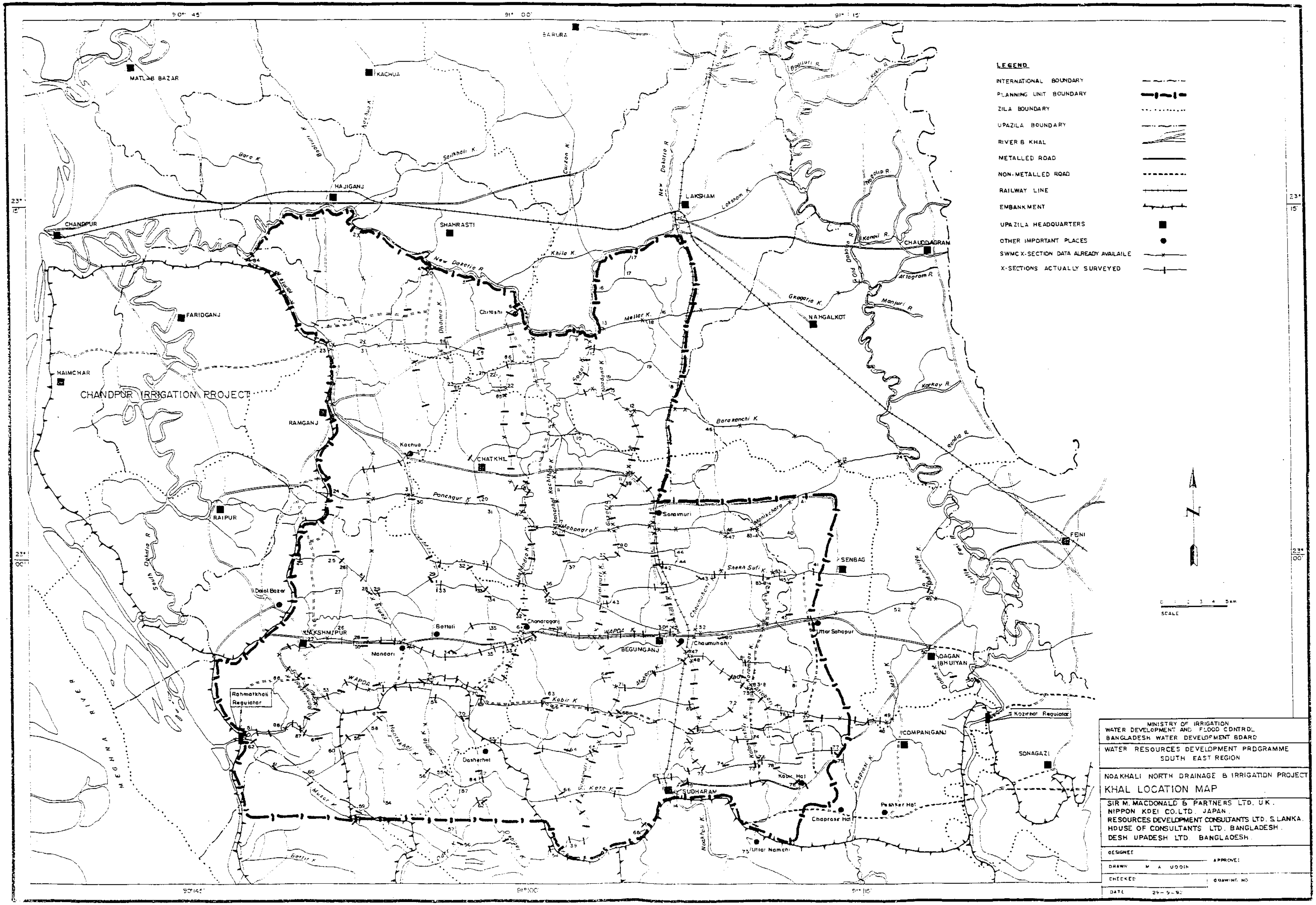
149 140

Figure I.IV.1



150 150

Figure I.IV.2



APPENDIX I.V

WATER LEVEL OBSERVATIONS AT RAHMATKHALI REGULATOR

TABLE I.V.1

Water Levels Downstream of Rahamatkhali Regulator

DATE	Water Level (m above PWD)																
	0600 hrs	0700 hrs	0800 hrs	0900 hrs	1000 hrs	1100 hrs	1200 hrs	1300 hrs	1400 hrs	1500 hrs	1600 hrs	1700 hrs	1800 hrs	HWL	TIME	LWL	TIME
2.2.93											0.5244	0.3720	0.2195			0.0671	19.30
3.2.93	0.5488	0.3994	0.2957	0.1951	0.1677	0.3720	0.7043	0.9055	1.3140	1.0091	0.8049	0.5762	0.4482	1.0091	15.00	0.1433	8.30
4.2.93	0.8049	0.6006	0.4482	0.2957	0.1951	0.1433	0.3720	0.7774	0.9817	1.1341	1.0579	0.8811	0.6524	0.8049	6.00	0.0671	9.30
5.2.93	1.0091	0.8293	0.6006	0.4482	0.2957	0.1433	0.1189	0.7043	1.0335	1.3140	1.4146	1.2348	0.9055	1.8201	5.00	0.1189	12.00
6.2.93	1.3628	1.0579	0.7774	0.6006	0.3994	0.2195	0.0671	0.2713	1.0335	1.0823	1.3872	1.5915	0.8537	2.1250	5.00	-0.0854	12.30
7.2.93	1.7957	1.3628	1.0579	0.7530	0.5488	0.3201	0.1433	-0.0091	0.9817	1.4634	1.8201	1.9970	1.7439	2.2012	5.30	-0.0091	13.00
8.2.93	2.0488	1.6677	1.3140	0.9817	0.7043	0.4482	0.2195	0.0671	0.0945	1.3628	1.7683	2.1494	2.1006	2.1494	7.00	0.0671	13.30
9.2.93	2.2774	1.9726	1.5152	1.1860	0.9055	0.2957	0.0671	0.1433	-0.0091	0.9055	1.5152	1.9726	2.2774	2.2774	17.30	0.0671	12.00
10.2.93	2.2012	2.1250	1.7439	1.3628	1.0091	0.7043	0.4238	0.2957	0.1433	-0.0335	1.2622	1.6677	2.0732	2.2012	6.40	-0.0335	15.00
11.2.93	1.7744	2.0732	1.9238	1.5152	1.1860	0.8537	0.6006	0.3720	0.2195	0.0945	0.1189	1.0579	1.5396	2.0732	7.00	-0.0091	15.30
12.2.93	1.3628	1.6189	1.8201	1.6677	1.2348	0.9817	0.7043	0.5244	0.2957	0.1433	0.0671	0.1433	0.8811	1.8201	7.30	0.0671	16.00
13.2.93	0.9055	1.2104	1.4390	1.6677	1.4634	1.1341	0.9055	0.6006	0.4726	0.2713	0.1189	0.1189	0.6006	1.6433	8.00	0.0945	16.40
14.2.93	0.2957	0.7530	1.0579	1.3628	1.4909	1.4390	1.0579	0.8293	0.5244	0.5244	0.3201	0.2195	0.1677	1.4909	8.45	0.2195	17.30
15.2.93	0.3720	0.2957	0.4482	0.8537	1.0823	1.2866	1.3384	1.1341	0.9299	0.7530	0.6006	0.3720	0.0671	1.2104	9.45	0.0671	18.00
16.2.93	0.6006	0.4482	0.2957	0.2713	0.5000	0.8293	1.0579	1.2104	1.3140	1.2104	1.0091	0.8293	0.7043	1.3140	14.00	0.2713	21.00
17.2.93	1.0579	0.7530	0.5762	0.4482	0.2957	0.4482	0.9055	1.1585	1.3628	1.5152	1.4146	1.2104	1.0579	1.5152	15.00	0.2957	22.00
18.2.93	1.5152	1.2104	0.8537	0.6768	0.3720	0.2439	0.5762		1.1341	1.6677	1.8201	1.5915	1.2866	1.8201	16.00	0.2439	23.00

Note: These water levels were taken by measurement from the downstream right wingwall top with an assumed elevation of 25.47 ft (7.76 m) rather than 25.00 ft (7.62 m) as shown on the design drawing of the regulator.

Source: Consultant's Observations.

TABLE I.V.2

Water Levels at Rahmatkhali Regulator
Monthly Highest High Water and Lowest Low Water

Month	Downstream Water Level (m above PWD)											
	1987		1988		1989		1990		1991		1992	
	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL
January	1.92	-0.12	1.83	-0.24	1.71	0.00	2.21	0.00	2.07	0.00	1.74	0.00
February	2.09	-0.02	1.80	-0.24	1.83	0.15	2.26	0.00	2.38	0.00	2.13	0.00
March	2.07	-0.29	2.42	-0.29	2.29	0.15	2.39	0.08	2.44	0.06	2.65	0.00
April	2.44	-0.23	2.38	-0.29	2.71	0.00	2.90	0.15	3.51	0.27	2.44	0.09
May	2.62	0.21	2.59	0.00	2.90	0.06	3.26	0.24	3.05	0.49	2.74	0.24
June	4.15	0.56	3.34	1.16	3.51	0.76	3.66	0.76	3.90	0.98	2.68	0.37
July	3.96	0.56	3.63	1.22	5.56	1.40	4.18	1.52	4.21	1.68	3.75	0.76
August	4.12	1.89	4.21	1.83	4.12	1.37	4.42	1.71	4.27	1.74	3.81	0.91
September	4.09	1.62	3.81	1.49	3.90	1.37	3.45	1.52	4.04	1.52	3.93	1.37
October	3.66	1.07	3.81	0.82	4.27	0.91	4.79	0.85	3.26	1.31	2.99	1.22
November	2.68	0.61	3.35	0.49	2.68	0.24	3.84	0.40	2.65	0.43		
December	2.44	0.30	2.74	0.06	2.13	0.09	2.50	0.09	2.62	0.00		

Month	Upstream Water Level (m above PWD)											
	1987		1988		1989		1990		1991		1992	
	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL
January	1.98	0.91	2.07	0.82	2.04	1.17	1.81	1.10	2.32	1.40	2.04	0.69
February	1.37	0.82	1.83	0.61	1.37	0.79	1.74	1.22	2.04	1.10	2.21	0.91
March	0.91	0.49	1.31	0.30	1.68	0.79	2.68	1.25	1.98	1.60	2.16	1.30
April	2.44	0.71	1.34	0.61	1.75	0.91	2.29	1.22	2.01	1.04	1.98	0.76
May	1.37	0.46	2.44	0.47	2.44	1.40	2.44	1.52	2.44	1.28	2.38	0.91
June	2.13	0.56	2.71	1.52	3.05	1.39	2.71	1.52	3.35	1.65	2.32	0.88
July	3.17	2.20	3.20	1.83	3.05	1.22	2.99	1.91	3.35	1.77	2.68	1.22
August	3.60	2.65	3.96	2.20	2.56	1.95	3.35	2.07	3.54	1.83	2.90	1.22
September	3.60	1.77	3.41	1.83	3.23	1.98	3.05	1.74	3.31	2.01	2.71	1.55
October	3.20	1.07	3.51	1.10	3.57	1.92	3.61	1.59	3.26	1.40	2.53	1.43
November	2.97	1.07	3.02	0.91	2.44	1.37	3.05	0.84	2.94	1.10		
December	2.30	2.09	2.68	2.07	2.38	1.83	2.29	2.13	2.48	2.07		

Source :

Sub-Divisional Engineer's Office, BWDB
Dalal Bazar, Lakshmipur

APPENDIX I.VI

PERSONAL COMMUNICATION ON SEA LEVEL RISE

The University of Waikato

Te Whare Wānanga o Waikato
Private Bag 3105, Hamilton, New Zealand.
Telephone 0-7-856 2889, Central Fax 0-7-856 0135.

Centre for Environmental and Resource Studies (CEARS)

February 4, 1993

Mike Polnitz
Mott MacDonald Asia
122 Gulshan Avenue
PO Box 194
Dhaka
Bangladesh

Dear Mike

Thank you for your time in Dhaka during late January 1993.

As promised I have enclosed the latest sea-level rise curves and a draft summary of these figures from our project. I trust they are useful. I have highlighted the Wigley and Raper reference. This article gives the latest sea-level rise projections.

Thank you again for your time. My next visit to Dhaka will be in mid-June 1993. If you feel there is any information you think may be important for our project, or any further help I can provide to your team, please do not hesitate to contact me at the above address.

Sincerely

Dr Robert Kay.

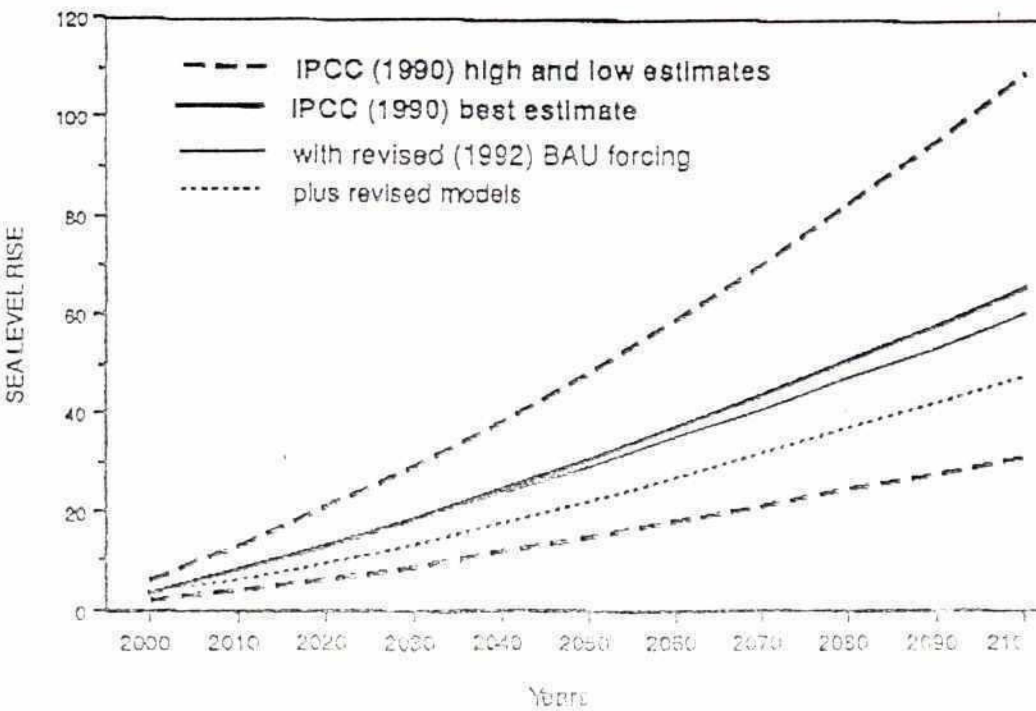
Phone: 07 838 4283
Fax: 07 838 4289

156

PROJECTING FUTURE SEA LEVEL RISE

Several recent projections of future sea level rise have been made based on IPCC "business-as-usual" GHG forcing scenarios. The IPCC (1990), using "best-estimate" climate and sea level model parameters, projected a 1990-2100 rise of **66cm**, with a range of uncertainty of **31-110cm**. A lower "business-as-usual" by IPCC (1992) results in a rise of **60cm**, assuming the same model parameters. With revised models based on recent IPCC (1992) findings, the projection is **48cm.** These estimates suggest a **rate** of sea level rise that is **2-6 times higher** than that experienced over the last 100 years.

Sources: R.A. Warrick and J. Oerlemans ((1990): Sea level rise. In J.T. Houghton, G. J. Jenkins and J.J. Ephraums (eds), *Climate Change: The IPCC Scientific Assessment*. Cambridge University Press, Cambridge. J.T. Houghton, B.A. Callander and S.K. Varney (eds) (1992): *Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment*. Cambridge University Press, Cambridge. T.M.L. Wigley and S.C.B. Raper (1992): *Implications for climate and sea level of revised IPCC emission scenarios*. Nature, Vol. 357, No. 6376, p. 293-300.



APPENDIX I.VII

SHALLOW BOREHOLE INVESTIGATION RESULTS

TABLE I.VII.1

Grain Size Analysis of Samples Collected from Exploratory Boreholes in the Noakhali North Area

Sample No.	% sand	% of silt	% of clay	Total
2A	0.667	77.56	21.776	
2B	0.667	69.720	29.613	
3C	6.87	89.51	3.62	
4C	6.48	84.09	9.43	
4D	3.89	86.16	9.95	
5C	6.89	76.29	16.82	
5D	82.10	14.81	3.09	
6D	50.20	44.55	5.25	
6F	37.0	55.01	7.99	
9A	92.06	5.29	2.65	
10A	42.08	49.05	8.87	
10F	92.22	4.66	3.12	
11B	71.87	23.55	4.58	
12A	0.16	85.95	13.89	
12C	24.05	58.62	17.33	

TABLE I.VII.2

Chemical Analysis of Soil Samples Collected from Exploratory Boreholes in the Noakhali North Project Area

No of Samples	pH	Ec us/cm	% organic carbon	% organic matter	Phosphorus PPM
BH-2A	7.55	710	0.5780	0.9964	570
BH-2B	7.66	810	0.5866	1.0112	630
BH-3C	7.62	480	0.5176	0.8923	570
BH-4C	7.42	740	0.6039	1.0411	600
BH-4D	7.57	620	0.3105	0.5353	530
BH-5C	7.00	280	0.3278	0.5651	530
BH-5D	7.33	120	0.0690	0.1189	660
BH-6D	7.26	270	0.2760	0.4758	650
BH-6F	7.22	260	0.3019	0.5204	700
HTW-9A	7.21	100	0.0862	0.1486	950
BH-10A	7.27	260	0.2847	0.4908	630
BH-10F	7.37	240	0.2502	0.4313	810
BH-11B	7.35	160	0.1294	0.2230	650
BH-12A	7.60	270	0.3019	0.5204	680
BH-12C	7.50	370	0.3537	0.6097	650

BOREHOLE NO : BH-1
HTW NO. HTW-1

WATER QUALITY

Water from Kata Khal adj to BH-1
EC = 450 µs/cm
TDS = 310

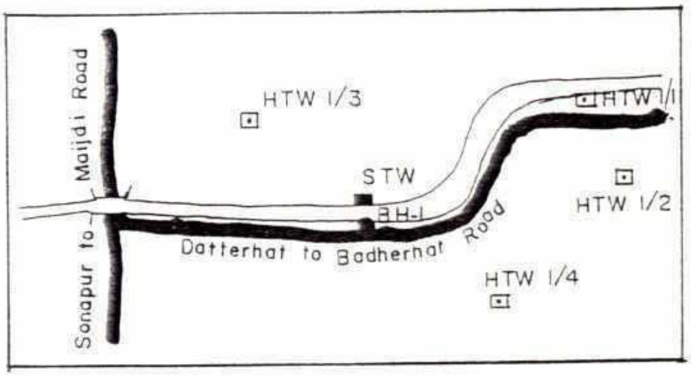
HTW 1/1. 200'-0" NE of BH-1
EC = 1200 µs/cm
TDS = 1900

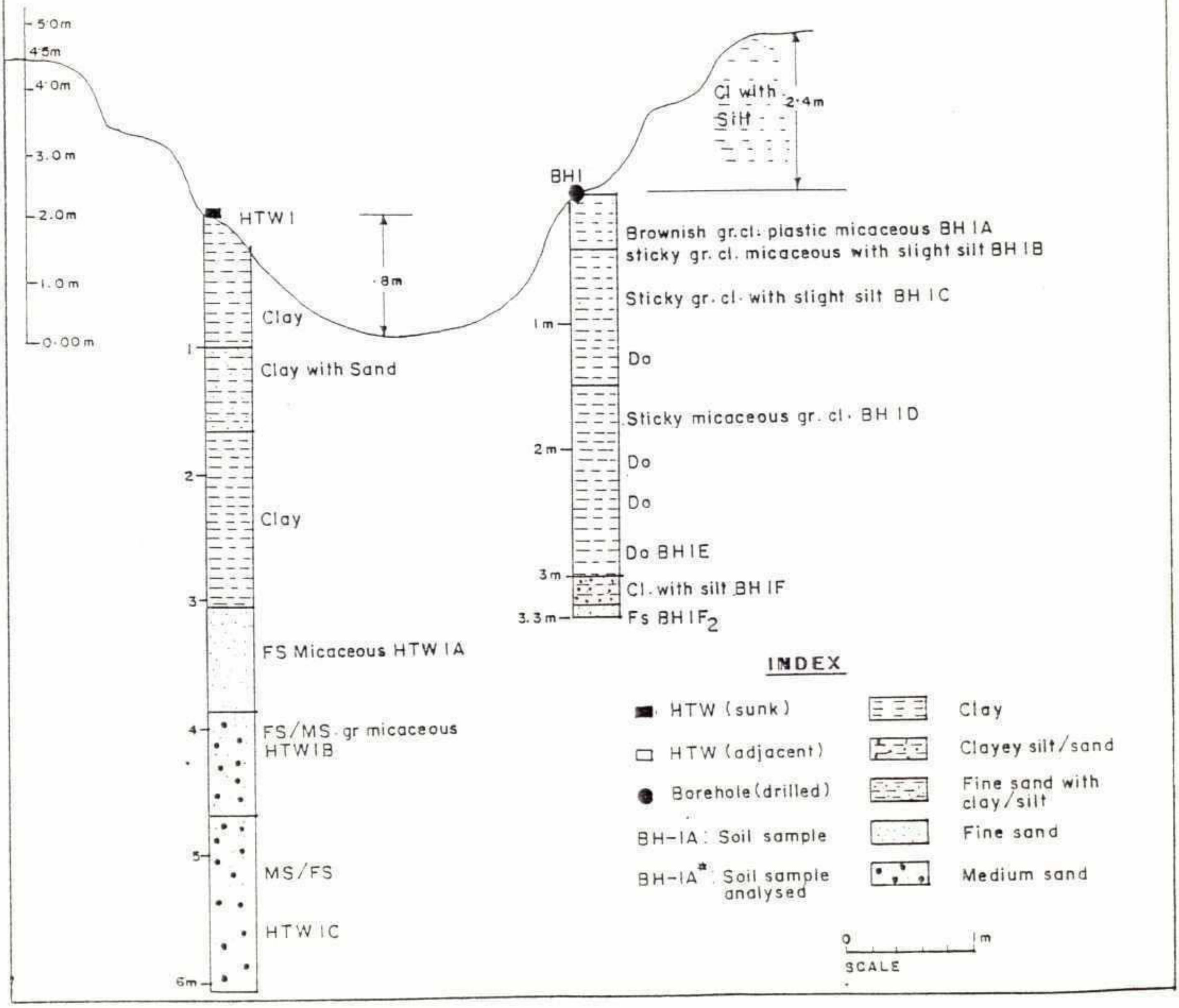
HTW 1/2 200'-0" NE of BH-1
EC = 1200 µs/cm
TDS = 900

HTW 1/3. 100'-0" N of BH-1
EC = 1000 µs/cm
TDS = 700

HTW 1/4. 200'-0" SE of BH-1
EC = 1000 µs/cm
TDS = 700

SITE LOCATION

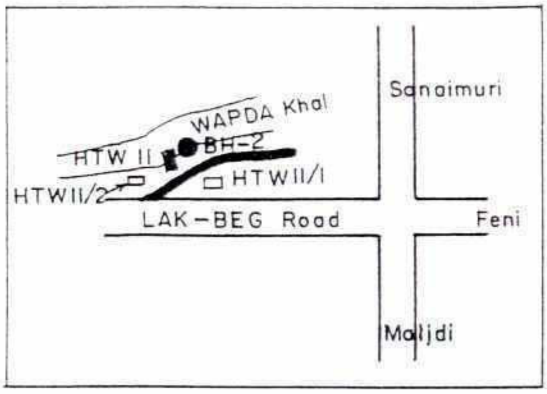


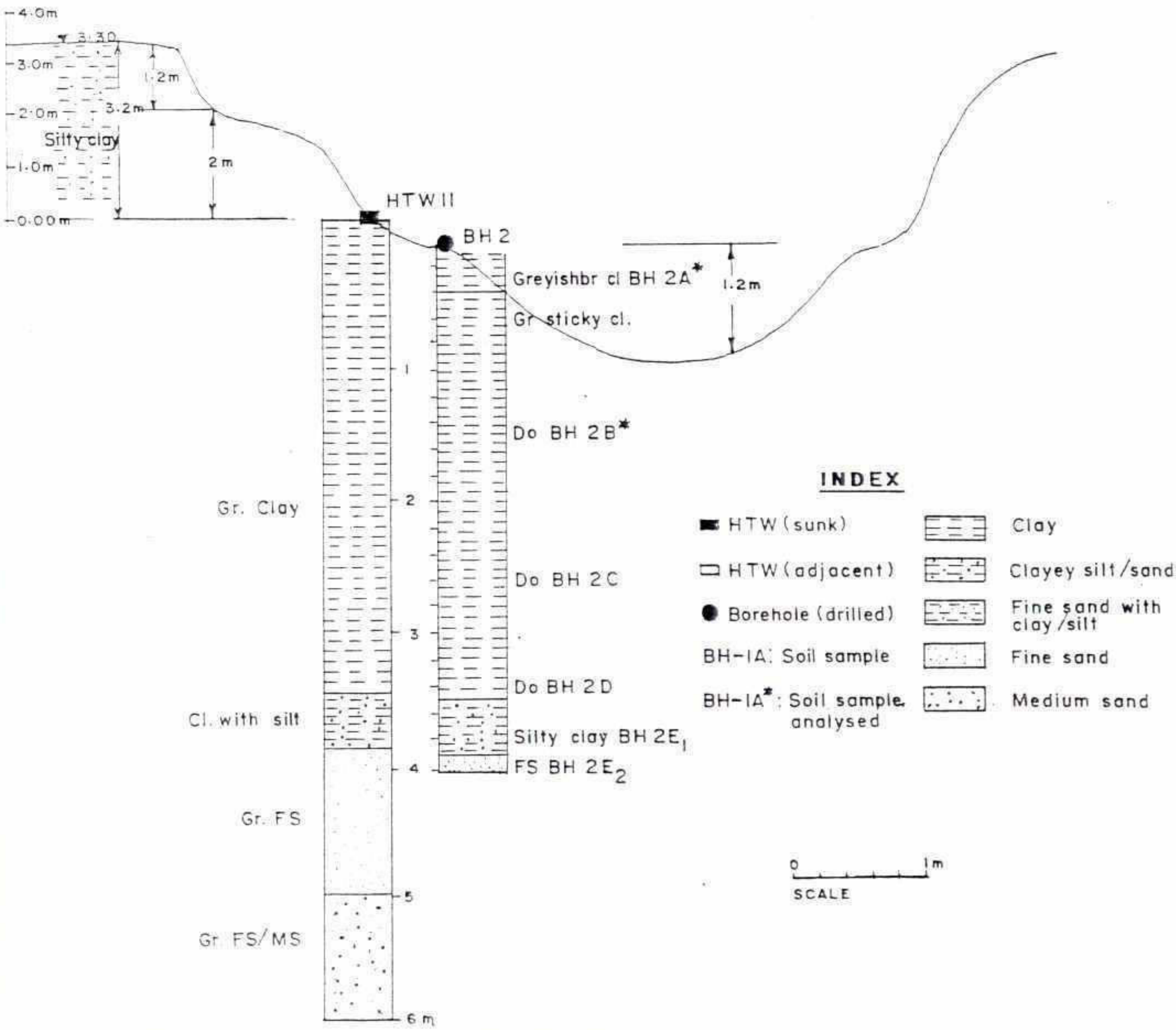


BOREHOLE NO: BH-2
HTW NO. HTW-II
WATER QUALITY

HTW II/I = Adj to BH-2
EC = 2300 μs/cm, TDS = 1600
HTW II/2 200' w of HB-2
EC = 2300 μs/cm TDS = 1600
Pond water, adj to HB-2
EC = 260 μs/cm, TDS = 210
Khal water, adj to HB-2
EC = 1400 μs/cm
TDS = 1000

SITE LOCATION





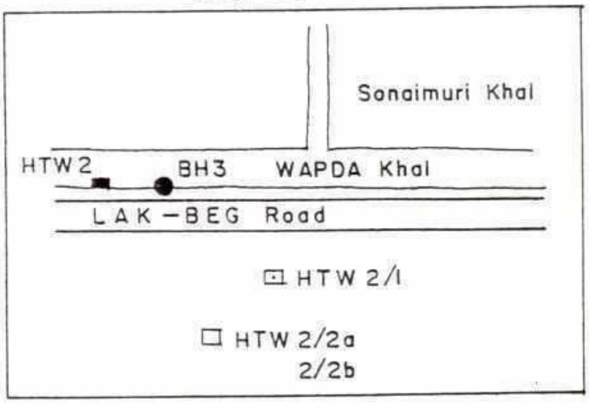
BOREHOLE NO: BH-3

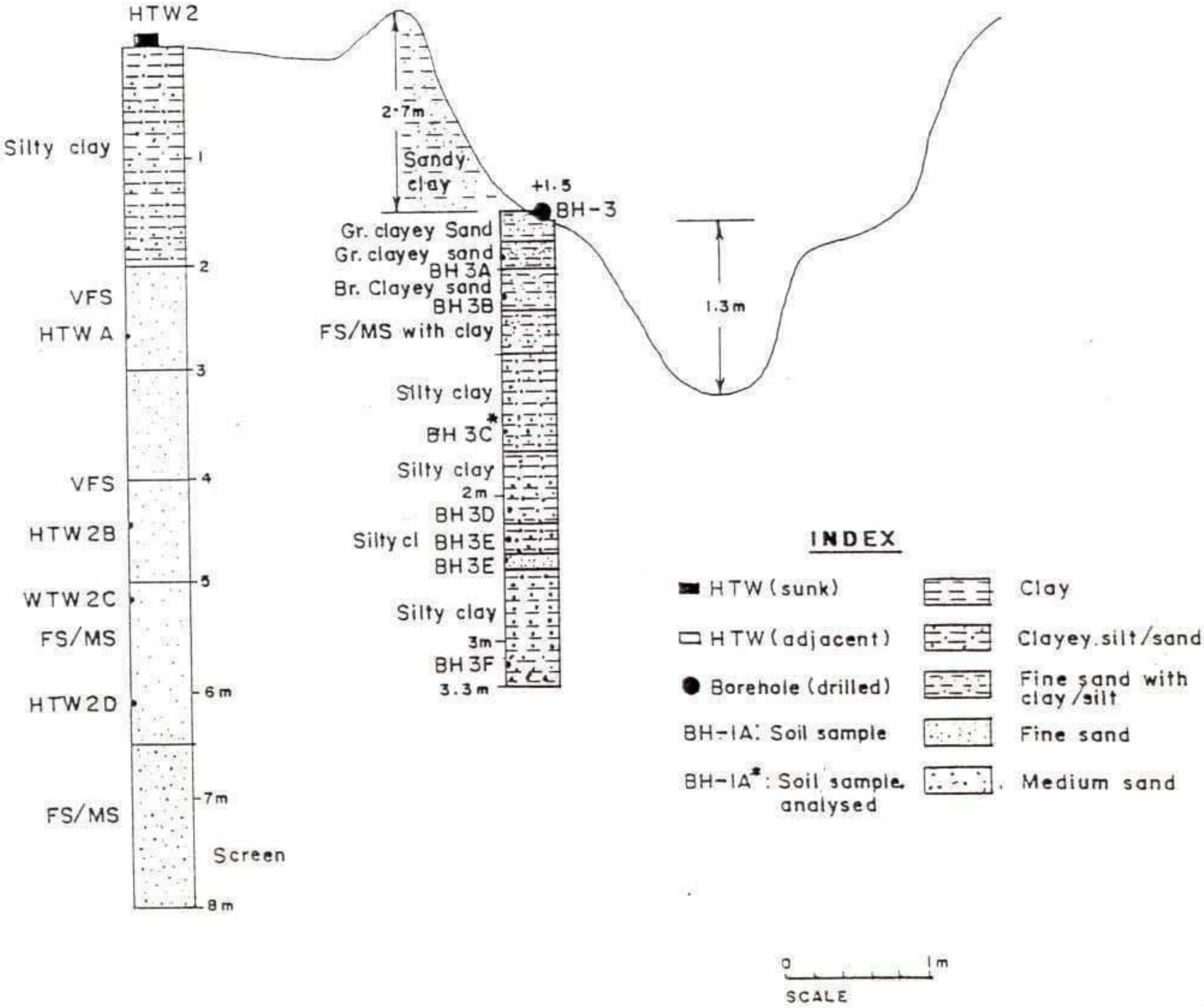
HTW NO. HTW-2

WATER QUALITY

WAPDA Khal water adj to BH-3
EC= 900 μs/cm, TDS= 600
HTW 2/1 100' SE of BH=3
EC= 1200 μs/cm, TDS= 850
HTW 2/2a 200' SE of BH-3
EC= 650 μs/cm, TDS= 450
HTW 2/2b 200' SE of BH-3
EC= 2000 μs/cm, TDS= 1400

SITE LOCATION

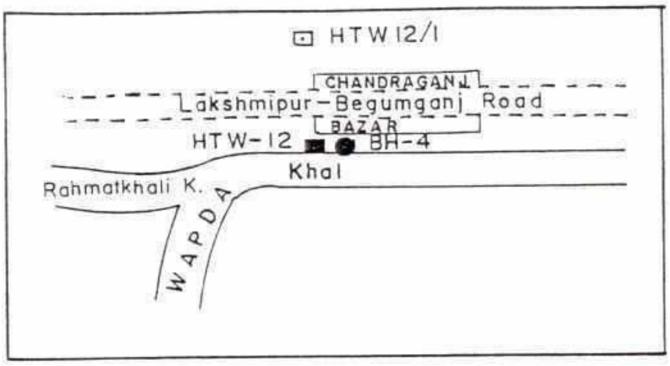


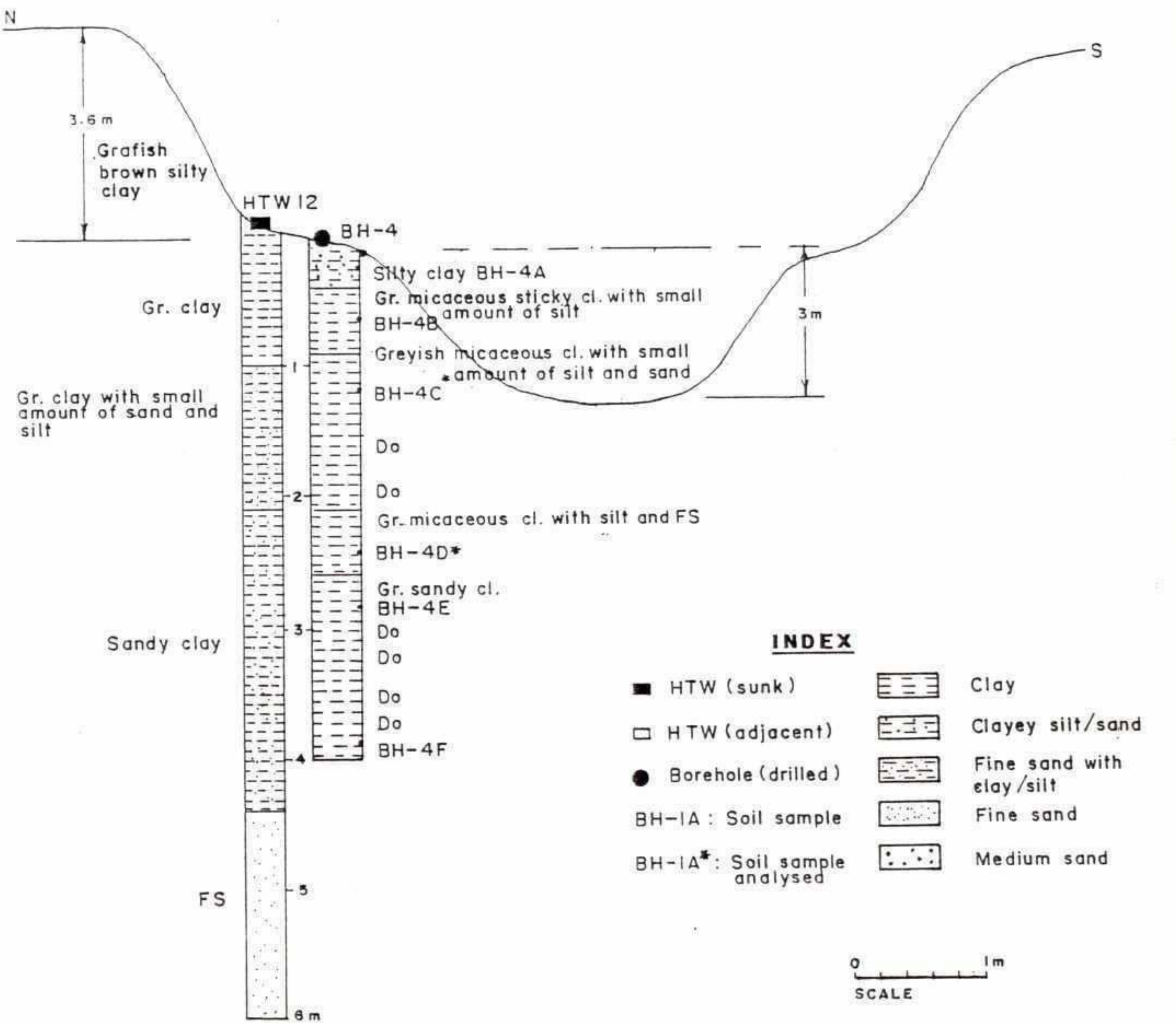


BOREHOLE NO. BH-4
HTW NO. HTW-12
WATER QUALITY

WAPDA Khal water Adj to BH-4
EC = 410 µs/cm
TDS = 290
HTW12/1 = 300' N of BH-4
EC = 380 µs/cm
TDS = 275

SITE LOCATION

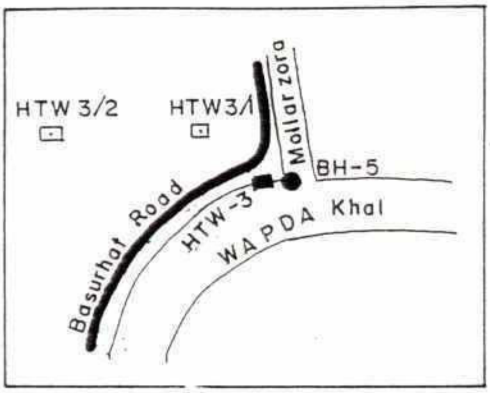


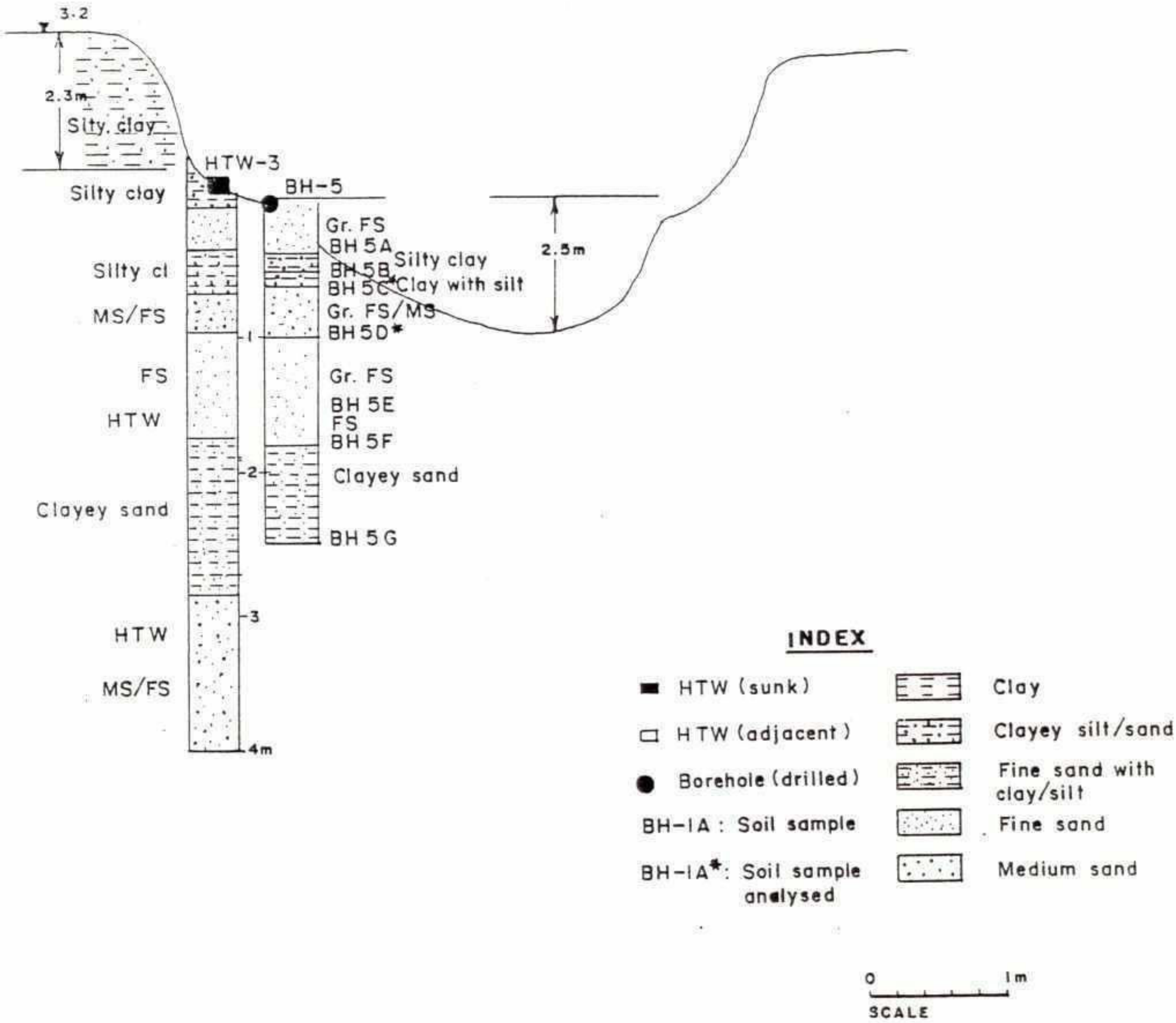


BOREHOLE NO. BH-5
HTW NO. HTW-3
WATER QUALITY

WAPDA Khal Water:
EC = 360 µs/cm
TDS = 260
HTW 3/1 100' NW of BH-5
EC = 800 µs/cm
TDS = 600
HTW 3/2 300' W of BH-5
EC = 450 µs/cm
TDS = 320

SITE LOCATION

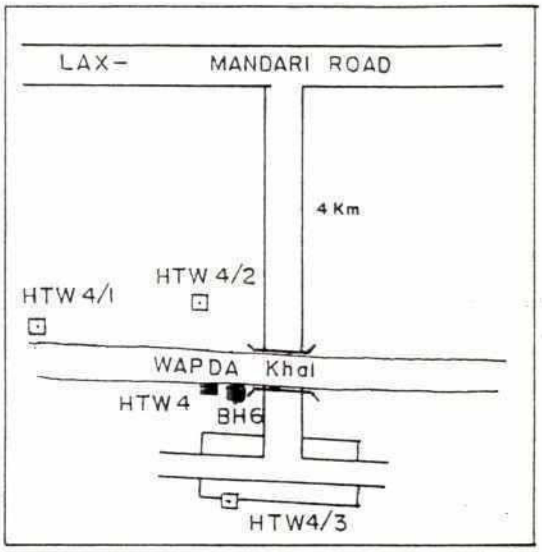


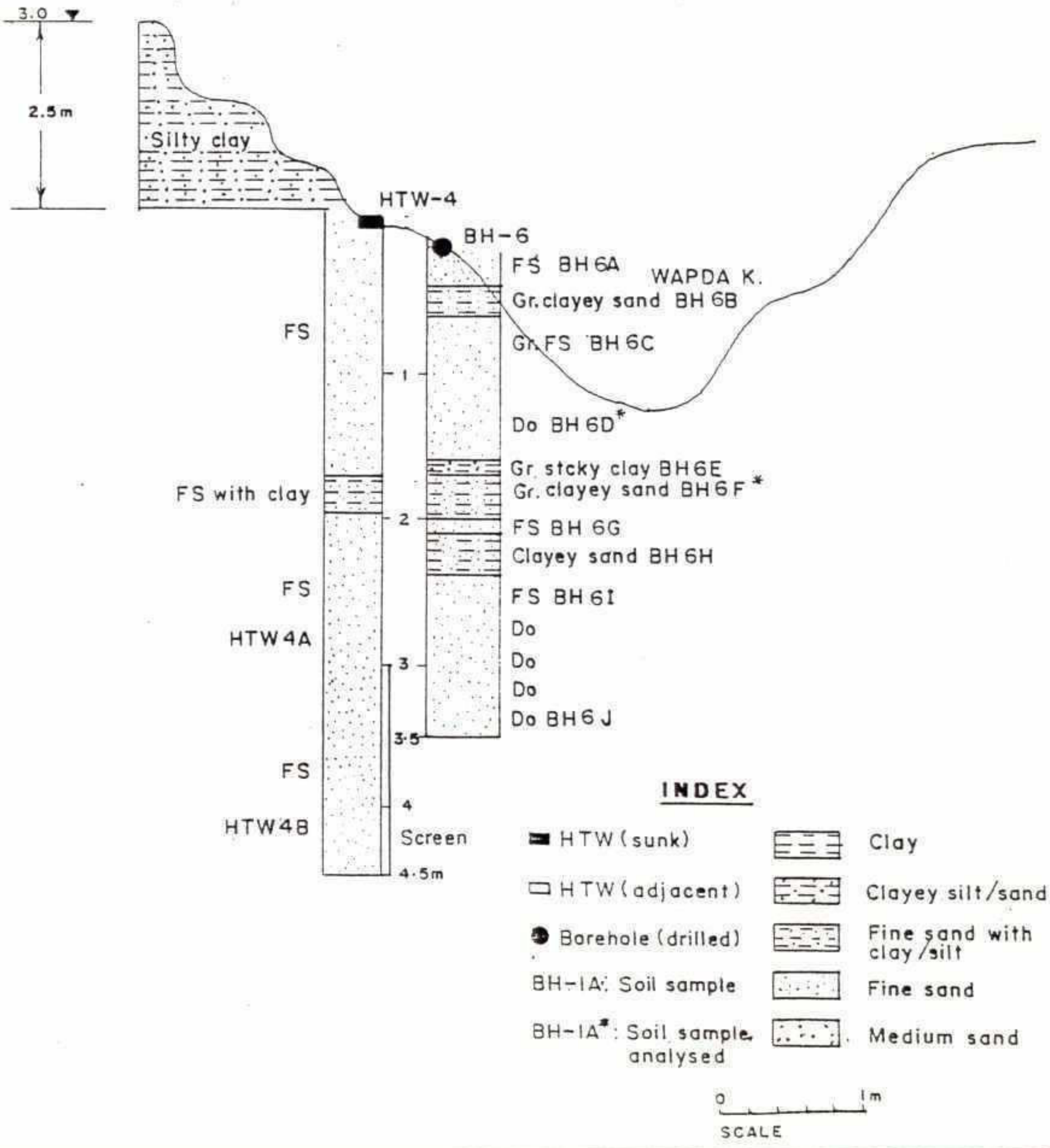


BOREHOLE NO. BH-6
HTW NO. HTW-4
WATER QUALITY

WAPDA Khal Water adj to BH-6
EC = 290 µs/cm, TDS = 250
HTW 4/1 300' W of BH-6
EC = 980 µs/cm, TDS = 680 — Time 4.15 PM
HTW 4/2 100' NW of BH-6
EC = 1000 µs/cm, TDS = 700 — Time 4.30 PM
HTW 4/3 100' SW of BH-6
EC = 810 µs/cm, TDS = 565
Water from HTW-4
EC = 820 µs/cm, TDS = 580 — Time 4.45 PM, Temp. 25°C

