Government of the People's Republic of Bangladesh
Bangladesh Water Development Board
Flood Plan Coordination Organisation

FLOOD ACTION PLAN

NORTHEAST REGIONAL WATER MANAGEMENT PROJECT (FAP 6)

NARSINGDI DISTRICT DEVELOPMENT PROJECT

PRE-FEASIBILITY STUDY

Draft Final
January 1994

Shawinigan Lavalin (1991) Inc.
Northwest Hydraulic Consultants

in association with

Engineering and Planning Consultants Ltd.
Bangladesh Engineering and Technological Services
Institute For Development Education and Action
Nature Conservation Movement

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ACRONYMS AND ABBREVIATIONS

BANBEIS	Bangladesh Bureau of Educational Information and Statistics
BBS	Bangladesh Bureau of Statistics
BIWTA	Bangladesh Inland Water Transport Agency
BFRSS	Bangladesh Fisheries Resource System Survey
BRDB	Bangladesh Rural Development Board
BWDB	Bangladesh Water Development Board
DAE	Department of Agricultural Extension
DPHE	Department of Public Health Engineering
DTW	deep tube well
EIA	environmental impact assessment
EIRR	economic internal rate of return
EMP	Environmental Management Plan
EPWAPDA	East Pakistan Water and Power Development Agency
FAP	Flood Action Plan
FFW	Food for Work
FPCO	Flood Plan Coordination Organization
FW	future with project scenario
FWO	future without project scenario
HTW	hand tube well
HYV	high yielding variety
IBRD	International Bank for Reconstruction and Development
IEE	Initial Environmental Evaluation
ISPAN	Irrigation Support Project Asia Near East
LLP	low-lift pump
LT	local transplanted
MPO	Master Planning Organization
NERP	Northeast Regional Water Management Project
NGO	non-governmental organization
NHC	Northwest Hydraulic Consultants
NPV	net present value
PD	person-day
PWD	Public Works Department
RCC	reinforced concrete
SLI	SNC-Lavalin International
STW	shallow tube well
WASA	Water and Sewerage Authority

US $1 = Tk 38

EXECUTIVE SUMMARY

The purpose of the project is to protect crops from pre-monsoon and monsoon flood damage, to protect roads and homesteads from river flooding, to prevent overland flooding of existing projects within the project area during the monsoon season, and to enhance the supply of irrigation water, and expansion of open-water fisheries by re-excavation of silted-up channels.

The project area is bordered by the Old Brahmaputra River to the north, Lakhya River to the west, Meghna River to the east, and the Kaliganj-Narsingdi railway line to the south. The project is affected by flooding when the Old Brahmaputra River, flowing from the north, spills its banks. The flooding situation has been further aggravated by a locally built closure on the Old Brahmaputra downstream of its confluence with the Arial Khan, near Katiadi thana. This has resulted in most drainage being affected through the Arial Khan which has infilled with sediment and thus does not provide adequate drainage. The Arial Khan also regularly spills its banks. The Binabaid area is the most affected.

To improve the flood regime it is proposed that 54 kilometres of embankments be built along the Old Brahmaputra and the Arial Khan Rivers. Drainage would be improved by re-excavating about 90 kilometres of drainage channels including the Arial Khan, Paharia-Kharia Nadi, Old Lakhya River, and lateral channels. Two regulators are proposed for the Binabaid area for flushing and drainage. One flushing sluice is proposed at the offtake of the Old Lakhya River for supplemental irrigation during the monsoon season.

The project would be implemented by the BWDB. The estimated cost of the project is about US$3.7 million

NERP DOCUMENTS

The Northeast Regional Water Management Plan is comprised of various documents prepared by the NERP study team including specialist studies, the outcome of a series of public seminars held in the region, and pre-feasibility studies of the various initiatives. A complete set of the Northeast Regional Water Management Plan Documents consists of the following:

Northeast Regional Water Management Plan

- Main Report
- Appendix: Initial Environmental Evaluation

Specialist Studies

- Participatory Development and the Role of NGOs
- Population Characteristics and the State of Human Development
- Fisheries Specialist Study
- Wetland Resources Specialist Study
- Agriculture in the Northeast Region
- Ground Water Resources of the Northeast Region
- Surface Water Resources of the Northeast Region
- Regional Water Resources Development Status
- River Sedimentation and Morphology
- Study on Urbanization in the Northeast Region
- Local Initiatives and People's Participation in the Management of Water Resources
- Water Transport Study

Public Participation Documentation

- Proceedings of the Moulvibazar Seminar
- Proceedings of the Sylhet Seminar
- Proceedings of the Sunamganj Seminar
- Proceedings of the Sherpur Seminar
- Proceedings of the Kishoreganj Seminar
- Proceedings of the Narsingdi Seminar
- Proceedings of the Habiganj Seminar
- Proceedings of the Netrokona Seminar
- Proceedings of the Sylhet Fisheries Seminar

Pre-feasibility Studies

- Jadukata/Rakti River Improvement Project
- Baulai River Improvement Project
- Mrigi River Drainage Improvement Project
- Kalni-Kushiyara River Improvement Project
- Fisheries Management Programme
- Fisheries Engineering Measures
- Environmental Management, Research, and Education Project (EMREP)
- Habiganj-Khowai Area Development
- Development of Rural Settlements
- Pond Aquaculture
- Applied Research for Improved Farming Systems
- Manu River Improvement Project
- Narayanganj-Narsingdi Project
- ***Narsingdi District Development Project***
- Upper Kangsha River Basin Development
- Upper Surma-Kushiyara Project
- Surma Right Bank Project
- Kushiyara-Bijna Inter-Basin Development
- Dharmapasha-Rui Beel Project
- Updakhali River Project
- Sarigoyain-Piyain Basin Development

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1. INTRODUCTION

1.1 General Information

BWDB Division:	Dhaka
District:	Narsingdi
Thanas:	Narsingdi, Palash, Raipura, Shibpur, Belabo, Monohardi, Bhairab, Kapasia, Katiadi, Kuliarchar, and Bajitpur
MPO Planning Areas:	18, 20, and 30
Gross Area:	99,600 ha
Net Area:	74,800 ha

1.2 Scope and Methodology

This is a pre-feasibility study that was undertaken intermittently over a period of five months in 1993. The study team consisted of a water resources engineer, a socio-economist, an agronomist, a fisheries specialist, and a wetland resources specialist. Additional analytical support was provided by an environmental specialist and an economist.

1.3 Data Base

The project analyses presented in this report were carried out using mainly secondary data sources, and information obtained during field inspections and personal interviews.

The information and data sources used in different specialist analyses are listed below:

Engineering analysis: Existing topographic maps and MPO developed one square kilometre grid, historic climatological and hydrological records, river and khal cross-sections surveyed by BWDB Morphology Directorate and SWMC, BWDB reports, MPO reports, personal field observations and interviews with beneficiaries, recommendations by BWDB officials and local representatives.

Agricultural analysis: Data published in Land Resources Appraisal for Agricultural Development in Bangladesh (AEZ Reports) for soils and Water Resources Planning Organization (WARPO) for agricultural inputs, interviews with individuals and groups of farmers in different areas and on each land type, and hydrological data developed by the hydrology and engineering sections of the NERP.

Fisheries analysis: Topographic maps, BFRSS data, CIDA Inception Report, NERP Fisheries Specialist Study, field observations and local interviews, information provided by local representatives during field seminars held at Sylhet in June, 1992 and at Narsingdi in April, 1993.

Wetland analysis: Topographic maps, local revenue department records, personal field observations and interviews with local people, CIDA Inception Report (1990).

Socio-economic analysis: Published BBS data on demographic features, education and agriculture; reports of the Directorate of Public Health and Engineering, and NERP data base on Population and Human Development, personal field observations and field interviews with various cross-sections of local people, opinion and suggestions from local representatives including NGO personnel and the Honourable Members of Parliament.

1.4 Report Layout

A description of the biophysical features of the project area is provided in Chapter 2. Chapter 3 describes the current status of development and resource management including a summary of the types of problems faced by people living in the area. Chapter 4 briefly reviews previous studies of the area and Chapter 5 lists trends which are occurring and which will continue if no interventions are made. Chapter 6 reviews water resource development options which were considered and Chapter 7 provides an analysis of the best option. The annexes consist of detailed information to support the main body of the report.

2. BIOPHYSICAL DESCRIPTION

2.1 Location

The Narsingdi district Development Project covers a gross area of 99,600 ha in the north and northwest of Narsingdi district, between latitude 24° 15' and 23° 54' N, and longitude 91° 0' and 90° 30' E. The project area is bounded by the Old Brahmaputra River in the north, Lakhya River in the west, Meghna River in the east, and the Kaliganj-Narsingdi railway line in the south (Figure 1).

2.2 Climate

The climate of the project area is monsoon tropical with hot wet summers and cool dry winters. The highest temperature in the area was recorded at 37 C in April and the lowest at 8.8 C in January. The lowest monthly temperature is in January when the mean is 19.1 C, and the highest monthly temperature is in April, when the mean is 28.9 C. The climate of the area is based on data from Bangladesh Meteorological Department (BMD) and is summarized in Table A.1.

Rainfall distribution shows a general pattern of gradual increase from south to north. Average annual rainfall in the area ranges from about 2300 mm in the north near Toke to about 2000 mm in the south near Narsingdi (Figure 2). Mean monthly rainfall varies from 8 mm in January to 395 mm in June, and mean annual rainfall is 2074 mm. Potential evapotranspiration is lowest in December at 100 mm/month and highest in April at 188 mm/month.

2.3 Land (Physiography)

2.3.1 General Description

The Narsingdi district in general is lowland floodplains of the Meghna and Old Brahmaputra Rivers with some scattered terraces which are an extension of the Madhupur Tracts from the north. The terraces are mainly in two areas: 1) the northwestern part of the area close to the Old Brahmaputra and Lakhya confluence and 2) the central area around the Arial Khan-Paharia River. About 88% (85,000 ha) of the project area has elevations between 3.5 and 9.0 m PWD. The terraces have high elevations of about 15 m PWD.

The land is undulating and generally slopes from north-east to south-west. Due to the severe siltation in the Old Brahmaputra, Arial Khan, and Paharia River channels drainage is impeded during the pre-monsoon and monsoon seasons.

The topography of the area is presented in Figure 3.

2.3.2 Soils

The project area is covered by an extension of the Madhupur Tract, the Old Brahmaputra floodplain, and the Young Brahmaputra floodplain.

The Madhupur Tract is a terrace which has been dissected by valleys of varying depths and includes a wide variety of soils. Extensive level terraces have deeply weathered soils which are red, brown or grey, friable, clay loams to clays. Deeply dissected terrace areas have broad, level uplands with deep red, friable, clay loams to clays. They stand three to six metres above broad, steep-sided valleys which are deeply flooded in the monsoon season. The valleys mainly have dark grey heavy clays, but light grey silty soils are found in a few areas. Closely dissected terrace areas have an undulating or rolling landscape broken by many shallow, narrow valleys which are mainly shallowly flooded in the monsoon season. The uplands have a variety of red, brown and grey soils in which there is heavy grey clay within 0.3 to 1.0 m of the ground surface. The valleys mainly have light grey silty soils; a few have dark grey clays.

The section of the Old Brahmaputra floodplain which covers the project area includes dark grey clays developed in basin sites. The top soil consists of about 15 cm of grey (dry) to dark grey (wet) silty clay loam to clay, iron stained along root channels and cracks. Below this there is about 0.3 m of dark grey, finely mottled yellow-brown, compact, silty clay to clay which cracks into blocks on drying. These blocks have dark grey coatings. Below about 0.5 m, this layer grades into a light grey, finely mottled yellow-brown, silt loam or silty clay loam with dark grey coatings penetrating deeply along vertical cracks.

Relief of the Young Brahmaputra floodplain is low and gentle comprised of a complex landscape of ridges, basins, and beels crossed by numerous rivers and abandoned channels. The young meander floodplain which covers the project area, is less irregular in relief than the active floodplain. Grey silty soils predominate on the ridges and grey clays predominate in the basins. The cultivated topsoil consists of about 15 cm of light grey (dry) to olive-grey (wet) silt loam or fine sandy loam, iron stained along root channels. The subsoil consists of about 0.3 m or sometimes more of olive-grey, finely mottled brown or brownish yellow, very friable silt loam or occasionally, fine sandy loam. This overlies stratified alluvium, usually of similar texture to the subsoil.

2.4 Water (Hydrology)

2.4.1 Runoff Patterns

The major river systems which border the area are the Meghna River in the east and south, the Old Brahmaputra River in the north, and the Lakhya River in the west (Figure 1).

The Old Brahmaputra is a distributary of the Brahmaputra River. The Old Brahmaputra River originates just north of Bahadurabad and follows a east-southeasterly course to Mymensingh, after which it flows in a southeasterly direction to Toke. At Toke the Old Brahmaputra River bifurcates into the Lakhya and Old Brahmaputra Rivers. The Lakhya River flows to the Dhaleswari at Narayanganj and then flows to the Meghna River. Currently, the Lakhya River carries most of the flow from the upper reaches of the Old Brahmaputra River. At Katiadi the Old Brahmaputra bifurcates into the Arial Khan and Old Brahmaputra Rivers. The lower reach of the Old Brahmaputra flows to the Meghna River at Bhairab Bazar, while the Arial Khan flows to the Meghna around Narsingdi town.

The Old Brahmaputra River at Katiadi just below its confluence with the Arial Khan has been closed by local people. As a result flows are diverted through the Arial Khan River, except during the monsoon season.

The Meghna River is formed by the confluence of the Baulai and the Kushiyara Rivers at Dilalpur. From Dilalpur it follows a semi-circular course for 20 km to Bhairab Bazar where the flow is mostly confined within the river channel. During the pre-monsoon and monsoon seasons, the peak river flows spill over into the project area.