SITE LOCATION

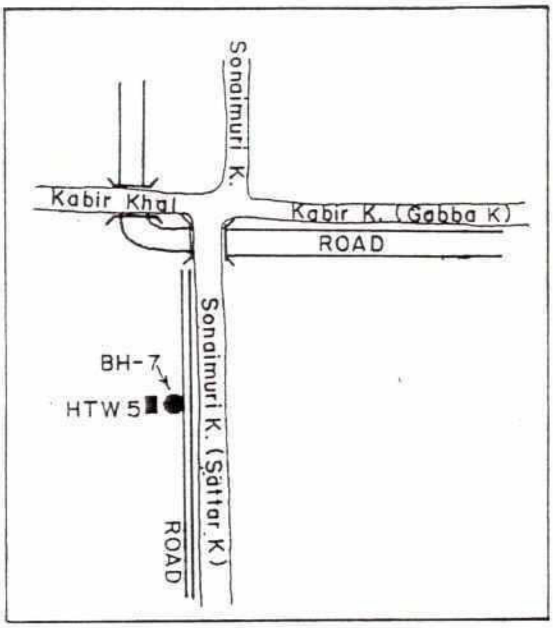


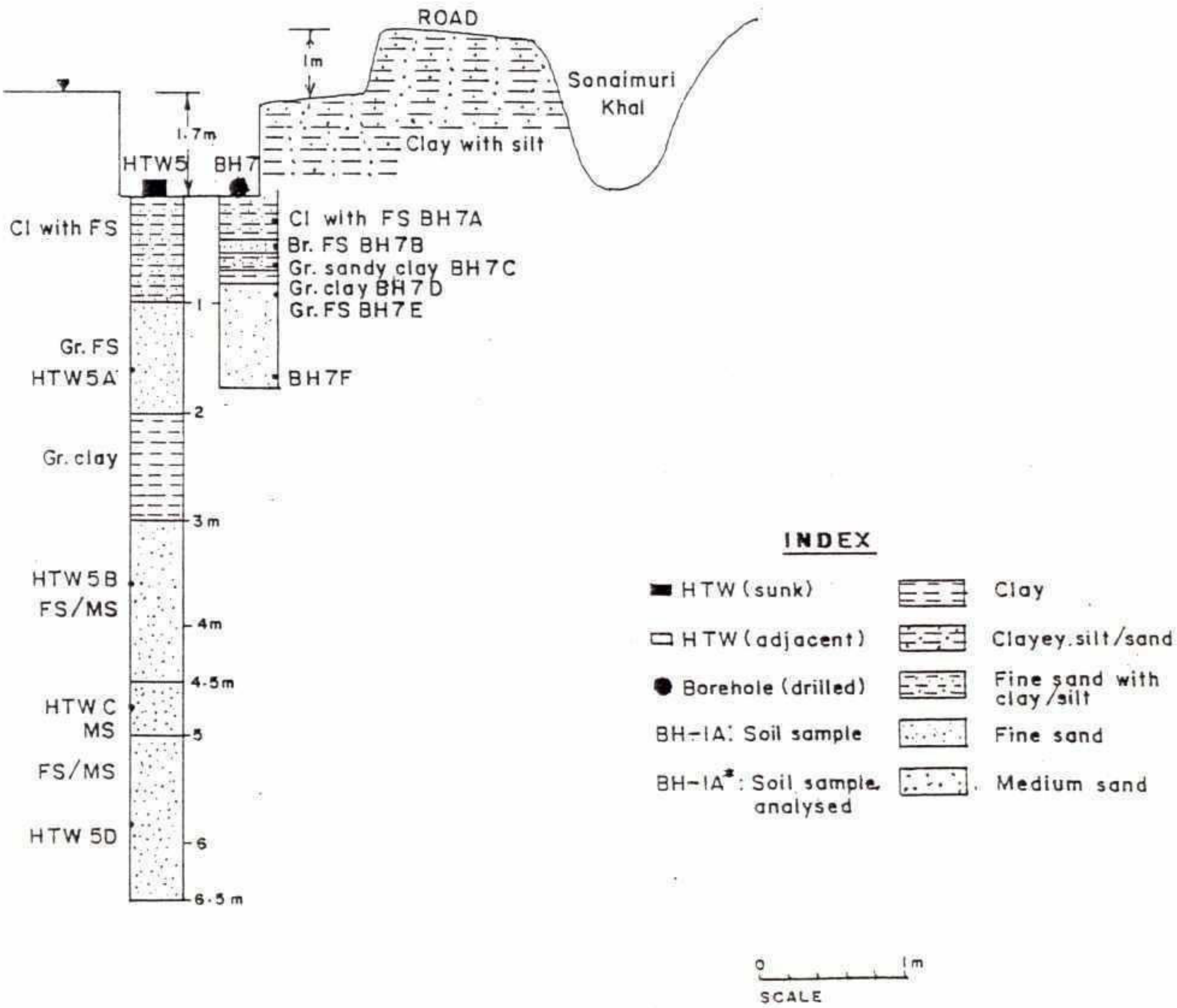


BOREHOLE NO. BH-7
HTW NO. HTW-5
WATER QUALITY

HTW-5
5A EC = 570 µs/cm, TDS = 400
5B EC = 580 µs/cm, TDS = 410
Khal Water, EC = 1250 µs/cm, TDS = 850
H_1, EC = 470 µs/cm, TDS = 330
H_2, EC = 2800 µs/cm, TDS = 2000
H_3, EC = 570 µs/cm, TDS = 400
HTW X_1, EC = 1100 µs/cm, TDS = 750
HTW X_2, EC = 3500 µs/cm, TDS = 2450

SITE LOCATION





BOREHOLE NO. BH-8
HTW NO. HTW-6
WATER QUALITY

S_1, 100' SW of BH-8
EC = 4000 μs/cm
TDS = 2800

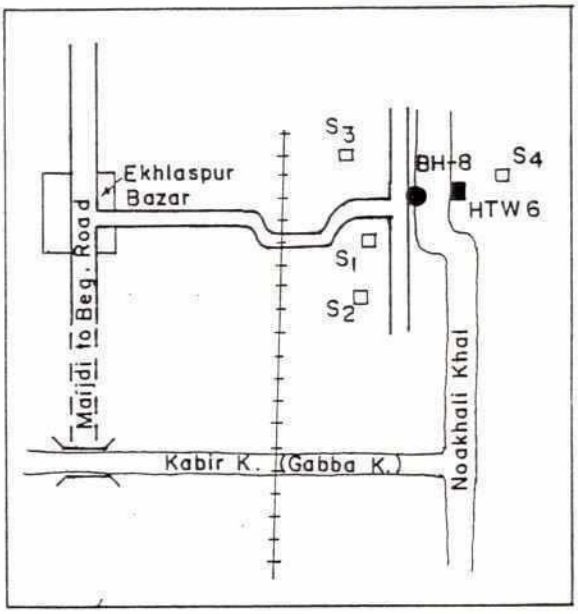
S_2, 300' SW of BH-8
EC = 2500 μs/cm, TDS = 1750

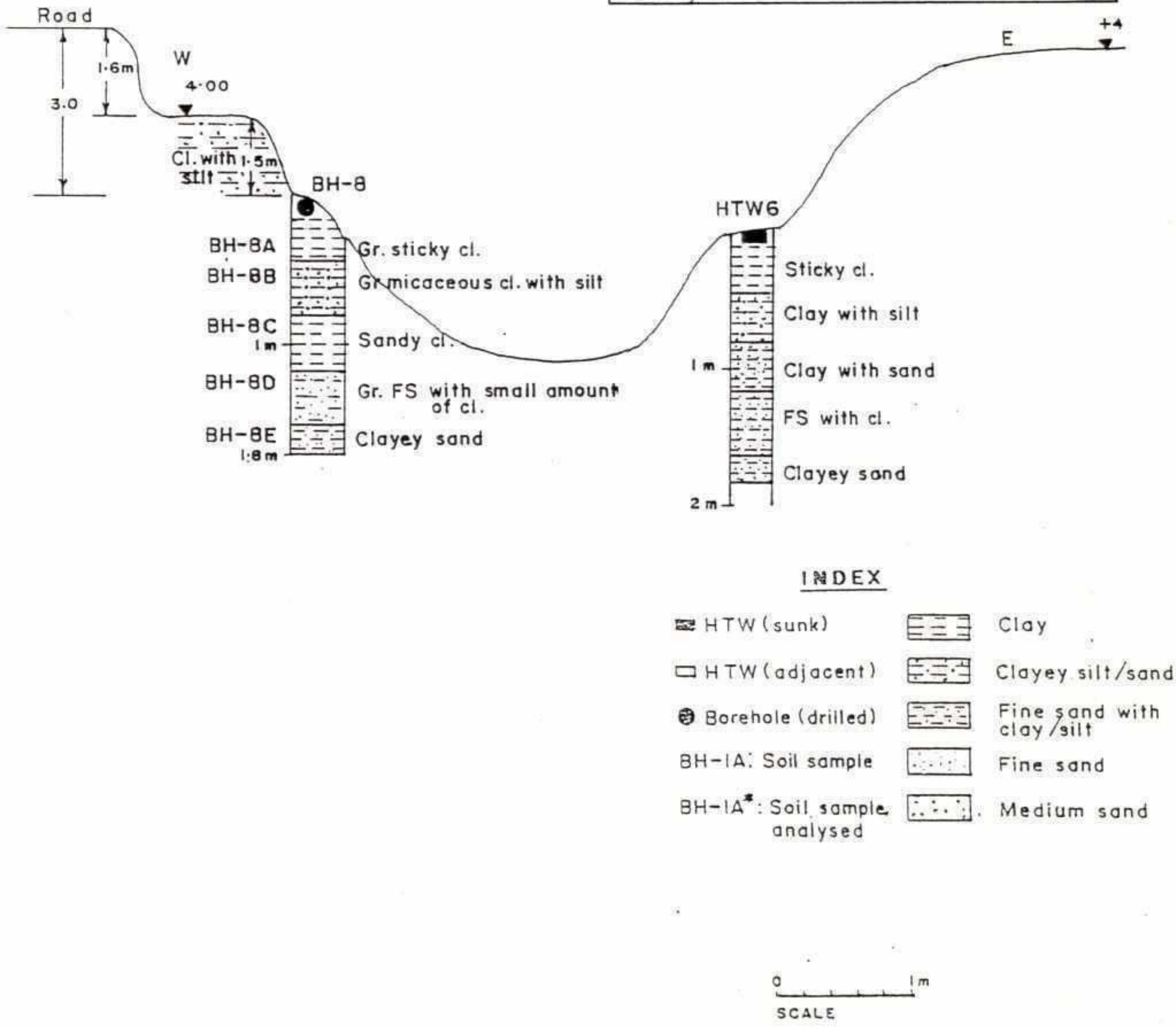
S_3, 100' NW of BH-8
EC = 530 μs/cm, TDS = 370

Khal Water adj to BH-8
EC = 7300 μs/cm, TDS = 5100

S_4, Adj to HTW-6
EC = 6700 μs/cm, TDS = 4700

SITE LOCATION

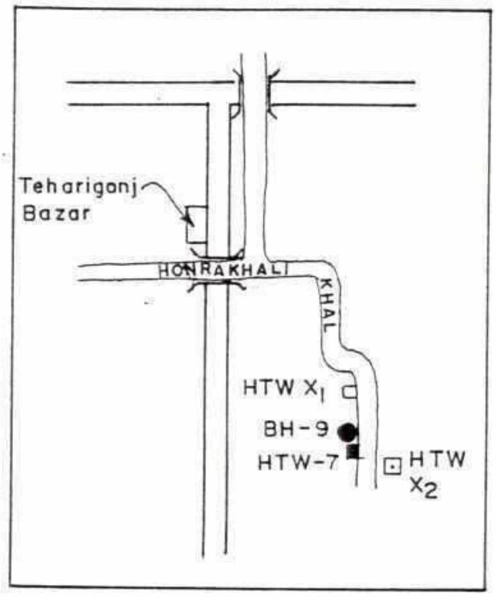


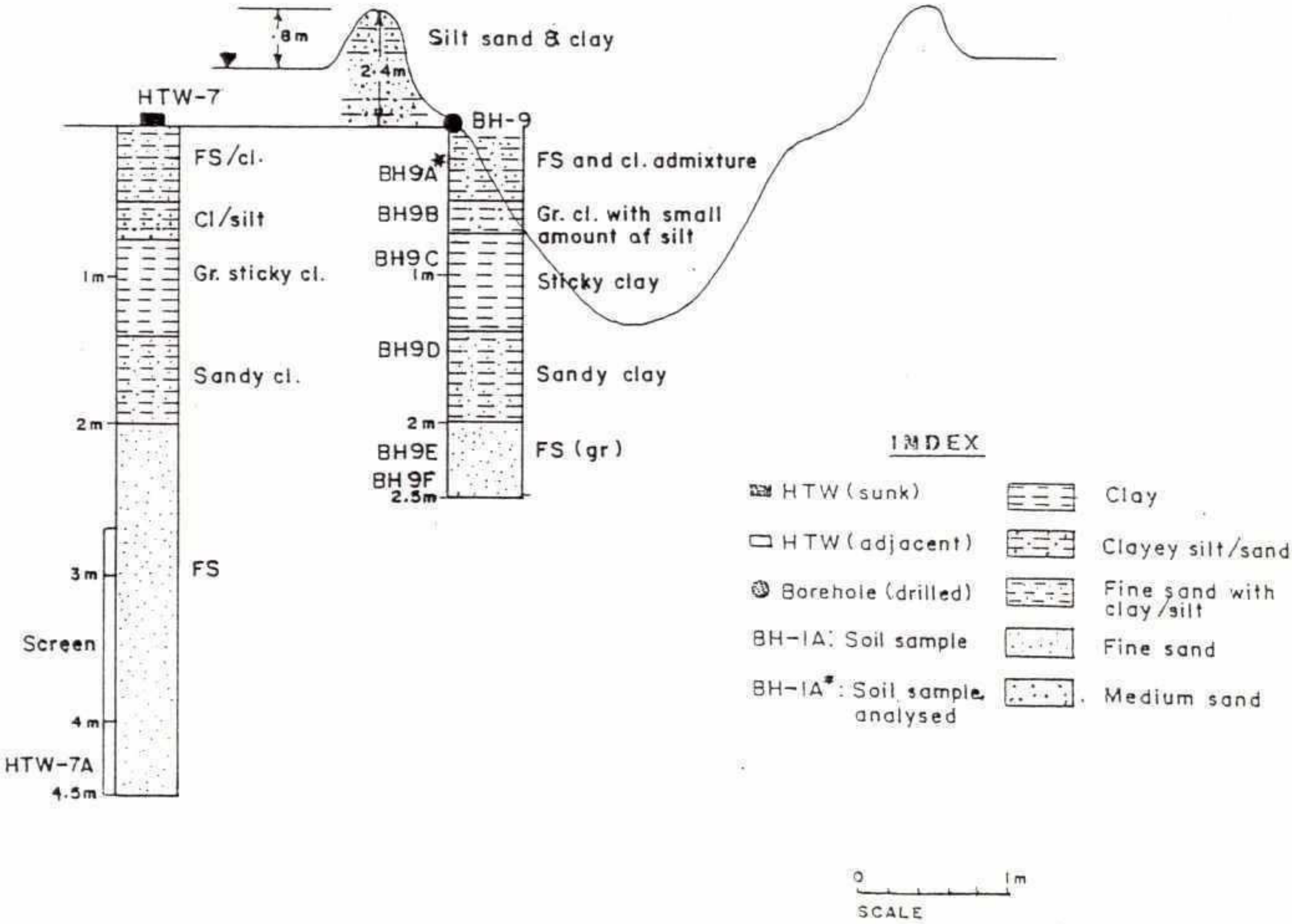


BOREHOLE NO. BH-9
HTW NO. HTW-7
WATER QUALITY

HTW X_1, 50' N of BH-9
EC = 440 µs/cm, TDS = 310, Time - 10.30 AM
HTW X_2, 100' E of BH = 9
EC = 1000 µs/cm, TDS = 700 — Time - 11.20 AM
Khal Water adj. to BH-9
EC = 430 µs/cm, TDS = 300
Water from HTW-7
Test no. 1 — Time 11.28 — EC = 2800 µs/cm — TDS = 1950
2nd. Test — Time 11.30 — EC = 3300 µs/cm — TDS = 2300

SITE LOCATION





BOREHOLE NO. BH-10
HTW NO. HTW-8
WATER QUALITY

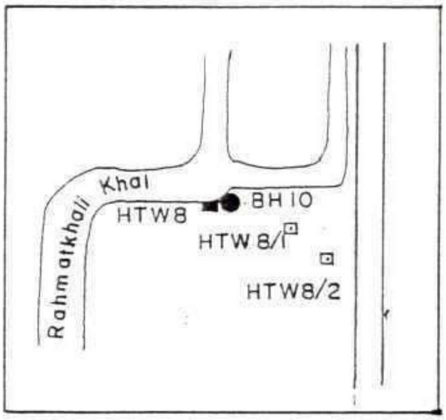
HTW 8/1, 100 SE of BH-10
EC = 1500 µs/cm, TDS = 1000 — Time 1·45 PM

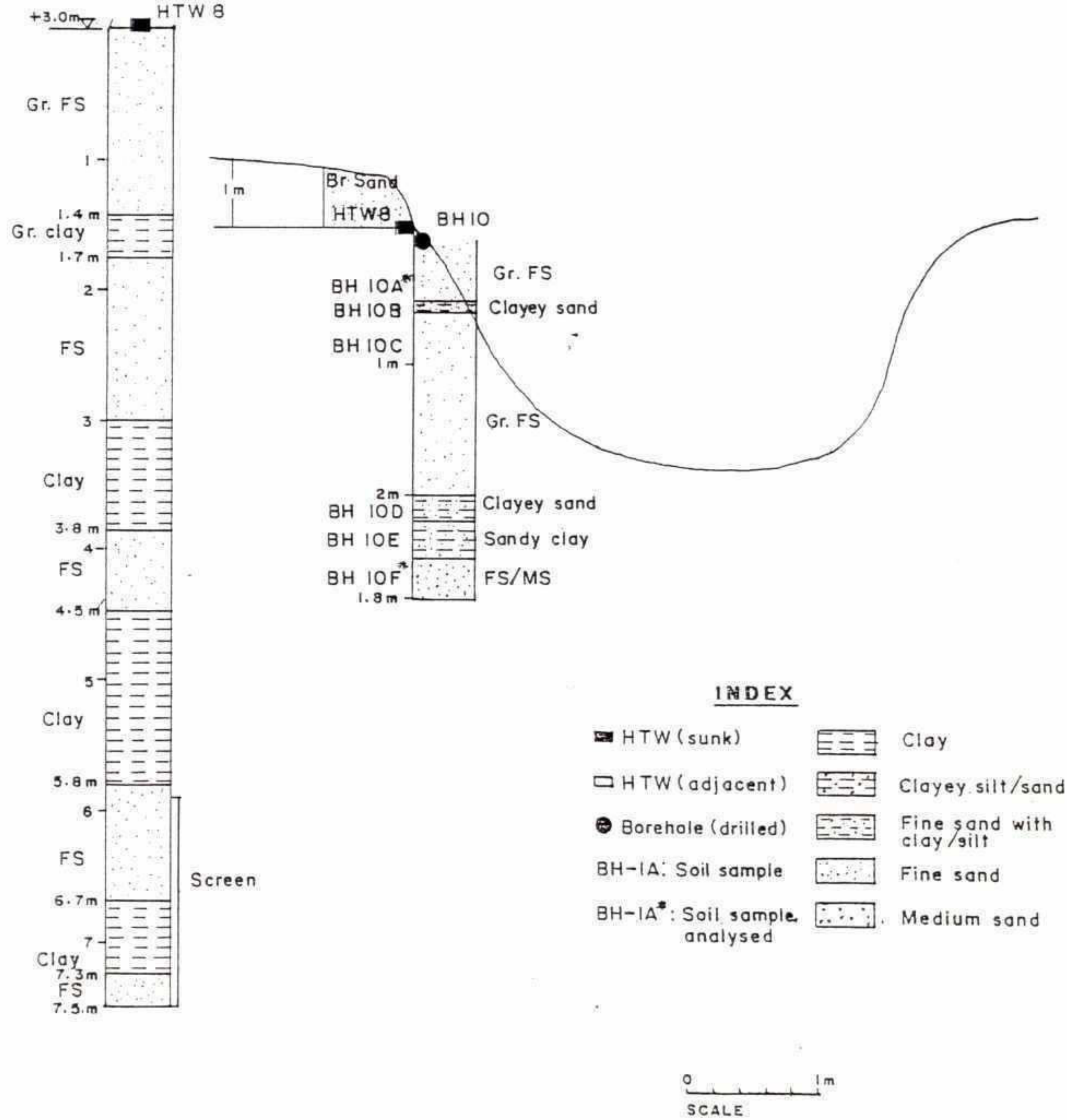
HTW 8/2, 200' SE of BH-10
EC = 985 µs/cm, TDS = 690 — Time 1·46 PM

Khal Water, EC = 290 µs/cm
Time - 1·30 PM. TDS = 200

Water from HTW-8
EC = 560 µs/cm, TDS = 390 — Time 1·35 PM

SITE LOCATION

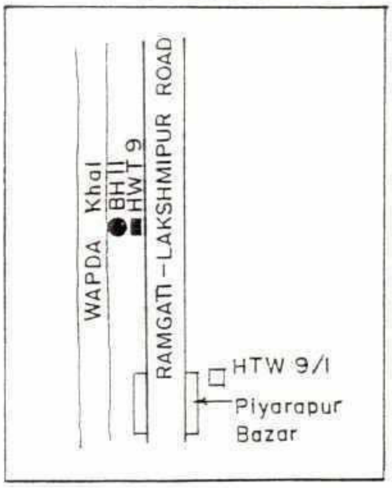


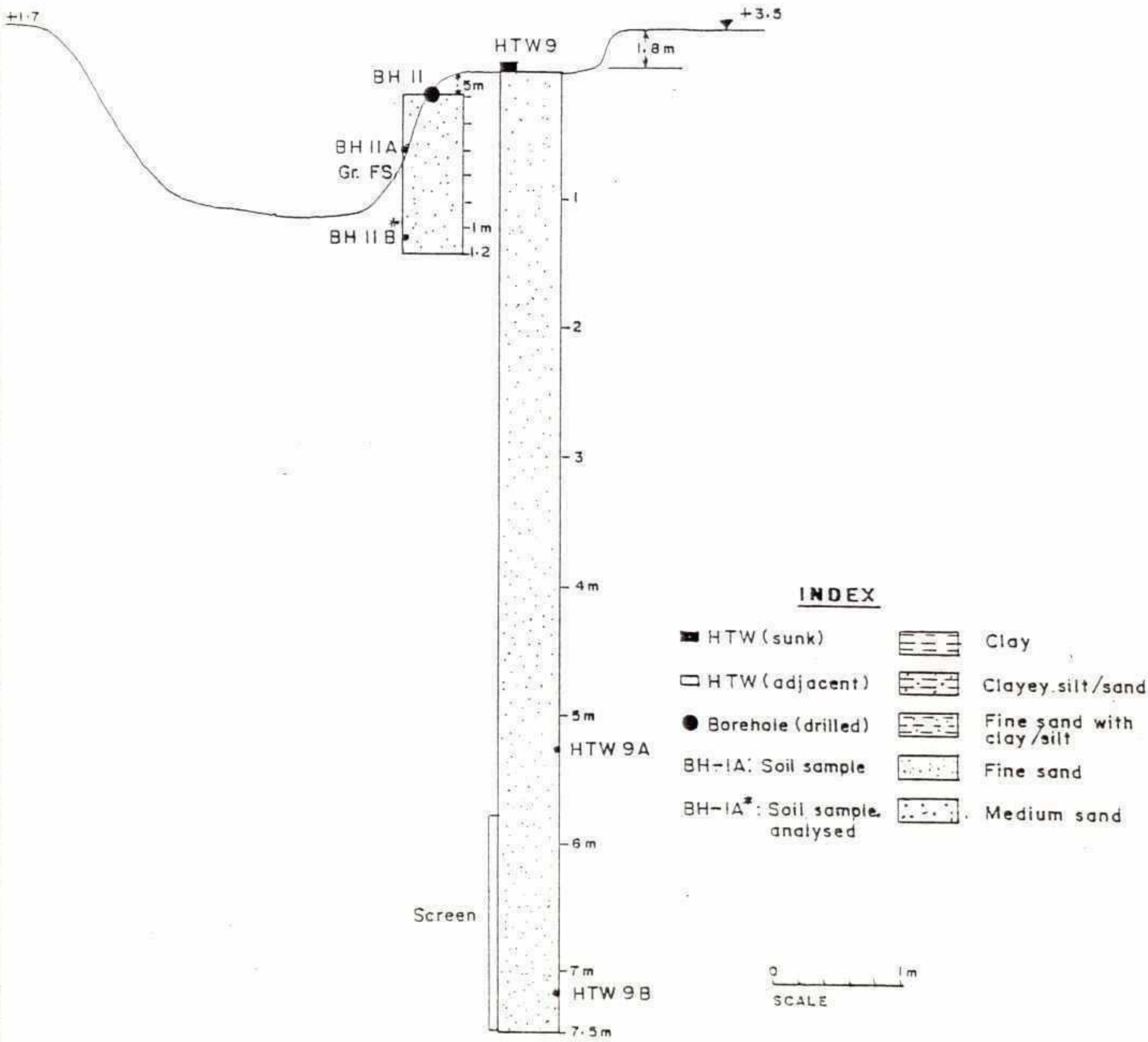


BOREHOLE NO. BH-11
HTW NO. HTW-9
WATER QUALITY

Water from WAPDA Khal
EC= 290 µs/cm
TDS = 200
HTW 9/1 200' SE of BH9-11
EC= 710 µs/cm
TDS= 500
Time 2·35 PM
Water from HTW 9
1st test: EC= 430 µs/cm
TDS=300
2nd test: EC= 440 µs/cm
TDS = 310

SITE LOCATION

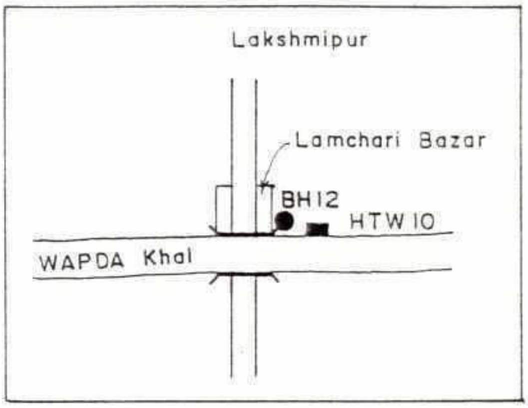


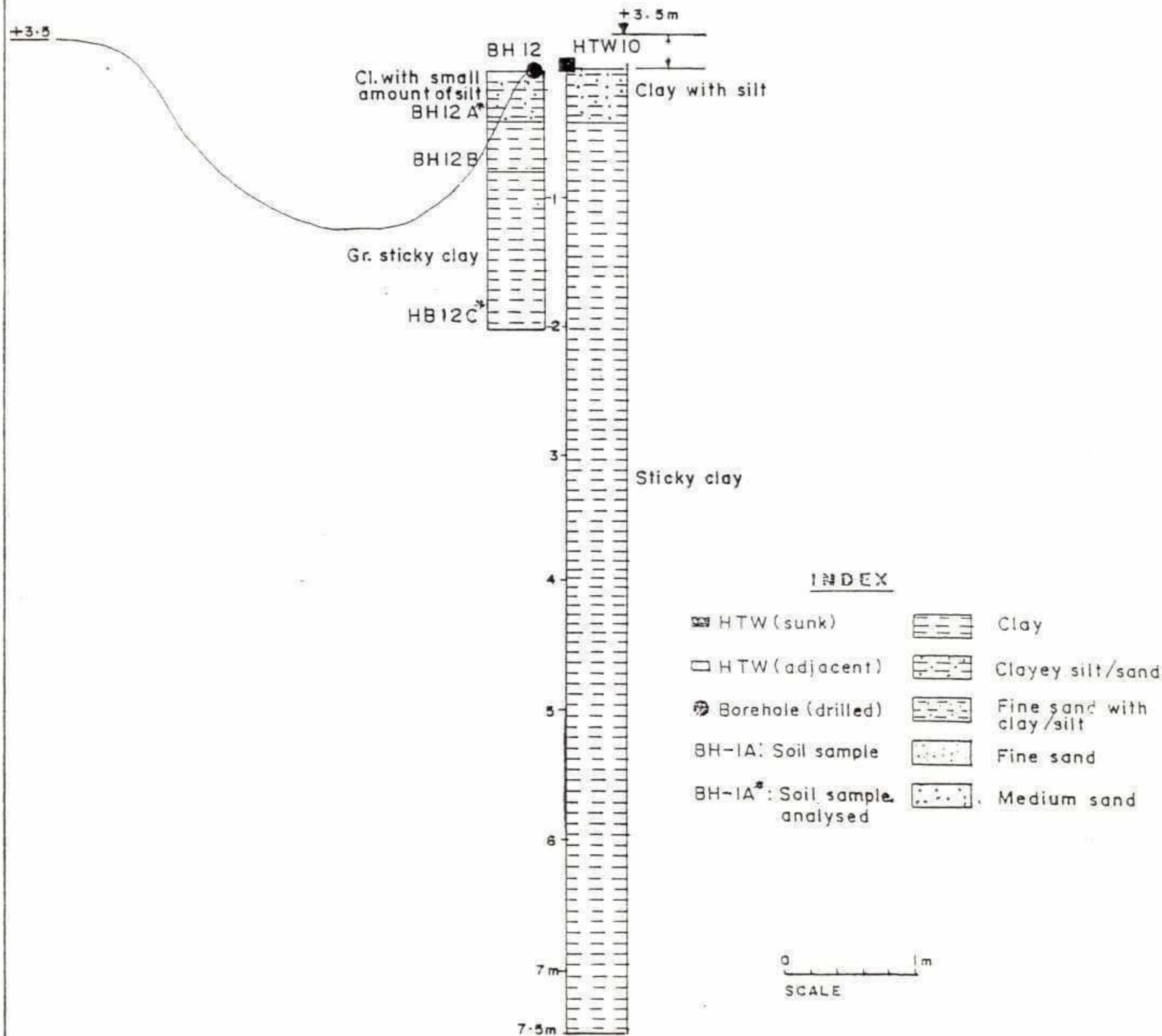


BOREHOLE NO: BH-12
HTW NO. HTW-10
WATER QUALITY

Khal water adj to BH-12
EC = 250 µs/cm, TDS = 160 (Time 4.45)
HTW adjacent to BH-12
EC = 1000 µs/cm
TDS = 200

SITE LOCATION





APPENDIX I.VIII

INVENTORY OF EXISTING ROAD STRUCTURES

TABLE I.VIII-1

Bridge Inventory Survey on Rahmatkhali and WAPDA Khals

A. Rahmatkhali Khal

Sl. Nr.	Bridge at Chainage km starting from Noakhali Khal	Description of Bridge				Description of existing khal			Proposed khal section			Remarks	Action Proposed
		Length m (Nr.Spans)	Width m	Soffit level m	Bed level m	Top with at Bank level m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m		
1	RCC Kalapal bridge, 0+350	55 (3)	8.66	8.77	1.33	40	5		40	24	-0.5	RCC pile foundation, Condition-good, owner-R&HD.	No action
2	RCC Kendrabag Bridge, 3+620	30.6(4)	2.7	6.87	1.86	40	4.8		40	24	-0.70	Wooden pile foundation, condition-good, owner-Chittagong Development division board.	Scour Protection to piers
3	Steel trussed Kalikapur Bridge, 6+170	39.3(1)	4.96	6.9	0.4	40	5	0.88	50	30	-1.0	Masonary abutment bridge. Condition - good, Owner-Relief and Rehabilitation Directorate	No action
4	RCC Banglabazar Bridge 6+570	31 (3)	3.55	6.54	-0.17	40	5		50	30	-1.05	Wooden pile foundation, Condition-good, Owner-Noakhali Zilla Parishad	Scour Protection to piers

174

Sl. Nr.	Bridge at Chainage km starting from Noakhali Khal	Description of Bridge				Description of existing khal			Proposed khal section			Remarks	Action Proposed
		Length m (Nr.Spans)	Width m	Soffit level m	Bed level m	Top with at Bank level m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m		
5	RCC Amin Bazar Bridge 9+120	25.6(3)	3.05	6.37	-0.19	40	5	0.16	50	30	-1.25	Wooden pile foundation, Condition - good, Owner - Relief and Rehabilitation Directorate	Add 1 span (8m) + new abutment
6	RCC Halanbari Bridge 10+030	25.35(1)	4.5	6.5	0.58	35	4.5	0.48	50	30	-1.35	Precast RCC piles below abutment, Condition - good but constriction, Owner - Relief and Rehabilitation Directorate	Add 1 span (15m) and new abutment and scour protection to piers
7	RCC Chandraganj Bridge 11+960	53 (3)	8.65	7.51	0.72	30	4.5	1.47	50	30	-1.50	RCC pile foundation, condition - good, Owner - R&HD	Scour protection to foundations
8	RCC Chandraganj Bridge 12+570	38.6(5)	3.05	6.5	-0.45	40	4		58	38	-1.50	Precast RCC piles below abutment and wooden piles below pier, condition - good, owner - LGED (DANIDA)	Add 1 span and scour protection

Sl. Nr.	Bridge at Chainage km starting from Noakhali Khal	Description of Bridge				Description of existing khal			Proposed khal section			Remarks	Action Proposed
		Length m (Nr.Spans)	Width m	Soffit level m	Bed level m	Top with at Bank level m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m		
9	RCC Sherpur Bridge 13+690	19.25(3)	3.65	5.61	1.14	25	4		25	7.0	-1.00	Wooden pile foundation, condition - good, owner - Zila Parishad	Scour protection
10	RCC Hadarghar Bridge 14+040	18. (3)	3.7	6.4	0.33	25	4	0.27	25	7.0	-1.00	Wooden pile foundation, condtion - good, owner - zila parishad	Scour protection
11	RCC Hajirpara Bridge 15+810	42.35(3)	4.3	6.93	0.2	25	4	0.5	25	7	-1.00	RCC pile foundation but top of pile cap at existing canal bed, condition - good, owner - Relief and Rehabilitation Directorate	No action necessary (large existing span)
12	- 16+810	42.35(3)	4.3	6.27	-0.66	25	4		26	7	-1.00	-	No action
13	RCC Mandari Bazar Bridge 21+940	28 (3)	4.4	6.55	0.95	20	4		26	7	-1.00	Pile foundation, condition - good, owner - zila parishad	Scour protection to piers

Sl. Nr.	Bridge at Chainage km starting from Noakhali Khal	Description of Bridge				Description of existing khal			Proposed khal section			Remarks	Action Proposed
		Length m (Nr.Spans)	Width m	Soffit level m	Bed level m	Top with at Bank level m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m		
14	RCC Mandari Bazar Bridge 22+040	36.9(3)	4.2	7.01	1.01	20	4	0.6	26	7	-1.00	Clustered 6" dia pipe columns foundation, condition - not good (to be replaced) owner - Road and Highways Department	No action (RHD are replacing)
15	RCC Mandari Bazar Bridge 22+100	36 (3)	6.02	6.86	0.51	20	4		24	6	-1.00	Brick well foundation, condition - good, owner - zila parisahd	No action (large span)
16	- 23+380	30.7(7)	2.8	5.89	0.63	20	4	0.36	24	6	-1.00	-	Scour protection
17	RCC Jokshin Bridge (New) 25+170	31.2(3)	2.9	7.95	0.31	25	3	0.55	24	6	-1.00	RCC pile foundation, condition - good, owner - LGED (under construction)	Scour protection
18	RCC Jokshin Bazar Bridge (25+760	30 (4)	3.5	5.75	0.14	25	3	0.13	25	7	-1.00	Wooden pile foundation, condition - good, owner - zila parishad	No action
19	RCC Madari Bridge 29+900	53 (3)	8.16	5.56	0.48	30	4	0.31	35	14	-1.80	RCC pile foundation, condition - good, owner - Road and Highways Department	Scour protection to piers

Sl. Nr.	Bridge at Chainage km starting from Noakhali Khal	Description of Bridge				Description of existing khal			Proposed khal section			Remarks	Action Proposed
		Length m (Nr.Spans)	Width m	Soffit level m	Bed level m	Top with at Bank level m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m		
20	RCC Lakshmipur Bridge, 32+090	32 (3)	6.5	5.86	0.27	30	3.5		42	18	-2.00	RCC pile foundation, condition - good, owner - zila parishad	Scour protection to piers
21	RCC trussed Dhanhata Bazar Bridge 32+360	37.8(8)	3.04	5.9	-0.63	35	3.5	1.14	42	18	-2.00	RCC trussed (size 8 x10) pier foundation, condition - good, owner - zila parishad	No action
22	Steel trussed Terabeki Bridge 34+580	51 (2) 1x30 1x18	3.9	5.23	1.3	40	3.5	- 0.9	50	27	-2.5	RCC pile foundation, Condition - good, owner - zila parishad	No action
23	RCC trussed Terabeki Bridge 34+750	45.15(8)	2.73	5.21	-1.4	40	3.5	- 1.19	50	27	-2.5	RCC trussed (size 8 x10) pier foundation, condition - good, owner - zila parishad	No action
24	RCC trussed Ayub Ali Bridge 36+950	46.5(11)	2.35	5.25	-0.78	40	3.5	0.78	58	32	-2.75	- do -	Scour protection
25	RCC Tomchar Bridge 40+100	46.45(3)	4.3	5.44	-3.46	60	3.5	-1.4	64	36	-3.00	Pier and pile foundation, condition - good, owner - Relief and Rehabilitation Directorate	No action

178

B. WAPDA Khal

Sl Nr.	Bridge at Chainage km starting from Noakhali Khal	Description of Bridge				Description of existing khal			Proposed khal section			Remarks	Action Proposed
		Length m (Nr.Spans)	Width m	Soffit level m	Bed level m	Top with at Bank level m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m		
1	RCC Bashurhat Bridge 7+922	30.5(5)	3.1	6.05	-1.53	30	3.5	-0.87	60	40	-1.8	Wooden pile foundation, condition - good, owner -LGED (DANIDA)	Add 3 spans (6m each)
2	RCC Dhigali Bridge 12+569	59.45(5)	3.5	5.5	-0.73	35	4	-1.25	60	38	-2.0	Wooden pile foundation, condition - good, owner - LGED (DANIDA)	Scour protection
3	RCC Amin Bazar Bridge 16+303	63 (5)	5.5	6.3	-1.91	40	4	-2.01	70	48	2.5	Brick well foundation, condition - good, owner - BWDB	No action
4	RCC trussed Gagirhat Bridge 23+000	54 (12)	3		-3.13	60	3.0	-3.13	70	48	-3.0	RCC trussed (size 8 x10) pier foundation, condition - good, owner - zila parishad	Add 2 spans and new abutment
5	RCC Pearapur Bridge 23+808	44.6(3)	5.6	6.77	-3.24	60	3	-3.24	70	48	-3.0	Brick well foundation, condition - good, owner - BWDB	Add 1 span and abutment

Note:
1. Top of pile cap at 1.5-1.8 m depth from existing canal bed.
2. Wooden pile of 4.5 m length and RCC pile of 7.5 m length.
3. Trussed pier of 4.5 m depth below existing canal bed level.

As reported

Summary of Action Required:

No Action	12
Scour Protection Alone	12
Add Spans etc.	6

TABLE I.VIII.2

Bridge and Culvert Inventory Survey on Secondary Khals to be Excavated under Project Proposals

Sl. Nr.	Name of Khal (Code Nr) and Chainage starting from (khal code Nr.)		Description of Bridge					Description of existing khal			Proposed khal section			Action Proposed
			Bridge Length m	Width m	Soffit level m	Bed level m	Nr Spans/ Length m	Top width m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m	
1	Mara Meghna (87) from 55													
		1+500	12.3	3.1	5.6	1.52	2x5.7m				19	1.0	-0.5	Pier foundation to be deepened.
	L = 8 km	2+400	13.3	3.5	5.33	1.65	3.1+2.1	20	4.0	1.45				Deepen pier foundation
		7+140	34.6	3.7	5.88	0.58	6.5+6.3+6.2 6.2+5.6							N/A
2	Honrakhali (55) from 51													
		2+174	17	3.0	6.3	1.36	6.1+4.25+5.5							N/A
	L = 14 km	3+734	13	2.15	5.42	1.04	3.1+4.4+3.4							N/A
	WCS -	4+149	13	3.65	-	1.03		20	4	1.04	19	1.0	-0.5	N/A
		5+999	17	3.8	5.99	-.04	4.6+5.7+4.0							N/A
		6+515	12.6(2)	3.0	6.44	1.58	5.5+5.5	25	4.5	0.67				Deepen pier foundation
		10+290	13.5(3)	3.5	5.72	0.47	2.2+5.3+3.0							N/A

Sl. Nr.	Name of Khal (Code Nr.) and Chainage starting from (khal code Nr.)		Description of Bridge					Description of existing khal			Proposed khal section			Action Proposed
			Bridge Length m	Width m	Soffit level m	Bed level m	Nr. Spans/ Length m	Top width m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m	
3	Debipur (54) starting from Dighali													
	L = 12 km	8+305	15(2)	3.7	6.3	1.67	6.5+6.5	30	3.5	1.86	17	1	-0.5	Deepen pier foundation
4	Kabir Khal (69) starting from 70													
		0+600	12(3)	4	5.74	0.32	2x3+4.0	20	5.5	2.0	19	1	-0.5	N/A
	L = 6.5 km	0+880	14.6(3)	2.5	5.43	1.01	2x4.1+4.4							N/A
		1+620	16.5(1)	3.9	5.43	1.27	1x14.9m							N/A
5	Noakhali Khal (14) starting from Dakatia													
		1+137	14.5(2)	4.2	7.37	0.32	2x5.7	30	3.9	.28	19	1	-0.5	N/A
	L = 30 km	11+750	31(3)	4.87	6.98	1.48	11.7+2x9.0	30	4.0	1.02				N/A
		26+280	17.7(3)	3.6	7.5	2.5	5.0+6.2+5.3	25	6.0	1.72		1.00	-0.5	Deepen pier foundation
		27+490	21.5(3)	4.0	7.63	1.95	6.5+7.1+6.1							N/A
		29+700	17(3)	2.8	6.77	1.48	4.0+7.3+3.8	25	5.5	1.69				N/A
		32+780	39.55(3)	6.75	7.67	0.98	11.7+12.2+1 2.05	25	5.0	1.72				N/A

Sl. Nr.	Name of Khal (Code Nr.) and Chainage starting from (khal code Nr.)	Description of Bridge					Description of existing khal			Proposed khal section			Action Proposed
		Bridge Length m	Width m	Soffit level m	Bed level m	Nr. Spans/ Length m	Top width m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m	
6	Sonaimuri (39) starting from Ramganj-Sonaimuri road												
	L = 23 km 8+240	10.3(1)	3.6	5.09	1.21	1x9.10 m	16	4.5	1.07	19	1.0	-0.5	N/A
	9+460	7.1(1)	3.7	6.48	1.94	1x5.9 m	15	4.0	2.2				Rebuild
	11+570	8.7(1)	4.3	6.65	2.0	7.4 m	16	4.0	2.01				N/A
	13+900	8.4(1)	3.6	6.59	2.07	6.9 m							N/A
	14+090	10(3)	2.75	6.33	1.81	2x1.8+4.3	16	5.0	2.15				Deepen pier foundation
	15+040	8(3)	2.75	6.79	2.29	2x1.8+4.3	15	5.0	2.01				Deepen pier foundation
	15+720	13(3)	2.9	6.33	2.22	4.4+4.2+2.5	15	5.0	1.65				Deepen pier foundation
	17+180	10.7(3)	1.1	6.54	1.41	2.3+5.2+2.2							Deepen pier foundation
	17+310	12.35(3)	1.55	6.36	2.25	2.7+4.7+2.3							Deepen pier foundation
	17+520	12(3)	2.9	6.02	1.33	2.7+4.7+2.3							N/A
	17+700	10.2(2)	7.9	6.53	2.31	2x4.55							Deepen pier foundation
	17+890	7.4(1)	3.7	6.31	2.77	1x6.2 m	10	4.5	1.97				Rebuild

Sl. Nr.	Name of Khal (Code Nr.) and Chainage starting from (khal code Nr.)		Description of Bridge					Description of existing khal			Proposed khal section			Action Proposed
			Bridge Length m	Width m	Soffit level m	Bed level m	Nr. Spans/ Length m	Top width m	Ground level (av) m	Bed Level m	Top width m	Bottom width m	Bed level m	
7	Mohendra (6) from 51													
	L = 10 km													
		1+480	26.3(5)	1.86	6.68	1.13	3.4+4.0+5.6 3.9+2.9	20	4.0	1.63	36	20	-0.5	Scour Protection to bed.
		8+010	22(3)	3.75	5.29	1.79	2x6.6+6.85	18	4.0	1.21	23	7	-0.5	Deepen pier foundations
8	Unnamed Khal (28) from 84													
	L = 3.0 km	0+56	13.2(3)	3.5	5.15	.63	2.9+5.9+2.9	15	4.0	1.40	19	1.0	-.5	N/A
		1+210	13.0(3)	2.87	6.0	.99	3.6+5.1+3.2							N/A
		3+000	9.3(1)	3.1	5.44	.95	1x7.7	20	4.0	1.08				N/A

Summary of Action Required:

N/A : 21 Nr.
Deepen pier foundation : 12 Nr.
Demolish and Rebuild : 2 Nr.
Scour Protection : 1 Nr.

Note : Khal Code numbers refer to numbering system on Khal Location Map in Appendix IV.

TABLE I.VIII.3

Bridge and Culvert Inventory Survey on Additional Secondary Khals not now included in excavation proposals

Sl. Nr.	Name of Khal (Code Nr.) and Chainage starting from (Khal Code Nr.)		Description of Bridge					Description of existing khal		
			Bridge Length m	Width m	Soffit Level m	Bed Level m	Nr. Spans/ Length m	Top width m	Ground level (av) m	Bed Level m
1	Mellar (13) from Dakatia									
		0+100	42(3)	4.2	7.2	-0.69	7.1 m		6.0	3.8
2	Chitoshi/Thanarhat (7) from Dakatia									
		0+346	29.4(5)	3.1	6.82	1.07	5.0+5.2+5.5 5.2+4.2			
		3+822	9.6(2)	3.63	7.12	1.37	2x4.22			
	L = 13 km	3+937	11.4(1)	4.9	5.96	1.86	1x9.2	?	4.0	2.0
		4+180	12(3)	3.1	6.31	1.91	2x2.8+1x4.6			
		6+169	25(1)	5.2	5.51	1.38	1x23			
		8+269	12.4(3)	2.5	5.24	2.02	2x2.9+1x4.8			
		11+694	12.2(1)	4.25	4.84	1.7	1x10.95			

Sl. Nr.	Name of Khal (Code Nr.) and Chainage starting from (Khal Code Nr.)		Description of Bridge					Description of existing khal		
			Bridge Length m	Width m	Soffit level m	Bed level m	Nr.Spans/ Length m	Top with m	Ground level (av) m	Bed Level m
3	Unnamed Khal (8) from 7									
	L = 5 km	0+ 400	18(3)	2.45	5.78	1.58	5.5+5.4+5.9	20	4.0	1.46
		3+600	18.6(1)	8.6	7.18	1.68	18			
		4+825	16.4(3)	2.7	6.62	2.23	2x4.6+5.4	20	5.0	1.63
4	Dharma (20) from 4									
		0+000	16.3(3)	3.65	6.12	.94	4.3+5.5+4.5	25	3.0	1.18
	L = 10 km	7+374	13.6(1)	3.65	6.82	1.64	1x10.8		4.0	1.74
		9+758	8.9(1)	4.55	6.11	2.05	1x7.7	20	4.0	1.14
5	Birendra Khal (addl) from Kamta 84									
		0+180	14.3(3)	3.75	6.67	1.89	2.95+5.6+3.1			
	L = 11 km	1+890	19(3)	2.0	7.02	1.2	5.8+5.5+5.8	25	4.0	1.73
		5+090	9.2(1)	2.83	5.74	1.58	1x8.22			

Sl. Nr.	Name of Khal (Code Nr.) and Chainage starting from (Khal Code Nr.)	Description of Bridge					Description of existing khal		
		Bridge Length m	Width m	Soffit level m	Bed level m	Nr. Spans/ Length m	Top with m	Ground level (av) m	Bed Level m
	5+840	18.2(3)	3.72	6.4	1.8	5.37+5.6+5.0	16	4.0	2.11
	8+250	13(3)	3.62	7.16	1.88	2.2+5.65+2.5 5			
	10+400	16.55(3)	2.32	6.28	1.57	4.92+5.46+4. 87	18	4.0	1.67
6	Unnamed Khal (4) from Dakatia L = 4 km	No structure					20	3.0	1.71

Note : Khal Code numbers refer to numbering system on Khal Location Map in Appendix IV.

TABLE I.VIII.4

Inventory Survey of Bridge/Culverts on R&HD Roads

1. Lakshmipur-Begumganj Road

Sl. Nr.	Approx Chainage	Bridge/Culvert Description	Remarks
1	0+300 m	Masonry abutment and slab bridge, clear length = 17.5 ft	
2	3+500 km	RCC abutment and 1 ft thick RCC pier (1 No), slab bridge, clear length = 21 ft	
3	5+000 km	As above, clear length = 31 ft	
4	7+000 km	RCC abutment, 2 ft thick RCC pier (1 No), slab bridge, length = 60 ft	Over Sonaimuri Khal
5	9+000 km	RCC abutment 2 ft thick RCC pier (1 No), slab bridge length 21.5 ft	
6	16+500 km	RCC abutment, 1 ft thick RCC pier, slab bridge (1 span) length = 20.75 ft	Old bridge
7	17+500 (Hajirpara)	RCC abutment, 1 ft thick RCC pier, slab bridge (1 span) length = 20.75 ft	Near village Yousufpur
8	18+500 km	RCC abutment, 1 ft thick RCC pier, slab bridge (1 span) length = 20.75 ft	
9	20+500 km (Battali)	RCC abutment, slab bridge, length=25 ft	
10	23+500	2 -vent Box culvert with 1 ft thick middle wall, length = 30.5 ft	
11	25+000 km	RCC abutment, slab bridge, clear length = 41 ft	Old Structure
12	26+000	Masonary Arch culvert (2-vents) clear length - 18.5 ft	Constricted old Structure over Jakshim Khal
13	26+500	2-vent Box culvert to be constructed, length 20 ft	

187

Sl. Nr.	Approx Chainage	Bridge Culvert Description	Remarks
14	27+000 km	One vent Box culvert, clear length = 10 ft	
15	28+000	RCC abutment, slab bridge, clear length = 40 ft	Over Canal near BRDB office

2. Sonaimuri-Ramganj Road

Sl. Nr.	Approx Chainage	Bridge/Culvert Description	Remarks
1	0+500	1-vent 11 ft Box culvert	
2	4+000 km	Pile founded new RCC bridge of three spans (28 ft, 68 ft, 28 ft)	Over Gazaria Khal
3	8 km	1 span RCC bridge of clear length = 33 ft	
4	8.5 km	1 span RCC bridge of clear length = 21 ft	
5	8+ 750	2-vent Box culvert Newly Constructed (Length = 30 ft and height = 18 ft)	Over Thanarhat Kachihata Khal
6	9.5	One span new skew RCC bridge, length = 60 ft	Over Mahendra Khal
7	10	1-vent RCC Box culvert (Length = 20 ft)	No flow due to khal siltration
8	11	2-vent RCC Box culvert (Length = 30 ft)	
9	14	2-vent RCC Box culvert (Length = 27.5 ft)	
10	15	4-vent RCC Box culvert (Length = 31 ft)	
11	16	2-vent RCC Box culvert (Length 31 ft)	
12	20	1-vent RCC Box culvert (Length = 20 ft)	
13	22	1-vent RCC Box culvert (Length = 20 ft)	

Sl. Nr.	Approx Chainage	Bridge/Culvert /Description	Remarks
14	23	1-vent RCC Box culvert (Length = 20 ft)	
15	24	Two spans (total opening - 27.5 ft) new RCC bridge having 2.5 ft RCC pier wall and RCC abutment over pile foundation	
16	25	1-vent RCC Box culvert (Length= 20 ft)	
17	26	1-vent RCC Box culvert (Length= 20 ft)	
18	27	1-vent New RCC Box culvert (Length = 15 ft)	

3. Ramganj-Chitoshi Road

Sl. Nr.	Approx Chainage	Bridge/Culvert Description	Remarks
1	2+500	Masonry abutment, 2.5 ft RCC pier, 3 spans, Length = 33 ft	
2	3+750	One span RCC bridge, Length = 25 ft	
3	5+000	1-vent RCC slab bridge and Masonry abutment, Length = 20 ft	
4	6+250	1-vent slab bridge, Masonry abutment, Length =25 ft	
5	8+000	1-vent RCC slab bridge, Masonry abutment, Length = 25 ft	
6	9+500	1-vent RCC slab bridge, Masonry abutment, Length = 15 ft	
7	10+000	Masonry abutment over one span RCC slab bridge, length = 9.5 ft	
8	10+500	Masonry abutment, one span slab bridge, length = 37 ft	
9	12+500	Masonry abutment, one span slab bridge, length = 10 ft	

Sl. Nr.	Approx Chainage	Bridge/Culvert Description	Remarks
10	13+000	Masonry abutment, one span slab bridge, length = 10 ft	
11	14+000	Masonry abutment, one span slab bridge, length = 10 ft	
12	15+500	Masonry abutment, one span RCC slab bridge, length = 15 ft	
13	16+500	Do	

TABLE I.VIII.5

Roads & Highways Department (Noakhali Division) Planned Road Works.

Sl. Nr.	Proposed Road	Length in km	Remark
1	Lakshmipur - Ramgati	54 km	To be Rehabilitated
2	Lakshmipur-Ramganj	21	To be Rehabilitated
3	Senbagh Thana Link Road	6.45	To be Rehabilitated
4	Begumganj-Matabi-Raipur	44.0	To be Rehabilitated
5	Lakshmipur-Mazu chowdhuryhat	9.6	Tendering in Process and would be completed in 1995
6	Senbagh-Sonaimuri-Chandrerhat	19	Under construction
7	Battali-Dattapara	5.40	To be Rehabilitated
8	Kachhua-Dattapara	11.4	To be constructed
9	Chatkhil Chitoshi	9.0	To be Rehabilitated
10	Mandari-Gandrabpur-Bhabaniganj	10.62	To be constructed
11	Maijdi-Islamia -Order Hat	16.0	To be constructed
12	Zaminder Hat - Kazirhat	4.5	To be constructed
13	Kachihata-Thanahat	20.0	To be constructed
14	Ramganj-Hajiganj	8.0	Under construction
15	Chumuhuni-Chattarpai	12.0	To be constructed
16	Ramganj-Chitoshi Bazar	18.0	To be rehabilitated

Sl. Nr.	Proposed Road	Length in km	Remark
17	Mandari-Dighali-Dasherhat	9.0	To be constructed
18	Jakshin Darbeshpur	19.4	To be constructed
19	Maijdi Bazar-Rajganj Chaiani-Bashurhat	19.0	To be constructed
20	Bhuyarhat -Battali-Fazilpur	16.0	To be constructed
21	Chatkhil-Chandraganj	36.0	To be constructed
22	Nalpara-Khamarhat	10.0	To be constructed
23	Bashurhat-Bangla Bazar-Chaprashirhat	16.5	To be constructed

Source: Roads and Highways Department.

TABLE I.VIII.6

Roads and Structures under the Responsibility of the Local Government Engineering Department

Upazila	Road Name	Description of Structure					
		Types	Nos	Span(m)	Width(m)	Status	Condition
Chatkhil	Chatkhil UP HQ	Culvert	6	3.05-6.1	3.45-3.5	Exist. 5 Prop. 1	Good 6
	Kilpara road	Bridge	2	6-9	3.66-3.71	Exist. 1 Prop. 1	Good 1 Bad 1
	Chatkhil Bazar - Khilpara Road via Nayanpur	Bridge Culvert	6 2	4.86-18.9 2.13	3.5-4.27 -	Exist. 6 Exist. 2	Good 2 Bad 3
Begumganj	Aminshapara-Sonaimuri GCCR	Bridge	9	0.91-15.24	3.0-7.33	Exist.3 Prop.6	Bad 3
		Culvert	10	0.9-4.5	3.66-7.3	Exist.0 Prop. 10	
	Chandraganj-Chagari GCCR	Bridge	14	3.66-17.68	3.35-3.7	Exist.14	Good 1
Sadar/Noakhali	From RHD Road at - Chamirhat via Bairagirhat	Culvert	8	.9-4.5	3.66-7.33	Prop.8	
	From RHD Road at - Kalitara to Koromulla	Culvert	8	0.9-2.5	3.66-7.33	Exist.4 Prop.4	Good
		Bridge	1	12.0	3.66	Exist.1	Good
	Sonapur-Chaprashi Hat GCCR	Culvert	25	1.0-48	3.05-7.31	Exist.8 Prop.17	Good
Senbagh	Senbagh-Kankir Growth Centre connecting road	Culvert	14	.6-3.7	6.0-12.19	Exist.7 Prop.7	Bad 2
		Bridge	1	9.25	6.0	Exist.1	
Sadar/Lakshmipur	Jakshim-Podder Bazar Road	Bridge Culvert	10 9	1.2-30.48 1.2-6.71	3.05-7.3 3.66-7.3	Exist. 10 Exist.9	Good Good
Raipur	Raipur-Panpur road	Bridge	2	9.15-12.2	6.1-7.3	Exist.	Good
		Culvert	5	1.83-2.4	6.1-7.3	Exist.4 Prop.1	Good
Ramganj	Sonapur Bazar Paiwla Bazar road	Bridge Culvert	1 -	9.0 -	3.6 -	Prop. Existing	Prop. Existing

GCCR - Growth Centre Connecting Road.

Source - Local Government Engineering Department

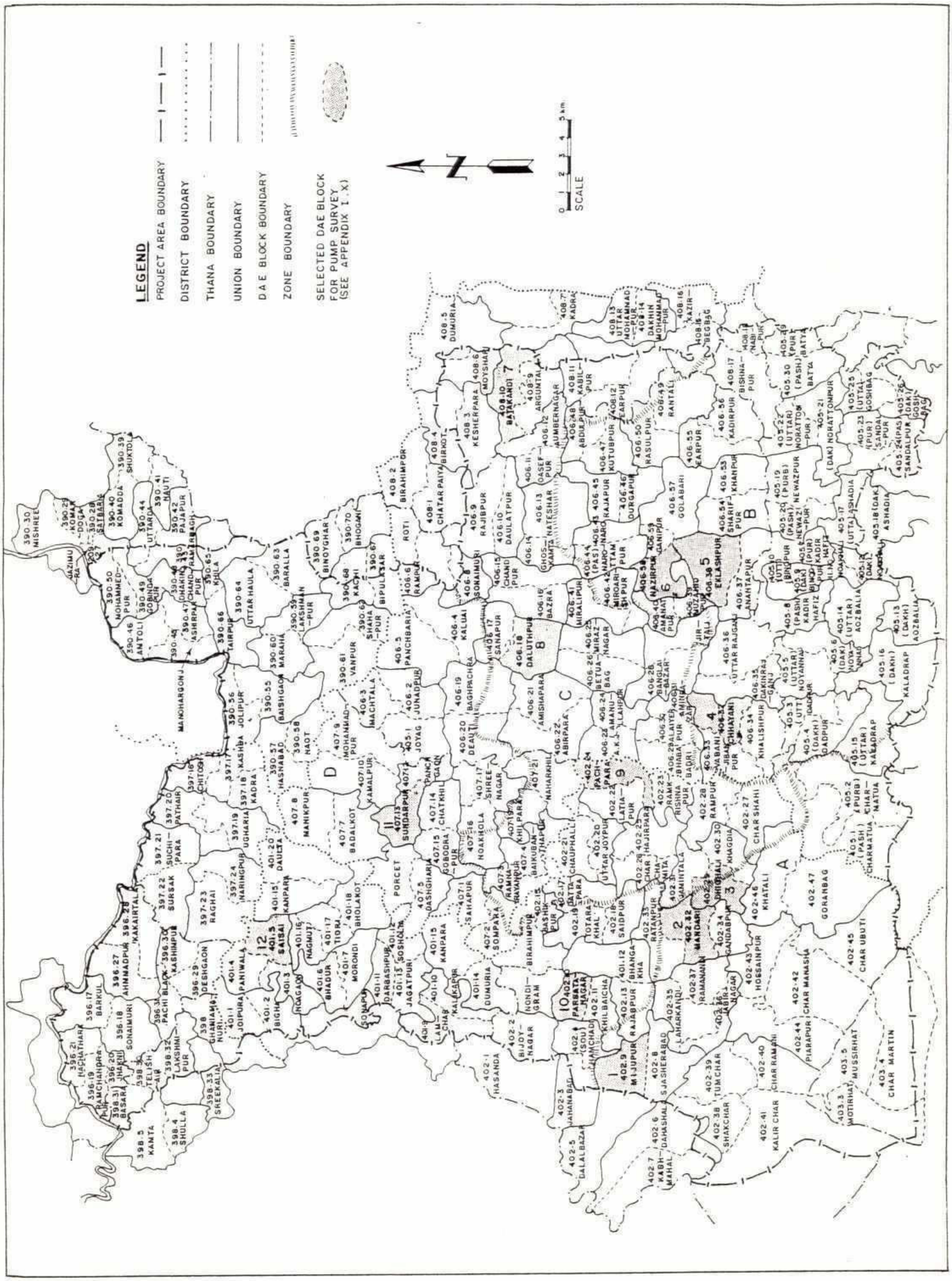
193

APPENDIX I.IX

AGRICULTURE SECTOR TEAM (AST) 1991
MINOR IRRIGATION DATA

Figure I.IX.1

Department of Agriculture Extension Blocks



NOAKHALI NORTH PROJECT

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3-5 cs Nr	LLP 3-5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
405	Noakhali	1 Charmatua (Pash)	0	0	0	0	0	0	0	0	6	0	16	1	40	0	0	0	0	63	0	63
405	Noakhali	2 Charmatua (Purb)	0	0	0	0	0	0	0	0	6	4	16	1	49	0	0	0	0	71	0	71
405	Noakhali	3 Dadpur (Uttar)	0	0	0	0	0	0	0	0	10	0	30	0	81	0	0	0	0	121	0	121
405	Noakhali	4 Dadpur (Dakhin)	0	0	0	0	0	0	0	0	20	5	61	4	162	0	0	0	0	243	0	243
405	Noakhali	5 Noyannai (Uttar)	0	0	0	0	0	0	0	0	28	0	20	0	0	0	0	0	0	49	0	49
405	Noakhali	6 Noyannai (Dakhi)	0	0	0	0	0	0	1	0	38	1	16	0	18	0	0	0	0	72	0	73
405	Noakhali	7 Kadir Hafiz (Pu)	0	0	0	0	0	0	1	1	20	4	24	8	127	0	0	0	0	172	1	173
405	Noakhali	8 Kadir Hafiz (Pa)	0	0	0	0	0	0	1	1	40	8	49	5	71	0	0	0	0	160	1	161
405	Noakhali	9 Binodpur (Dakhi)	0	0	0	0	0	0	0	0	49	6	18	2	8	0	0	0	0	75	0	75
405	Noakhali	10 Binodpur (Uttar)	0	0	0	0	0	0	0	0	60	7	22	1	5	0	0	0	0	87	0	87
405	Noakhali	11 Noakhali (Uttar)	0	0	0	0	0	0	7	1	10	2	10	0	0	0	0	0	0	20	1	21
405	Noakhali	12 Noakhali (Dakhi)	0	0	0	0	0	0	2	0	1	0	4	0	0	0	0	0	0	5	0	5
405	Noakhali	13 Aozbalia (Dakhi)	0	0	0	0	0	0	3	1	6	0	0	0	0	0	0	0	0	6	1	7
405	Noakhali	14 Aozbalia (Uttar)	0	0	0	0	0	0	2	1	8	1	10	0	0	1	2	0	0	20	1	21
405	Noakhali	15 Kaladrap (Uttar)	0	0	0	0	0	0	0	0	12	0	4	0	0	0	0	0	0	16	0	16
405	Noakhali	16 Kaladrap (Dakhi)	0	0	0	0	0	0	0	0	11	0	2	0	0	0	0	0	0	13	0	13
405	Noakhali	17 Ashadia (Uttar)	0	0	0	0	0	0	0	0	10	0	6	3	57	0	0	0	0	73	0	73
405	Noakhali	18 Ashadia (Dakhin)	0	0	0	0	0	0	0	0	2	0	0	1	14	0	0	0	0	16	0	16
405	Noakhali	19 Newazpur (Purba)	0	0	0	0	0	0	1	4	405	12	162	2	65	0	0	0	0	631	4	635
405	Noakhali	20 Newazpur (Pashi)	0	0	0	0	0	0	2	7	324	9	167	1	20	0	30	0	0	541	7	549
405	Noakhali	21 Narattompur (Da)	0	0	0	0	0	0	0	0	320	5	14	8	121	1	30	0	0	486	0	486
405	Noakhali	22 Narattompur (Ut)	0	0	0	0	0	0	0	0	121	4	567	5	283	0	0	0	0	971	0	971
405	Noakhali	23 Sandalpur (Purb)	0	0	0	0	0	0	0	0	4	4	20	1	10	1	22	0	0	57	0	57
405	Noakhali	24 Sandalpur (Pash)	0	0	0	0	0	0	0	0	6	3	16	2	34	1	24	0	0	81	0	81
405	Noakhali	25 Goshbag (Uttar)	0	0	0	0	0	0	1	0	40	4	194	2	121	2	162	1	73	591	0	591
405	Noakhali	26 Goshbag (Dakhin)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
405	Noakhali	27 Chaprashirhat	0	0	0	0	0	0	0	0	0	0	6	0	26	0	16	0	0	49	0	49
405	Noakhali	28 Chaprashirhat	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1
405	Noakhali	29 Batya (Purba)	0	0	0	0	0	0	0	0	8	2	10	0	6	0	0	0	0	24	0	24
405	Noakhali	30 Batya (Pashim)	0	0	0	0	0	0	0	0	11	3	7	0	6	0	0	0	0	25	0	25
405	Noakhali	31 Charjabbar (Pas)	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	2
405	Noakhali	32 Charjabbar (Dak)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1
405	Noakhali	33 Charjabbar (Pur)	0	0	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0	5	0	5
405	Noakhali	34 Charjabbar (Utt)	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	2
405	Noakhali	35 Charbata (Dakhi)	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	3	0	3
405	Noakhali	36 Charbata (Uttar)	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	2
405	Noakhali	37 Charclerk (Dakh)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1
405	Noakhali	38 Charclerk (Utta)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3–5 cs Nr	LLP 3–5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
406	Begumganj	1 Joyag	0	0	0	0	0	0	0	0	47	27	87	11	67	6	73	0	0	274	0	274
406	Begumganj	2 Junukhpur	0	0	0	0	0	0	0	0	51	24	78	10	61	0	0	0	0	189	0	189
406	Begumganj	3 Machtala	0	0	0	0	0	0	0	0	51	19	92	9	55	5	61	0	0	258	0	258
406	Begumganj	4 Kaluai	0	0	0	0	0	0	0	0	30	22	134	10	81	1	20	0	0	265	0	265
406	Begumganj	5 Panchbaria	0	0	0	0	0	0	0	0	121	30	243	5	81	2	20	0	0	465	0	465
406	Begumganj	6 Rampur	0	0	12	73	0	0	0	0	219	20	49	5	20	0	0	0	0	287	73	360
406	Begumganj	7 Tathi	1	28	6	36	0	0	0	0	306	15	30	4	24	0	0	0	0	360	65	425
406	Begumganj	8 Sonaimuri	0	0	10	61	0	0	1	0	255	15	30	5	20	0	0	0	0	306	61	366
406	Begumganj	9 Razibpur	0	0	0	0	0	0	8	16	20	5	16	9	24	9	30	0	0	91	16	107
406	Begumganj	10 Daulatpur	0	0	0	0	0	0	10	32	24	5	16	8	20	10	32	0	0	93	32	125
406	Begumganj	11 Oasefpur	0	0	9	61	0	0	0	0	20	18	162	2	20	0	0	0	0	202	61	263
406	Begumganj	12 Aumbarnagar	0	0	10	121	0	0	0	0	28	30	243	5	101	0	0	0	0	372	121	494
406	Begumganj	13 Nateshar	0	0	3	24	0	0	0	0	16	4	16	2	12	0	0	0	0	45	24	69
406	Begumganj	14 Ghoskamta	0	0	2	20	0	0	0	0	14	3	14	2	10	0	0	0	0	38	20	59
406	Begumganj	15 Chandpur	0	0	0	0	0	0	0	0	8	8	23	0	0	0	0	0	0	31	0	31
406	Begumganj	16 Bazra	0	0	0	0	0	0	0	0	6	7	20	0	0	0	0	0	0	26	0	26
406	Begumganj	17 Sanapur	0	0	0	0	0	0	0	0	12	8	16	0	0	0	0	0	0	28	0	28
406	Begumganj	18 Daulatpur	0	0	0	0	0	0	0	0	8	12	20	0	0	0	0	0	0	28	0	28
406	Begumganj	19 Baghpachra	0	0	0	0	0	0	0	0	20	5	30	2	16	0	0	0	0	67	0	67
406	Begumganj	20 Deauti	0	0	0	0	0	0	0	0	12	7	23	5	20	0	0	0	0	55	0	55
406	Begumganj	21 Amishapara	0	0	0	0	0	0	0	0	61	8	12	2	8	0	0	0	0	81	0	81
406	Begumganj	22 Abirpara	0	0	0	0	0	0	0	0	70	12	25	1	5	0	0	0	0	101	0	101
406	Begumganj	23 A.K.G	0	0	0	0	0	0	0	0	4	5	10	0	0	3	109	0	0	123	0	123
406	Begumganj	24 Amanullahpur	0	0	0	0	0	0	0	0	28	8	45	2	61	0	0	0	0	134	0	134
406	Begumganj	25 Miraznagar	0	0	0	0	0	0	0	0	3	5	21	2	14	0	0	0	0	38	0	38
406	Begumganj	26 Betuabag	0	0	0	0	0	0	0	0	57	6	12	1	8	0	0	0	0	77	0	77
406	Begumganj	27 Nazartali	0	0	0	0	0	0	0	0	30	7	28	2	20	0	0	0	0	79	0	79
406	Begumganj	28 Bengla Bazar	0	0	0	0	0	0	0	0	243	7	28	4	40	2	121	0	0	433	0	433
406	Begumganj	29 Bhababadri	0	0	0	0	0	0	0	0	121	5	20	1	20	6	130	1	51	342	0	342
406	Begumganj	30 Alaiyarpur	0	0	0	0	0	0	0	0	40	8	23	3	16	1	8	0	0	87	0	87
406	Begumganj	31 Aminbazar	0	0	0	0	0	0	1	0	40	6	101	3	142	1	61	0	0	344	0	344
406	Begumganj	32 Chayani	0	0	0	0	0	0	0	0	20	8	14	2	12	0	0	0	0	47	0	47
406	Begumganj	33 Bhabani Jibonpu	0	0	0	0	0	0	0	0	10	8	12	2	10	0	0	0	0	32	0	32
406	Begumganj	34 Khalishpur	0	0	0	0	0	0	0	0	30	5	10	5	20	0	0	0	0	61	0	61
406	Begumganj	35 Dakhin Rajgaon	0	0	0	0	0	0	0	0	16	5	20	0	0	0	0	0	0	36	0	36
406	Begumganj	36 Uttra Rajgaon	0	0	0	0	0	0	0	0	12	6	19	2	12	0	0	0	0	44	0	44
406	Begumganj	37 Anantapur	0	0	0	0	0	0	0	0	364	7	24	2	20	0	0	0	0	409	0	409
406	Begumganj	38 Aklashpur	0	0	0	0	0	0	0	0	486	13	36	3	28	0	0	0	0	550	0	550

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3-5 cs Nr	LLP 3-5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
406	Begumganj	39 Muzahidpur	0	0	0	0	0	0	0	0	61	4	16	0	0	0	0	0	0	77	0	77
406	Begumganj	40 Amanatpur	0	0	0	0	0	0	0	0	40	5	14	3	20	0	0	0	0	75	0	75
406	Begumganj	41 Mir Alipur	0	0	0	0	0	0	0	0	42	14	45	3	24	0	0	0	0	112	0	112
406	Begumganj	42 Mir Oarishpur	0	0	0	0	0	0	0	0	8	13	28	8	61	2	49	0	0	146	0	146
406	Begumganj	43 Narottampur	0	0	0	0	0	0	0	0	125	6	22	0	0	0	0	0	0	148	0	148
406	Begumganj	44 Narottampur (Pa)	0	0	0	0	0	0	0	0	190	3	6	2	8	0	0	0	0	204	0	204
406	Begumganj	45 Razapur	0	0	0	0	0	0	0	0	12	1	8	3	32	0	0	0	0	53	0	53
406	Begumganj	46 Durgapur	0	0	0	0	0	0	0	0	81	2	16	4	49	0	0	0	0	146	0	146
406	Begumganj	47 Kutubpur	0	0	0	0	0	0	0	0	121	10	32	8	28	6	40	0	0	223	0	223
406	Begumganj	48 Abdulpur	0	0	0	0	0	0	0	0	198	23	49	1	5	0	0	0	0	252	0	252
406	Begumganj	49 Rantali	0	0	0	0	0	0	0	0	18	5	16	0	0	0	0	0	0	34	0	34
406	Begumganj	50 Rasulpur	0	0	0	0	0	0	0	0	30	9	29	0	0	0	0	0	0	59	0	59
406	Begumganj	51 Purba Hazipur	0	0	0	0	0	0	0	0	12	4	13	8	32	0	0	0	0	57	0	57
406	Begumganj	52 Pashim Hazipur	0	0	0	0	0	0	0	0	20	5	14	4	24	0	0	0	0	59	0	59
406	Begumganj	53 Khanpur	0	0	0	0	0	0	0	0	4	13	26	11	31	0	0	0	0	62	0	62
406	Begumganj	54 Sharifpur	0	0	0	0	0	0	0	0	5	0	0	1	3	1	7	0	0	15	0	15
406	Begumganj	55 Earpur	0	0	0	0	0	0	0	0	28	3	14	0	0	0	0	0	0	42	0	42
406	Begumganj	56 Kadirpur	0	0	0	0	0	0	0	0	20	2	10	0	0	0	0	0	0	30	0	30
406	Begumganj	57 Golabaria	0	0	0	0	0	0	0	0	121	3	9	0	0	0	0	0	0	130	0	130
406	Begumganj	58 Nazirpur (Paura)	0	0	0	0	0	0	0	0	20	9	20	4	24	0	0	0	0	65	0	65
406	Begumganj	59 Ganipur	0	0	0	0	0	0	0	0	152	2	5	1	4	0	0	0	0	161	0	161

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3–5 cs Nr	LLP 3–5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
407	Chatkhil	1 Sahapur	0	0	0	0	0	0	0	0	0	6	22	0	0	0	0	0	0	22	0	22
407	Chatkhil	2 Sompara	0	0	0	0	0	0	0	0	0	4	16	1	8	0	0	0	0	24	0	24
407	Chatkhil	3 Ramnarayanpur	0	0	0	0	0	0	1	0	0	7	28	0	0	0	0	0	0	29	0	29
407	Chatkhil	4 Baikubnthapur	0	0	0	0	0	0	2	0	0	4	18	0	0	0	0	0	0	18	0	19
407	Chatkhil	5 Dashgharia	0	0	0	0	0	0	0	0	20	8	36	1	6	0	0	0	0	63	0	63
407	Chatkhil	6 Narkopt	0	0	0	0	0	0	0	0	0	7	28	1	7	0	0	0	0	35	0	35
407	Chatkhil	7 Badalkot	0	0	0	0	0	0	0	0	12	50	304	4	40	0	0	0	0	356	0	356
407	Chatkhil	8 Manikpur	0	0	0	0	0	0	0	0	20	28	186	1	6	0	0	0	0	212	0	212
407	Chatkhil	9 Mohammadpur	0	0	0	0	0	0	0	0	20	18	101	0	0	0	0	0	0	121	0	121
407	Chatkhil	10 Kamalpur	0	0	0	0	0	0	0	0	16	20	81	0	0	0	0	0	0	97	0	97
407	Chatkhil	11 Palla	0	0	0	0	0	0	0	0	1	48	194	2	16	0	0	0	0	211	0	211
407	Chatkhil	12 Panchgaon	0	0	0	0	0	0	0	0	1	29	121	2	12	0	0	0	0	134	0	134
407	Chatkhil	13 Sundarpur	0	0	0	0	0	0	1	0	0	30	121	1	10	0	0	0	0	132	0	132
407	Chatkhil	14 Chatkhil	0	0	0	0	0	0	0	0	20	22	121	0	0	0	0	0	0	142	0	142
407	Chatkhil	15 Gobondrapur	0	0	0	0	0	0	0	0	20	19	101	0	0	0	0	0	0	121	0	121
407	Chatkhil	16 Noakhola	0	0	0	0	0	0	0	0	6	12	45	0	0	0	0	0	0	51	0	51
407	Chatkhil	17 Shreenagar	0	0	0	0	0	0	0	0	3	5	20	2	9	0	0	0	0	32	0	32
407	Chatkhil	18 Karihati	0	0	0	0	0	0	0	0	0	13	47	0	0	0	0	0	0	48	0	48
407	Chatkhil	19 Khilpara	0	0	0	0	0	0	0	0	8	22	69	5	18	2	14	0	0	109	0	109
407	Chatkhil	20 Daliai	0	0	0	0	0	0	0	0	4	32	134	1	8	0	0	0	0	146	0	146
407	Chatkhil	21 Naharkhil	0	0	0	0	0	0	0	0	4	44	119	3	12	0	0	0	0	136	0	136

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3−5 cs Nr	LLP 3−5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
408	Senbag	1 Chatar paiya	5	111	14	91	0	0	0	0	20	20	69	0	0	0	0	0	0	89	202	291
408	Senbag	2 Birahimpur	9	200	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	12	200	212
408	Senbag	3 Kesherpara	2	45	33	214	0	0	0	0	67	9	31	4	32	0	0	0	0	130	258	389
408	Senbag	4 Birkot	3	67	10	65	0	0	0	0	71	5	17	8	65	0	0	0	0	153	132	284
408	Senbag	5 Dumuria	0	0	2	13	0	0	2	0	4	13	45	1	8	0	0	0	0	57	13	70
408	Senbag	6 Moyshari	3	67	0	0	0	0	2	1	2	11	38	0	0	0	0	0	0	40	68	107
408	Senbag	7 Kadra	0	0	0	0	0	0	0	0	20	6	21	0	0	0	0	0	0	41	0	41
408	Senbag	8 Jamalpur	0	0	0	0	0	0	0	0	20	3	10	0	0	0	0	0	0	30	0	30
408	Senbag	9 Argumtala	3	134	12	78	0	0	0	0	40	8	28	2	16	0	0	0	0	84	211	295
408	Senbag	10 Batakandi	1	26	17	110	0	0	0	0	34	10	36	3	24	0	0	0	0	95	136	231
408	Senbag	11 Kabilpur	3	67	0	0	0	0	0	0	20	2	8	0	0	0	0	0	0	28	67	95
408	Senbag	12 Earpur	1	22	7	45	0	0	0	0	20	3	10	0	0	0	0	0	0	30	68	98
408	Senbag	13 Uttar Mohammadp	0	0	0	0	0	0	0	0	18	8	28	4	32	0	0	0	0	78	0	78
408	Senbag	14 Dakhin Mohammad	0	0	0	0	0	0	0	0	14	8	28	2	16	0	0	0	0	58	0	58
408	Senbag	15 Begbag	1	24	1	6	0	0	0	0	14	5	18	0	0	1	15	0	0	48	31	79
408	Senbag	16 Kazirkhil	0	0	0	0	0	0	0	0	0	2	7	3	4	1	15	0	0	26	0	26
408	Senbag	17 Bishnapur	0	0	0	0	0	0	0	0	101	16	55	0	0	2	31	0	0	187	0	187
408	Senbag	18 Nabipur	1	24	1	6	0	0	0	0	11	15	52	2	16	0	0	0	0	79	31	110

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3–5 cs Nr	LLP 3–5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
390	Laksam	1 Keshonpar	3	38	26	113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	152	152
390	Laksam	2 Saidpure	8	182	15	101	0	0	0	0	8	1	2	8	89	2	32	0	0	132	283	415
390	Laksam	3 Bagmara	2	40	36	172	0	0	0	0	8	0	0	3	24	0	0	0	0	32	212	245
390	Laksam	4 Joynagar	4	111	24	101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	212	212
390	Laksam	5 Lolai	2	32	13	61	0	0	0	0	4	1	2	0	0	8	101	0	0	107	93	200
390	Laksam	6 Gosai Pokrani	6	132	15	83	0	0	0	0	8	0	0	0	0	0	0	0	0	8	214	223
390	Laksam	7 Baratula	9	182	14	57	0	0	0	0	4	0	0	0	0	0	0	0	0	4	239	243
390	Laksam	8 Vushibazar	3	23	11	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	81
390	Laksam	9 Hazat Khola	14	227	14	79	0	0	0	0	0	0	0	0	0	1	18	0	0	18	306	324
390	Laksam	10 Hszatia (Dakhin	7	97	30	147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	244	244
390	Laksam	11 Alishar	6	91	25	101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	192	192
390	Laksam	12 Matailkot	6	81	8	26	0	0	0	0	2	0	0	0	0	0	0	0	0	2	107	109
390	Laksam	13 Atiti	4	83	3	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101	101
390	Laksam	14 Perul	7	123	10	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	165	165
390	Laksam	15 Kanakshree	2	65	5	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	114	114
390	Laksam	16 Jagatpur	5	51	11	44	0	0	0	0	0	0	0	0	0	1	19	0	0	19	95	114
390	Laksam	17 Bakai	4	81	15	65	0	0	0	0	0	0	0	0	0	2	16	0	0	16	146	162
390	Laksam	18 Noorpur	6	94	31	202	0	0	0	0	0	1	10	0	0	3	42	0	0	53	296	348
390	Laksam	19 Bizra	10	190	11	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	263	263
390	Laksam	20 Kaitra	3	69	2	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	81
390	Laksam	21 Paranpur	0	0	0	0	0	0	0	0	12	10	31	7	78	0	0	0	0	121	0	121
390	Laksam	22 Pashapur	1	20	2	12	0	0	0	0	20	10	51	2	32	0	0	0	0	103	32	136
390	Laksam	23 Auspara	1	28	0	0	0	0	0	0	24	8	49	5	61	0	0	0	0	134	28	162
390	Laksam	24 Changaon	3	93	4	24	0	0	0	0	10	3	4	2	2	2	14	0	0	30	117	148
390	Laksam	25 Satbaria	0	0	0	0	0	0	0	0	8	4	8	1	6	10	237	0	0	259	0	259
390	Laksam	26 Manoharpur	3	40	1	7	0	0	0	0	9	0	0	2	4	0	0	0	0	13	48	61
390	Laksam	27 Jazimura	0	0	12	69	0	0	0	0	40	0	0	0	0	6	148	0	0	188	69	257
390	Laksam	28 Satbaria	7	132	5	27	0	0	0	0	16	1	1	3	9	0	0	0	0	26	158	184
390	Laksam	29 Komardoga	5	156	4	18	0	0	0	0	18	0	0	0	0	0	0	0	0	18	174	192
390	Laksam	30 Mishree	5	106	3	17	0	0	0	0	8	0	0	0	0	0	0	0	0	8	124	132
390	Laksam	31 Narpati	0	0	18	77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	77
390	Laksam	32 Fulgaon	3	67	3	30	0	0	0	0	2	0	0	0	0	0	0	0	0	2	97	99
390	Laksam	33 Alaich	2	16	7	29	0	0	1	0	2	0	0	0	0	0	0	0	0	2	45	47
390	Laksam	34 Premnal	3	57	8	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	121	121
390	Laksam	35 Belghar	3	49	6	53	0	0	0	0	4	0	0	0	0	0	0	0	0	4	101	105
390	Laksam	36 Khilpara	5	79	7	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113	113
390	Laksam	37 Bhushi	9	162	3	32	0	0	0	0	4	0	0	0	0	0	0	0	0	4	194	198
390	Laksam	38 Gayarbanga	5	69	22	125	0	0	0	0	20	0	0	0	0	0	0	0	0	20	194	214

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3–5 cs Nr	LLP 3–5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
390	Laksam	39 Shuktola	2	18	10	41	0	0	0	0	3	0	0	0	0	0	0	0	0	3	59	62
390	Laksam	40 Komadda	4	63	7	26	0	0	0	0	9	1	4	0	0	0	0	0	0	12	89	101
390	Laksam	41 Nauti	4	53	4	18	0	0	0	0	10	0	0	0	0	0	0	0	0	10	71	81
390	Laksam	42 Rajapur	0	0	17	98	0	0	0	0	23	0	0	8	65	0	0	0	0	88	98	186
390	Laksam	43 Ramarbagh	0	0	0	0	0	0	0	0	81	0	0	7	40	0	0	0	0	121	0	121
390	Laksam	44 Uttarda	2	36	9	59	0	0	0	0	22	0	0	3	8	0	0	0	0	30	95	125
390	Laksam	45 Manoharganj	0	0	0	0	0	0	0	0	111	1	2	4	38	11	192	0	0	344	0	344
390	Laksam	46 Amtoli	0	0	0	0	0	0	0	0	24	0	0	2	15	8	177	0	0	216	0	216
390	Laksam	47 Ashirpar	0	0	0	0	0	0	0	0	22	1	2	3	40	1	36	0	0	101	0	101
390	Laksam	48 Dakhin Chandpur	0	0	0	0	0	0	0	0	61	7	38	2	20	3	32	0	0	152	0	152
390	Laksam	49 Gobindapur	0	0	2	18	0	0	0	0	126	7	19	6	23	5	40	0	0	208	18	227
390	Laksam	50 Mohammedpur	0	0	0	0	0	0	0	0	20	0	0	0	0	16	445	0	0	465	0	465
390	Laksam	51 Jhalam	0	0	0	0	0	0	0	0	16	16	64	0	0	5	105	2	81	266	0	266
390	Laksam	52 Mirzapur	0	0	0	0	0	0	0	0	9	11	65	8	103	5	103	1	24	305	0	305
390	Laksam	53 Balaish	2	61	0	0	0	0	0	0	8	15	72	0	0	0	0	0	0	80	61	140
390	Laksam	54 Bara Keshtala	0	0	0	0	0	0	0	0	12	16	50	1	12	13	384	0	0	459	0	459
390	Laksam	55 Baishgaon	0	0	0	0	0	0	0	0	45	30	127	6	36	8	148	0	0	356	0	356
390	Laksam	56 Jolipur	0	0	0	0	0	0	0	0	34	16	85	1	8	8	202	0	0	330	0	330
390	Laksam	57 Hasnabad	0	0	0	0	0	0	0	0	57	16	65	0	0	0	0	0	0	121	0	121
390	Laksam	58 Naotala	0	0	0	0	0	0	0	0	20	32	121	0	0	0	0	0	0	142	0	142
390	Laksam	59 Lakshmanpur	0	0	0	0	0	0	1	0	63	25	134	5	49	0	0	0	0	245	0	245
390	Laksam	60 Maraha	0	0	0	0	0	0	0	0	12	17	91	3	28	2	32	0	0	164	0	164
390	Laksam	61 Vanpur	0	0	0	0	0	0	0	0	14	41	249	3	24	0	0	0	0	287	0	287
390	Laksam	62 Shahapur	0	0	0	0	0	0	0	0	29	23	140	0	0	0	0	0	0	168	0	168
390	Laksam	63 Baralla	0	0	0	0	0	0	0	0	32	18	61	14	81	0	0	0	0	174	0	174
390	Laksam	64 Uttar Haula	0	0	0	0	0	0	0	0	24	18	73	6	49	0	0	0	0	146	0	146
390	Laksam	65 Khila	0	0	3	4	0	0	0	0	89	7	61	15	121	0	0	0	0	271	4	275
390	Laksam	66 Tairpur	0	0	0	0	0	0	0	0	101	7	61	15	121	0	0	0	0	283	0	283
390	Laksam	67 Bipulasar	0	0	17	40	0	0	0	0	16	15	49	7	40	1	20	0	0	125	40	166
390	Laksam	68 Kachi	0	0	0	0	0	0	0	0	36	30	146	0	0	0	0	0	0	182	0	182
390	Laksam	69 Binoyghar	0	0	1	8	0	0	0	0	8	30	146	0	0	0	0	0	0	154	8	162
390	Laksam	70 Bhogani	0	0	0	0	0	0	0	0	16	18	61	5	40	1	30	0	0	148	0	148