Discharges of the Old Brahmaputra River are measured by BWDB at one location: Nilukhirchar (#228.5), downstream of Mymensingh town. Discharges of the Lakhya are measured at Demra, but no complete years of records are available. The Meghna River discharges are measured at Bhairab Bazar.

The daily discharges of the major rivers show wide fluctuation (Table 2.1). The daily discharge for the Meghna at Bhairab Bazar varies from about 2 m^3/sec to 19,800 m^3/sec, while the Old Brahmaputra River at Nilukhirchar varies from about 6 m^3/sec to 4,890 m^3/sec. Flood discharges and water levels for the pre- and monsoon seasons for the Old Brahmaputra, Lakhya, and Meghna Rivers are presented in Tables A.2 and A.3. Mean monthly discharges and water levels are presented in Tables A.4 and A.5.

2.4.2 Flooding

The project area experiences mainly seasonal monsoon floods from June to October. These floods damage aus and aman crops. Pre-monsoon crops are damaged by accumulated rainfall runoff from the surrounding high lands as there is inadequate drainage. Reportedly pre-monsoon peak water levels have increased in recent years and this has caused further crop damage particularly in the area north of the project.

Excluding the area covered by existing projects, there are three unprotected units in Narsingdi district (Figure 4). These unprotected units are mainly flooded by over bank spills from the Old Brahmaputra (from the north, particularly in the reach between Toke and Katiadi). The amounts of over bank spill have increased due to severe siltation of the Old Brahmaputra channel and closing of the Old Brahmaputra at Katiadi. These unprotected units are also flooded due to the back water effects of the Meghna, through the Paharia-Kharia Khal and Arial Khan from the south, and by the Lakhya River through the Old Lakhya River. The Binabaid unit is the most severely flooded, by over bank spills of the Old Brahmaputra and Arial Khan Rivers (Figure 4).

Peak monsoon water levels at six gauging stations in the area are given in Table A.3. Water levels at Katiadi and Binabaid have been interpolated and are based on levels taken at Motkhola and Bhairab Bazar gauging stations. Average water levels in the three unprotected units are presented in Table 2.2.

During the monsoon season about 16,400 ha (33% of the gross area) are inundated by average floods (1:2 year return period). Larger areas are inundated for higher return periods; about 18,800 ha for the 1:5 year flood, and about 23,000 ha for the 1:10 year flood (Table 2.3)

Table 2.1: Recorded Mean Daily Discharges in m^3/sec

River	Station	Range of Daily Discharge			Period (Years)
		Minimum	Mean	Maximum	
Meghna	Bhairab Bazar	2	4815	19800	21
Old Brahmaputra	Nilukhirchar	6	698	4890	25
Lakhya	Demra	NA	NA	2610	17

Source: NERP

Table 2.2: Peak Water Levels (m,PWD)

Units	Flood Condition	Return periods			
		1:2	1:5	1:10	1:20
Old Lakhya	Monsoon	7.66	8.04	8.27	8.47
Binabaid		7.61	8.10	8.35	8.57
Shibpur Area		5.88	6.26	6.48	6.68

Source: NERP

Table 2.3: Flooded Areas

Flood Condition	Return Period	Non Flooded	Flooded Area (ha)			
		< 0.3 m	0.3 to 0.9 m	0.9 to 1.8 m	> 1.8 m	TOTAL
Monsoon	1:2	34179	9900	3950	2550	16400
	1:5	31779	9000	6000	3800	18800
	1:10	27579	11610	6490	4900	23000

Source: NERP

Depth of flooding is more acute in the Binabaid Unit where about 80% of the gross area (3980 ha) is inundated by average floods (1:2 year return period). About 1200 ha (30%) is flooded to depths exceeding 1.8 m (Table A.6).

2.4.3 Drainage

The eastern half of the project area mainly drains to the Meghna River through the Arial Khan and Kharia-Paharia River systems. The western area drains to the Lakhya River at Lakhpur through the Old Lakhya River (Figure 1).

During the pre-monsoon season, water levels can rise rapidly on the farm lands due to local runoff from the surrounding high lands (locally called teks). This damages boro crops and prevents the cultivation of aus crops. During the monsoon season drainage is impeded by the high water levels in the Meghna and Lakhya Rivers. Over bank spill from the Old Brahmaputra and Arial Khan Rivers aggravates the situation. Local people reported that the majority of the Old Brahmaputra discharge is currently flowing through the Arial Khan River due to the construction of a closure dam across the Old Brahmaputra River near Katiadi. As a result, the rates of over bank spill in the upstream sections of the Old Brahmaputra River have increased.

Siltation has taken place in many of the drainage channels in the project area and at some locations boro crops are grown in the channel beds. This further impedes drainage and has increased the depth and duration of pre-monsoon and monsoon flooding.

During field visits, local people requested that all the major drainage channels be re-excavated. These requests were reiterated at the Narsingdi seminar.

2.4.4 Water Bodies

Open water bodies
About 32% (16,400 ha) of the project area is seasonally inundated to depths greater than 0.3 m, of which about 1.3% (187 ha) is perennial beels. The larger permanent water bodies are: Simulia Beel, Charnilokhi Beel, Kuthir Beel, Badar Beel, and Sonarchand Beel (Table A.7).

Closed water bodies
In addition to the open beels and khals there are about 3835 ponds which are used for fish trapping, bathing, washing, and so on. The ponds have a total area of about 484 ha (Table A.7).

2.4.5 Surface Water Availability

Surface water availability for irrigation (80% dependable low flow) for the months of January, February, and March is presented in Table 2.4. Available flow for the Meghna River at Bhairab Bazar for the critical month of February is about 108 m^3/sec. In Lakhya, the critical month is March which has a flow of about 12 m^3/sec at Nilukhirchar (Nilukhirchar is located about 78 km upstream of the northwest corner of the project area).

There is a substantial volume of surface water in the Meghna River during the critical months but large scale irrigation use in the project area appears limited and not economic. This is because the thalweg of the river generally remains far away from the project's cultivable lands,

Table 2.4: Surface Water Availability

River	Location	Decade	Low flow, 80% dependable (m3/sec)		
			January	February	March
Meghna	Bhaira Bazar	I	268.88	141.78	179.79
		II	164.97	110.89	236.92
		III	124.52	107.89	258.58
Lakhya	NilukhirCha r	I	24.44	17.45	12.40
		II	22.05	15.51	11.68
		III	19.92	13.78	11.22

Note: Decade-10 day period.
Source: NERP

and the Meghna River bank is mostly unstable making structure costs expensive. For small scale irrigation use, some LLPs are currently used in the winter months along the river bank where water is available within pump suction limits. This practice is expected to continue and may expand further.

In Lakhya River, flow measurements are made at Demra during the monsoon season but not during the winter months. Recorded discharges of the Old Brahmaputra at Nilukhirchar (upstream of Lakhya) suggest that flow availability in the Lakhya River is not significant during the winter months. Reportedly the Lakhya River at its offtake (at Banar) almost dries up in the winter season. This suggests that any water resource development along the Lakhya River would have to rely on back flows from the Lower Meghna River. There are some LLPs along both banks of the Lakhya River where surface water is available within pump suction limits.

2.4.6 Ground Water

Based on MPO (WARPO) data the estimated usable ground water recharge within the project area is 265 Mm^3. Of this, about 223 Mm^3 is estimated as being accessible by DTW force mode technology. Ground water available by suction mode STW technologies is very small. About 47 Mm^3 could be withdrawn by DSSTW technologies (Table 2.5). The majority of the ground water resource potential is located in Shibpur, Monohardi, Belabo, and Raipura thanas (Table A.8).

2.5 Land/Water Interactions

2.5.1 Siltation

Sediment deposition has taken place in the lower reaches of the Old Brahmaputra River from its confluence with the Arial Khan to its outfall at Bhairab Bazar. The offtake of the Old Brahmaputra River at Bahadurabad has also been silted up and is now almost dry during the winter months.

Table 2.5: Estimated Ground Water Recharge

Mode	Usable Recharge (Mm^3)	Available Recharge (Mm^3)
STW	5.28	4.53
DSSTW	55.88	46.77
DTW	265.36	222.77

Source: MPO (WARPO)

Siltation has taken place in the channel bed of the Arial Khan River from its offtake with the Old Brahmaputra River to its outfall around Narsingdi. The offtake of Old Lakhya River at Motkhola and sections along the river channel have been silted up.

Siltation has occurred in various khals and beels in Monohardi, Belabo, Shibpur, and Raipura thanas. Siltation affects fishery resources and causes drainage congestion which has intensified flooding during both the pre-and monsoon seasons.

2.5.2 River Erosion

In the east part of the project the area is subjected to severe wave action and erosion by the Upper Meghna River. River bank erosion in the north and west parts of the area is not significant.

Embankments of the Kakon Nadi Project around Aligi-Bakernagar sluice (about seven kilometres in length) have almost completely been washed away by Upper Meghna wave action. The project was constructed between 1978-88 using FFW, WB, and CIDA support and funding. During discussions at the Narsingdi seminar and with BWDB officials, it appears that flood embankments along this reach can only be maintained if gabions or concrete protective works are installed (earthworks are too easily eroded).

In Bhairab Bazar town, two transmission towers and the railway bridge have been subjected to right bank erosion from the Upper Meghna. Deep scouring on the right bank of the Upper Meghna River upstream and downstream of the Bhairab Bazar railway bridge has resulted in steep, unstable underwater slopes. This railway bridge provides the only rail link across the Upper Meghna River to the Northeast Region. Bangladesh Railway have recently carried out limited protection works around the railway bridge piers but additional work is required.

2.5.3 Crop Damage

Crops are damaged by floods, drainage congestion, hailstorm, cyclones, pests, and so on. Field data was collected on crop damage due to floods and drainage congestion and this data was cross checked with the results obtained from hydrologic analysis.

Crops damaged in the area include high yielding varieties of boro rice in the reproductive phase and local varieties of broadcast aman in the early vegetative growth phase. The extent of damage depends on the growth stage of the crop and the duration of submergence. Often the boro crops are submerged when water levels rise rapidly without any warning. Farmers try to collect the partially matured panicles of high yielding varieties of boro rice from underneath the water but yield levels are low. Local varieties of broadcast aman seedlings are damaged when they are submerged before they acquire the ability to elongate with a gradual rise in flood levels.

Local and high yielding varieties of transplanted aman rice are damaged in the monsoon season by flooding and drainage congestion. Water levels in the Arial Khan River have risen due to the cross-dam at its confluence with the Old Brahmaputra River. Over bank spills enter the area and damage the crops. The damage takes place mostly at the vegetative growth stage and this hampers tillering and reduces yield levels.

2.6 Wetlands and Swamp Forest

2.6.1 Natural Wetlands

The project is located in a seasonally flooded area and most of the wetlands exhibit similar characteristics; they are flat and shallow and include very few perennial water bodies (See section 2.4.4). The wetlands of this area show similar ecological characteristics; all have a luxuriant growth of aquatic plants in the monsoon season especially when flood waters start to recede. The most common plants are Hydrilla verticillata, Vallisnaria spiralis, Aponogeton sp., Eichhornia crassipes, Sagittaria sagittifolia, Utricularia sp., Limnophila sp., Ottelia alismoides and some other grasses.

Due to their fragmented nature and high human interference, the presence of migratory waterfowls is very rare in these wetlands. Wildlife is scarce due to habitat degradation.

2.6.2 Swamp Forest Trees

There are no swamp forests in the project area, and even individual swamp forest plants are not common in the homestead areas.

3. SETTLEMENT, DEVELOPMENT, AND RESOURCE MANAGEMENT

3.1 Human Resources

3.1.1 Land Use and Settlement Pattern

Land Use
Current land use is summarized in Table 3.1.

Table 3.1: Current Land Use

Use	Area (ha)
Cultivated (F0+F1+F2+F3)	38058
Homesteads	3500
Beels	187
Ponds	484
Channels	1700
Hills	5000
Fallow[1]	600
Infrastructure[2]	1050

[1] Multi-use land, wetlands, grazing lands, village grounds. Includes F4 land.
[2] Government-owned land not appearing elsewhere.

General Description of Settlements
The Narsingdi district headquarters are situated within the project area. Narsingdi includes business complexes, mills, and factories. Settlements in the thanas of Shibpur, Belabo, and Roypura are constructed on hills. In other areas, settlements are constructed on road sides, river levees, and on lands close to agricultural fields. Settlements are also constructed on the char lands along the Meghna River in Roypura, Belabo, and Narsingdi thanas. Settlements along the roadside and river levees are dense. Settlements in the char lands are extremely sparse. Many homesteads in the project area, particularly on higher lands, are covered with trees (mango, lichies, jackfruit, lemon, guava, and so on).

Flood Damage to Housing
Most of the thana headquarters including Shibpur, Belabo, Monohordi, and Roypura, and the district headquarters of Narsingdi are generally not affected by floods. In the eastern part of the project area, many homesteads along the Meghna River in Roypura, Belabo, and Narsingdi thanas are affected by monsoon floods and are damaged by wave erosion. The homesteads in the charlands along the Meghna and the Arial Khan Rivers are also affected by monsoon flooding and wave erosion.

Coping Strategies
Homestead platforms located in lower lands, including char lands and along the river banks of the Meghna and Arial Khan Rivers, are raised by earthfill to about one meter or more above natural ground levels to avoid monsoon flooding. In the char lands, homesteads are protected against monsoon wave action. Protective measures include the construction of boundary walls using bamboo and locally available wetland grasses (pawra, water hyacinths, and so on). Some of the more well-off farmers have constructed concrete walls to protect their homesteads from wave erosion. Many of the protective measures taken along the Meghna River have not been effective.