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3–5 cs Nr	LLP 3–5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
396	Hajiganj	1 Mukundasar	0	0	0	0	0	0	0	0	4	6	2	3	2	0	0	0	0	8	0	8
396	Hajiganj	2 Menapur	0	0	0	0	0	0	0	0	8	1	1	1	2	0	0	0	0	11	0	11
396	Hajiganj	3 Rajargaon	0	0	0	0	0	0	0	0	2	3	10	1	11	0	0	0	0	22	0	22
396	Hajiganj	4 Bakila	0	0	1	2	0	0	0	0	8	5	14	4	24	1	12	0	0	59	2	61
396	Hajiganj	5 Sreepur	2	49	0	0	0	0	0	0	32	0	0	2	20	0	0	0	0	53	49	101
396	Hajiganj	6 Ghanna	0	0	0	0	0	0	0	0	14	4	8	4	12	0	0	0	0	34	0	34
396	Hajiganj	7 Kapaikap	0	0	0	0	0	0	0	0	2	0	0	4	12	0	0	0	0	14	0	14
396	Hajiganj	8 Tarapalla	0	0	0	0	0	0	0	0	2	0	0	4	12	0	0	0	0	14	0	14
396	Hajiganj	9 Rampur	0	0	0	0	0	0	0	0	4	0	0	5	9	0	0	0	0	13	0	13
396	Hajiganj	10 Urpur	0	0	0	0	0	0	0	0	4	0	0	3	6	0	0	0	0	10	0	10
396	Hajiganj	11 Sayadpur	0	0	1	1	0	0	2	1	3	0	0	6	8	0	0	0	0	11	2	13
396	Hajiganj	12 Kazirgaon	1	28	0	0	0	0	0	0	4	0	0	0	0	5	113	0	0	117	28	146
396	Hajiganj	13 Sudia	0	0	0	0	0	0	0	0	4	0	0	1	8	6	164	1	0	176	0	176
396	Hajiganj	14 Suhilpur	0	0	7	55	0	0	0	0	16	0	0	3	26	0	0	0	0	43	55	97
396	Hajiganj	15 Uchchanga	0	0	0	0	0	0	0	0	4	0	0	1	26	2	61	0	0	91	0	91
396	Hajiganj	16 Alipur	0	0	0	0	0	0	0	0	12	0	0	5	31	8	139	0	0	182	0	182
396	Hajiganj	17 Barkul	0	0	0	0	0	0	0	0	57	0	0	5	38	13	552	0	0	648	0	648
396	Hajiganj	18 sonaimuri	2	49	0	0	0	0	0	0	40	0	0	15	150	4	105	0	0	295	49	344
396	Hajiganj	19 Ramchandrapur	0	0	0	0	0	0	0	0	0	0	0	2	22	11	186	0	0	208	0	208
396	Hajiganj	20 Jhakni	0	0	0	0	0	0	0	0	2	0	0	2	20	8	202	0	0	225	0	225
396	Hajiganj	21 Nachathara	0	0	0	0	0	0	0	0	38	0	0	2	24	10	263	0	0	326	0	326
396	Hajiganj	22 Hatila	0	0	0	0	0	0	0	0	0	0	0	0	0	6	162	0	0	162	0	162
396	Hajiganj	23 Belghar	0	0	0	0	0	0	0	0	16	0	0	9	61	0	0	1	22	99	0	99
396	Hajiganj	24 Ratali	1	28	0	0	0	0	0	0	18	0	0	8	36	3	28	0	0	81	28	109
396	Hajiganj	25 Dhadda	0	0	0	0	0	0	0	0	12	5	28	0	0	4	69	0	0	109	0	109
396	Hajiganj	26 Tangirpar	1	32	0	0	0	0	0	0	4	0	0	1	4	0	0	0	0	8	32	40
396	Hajiganj	27 Ahmmadpur	0	0	0	0	0	0	0	0	4	3	16	9	176	7	212	0	0	409	0	409
396	Hajiganj	28 Kakairtala	0	0	0	0	0	0	0	0	14	4	28	5	105	10	338	0	0	486	0	486
396	Hajiganj	29 Deshgaon	2	40	0	0	0	0	0	0	0	2	16	6	61	3	63	0	0	140	40	180
396	Hajiganj	30 Rashimpur	2	81	0	0	0	0	0	0	8	0	0	4	40	3	69	0	0	117	81	198
396	Hajiganj	31 Panchai Black	1	4	1	4	0	0	0	0	4	0	0	2	8	4	40	0	0	53	8	61
396	Hajiganj	32 Teragar	0	0	0	0	0	0	0	0	0	1	20	2	61	13	250	0	0	331	0	331
396	Hajiganj	33 Kangaish	0	0	0	0	0	0	0	0	6	0	0	2	16	7	227	0	0	248	0	248
396	Hajiganj	34 Balakhal	0	0	0	0	0	0	0	0	5	2	2	7	31	9	233	0	0	271	0	271
396	Hajiganj	35 Khatra Biloai	0	0	0	0	0	0	0	0	0	1	2	0	0	14	227	0	0	229	0	229

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3–5 cs Nr	LLP 3–5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
397	Shahrasti	1 Nijmeher	3	81	1	2	0	0	0	0	12	3	12	4	32	7	111	0	0	168	83	251
397	Shahrasti	2 Bhupaldi	4	182	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	20	182	202
397	Shahrasti	3 Debakra	1	24	0	0	0	0	0	0	16	2	7	3	22	5	103	0	0	149	24	173
397	Shahrasti	4 Upalatar	8	194	0	0	0	0	0	0	8	2	8	4	20	2	12	0	0	49	194	243
397	Shahrasti	5 Loura	6	113	0	0	0	0	1	0	8	6	5	3	3	0	0	0	0	16	114	130
397	Shahrasti	6 Kaliapara	4	190	0	0	0	0	0	0	2	8	20	0	0	0	0	0	0	22	190	212
397	Shahrasti	7 Dupalla	0	0	0	0	0	0	0	0	8	0	0	0	0	10	316	0	0	324	0	324
397	Shahrasti	8 Kulashi	0	0	0	0	0	0	0	0	4	0	0	3	16	9	304	0	0	324	0	324
397	Shahrasti	9 Oaruk	4	200	0	0	0	0	10	1	10	9	10	2	10	0	0	0	0	30	202	232
397	Shahrasti	10 Isapur	3	81	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	81	83
397	Shahrasti	11 Balshid	6	145	0	0	0	0	0	0	21	2	4	0	0	0	0	0	0	25	145	170
397	Shahrasti	12 Unakilla	4	57	0	0	0	0	0	0	4	5	28	0	0	2	20	0	0	53	57	109
397	Shahrasti	13 Ullashawar	6	121	0	0	0	0	0	0	2	0	0	6	40	0	0	0	0	42	121	164
397	Shahrasti	14 Bijoypur	7	142	0	0	0	0	0	0	4	2	8	4	32	2	32	0	0	77	142	219
397	Shahrasti	15 Khila	0	0	1	2	0	0	0	0	4	0	0	3	10	9	162	0	0	176	2	178
397	Shahrasti	16 Chitoshi	0	0	0	0	0	0	0	0	2	2	2	10	58	4	81	0	0	144	0	144
397	Shahrasti	17 Kashba	0	0	0	0	0	0	0	0	12	1	6	8	81	1	20	0	0	119	0	119
397	Shahrasti	18 Kadra	0	0	0	0	0	0	0	0	9	8	24	4	49	0	0	0	0	82	0	82
397	Shahrasti	19 Ugharia	2	22	0	0	0	0	0	0	16	6	36	1	10	0	0	0	0	63	22	85
397	Shahrasti	20 Pathair	2	28	0	0	0	0	0	0	20	1	6	2	10	8	162	1	47	245	28	273
397	Shahrasti	21 Suchipara	2	40	0	0	0	0	0	0	12	0	0	11	93	9	121	0	0	227	40	267
397	Shahrasti	22 Sursak	2	81	0	0	0	0	0	0	24	5	30	3	49	0	0	0	0	103	81	184
397	Shahrasti	23 Raghai	0	0	0	0	0	0	0	0	13	18	81	5	40	0	0	0	0	134	0	134
397	Shahrasti	24 Naringpur	1	24	0	0	0	0	0	0	8	4	24	11	154	0	0	0	0	186	24	210

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3–5 cs Nr	LLP 3–5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
398	Faridganj	1 Shekdi	0	0	0	0	0	0	0	0	101	0	0	1	8	14	312	0	0	421	0	421
398	Faridganj	2 Chandra	0	0	0	0	0	0	0	0	45	0	0	0	0	16	304	0	0	348	0	348
398	Faridganj	3 Balithuk	0	0	0	0	0	0	0	0	30	0	0	0	0	15	283	0	0	314	0	314
398	Faridganj	4 Shulla	0	0	0	0	0	0	0	0	0	0	0	6	28	22	275	0	0	304	0	304
398	Faridganj	5 Kamta	0	0	0	0	0	0	0	0	0	0	0	1	4	11	196	0	0	200	0	200
398	Faridganj	6 Gallak	0	0	0	0	0	0	0	0	0	0	0	4	34	11	176	0	0	210	0	210
398	Faridganj	7 Khajuria	0	0	0	0	0	0	0	0	4	2	6	12	93	21	306	0	0	409	0	409
398	Faridganj	8 Rupsha	0	0	0	0	0	0	0	0	5	0	0	2	16	26	328	0	0	349	0	349
398	Faridganj	9 Badarpur	0	0	0	0	0	0	0	0	56	0	0	3	18	26	316	0	0	390	0	390
398	Faridganj	10 Charmandari	0	0	0	0	0	0	0	0	1	0	0	2	15	13	235	0	0	250	0	250
398	Faridganj	11 Shahebganj	0	0	0	0	0	0	0	0	3	0	0	0	0	19	358	0	0	361	0	361
398	Faridganj	12 Birampur	0	0	0	0	0	0	0	0	40	0	0	3	30	33	633	0	0	704	0	704
398	Faridganj	13 Bishkatali	0	0	0	0	0	0	0	0	40	0	0	4	40	22	429	0	0	510	0	510
398	Faridganj	14 Gual Bhangar	0	0	0	0	0	0	0	0	81	0	0	7	40	27	461	0	0	583	0	583
398	Faridganj	15 Hasa	0	0	0	0	0	0	0	0	61	0	0	0	0	27	510	0	0	571	0	571
398	Faridganj	16 Nayarhat	0	0	0	0	0	0	0	0	0	0	0	0	0	34	607	0	0	607	0	607
398	Faridganj	17 Prathwashi	0	0	0	0	0	0	0	0	12	0	0	1	8	26	465	0	0	486	0	486
398	Faridganj	18 Gazipur	0	0	0	0	0	0	0	0	49	0	0	0	0	33	486	0	0	534	0	534
398	Faridganj	19 Shashiali	0	0	0	0	0	0	0	0	16	0	0	0	0	19	324	0	0	340	0	340
398	Faridganj	20 Paikpara	0	0	0	0	0	0	0	0	24	0	0	0	0	20	243	0	0	267	0	267
398	Faridganj	21 Kerua	0	0	0	0	0	0	0	0	119	0	0	2	12	26	415	0	0	546	0	546
398	Faridganj	22 Faridganj	0	0	0	0	0	0	0	0	12	0	0	3	18	17	253	0	0	283	0	283
398	Faridganj	23 Char Barali	0	0	0	0	0	0	0	0	8	0	0	2	12	8	142	0	0	162	0	162
398	Faridganj	24 Kalir Bazar	0	0	0	0	0	0	0	0	8	0	0	2	12	36	575	0	0	595	0	595
398	Faridganj	25 Shantushpur	0	0	0	0	0	0	0	0	81	0	0	2	20	18	304	0	0	405	0	405
398	Faridganj	26 Sakadirampur	0	0	0	0	0	0	0	0	22	0	0	0	0	7	113	0	0	136	0	136
398	Faridganj	27 Debipur	0	0	0	0	0	0	0	0	53	0	0	0	0	2	49	1	53	154	0	154
398	Faridganj	28 Fhurpara	0	0	0	0	0	0	0	0	22	0	0	0	0	6	295	0	0	318	0	318
398	Faridganj	29 Munshirhat	0	0	0	0	0	0	0	0	0	0	0	8	62	4	65	0	0	126	0	126
398	Faridganj	30 Telishair	0	0	0	0	0	0	0	0	10	0	0	3	13	17	227	0	0	250	0	250
398	Faridganj	31 Basara	0	0	0	0	0	0	0	0	10	0	0	1	10	7	112	0	0	132	0	132
398	Faridganj	32 Lakshmipur	0	0	4	22	0	0	0	0	10	0	0	2	18	16	204	0	0	232	22	255
398	Faridganj	33 Sree Kalia	0	0	0	0	0	0	0	0	0	0	0	7	57	12	194	0	0	251	0	251
398	Faridganj	34 Ghaniamanuri	0	0	5	38	0	0	0	0	2	0	0	5	40	10	146	0	0	188	38	227

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3-5 cs Nr	LLP 3-5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
401	Ramganj	1 Joipura	0	0	0	0	0	0	0	0	24	4	16	10	121	5	101	0	0	263	0	263
401	Ramganj	2 Bigha	0	0	0	0	0	0	0	0	65	5	20	10	121	4	81	0	0	287	0	287
401	Ramganj	3 Noagaon	0	0	0	0	0	0	1	0	1	12	25	12	53	5	53	0	0	132	0	132
401	Ramganj	4 Paniwala	0	0	0	0	0	0	0	0	2	19	44	6	29	5	53	0	0	127	0	127
401	Ramganj	5 Saisai	0	0	0	0	0	0	0	0	4	24	79	3	24	1	20	0	0	127	0	127
401	Ramganj	6 Bhadur	0	0	0	0	0	0	1	0	8	13	47	2	8	2	14	0	0	77	0	77
401	Ramganj	7 Morondi	0	0	0	0	0	0	0	0	4	9	18	23	160	0	0	0	0	182	0	182
401	Ramganj	8 Sonapur	0	0	0	0	0	0	0	0	2	13	26	11	36	6	61	0	0	125	0	125
401	Ramganj	9 Lamchar	0	0	0	0	0	0	1	0	57	20	65	5	30	0	0	0	0	152	0	152
401	Ramganj	10 Kalikapur	0	0	0	0	0	0	0	0	4	6	14	7	40	8	113	0	0	172	0	172
401	Ramganj	11 Darbashpur	0	0	2	8	0	0	0	0	8	9	36	14	81	4	32	0	0	158	8	166
401	Ramganj	12 Sosholia	0	0	0	0	0	0	0	0	2	37	120	10	61	0	0	0	0	182	0	182
401	Ramganj	13 Jagatpur	0	0	0	0	0	0	0	0	8	16	52	3	18	0	0	0	0	78	0	78
401	Ramganj	14 Dumuria	0	0	0	0	0	0	0	0	4	23	70	2	14	0	0	0	0	88	0	88
401	Ramganj	15 Kanpara	0	0	0	0	0	0	1	0	8	26	127	2	20	0	0	0	0	156	0	156
401	Ramganj	16 Nagmut	0	0	0	0	0	0	0	0	2	19	53	2	12	1	8	0	0	75	0	75
401	Ramganj	17 Tiori	0	0	0	0	0	0	0	0	16	7	28	1	6	0	0	0	0	51	0	51
401	Ramganj	18 Bholakot	0	0	0	0	0	0	0	0	20	8	32	1	8	0	0	0	0	61	0	61
401	Ramganj	19 Vatra	0	0	0	0	0	0	0	0	10	11	22	4	16	0	0	0	0	49	0	49
401	Ramganj	20 Daulta	0	0	2	6	0	0	0	0	0	20	28	3	8	0	0	0	0	37	6	43
401	Ramganj	21 Panbara	0	0	0	0	0	0	0	0	6	7	18	1	6	15	212	0	0	243	0	243
401	Ramganj	22 Fathepur	0	0	0	0	0	0	0	0	0	0	0	2	12	14	117	0	0	129	0	129
401	Ramganj	23 Madimpur	0	0	0	0	0	0	0	0	0	0	0	1	4	16	164	0	0	168	0	168
401	Ramganj	24 Chandipur	0	0	0	0	0	0	0	0	4	0	0	2	8	0	0	7	113	125	0	125
401	Ramganj	25 Sonapur	0	0	0	0	0	0	0	0	4	4	12	2	9	20	229	0	0	255	0	255
401	Ramganj	26 Kanchanpur	0	0	0	0	0	0	0	0	40	3	6	5	16	13	221	0	0	283	0	283
401	Ramganj	27 Srirampur	0	0	0	0	0	0	0	0	4	0	0	0	0	14	255	0	0	259	0	259
401	Ramganj	28 Narayanpur	0	0	0	0	0	0	0	0	20	6	12	0	0	15	198	0	0	230	0	230

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3-5 cs Nr	LLP 3-5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
402	Laksmipur	1 Hasanda	0	0	0	0	0	0	0	0	4	4	10	5	51	3	53	0	0	117	0	117
402	Laksmipur	2 Bijoynagar	0	0	0	0	0	0	0	0	6	12	34	7	73	34	490	0	0	603	0	603
402	Laksmipur	3 Jahanabad	0	0	0	0	0	0	0	0	0	1	1	2	6	1	9	0	0	16	0	16
402	Laksmipur	4 Hamchadi (South)	0	0	0	0	0	0	0	0	0	6	13	12	81	30	295	0	0	389	0	389
402	Laksmipur	5 Dalalbazar	0	0	0	0	0	0	0	0	81	4	16	4	28	30	405	0	0	530	0	530
402	Laksmipur	6 Dahashala	0	0	0	0	0	0	0	0	6	0	0	5	28	45	637	0	0	672	0	672
402	Laksmipur	7 Kashmahal	0	0	0	0	0	0	0	0	14	0	0	2	14	20	299	0	0	328	0	328
402	Laksmipur	8 Sjasherabad	0	0	0	0	0	0	0	0	8	5	30	7	99	3	61	0	0	198	0	198
402	Laksmipur	9 Mijupur	0	0	0	0	0	0	0	0	20	15	91	13	184	5	101	0	0	397	0	397
402	Laksmipur	10 Parbatanagar	1	38	0	0	0	0	1	0	10	15	36	2	16	4	40	0	0	103	39	142
402	Laksmipur	11 Khilbaicha	0	0	0	0	0	0	0	0	16	7	28	5	53	3	65	0	0	162	0	162
402	Laksmipur	12 Bhangakha	0	0	0	0	0	0	0	0	8	3	12	0	0	16	324	0	0	344	0	344
402	Laksmipur	13 Rajabpur	0	0	0	0	0	0	0	0	6	2	8	0	0	10	202	0	0	217	0	217
402	Laksmipur	14 Rashedpur	1	16	0	0	0	0	0	0	81	5	24	4	32	2	28	0	0	166	16	182
402	Laksmipur	15 Bashikpur	0	0	0	0	0	0	0	0	61	6	24	2	12	1	14	0	0	111	0	111
402	Laksmipur	16 Rokanpur	0	0	0	0	0	0	0	0	81	4	16	5	24	2	20	0	0	142	0	142
402	Laksmipur	17 Sattapara	1	18	0	0	0	0	0	0	2	4	8	3	16	0	0	0	0	26	18	45
402	Laksmipur	18 Saidpur	2	40	2	10	0	0	0	0	11	4	6	2	11	1	12	0	0	40	51	91
402	Laksmipur	19 Totarakhal	2	32	0	0	0	0	0	0	4	5	12	3	16	1	4	0	0	37	32	69
402	Laksmipur	20 Joypur (North)	3	73	1	2	0	0	0	0	30	13	53	12	101	0	0	0	0	184	75	259
402	Laksmipur	21 Chaupalli	2	49	0	0	0	0	0	0	57	14	57	8	81	1	20	0	0	214	49	263
402	Laksmipur	22 Latiapur	0	0	6	32	0	0	0	0	20	22	97	5	57	7	146	0	0	320	32	352
402	Laksmipur	23 Ram Krishnapur	0	0	0	0	0	0	0	0	2	2	4	3	30	13	263	0	0	299	0	299
402	Laksmipur	24 Pachpara	2	75	6	30	0	0	0	0	63	37	113	8	75	0	0	0	0	251	105	356
402	Laksmipur	25 Hajirpara	0	0	1	6	0	0	0	0	20	1	4	7	51	19	324	0	0	399	6	405
402	Laksmipur	26 Char Chamita	0	0	2	20	0	0	0	0	8	5	20	3	28	1	12	0	0	69	20	89
402	Laksmipur	27 Char Shahi	0	0	0	0	0	0	0	0	277	4	16	9	91	15	364	0	0	749	0	749
402	Laksmipur	28 Rampur	0	0	0	0	0	0	0	0	40	0	0	2	20	0	0	0	0	61	0	61
402	Laksmipur	29 Dhighali	0	0	0	0	0	0	0	0	2	0	0	5	45	6	109	0	0	156	0	156
402	Laksmipur	30 Khagdia	0	0	0	0	0	0	0	0	12	0	0	2	16	3	51	0	0	79	0	79
402	Laksmipur	31 Jamintala	0	0	0	0	0	0	0	0	0	0	0	4	42	11	314	0	0	356	0	356
402	Laksmipur	32 Mandari	0	0	0	0	0	0	2	0	10	4	12	5	34	9	91	0	0	148	0	148
402	Laksmipur	33 Ratanpur	0	0	0	0	0	0	0	0	1	0	0	1	8	10	109	0	0	118	0	118
402	Laksmipur	34 Gandabpur	0	0	0	0	0	0	0	0	2	0	0	1	6	1	10	0	0	18	0	18
402	Laksmipur	35 Laharkandi	0	0	0	0	0	0	0	0	10	0	0	2	14	11	182	0	0	206	0	206
402	Laksmipur	36 Jabir nagar	0	0	0	0	0	0	0	0	0	2	4	2	10	2	22	0	0	36	0	36
402	Laksmipur	37 Ramanandi	0	0	0	0	0	0	0	0	4	0	0	0	0	3	53	0	0	57	0	57
402	Laksmipur	38 Shakchar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
402	Laksmipur	39 Tumchar	0	0	0	0	0	0	0	0	8	0	0	0	0	8	125	0	0	134	0	134
402	Laksmipur	40 Char Ramani	0	0	0	0	0	0	0	0	49	0	0	1	8	27	382	0	0	439	0	439
402	Laksmipur	41 Kalirchar	0	0	0	0	0	0	0	0	16	0	0	3	18	28	393	0	0	427	0	427
402	Laksmipur	42 Char Manasha	0	0	0	0	0	0	0	0	0	0	0	2	18	0	0	0	0	19	0	19
402	Laksmipur	43 Hossainpur	0	0	0	0	0	0	0	0	2	0	0	0	0	1	24	0	0	26	0	26
402	Laksmipur	44 Piarapur	0	0	0	0	0	0	0	0	2	0	0	1	3	5	55	0	0	59	0	59
402	Laksmipur	45 Char Ubuti	0	0	0	0	0	0	0	0	8	5	20	2	16	21	380	0	0	425	0	425
402	Laksmipur	46 Kathali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
402	Laksmipur	47 Goranbag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Than Code	Thana name	DAE Block Nr & Name	DTW Nr	DTW (ha)	STW Nr	STW (ha)	DSSTW Nr	DSSTW (ha)	MTW Nr	MTW (ha)	Traditional Irrigation (ha)	LLP <1 cs Nr	LLP <1 cs (ha)	LLP 1 cs Nr	LLP 1 cs (ha)	LLP 2 cs Nr	LLP 2 cs (ha)	LLP 3-5 cs Nr	LLP 3-5 cs (ha)	Surface Irrigation (ha)	Groundwater Irrigation (ha)	Total Irrigation (ha)
403	Ramgati	1 Taltali	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	4	0	4
403	Ramgati	2 Charjagabandhu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	3 Motirhat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	4 Char Lauranch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	5 Char Martin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	6 Musshirhat	0	0	0	0	0	0	0	0	0	0	0	6	45	0	0	0	0	45	0	45
403	Ramgati	7 Char Falcon (So)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	8 Char Falcon (No)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	9 Jan galia (Nort)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	10 Char Jangalia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	11 Torabganj	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	12 Fijumiarhat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	13 Char bashu	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	2
403	Ramgati	14 Char shita	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	15 Char kalkopa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	16 Char poragacha	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1
403	Ramgati	17 Shebagram	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	18 Maydha char Ale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	19 Alexander (Nort)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	20 Sonarchar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	21 Char Abdullah	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	22 Ramdayal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	23 Char Hasan Hoss	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	24 Char Ramji	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	25 Char Afjal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	26 Char Meher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	27 Barakhesi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	28 Rugunathpur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	29 Char Lakshmi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
403	Ramgati	30 Tumchar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

208

APPENDIX I.X

IRRIGATION PUMP OPERATOR SURVEY RESULTS AND LLP DATA EXTRACTED FROM KHAL SURVEYS

APPENDIX I.X

Irrigation Pump Operator Surveys

		LLP		STW		DTW		Total	
Zone	Block Name	Nr. Existing	Nr. Interviewed	Nr. Existing	Nr. Interviewed	Nr. Existing	Nr. Interviewed	Nr. Existing	Nr. Interviewed
A	Mijupur	30	8	-	-	-	-	30	8
	Mandari	21	8	-	-	-	-	21	8
	Dighali	15	8	-	-	-	-	15	8
B	Nazirpur	18	8	-	-	-	-	18	8
	Eklashpur	30	8	-	-	-	-	30	8
	Chhayani	12	8	-	-	-	-	12	8
C	Batakandi	13	4	17	4	1	Not Operated	31	8
	Daluthpur	15	8	-	-	-	-	15	8
	Pachpara	45	4	6	1	3	3	54	8
D	Parbata Nagar	25	8	-	-	1	Not Operated	26	8
	Sundarpur	31	8	-	-	-	-	31	8
	Saisai	30	8	-	-	-	-	30	8
	Total	285	88	23	5	5	3	313	96

Note : For location of sample blocks see map of Department of Agriculture Extension (DAE) Blocks in Appendix I.IX.

210

Name of Project: Noakhali North Project

Zone : Agri. Block Name:

IRRIGATION PUMP QUESTIONNAIRE

Date:

Enumerator

Serial no.

1. JL. No.:	2. Plot Nr. (where pump is located):	Flood depth:

3. Village:	4 .Mouza:	5. Thana:	6. District:

7. Type of pump
1. DTW (Well Nr.)
2. STW
3. LLP 1 cfs. 2 cfs. 3 cfs.
4. MOSTI
5. traditional [type.........................]

8. Source of power
1. diesel
2. electricity
3. manual

9. Engine size		HP/KW
Pipe Diameter		RPM :
Depth of Pipe		Engine Name:
Length of screen		Country :

If LLP, Length of Suction pipe

10. Date installed

Capital Cost: Tk. New/Old

11. Ownership
1. private
2. KSS/BADC
3. other Government
4. NGO group
5. other group

12. Source of water:

1. Main River	
2. Khal	
3. Groundwater	

13. Crops irrigated

Crops	owners /group (Acres)	other farmer (Acres)	total (Acres)
boro			
aus			
aman			
wheat			
potato			
vegetable			
other [specify]			

14. Canal System

Total Length	M
Lining - Brick	M
Earth	M

15. Total area commandable (potentially irrigated) ______ acres

16. What factors limit area irrigated

tick	
	capacity of pump
	unreliability of pump
	poor supply of electricity
	supply of water in well or khal
	little demand from farmers/high cost fuel etc
	difficulties of transmission of water
	difficulties in management/payments
	competition from other pumps
	other [specify]
	GWT depletion
	Gas problems

17. Does the area irrigated adjoin land irrigated by other pumps
1. no
2. yes

if LLP 18. Is the location of the pump normally moved during the season
1. no
2. yes

If moved 19. Is the same land irrigated after the move as before
1. no
2. yes

19.A. Where moved?
- Pond
- River/khal
- STW

20. Has the area irrigated increased or decreased since the pump first started operation
1. no change
2. increase
3. decrease

21. If there has been a change in the area irrigated, what are the reasons

22. Is the supply of water in khal or well limited [ ]
1. no - water supply OK
2. water supply limited in some years
3. water supply limited every year

if yes: periods when supply limited [name months]

is this a problem getting worse year-by-year [ ]
1. no - no change in situation
2. getting worse every year
3. supply improving every year

if yes: what is the cause of this change ?

23. Water quality

is irrigation water saline [ ]
1. no - water good quality
2. yes - a little saline
3. yes - a very saline

if yes, at what times of year [name months]

does it reduce yields [ ] 1. no 2. yes

is salinity increasing year-by-year [ ] 1. no 2. yes

24. What improvements needed to improve irrigation supply or expand area

[tick]
- [ ] no improvement needed
- [ ] improve supply of water in khal
- [ ] install electical power supply
- [ ] line distribution channels
- [ ] replace/repair engine/pump
- [ ] improve management of pump/group
- [ ] other [specify]

25. Is any other use made of the engine when not used for irrigation [tick]
- [ ] no - irrigation only
- [ ] used in boat
- [ ] used for rice mill
- [ ] used for wheat mill
- [ ] used for oilseed crusher
- [ ] used in power tiller
- [ ] other [specify]

if yes, Income Tk: Per season

26. Water Charges

	Taka per acre		or	Share of crop (%)		Starting and ending date of Irrigation
	group member	other farmer		group member	other farmer	
boro						
aus						
aman						
wheat						
potato						
vegetable						[enter either Taka or crop share]
other [specify]						

27. Operating cost for last year (irrigation only)

Taka

	Boro (HYV)	Aus (HYV)	Aman (HYV)	Wheat	Potato	Vege-tables	Others (specify)	Total for year
fuel								
oil								
spare parts								
mechanic								
operator								
management								
Total:								

28. Operation Hours:

Maximum Daily	February	March	April	Total (Dry Season)

29. Name of respondant
Son of

30. Position [ ]
1. pump owner
2. group manager
3. farmer/water user
4. pump operator
5. other [specify]

TYPE OF PUMP

	Zone : A		Zone : B		Zone : C		Zone : D		Total	
	#	%	#	%	#	%	#	%	#	%
DTW					3	12.50			3	3.13
STW					5	20.83			5	5.21
LLP	24	100.00	24	100.00	16	66.67	24	100.00	88	91.67
Total	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00

SOURCES OF POWER

	Zone : A		Zone : B		Zone : C		Zone : D		Total	
	#	%	#	%	#	%	#	%	#	%
Diesel	23	95.83	24	100.00	24	100.00	24	100.00	95	98.96
Electricity	1	4.17							1	1.04
Total	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00

OWNERSHIP OF PUMPS

	Zone : A		Zone : B		Zone : C		Zone : D		Total	
	#	%	#	%	#	%	#	%	#	%
No response			1	4.17					1	1.04
Private	20	83.33	23	95.83	17	70.83	24	100.00	84	87.50
KSS/BADC					4	16.67			4	4.17
Other Govt.	2	8.33							2	2.08
Other group	2	8.33			3	12.50			5	5.21
Total	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00

SOURCES OF WATER

	Zone : A		Zone : B		Zone : C		Zone : D		Total	
	#	%	#	%	#	%	#	%	#	%
Khal	24	100.00	24	100.00	16	66.67	24	100.00	88	91.67
Groundwater					8	33.33			8	8.33
Total	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00

TOTAL AREA COMMANDABLE(ha)

	Zone : A		Zone : B		Zone : C		Zone : D		TOTAL	
	(ha)	(ha/pump)	(ha)	(ha/pump)	(ha)	(ha/pump)	(ha)	(ha/pump)	(ha)	(ha/pump)
DTW					129.55	43.18			129.55	43.18
STW					43.32	8.66			43.32	8.66
LLP	247.37	11.24	202.43	8.80	92.31	5.77	147.37	6.41	689.47	8.21
TOTAL	247.37	11.24	202.43	8.80	265.18	11.05	147.37	6.41	862.35	9.37

	Zone : A		Zone : B		Zone : C		Zone : D		TOTAL	
	#	%	#	%	#	%	#	%	#	%
QEST. NO 17										
No							2	8.33	2	2.08
Yes	24	100.00	24	100.00	24	100.00	22	91.67	94	97.92
TOTAL	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00
QUES. NO 18										
No	15	71.43			2	10.53	3	12.50	20	22.73
Yes	6	28.57	24	100.00	17	89.47	21	87.50	68	77.27
TOTAL	21	100.00	24	100.00	19	100.00	24	100.00	88	100.00
QUES. NO 19										
No	4	44.44	6	25.00	6	37.50	7	33.33	23	32.86
Yes	5	55.56	18	75.00	10	62.50	14	66.67	47	67.14
TOTAL	9	100.00	24	100.00	16	100.00	21	100.00	70	100.00
WHERE MOVED										
Pond	5	83.33	23	95.83	16	100.00	19	100.00	63	96.92
River	5	83.33	24	100.00	16	100.00	19	100.00	64	98.46
TOTAL	6	100.00	24	100.00	16	100.00	19	100.00	65	100.00

IRRIGATED AREA CHANGED SINCE THE PUMP FIRST STARTED OPERATIN

	Zone : A		Zone : B		Zone : C		Zone : D		TOTAL	
	#	%	#	%	#	%	#	%	#	%
No change	9	37.50	5	20.83	4	16.67	9	37.50	27	28.13
Increase	7	29.17	12	50.00	8	33.33	11	45.83	38	39.58
Decrease	8	33.33	7	29.17	12	50.00	4	16.67	31	32.29
TOTAL	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00

NUMBER OF RESPONSE BY FACTORS OF LIMITS AREA IRRIGATED

	Zone : A		Zone : B		Zone : C		Zone : D		Total	
	#	%	#	%	#	%	#	%	#	%
Capacity of pump			2	8.3	1	4.2	1	4.2	4	4.2
Unreliability			2	8.3	1	4.2	2	8.3	5	5.2
Poor supply of electricity					1	4.2			1	1.0
Supply of water in well or khal	8	33.3	21	87.5	16	66.7	24	100.0	69	71.9
Little demand from farmers/high cost fuel	2	8.3	6	25.0	4	16.7	2	8.3	14	14.6
Difficulties of transmission of water	13	54.2	7	29.2	10	41.7	1	4.2	31	32.3
Difficulties in management/payments	4	16.7	3	12.5	3	12.5	2	8.3	12	12.5
Competition frlm other pumps	4	16.7	3	12.5	8	33.3	12	50.0	27	28.1
Other	5	20.8							5	5.2
GWT depletion					4	16.7			4	4.2
Gas problems					2	8.3			2	2.1

216

	Zone : A		Zone : B		Zone : C		Zone : D		TOTAL	
	#	%	#	%	#	%	#	%	#	%
WATER SUPPLY ?										
Water supply OK	16	66.67	2	8.33	4	16.67			22	22.92
Water supply limited in some years	4	16.67	8	33.33	9	37.50	1	4.17	22	22.92
Water supply limited every year	4	16.67	14	58.33	11	45.83	23	95.83	52	54.17
TOTAL	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00
PROBLEM										
No change in sotuation	10	66.67	6	26.09	5	25.00			21	25.61
Getting worse evry year	5	33.33	17	73.91	14	70.00	24	100.00	60	73.17
Supply improving evry year					1	5.00			1	1.22
TOTAL	15	100.00	23	100.00	20	100.00	24	100.00	82	100.00
MONTHS										
2	4	50.00	7	31.82	9	45.00	20	83.33	40	54.05
3	8	100.00	22	100.00	19	95.00	23	95.83	72	97.30
4			14	63.64	9	45.00	1	4.17	24	32.43
TOTAL	8	100.00	22	100.00	20	100.00	24	100.00	74	100.00
CAUSES										
Insufficiant water in river	2	40.00	16	94.12	11	78.57	23	100.00	52	88.14
Siltation	3	60.00	1	5.88					4	6.78
Ground water depletion					3	21.43			3	5.08
TOTAL	5	100.00	17	100.00	14	100.00	23	100.00	59	100.00

The above table has been genrated from Q22

NOAKHALI\NFUMI\TAB\NFUMP.TAB

	Zone : A		Zone : B		Zone : C		Zone : D		TOTAL	
	#	%	#	%	#	%	#	%	#	%
WATER QUALITY										
Water goof quality	24	100.00	23	95.83	23	95.83	24	100.00	94	97.92
A little saline			1	4.17					1	1.04
A very saline					1	4.17			1	1.04
TOTAL	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00
MONTHS										
2					1	100.00			1	50.00
3			1	100.00					1	50.00
4					1	100.00			1	50.00
TOTAL			1	100.00	1	100.00			2	100.00
YIELD REDUCED										
No	1	100.00	1	100.00					2	66.67
Yes					1	100.00			1	33.33
TOTAL	1	100.00	1	100.00	1	100.00			3	100.00
SALINITY INCREASE ?										
Yes					1	100.00			1	100.00
TOTAL					1	100.00			1	100.00

The above table has been generated from Q23

WHAT IMPROVEMENTS NEEDED TO IMPROVE IRRIGATION SUPPLY OR EXPAND AREA

	Zone : A		Zone : B		Zone : C		Zone : D		TOTAL CASES	
	#	%	#	%	#	%	#	%	#	%
Improve supply of water in khal	7	29.17	22	91.67	16	66.67	24	100.00	69	71.88
Install electrical power supply	10	41.67	10	41.67	13	54.17	8	33.33	41	42.71
Line distribution channels	18	75.00	1	4.17	10	41.67	3	12.50	32	33.33
Replace/repair engine/pump	4	16.67	5	20.83	8	33.33	5	20.83	22	22.92
Improve management of pump/group	2	8.33	4	16.67	2	8.33	8	33.33	16	16.67
Other					2	8.33			2	2.08
TOTAL CASES	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00

OTHER USE MADE OF THE ENGINE WHEN NOT USED FOR IRRIGATION

	Zone : A		Zone : B		Zone : C		Zone : D		TOTAL CASES	
	#	%	#	%	#	%	#	%	#	%
Irrigation only	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00
TOTAL CASES	24	100.00	24	100.00	24	100.00	24	100.00	96	100.00

NUMBER OF RESPONDENTS (PAID TAKA FOR IRRIGATION) BY CROP

	GROUP	OTHER	TOTAL COST
	#	#	#
Boro	42	93	94

AVERAGE PAID (tk/ac) FOR IRRIGATION

	GROUP	OTHER	TOTAL COST
Boro	1984	1933	2799

	GROUP	OTHER	TOTAL COST
	Sum	Sum	Sum
Boro	83310	179760	263070.00

AVERAGE OPERATING COST (tk/ac) FOR LAST YEAR

	Fuel	Oil	Sparts parts	Machanic	Operator	Management	Total cost
Boro	585	66	158	54	265	165	1137

NUMBER OF RESPONSES

	Fuel	Oil	Sparts parts	Machanic	Operator	Management	Total cost
	#	#	#	#	#	#	#
Boro	90	89	70	65	67	69	90

	Fuel	Oil	Sparts parts	Machanic	Operator	Management	Total cost
	Sum	Sum	Sum	Sum	Sum	Sum	Sum
Boro	52685.09	5898.50	11058.18	3498.07	17752.73	11395.98	102288.56

TOTAL IRRIGATED (ac)

	Ownrs/Group		Others		Total	
	(ac)	#	(ac)	#	(ac)	#
Boro	328.6	74	1352.8	93	1681.40	96
TOTAL	328.6	74	1352.8	93	1681.40	96

APPENDIX I.X

Low Lift Pump Data Collected During Khal Surveys

Khal Nr.	Chainage (km)	Power (hp)	Area Served (ha)
4	35.35	3	16.2
	35.55	3	16.2
6	1.00	5	48.6
	15.44	4	29.1
	17.40	4	24.3
	17.55	4	24.3
	19.64	4	24.3
	26.34	6	40.5
	28.56	3	8.1
	28.64	6	16.2
	28.86	6	16.2
	29.67	8	15.2
	30.18	8	16.4
7	2.55	4	24.3
	5.05	4	24.3
	5.15	4	20.2
	5.80	5	19.8
13	36.15	10	10.12
14	10.13	5	32.74
	14.85	4	24.3
	15.05	4	29.1
	44.74	20	?
21	0.65	4	28.3
28	0.91	18	12.1
	1.29	18	18.2
	1.99	18	12.1
	2.33	18 x 2	12.1 + 8.1
	2.67	18	12.14
30	9.37	5	16.2
36	6.78	4	24.3
39	2.35	5	3.6
	24.1	4	12.1

Low Lift Pump Data Collected During Khal Surveys (Contd.)

Khal Nr.	Chainage (km)	Power (hp)	Area Served (ha)
51	14.5	25 (E)	40.5
	21.6	18	20.2
	24.84	16	16
	26.65	16	?
65	2.68	6	19.2
	6.37	4	24.3
68	0.36	4	4.1
69	13.67	12	?
	18.29	10	?
75	1.1	4	16.2
	1.4	4	16.2
Borrow Pit.	1.67	12	?
85	11.00	4	24.3
	1.83	4	24.3
	2.53	4	24.3
	2.73	4	28.3
	2.83	4	24.3
	3.49	4	24.3
	4.10	4	24.3
	4.9	4	24.3
86	6.68	4	48.6
	7.18	4	28.1
	8.50	4	24.3
		Average	21.5

Notes:

(i) For khal identification see Khal Location Map in Appendix I.IV

(ii) Data were not collected for all khals surveyed.

(iii) E - Electric Pump

APPENDIX I.XI

HYDRAULIC GATES AND OTHER ELECTROMECHANICAL PLANT

223

APPENDIX I.XI

HYDRAULIC GATES AND OTHER ELECTRO-MECHANICAL PLANT

1 Preamble

One pumping station and a variety of control structures have been conceived in the feasibility study of the Noakhali North Drainage and Irrigation Project.

Designs, specifications and feasibility drawings of hydraulic gates, gate hoists, pumps, and other plant and equipment necessary for these structures have been finalised. This report describes the design philosophy adopted for designing these works, their modes of operation, selection of materials and finishes, and unit cost estimates.

2 Design Philosophy

The regulating structures for this project have been designed with medium sized vents. Hence, other than the large fixed wheel gates required for a Dakatia Navigation Lock, all other gates required for the project could be manufactured locally and this aspect was given priority when detailing design features.

Recommendations of the following International Standards and standard references have been adopted in the designs of gates and other appurtenant steel structures:

a Design Supplement No 7 to Part 2, Engineering Design, Reclamation Volume X: **Valves, Gates and Steel Conduits,** United States Department of Interior, Bureau of Reclamation. Volume X.

b Indian Standard 4622-1978: **Recommendations for Structural Design of Fixed Wheel Gates,** Indian Standards Institution.

c Indian Standard 5620-1968: **Recommendations for Structural Design Criteria for Low Head Gates,** Indian Standards Institution

d Indian Standard 6938-1973: **Code of Practice for Design of Drum and Chain Hoists for Hydraulic Gates,** Indian Standards Institution.

e Baumeister, T: **Marks' Standard Handbook for Mechanical Engineers,** McGraw Hill Book Company.

f Deutsche Normen DIN 19 704-1976: **Hydraulic Steel Structures: Criterion for Design and Calculation,** Deutsches Institute fur Normung.

g Kubota Pump Handbook, Vols 1 and 2, Kubota Limited

224

The structural layouts of gate leaves were optimised with the main load carrying beams oriented horizontally. They were spaced out vertically in such a manner that they received equal loads from the triangularly distributed hydrostatic pressure. Loads on the horizontal beams were distributed in the vertical direction by means of two load distribution beams located at one fourth the span from each end. A typical gate leaf is shown in Figure 1. Standard rolled steel angles and T-sections were combined with the skin plate (to the extent permitted by relevant standards) to form economical composite beams. Additional stiffeners were provided wherever deflections of the unsupported skin plate panels were found excessive. All gates are designed with the skin-plate located on the sealing side of the gates.

Moulded rubber seals are manufactured locally to a good standard. Hence, unreinforced rubber J-seals are incorporated in all the gates. The sealing arrangements for the top and bottom corners could be formed by vulcanizing as indicated in the drawings. However, the more expensive moulded corner joints are recommended for longer seal life.

Multi-stage reduction screw hoists (similar to Armco design) and cable winches are specified since these are manufactured extensively in Bangladesh. Ratchet-and-pawl link-chain hoists of the type shown in the Figure 2 or similar are to be provided wherever removable gate hoists are recommended.

All gates shall be sand-blasted to the relevant specification and painted with a suitable marine quality paint to an adequate dry film thickness. The final surface finishes are of utmost importance since proper preventive maintenance measures do not appear to be implemented at existing schemes due to budget constraints.

Exposed parts of embedded parts shall be of stainless steel. All pivot pins of flap gates are to be machined from stainless steel bar stock. All hinge bearings shall be of a suitable bronze with provision for lubrication.

All embedded parts are designed and costed for installing in two stages. In the first stage the Civil Contractor shall install pre-embedded parts supplied by the Gate Contractor leaving blockouts for embedded parts. In the second stage, the Gate Contractor shall attach the embedded parts to the pre-embedded parts, align them to the required tolerance, and cast the second stage concrete in the blockouts. The Gate Contractor takes full responsibility for the proper alignment of the embedded parts.

3 Scope of Scheme

Feasibility of the following structures is being considered:

- a A Modifications to the existing regulator at Rahmatkhali;
- b A new regulator at Rahmatkhali;
- c A pumping station at Rahmatkhali;
- d A new regulator at Musapur on the Little Feni;
- e A new regulator at Chandpur on the Dakatia River with a navigation lock; and
- f A small regulator on the Noakhali Khal.

Figure 1
Typical Gate Leaf Layout

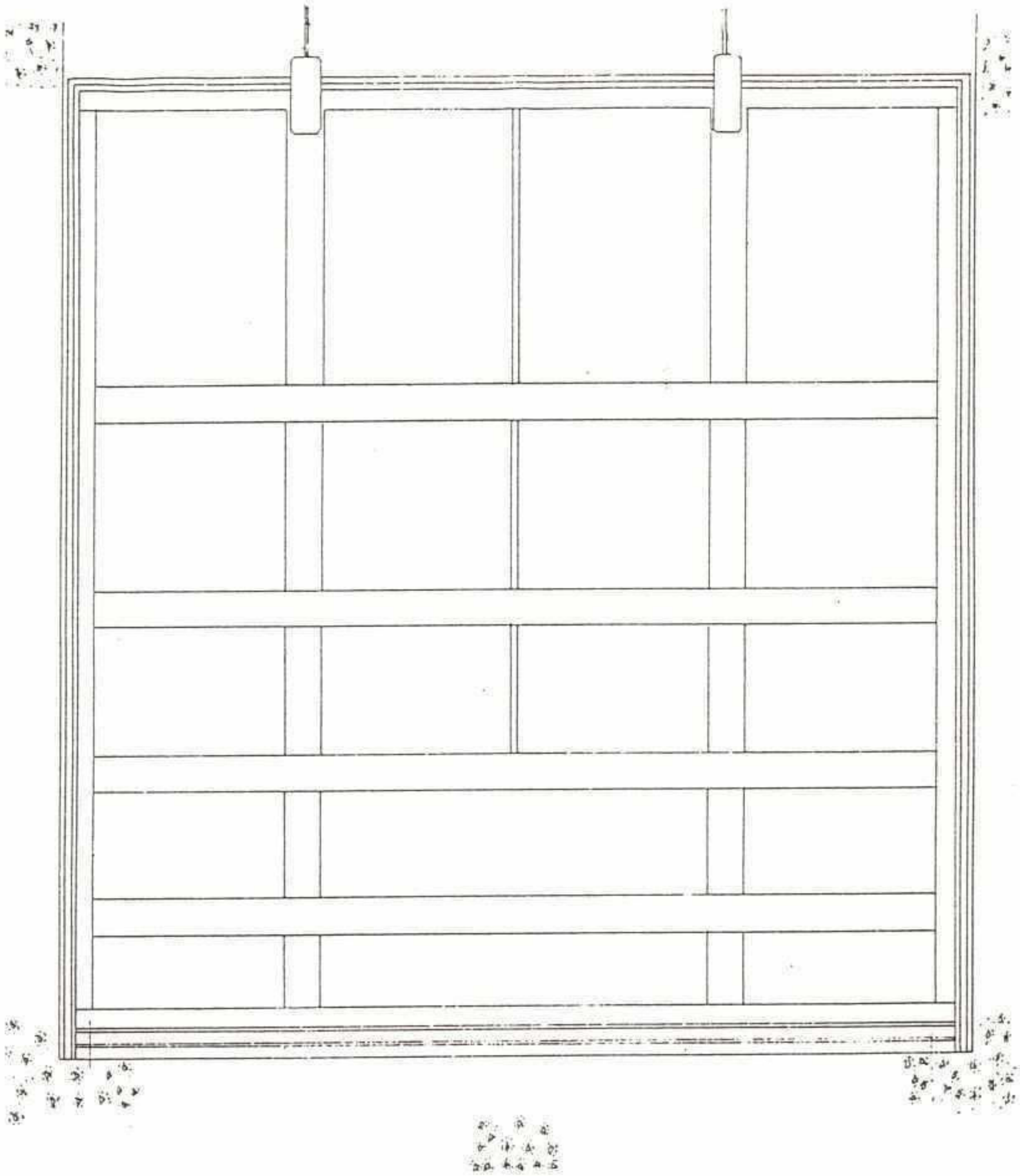
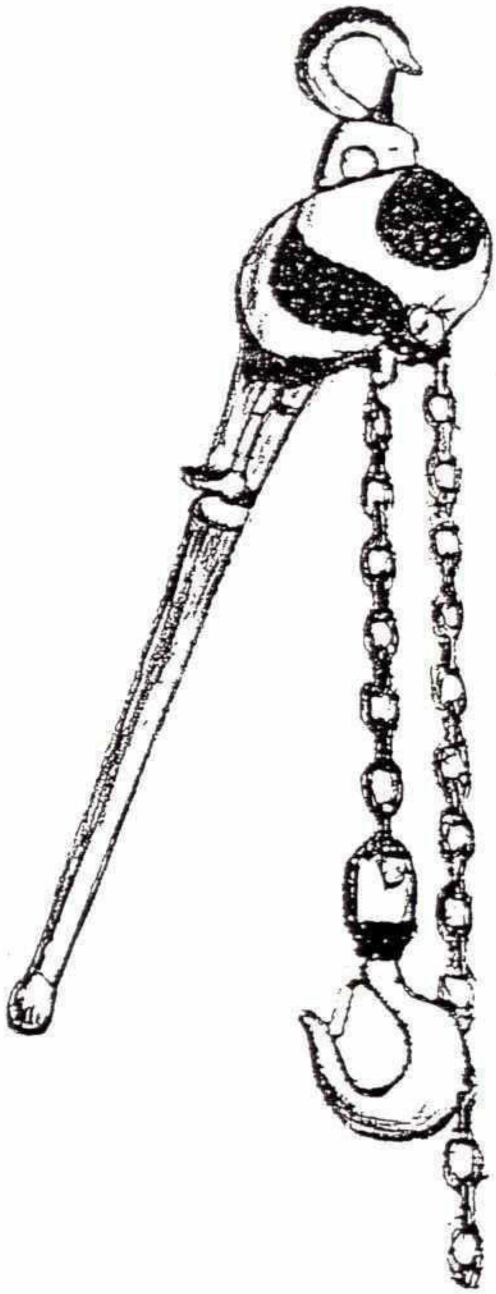


Figure 2
Type of Recommended Hand Hoist



4 Rahmatkhali

Rahmatkhali Khal is now badly overloaded and the Rahmatkhali Regulator needs rehabilitation and improvements to cater for the extra demand on drainage. This is to be achieved by:

a Modifying the existing regulator to improve its performance;

b Constructing a second regulator at Rahmatkhali in parallel; and/or

c Constructing a dual-purpose pumping station at Rahmatkhali for both drainage pumping and irrigation pumping.

4.1 Modifications to Existing Regulator

Two options are being considered to improve the performance of the regulator. These are:

a Modify the downstream flap gates so that they could be opened fully and kept in the open position during the dry season so that irrigation water could be taken into the country side by operating the radial gates at appropriate tide levels; or

b Modify the downstream flap gates in the manner described in (a) above and, in addition, replace the radial gates with balanced flap gates on the upstream side with suitable modifications to the concrete structure.

In order that Option (a) could be adopted, the upstream radial gates must be motorised in addition to modifying the downstream flap gates. The existing gate hoists have provision for installing electric motors but there is no power available at Rahmatkhali at present. This will be a cost item in considering the feasibility of this option.

Operating 14 radial gates twice a day throughout the dry season to admit irrigation water will be a difficult task. Hence, the configuration of the second option is more suitable since the gate operations are automatic. With flap gates of the balanced type the gates will open under very small head differences to admit irrigation water during high tide.

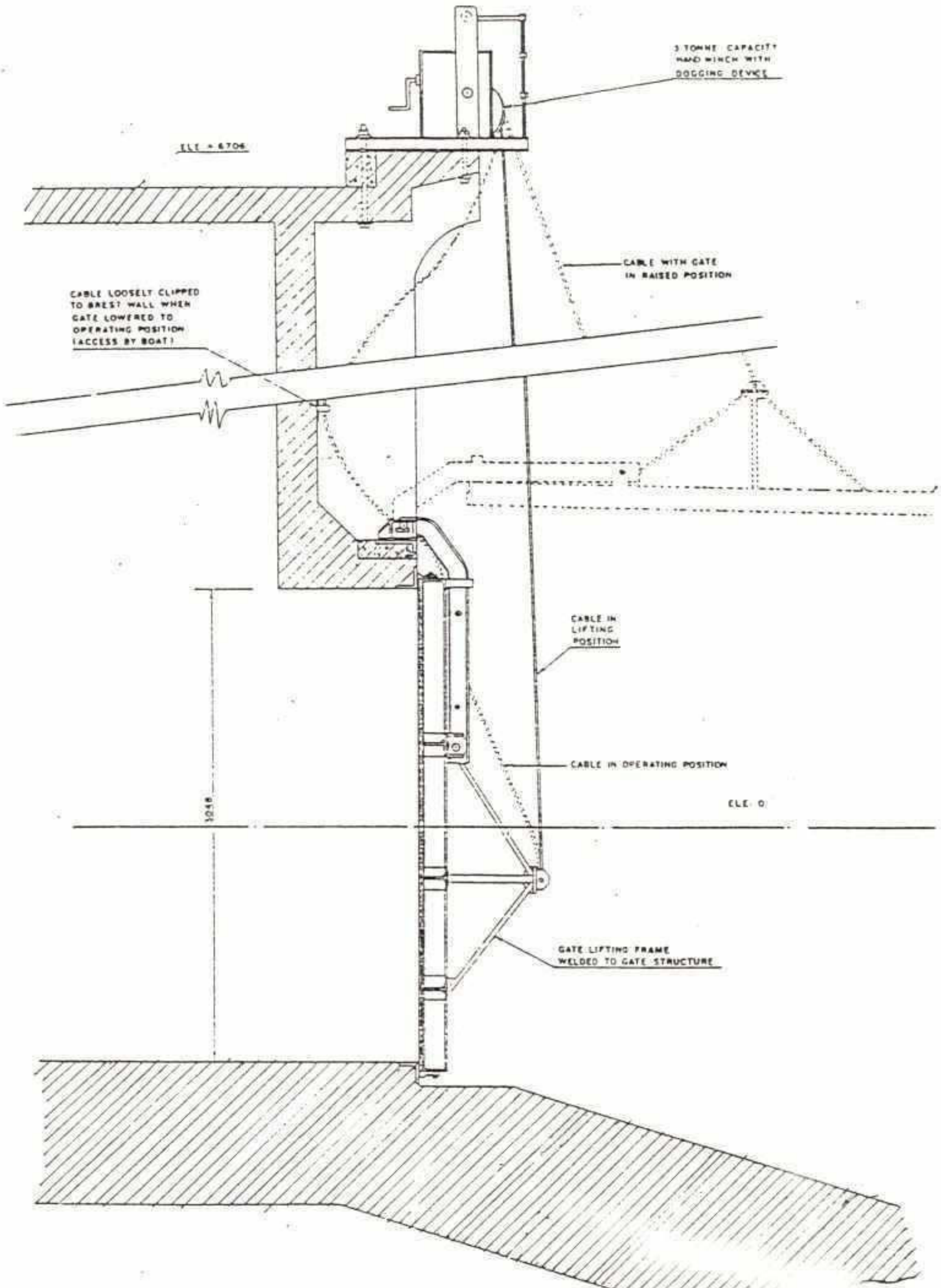
4.1.1 Modifications to Downstream Flap Gates

Two basic modifications to the downstream flap gates are necessary to make them suitable for the operations envisaged, as shown in Figure 3. These are : (i) the hinge arrangements on the flap gates must be made more robust so that additional forces imposed on the gates by these operations could be withstood, and (ii) a suitable lifting arrangement for the gates must devised.

The leaf design of existing gates is structurally adequate for the hydraulic loads imposed on them. Hence, the present gate leaf design will be adopted without change.

Figure 3

Modified Arrangemment of Rahmatkhali Flap Gate



The existing flap gates have a single hinge at the top centre. This has to be modified and made more robust. The pivot arrangement is replaced with the improved two-hinge system whereby the main swing is about the two upper hinges (marked A in Figure 4) while the bottom hinges (marked B) provide a limited flexibility to the gate leaf for proper seating on the gate seat.

The existing gates close with the gate leaf in the vertical position. Hence, in order to obtain a reasonable lever arm for opening, either the top operating platform will have to be cantilevered out requiring a major modification to the deck structure, or the gate leaf will have to be suitably changed to offer a lever arm when the gate is being hoisted from the existing top deck. A compromise solution was achieved with minor changes to both the gate and the operating platform.

Figure 3 shows these changes. The space frame is designed to offer a lever arm when the gate is hoisted with a vertical pull on the hoisting cable. The space frame is light and can be attached to the gate easily.

Since these gates are to be operated only twice in a year, a manually operated hoist is adequate.

The complete arrangement is given in the Drawing No. 5109-M002.

4.1.2 Balanced Flap Gates for Upstream Control

The vents of the existing Rahmatkhali Regulator are 3.05 m x 3.05 m (10 ft x 10 ft). A lip on the vertical faces will have to be provided at the proposed upstream flap gate position to form the seat for the flap gates. Hence, the size of the flap gate opening will become 3.05 m x 2.8 m.

Balanced flap gates in several sizes have been designed for the project. In all gates, approximately 80% of the weight of the gate leaf is counter-balanced with pre-cast concrete kentledge. With this degree of counter-balancing a 3m x 3m gate, for instance, would begin to open under a static head difference as small as 75 mm.

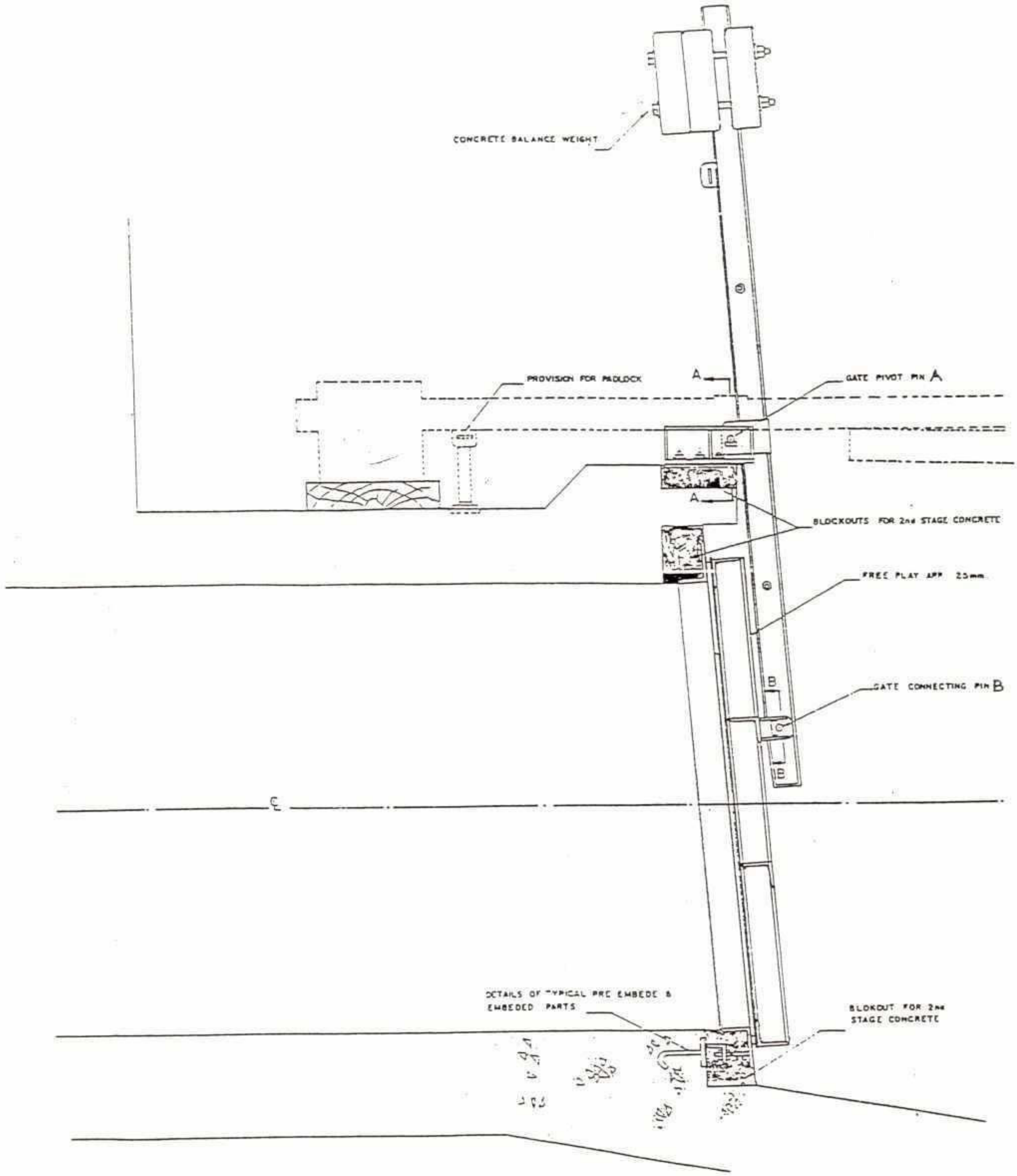
Figure 4 depicts the typical arrangement of balanced flap gates designed. Details of the structural layout, sealing, and the hinges are given in the Drawing No. 5109-M001.

For proper seating of all flap gates, a double hinge arrangement has been provided. The main pivot action is about the upper hinges marked A in the Figure 4. Limited flexibility when seating is provided by the bottom hinges (marked B).

Sealing is achieved in two stages. The primary seal bars small be in bronze and they seat against an embedded stainless steel soleplate. The seal bars also perform the function of transferring the hydraulic load on the gate to the regulator structure. The mating surfaces are not required to be machined. Final sealing will be achieved by moulded rubber J-seals as shown in the Drawing No. 5109-M001.

The arms of the flap gate are aligned with their bottom hinges B mounted on the vertical distribution beams of the gate. They are extended beyond the upper hinges A as seen in the Figure 4, and partially counter-balanced. With 80% counter-balancing the system could be adjusted for the gate to open under a static head difference as low as 75 mm.

Figure 4
Arrangement of Balanced Flap Gate



The counterbalance weights are pre-cast concrete slabs. The system is designed so that the balance weights could be assembled and adjusted with the gate leaf lifted to its horizontal position, to its limit. The weights could be moved on the arms until the desired balance is achieved and are clamped into position. After this once-and-for-all operation, steel limits are welded to the arms.

By inclining the barrel face (along with the embedded seal seat), the gate leaf is given a small inclination (1 in 15) so that a positive closing moment is built into the system. This feature is specially important in tidal zones. It must be appreciated that the resulting effect is negated by counter-balancing of the gate leaf. Hence, a reasonable out of balance (20% is suggested) should be maintained as a compromise. Furthermore, the position of the centre of gravity of the counterweight could be so adjusted to give a positive closing moment when the gate is in this fully closed position but offers counterbalanced operation as soon as the gate is opened.

With the gate partially balanced, the effort required to raise the gates will be quite small. The gates shall be provided with simple ratchet-and-pawl chain hoists which would be adequate for a single operator to manually raise the gate and lock it into position.

The structural design of gate leaves was carried out as described in Section 2.

4.2 Gates for the Proposed Regulator

The new regulator proposed for Rahmatkhali is to have 10 vents of 3.0 m x 3.0 m size. The structure is to be fitted with partially balanced flap gates on both sides. Details of the gates proposed for this structure are detailed in Drawing No. 5109-M001 and were described in Section 4.1.2.

4.3 Pumping Station

A pumping station may be constructed at Rahmatkhali in a second phase. It would be located next to the proposed new regulator. This would be a dual purpose pumping station which would operate throughout the year. It would augment drainage by pumping when the country side water level is below high tide level during the monsoon period, and would pump irrigation water from the Meghna when the tide level is below the country side water level during the dry season.

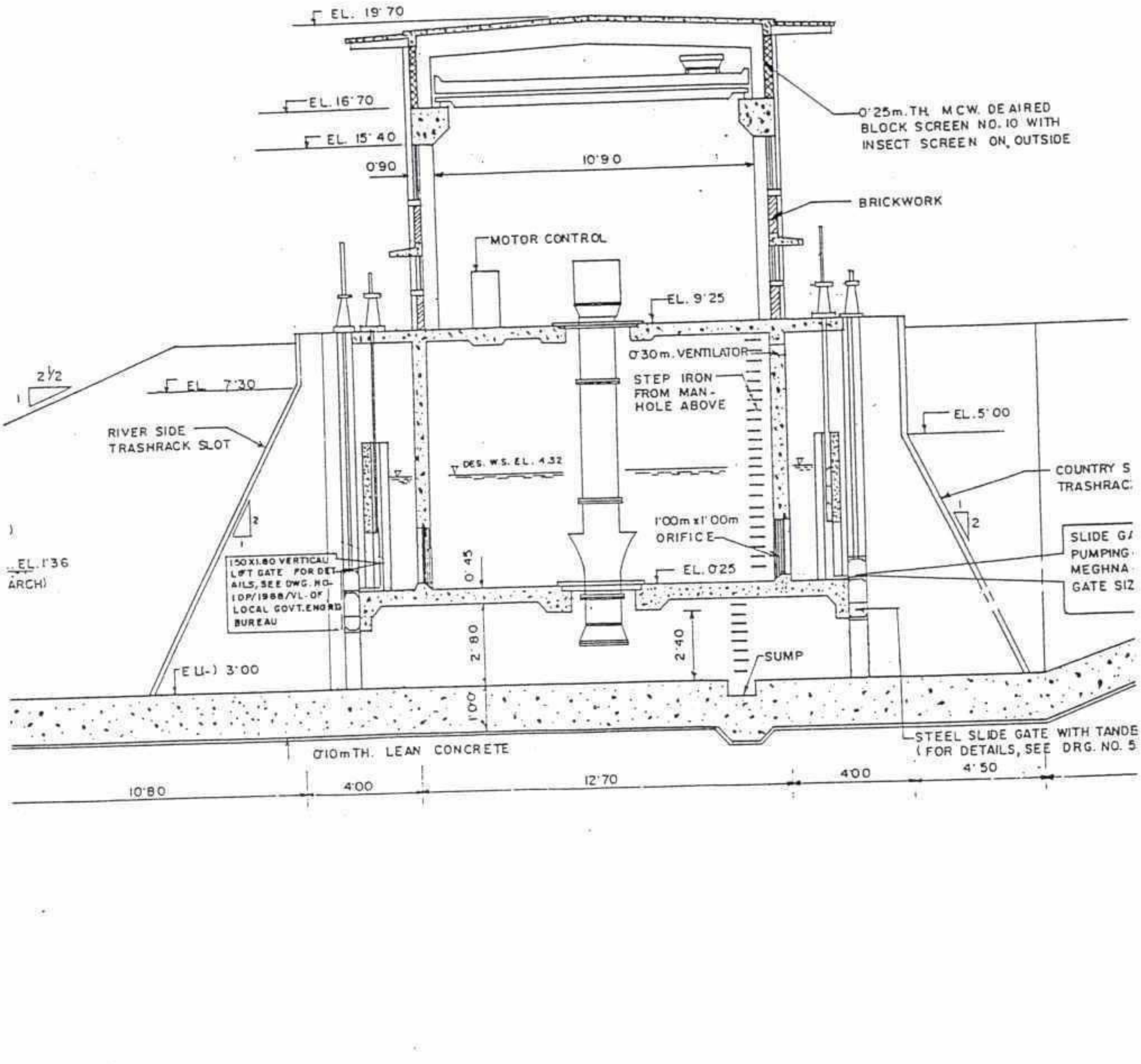
The proposed capacity of the pumping station is 50 m^3/s against a design static head of 2m.

Pumps required for this project were found to be in the axial-flow range. The general layout of the station designed for the project is shown in Figure 5.

The dimensions of the pump suction chamber shall be sized according to standard practice.

Figure 5

Typical Pumping Station Layout



4.3.1 PUMPS

Considering the construction cost of the pump station and flexibility of operation, a pump discharge capacity of 5 m^3/s was chosen for the proposed pump station. On this basis there would be ten pumps at this pumping station.

Restricting the velocity in the pump line to be approximately 2.5 m/s (1.5 to 3.0 m/s is recommended for irrigation and drainage pumping), the pump diameter is fixed at 1.6 m. At this velocity, the total loss in the system is approximately 0.5 m. Thus, the design pumping head of the pumps work out to 2.5m.

With allowances for efficiencies of the pump and electric motor, power factor losses, etc the motor capacity is found to be 172 kW. On this basis, the total power requirement for the pumping station is 1,800 kW.

4.3.2 Auxiliary Equipment

An overhead travelling crane of 15 tonne capacity is provided for the pumping station. This is required for handling the pumps and motors during installation and for maintenance. Other auxiliary equipment includes (a) bilge pumps for de-watering, (b) a mobile gantry crane for lifting the control gates from their slots for maintenance, and (c) a 25 kw three-phase stand-by generator for operating auxiliary equipment and for lighting in case of a power failure.

The pumping station shall be provided with a well equipped maintenance workshop which will serve the requirement of both the pumping station and the regulators.

4.3.3 HT Switchgear

In keeping with current standard practice of the BWDB, 3.3KV electric motors have been selected for the pumps.

The closest high tension power supply is at Lakshmipur and an estimated total length of 10 kM of 11kV HT line has to be laid to the pumping station. The HT sub-station shall have a 11kV/3.3kV transformer of 2,250 kVA capacity with switchgear and protection system for pump operation, and a 3.3kV/440V transformer in the control room for the LT requirements.

4.3.4 Control Gates

Four sets of slide gates are required at the pumping station. As seen in Figure 5 (section of a typical Pumping Station of the envisaged design), two sets are needed at the pump inlets for selecting either the country side (for drainage pumping) or the river side (for irrigation pumping), and two sets for the delivery side. All gates were designed to suit a vent size of 2.5mx2.5m and a design head of 4 m.

The vertical lift gates required for this station are described in the Drawing No. 5109-M004 and criteria for their structural design were discussed in Section 2.

234

Bronze seal plates on the gate frame bear directly on stainless steel embedded frames. These plates are connected to the gate frame by means of counter-sunk stainless steel bolts. Sealing is provided by means of moulded, unreinforced, rubber J-seals on all four sides.

Hoisting is by means of two screw hoists fixed at the two ends of the gates to avoid the full impact of delivery jets. They are mechanically coupled in tandem as shown in the drawing so that perfectly synchronised tilt-free lifting is possible. The hoists are motorised with provision for manual operation.

4.3.5 Trash Racks

Inclined trash racks provide protection for both inlets to the pumping station to exclude debris from entering the suction chamber. In addition, a simple floating debris collector is to be installed on both sides of the pumping station.

The trash racks are inclined at 26 degrees to the vertical. Trash removal will be carried out manually and no mechanical means is provided.

5. Gates for New Regulator at Musapur

A new regulator may be constructed on the Little Feni River at Musapur. This regulator is intended to solve the siltation problem presently experienced by the regulator at Kazirhat.

The proposed structure will have 3.0mx3.5m slide gates and non-balanced flap gates of 3.0mx3.8m vent size on the downstream side. Figure 6 shows a section of the regulator.

5.1 Flap Gates

The flap gate is of the double hinge type described in Section 4.1.2 but without counter-balancing. This gate is required for automatic operation only and, hence, a lifting arrangement is not provided. Details of the gate are given in the Drawing No. 5109-M001.

The gate leaf design was carried out as described in Section 2.

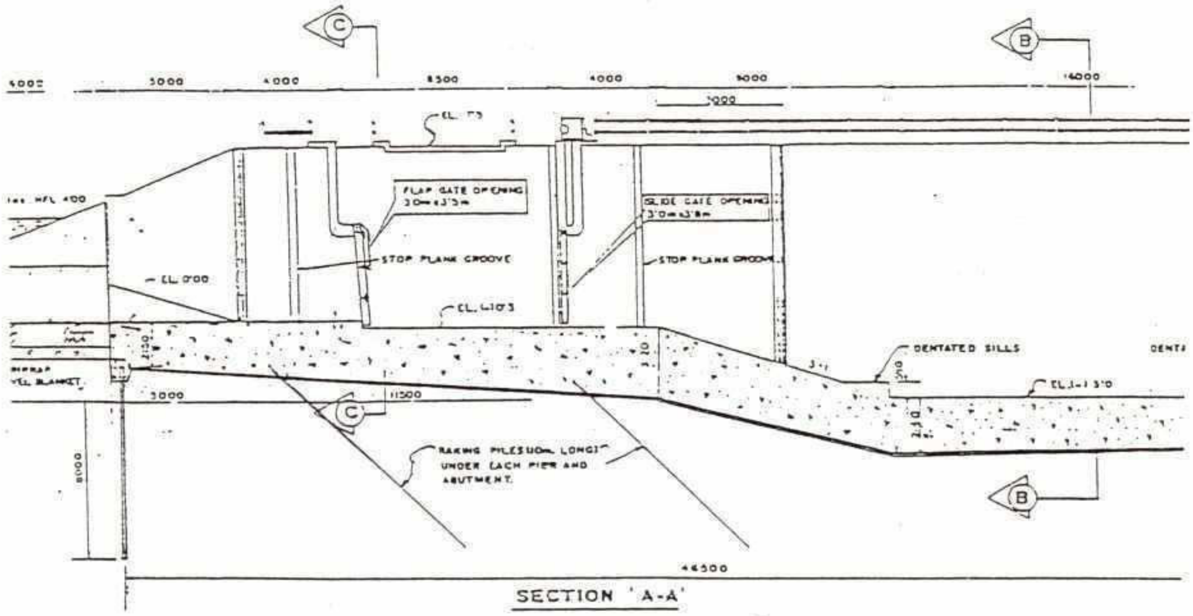
5.2 Slide Gates

The slide gate design is similar to the control gates designed for the pumping station. Hoisting gear will be of the tandem cable type. Since these gates are to be operated at frequent intervals during the dry season for flushing the downstream side, the hoists shall be electrically operated with provision for manual stand-by operation.

The layout of the slide gate and the hoist arrangement is shown in the Drawing No. 5109-M003.

Figure 6

Section of Proposed Musapur Regulator



6. Dakatia Regulator

A regulator may be constructed near Chandpur on the Dakatia River. Although this regulator has not been designed the following decisions have been taken:

a The vent size of the regulator would be 3.0mx3.50m;

b the vents would be fitted with counter-balanced double flap gates;

c The regulator would have a navigation lock adjacent to it.

6.1 Control Gates

The regulator would be identical in general layout to the new regulator proposed for Rahmatkhali. The counterbalanced double flap gate arrangement to be used was described in Section 4.1.2 and is shown in Figure 4 and Drawing No. 5109-M001.

6.2 Navigation Lock

The following parameters have been established for designing the proposed navigation lock:

a The lowest low water level is +0.0 m;
b The minimum draft to be provided for floating craft is 1.5 m;
c The maximum high water level is 5.0m;
d The adjacent finished ground level is to be +5.5m;
e The maximum width of floating crafts is 6m; and
g The maximum height of vessels above water level is 5m.

The navigation lock shall be located to one side of the regulator.

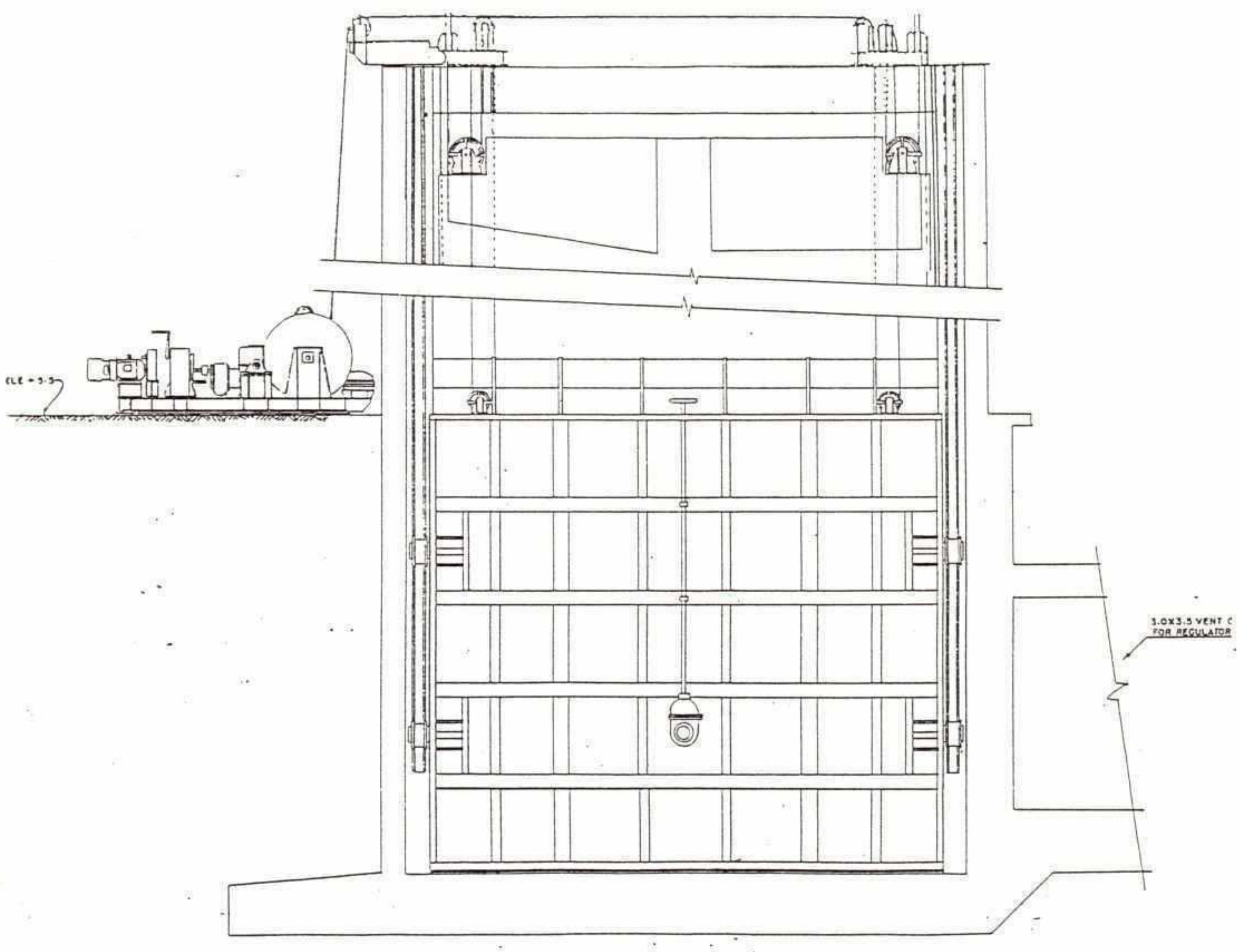
6.2.1 Details of Lock

On the basis of low water level and draft requirement, the still level of the lock is fixed at -2.0 m. Fixing the level of the top of the gate 0.5m over the high water level, the gate will be 7.5 m tall. Leaving a clearance of 1 m on both sides, the width of the lock will be 8.0 m. The lock is likely to be about 40 m long. A partial section of the proposed structure showing the general gate features is given in Figure 7.

The portal structure is to be designed to take the loads of the gate, counter-balance weight, and the hoist mechanism.

Figure 7

Section of Lock Gate



A walkway shall be provided on top of the gate to cross-over to the opposite side and there must be free access along the full lengths of both retaining walls. Furthermore, the bridge deck must clear the ground level adjacent to the lock by at least 2 m. An elevated control room with a good view of the complete lock at all water levels shall be provided at a suitable location.

Stop log grooves on both sides are necessary for gate maintenance. The gates are not designed to withstand the water pressure in the lock empty condition.

6.2.2 Lock Gates

Mitre gates are not suitable for this lock on account of variation of levels on both sides. Hence, a vertical lift gate has to be adopted. Considering the large gate size (8.0mx7.5m), a fixed-wheel gate will be most suitable.

The maximum head difference to be withstood by the lock gates is 0.8 m. With a factor of safety of 25% on the load, the gates are designed for a maximum head difference of 1.0 m.

The gate leaf is designed generally as described in Section 2 except that the horizontal main beams are equally spaced since the hydrostatic load is uniform over 6.5 m of the gate under differential pressure conditions. The general arrangement of the gate leaf is shown in Figure 7.

Sealing is provided by rubber J-seals for both sides. The gate rolls on two sets of light gauge rails.

The gate is estimated to weigh 14 tonnes. With a view to reducing the capacity of the lifting arrangement 75% of this weight of the gate will be counter-balanced with a precast concrete block as shown in the Drawing No 5109-M005. Thus, the double drum cable winch mounted at ground level is required to lift only the unbalanced portion of the gate weight and the rolling frictional forces.

Each gate is provided with a 250 mm gate valve which is mounted directly on the gate leaf, below the low water mark as shown in the Figure 7. The valve stem is extended to the walkway on top of the gate for manual operation.

7. Control Structures

Small control structures for this project are limited to one (Noakhali Khal) with a vent opening of 3.0mx1.5m. Only vertical lift gates are required for this structure. These gates are designed to be lifted with hand operated cable hoists.

The general arrangement of these gates is shown in the Drawing Nr. 5109-M003. The hoist equipment is designed for manual operation only.

8. Costs

Unit cost estimates for various sizes and types of gate are given in Table 1.

239

TABLE 1

Unit Rates for Gates

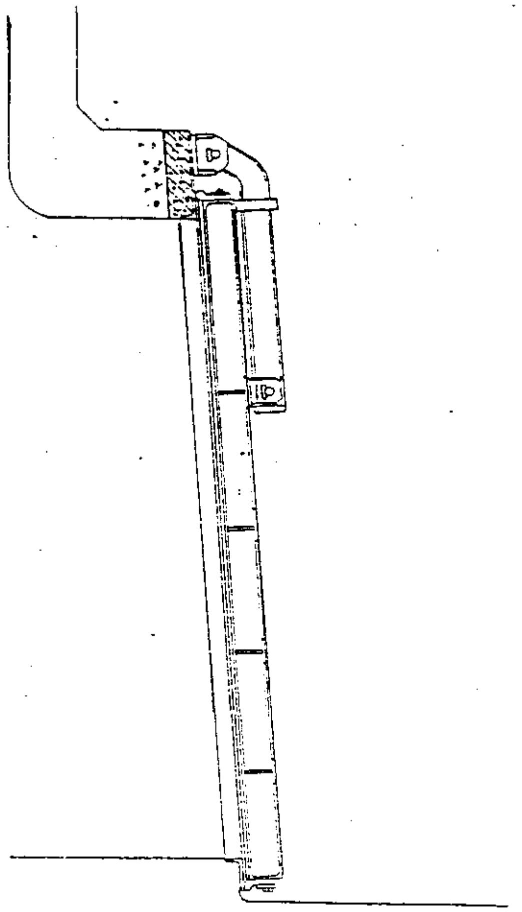
Item	Description	Unit	Unit rate Tk 000
1	2.8 m x 3.0 m balanced flap gate, embedded parts and hand hoist	Nr	160
2	3.0 m x 3.0 m unbalanced flap gate, embedded parts and hoist	Nr	160
3	3.0 m x 3.0 m balanced flap gate, embedded parts and hand hoist	Nr	183
4	1.5 m x 3.0 m slide gate with embedded parts and hand hoist	Nr	100

9. Drawings

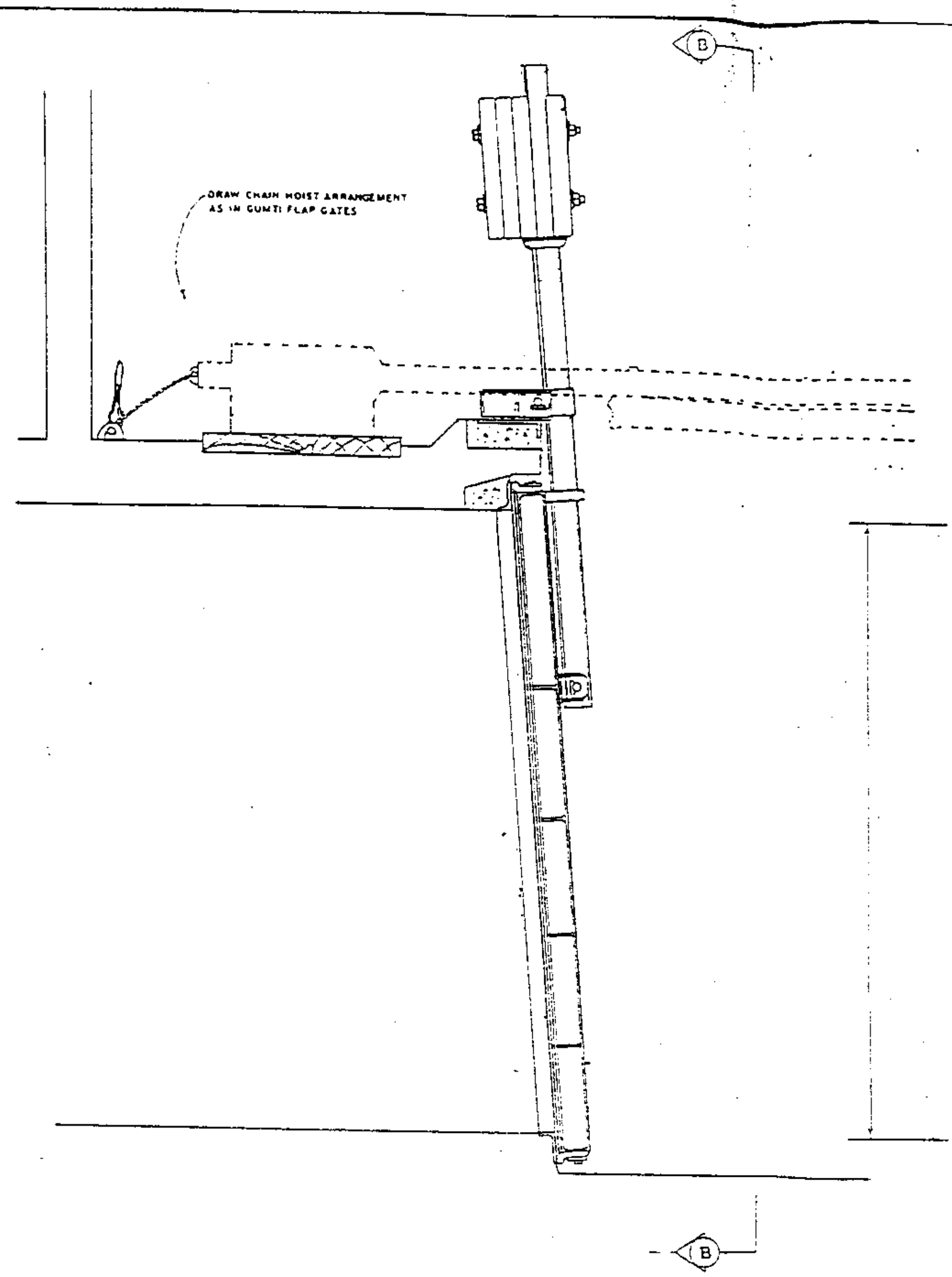
Feasibility design drawings have been prepared for the various gates designed for this project. These are:

Drawing No 5109-M001: Flap Gates for Regulators
Drawing No 5109-M002: Modification to Rahmatkhali Flap Gates
Drawing No 5109-M003: Slide Gates for Musapur Regulator
Drawing No 5109-M004: Slide Gates for Pumping Station
Drawing No 5109-M005: Fixed Wheel Gates for Navigation Lock

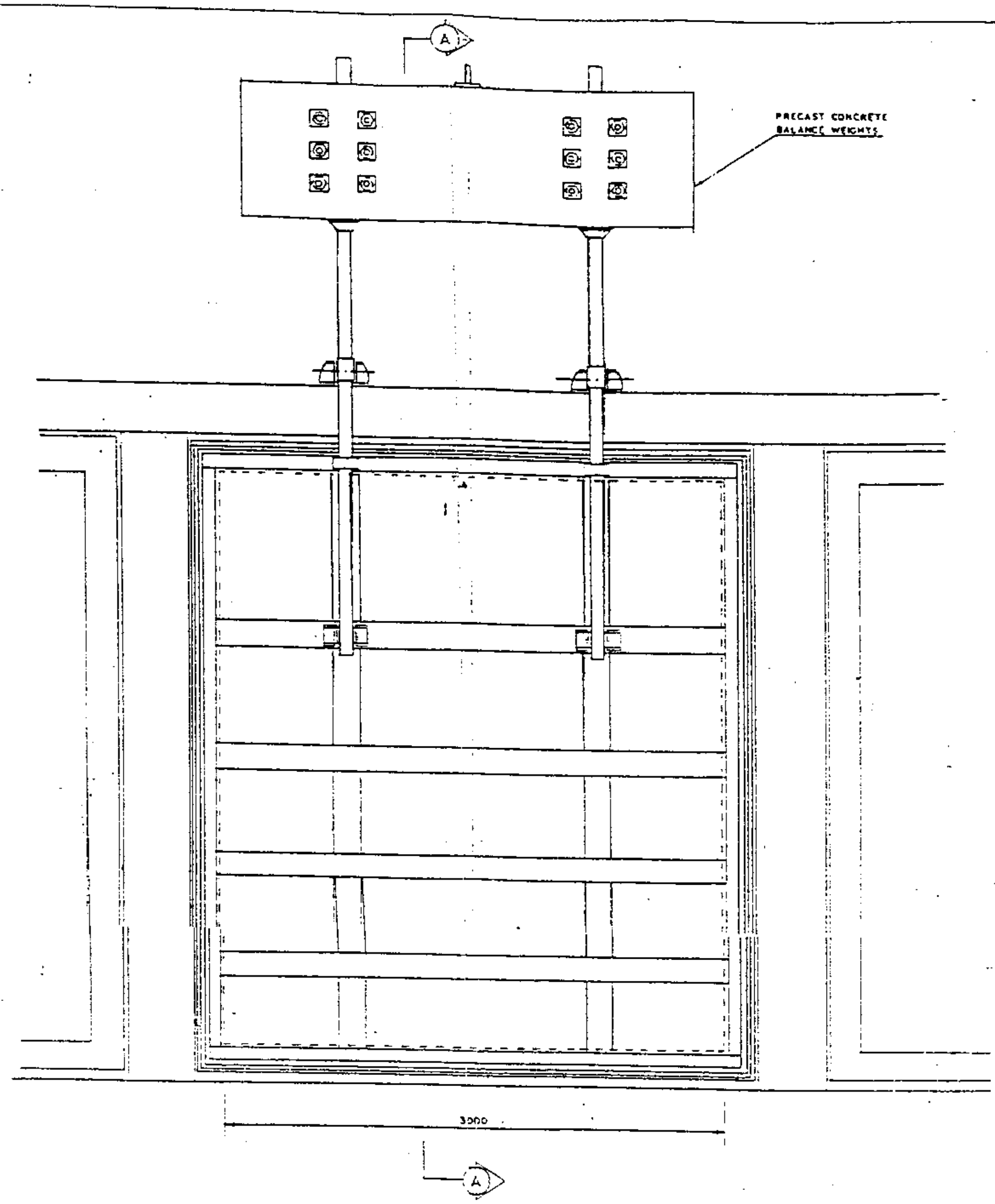
A3 size reproductions of these drawings are included in this Appendix.