Table 3.2: Population Distribution by Age Group (%)

Sex	Population Age Group (Years)						Total
	0-4	5-9	10-14	15-54	55-59	>60	
Male	16.2	15.4	13.1	46.8	2.2	6.3	100.0
Female	17.2	16.0	11.3	48.7	1.7	5.1	100.0
Total	16.7	15.7	12.2	47.8	1.9	5.7	100.0

Source: BBS, 1981 Population Census

During unusually high floods (as occurs in some years), the villagers make platforms inside their houses for living and shift their belongings to these higher platforms. Some family members may take their household assets and move to safer places in the neighbourhood (high ground) or to nearby cities. People sometimes live in country boats during times of high floods and use the boat to move their necessities. Mostly people in isolated villages in the lower lands do this.

3.1.2 Demographic Characteristics

The total population of the project area is estimated at 1,255,640 of whom 607,760 are female. The gender ratio is calculated to be 106.6 (males to 100 females). The total households are estimated to be 240,700 within 870 villages. The population increased by 24.3% between 1981 and 1991.

The cohort distribution for males is: 31.6% are below 10 years of age, 46.8% are between 15 and 54 years of age, and 6.3% are above 60 years of age. The corresponding distribution for females is 32.2%, 48.7%, and 5.1% (see Table 3.2).

The average population density is 1367 persons per km^2, with the density ranging from a maximum of 1980 persons per km^2 in Narsingdi Sadar thana to 1008 persons per km^2 in Kapasia thana. The average household size in the area is estimated to be 5.2 persons.

3.1.3 Quality of Life Indicators

Quality of life is usually determined by several key indicators. Those described here are literacy, access to health, sanitation, and pure drinking water facilities.

Literacy

The literacy rate in the project area is varied. According to the 1981 census, the literacy of the population at 5 years of age and above varied from 14.9% in Katiadi thana to 31.5% in Palash thana. The corresponding figures for females were 10.0% and 22.2% respectively for the same thanas. The rate appears to have increased during the last 10 years. According to the 1991 census, the literacy rate for all people of Narsingdi district is recorded as 23.1% for both male and female.

According to the 1981 census, school attendance in the project area for all children five to nine years of age varies from 16.1% in Raipura thana to 31.9% in Palash thana. Attendance for females in this age cohort in these two thanas varies from 13.8% to 29.2% respectively. Attendance for all youths between the ages of five and 24 is 16.1% and 26.8% for these thanas while the corresponding attendance for females is 11.7% and 23.0%.

The situation is worse for the rural poor. They can not afford to send their children to school. Moreover, many villages, especially in Katiadi, Kuliarchar, Roypura and Bhairab Bazar thanas, have no primary schools. The school attendance rate of children was also reported to be poor in rural areas. The average number of primary schools per 10,000 population is estimated to be 3.7 for Narsingdi district, while for Kishoreganj district it is 4.1 (BANBEIS, 1990).

Access to Health Services
The district headquarters of Narsingdi, Gazipur, and Kishoreganj each have hospital facilities. Similarly, all thanas have hospital facilities located at their headquarters. Moreover, some richer people in the project area use the hospital/treatment facilities in Dhaka city. Access to health services is generally limited for rural villagers and is out of reach of the poor. According to the Directorate General of Health Services (1992), there is one hospital for every 284,727 persons and one doctor for every 41,667 persons in the district of Narsingdi. The situation is similar for Gazipur district. In Kishoreganj district there is one hospital for 174,712 persons and one doctor for every 22,267 persons. One hospital bed is meant for 11,947 people in Narsingdi district, 5,809 people in Kishoreganj district, and for 9,790 people in Gazipur district. Immunization coverage of children below two years of age is low for the project area. The rate varies from 12% in Kapasia thana to 39% in Bhairab thana (1990).

Rural Water Supply
Detailed information on access to rural water supply for drinking purposes is not available for the project area. However, for the rural areas of the district of Narsingdi, DPHE[1] reports the availability of one working tube well for 124 persons. For Gazipur and Kishoreganj districts, these figures are 135 and 122 respectively. In 1990, 96% of the households had reportedly access to potable water in the district of Narsingdi. For the other two districts of the project area, 90% had access. It is noted that most tube wells are located in the houses of the rich. This results in the poor having limited access to potable water.

Sanitation
Specific information on sanitation facilities are not available at the project level. During field reconnaissance, it was noted that open space defecation is a common practice in the rural villages and in char areas, particularly for males. Women generally use kutcha latrines or defecate at a fixed spot which is protected by bamboo mats or banana leaves. During monsoon months, the people in the char and low-lying areas generally defecate in running water. Sanitary latrines are uncommon in the village environment, except for the very well-off and educated families.

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[1] DPHE, 1991-92

3.1.4 Employment and Wage Rates

Village employment opportunities are generally limited to agricultural activities. The major crop in the area is HYV boro and t aman. Employment for men mainly consists of transplanting which occurs between July and August and harvesting which occurs in late November and December for t aman. Employment for HYV boro cultivation takes place in January-February for transplanting and in May-June for harvesting .

The wage rate for male agricultural labourers varies from Tk 30 to 50 with three meals per day during peak agricultural months. During months when there is little agriculture work, wages vary from Tk 25 to 35. During the monsoon months there is little employment opportunity for the poor of the char and low-lying areas of Narsingdi and Kishoreganj districts as they mainly depend on agricultural wage labour. It is reported that there are year-round employment opportunities in the weaving factories, especially in Narsingdi, Araihazar, Raipura, and Sonargaon thanas. Most of them work on a contract basis and earn a daily income which varies from Tk 40 to Tk 60 for men. Women also work at the weaving factories and earn about Tk 50 to Tk 100 per week. Generally they work during their slack periods after doing their household activities.

Employment for the poor in vegetable cultivation is common in the area, especially in Raipura, Belabo, and Shibpur thanas. Reportedly many women carry out this work in these thanas. The average daily income for men varies from Tk 30 to Tk 50 with three meals per day, while for women the rate varies from Tk 20 to Tk 25 without meals.

During the months when employment opportunities are limited, some poor people migrate to the district headquarters within the project area and to Dhaka city to work as rickshaw pullers, construction workers, or sometimes in household activities. Some of them are employed in the mills and factories, especially in Narsingdi and Palash thanas. A few poor women are employed for the Rural Maintenance Program of CARE.

There is migration into the project area, mainly from Mymensingh, Kishoreganj, and Comilla districts. They come to the project area and stay seasonally to work mainly on cultivation and harvesting of rice crops. The agricultural activities in areas such as Shibpur, Roypura, and Belabo are mainly performed by outside labourers.

3.1.5 Land Ownership Pattern

Nearly 48.0% of the households are landless (with cultivable land less than 0.2 ha). Among the landless, about 1.7% have no homesteads of their own. Among the others, the small (0.21 -1.00 ha), medium (1.01 - 3.00 ha) and large farmers (more than 3.00 ha) are 37.4%, 13.4%, and 1.4%, respectively.

Most of the land in the project area is available for cultivation. Land not available includes deeper wetlands and charlands. The higher lands are mainly under fruit trees and vegetable cultivation. The price of agricultural land varies from Tk 10,000 to Tk 100,000 per bigha (0.12 ha) depending on the demand and quality of the land, and the intensity with which it can be cropped.

3.1.6 Land Tenure

Owner operation is a common practice for rural farmers in the area. The large land owners generally share out part or all of their lands to tenants for operation. The share cropping systems in the area are: (1) when the land owner provides no inputs, one-third of the produce is retained by the land owner, and (2) when the land owner provides one-half of the input costs, then one-half of the produce is retained by the land owner. The leasing out of land with advance cash payment (pattani) is practised in some areas, the usual rate varying from Tk 500 to Tk 1200 per bigha (0.12 ha), paid in advance to the land owner for one crop season. For vegetable cultivation the rate is up to Tk. 2,000 - 2,500 per bigha for one year.

3.1.7 Fishermen

Fishing is an important activity in the project area, particularly in Kuliar char, Bhairab thana, Roypura thana, and in villages along the Meghna and Arial Khan Rivers. Competition over fish resources is increasing every year. There are two types of fishermen who catch fish for income: traditional and non-traditional. For traditional fishermen, fishing is their livelihood and they have been engaged in the profession for generations. Some of them also work as fishing labourers. There are an estimated 2,000 to 3,000 traditional fisherman households in the project area. Additional information on fishing practices is given in Section 3.5.1.

The non-traditional fishermen generally catch fish for their own consumption. Among them, the poor sell part of their catch to earn an income, especially during the monsoon lean months, when there is less scope for agricultural employment. This occurs mainly in the lowlands and in char areas.

3.1.8 Situation of Women

Women's role in agricultural production is important, especially in post-harvest activities. Women's contribution, however, tends to be devalued and under-reported. Though women generally do not work in the field, some poor women are reported to be working outside their homes, mainly for the Road Maintenance Program of CARE and in activities like vegetable cultivation and fuel collection. A significant number of poor women, especially from Roypura, Narsingdi, and Belabo thanas work in the weaving factories. Women sometimes grow winter vegetables in nearby fields. Village women generally work in the post-harvesting activities of rice crops, especially drying, winnowing, par-boiling, and storing of rice. Most women have homestead gardens and raise chickens or ducks.

3.1.9 People's Perception

General
Local people's perception of their problems were solicited. These were related mainly to water and its impact on their livelihood and their suggestions as to the nature of interventions which could solve these problems. These were collected through personal interviews, group discussions, and meetings with various cross-sections of people during the relatively short field work in the project area. Also, opinions and suggestions were sought at two seminars which were held in Narsingdi and Kishoreganj towns. Participants at the seminars included the Honourable Members of Parliament, District and Thana level officials, Union Parishad

Chairman, representatives from village level organizations, and NGOs. The problems and suggestions are described below.

Problems

Flooding is described as the major problem of the area. When there are pre-monsoon floods in the greater Sylhet district, the agricultural fields in Belabo, Roypura, and Narsingdi thanas are affected and crops are damaged. The damage is severe in many places such as Binabaid, Char Lakshmipur, Musapur, Begumabad union of Belabo, and Roypura thana. During monsoon months, the flood waters overspill the banks of the Old Brahmaputra, Arial Khan and Meghna Rivers and cause damage to rice crops, particularly in Monohardi, Belabo, Roypura and Narsingdi thanas. These monsoon flood waters mainly damage aus and aman crops (both b.aman and t.aman). The situation is aggravated when water hyacinths accompany the flood water. Reportedly water hyacinths cause extensive damage to aman and aus crops.

Flooding is aggravated by back flows from the Meghna River through the Old Lakhya, Haridhoa, and Paharia-Kharia Rivers. Aus and aman crops are severely damaged in Kapasia, Palash, and Shibpur thanas. Aus and the seed beds of t aman are also damaged in these areas by early monsoon floods, while t aman is damaged between July and September by monsoon floods which overspill the banks of the above mentioned rivers and their tributaries. The siltation in the Arial Khan River, Old Brahmaputra River and some internal rivers has aggravated flood problems.

Lack of irrigation water for HYV boro is a problem in the dry season in many areas including Fulbaria of Polash thana, Gouripur of Belabo thana, and so on.

Drainage congestion causes boro crop damage in many areas including Lachir char village, Paturia village, and Darbesh Kanda in Monohordi thana.

Wave erosion damages homesteads along the Meghna River and in the char lands in Belabo, Roypura and Narsingdi thanas. Many villages were reportedly washed away and others have experienced severe damage.

Poor fishermen expressed their concerns about the leasing system. Leaseholders influence the jalmahal bids. In the name of Nitimala fishing, the influential fishermen group members especially the chairman and secretary of the societies reportedly exploit the poorer members by not allowing them to fish in the jalmahals. The fishermen complain about the reduction in fish production due to sediment deposition in rivers and beels. They also stated that roads, embankments, and the closing of rivers/khals has obstructed fish migration, and thus reduced fish production. Of particular concern were the obstructions to fish migration from the Meghna River caused by the silting up of sections of rivers, including the Old Brahmaputra, the Arial Khan, and Kharia Rivers. Industrial pollution is a problem for fish production especially in the Lakhya River.

Concern was expressed about the reduced depths of rivers including the Old Lakhya, Old Brahmaputra, and Arial Khan Rivers. This has reduced navigation. Previously these rivers were important navigation routes, but recently many of them have lost their navigability, especially during winter months.

Suggestions
Various suggestions for improvement were proposed during the discussions with local people and in the district level seminars. Some of these suggestions were focused on small and very localized issues. The most common suggestions received include:

- Re-excavate the Old Brahmaputra, Haridhoa, Old Lakhya, Arial Khan, and Kharia Rivers, and a section of the Meghna River from Panchabati to Paikerchar via Narsingdi River port.
- Re-excavate Newaz Mollar Khal from Fuldi village of Polashtoli union to Niazir beel, Kalagachia Khal in Daulatpur union, and Nurpur Khal up to Sachiamara.
- Construct embankments from Bhawaler char to Binabaid via Meratola.
- Re-construct embankments from Mallikpur to Sapmara (Kakan Nadi project area).
- Extend Palash Irrigation Project.
- Construct sluice gates in Chandipara, Kewateki, Radhakhali bazar, at the outfall of Haridhoa River, and other places as necessary.
- Prepare alternate development options for the Kakan Nadi and Hairmara projects, as the initial plans were not successful.
- Stop over bank spilling from the Old Brahmaputra, Arial Khan and Old Lakhya Rivers during the monsoon season.
- Develop beels and lowlands for fisheries including Nali Beel, Paikan Beel, Bara Beel, Nalua Beel, Shamibad lowland, Nurpur lowland, and Majhir char lowland.
- Afforestation programmes should be implemented along the banks of the beels and on embankments along various rivers.
- The Nitimala fisheries should be properly managed.
- Allow the poor and subsistence fishermen to catch fish in the floodplains during the monsoon period.
- Select suitable jalmahals for fish sanctuaries and preserve them for increasing fish production.
- Provide facilities for navigation, especially during monsoon months, while constructing embankments and sluice gates.