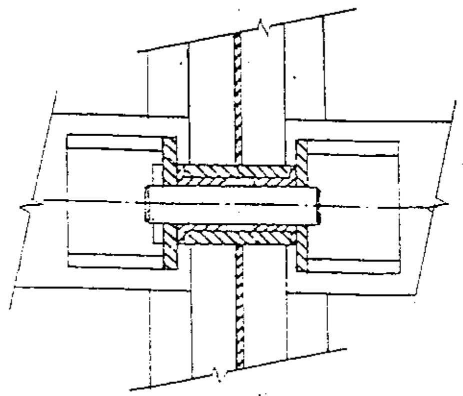
SECTION A–A FOR NONBALANCED

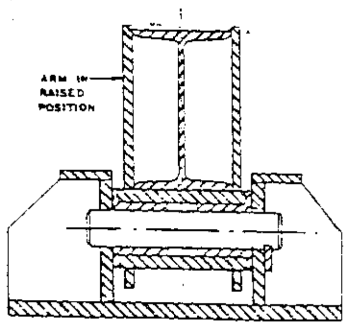


SECTION A–A OF COUNTER-BALANCED GATE

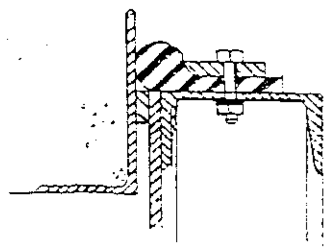


TYPICAL END ELEVATION B–B





TYPICAL HINGE ARRANGEMENT



SEALING ARRANGEMENT

Gate Size W x H m	Type	Weight kg
3.0 x 3.0	Balanced	1690
3.0 x 3.5	Balanced	1900
3.0 x 3.5	Non-balanced	1160
2.8 x 3.0	Balanced	1620

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NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT

FLAP GATES FOR REGULATORS

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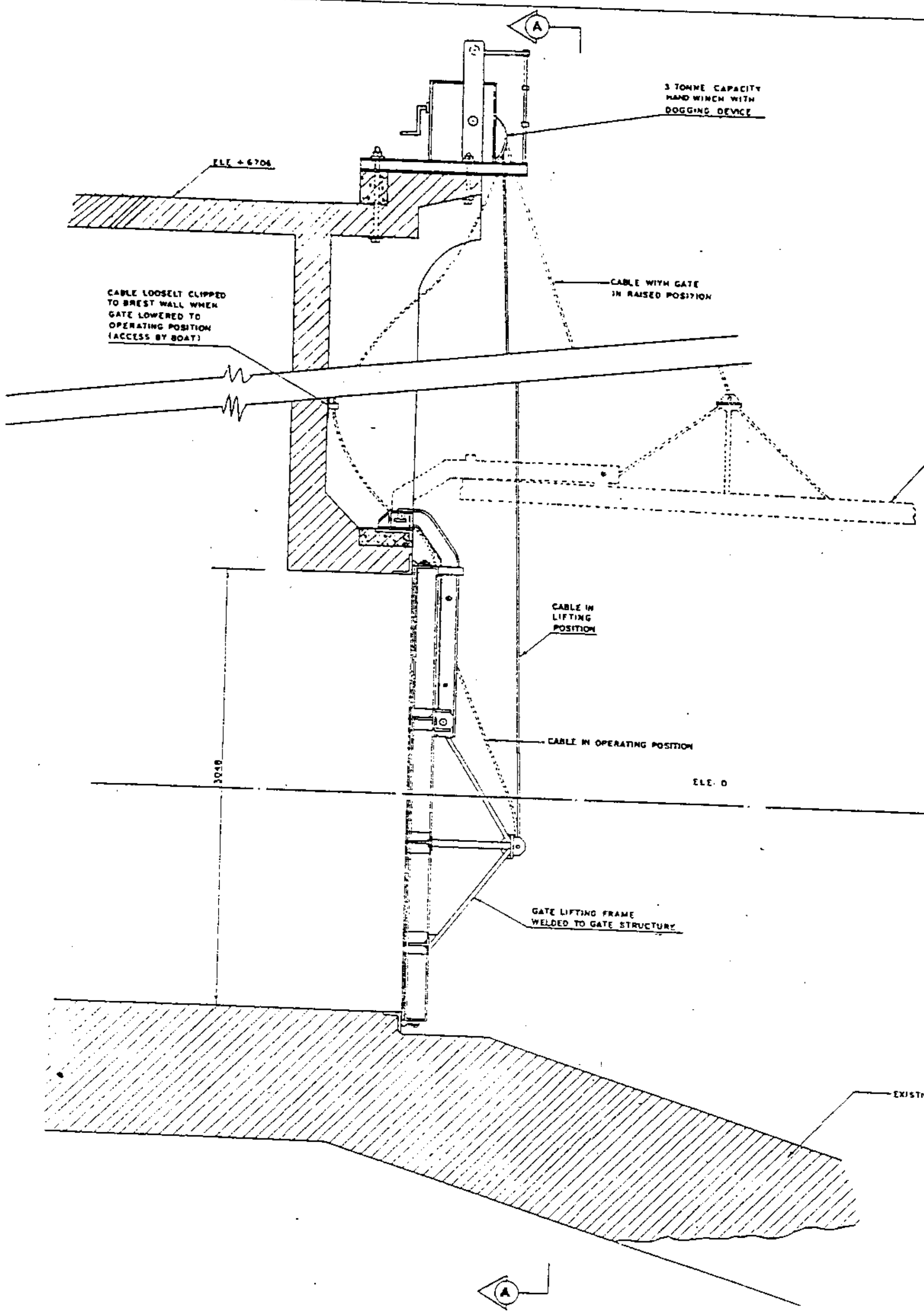
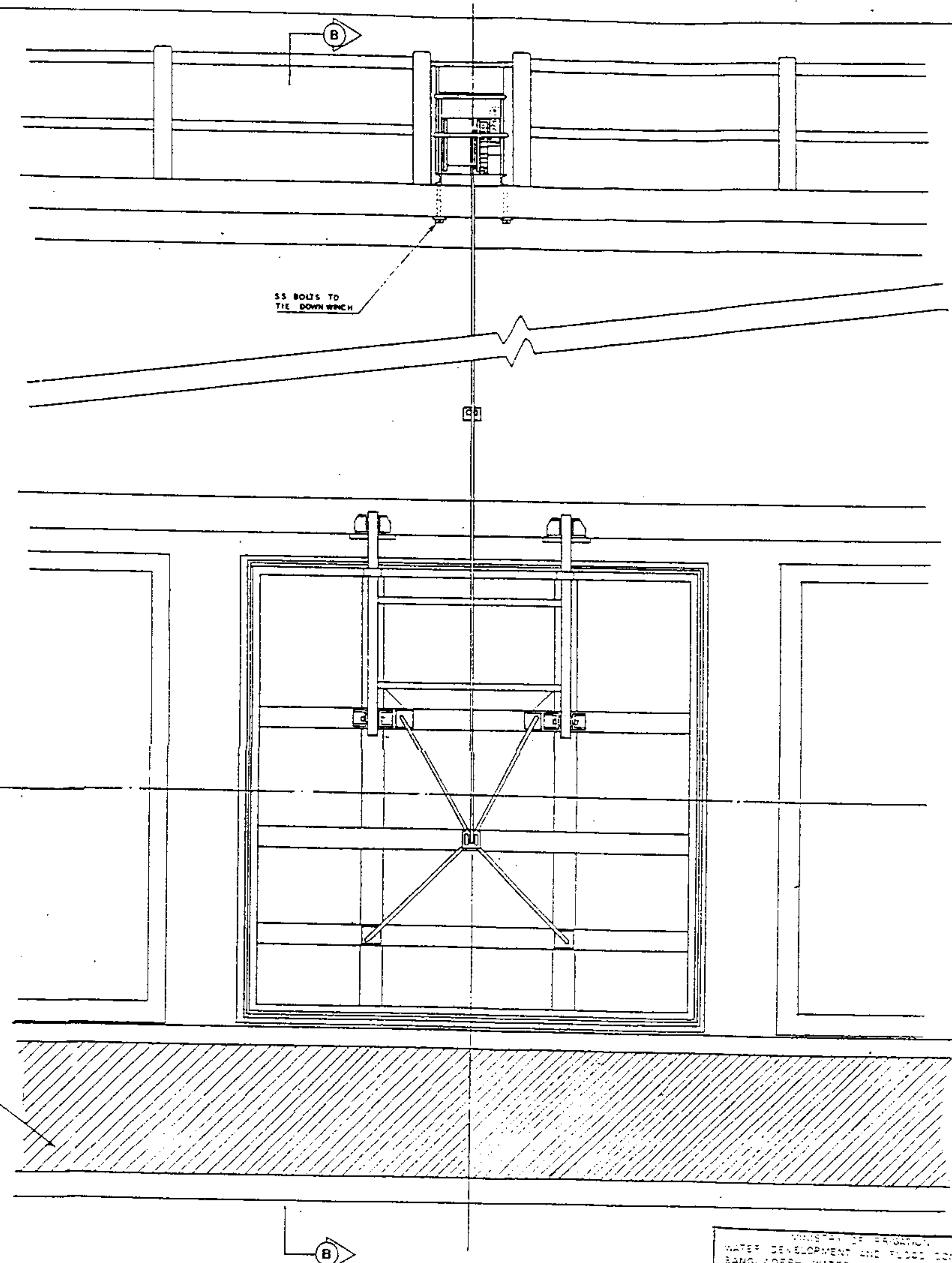
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
HOUSE OF CONSULTANTS LTD BANGLADESH.
DESH UPADESH LTD BANGLADESH

DESIGNED	A P Jayasinghe M Kanmar	APPROVED	
DRAWN	MD SALIM		
CHECKED	[signature]	DRAWING No	5109-M001
DATE	20-04-93		



SECTION B-B



SECTION A-A

MINISTRY OF IRRIGATION
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BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT

MODIFICATIONS TO RAHMATHKALI GATES

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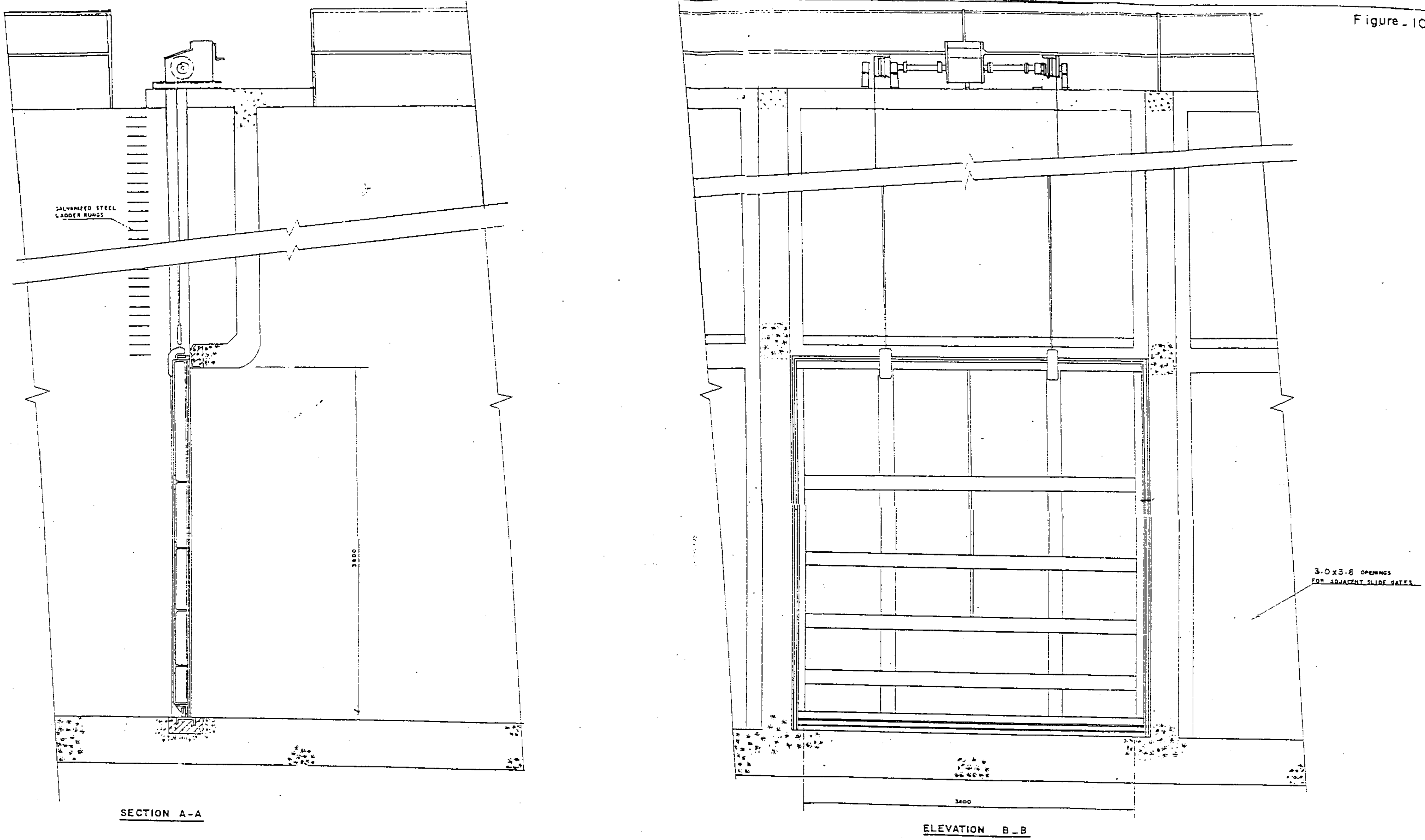
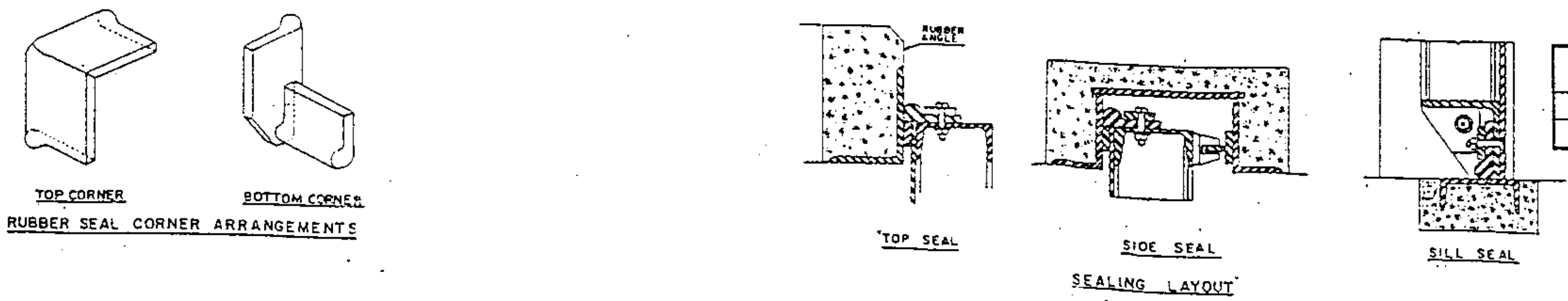
NIPPON KOEI CO. LTD. JAPAN
RESOURCES DEVELOPMENT CONSULTANTS LTD SRILANKA
HOUSE OF CONSULTANTS LTD BANGLADESH
DESH UPADESH LTD BANGLADESH

DESIGNED	A P Jayasinghe M Rahman		
DRAWN	MD SALIM	APPROVED	
CHECKED	[signature]		
DATE	20-04-93	DRAWING N	5109-M002

Figure_10





Gate Size W x H m	Weight kg
3.0 x 3.5	1820
3.0 x 1.5	1050

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NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT

SLIDE GATES FOR REGULATORS

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NIPPON KOEI CO. LTD. JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH.
DESH UPADESH LTD. BANGLADESH.

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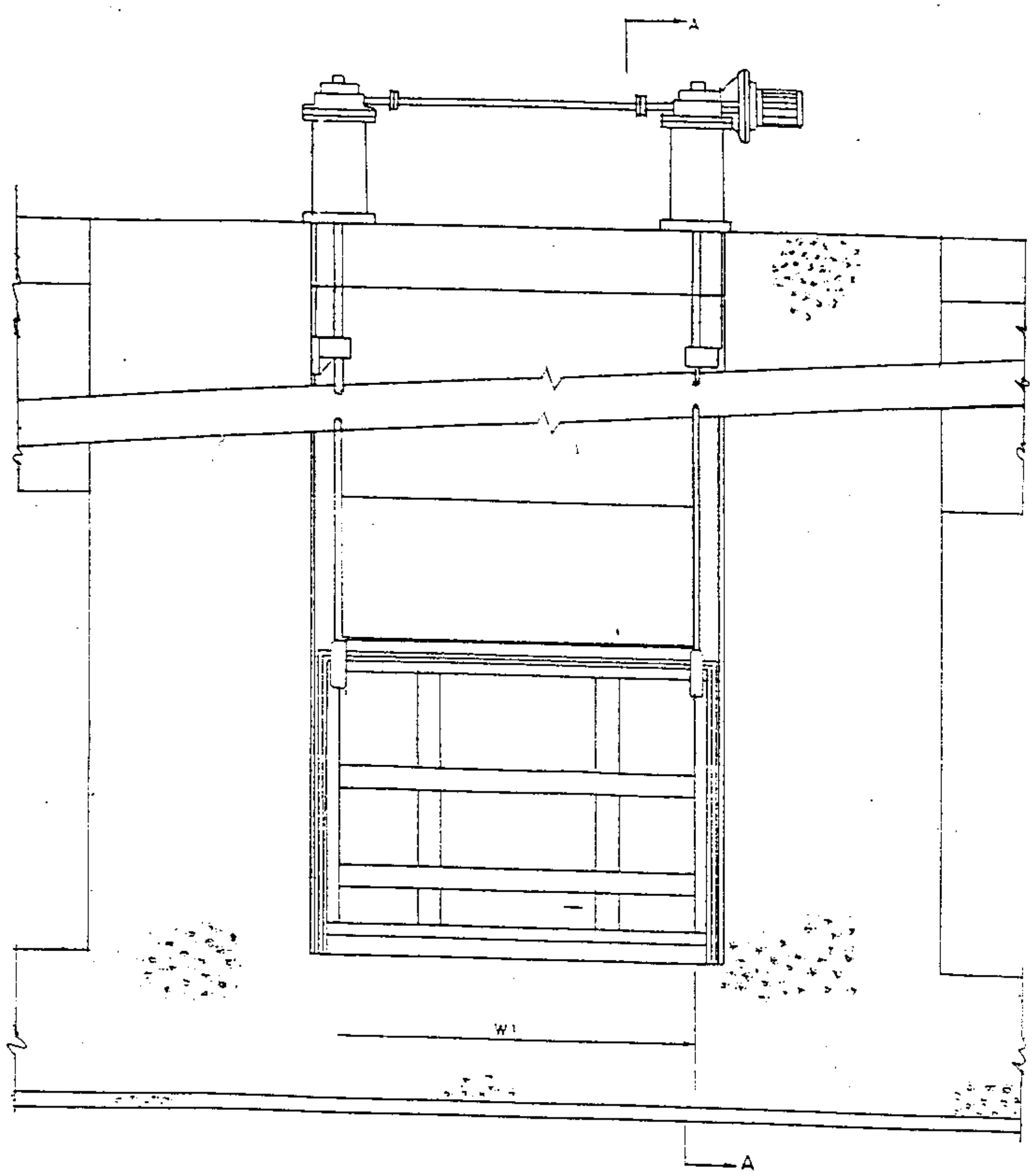
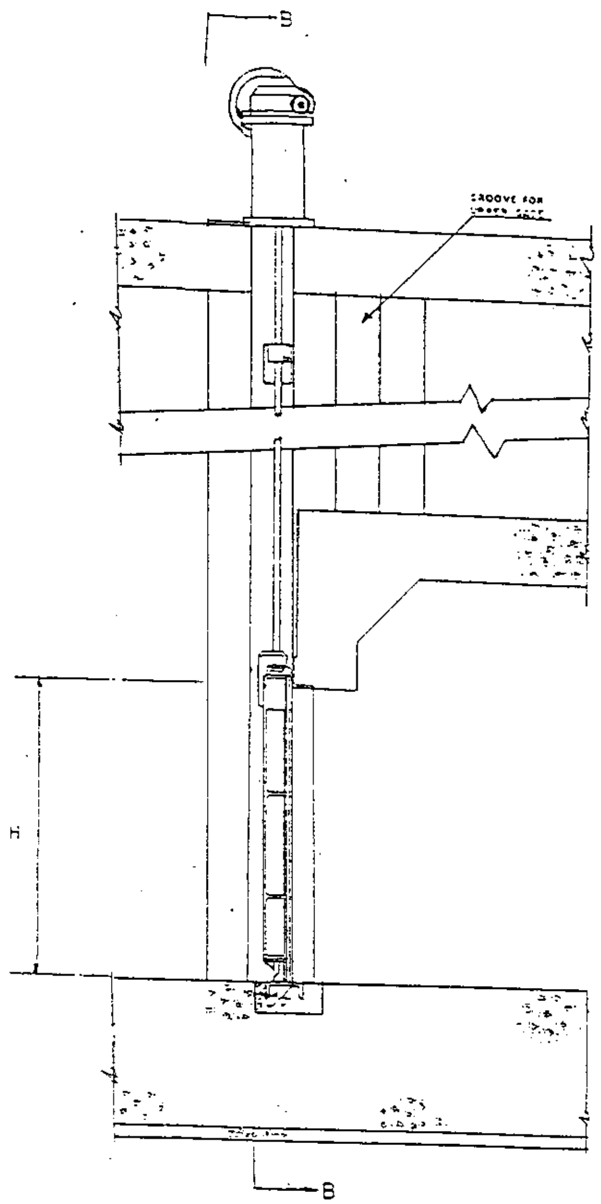
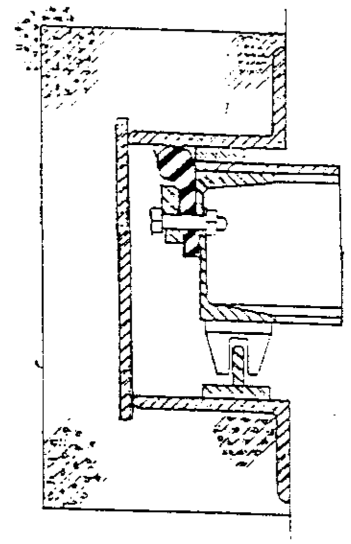
DRAWN	MD. SALIM		
CHECKED	[signature]	DRAWING NO	5109-M003
DATE	20-04-93		



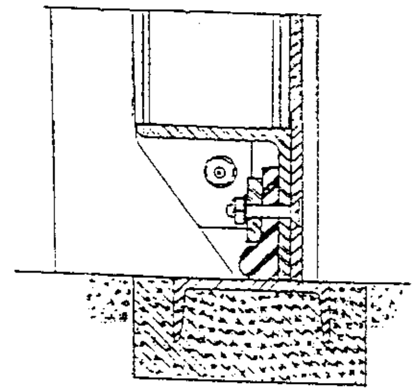
SECTION A-A



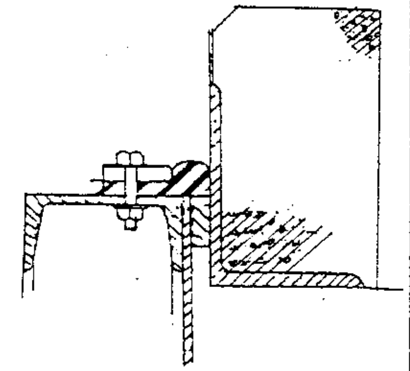
SECTION B-B



SIDE SEAL

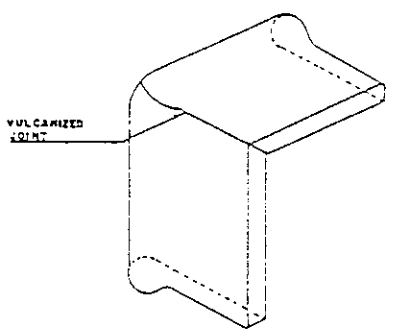


BOTTOM (SILL) SEAL

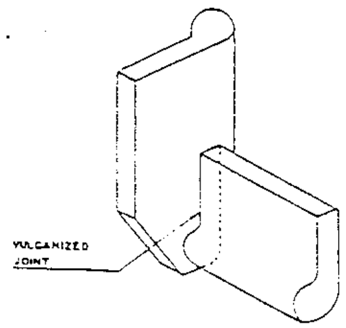


TOP SEAL

SEALING ARRANGEMENTS



TOP CORNER



BOTTOM CORNER

RUBBER SEAL CORNER ARRANGEMENTS

Gate Size W x H m	Weight kg
2.5 x 2.5	1400

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SLIDE GATES FOR PUMPING STATION

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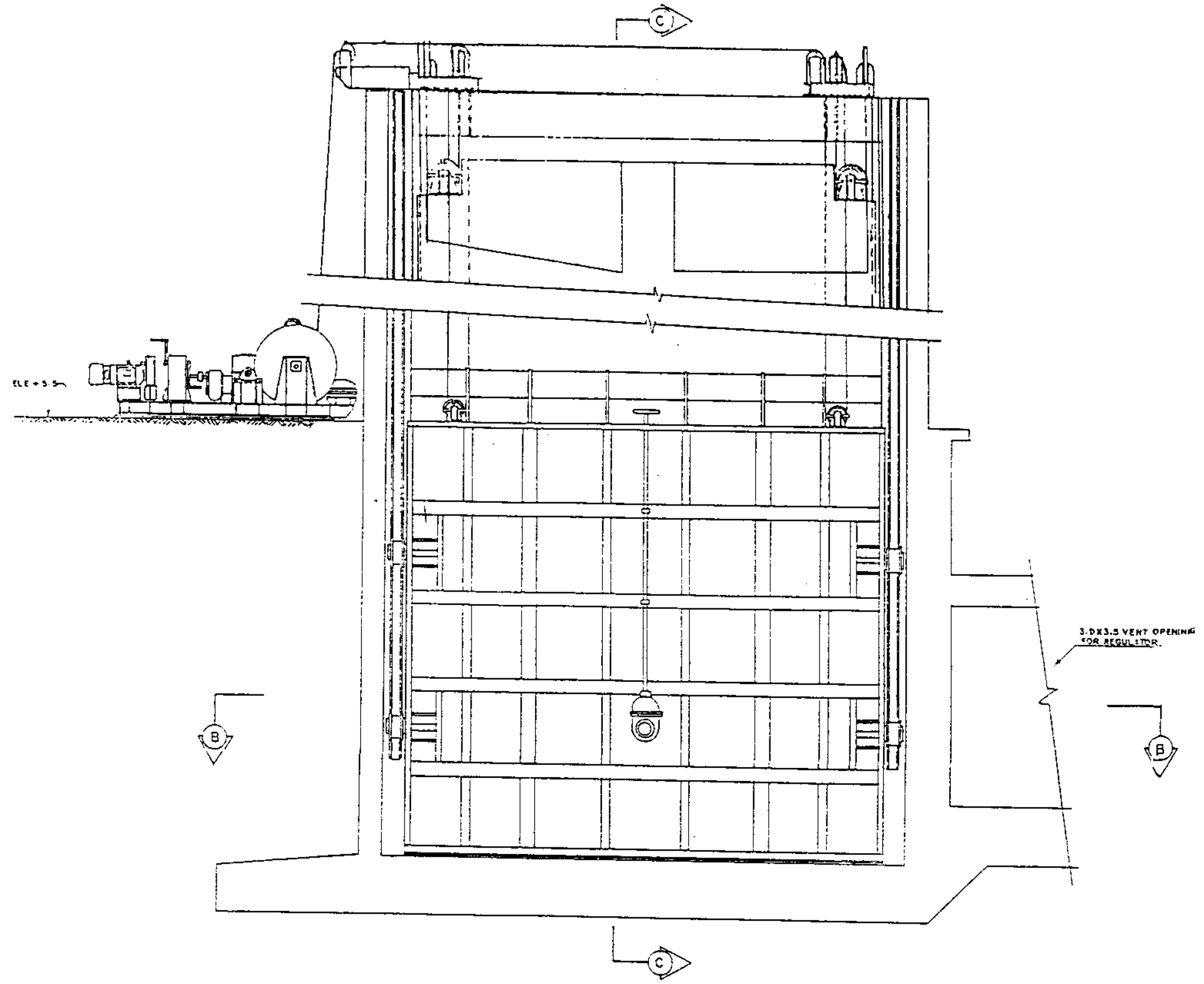
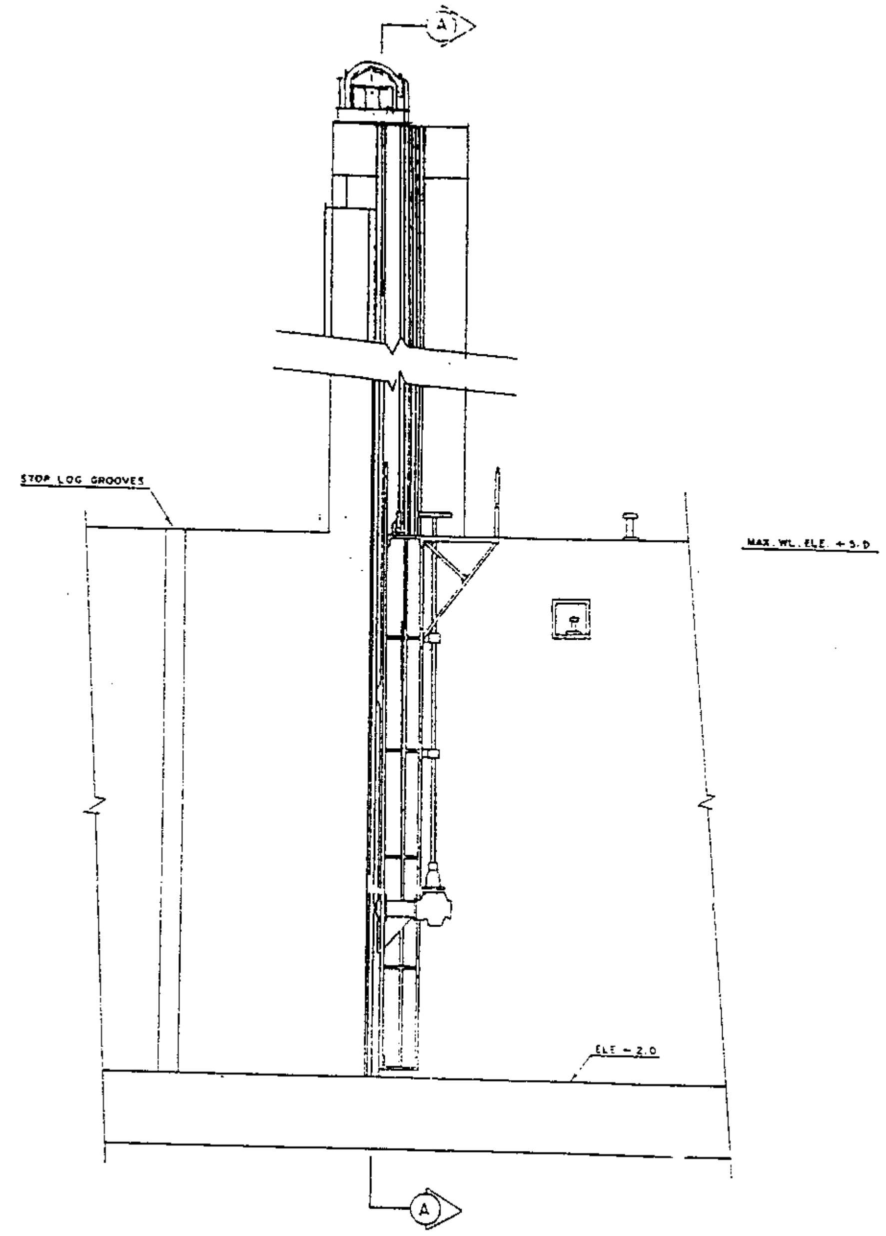
NIPPON KOEI CO. LTD. JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA.
HOUSE OF CONSULTANTS LTD. BANGLADESH.
DESH UPADESH LTD. BANGLADESH.

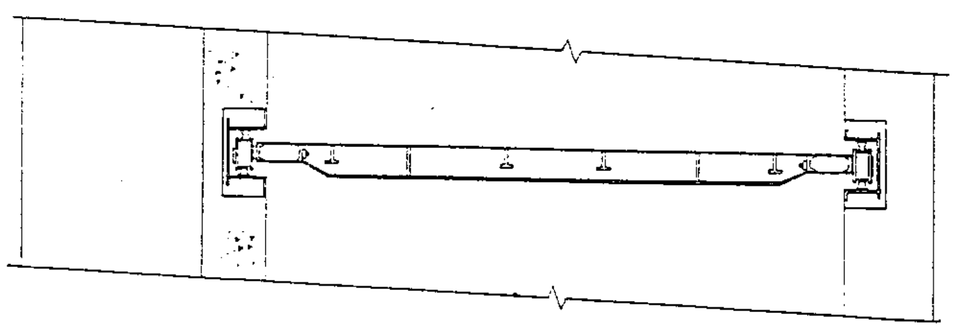
DESIGNED	A. P. Jayasinghe, M. Rahman	APPROVED	
DRAWN	MD. SALIM		
CHECKED	[signature]	DRAWING NO	5109-M004
DATE	20-04-93		



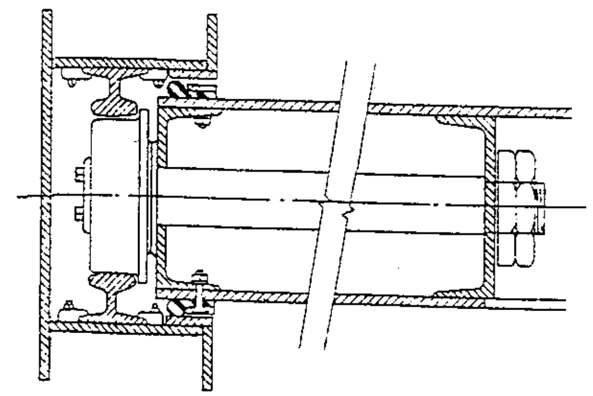
ELEVATION A-A



SECTION C-C



SECTIONAL PLAN B-B



DETAIL OF POLLER ARRANGEMENT AND SEAL

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WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT

FIXED WHEEL GATES FOR NAVIGATION LOCK

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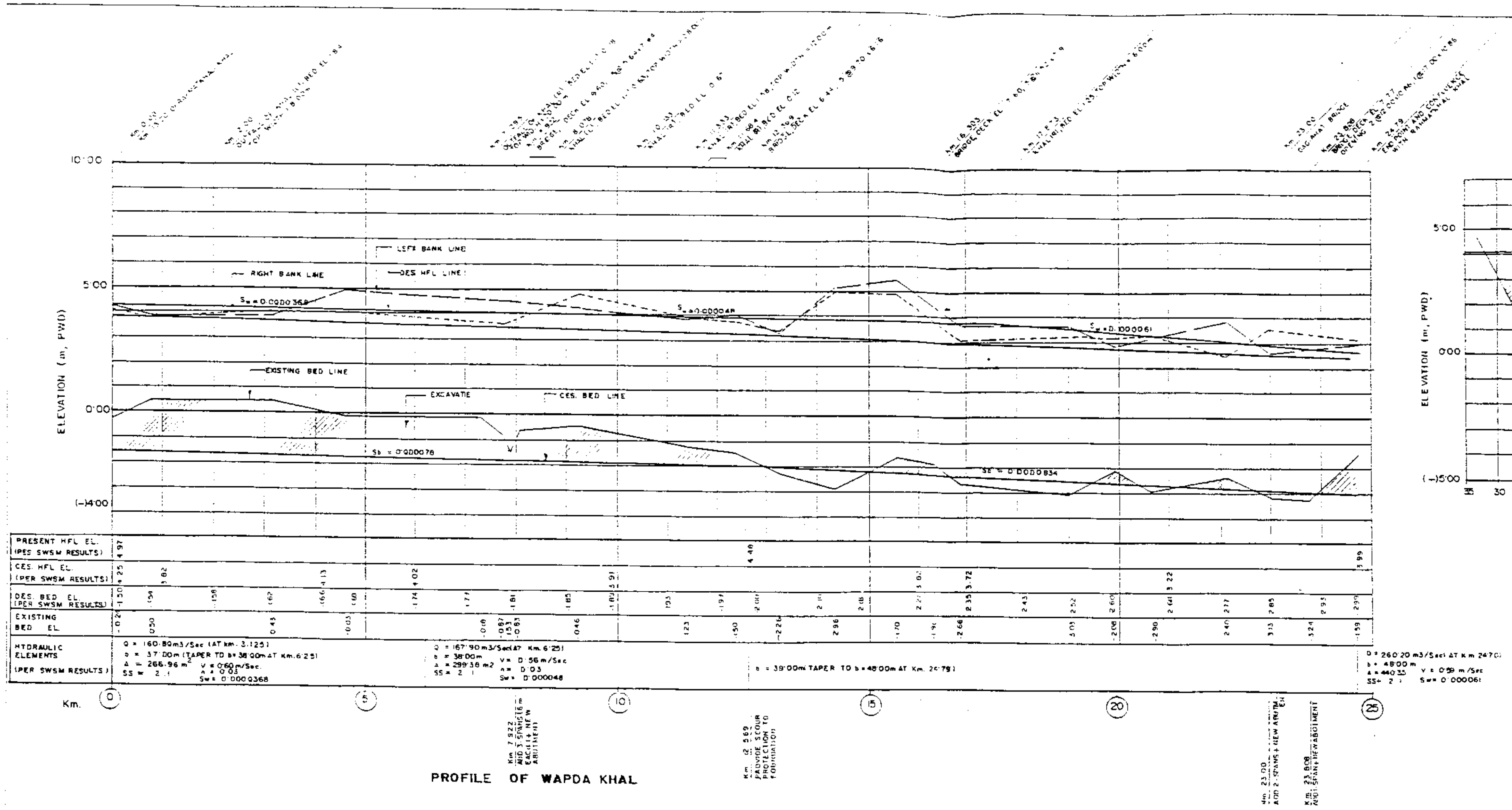
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH.
DESH UPADESH LTD. BANGLADESH.