3.1.10 Local Initiatives

The main activity is to construct dams on various localised canals to stop the entry of pre-monsoon floods to save the boro crop. Local people of Katiadi thana have constructed a dam on

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the Old Brahmaputra River to prevent the entry of flood water from the Arial Khan River. These dams are generally done on a voluntary basis by the villagers around a particular canal which is threatening their property. More recently the Union Parishad has also allotted wheat/rice for this purpose.

3.2 Water Resources Development

3.2.1 Flood Control & Drainage

There are seven existing flood control, drainage and irrigation projects within the project area which provide protection to a gross area of about 49,200 ha (Figure 4). These projects are described below.

Dardaria Khal Project

The project objective was to provide full flood protection to the project area through the construction of an embankment along the left bank of the Banar (Lakhya) River from Sonapur to Dardaria. More than 60% of the project area is covered with isolated high lands of the Madhupur Tracts, locally called teks. The project's rice cultivable areas are in the low lands between the teks. Rapid drainage is needed to save the boro crops in the project.

Drainage was to be provided by a regulator at Ecuria and the re-excavation of the Dardaria Khal. The project has not achieved its objectives. Farmers have complained that since project implementation, their boro crops are damaged each year by poor of local rainfall and upland runoff.

There is one three-vent (1.5m * 1.9m) regulator. An additional one-vent regulator was constructed by the BWDB under the SRP programme in 1993 to improve drainage. Reportedly this new regulator has an invert level lower than the older one to permit inflows of the Lakhya River during the dry months for irrigation. The performance of the project with the new regulator is not known as it was only installed recently.

Harikhali Khal Project

The problems of the area and existing interventions are similar to that of the Dardaria Khal Project.

The project has a gross area of about 2600 ha and is bounded by the Banar (Lakhya) River in the west, the Dhaka-Bhairab Bazar road in the south and east, and the Old Brahmaputra River in the north.

The project's physical infrastructure includes one two-vent (1.5m * 1.8m) regulator with embankments on both sides connected to adjacent high lands. Harikhali Khal was re-excavated.

Performance of the project is not known since the area could not be visited by the NERP team. No comments on the project were received during the public seminar held at Narsingdi in April, 1993.

Dewankhali Khal Project
Project objectives are to prevent flooding from the Lakhya River and relieve drainage congestion of accumulated pre-monsoon rainfall, thereby preventing damage to boro crops.

The project works include 12.5 km of flood embankments along the Lakhya, re-excavation of 21.7 km of main drainage channels, and a three vent drainage regulator at Shekherda Khal. In addition, existing village roads along the remaining periphery also function as flood embankments.

The project concept is sound. The project has achieved its objectives of preventing flood damage to boro crops.

Recently, the project was studied by the Systems Rehabilitation Program and further improvements were proposed including partial rehabilitation of existing infrastructure and the construction of a new drainage sluice at Harinarayanpur to supplement existing box culverts. The proposed rehabilitation works are needed. However, the project area is also partially affected by flooding from Paharia Nadi and Haridhoa Khal through existing culverts. Improvements in these drainage channels under the proposed Narsingdi District Development Project (Chapter 7) would improve pre-monsoon flooding characteristics and may make further work unnecessary.

Kanchikata Khal Regulator Scheme
The project objective was to relieve drainage congestion in Kanchikata Khal basin by replacing a one-vent drainage sluice with a four-vent structure. The one-vent structure was constructed in 1955.

Project infrastructure includes one four-vent drainage sluice and re-excavation of main drainage channels (about 2 km.). The existing village roads along the periphery of the project also function as flood embankments (Figure 5).

After installation of the four-vent regulator the project functioned effectively. Recently a culvert was constructed by the LGED on a new feeder road which crossed the Kanchikata Khal. A culvert was installed at the river crossing but the culvert invert level was higher than the Kanchikata Khal bed level. As a result drainage is impeded and causes crop damage.

Recently, the project has been studied under the Systems Rehabilitation Program to further improve the project. The study has proposed some drainage improvement works including a relief channel with a single-cell culvert near to the existing twin-cell box culvert. The study shows that demolition of the existing culvert and replacement with a new larger culvert is more costly than leaving the existing structure in place and adding the proposed smaller culvert. The Kanchikata Khal is the main drainage channel of the project area. To achieve project objectives the construction of the proposed by-pass channel and culvert appears appropriate.

Much of the project area appears to be agriculturally fully developed. Future development in the surrounding area will require an integrated planning approach so that problems are not created for the more developed project areas.

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Barachapa Project

The project area is bounded by the Arial Khan River in the east, Rasulpur-Banbari road in the south, and Rasulpur-Rayerpur road in the north and west. The project has a gross area of about 8,000 ha.

The project objective is to protect the area and crops from over bank spills from the Old Brahmaputra and Arial Khan Rivers. Project infrastructure includes 13.4 km of flood embankments, 36 km of channel re-excavation, and four drainage regulators.

Construction of the project was completed recently but reportedly it is not performing as intended. Over bank spills from the Old Brahmaputra River enter into the project area through openings in the Barachapa-Monohordi road. The road was planned to also act as a project flood embankment.

The road in Barachapa union from Barachapa to Belabo was originally constructed by the BWDB. Later in 1993 the road was reconstructed by LGED to connect a growth centre. At the Narsingdi seminar it was pointed out that construction works in the area should be more coordinated so that works are not duplicated.

Kakon Nadi Scheme

The project objectives were: (1) to provide monsoon flood protection in order to facilitate a shift to higher yielding transplanted aman, (2) improve drainage for aman crops, and (3) provide pump irrigation for a winter season crop.

The project development plan included 44 km of full flood embankments, 11 drainage regulators, re-excavation of internal khals, and construction of a pumping station on Kakon Nadi.

Construction of flood embankments started in 1977/78 under FFW (Figure 6). Four regulators were constructed during 1979-81 with WB/CIDA support. Five drainage sluices, one regulator, and three drainage/flushing inlets with a provision for low lift pump irrigation were constructed between 1984 and 1988 under IDA Credit 955-BD. The pumping station was not constructed.

In general, the project has not fulfilled its purpose for several reasons. One of the main reasons is the failure of the southern embankment along the Upper Meghna River. Reportedly about seven kilometres of embankments were washed away by wave action of the Upper Meghna River.

There are numerous village roads within the project area which restrict flow and act partly as compartmental bunds. A few of the channels and culverts which connect the lowland areas suffer from drainage congestion. Some existing regulators particularly in the west appear to be undersized and require upgrading.

Southern Embankment

There are two alternatives for re-constructing the southern embankment:

- Retire the existing embankments to a safe distance to reduce wave action erosion; and
- Provide embankment slope protection by revetment works at the present location.

Slope protection works would be required if the embankment is to remain at its present location and become a permanent structure. Protective works would require a substantial investment and may not be economic. During discussions with residents of the area and at the Narsingdi seminar, it appears that local people have mixed opinions about this costly investment since there is scope to retire the embankments.

Retiring the embankment to the existing road from Algibath to Raipura was reviewed. This alternative appears the more cost effective. However some homesteads would be outside the retired embankment. This is an important issue and needs to be resolved partly by detailed field level discussions.

Pump Irrigation

The original proposal was that water be pumped from the Meghna River to Kakon Nadi during the dry season for boro irrigation. This proposal does not appear attractive under present conditions as the majority of the Kakon Nadi command area is currently irrigated from ground water supplies (Table 3.3).

In addition, the original pump proposal includes a long intake channel. Maintenance costs would be substantial due to channel siltation in the active floodplain. Moreover, sedimentation has also taken place in the Kakon Nadi channel bed over recent years and boro crops are now being cultivated within the channel. It appears that the pump irrigation aspects of the Kakon Nadi project under present conditions are not beneficial.

Drainage Improvement

The Kakon Nadi project suffers from drainage congestion. During rehabilitation of the project special attention should be given to improving drainage. Improvements may include additional drainage structures, modification of the existing structures, and re-excavation of some drainage channels. The Narsingdi District Development Project proposes re-excavation of the Arial Khan River which will improve drainage from the Kakon Nadi Project.

Palash Irrigation Scheme

This is a surface water irrigation scheme. The project uses cooling water from the Ghorasal power plant for irrigation. BADC has constructed a check structure at the outlet channel of the power plant and is diverting about 1 m^3/sec. The power plant currently withdraws about 22 m^3/sec. It is planned to withdraw about 35 m^3/sec by 1995.

3.2.2 Irrigation

Surface Water

Present surface water irrigation coverage by LLPs and traditional modes is about 5,730 ha (AST, 1991). There are about 278 LLPs operating in the project area. Of these about 230 have capacities equivalent to 57 litre/sec. The total area irrigated by LLPs is about 2,840 ha. Most of the surface water irrigation takes place in Narsingdi, Raipura, Bhairab, Kapasia and Bajitpur thanas (Table A.9).

Ground Water

A large area is irrigated by ground water supplies; reportedly, there are 3634 STWs, 297 DTWs, and 2,909 MOSTIs in the project area (AST, 1991). The total area irrigated from ground water supplies is about 21,636 ha, of which 16,441 ha are from STWs, 4,726 ha from DTWs and 469 ha from MOSTIs. A total of 145 Mm^3 of ground water is abstracted based on MPO estimates. According to AST information, ground water irrigation occurs mainly in Belabo, Monohordi, Raipura, Shibpur, Narsingdi, and Bhairab thanas (Table A.9).

The 1991 estimates of STW irrigated areas in Narsingdi district were greater than the MPO estimates for DSSTW irrigated areas based on usable recharge (Table 3.3). Estimates of ground water resources require careful review, monitoring, and re-evaluation to avoid over exploitation of ground water. MPO estimates of average ground water irrigation duty in these thanas is about 149 ha/Mm^3 which appears low. The reported size of irrigated area and the type of crops grown require field verification.

3.3 Other Infrastructure

The Dhaka-Sylhet National highway (under the jurisdiction of the Roads and Highway Department) passes through the project area. There are several feeder roads which connect most of the thana centres to the National highway. The total length of existing feeder roads within the project area is about 55 km of which about 38 km are metalled. The majority of these roads have elevations at or above the average annual flood water level. There are insufficient hydraulic openings in the roads and this causes drainage congestion, overtopping, and damage to the road.

There are about 80 km of main village roads in the project area which connect all the thana centres. Most of these roads are not passable during the monsoon season due to flooding. These roads are damaged annually, with an average damage rate estimated at about 15% of the capital cost. This translates into an average annual flood damage of about Tk 1.0 million.

The Dhaka-Sylhet National railway (under the jurisdiction of the Railway Department) passes through the project area. There are several industries within the project area. The two more major industries are the Palash Power Plant and Palash Fertilizer Factory which are both located on the left bank of the Lakhya River.

Table 3.3: Estimated and Present Ground Water Use (Narsingdi District)

Thana	Irrigation Duty (ha/Mm^3)	DSSTW Irrig. Area with Usable Recharge (ha)	STW Irrigated Area 1991 (ha)
Narsingdi	145	1798	3170
Shibpur	147	1911	3966
Monohordi	150	2385	4575
Belabo	161	1420	2653
Raipura	148	3270	6887

Sources: DSSTW data is from WARPO (MPO)
STW data is from AST (1991).

3.4 Agriculture

The hydrologic regime dictates the crop production practices in the project area. Present cropping patterns reflect the farmers' efforts to adjust crop production practices to the hydrologic regime. About 63% of the cultivated area is flooded by less than 0.3 meter (F0 land type) in the monsoon season. Local and high yielding varieties of transplanted aman are grown extensively in these areas. Following these crops high yielding varieties of boro rice are grown where irrigation facilities are available. Jute is the dominant crop grown in sequence with local and high yielding varieties of aman rice where irrigation facilities are not available.

Similar cropping patterns with a higher proportion of local varieties of transplanted aman are practiced on F1 land (flooded between 0.3 to 0.9 m) on about 26% of the cultivated area. Rabi crops are grown in the winter season using residual soil moisture, except on a small area where vegetables and potatoes are grown with irrigation. Sugarcane is mostly grown without irrigation.

HYV boro is the dominant crop on F2 and F3 land (on about 11% of the cultivated area). Low lift pumps and shallow tubewells are the major modes of irrigation in these areas, which are mostly single cropped. Boro is often damaged by floods in the pre-monsoon season. Local varieties of broadcast aman are grown in sequence with rabi crops on unirrigated F2 land.

Cropping patterns presently practiced in the project area are shown in Table 3.4.

The agricultural production system is closely linked with farm family needs, storage, and marketing. The proximity of the project area to Dhaka city and good road communications provide the producers with good marketing opportunities. Most farmers sell their agricultural produce in the village market. Traders collect the produce and truck it to Dhaka.

Homesteads are an integral part of the farming system. Homestead vegetation varies depending on the size of the homestead area and its vulnerability to flood. Most of the homesteads in flood-free areas have dense vegetation cover. This includes different types of trees including jack fruit, mango, guava, litchi, coconut, betel nut, bamboo, banana, papaya, and so on. These trees provide fruit, fuel, and building materials. Most of the vegetables consumed by the family are produced in the kitchen garden, adjacent to the homestead. Several homestead areas have nursery beds and are engaged in raising saplings for timber and fruit trees. This provides another source of income for these households.

The present use of inputs in Narsingdi District is low for local varieties and moderate for high yielding varieties of crops. Crop yields vary depending on the level of input use and on flood damage. Yield data was collected for both damaged and damage-free conditions and present crop production data was generated separately for each category (Table 3.5).

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Table 3.4: Present Cropping Patterns in Narsingdi District

Cropping Pattern	F0		F1		F2		F3		Total
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)
orchard	1683	7	0						1683
sugarcane	1202	5	0		0				1202
fallow-hyv boro	0		0		3555	90	160	100	3715
b aus-lt aman	3607	15	0		0		0		3607
b aus-lt aman-potato	1443	6	0		0		0		1443
b aus-lt aman-rabi	1202	5	495	5	0		0		1697
b aus-hyv aman-rabi	2886	12	0		0		0		2886
jute-lt aman	1924	8	0		0		0		1924
jute-wheat	0		693	7	0		0		693
jute-rabi	1924	8	0		0		0		1924
jute-hyv aman	721	3	0		0		0		721
hyv aus-wheat	0		792	8	0		0		792
hyv aus-rabi	1202	5	0		0		0		1202
lt aman-wheat	0		495	5	0		0		495
lt aman-hyv boro	0		4950	50	0		0		4950
hyv aman-wheat	1683	7	1485	15	0		0		3168
hyv aman-rabi	1202	5	0		0		0		1202
hyv aman-hyv boro	3367	14	990	10	0		0		4357
b aman-rabi	0		0		395	10	0		395
Total	**24048**		**9900**		**3950**		**160**		**38058**

Table 3.5: Present Crop Production

Crop	Damage free area			Damaged Area			Total
	Area (ha)	Yield (mt)	Prod. (mt)	Area (ha)	Yield (mt)	Prod. (mt)	Prod. (mt)
b aus	9133	1.25	11416	500	1.05	525	11941
hyv aus	1994	3.75	7479	0	2.75	0	7479
b aman	295	1.75	516	100	1.45	145	661
lt aman	11616	2.15	24975	2500	1.75	4375	29350
hyv aman	10835	3.95	42797	1500	3.55	5325	48122
hyv boro	11522	4.55	52424	1500	3.25	4875	57299
Paddy			139607			15245	154852
wheat	5148	2.05	10554				
potato	1443	12	17315				
pulses	1396	0.85	1186				
oilseeds	4653	0.75	3490				
spices	465.3	2.25	1047				
vegetables	2792	9.25	25826				
jute	5262	1.65	8682				
sugarcane	1202	45	54108				
orchard	1683	15	25250				

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3.5 Fisheries

3.5.1 Floodplain Fishery

There are about 15 important permanent and seasonal beels in the project area. Of these the most important for fish production are: Simulia Beel, Charnilokhi Beel, Kuthir Beel, Badar Beel, Sonarchand Beel, Chandpur Beel, Lemutala Beel, Nalua Beel, Char Bagber, Monoharabad Dhu Samudra Beel, and Adgatia Beel. The fish of the area use the beels for overwintering. During the monsoon season, water from the Lakhya and Arial Khan Rivers flows into the area through open khals, and by overtopping the rivers banks. Most of the beels are in isolated basins and some are interlinked with each other by narrow channels. Fish can only move freely between the rivers, channels, beels, and floodplain during the monsoon season.

The jalmohal leaseholders construct and maintain water retention dams on some of the drainage canals leading from the beels which prevents timely boro cultivation in the peripheral zone of the beels. On the other hand, annual beel fishing in mid-winter is common and results in the beels being completely drained to maximize the catch. Neither of these practices are in the interests of the farmers.

3.5.2 Species Present in the Area

Of the 155 species identified in the region, about 50 species inhabit the project area. The most common of these species are listed in Table 3.6.

3.5.3 Duar Fishery

There are no important duars in the area.

Table 3.6: Major Fish Species in the Narsingdi District Project

Large Fish	Small Fish
Catla, Rui, Mrigel, Kalibaus, Boal, Air, Ghagot, Gazar, Shoal, Ilish.	Singi, Magur, Koi, Kholisha, Lati, Tengra, Gulsha, Bajori, Bheda, Fali, Napit, Darkina, Mola, Dhela, Chela, Tit puti, Puti, Chanda, Boicha, Tatkini, Kanipona, Bashpata, Batashi, Chapila, Keski, Laso, Tara baim, Baim, Gutum, Cirka, Kaikka, Ek Tuitta, Chanda, Icha .

3.5.4 Sources of Fish and Breeding

Most of the species breed more or less everywhere in the area except for major carp, Pangus, and Ilish. Localized breeding migration takes place for Chapila, Fali, Koi, Singi, Magur, Puti, Chanda, Tengra, Gulsha, Kholisha, Bheda, Lati, Shoal, Gazar, and some other smaller varieties of fish. The existence of permanent water bodies with shallow floodplains makes the area suitable for fish breeding for these species. Within the project area, species composition of capture fishery is dominated by chotomaach (70-80%), followed by catfish (10-15%), and carp (3-5%).

3.5.5 Production Trends

Fish production in the project area has reportedly declined by about 40% over the last five years. The estimated production is 1069 metric tonnes per year (see Table 3.7).

According to the NERP study, open water fish abundance is directly related to the level and duration of flooding, and access to flood lands. The causes for the decline in fish production in this area are:

- Siltation of beels. The beel water hectarage has been reduced over the last 50 years; both the depth of water and water hectare-months are declining.
- Reduction of fish population due to over-fishing and loss of fish habitat.
- Increased fish mortality due to fish diseases caused by water pollution in the beels, particularly during the months of December and January.
- Reduction of fish habitat by encroachment of agriculture into beels.

3.5.6 Fishing Practice

Floodplain
About 64% of fish production in the area is from open water fisheries of which floodplain accounts for 29%, beels for 7%, and channels for 28%). Subsistence fishing takes place mainly during the flood period; beel fishing mostly takes place from November to February. In all cases, beel fishing is done on an annual basis.

The installation of katha for annual fishing is common. Since hizal and koroch trees are scarce in the area, shawra, bamboo and mango tree branches are used for katha. Kathas are installed in the months of August and September when water is receding from the floodplain.

Closed Water
About 36% of the fish production in the project area is from pond aquaculture. The pond fish culture practices for many of the ponds in the Narsingdi area are different from other parts of the country. Some of the ponds are located in flood prone areas, so owners do not release fingerlings into them. Instead ponds are used to trap fish from the floodplains and in most cases katha is installed when the flood waters recede. In some cases supplementary feed is provided in the pond to attract more fish into the ponds. The fish are usually harvested during the dry season. It should be noted that the many ponds that adjoin homestead land provide

domestic water supply for a wide variety of activities (bathing, washing clothes and dishes, occasionally watering homestead vegetable plots, and so on) during the winter and dry season.

Table 3.7: Present Fish Production

Types of water body	Area (ha)	Rate of Production (kg/ha)	Total Production (mt)
Beel	187	410	77
Floodplain	14010	22	308
River/channel	1700	175	297
Pond	484	800	387
Total	16081		1069

Source: NERP & BFRSS

3.6 Navigation

As classified by BIWTA, the Meghna River is a class I navigation route and the Old Brahmaputra and Lakhya Rivers are class II routes. The Meghna River is navigable year round, as were the Old Brahmaputra and Lakhya Rivers. Now the Old Brahmaputra River is navigable only in the lower reaches during the monsoon season, and only small mechanised vessels can use the Lakhya River during the dry season. Reduced navigability is due to a decrease in upstream river discharges and increased channel bed siltation.

The Meghna River is used by large country boats, launches, and cargo vessels except in its upper reaches. It is the main gateway for riverine transport for the northeast region, both nationally and internationally. Narsingdi, Bhairab, and Ashuganj are the important river centres in the eastern side of the project and are served by the Meghna River. Palash, Gorashal, and Lakhpur are the important centres along the Lakhya River. The other internal rivers such as the Arial Khan, Old Lakhya, Kharia-Paharia, and Haridhoa provide transportation during monsoon months only. These rivers are silted up in many places or carry little water for winter navigation.

During the monsoon months, small boats are used for transport by villages in the lower areas and the char lands. However boat transportation is declining due to improvements in the road network and blockages of traditional navigation routes across the flood plains by new roads and embankments.

3.7 Wetland Resources Utilization and Management

The most important use of wetland products is fodder. In the western part of the area people depend on this material, particularly during the monsoon season as flood waters cover most of the low-lying grazing land. People from the shallowly flooded area also use this material for green fodder. Plants such as Nymphaea sp. (*shapla*), Nymphoides sp. (*chandmela*) and other grasses are commonly used. Quantification of their real economic value is difficult as most of the people collect the plants themselves. Estimates were prepared using replacement values and data collected from other projects. The plants are mostly produced on F3 lands which remain fallow in the summer. The estimated area is about 5,000 ha, and the estimated gross total value is about Tk 0.20 million per year (the yield is about Tk 40 per ha). The estimated employment in gathering this product is negligible (about 5000 pd per year, using one pd/ha).

Another important use of wetland resources is for fuel. Due to the scarcity of fuel wood around the homesteads people are becoming increasingly dependant on wetland products. All the woody shrubs as well as grasses are used as fuel. The saplings of swamp forest trees are being damaged and degraded swamp forest trees can not be regenerated.

Wetland products are used as a biofertilizer or green manure. Products used for green manure include small herbs and grasses which grow in the wetlands. The farmers living around these lands use these wetland products instead of chemical fertilizers. After the monsoon season farmers gather these soft aquatic plants and stack the plants in their fields for decomposition. The decomposed material is used as green fertilizer. The production area, economic value and employment in gathering these plants is similar to that for fodder.

Other uses of the wetlands are:

- Food material. Mostly from Nymphaea sp. (*shapla*), Aponogeton sp. (*ghecchu*) and Ottelia alismoides (*panikola*).

- Medicinal plants. Mostly from Polygonum sp. (*kukra*) and many others.

These common property resources are of some importance to the poor, who are the most likely to engage in wetland gathering, to eat wetland food in times of scarcity, to depend on income from wetland products, and so on. Fodder tends to be collected by men, and food and medicinal materials tend to be collected by women. Information on resource management practices is not available.

4. PREVIOUS STUDIES

4.1 Systems Rehabilitation Project (SRP), BWDB

The System Rehabilitation Project is in the process of completing feasibility studies to rehabilitate three existing projects in Narsingdi district. The project is co-financed by IDA, EEC, and the Netherlands Government in association with the World Food Programme (WFP). The three projects being studied by SRP are Dardaria Khal Project, Dewankhali Khal Project, and Kanchikata Regulator. Results from SRP's investigations have been used in this pre-feasibility study.

4.2 Second Small Scale Flood Control, Drainage and Irrigation Project

4.2.1 Palash Irrigation Scheme

There is an existing scheme at Palash (Section 3.2). In 1990 BWDB proposed that the scheme be further developed as a gravity irrigation scheme with a gross area of about 2,500 ha under IDA Credit 1870-BD.

A preliminary analysis by the Second Small Scale Flood Control, Drainage and Irrigation Project indicates that the development of a comprehensive gravity irrigation scheme in Palash would be costly and inefficient because of the complex topographic relief.

4.2.2 Proposed Hairmara Project

The project has a gross area of about 7,300 ha and is bounded by the Meghna River in the east and south, Kakon Nadi Project in the north and Arial Khan River in the west (Figure 4).

The proposed project objective is to protect broadcast aman crops, to reduce monsoon flood depths thereby facilitating a shift to higher yielding transplanted aman crops, and to improve drainage for aman crops.

The proposed development plan includes re-sectioning of 33 km of flood embankments, excavation of 33 km of drainage channels, and construction of six drainage structures.

The project report has not yet been published by the SSFCDI Project but their preliminary analysis shows a low EIRR. The project is subjected to severe wave action from the Upper Meghna River and maintenance costs would be high.

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4.3 National Water Plan, MPO (WARPO)

4.3.1 Lakhya River Development

The National Water Plan prepared a report which looked at existing and planned projects along both banks of Lakhya River and estimated the water availability and demand of the river.

The study shows that about 2 m^3/sec is available during the winter months. Present and planned water uses for Lakhya River include irrigation, cooling water, navigation, domestic, and industrial uses. The design irrigation water demand including Dhaka-Narayanganj-Demra and Narayanganj-Narsingdi Irrigation Projects is about 24.5 m^3/sec, of which about 12 m^3/sec is currently used. Cooling water requirements are around 30 m^3/sec; of which about 22 m^3/sec is being withdrawn by the Palash power plant. Dhaka WASA has proposed that a water filtration plant be established at Demra with a capacity of about 200 mgd or 10.5 m^3/sec. Therefore, the total water demand is about 65 m^3/sec. Lakhya River receives negligible upland flows during the winter months. MPO have concluded that the existing and planned projects will have to rely on back flows from the Meghna River. The increased water demand of the planned projects may create conflicts over water use on the Lakhya between domestic water users, irrigation, and navigation.

River aggradation of about three metres has taken place at Demra (Figure 8) during the period 1970-81, and dredging to depths of about two metres is required to maintain the IWTA class II waterway at the confluence of the Buriganga/Dhaleswari and Lakhya Rivers.

There are development possibilities which would benefit the various water user groups. Lakhya flow could be increased by: (1) increasing the Old Brahmaputra flow which in turn flows to Lakhya, or (2) dredging the Lakhya channel to allow back flows to enter the channel. Coordinated planning could enhance the economic viability of all the projects.

4.3.2 Lakhya-Meghna Project

The proposed project is bounded by the Old Brahmaputra River to the north, Lakhya River to the west, and Meghna River to the east and south. The estimated net project area is about 109,000 ha.

The proposed project is divided into two units by the Kaliganj-Narsingdi railway line. The upper unit is recommended for flood control and drainage development only and was targeted to be developed during the fifth and sixth Five Year Plan periods. The lower unit, called the Narayanganj-Narsingdi project, was recommended for flood control, drainage, and pump irrigation.

4.4 Bhairab Bazar Town Protection (FAP 9B)

A feasibility report on erosion protection at Bhairab on the right bank of the Upper Meghna River has been prepared as a part of the Flood Action Plan (FAP 9B). The objectives of this study are to protect Bhairab Bazar town (including commercial buildings, homesteads, and industrial buildings), the railway bridge, and two transmission towers from damage caused by erosion of the right bank of the Upper Meghna River.