DESIGNED	A P Jayasinghe M Rahman	APPROVED	
DRAWN	MD. SALIM		
CHECKED		DRAWING NO	5109-M005
DATE	20-04-93		

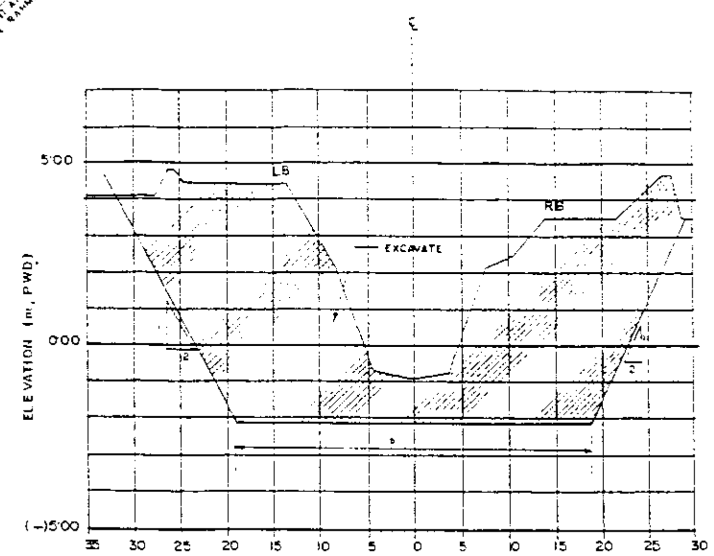
APPENDIX I.XII

LONGITUDINAL PROFILES OF CHANNELS PROPOSED FOR EXCAVATION

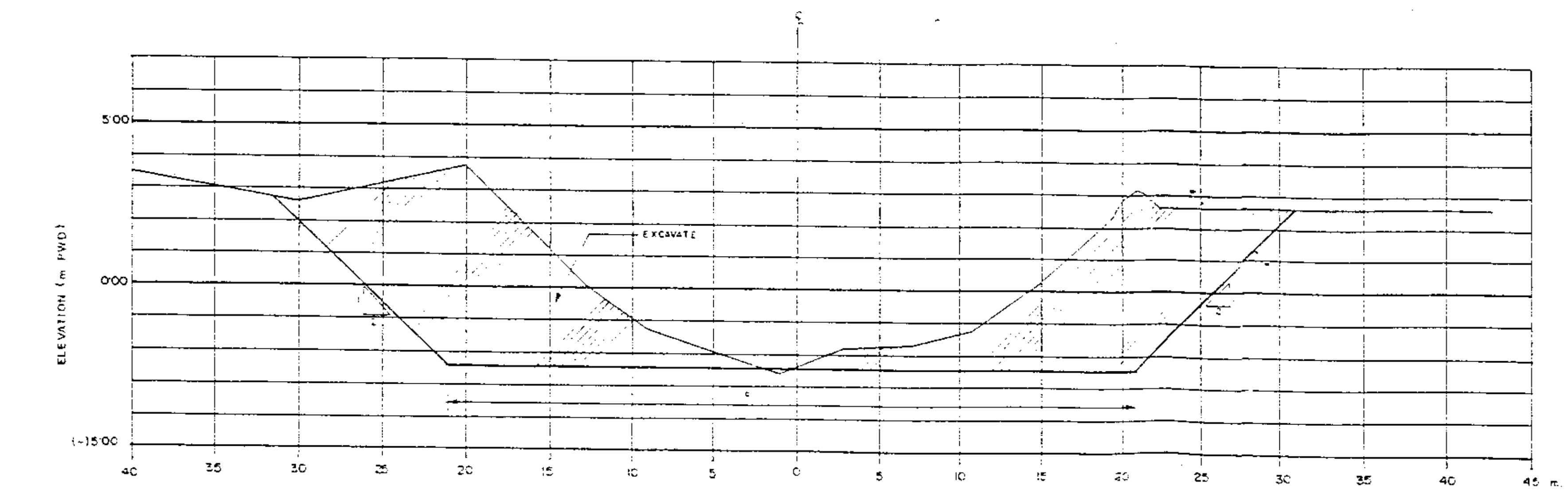
Figure I.XII.1



PROFILE OF WAPDA KHAL



TYPICAL SECTION OF WAPOA KHAL
(SECTION TAKEN AT Km. 7.795)



TYPICAL SECTION OF WAPDA KHAL
(SECTION TAKEN AT Km. 16.947)

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NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
PROFILE OF WAPOA KHAL

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RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
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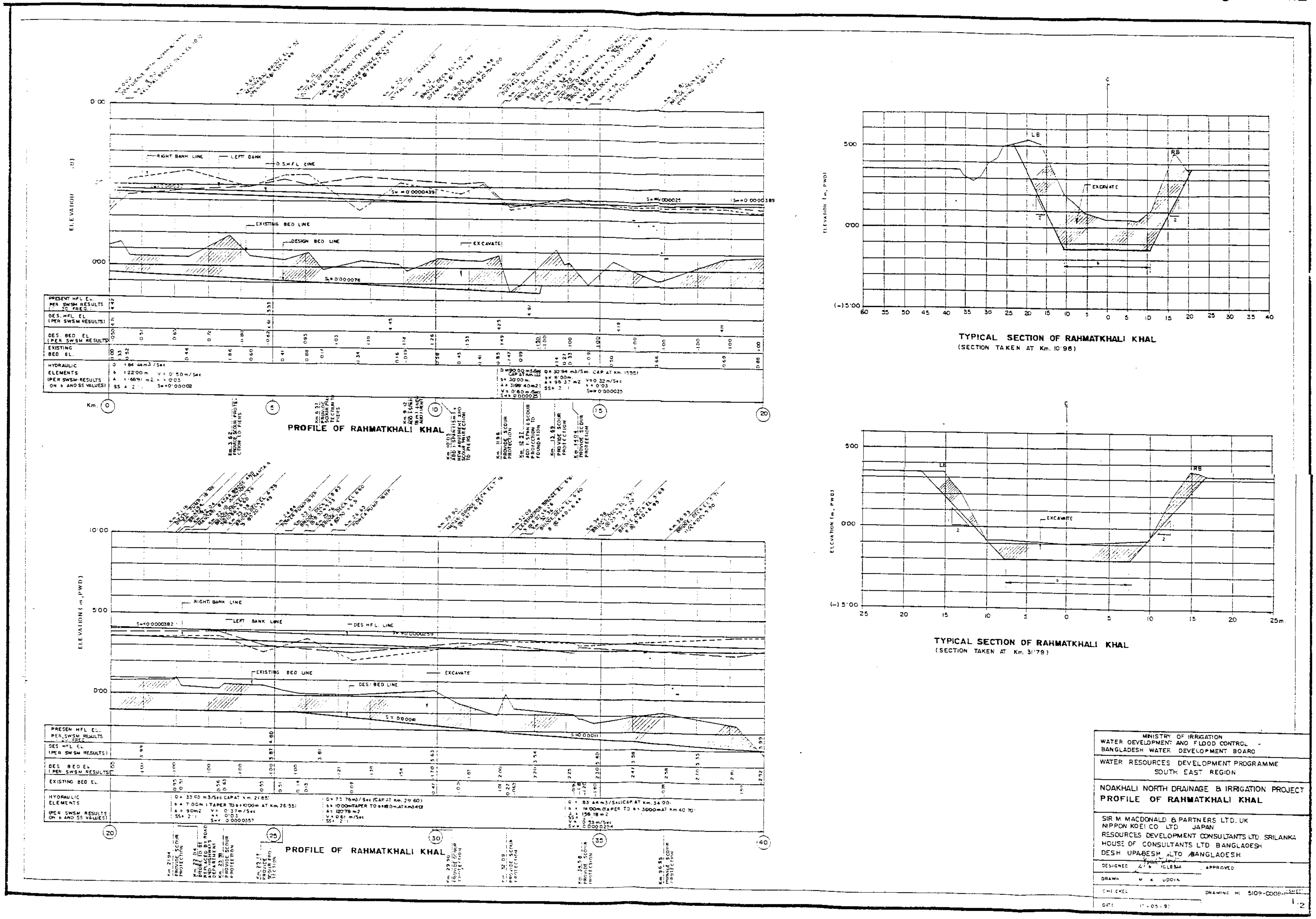
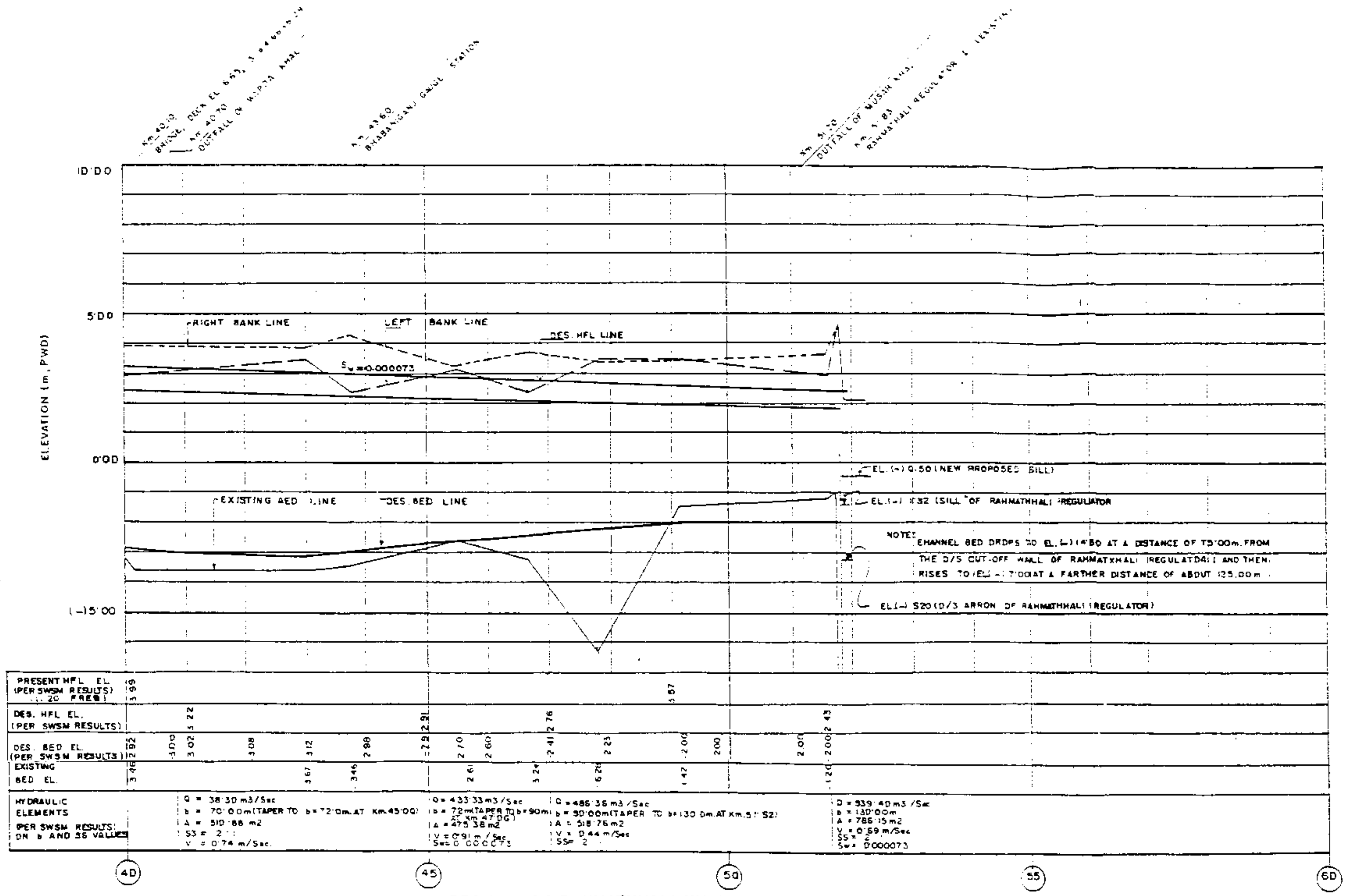
CHECKED		DRAWING NO.	5109-C006
DATE			

Figure I.XII.2

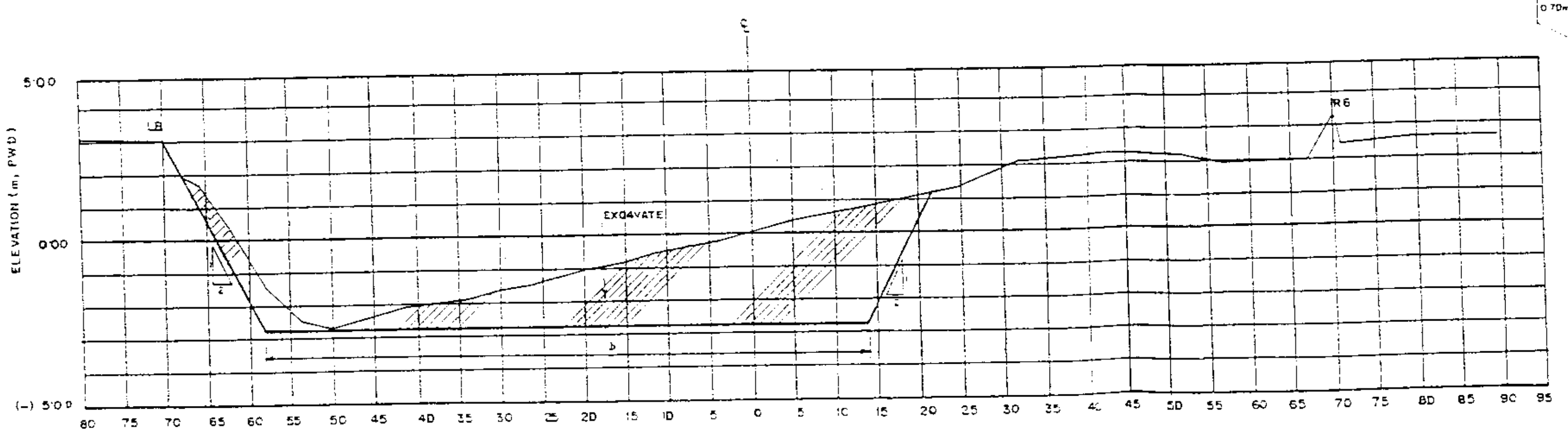


248 2...

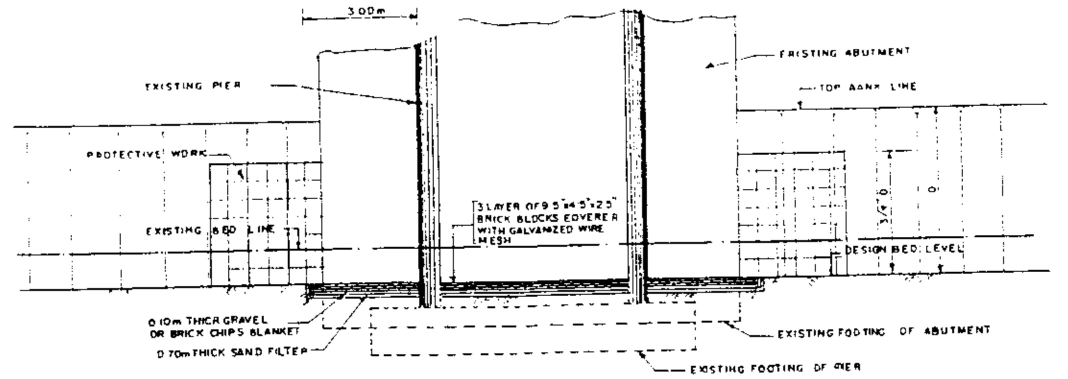
Figure I.XII.3



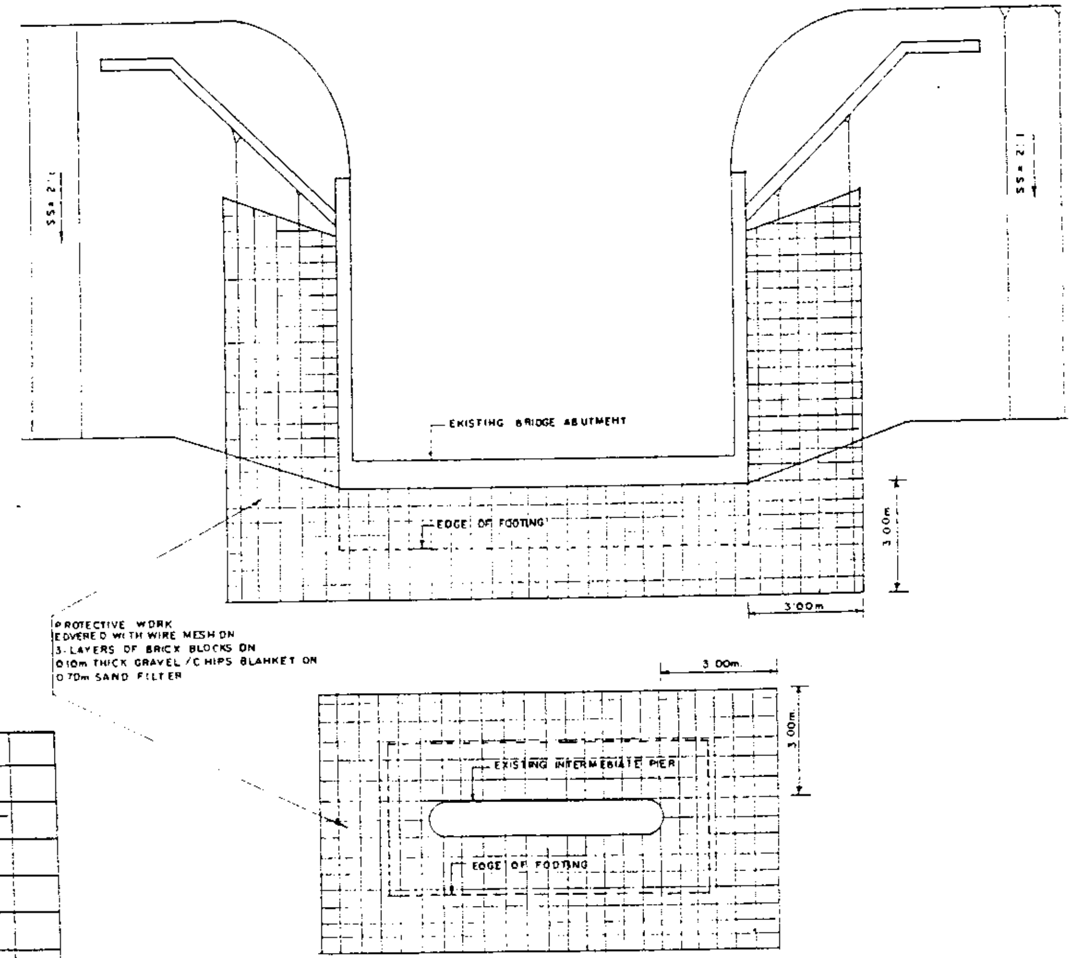
PROFILE OF RAHMATKHALI KHAL



TYPICAL SECTION OF RAHMATKHALI KHAL
(SECTION TAKEN AT Km. 45.50)



LONGITUDINAL SECTION



PART PLAN
SCOUR PROTECTION AT BRIDGES

MINISTRY OF IRRIGATION
WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
PROFILE OF RAHMATKHALI KHAL

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RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
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DESH UPADESH LTD. BANGLADESH

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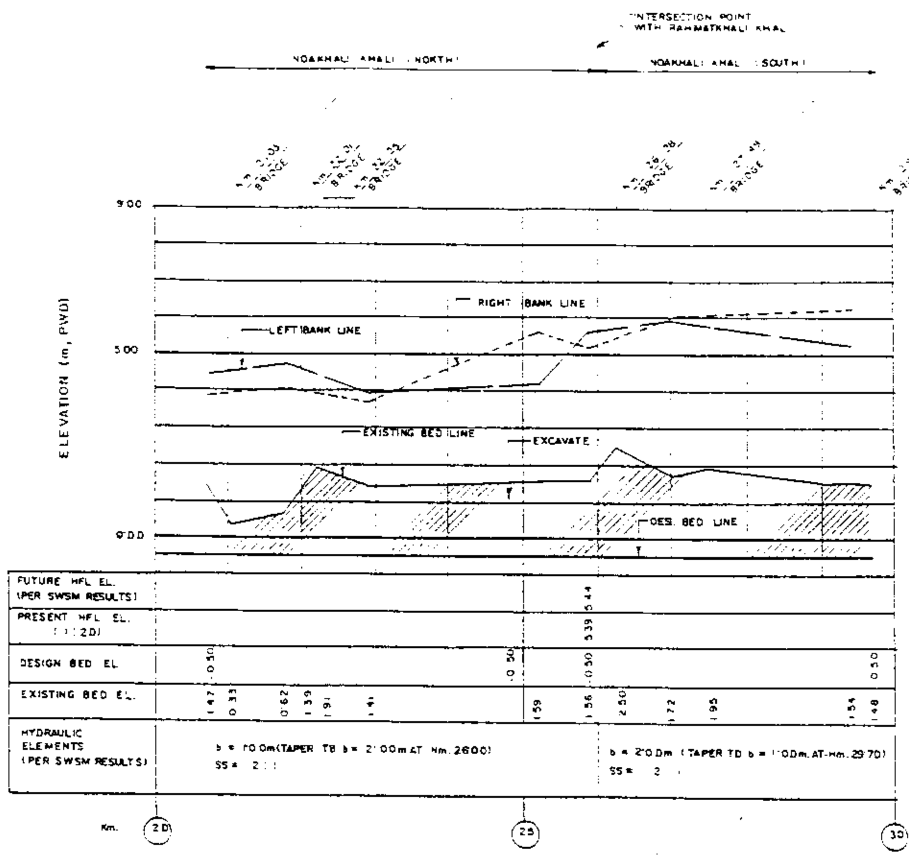
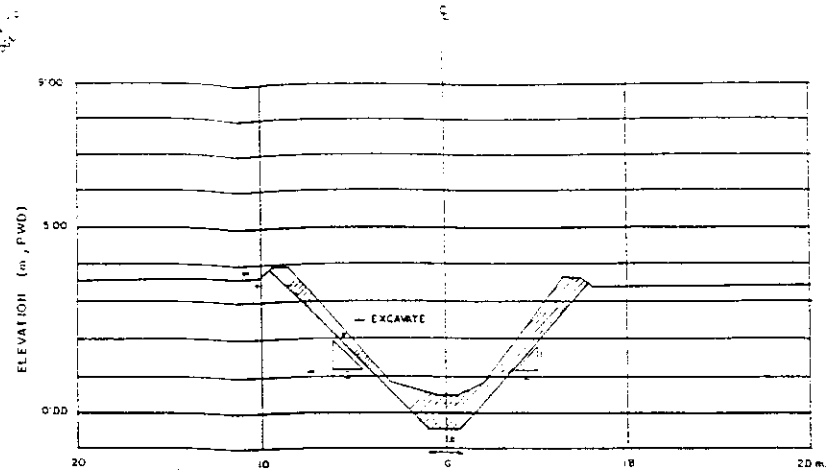
CHECKED		DRAWING NO.
DATE		5105 - C006 - 2

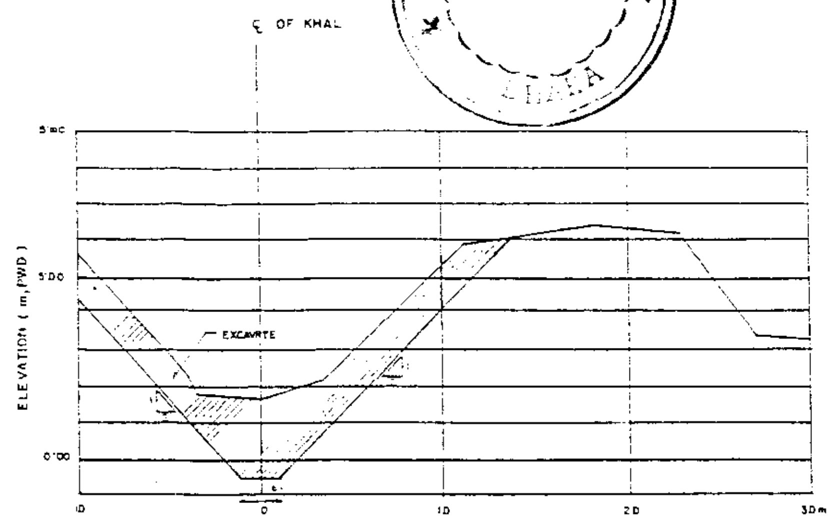
Figure I.XII.4



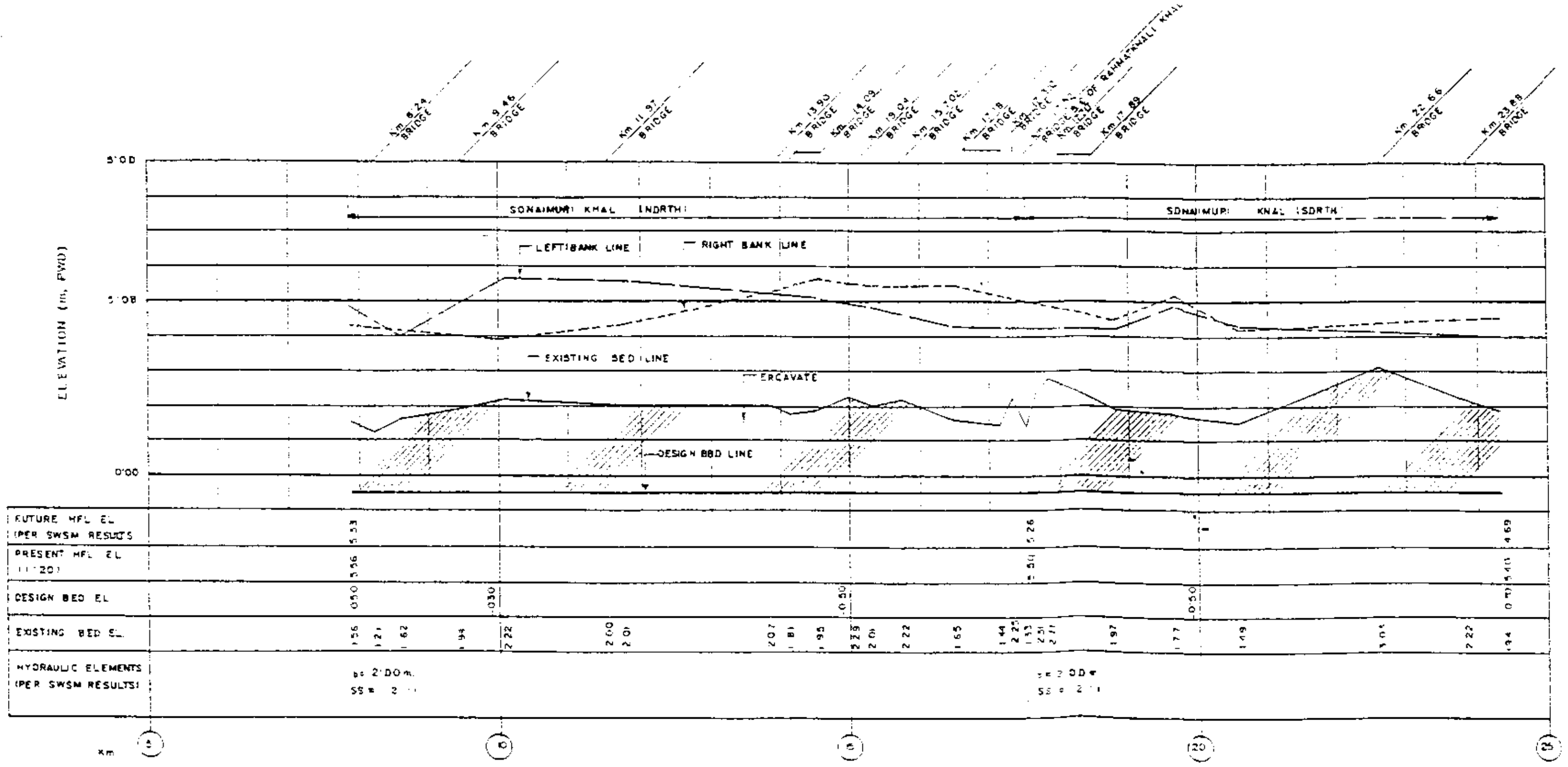
PROFILE OF NOAKHALI KHAL



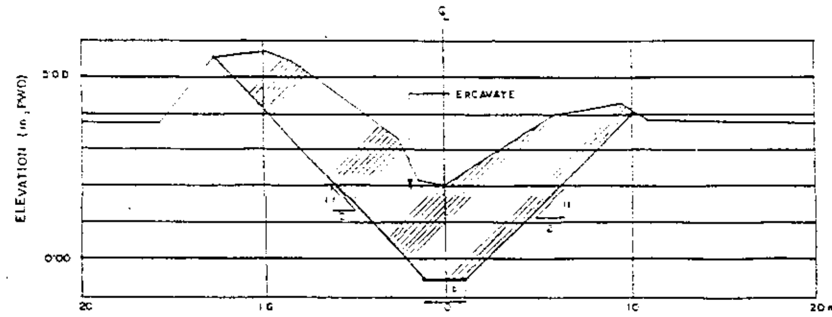
TYPICAL SECTION OF NOAKHALI KHAL (NORTH)
(SECTION TAKEN AT Km. 22.90)



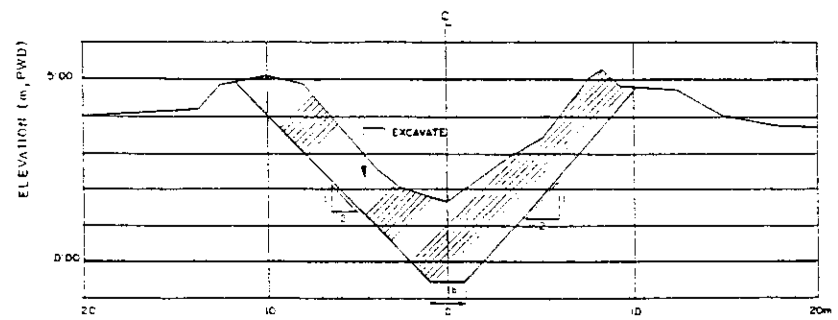
TYPICAL SECTION OF NOAKHALI KHAL (SOUTH)
(SECTION TAKEN AT Km. 26.96)



PROFILE OF SONAIMURI KHAL



TYPICAL SECTION OF SONAIMURI KHAL (NORTH)
(SECTION TAKEN AT Km. 11.70)



TYPICAL SECTION OF SONAIMURI KHAL (SOUTH)
(SECTION TAKEN AT Km. 19.71)

MINISTRY OF IRRIGATION
WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
PROFILE OF NOAKHALI KHAL AND SONAIMURI KHAL

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NIPPON KOEI CO. LTD. JAPAN
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
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DESH UPADESH LTD. BANGLADESH

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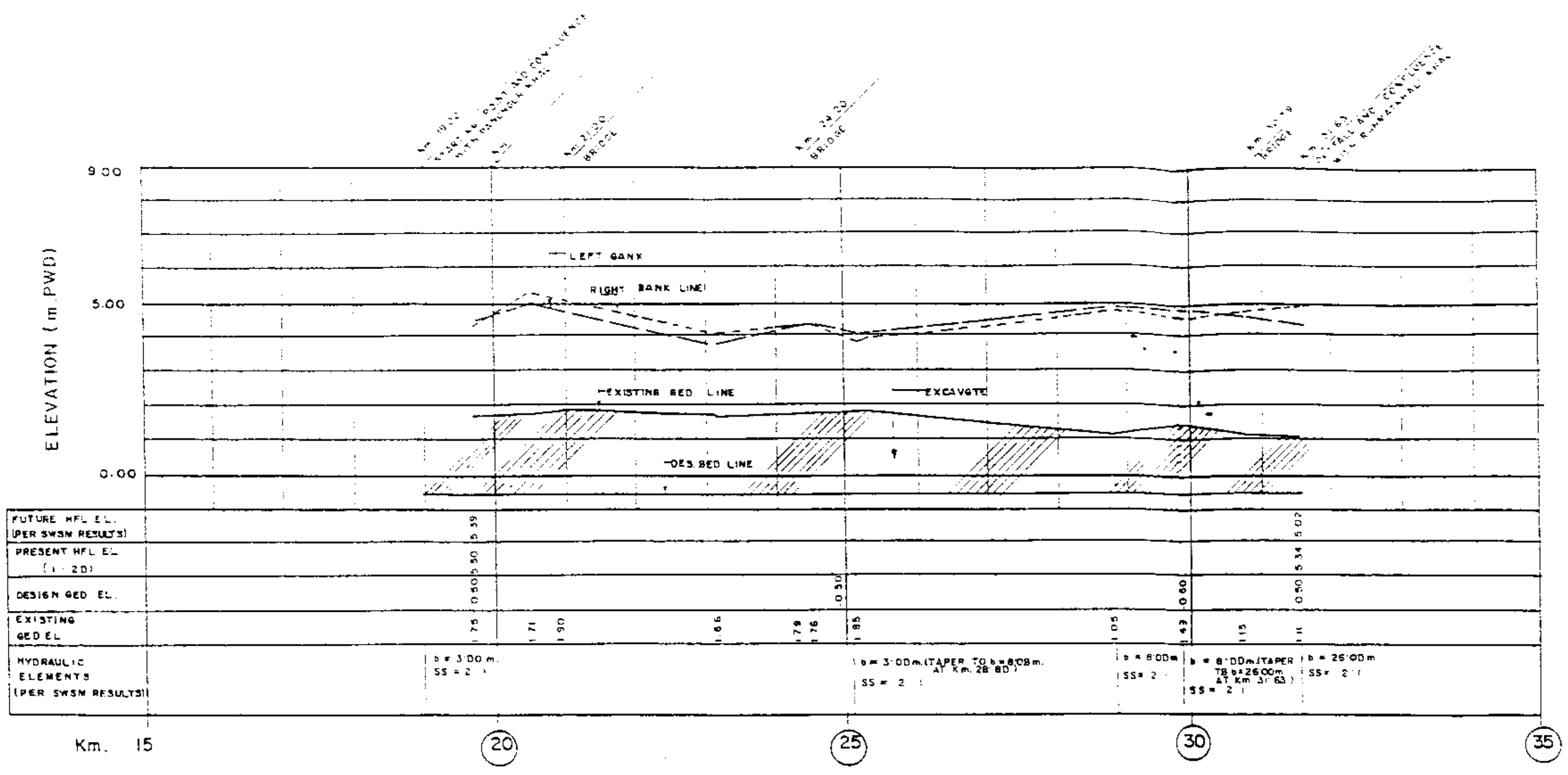
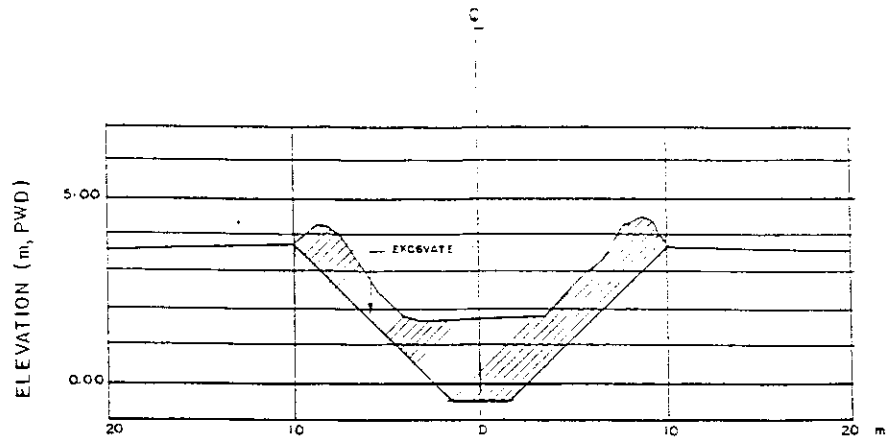
DATE			

Figure I.XII.5



PROPILE OF MOHANDRA KHAL (NORTH)



TYPICAL SECTION OF MOHANDRA KHAL (NORTH)
(SECTION TAKEN AT Km. 24.36)

MINISTRY OF IRRIGATION
WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & ~~IRRIGATION~~ PROJECT
PROFILE OF MOHANDRA KHAL (NORTH)

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DESH UPADESH LTD. BANGLADESH

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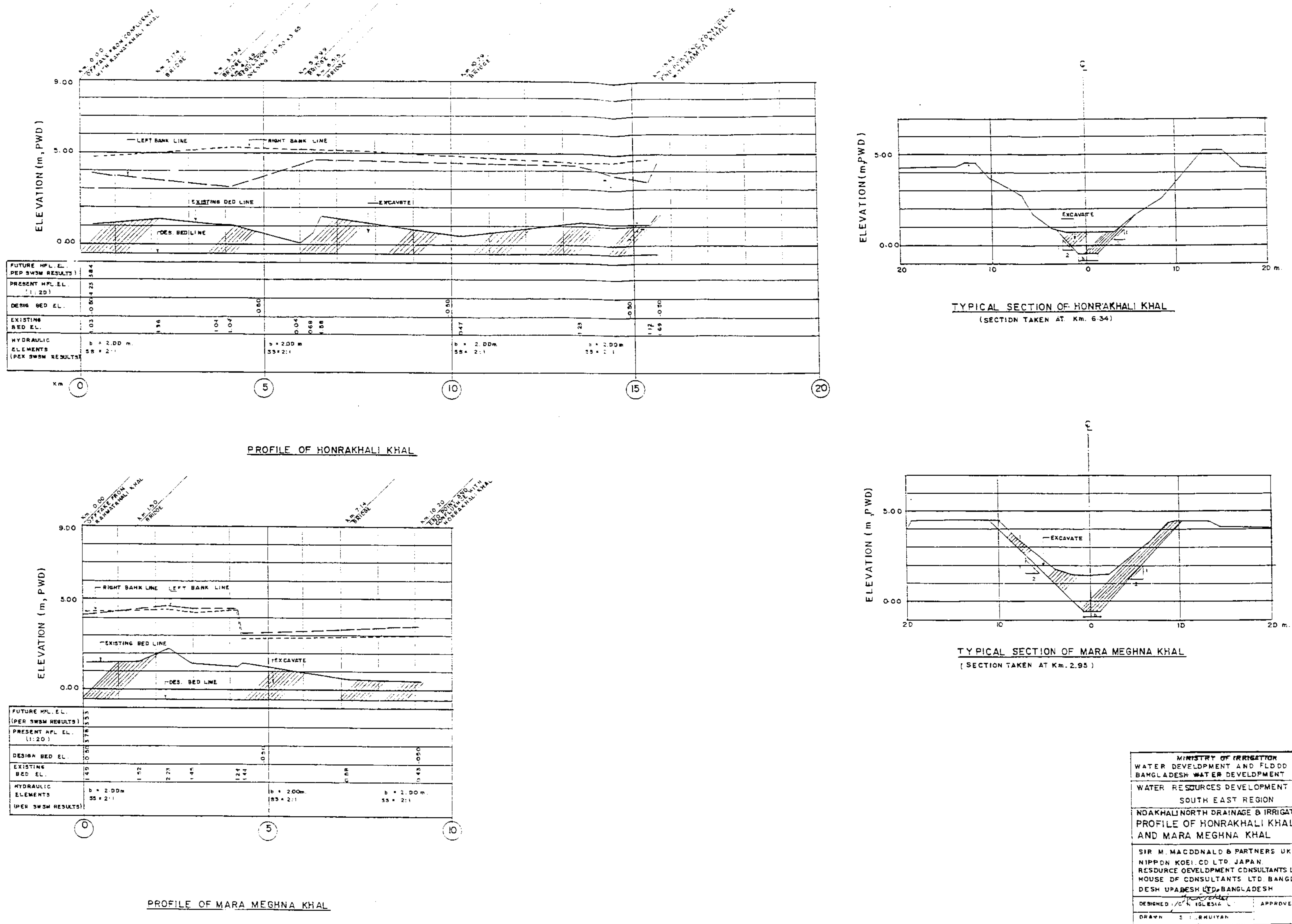
DRAWN / BHUIYAN
CHECKED / DRG. NO. 5109-C012 / SHEET
DATE

Figure I.XII.6



MINISTRY OF IRRIGATION
WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

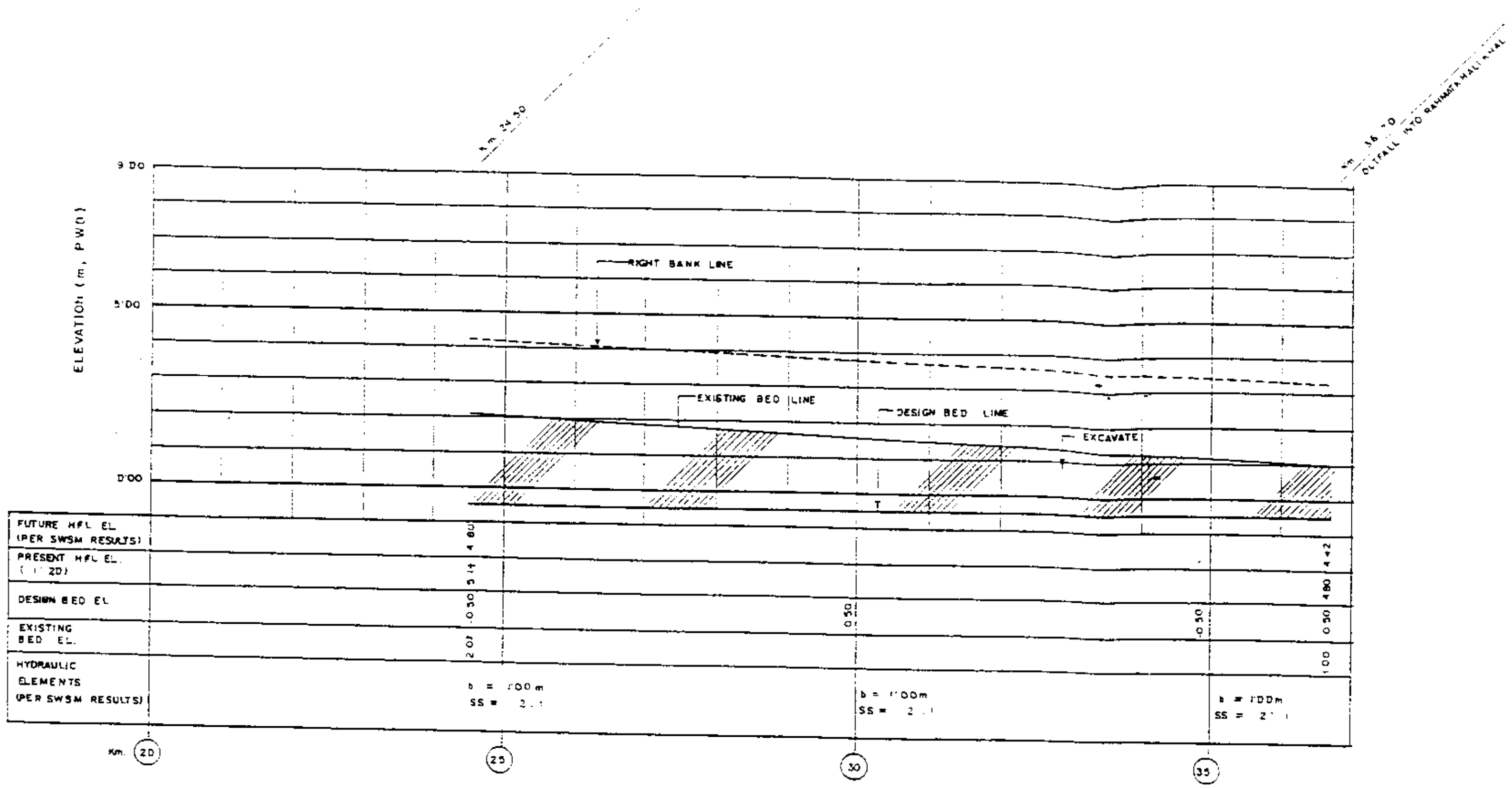
NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
PROFILE OF HONRAKHALI KHAL AND MARA MEGHNA KHAL

SIR M. MACDONALD & PARTNERS UK.
NIPPON KOEI CO LTD. JAPAN.
RESOURCE DEVELOPMENT CONSULTANTS LTD. S. LANKA.
HOUSE OF CONSULTANTS LTD. BANGLADESH
DESH UPADESH LTD. BANGLADESH

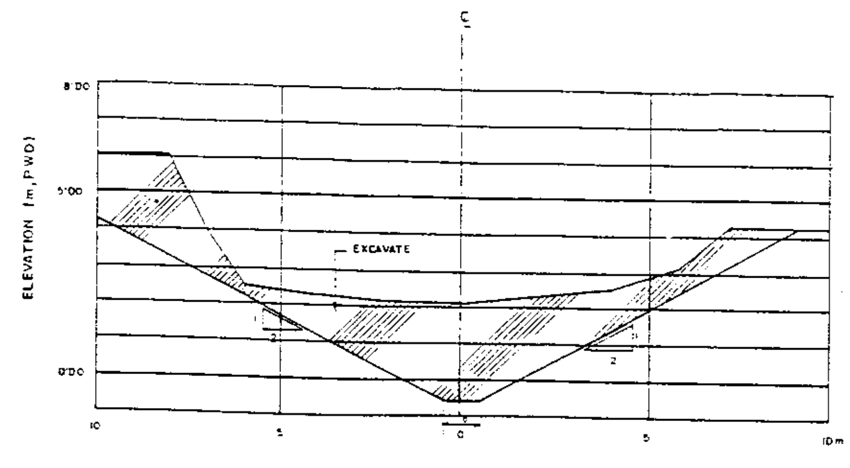
DESIGNED: /C/ K. IGLESIA L.	APPROVED:
DRAWN: S. I. BHUIYAN	
CHECKED:	DRG. No. 5109-C014
DATE: 16. 5. 93	SHEET

252

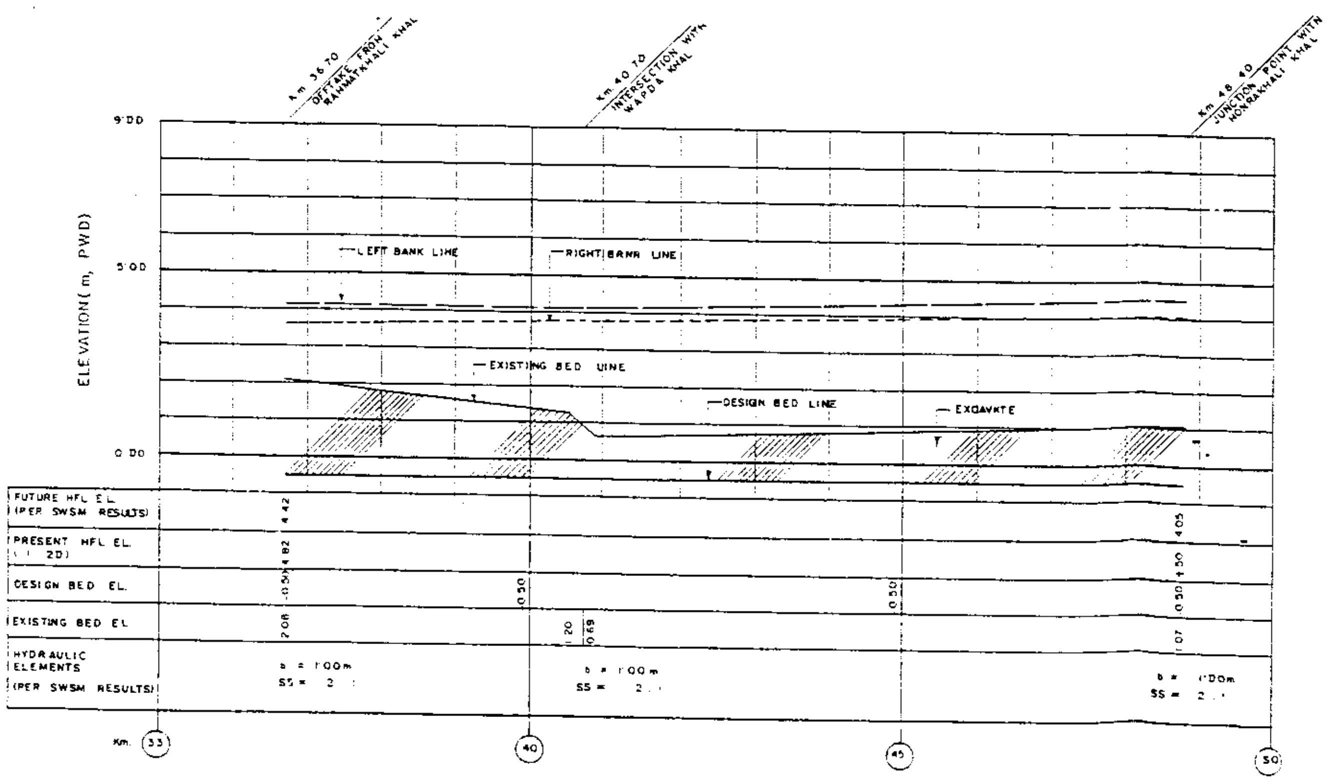
Figure LXII.7



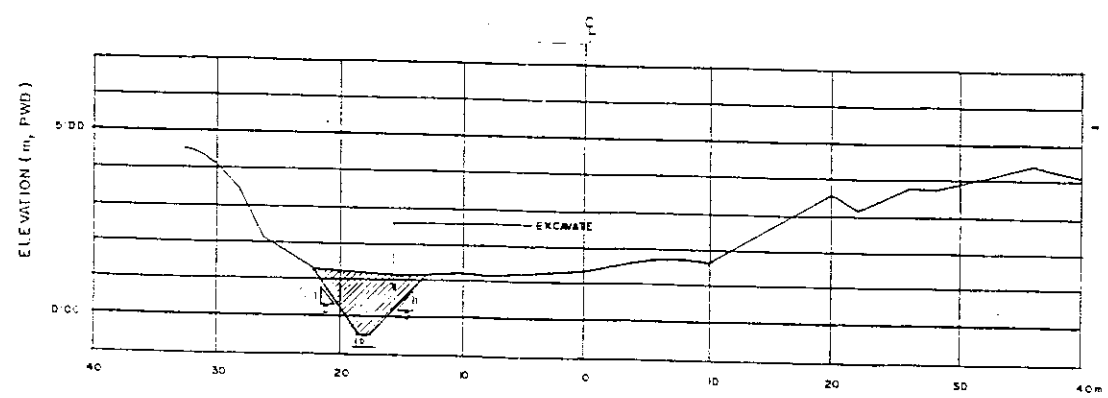
PROFILE OF KAMTA KHAL (NORTH)



TYPICAL SECTION OF KAMTA KHAL (NORTH)
SECTION TAKEN AT Km.24·50)



PROFILE OF KAMTA KHAL (SOUTH)



TYPICAL SECTION OF KAMTA KHAL (SOUTH)
(SECTION TAKEN AT Km 48·40)