The study concluded that erosion protection on the right bank was technically feasible and economically viable (the EIRR was estimated at 36%). An advanced bank protection scheme was proposed. This includes the construction of a new bank line extending some 20 metres from the existing bank line into the river channel. The project extends from the ferry Ghat just north of the railway bridge to the confluence of the Old Brahmaputra River, a distance of some two kilometres.

To provide the necessary degree of protection (for a 1:100 year return period) the following work is proposed:

- Dredging;
- Placing hydraulic fill to form the new bank line;
- Constructing a falling apron section at the toe of the new slope;
- Underwater boulder slope protection placed on a geotextile fabric; and
- Open stone asphalt slope protection on a geotextile fabric above the water surface.

The proposed project is in the process of being implemented at an estimated capital cost of about US $ 15.8 million.

5. WITHOUT-PROJECT TRENDS (NULL OPTION)

The purpose of this chapter is to characterize the future of the project area, assuming no new intervention is carried out. This chapter provides a "future without project" scenario. Comparison of conditions "with" and "without" interventions are summarized in Chapter 7. The time frame considered in this analysis extends to the year 2015. The main trends that can be identified are as follows.

Net population growth
The population of the project area is estimated to be 1,504,300 by 2000 and 2,078,200 by 2015. This assumes the population growth rate will decrease from the rate of 2.43% experienced over the last 10 years to 2.0% per year by year 2015.

Openwater fisheries production
To assess project fish impacts (FW production minus FWO production), some assumption must be made about FWO trends. Observations of past fish production indicate that it is declining by 1-3% per year overall. Conversely, estimates of future production taking into account interventions to improve biological fisheries management suggest that great increases in fish production are possible. If the FWO trend is assumed to be negative, project negative impacts on fish production will be of significantly smaller magnitude than if the FWO trend is assumed to be positive. Lacking any way to decide between these two scenarios, it is assumed that FWO production will be equal to present production.

River course changes
The Meghna River is actively eroding its banks upstream of the Bhairab Bazar bridge. The main process of erosion appears to be a progressive downstream evolution of the meander pattern. For example, in the 10 km reach upstream of the bridge, the concave bank has retreated by about 500 m on average over the last 20 years (1968-89). The erosion from this single bend represents a loss of about 500 ha of land and input of roughly 3 - 5 million m^3/year of sediment (Figures 9, 10 and 11). Without any project intervention erosion of the Meghna River banks is expected to continue.

The channel bed of the Old Brahmaputra River in the lower reach has been silted up to the extent that it becomes dry during the winter months. In addition, the river has been closed by the local people below its confluence with the Arial Khan at Katiadi. The Arial Khan channel bed has also been silted up to a large extent. Without any project intervention this ongoing process of siltation is expected to continue. The rates of siltation in the Old Brahmaputra River upstream of Katiadi may increase and consequently the entire flow of the Old Brahmaputra could be diverted through the Lakhya River. This might lead to adverse impacts on the ground water recharge and ecology of the Narsingdi district.

Food grain production growth
Current trends in agricultural production would continue in the absence of any intervention in Narsingdi District area. Local varieties of transplanted aman would continue to be replaced by high yielding varieties of transplanted aman on F0 land. The areas planted with high yielding varieties of boro are expected to increase with expansion of irrigation facilities.

Future cropping patterns and crop production, assuming no intervention, are presented in Tables 5.1 and 5.2.

Table 5.1: Cropping Patterns under Future Without Project Condition

Cropping Pattern	F0		F1		F2		F3		Total
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)
orchard	1683	7	0						1683
sugarcane	1202	5	0		0				1202
fallow-hyv boro	0		0		3555	90	160	100	3715
b aus-lt aman	2405	10	0		0		0		2405
b aus-lt aman-potato	1443	6	0		0		0		1443
b aus-lt aman-rabi	1683	7	495	5	0		0		2178
b aus-hyv aman-rabi	2886	12	0		0		0		2886
jute-lt aman	1924	8	0		0		0		1924
jute-wheat	0		693	7	0		0		693
jute-rabi	1924	8	0		0		0		1924
jute-hyv aman	721	3	0		0		0		721
hyv aus-wheat	0		792	8	0		0		792
hyv aus-rabi	1202	5	0		0		0		1202
lt aman-wheat	0		495	5	0		0		495
lt aman-hyv boro	0		4950	50	0		0		4950
hyv aman-wheat	1683	7	1485	15	0		0		3168
hyv aman-rabi	1202	5	0		0		0		1202
hyv aman-hyv boro	4088	17	990	10	0		0		5078
b aman-hyv boro	0		0		395	10	0		395
Total	24048		9900		3950		160		38058

Table 5.2: Crop Production Under Future Without Project condition

Crop	Damage free area			Damaged Area			Total
	Area (ha)	Yield (mt)	Prod. (mt)	Area (ha)	Yield (mt)	Prod. (mt)	Prod. (mt)
b aus	8412	1.25	10515	500	1.05	525	11040
hyv aus	1994	3.75	7479	0	2.75	0	7479
b aman	295	1.75	516	100	1.45	145	661
lt aman	10895	2.15	23424	2500	1.75	4375	27799
hyv aman	11556	3.95	45647	1500	3.55	5325	50972
hyv boro	12638	4.55	57504	1500	3.25	4875	62379
Paddy			145085			15245	160330
wheat	5148	2.05	10554				
potato	1443	12	17315				
pulses	1409	0.85	1197				
oilseeds	4696	0.75	3522.3				
spices	469	2.25	1056				
vegetables	2818	9.25	26065				
jute	5262	1.65	8682				
sugarcane	1202	45	54108				
orchard	1683	15	25250				

Analysis of the historical data shows that yield levels of individual varieties have not changed over time. Changes in production have come mainly from shifts in variety. Without any change in the flood regime, levels of input use are not expected to change and damage to different crops would continue. This would include high yielding varieties of boro in the pre-monsoon season. Damage to local and high yielding varieties of transplanted aman through drainage congestion would continue, especially on F1 land.

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6. WATER RESOURCES INFRASTRUCTURE DEVELOPMENT OPTIONS

6.1 Summary of Problems

The main problems of the area include flooding and sedimentation. These have been addressed in subsequent sections and are as follows:

- Floods and seasonal inundation over part of the area. Flooding of crops during the monsoon season causes yield reduction and limits the area of higher yielding transplanted monsoon crops. Flooding causes losses to agriculture, and damages homesteads and roads;

- Pre-monsoon drainage congestion due to pre-monsoon rainfall and upland run-off. Drainage congestion during the pre-monsoon season damages boro crops and limits the cropped area;

- Severe siltation has taken place in many of the channels. This siltation affects fisheries and navigation, and causes drainage congestion which increases flood risk; and

- Development of other infrastructure (roads, culverts) causes drainage congestion, and increases crop damage.

6.2 Water Resources Development Options

There are three unprotected units in the Narsingdi area: Old Lakhya Unit, Binabaid Unit, and Shibpur-Narsingdi Unit, excluding the areas covered by existing projects and projects already proposed (Figure 4). The gross area of these three units is about 50,600 ha and the estimated net cultivable area is about 38,100 ha.

Initially full flood control development was examined for each of the three unprotected units. Other forms of water resource development including channel re-excavation and controlled flooding were later reviewed and the most attractive components were selected.

Four development options were reviewed:

- Protection of the entire Narsingdi area as a single unit;
- Development of the Old Lakhya unit;
- Development of the Binabaid unit; and
- Development of the Shibpur-Narsingdi unit.

6.2.1 Protection of the Entire Narsingdi Area

The objective of this option is to prevent monsoon flooding from the north which will affect the entire Narsingdi project area, including existing projects.

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Full flood protection would include embankments along the right bank of the Old Brahmaputra River from its confluence with the Arial Khan near Banbari to the highlands around Toke. Two regulators would be installed, one at each end of the Arial Khan River at its confluences with the Old Brahmaputra River. These regulators would regulate flow in the Arial Khan River and would be designed to accommodate navigation and fisheries (Figure 12).

This flood control proposal does not appear attractive for the following reasons:

- Regulation of main river flows through a gated structure would be difficult. Rates of channel bed siltation are significant and a large annual channel maintenence programme would likely be required.

- A large structure would be required to pass the flood flows and this would make the option uneconomic; and

- water levels upstream might increase causing flooding there.

6.2.2 Old Lakhya Unit

Full flood control would include embankments along the right banks of the Old Brahmaputra and Arial Khan Rivers from the high land at Toke to the existing embankments of the Brachapa Project (Figure 4). Embanking the area appears attractive and is discussed further in Chapter 7.

6.2.3 Binabaid Unit

Binabaid unit is encircled by the Old Brahmaputra and Arial Khan Rivers (Figure 4) and has a gross area of about 3,980 ha. The area is flooded by over bank spills from the Arial Khan and Old Brahmaputra Rivers. Flooding is further aggravated by the back water effects of the Upper Meghna River.

Binabaid area remains flood free during the pre-monsoon season for average year floods (Table 6.1). For higher return period floods the inundated area does not appear to increase much. However, at the Narsingdi seminar and in field discussions with area residents it was reported that rates of hyv boro crop damage have increased substantially in recent years. This may be due to higher pre-monsoon peak water levels due to sedimentation, or farmers encroaching on more flood prone areas. This should be reviewed during feasibility level studies.

Table 6.1: Area Flooded by Depth Category (Binabaid Unit)

Flood condition	Peak Water levels (m PWD)	Return period	Gross Area by Depth Category (ha)				Total Flooded Area (ha)
			F0	F1	F2	F3	
			<0.3 m	0.3 to 0.9 m	0.9 to 1.9 m	>1.8 m	
Pre-monsoon	3.19	1:2	3980	0	0	0	0
	3.69	1:5	3830	150	0	0	150
	4.02	1:10	3670	210	100	0	310
Monsoon	7.61	1:2	780	1100	900	1200	3200
	8.10	1:5	680	700	800	1800	3300
	8.57	1:10	480	710	790	2000	3500

Source: NERP

During the monsoon season, about 3,200 ha (82%) of the Binabaid area is inundated by floods having a 1:2 year return period. About 1,200 ha (30%) is flooded to depths exceeding 1.8 m (Table 6.1).

Full flood control would include embankments along the right bank of the Old Brahmaputra River from Katiadi to Banbari and along the left bank of the Arial Khan from Katiadi to Banbari.

Comparison of topography and water balance (Figure 13 and Table A.10) shows that the depths of flooding during the pre-monsoon and monsoon seasons would be substantially reduced with full flood protection. The estimated polder water level due to accumulated rainfall is about 6 m PWD which corresponds to an area of less than 2,000 ha. This would leave a flood free gross area of about 1,900 ha. These are very preliminary estimates which would need updating during feasibility level studies.

The full flood protection scheme will protect homesteads, roads, and other infrastructure, and will reduce siltation.

Development of embankments around the Binabaid Unit appears attractive and is discussed further in Chapter 7.

6.2.4 Narsingdi-Shibpur Unit

The proposed development area is almost an independent unit with a gross area of about 26,000 ha. It is bounded by the Barachapa project in the north, Arial Khan River in the east, Dewankhali Khal Project, Palash Irrigation Scheme and Lakhya River in the west, and Kaliganj-Narsingdi railway line in the south.

Table 6.2: Area Flooded by Depth Category
(Narsingdi-Shibpur Unit)

Flood condition	Return period	Gross Area by Depth Category (ha)				Total Flooded Area (ha)
		F0	F1	F2	F3	
		<0.3 m	0.3 to 0.9 m	0.9 to 1.8 m	>1.8 m	
Monsoon	1:2	18700	4500	2000	1000	7500
	1:5	16200	5800	3000	1200	10000

Source: NERP

The area is flooded by local runoff from the surrounding high lands and from upland flows from the north and east during the pre-monsoon and monsoon seasons. The depth of inundation is further increased by the back water effects of the Upper Meghna River mainly through the Arial Khan and Haridhoa Rivers.

During the monsoon season about 7,500 ha (29%) of the Narsingdi-Shibpur Unit is inundated by average year floods (Table 6.2). Only about 1,000 ha are deeply flooded to depths exceeding 1.8 m.

Full flood control to the Narsingdi-Shibpur Unit would be achieved by closing all the drainage outlets along the Rasulpur-Banbari road (including a control structure on the Paharia-Kharia Nadi), Shibpur-Rasulpur road, and from the Dewankhali Project. Regulating structures would be provided at the outfalls of the Arial Khan and Haridhoa Rivers (Figure 14).

Disadvantages of the development plan are:

- Paharia-Kharia Nadi is the main drainage channel from the Barachapa Project area. Any restriction of flows in this channel would create drainage congestion in Barachapa Project;

- Drainage from the eastern part of Dewankhali project would be restricted causing increased crop damage within the project;

- Any channelization of Paharia-Kharia, Haridhoa and the lower reaches of the Arial Khan would cause drainage congestion, as these channels now collect local runoff from both banks; and

- Navigation and fish migration would be restricted. It may be possible to provide a navigation lock and fish migration facilities to mitigate some of the impacts.

Full flood control development for the Narsingdi-Shibpur unit does not appear technically appropriate and further analysis of this option was not carried out.

During the field visit, it was observed that sediment deposition has taken place in many of the drainage channel beds. Currently, most of the drainage channels have bed levels almost equal to bank levels and boro crops are grown at several locations within the channel. Local people requested the drainage channels be re-excavated.

During Narsingdi seminar (refer Proceeding of the Narsingdi Seminar, 25 April 1993, NERP) siltation of river channel beds was highlighted by many of the participants as requiring immediate attention. Group discussions at the seminar identified improved drainage as the most attractive option for development of the Shibpur-Narsingdi unit. Improved drainage appears attractive for this unit and is described further in Chapter 7.

6.2.5 Conclusion

After evaluating the available alternatives, the more attractive water resource components are: (1) embanking of the Binabaid and Old Lakhya units, and (2) channel improvements in the Old Lakhya and Narsingdi-Shibpur units. These development components were adopted as the most appropriate for Narsingdi district and are described in Chapter 7.

7. PROPOSED FLOOD CONTROL AND DRAINAGE PROJECT

7.1 Rationale

The project area is presently subjected to flooding by overbank spills from the Old Brahmaputra and Arial Khan Rivers and is subjected to drainage congestion due to siltation of the major drainage outlets.

The rationale for the Narsingdi District Development Project proposed here is that it provides the best option for water resource development in the area. It provides flood control and improved drainage to a gross project area of 50,600 ha. Broadly, the objectives are:

- Protection of crops from pre-monsoon and monsoon-season flood damage;
- Protection of roads and homesteads from river flooding;
- Prevention of overland flooding of existing projects within the project area during the monsoon season;
- Improved drainage, enhanced supply of irrigation water, and expansion of open-water fisheries by re-excavation of silted-up channels.

7.2 Objectives

The specific objectives of the project are:

- To reduce flood damage to boro crops and monsoon crops by reducing the overbank spills from the Old Brahmaputra and Arial Khan Rivers and by improving drainage systems;
- To promote expansion of hyv rice crops onto the lower lands by reducing flood depths on these lands, by improving internal drainage, and by reducing the risk of early flooding;
- To promote expansion of hyv monsoon crops onto higher lands by reducing the risk of flooding and by providing a supply of water from the Old Brahmaputra River for supplemental irrigation;
- To reduce flood damage to homesteads and infrastructure;
- To facilitate navigation, drainage, and expansion of fishery resources by re-excavating the silted-in Arial Khan River, Paharia Nadi, and Haridhoa Nadi channels so as to increase the dry season water depth and surface area in these channels, and improve migration access and flushing of what are now relatively isolated beels.

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7.3 Description

Figure 15 provides an outline of the proposed project works. The proposed development plan consists of the following elements:

- Full flood embankments along the right bank of the Old Brahmaputra and Arial Khan Rivers, extending from the highlands near Toke to the existing Barachapa project embankment near Barachapa. These embankments in conjunction with the existing embankments of the Barachapa project will prevent overbank spills from the Old Brahmaputra and Arial Khan into the Old Lakhya unit, the existing Barachapa project, and the Narsingdi-Shibpur Unit. Existing embankments will close off the project area from the west (from the Lakhya River). The Old Lakhya River will be kept open at its junction with the Lakhya River so as to facilitate drainage. High ground along the downstream section of Arial Khan will prevent spills into the project area from the east. The southern boundary of the project area will be kept open to facilitate drainage and fish migration.

- A flushing sluice at the offtake of the Old Lakhya River, in conjunction with re-excavation of the Old Lakhya River, to facilitate supplemental irrigation during the monsoon season;

- High embankments around the Binabaid unit to protect it from flooding from the surrounding Arial Khan and Old Brahmaputra Rivers and from the backwater of the Upper Meghna River. The embankments would be fitted with two drainage regulators to facilitate pre-monsoon and monsoon drainage.

- Re-excavation of the Kharia-Paharia Nadi and Haridhoa Nadi, so as to prevent pre-monsoon flooding of winter crops in the Narsingdi-Shibpur Unit due to accumulation of rainfall runoff;

- Re-excavation of shallow areas of the Arial Khan River to significantly improve pre-monsoon and monsoon drainage from the protected areas (including existing Barachapa and Kakon Nadi projects), to facilitate navigation, and to enhance fishery resources within the project area .

Preliminary analysis also indicates that some areas on the left bank of the Old Lakhya may be inundated by backwater from the Lakhya River. The ongoing installation of two drainage structures in association with the existing Monohordi-Rayerpur road are expected to prevent flooding and facilitate drainage to these areas. Therefore, no additional work has been proposed except the re-excavation of the Old Lakhya River to improve internal drainage. However, these developments need to be reviewed during the feasibility study and any adjustments to the plan will be made at that time.

The project work consists of:

- 54 km of full flood embankments
- 2 drainage regulators
- 1 flushing sluice
- re-excavation of 90 km of drainage channels

7.3.1 Flood Protection

Embankments

Full flood control embankments are proposed to prevent overbank spill of the Old Brahmaputra and Arial Khan Rivers and to provide flood protection to the Binabaid unit. These flood control embankments would be designed for the 1:20 year return period monsoon flood.

The average heights of embankments along the Old Brahmaputra River and Binabaid Unit are about 1.2 m and 2.4 m, respectively. The embankments are proposed to have a crest width of 4.27 m and side slopes of 2(h):1(v) on the country side and 3(h):1(v) on the river side.

Proposed embankment crest elevations are shown in Table 7.1. Design details are provided in Table A.11.

Table 7.1: Design Embankment Crest Elevations

Locations	Section (km)	Crest Level (m PWD)
Old Brahmaputra River		
Toke	0.0	10.45
Barachapa Project	11.0	9.90
Ajmiriganj	70.0	6.09
Katiadi	0.0	9.90
Belabo	26.0	9.05
Arial Khan River		
Katiadi	0.0	9.90
Belabo	17.0	9.05

As a result of the flood protection measures the depth of flooding will be reduced and the area of flood-free land will be increased as shown in Table 7.2. Crop damage by overland flooding will be prevented within the protected area.

7.3.2 Drainage

Following completion of the project, the drainage requirements of the project area will be greatly reduced since the present flood spills from the Old Brahmaputra and Arial Khan Rivers will be decreased. Consequently the outflow discharge will be smaller.

The existing natural drainage system of khals and beels, with some improvements, will be used for drainage of the project area. The project basin internal runoff will be evacuated through the four main drainage collectors of the project: the Old Lakhya River in the west and the

Table 7.2: Monsoon Depth of Flooding (by 1:2 Year Max Annual Flood)

Flood Depth (m)	Net Area (ha)	
	Pre-Project	Post-Project[a]
0.00-0.30	24,048	24,508
0.30-0.90	9,900	9,700
0.90-1.80	3,950	3,810
>1.80	160	0
Total	38,058	38,018

[a] These figures reflect cultivable land acquired for infrastructure. Production impacts of land acquisition are documented in Section 7.8.

Haridhoa Nadi, the Paharia-Kharia Nadi, and the Arial Khan River in the south and east.

Channels
Re-excavation of about 40 km of the Arial Khan channel is proposed over more or less the entire length. The Paharia-Kharia Nadi and Old Lakhya River will be re-excavated over about 20 km and 10 km, respectively, at strategic locations (Figure 15).

To eliminate water logging and improve local drainage, it is proposed that about 20 km of lateral khals be re-excavated, including Haridhoa River.

In the absence of adequate data regarding the main drainage channels, a cross-section was assumed for cost estimation, having side slopes of 1.5(h):1(v), average depth of excavation of 1.5 m, and a bed width of 15 m over the entire length. These assumptions were made to develop a reasonable cost estimate for the proposed re-excavations. However, these are very preliminary estimates which should be updated during feasibility studies.

In the Narsingdi seminar, it was proposed that the Haridhoa River should be re-excavated and some portion be preserved as a fish sanctuary. An appropriate sluice gate which would minimize interruptions to navigation activities would be constructed to store water for dry season irrigation. It was also proposed that both banks of the river should be brought under afforestation programmes[1]. These proposals seem to have merit except for the sluice gate which might increase the depth and duration of inundation in the Haridhoa River basin. This issue should be reviewed during feasibility studies when the effect on water levels can be defined more precisely.

7.3.3 Structures

Regulators
Construction of two new regulators for flushing and drainage are proposed for the Binabaid Unit: one two-vent (1.5 x 1.8 m) regulator on the Arial Khan River in the south around Char Bharber village and one two-vent (1.5 x 1.8 m) regulator on the Old Brahmaputra River in the north around Jalalpur village. Preliminary locations for the regulators have been selected based on the available topographic maps (4 inch to a mile) and should be reviewed during feasibility studies.

In addition, one two-vent (1.5 x 1.8 m) flushing sluice is proposed at the offtake of the Old Lakhya River for supplemental irrigation during the monsoon season. This structure will be installed if there is sufficient local interest in water supply for irrigation. There is concern, however, that the inlet to this structure could be silted in. These aspects should be investigated further during feasibility studies.

7.3.4 Expected Benefits and Achievement of Objectives

The benefits which are expected from the project mainly relate to agriculture. Protection from pre-monsoon and monsoon floods would be provided in Binabaid area where there would be a small reduction in the depth of flooding as reflected in Table 7.2. Some overbank spill from Arial Khan River would be prevented which would reduce crop damage. Drainage improvements would also contribute towards improved hydrologic conditions for crop production and would

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[1] Proceedings of the Narsingdi Seminar, April 25, 1993, NERP, page 17

make the land available for cultivation earlier in the rabi season.

These hydrologic improvements are expected to encourage farmers to change their cropping patterns. These changes include:

- Increased area under cultivation of high-yielding varieties of aman and boro resulting from drainage improvements, protection from floods, and provision of irrigation, with a corresponding reduction in area of local varieties of aus and transplanted aman rice;

- More opportunity for rabi crop cultivation using residual soil moisture, because the land will be available for cultivation earlier in the rabi season;

- Increase in high-value agricultural crops and use of irrigation in the rabi season.

Good all-weather road communication and proximity of the project area to Dhaka would provide for marketing of the increased production. In fact, the project area is a net importer of rice and thus the increased paddy production would likely be sold and consumed locally.

Cropping patterns which are expected in the future for the with-project condition are presented in Table 7.3.

Protection from pre-monsoon floods would reduce the damage to local varieties of transplanted aman rice and high-yielding varieties of boro and aman. Future crop production for the with-project condition is presented in Table 7.4.

Annual cereal and non-cereal production is given in Section 7.8, Evaluation.

7.3.5 Mitigation Measures Incorporated

In the Binabaid Unit, fishery resources will be negatively impacted by the construction of embankments which will cut off direct connection to the adjacent rivers. Two flushing/drainage regulators have been incorporated with provisions for the passage of fish. This will help mitigate some of the fishery impacts.

Table 7.3: Cropping Patterns for the With-Project Condition

Cropping Pattern	F0		F1		F2		F3		Total
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)
orchard	1716	7	0						1716
sugarcane	1225	5	0		0				1225
fallow-hyv boro	0		0		3429	90	0		3429
b aus-lt aman	735	3	0		0		0		735
b aus-lt aman-potato	1470	6	0		0		0		1470
b aus-lt aman-rabi	1716	7	485	5	0		0		2201
b aus-hyv aman-rabi	2941	12	0		0		0		2941
jute-lt aman	1225	5	0		0		0		1225
jute-wheat	490.2	2	679	7	0		0		1169
jute-rabi	1961	8	0		0		0		1961
jute-hyv aman	735	3	0		0		0		735
hyv aus-wheat	0		776	8	0		0		776
hyv aus-rabi	1470	6	0		0		0		1470
lt aman-wheat	0		485	5	0		0		485
lt aman-hyv boro	735	3	4850	50	0		0		5585
hyv aman-wheat	1716	7	1455	15	0		0		3171
hyv aman-rabi	1470	6	0		0		0		1470
hyv aman-hyv boro	4902	20	970	10	0		0		5872
b aman-rabi	0		0		381	10	0		381
Total	**24508**		**9700**		**3810**		**0**		**38018**

Table 7.4: Future Crop Production for the With-Project Condition

Crop	Damage free area			Damaged Area			Total
	Area (ha)	Yield (mt)	Prod. (mt)	Area (ha)	Yield (mt)	Prod. (mt)	Prod. (mt)
b aus	7347	1.25	9184	0	1.05	0	9184
hyv aus	2246	3.75	8424	0	2.75	0	8424
b aman	381	1.75	666	0	1.45	0	666
lt aman	11702	2.15	25159	0	1.75	0	25159
hyv aman	14189	3.95	56046	0	3.55	0	56046
hyv boro	14886	4.55	67731	0	3.25	0	67731
Paddy			167211			0	167211
wheat	5601	2.05	11481				
potato	1470	12	17646				
pulses	1564	0.85	1329				
oilseeds	5212	0.75	3909				
spices	521	2.25	1172				
vegetables	3127	9.25	28927				
rabi crops							
jute	5090	1.65	8399				
sugarcane	1225	45	55143				
orchard	1716	15	25733				

7.4 Operation and Maintenance

Under this development plan, operation of the flushing/drainage regulators will be required for drainage, supplemental irrigation, and fish passage. In addition, maintenance of the flood control embankments and the drainage channels would be required to assure effective flood control and drainage. An Environmental Management Plan, detailing actions necessary to achieve the desired environmental objectives, will need to be prepared and costed as part of the feasibility study. An operators' handbook will need to be prepared as part of the project design process.

7.5 Organization and Management

During the early part of the feasibility study process, client groups will need to be organized to oversee project development. These client groups would be composed of representatives from the local farming community, the fishing community, and relevant thana-level technical officers. The groups would ensure that the problems of the area are clearly understood and adequately reflected in the feasibility work and that the technical solutions which are being proposed address the problems in an acceptable manner. They would be continually briefed as the feasibility work was carried out and would need to confirm the conclusions of the work. They would also be informed as to details of designs as they are proposed by BWDB design engineers and these designs, in the end, would require the approval of the client groups. The groups would also monitor the construction program which would be carried out by BWDB.

BWDB would be responsible for undertaking technical work related to implementation of the project, in accordance with current practice, but they would be responsive to the client groups described above. The general tasks include completion of final designs, preparation of tenders, pre-qualification of contractors, awarding of contracts, and supervision of construction. The general management of BWDB activities would be under the Executive Engineer who is stationed in Dhaka. Construction supervision would be carried out by sub-divisional field staff.

The Department of Agricultural Extension (DAE) is responsible for the provision of extension services to the farmers within the project.

Bangladesh Rural Development Board (BRDB) is responsible for assisting with command area development through training farmers and through organizing farmers into cooperatives which will then have access to short term crop production loans. Medium term credits are available to these cooperatives from all nationalized banks.