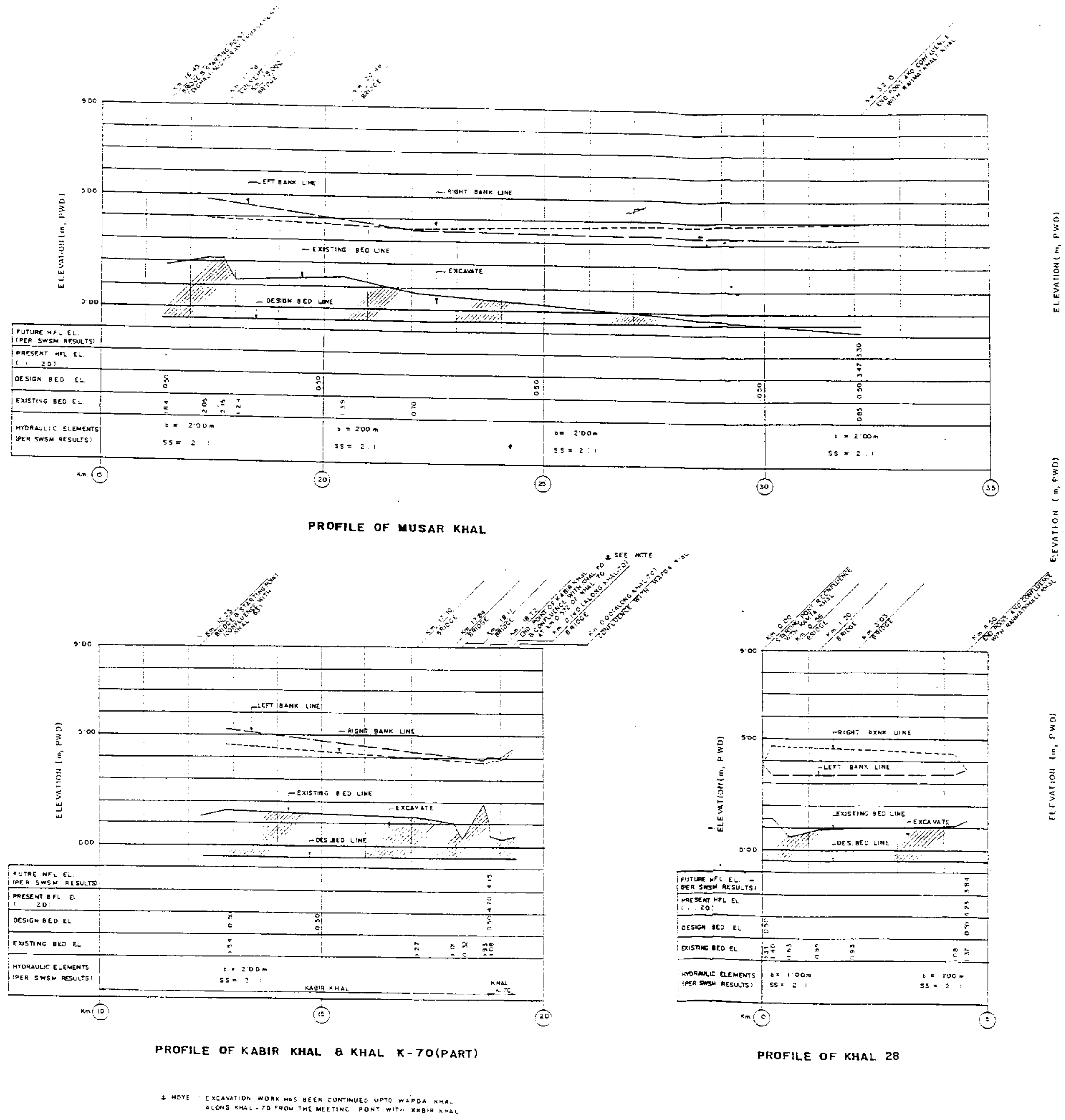
MINISTRY OF IRRIGATION
WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT
PROFILE OF KAMTA KHAL

SIR M. MACDONALD & PARTNERS LTD. UK
NIPPON KOEI CO. LTD. JAPAN
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRILANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH
DESH UPADESH LTD. BANGLADESH

DESIGNED	N. IGLESIW	APPROVED	
DRAWN	M. A. UDDIN		
CHECKED		DRAWING NO	SHEET
DATE		5109-CO.15	1

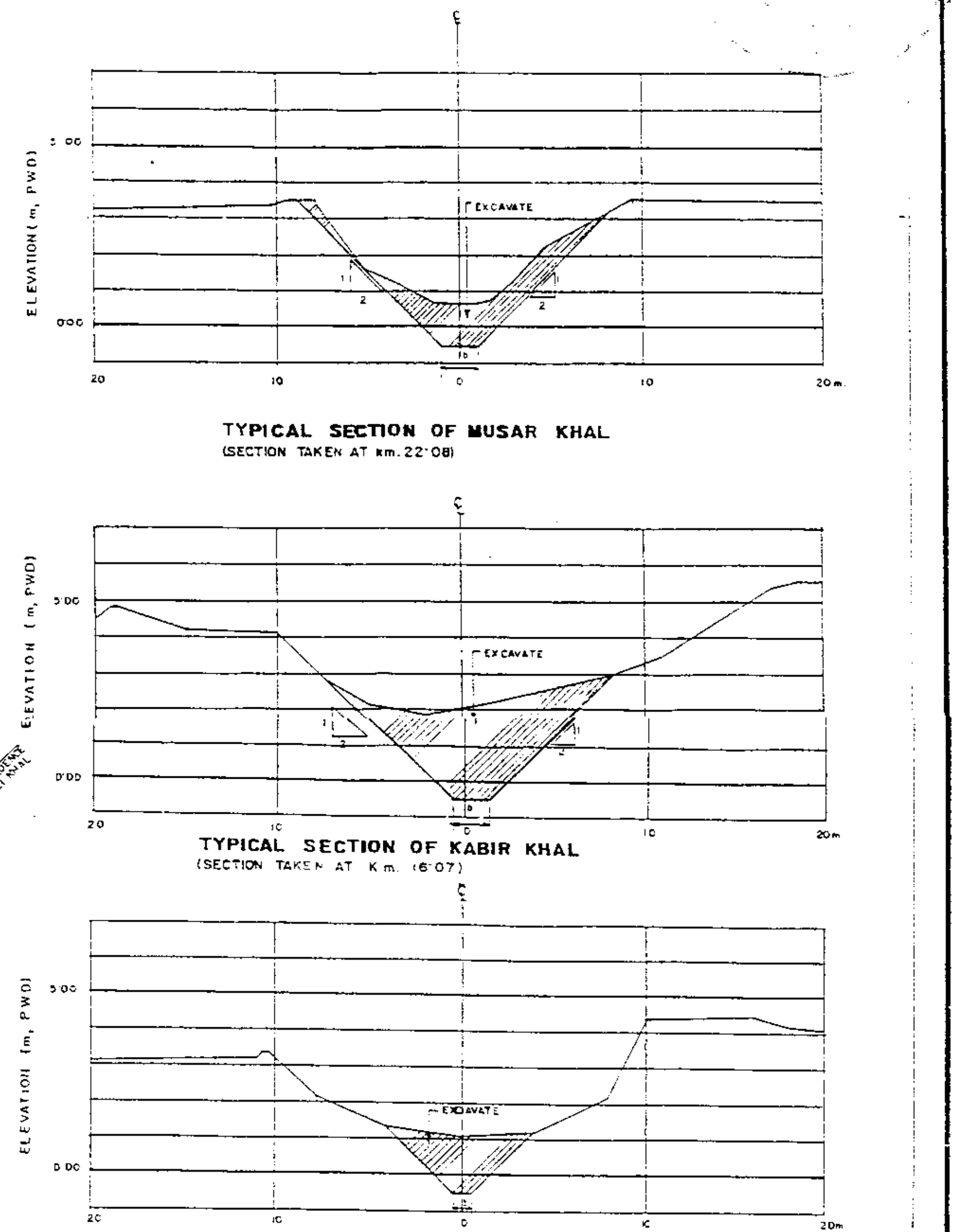


PROFILE OF MUSAR KHAL

PROFILE OF KABIR KHAL & KHAL K-70(PART)

PROFILE OF KHAL 28

* NOTE : EXCAVATION WORK HAS BEEN CONTINUED UPTO WAPDA KHAL ALONG KHAL-70 FROM THE MEETING POINT WITH KABIR KHAL



TYPICAL SECTION OF MUSAR KHAL
(SECTION TAKEN AT km. 22.08)

TYPICAL SECTION OF KABIR KHAL
(SECTION TAKEN AT Km. 16.07)

TYPICAL SECTION OF KHAL 28
(SECTION TAKEN AT Km. 4.23)

MINISTRY OF IRRIGATION
WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

WATER RESOURCES DEVELOPMENT PROGRAMME
SOUTH EAST REGION

NOAKHALI NORTH DRAINAGE & IRRIGATION PROJECT

PROFILE OF MUSAR KHAL KABIR KHAL AND KHAL - 28

SIR M. MACDONALD & PARTNERS LTD. UK.
NIPPON KOEI CO. LTD. JAPAN.
RESOURCES DEVELOPMENT CONSULTANTS LTD. SRI LANKA
HOUSE OF CONSULTANTS LTD. BANGLADESH.
DESH UPADESH LTD., BANGLADESH

DESIGNED	A. IQLESIA	APPROVED	
DRAWN	M. S. UDDIN		
CHECKED		DRAWING NO.	SHEET
DATE		5105-C016	1/1

284

APPENDIX I.XIII

ENGINEERING QUANTITIES AND COSTS

TABLE I.XIII.1

Estimate of Renovation Work for Rahmatkhali Regulator

Sl No	Description	Quantity	Unit	Rate	Amount
1	Cement Concrete/R.C.C work(210 kg/sq.m)	465	cu.m	3740	1,739,100
2	Reinforcement Bars (1.5 %)	54	tonne	25750	1,390,500
3	Steel Ladder	28	Nr	2500	70,000
4	Boulders (Filling Scour Hole)	4150	cu.m	2250	9,337,500
5	Unbalanced Flap Gate (3.0 m X 3.0 m)	14	Nr	160000	2,240,000
6	Balanced Flap Gate (2.8 m X 3.0 m)	14	Nr	160000	2,240,000
7	Demolished Concrete	112	cu.m	375	42,000
8	Removing Existing Gate	28	Nr	7050	197,400
9	Cofferdam	6	Gate	200000	1,200,000
10	Dewatering			LS	100,000

Direct Cost	18,556,500
Minor Items (@ 10% of Direct Cost)	1855650
Total Cost Tk.in Million	20.41215

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TABLE I. XIII.2

Estimate of new Regulator at Rahmatkhali
10 Vent each of 3m X 3.0m

Sl No	Description	Quantity	Unit	Rate	Amount
1	Earthwork in Excavation(Manual, Transport 100m)	40000	cu.m	37	1,480,000
2	Earthwork in Backfilling	15000	cu.m	27.5	412,500
3	Lean Concrete (1 : 3 : 6)	205	cu.m	2302	471,910
4	Structural Concrete (210 kg/sq.m)	5000	cu.m	3775	18,875,000
5	Reinforcement Bars (1.5 %)	585	tonne	25850	15,122,250
6	Concrete Blocks (1:3:6,Size .4mX.4mX.3m)	650	cu.m	2402	1,561,300
7	Khoa Filter	650	cu.m	985	640,250
8	Boulders (0.3 m Thick)	250	cu.m	2250	562,500
9	Brick Flat Soling (76mm Thick)	2050	Sq.m	100	205,000
10	Sheet Pile (10 mm Thick, Including Driving)	30	tonne	34000	1,020,000
11	Dewatering			L.S.	7,500,000
12	Balanced Flap Gate (3m X 3.0m)	20	Nr	183000	3,660,000
13	Diversion Channel Excavation				
	a) Manual, Transport to 50m	76000	cu.m	31	2,356,000
	b) Using Dredger (including Disposal)	100800	cu.m	70.5	7,106,400
	c) Using Mini Dredger(Including Disposal)	38000	cu.m	50.5	1,919,000

Direct Construction cost				62,892,110
Minor & Miscellaneous Items @ 10 % of Direct Cost				6,289,211
Total Cost in million Tk.				69,181,321
Land Acqusition				
a) Structure Site	1	ha	500000	500,000
b) Diversion Channel	9	ha	500000	4,500,000

TABLE I. XIII.3

Estimate of Noakhali Regulator
4 Vent each of 1.5m X 3.0m

Sl No	Description	Quantity	Unit	Rate	Amount
1	Earthwork in Excavation(Manual, Transport 100m)	3530	cu.m	37	130,610
2	Earthwork in Backfilling	1000	cu.m	27.5	27,500
3	Approach Road/Embankment Construction	500	cu.m	41	20,500
4	Lean Concrete (1 : 3 : 6)	40	cu.m	2302	92,080
5	Structural Concrete (210 kg/sq.m)	620	cu.m	3775	2,340,500
6	Reinforcement Bars (1.5 %)	80	tonne	25850	2,068,000
7	Khoa Filter	45	cu.m	985	44,325
8	Boulders (0.3 m Thick)	90	cu.m	2250	202,500
9	Slidegate (1.5m X 3.0m)	4	Nr	100000	400,000
10	Diversion Channel Excavation				
	Manual, Transport to 50m	1000	cu.m	31	31,000
11	Embedded M.S. Plate Angle etc.			L.S.	20000

Direct Construction cost				5,377,015
Minor & Miscellenious Items @ 10 % of Direct Cost				537,702
Total Cost in million Tk.				5,914,717
Land Acquisition	0	ha	500000	0

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287

TABLE I.XIII.4

Cost Estimate of Bridges/Culverts to be Rehabilitated
Noakhali North Project

Sl. No	Description	Amount
1.	Propping of Existing Deck Slabs	990000
	& Demolishing Abutments/Piers	
2.	Piers on Pile Foundation	6500000
3.	Abutments on Pile Foundation	3850000
4.	Deck Slabs Construction	3045000
5.	R.C.C. Trussed Pier	140000
6.	Wooden Deck Slab	100000
7.	Scour Protection	3300000

Total Amount in Million Tk. 17925000
Total amount 18.0 million Tk.

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TABLE I. XIII.5

Estimate of all Khals in Noakhali North Project

Sl No	Khal Name	Khal No	Length (km)	Excav. Volume (cu.m)	Land Aq. (ha)
1	Noakhali Khal	K-14	9.25	229026	0.00
2	Sonaimuri Khal	K-39	16.50	631608	0.00
3	Mohandra Khal	K-6	12.63	509238	0.23
4	Honrakhali Khal	K-55	15.63	195411	0.00
5	Marameghna Khal	K-87	10.20	169795	0.00
6	Khal 28	K-28	4.50	99154	0.00
7	Kamta Khal	-	23.90	406035	0.00
8	Kabir Khal/Khal 70	K-69	6.47	210972	0.48
9	Musar Khal	K-62	15.68	164614	0.00
		Total	114.76	2615853	0.71

Sl. No.	Khal	Mode of Excavation	Location (m)	Length (m)	Vol. (m³)	L.A (ha)	Remarks
1.	Rahmatkhali Khal (K-51)	Manual	000 - 32600	32600	2340206	6.29	
2.		dredging	32600 - 44027	11427	1501187	15.13	
3.		dredging	44027 -'45100	1073	564590	12.07	Loop cut
4.		dredging	"45866 - 51600	5734	1266062	0.99	
5.	WAPDA Khal (K-53)	dredging	000 - 1620	1620	313766	4.86	
6.		dredging	1620 -'1850	230	59587	1.38	Loop cut 1
7.		dredging	"2250 - 4730	2480	505171	6.54	
8.		dredging	4730 -'5110	380	99425	2.27	Loop cut 2
9.		dredging	'5110 -'5650	540	146285	3.29	Loop cut 3
10.		dredging	"6710 - 24790	18080	2932320	13.17	

Note:

- (') Measured along the new cut-off in continuation with the old chainage.
- (") Chainage at the end of new cut-off measured along the old loop.

ABSTRACT OF LOOP-CUTS

Sl. No.	Khal	Loop no	Location* (m)	Loop Length (m)	X-sec Area (m²)	Top width (m)
1.	Rahmatkhali Khal (K-51)	1	44027-45866	1839	238	100
2.	WAPDA Khal (K-53)	1	1620-2250	630	76	30
3.		2	4730-5580	850	57	28
4.		3	5580-6710	1130	67	25

Note:

- (*) Old chainages.

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260

Estimate of Earthwork for Excavation
Noakhali Khal (Khal No 14)

Sl No	C/S No	Chainage (m)	Width (m)	Bed El. (m PWD)	Excav. Area (Sq.m)	Excav. Volume (cu.m)	Land Acq. (ha)
1	14	21790	1.30	-0.5	11.11	0	0
2	15	22900	1.48	-0.5	21.30	17683	0
3	16	25200	1.86	-0.5	25.41	53647	0
4	17	25880	1.97	-0.5	15.04	13600	0
5	18	26960	1.76	-0.5	36.75	27108	0
6	19	29450	1.13	-0.5	25.91	77620	0

	Length (m)	Volume (cu.m)	Land acq. (ha)
Between last and first cross section	7660	189658	0
Adjusted over measured length of chanal	9250	229026	0

Estimate of Earthwork for Excavation
Sonaimuri Khal (Khal No 39)

Sl No	C/S No	Chainage (m)	Width (m)	Bed El. (m PWD)	Excav. Area (Sq.m)	Excav. Volume (cu.m)	Land Acq. (ha)
1	4	7866	2	-0.5	28.31	0	0
2	5	8610	2	-0.5	34.41	23295	0
3	6	10070	2	-0.5	47.13	59281	0
4	7	11700	2	-0.5	38.40	69586	0
5	8	14510	2	-0.5	40.20	110423	0
6	9	15300	2	-0.5	46.08	34054	0
7	10	16490	2	-0.5	37.22	49470	0
8	11	18810	2	-0.5	39.25	88695	0
9	12	19710	2	-0.5	41.75	36444	0
10	13	20560	2	-0.5	33.63	31974	0
11	14	24330	2	-0.5	33.87	127237	0

	Length (m)	Volume (cu.m)	Land acq. (ha)
Between last and first cross section	16470	630460	0
Adjusted over measured length of chanal	16500	631608	0

Estimate of Earthwork for Excavation
Mohandra Khal (Khal No 6)

Sl No	C/S No	Chainage (m)	Width (m)	Bed El. (m PWD)	Excav. Area (Sq.m)	Excav. Volume (cu.m)	Land Acq. (ha)
1	11	19700	3.00	-0.5	30.83	0	0
2	12	20500	3.00	-0.5	37.00	27095	0
3	13	23100	3.00	-0.5	18.00	70033	0
4	14	24360	3.00	-0.5	30.09	29972	0
5	15	25150	3.25	-0.5	29.17	23407	0
6	16	28820	12.06	-0.5	45.11	135245	0
7	17	29880	17.32	-0.5	70.47	60760	0.08
8	18	31630	26.00	-0.5	83.43	134503	0.15

	Length (m)	Volume (cu.m)	Land acq. (ha)
Between last and first cross section	11930	481015	0.23
Adjusted over measured length of chanal	12630	509239	0.23

Estimate of Earthwork for Excavation
Honrakhali Khal (Khal No 55)

Sl No	C/S No	Chainage (m)	Width (m)	Bed El. (m PWD)	Excav. Area (Sq.m)	Excav. Volume (cu.m)	Land Acq. (ha)
1	1	350	2	-0.5	21.40	0	0
2	2	4114	2	-0.5	17.02	72149	0
3	3	6340	2	-0.5	7.49	26564	0
4	4	13410	2	-0.5	12.25	69095	0
5	5	15370	2	-0.5	12.60	24352	0

	Length (m)	Volume (cu.m)	Land acq. (ha)
Between last and first cross section	15370	192160	0
Adjusted over measured length of chanal	15630	195411	0

262

Estimate of Earthwork for Excavation

Mara Meghna Khal (Khal No 87)

Sl No	C/S No	Chainage (m)	Width (m)	Bed El. (m PWD)	Excav. Area (Sq.m)	Excav. Volume (cu.m)	Land Acq. (ha)
1	1	100	2	-0.5	30.13	0	0
2	2	2950	2	-0.5	21.99	73967	0
3	3	9140	2	-0.5	4.81	76518	0

	Length (m)	Volume (cu.m)	Land acq. (ha)
Between last and first cross section	9040	150485	0
Adjusted over measured length of chanal	10200	169795	0

Estimate of Earthwork for Excavation

Khal No 28 (Khal No 28)

Sl No	C/S No	Chainage (m)	Width (m)	Bed El. (m PWD)	Excav. Area (Sq.m)	Excav. Volume (cu.m)	Land Acq. (ha)
1	1	200	1	-0.5	21.70	0	0
2	2	4230	1	-0.5	22.37	88798	0

	Length (m)	Volume (cu.m)	Land acq. (ha)
Between last and first cross section	4030	88798	0
Adjusted over measured length of chanal	4500	99154	0

Estimate of Earthwork for Excavation

Kamta Khal (Khal No nil, Ref. data collected from model)

Sl No	C/S No	Chainage (m)	Width (m)	Bed El. (m PWD)	Excav. Area (Sq.m)	Excav. Volume (cu.m)	Land Acq. (ha)
1	1	24500	1	-0.5	22.75	0	0
2	2	28630	1	-0.5	21.45	91260	0
3	3	32770	1	-0.5	18.81	83278	0
4	4	36700	1	-0.5	17.43	71194	0
5	5	36701	1	-0.5	28.55	23	0
6	6	40700	1	-0.5	8.53	70230	0
7	7	40701	1	-0.5	17.36	13	0
8	8	44850	1	-0.5	11.02	58378	0
9	9	48400	1	-0.5	6.97	31659	0

	Length (m)	Volume (cu.m)	Land acq. (ha)
Between last and first cross section	23900	406035	0
Adjusted over measured length of chanal	23900	406035	0

Estimate of Earthwork for Excavation

Kabir Khal (Khal No 69)/(Khal 70)

Sl No	C/S No	Chainage (m)	Width (m)	Bed El. (m PWD)	Excav. Area (Sq.m)	Excav. Volume (cu.m)	Land Acq. (ha)
1	4	10310	2	-0.5	31.07	0	0
2	5	16070	2	-0.5	34.17	187820	0.48

	Length (m)	Volume (cu.m)	Land acq. (ha)
Between last and first cross section	5760	187821	0.48
Adjusted over measured length of chanal	6470	210972	0.48

264

Estimate of Earthwork for Excavation

Musar Khal (Khal No 62)

Sl No	C/S No	Chainage (m)	Width (m)	Bed El. (m PWD)	Excav. Area (Sq.m)	Excav. Volume (cu.m)	Land Acq. (ha)
1	4	17380	2	-0.5	34.94	0	0
2	5	22080	2	-0.5	10.82	102152	0
3	6	31780	2	-0.5	1.02	49024	0

	Length (m)	Volume (cu.m)	Land acq. (ha)
Between last and first cross section	14400	151176	0
Adjusted over measured length of chanal	15680	164614	0

Rahmatkhali Khal (K-51)

Estimate of Earthwork and land acquisition

Sl No	C/S No	Chainage (m)	Bed Width (m)	Bed Elevn. (m PWD)	Excav. in reach (m^3)	Land acq. in reach (ha)	Excav. Cumulative (m^3)	Land acq. Cumulative (ha)
1	1	560	22.00	-0.53	32855	0.00	32855	0.00
2	2	2400	22.00	-0.68	123571	0.00	156426	0.00
3	3	4320	22.00	-0.81	157848	0.00	314274	0.00
4	4	5320	22.00	-0.87	91987	0.00	406261	0.00
5	5	6070	22.00	-0.88	70042	0.00	476303	0.00
6	6	7720	22.00	-1.08	14845	0.00	491148	0.00
7	7	8920	22.00	-1.17	124649	0.00	615797	0.00
8	8	10960	22.00	-1.32	194821	0.47	810618	0.47
9	9	11430	22.00	-1.36	40006	0.48	850624	0.94
10	10	12280	30.00	-1.40	787557	0.68	1638181	1.62
11	*10A	13200	30.00	-1.50	83799	0.74	1721980	2.36
12	*11A	13200	6.00	-1.00	0	0.00	1721980	2.36
13	11	13920	6.00	-1.00	40156	0.00	1762136	2.36
14	12	14630	6.16	-1.00	10385	0.00	1772521	2.36
15	13	15430	6.28	-1.00	11375	0.10	1783896	2.46
16	14	18860	6.65	-1.00	90800	0.09	1874696	2.55
17	15	19300	6.70	-1.00	13559	0.00	1888255	2.55
18	16	19880	6.77	-1.00	21666	0.19	1909921	2.73
19	17	23280	7.91	-1.00	136456	2.13	2046377	4.86
20	18	24660	8.79	-1.00	54763	0.17	2101140	5.02
21	19	26010	9.70	-1.00	45856	0.61	2146996	5.63
22	20	27400	10.00	-1.19	32139	0.07	2179135	5.70
23	21	30640	11.89	-1.83	88986	0.11	2268121	5.81
24	22	31790	13.98	-1.97	40186	0.20	2308307	6.00
25	23	32600	15.45	-2.07	31899	0.29	2340206	6.29
26	24	34130	18.29	-2.27	77526	0.38	2417732	6.68
27	25	34480	19.09	-2.32	20922	0.00	2438654	6.68
28	26	39180	29.79	-2.98	429961	2.59	2868615	9.26
29	*26A	40700	30.00	-3.00	188345	1.71	3056960	10.97
30	*27A	40700	70.00	-3.00	0	0.00	3056960	10.97
31	27	43000	71.07	-2.98	575741	9.20	3632701	20.17
32	28	43750	71.41	-2.98	158069	1.25	3790770	21.42
33	*28A	44027	73.12	-2.91	50623	0.00	3841393	21.42
34	*28B	44027	73.12	-2.91	0	0.00	3841393	21.42
35	*29A	(45100)	82.45	-2.53	564590	12.07	4405983	33.49
36	*29B	(45100)	82.45	-2.53	0	0.00	4405983	33.49
37	30	46650	86.85	-2.36	139507	0.00	4545490	33.49
38	31	47800	97.08	-2.19	239006	0.00	4784496	33.49
39	32	49100	108.12	-2.16	323160	0.36	5107656	33.85
40	33	51600	130.00	-2.00	564389	0.63	5672045	34.48

Note: (*)

10A & 11A Junction with WAPDA Khal at Chandraganj
26A & 27A Junction with WAPDA Khal at Piarpur
28A & 28B Start of Loop-cut (measured along old chainage)
29A & 29B End of Loop-cut at 45100m (measured along the new chainage which corresponds to 45866m along the old chainage).

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266

WAPDA Khal (53)

Estimate of Earthwork and land acquisition

Sl No	C/S No	Chainage	Bed Width	Bed Elevn.	Excav. in reach	Land acq. in reach	Excav. Cumulative	Land acq. Cumulative
		(m)	(m)	(m PWD)	(m^3)	(ha)	(m^3)	(ha)
1	1	800	37.00	-1.53	154456	2.40	154456	2.40
2	*1A	1620	37.25	-1.56	153910	2.46	313766	4.86
3	*1B	1620	37.25	-1.56	0	0.00	313766	4.86
4	*2A	1850	37.28	-1.57	59587	1.38	373353	6.24
5	*2B	1850	37.28	-1.57	0	0.00	373353	6.24
6	2	3155	37.48	-1.63	180272	2.70	553625	8.94
7	3	4595	37.70	-1.68	296425	3.56	850051	12.50
8	*3A	4730	37.73	-1.69	28474	0.28	878524	12.78
9	*3B	4730	37.75	-1.69	0	0.00	878524	12.78
10	*3C	5110	37.78	-1.70	99425	2.27	977949	15.05
11	*4A	5650	37.86	-1.72	146285	3.29	1124235	18.35
12	*4B	5650	37.86	-1.72	0	0.00	1124235	18.35
13	4	7795	38.08	-1.81	61395	0.20	1185629	18.55
14	5	9278	38.00	-1.87	303826	2.26	1489455	20.81
15	6	11370	38.00	-1.95	415786	2.46	1905241	23.27
16	7	12369	38.00	-2.00	180464	0.55	2085705	23.82
17	8	13269	39.00	-2.00	132684	1.08	2218389	24.90
18	9	14369	40.33	-2.15	191735	0.60	2410124	25.50
19	10	15569	41.21	-2.25	267335	0.00	2677459	25.50
20	11	16947	42.23	-2.36	251451	1.25	2928910	26.75
21	12	19030	43.76	-2.53	276980	2.89	3205890	29.64
22	13	19924	44.42	-2.60	118241	0.66	3224132	30.30
23	14	20649	44.95	-2.66	92939	0.24	3417070	30.54
24	15	22108	46.02	-2.78	233203	0.75	3650273	31.29
25	16	23008	46.76	-2.86	152066	0.23	3802339	31.52
26	*16A	24790	48.00	-3.00	254216	0.00	4056555	31.52

Note: (*)

1A & 1B Start of 1st. cut-off at 1620m (measured along the old chainage).
2A & 2B End of 1st. cut-off at 1850m (measured along the new chainage which corresponds to 2250m along the old chainage).
3A & 3B Start of 2nd. cut-off at 4730m (measured along the old chainage)
3C End of 2nd cut-off at 5110m (measured along the new chainage which corresponds to 5580m along the old chainage).
4A & 4B End of 3rd. cut-off at 5650m (measured along the new chainage which corresponds to 6710m (measured along the old chainage).
16A Out-fall of WAPDA Khal into Rahmatkhali Khal.

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Bank Protection Work

Noakhali North Project

	Sl No	Chainage From	Chainage To	Length (m)
WAPDA Khal				
	1	4300	4450	150
	2	11450	11600	150
	3	11900	12050	150
	4	14000	14150	150
	5	17200	17350	150
	6	20650	20800	150
	7	21750	21900	150
Rahmatkhali	1	40450	40850	400
Khal	2	42180	42580	400

Total Length (m) 1850

Rate Analysis

Description	Unit Rate (Tk.)	Quant./m Length	Cost per m (Tk.)
a) Geotextile Filter	100 per sq.m	16	1600
b) Brick Khoa Filter(100mm)	930 per cu.m	16	1488
c) Concrete Block(300X300X300)	2402 per cu.m	16	11530
d) Boulders at toe (.5 m thick)	2250 per cu.m	3	3375

Total 17993

Total cost per m length : 18000

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A. **Modification of Structures on Main Khal- WAPDA/Rahmatkhali**

Sl No.	Description of Bridge to be Rehabilitated	Quantity	Rate in Tk.	Cost in Taka
1	Amin Bazar Bridge (width -3.05m) - Adding 1 span (8m)+ new abutment			
	Propping the existing deck slab and demolishing the existing abutment	1 No.	2,50,000	2,50,000
	Constructing pile founded pier etc.	1 No.	3,75,000	3,75,000
	Constructing pile founded abutment etc.	1 No.	4,00,000	4,00,000
	Constructing deck slab of 8m length	8 M	30,000	2,40,000
				------------- 12,65,000
2	Halanbari bridge (width - 4.5m) - Adding 1 span (15 m) and new abutment			
	Propping the existing deck slab and demolishing the existing abutment	1 No.	2,50,000	2,50,000
	Constructing pile founded pier etc.	1 No.	5,00,000	5,00,000
	Constructing pile founded abutment etc.	1 No.	5,00,000	5,00,000
	Constructing deck slab of 15 m length etc.	15 M	35,000	5,25,000
				------------- 17,75,000
3	Chandraganj bridge (width - 3.05m) - Adding 1 span (8m)			
	Propping the existing deck slab and demolishing the existing Pre-cast RCC pile founded abutment cum wing wall (provision).	1 No.	2,50,000	2,50,000
	Constructing the RCC pile founded pier etc. (provision)	1 No.	3,75,000	3,75,000
	Constructing pile founded abutment etc.	1 No.	4,00,000	4,00,000
	Constructing deck slab of 8m length	8 M	30,000	2,40,000
				------------- 12,65,000
4	Bashurhat bridge (width -3.1m) - Adding 3 span (6m each)			
	Constructing pile founded piers etc.	2 Nos.	3,75,000	7,50,000
	Constructing pile founded abutment etc.	1 No.	4,00,000	4,00,000
	Constructing deck slab of 18 m length	18 M	30,000	5,40,000
				------------- 16,90,000

5	RCC trussed Gagirhat bridge (width -3m) - Adding 2 span Constructing RCC trussed piers (size-.25x.25m) foundation Constructing wooden deck slab of length 10m	 2 Nos. 10 M	 70,000 10,000	 1,40,000 1,00,000 -------------- 2,40,000
6	Pearapur bridge (width - 5.6m) - Adding 1 span (15m) and abutment Constructing RCC pile founded RCC abutment etc. Constructing deck slab of 15 m length	 1 No. 15 M	 6,50,000 40,000 Sub-Total	 6,50,000 6,00,000 ------------- 12,50,000 ------------- 74,85,000

B. Scour Protection of Bridge Piers

1	Scour Protection to the bridge piers considering 0.30 m brick Mattessing over 10 cm filter materials including wire netting tied with wooden pegs etc.	5500 M^2	600	33,00,000
			Total	1,07,85,000

C. Modification/Re-Construction of Bridges on Secondary Khal

Sl No.	Description of Works	Quantity	Rate in Tk.	Cost in Taka
1	Modification - (a) Propping the existing deck slab of average length 5 m and average width 3.5m. Also demolishing the existing RCC pier cap. pier, pile cap etc. (Propping Area - 20.m^2 and RCC works = $20m^3$)	12 Nos.	20,000	2,40,000
	(b) Constructing RCC pile founded pier etc.	12 Nos.	3,75,000	45,00,000
	Re-construction -			
2	Rebuilding 2 Nos. single span RCC bridge of length 15m and width 3.7 m with			
	(a) RCC pile founded Abutments	4 Nos.	3,75,000	15,00,000
	(b) RCC deck slab	30 M	30,000	9,00,000 --------------
			Sub-Total	**71,40,000**

Grand Total 1,79,25,000

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Summary of Analysis for Bridges (To be rehabilitated/reconstructed over WAPDA, Rahmatkhali and Secondary canal)

Bridge Size	Piers		Abutment		Deck Slab Rate per m
	Description	Rate	Description	Rate	
Width 6.7m Span 16m	0.8m dia RCC Pier and pre-cast pile size .4X.4X10 m, 15 Nos	650,000	0.8m dia RCC pier and Pre-cast piles size .4X.4X10 m 18 Nos including earth work in approach	550,000	40,000
Width 3.5m Span 16m	0.6 dia RCC pier and Pre-cast piles size .4X.4X10 m, 9 Nos	375,000	0.6m dia RCC pier and Pre-cast piles size .4X.4X10 m, 9 Nos including earth work in approach	400,000	30,000
Width 6.7m Span 8m	.6 m dia RCC pier and precast RCC piles Size 0.4X.4X10 m, 10 Nos	450,000	0.6m dia RCC pier and Pre-cast piles size .4X.4X10 m, 10 Nos including earth work in approach	500,000	35,000
Width 3.5m Span 8m	0.6 dia RCC pier and .2m dia (avg) wooden piles of length 4.5 m, 25 Nos	350,000	0.6m dia RCC pier .2m dia (avg) wooden piles of length 4.5 m 25 Nos including earth work in approach	375,000	20,000

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Bridge Modification

Calculation Sheet for alternate I and alternate II

Alternate I : Span length = 16 m and Width = 3.5 m
Alternate II : Span length = 16 m and Width = 7.5 m

(A1) Analysis of Deck Slab (Alternate I)

Length = 1.78m (Railing to Railing)

Sl No	Description	Quantity	Unit	Rate	Amount
1	Structural Concrete(210kg/sq.m)	4.672	cu.m	3775	17637
	Post (.25X.8X.25X2)	0.100			
	Railing (.3X1.78X4X.15)	0.320			
	Side Work (.71X.24x1.78 +.5X.71X.25X1.8)	0.463			
	Deck Slab (.25x3.5X1.78)	1.558			
	Main Girder(.55X1X1.78X2)	1.958			
	X-girder(2.4X.65X3.5X2X.25)	0.273			
2	Reinforcement Bars	1.006	tonne	25850	26000
	Post (6 %)	0.006			
	Railing (6 %)	0.019			
	Side Work (1 %)	0.005			
	Deck Slab (2 %)	0.031			
	Main Girder(3.33 %)	0.065			
	X-girder (1.5 %)	0.004			
3	Wearing Course			L.S.	1000
4	Jointing			L.S.	500
5	Extra Shuttering Cost			L.S.	500
6	Miscellaneous & unforeseen items			L.S.	5000
			Total Amount		50636
			Rate per m length		28447

Rate per m length (say) 30,000

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272

(A2) Analysis of Deck Slab (Alternate II)

Length = 1.78m (Railing to Railing)

Sl No	Description	Quantity	Unit	Rate	Amount
1	Structural Concrete(210kg/sq.m)	7.403	cu.m	3775	27946
	Post (.25X.8X.25X2)	0.100			
	Railing (.3X1.78X4X.15)	0.320			
	Side Work (.71X.24x1.78 +.5X.71X.25X1.8)	0.463			
	Deck Slab (.25x6.7X1.78)	2.982			
	Main Girder(.5X.85X1.78X4)	3.026			
	X-girder(4.5X.65X.35X2X.25)	0.512			
2	Reinforcement Bars	1.528	tonne	25850	39494
	Post (6 %)	0.006			
	Railing (6 %)	0.019			
	Side Work (1 %)	0.005			
	Deck Slab (2 %)	0.060			
	Main Girder(3 .33 %)	0.101			
	X-girder(1.5 %)	0.008			
3	Wearing Course			L.S.	2000
4	Jointing			L.S.	1000
5	Extra Shuttering Cost			L.S.	1000
6	Miscellaneous & unforeseen items			L.S.	2000
			Total Amount		73440
			Rate per m length		41258
			Rate per m length (say)		**40000**

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(B1) Analysis of Middle Support(Pier)
(Alternate I)

Sl No	Description	Quantity	Unit	Rate	Amount
1	Structural Concrete(210 kg/sq.m)	39.693	cu.m	3775	149841.83
	Pier Cap : .4X4+(4+2)X.5X.8	4.000			
	Pier : 3.14X.8^2*9X2X.25	9.043			
	Pile Cap : 3.5X3.5X1.0	12.250			
	Pile : 9X.4X.4X10	14.400			
2	Reinforcement Bars	6.13	tonne	25850	158466.7416
	Pier Cap (1.5 %)	0.060			
	Pier (3.3 %)	0.298			
	Pile Cap (1.5 %)	0.184			
	Pile (1.75 %)	0.252			
2	Lean Concrete:3.5X3.5X.1	1.225	cu.m	2302	2819.95
3	Earth work in excavation	20.000	cu.m	41.5	830
4	Pile driving	90.000	m	300	27000
5	Pile shoe			L.S.	4000
6	Bearing pad			L.S.	9000
7	Miscellaneous & unforeseen items			L.S.	10000
		Total Amount			361958.5216

Total Amount 40,000 say

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(B2) Analysis of Middle Support(Pier)
(Alternate II)

Sl No	Description	Quantity	Unit	Rate
1	Structural Concrete(210 kg/sq.m)	69.790	cu.m	3775
	Pier Cap : .4X7.34+(7.34+5)X.5X.8	7.872		
	Pier : 3.14X.8^2*9X2X.25	9.043		
	Pile Cap : 3.5X7.2X1.1	28.875		
	Pile : 15X.4X.4X10	24.000		
2	Reinforcement Bars	9.80	tonne	25850
	Pier Cap (1.5 %)	0.118		
	Pier (3.3 %)	0.298		
	Pile Cap (1.5 %)	0.433		
	Pile (1.75 %)	0.420		
2	Lean Concrete:3.5X7.5X.1	2.625	cu.m	2302
3	Earth work in excavation	40.000	cu.m	41.5
4	Pile driving	150.000	m	300
5	Pile shoe			L.S.
6	Bearing pad			L.S.
7	Miscellaneous & unforeseen items			L.S.

Total Amount

Total Amount 65,000 say

(C1) Analysis of Abutment (Alternate I)

Sl No	Description	Quantity	Unit	Rate	Amount
1	Structural Concrete(210 kg/sq.m)	36.682	cu.m	3775	138474.0135
	Pier cap : .4X4+(4+2)X.8X.5	4.000			
	Pier : 3.14X.8^2/4X6X2	6.032			
	Pile Cap : 3.5X3.5X1	12.250			
	Pile : 9X.4X.4X10	14.400			
2	Reinforcing Bars	5.363	tonne	25850	138637.9785
	Pier cap (1.5 %)	0.060			
	Pier (3.3 %)	0.199			
	Pile Cap (1.5 %)	0.184			
	Pile (1.75)	0.252			
3	Lean Concrete :3.5X3.5X.1	1.225		2302	2819.95
4	Earth work in Excavation	20		41.5	830
5	Pile Driving 9 no	90	m	300	27000
5	Pile Shoe			L.S.	4000
6	Bearing Pad			L.S.	9000
7	Earth work in approach:48X50/2	1200		41	49200
8	Miscellaneous & unforeseen items			L.S.	10000
		Total			379962

Total cost 400000 say

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(C2) Analysis of Abutment (Alternate II)

Sl No	Description	Quantity	Unit	Rate	Amount
1	Structural Concrete(210 kg/sq.m)	51.775	cu.m	3775	195449.7868
	Pier cap : .4X7.5+(7.5+5)X.8X.5	8.000			
	Pier : 3.14X1^2/4X6X2	9.425			
	Pile Cap :7.34X2.5X1	18.350			
	Pile : 10X.4X.4X10	16.000			
2	Reinforcing Bars	7.613	tonne	25850	196796.0542
	Pier cap (1.5 %)	0.120			
	Pier (3.3 %)	0.311			
	Pile Cap (1.5 %)	0.275			
	Pile (1.75)	0.280			
3	Lean Concrete :7.34X2.5X1	1.835		2302	4224.17
4	Earth work in Excavation	40		41.5	1660
5	Pile Shoe			L.S.	5000
6	Pile Driving 10 no	100	m	300	30000
7	Bearing Pad			L.S.	9000
8	Earth work in approach:64X50/2	1600		41	65600
9	Miscellaneous & unforeseen items			L.S.	20000
		Total			527730

Total cost 550000 say

(D) Analysis of Trussed Pier at Gagirhat(5m span length measured)

Sl No	Description	Quantity	Unit	Rate	Amount
1	Structural Concrete(210 kg/sq.m)	4.31	cu.m	3775	16279.6875

	Vertical Member :13.5X4X.25X.25	3.375			
	Horizontal member: 5X3X.25X.25	0.938			
2	Reinforcement bars	0.58	tonne	25850	15058.74382
3	Pile driving :4X4.5m	18	m	300	5400
4	Earth excavation in approach road			L.S.	25000
5	Miscellaneous & unforeseen items			L.S.	7000
			Total		68738.43132
			Total 70,000 say		
6	Construction Cost of Wooden deck slab		m	10000	

(E) Scour Protection Work

Sl No	Bridge	No of Piers	Breadth (m)/pier	Length (m)	Area (sq.m)
1	Kendrabag	3	9	15	405
2	Bangla Bazar	2	9	15	270
3	Halanbari	1	9	15	135
4	Chandraganj(R&H)	2	10	21	420
5	Chandraganj(DANIDA)	5	9	15	675
6	Sherpur	2	9	15	270
7	Hadarghat	2	9	15	270
8	Mandari Bazar	2	9	15	270
9	At 23+350 on Rahmatkhali khal	3	8	15	360
10	Jokshim (New)	2	9	15	270
11	Madari	2	9	21	378
12	Lakshimpur	2	9	18	324
13	Ayubali	5	10	16	800
14	Dighali	4	9	15	540
			Total Area (sq.m)		5387

(F) Propping the existing deck slab and demolishing abutment

Sl No	Description	Quantity	Unit	Rate	Amount
1	Structural concrete	5.76	cu.m	3775	21744
	Pile:4X15	60	m	2000	120000
	Beam:8X2X.6X.6	5.76			
2	Reinforcement bars	2.46	tonne	25850	63587.02556
	Pile (2.5 %)	2.34			
	Beam(2.0%)	0.12			
3	Demolishing and cleaning of abutment	40	cu.m	500	20000
4	Excavation & others			L.S.	10000
5	Miscellaneous items			L.S.	12000
			Total amount		247331.0255

Total 250000 say

(G) Propping the existing deck slab and demolishing the pier

Sl No	Description	Quantity	Unit	Rate	Amount
1	Propping	17.5	sq.m	500	8750
2	Demolishing RCC work	20	cu.m	400	8000
3	Cleaning & Excavation			L.S.	3000
			Total Amount		19750

Total 20000 say

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APPENDIX I.XIV

PROPOSED ADDITIONAL SURVEYS AND INVESTIGATIONS

APPENDIX I.XIV

ADDITIONAL SURVEYS AND INVESTIGATIONS

1 General

A number of additional surveys and investigations are required before detailed design and implementation can proceed, as identified in Chapter I.5 of this annex. Engineering aspects only are covered here; fisheries and environmental surveys are discussed in Annexes F and H.

2 Detailed Topographic Surveys

A longitudinal survey, with bed levels at 100 metre intervals and associated cross sections at 200 metre intervals should be taken along all the khals proposed for excavation. The total length is approximately 190 km. The sections would be used for refining the SERM as well as a "before project" measurement for design and estimation of quantities.

3 Cadastral Mapping

Accurate cadastral maps are required for identification of land-holdings, their ownership and occupation, leading to detailed recommendations and schedules for a land compensation/resettlement plan. Particular attention should be paid to Rahmatkhali and WAPDA Khals, especially at the proposed loop cuts (see Figures I.4.8, I.4.9 and I.4.10).

4 Geotechnical Surveys

(a) Structure Sites

At least three subsoil boreholes should be taken at each new structure site (Rahmatkhali Regulator and Noakhali Regulator). The depths of the boreholes should be approximately 20 metres.

The field work should include the following:

- disturbed and undisturbed soil samples,
- Standard Penetration Tests,
- determination of water table level, and
- determination of natural ground level at borehole location.

281

The laboratory tests should include the following:

- determination of natural moisture content,
- determination of unit weight and specific gravity,
- particle size analysis,
- unconfined compression tests,
- Atterberg Limits,
- consolidation tests, and
- direct shear tests.

(b) Shallow Borehole Investigations

Further shallow borehole investigations are required along all the khals designated for excavation, similar to those already performed as discussed in Section I.1.5 and Appendix I.VII, but without the chemical and salinity analyses. The objective is to identify those reaches where the excavated material will be too sandy for spreading on agricultural land without first stripping the topsoil and afterwards replacing it (see Section 1.4.9(b)). Boreholes should extend to just below the design bed level, as indicated in the longitudinal profiles presented in Appendix I.XII. It is suggested that the existing boreholes should be supplemented initially to achieve a spacing of 5 km along each khal. Additional boreholes should then be made, following analysis of the results of the first tests, to pinpoint more precisely the transitions from one soil type to another.

(c) Foundation Survey of Existing Bridges

Surveys are required of the foundations of all bridges across khals which are designated for excavation. Measurements are needed of the top elevations of all pile caps/pad footings and the spacing between them across the channel. Confirmation should also be sought as to whether piles are of timber or concrete, and what is their depth. However this can probably only be done by local enquiry rather than physical investigation.