The supply of all agricultural inputs has been deregulated and the distribution of these inputs has been placed into the hands of the private sector.

In summary, the organization and management of this project is partly dependent on central government for key inputs. The extent to which the project's targets are realized will be determined by how effectively the project serves people's needs and how actively the local community participates in all stages of project development.

7.6 Cost Estimate

Total project costs are estimated to be Tk 141.5 million.

The estimates of physical works are based on preliminary designs and lay-out plans which were prepared using four inch to one mile topographic maps and historic hydrological data.

Land costs reflect the current prices obtained from field interviews:

single cropped - Tk. 120,000/ha;

double cropped - Tk. 300,000/ha;

suitable for homesteads and gardens (including high ridges along the river) - Tk. 500,000/ha.

Earthwork costs are based on BWDB's Schedule of Rates for Dhaka O&M circle indexed to June 1991 prices. Structure costs are based on parametric costs developed for the Region, also indexed to June 1991 prices in accordance with the FPCO Guidelines for Project Assessment.

Table 7.5: Capital Cost Summary

Item	('000 Tk)
Structures	15,000
Embankments	25,000
Channels	41,200
Land Acquisition	17,200
BASE COST	98,400
Physical Contingencies (25%)	24,600
SUBTOTAL	123,000
Study Costs[1] (15% of Subtotal)	18,500
TOTAL	**141,500**
Net Area (ha)	38,018
Unit Cost (Tk/ha)	3,722

[1] Includes preparation of EIA and Environmental Management Plan.

A summary of total costs is presented in Table 7.5 and details are provided in Table A.12.

7.7 Project Phasing and Disbursement Period

Four years are required to implement the project. Feasibility studies and field surveys would require one year (year zero). Preparation of detailed designs should start in year one and should be completed in year two. Land acquisition should commence in year one, should be implemented in phases preceding construction, and should be completed in year three. Construction activities should start in year one and should be completed in year three.

An itemized implementation schedule is shown in Table 7.6.

Table 7.6: Implementation Schedule

Activity	Year (% Completion)			
	0	1	2	3
Preconstruction Activities				
Feasibility Study	100			
Engineering Investigation	100			
Detail Designs		70	30	
Land Acquisition		40	40	20
Construction Activities				
Construction of Embankments		30	40	30
Excavation of Channels		20	60	20
Construction of Structures		30	40	30

7.8 Evaluation

7.8.1 Environmental

The key areas of environmental impact by this project are described briefly below. Additional information is given in Annex C, Initial Environmental Examination.

Land Use
Land use changes are summarized in Table 7.7. A total of 86 ha of land (about 0.2% of the project gross area) will be required for embankments, drains, and regulators. Of this 40 ha will be taken from the cultivated area. Assuming that this area is all under rice production and that it has typical yields, this corresponds to foregone cereal production of about 164 tonnes per year or about 2% of the total incremental cereal production. This impact is incorporated into the economic analysis. The remaining 46 ha is already developed as a road.

Agriculture
The project is expected to facilitate an increase in cereal production from 171,010 tonnes per year (FWO) to 178,692 tonnes per year (FW). This change represents an increase of 7,682 tonnes per year (4.5%), inclusive of the impacts of land use changes which are described above.

Table 7.7: Changes in Land Use

Use	Change in area (ha)
Cultivated	-40
Homesteads	-
Beels	-
Ponds	-
Channels	+40
Hills	-
Fallow[1]	-
Infrastructure[2]	-

[1] Multi-use land, wetlands, grazing lands, village grounds.
[2] Government-owned land not appearing elsewhere.

The increased cereal production implies a per person increase in cereal availability from 225 gm per person per day (FWO) to 236 gm per person per day (FW), an increase of about 5% (Table 7.9). The current Bangladesh average consumption is 440 gm per person per day; therefore the project area is and will continue to be a net importer of rice. The calculation includes losses of 10% for seed, feed, and waste and 35% in the conversion of paddy to rice.

Non-cereal production is expected to increase by 4% from 137,176 tonnes per year (FWO) to 142,239 tonnes per year (FW). This change results from a 943 ha increase in area cultivated in non-cereals and implies an increase in the availability of non-cereals from 181 grams per person per day (FWO) to 188 grams per person per day (Table 7.9).

Openwater Fisheries Production
The project is expected to impact on fisheries in four ways, two negatively and two positively. On the negative side, some obstruction to migration will occur and the area of land which is flooded will be reduced. Positive impacts are the increased depth of the main drainage channels and the increased area of water surface in the dry season.

The proposed embankments along the Old Brahmaputra River are expected to cause only a minor impact on fish migration, since the access routes from the south will be left open. Generally the downstream channels in a system are more important for fish migration.

There will be a small reduction of about 460 ha (3.5%) in the seasonally flooded area within the Binabaid Unit (Table 7.2), plus 40 ha of floodplain (cultivated) area will be lost to infrastructure. This change is expected to reduce the annual fisheries production by 22 tonnes.

The increase in depth of the main drainage channels will have a positive impact on fisheries production since it will improve the overwintering habitat and will provide better migration routes than those which are currently obstructed by siltation. Furthermore the increased dry-season surface water area in the Old Lakhya, Paharia, Haridhoa, and Arial Khan Rivers is expected to benefit the fisheries resource by increasing the area of winter habitat. In addition, prevention of overbank spill of the Old Brahmaputra River should facilitate large scale expansion of pond aquaculture, although these benefits to pond aquaculture have not been included in the economic

Table 7.8: Fish Production Indicators

Regime	FWO (2015)		FW (2015)			
	Area (ha)	Production ('000 kg)	Area (ha)	Area Equivalent	Production Impact ('000 kg)	Net Value ('000 Tk)
Flood Plain	14010	308	13510	13510	-22	-678
Beels	187	77	187	187	0	0
Channels /River	1700	298	1742	1742	+7	+473
Net Project	38058	683	38018		-15	-205

and multi-criteria analysis.

Estimates of future fisheries production, with and without the project, were made using a simple model of fisheries production, which is documented in Annex B.

Results of the analysis are provided in Table 7.8. Overall the project is expected to reduce the fisheries production by about 15 tonnes per year. The net value of the fisheries production will decrease by an amount of Tk 205,000 per year. These values are thought to be conservative (likely over estimates the decrease in fish production in the Binabaid Unit and under estimates the increases due to the improved water linkages which are created by re-excavating the main channels). Fishery estimates would be further investigated during feasibility studies.

Fish availability per person per day is shown in Table 7.9.

Table 7.9: Indicators of Food Availability
(grams/person/day)

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	344	334	236	225
Non-Cereals	284	253	188	181
Fish	2.3	1.9	1.4	1.4

Homestead flooding

Homestead flood damage would be reduced. Due to the lack of historical data on flood damage costs, a simple model was used to estimate future costs. Assuming that there are about 241,000 homesteads in the area, that the average plinth level is at about the 1:5 year flood level, and that about 3% of the homesteads are affected by flooding of 20 to 50 cm in the 1:10 to 1:20 year floods, the annualized economic value of reduced flood damage is estimated to be Tk 3.9 million.

Wetland Habitats and Grazing Area

Impacts are difficult to quantify, but a general impression is given by Table 7.10, which shows the impact on:

- "Winter grazing area". Defined as F0, F1, and F2 lands that lie fallow in the dry season (winter) plus any perennially-fallow highlands, this land would have limited residual moisture. Although animals do graze on such areas, the productivity per unit area is not known.

- "Winter wetland". Defined as F3 land that lies fallow in the dry season, plus any perennially-fallow lowland (F4), beel, and channel areas, this land would likely have considerable residual moisture and could support a range of wetland plant communities.

Table 7.10: Floodplain Grazing and Wetland Changes

Land Type	Winter Grazing Area			
	FWO	FW	Change	%
sc/wf F0	64	840	+776	
sc/wf F1	6720	8232	+15120	
sc/wf F2	12600	9200	-3400	
Fallow Highland	2500	2500	0	
Total	21884	20772	-1112	-5

Land Type	Winter Wetland			
sc/wf F3	2592	0	-2592	
F4, Beel, Channel	9660	9660	0	
Total	12252	9660	-2592	-21

Land Type	Summer Wetland			
wc/sf F1	0	0	0	
wc/sf F2	3000	5290	+2290	
wc/sf F3	49248	43840	-5408	
F4, Beel, Channel	12160	12160	0	
Total	64408	61290	-3118	-5

FW areas shown here do not reflect cultivable land acquired for infrastructure (see Land Use, Section 7.8.1). 'sc' - summer cultivated. 'wc' - winter cultivated. 'sf' - summer fallow. 'wf' - winter fallow.

- "Summer wetland". Defined as F1, F2, and F3 land that lies fallow in the summer, plus perennially-fallow lowland (F4 land), beels, and perennial channel areas, this land would be inundated to a depth greater than 0.3 m and would support submerged, free-floating, rooted floating, and sedge/meadow plant communities.

The impact of the project would be to decrease winter grazing area by 5%, decrease winter wetland area by 21%, and decrease summer wetland area by 5%.

Economic and employment impacts of the project on wetland plant and animal production can only roughly be estimated. Assuming an annual economic production of Tk 100 per hectare for both summer and winter wetland areas, the economic value of the wetland loss is estimated to be Tk 60 thousand per year. Assuming 0.5 person days per ha per year are spent in harvesting, the impact on employment would be a loss of 2,900 person days per year.

Transportation/navigation
Road transportation will improve. People living along the Old Brahmaputra River will get road transport facilities during the monsoon season. The total length of existing roads in the project is 135 km of which 50 km are inundated every year. The project would make 8 km of these roads flood-free (up to the 1:20 year flood). Assuming a capital cost of Tk 190,000/km and flood damage of 15% the annual benefit of flood protection is Tk 1.0 million.

The channel re-excavation programme will improve navigation.

7.8.2 Social

The key areas of social impact (or lack thereof) for this project are described below. Additional information is given in Annex C, Initial Environmental Evaluation.

Employment
There will be an overall increase in employment of 0.044 million person-days per year (pd/yr). This is composed of:

- a decrease in owner-labour employment of 0.027 million pd/yr, of which very roughly 20% is post-harvest processing activities traditionally done by women of the household;

- a net increase in employment opportunities for landless people of 0.071 million pd/yr, composed of changes in the following areas:

  - Agricultural hired labour: increase of 0.075 million pd/yr, of which about 10% is for post-harvest processing traditionally done by women;

  - Fishing labour: decrease of 0.004 million pd/yr (based on an economic value of fish impact at Tk 50/day standard wage) in addition to a corresponding decrease in support activities such as net-making and post-catch processing (mainly drying) much of which is done by women;

  - Wetland labour (gathering wetland products): decrease of 0.003 million pd/yr. Fodder and building material are gathered mainly by men. Food, fuel, and medicine are gathered mainly by women.

Displacement impacts due to land use changes
There will be no displacement of households due to the project.

Conflicts
Improved drainage will encourage farmers to extend cultivation further into the lowlands. This will bring them into conflict with fishermen who will find the fishing area reduced.

Equity
The net impact on equity would appear to be neutral or slightly progressive. Who benefits?

- Landowners, in proportion to landholdings, benefit directly from investment in agriculture and high value crops. *Regressive.*

- Hired labourers. Introduction of high value crops will reduce the amount of owner labour and consequently increase hired labour. *Progressive.*

- Families dependent upon river/channel fishing. These families are mainly landless and will have more opportunity for fishing in the 90 km of re-excavated channels. *Progressive.*

Who loses?

- Families involved in subsistence floodplain fishing, and gathering wetland products. These families are mainly landless and tend to be poor. *Regressive.*

Gender Equity
The net impact on gender equity would be somewhat *progressive*. Employment opportunities for women will increase in all categories except wetland gathering. Reduced homestead flood damage will favour women, given that most women still spend most of their lives within the homestead.

Qualitative Impact Scoring
Impacts of the project are scored qualitatively in Table 7.11. Each score sums across five equally weighted logical (true/false) criteria, with each 'true' counting for a value of one and each 'false' for zero. The sign reflects whether the impact is positive or negative. Thus the aggregate score in each criteria can be between -5 and +5. The scoring procedure is analogous to that used in the FAP 19 EIA case studies, but is simplified to eliminate half-point scores (1.5, 2.5, 3.5, etc).

7.8.3 Economic

A summary of salient data in provided in Table 7.12.

The project has an economic rate of return of 42%, which compares well to the required rate of 12% as prescribed by government. It is a relatively low investment project, at about Tk 141 million or about Tk 3,720 per hectare, and it covers a large geographic area (50,600 ha gross). The rate of return is slightly sensitive to increases in capital costs (a 20% increase in capital costs would reduce the rate of return to 36.6%). A 20% reduction in net (agri+fish+wetlands) would reduce ERR by 6%. A more sensitive variable is the timing of the benefits; a delay in benefits by two years would reduce the ERR to 27%.

At 7% (excluding FFW contributions) the foreign costs associated with the project are low.

The major benefit of the project relates to increased rice production, mostly resulting from shifts to high-yielding varieties. Average crop yields would increase as a result of reduced flood damage, while cropping intensity would remain almost constant. Non-cereal production would

Table 7.11: Qualitative Impact Scoring

		True=1 False=0					
Qualitative Impact	Impact Sign	Sensitive	Magnitude	Immediate	Sustainable Pos Impact/ Irreversible Neg Impact	No Mitigation Required/ Possible	Score
Road Transportation	+1	1	1	1	1	1	+5
Navigation	+1	0	1	0	0	1	+2
Flood Levels Outside Project Area	-1	0	0	1	0	0	-1
Socioeconomic Equity	+1	0	0	1	1	0	+2
Gender Equity	+1	0	0	1	1	0	+2

increase by 4%. About 8% of the project benefits would result from reduced homestead flooding. The economic value of the floodplain fisheries output would increase marginally (by about Tk 100,000 per year) as a result of the project. A small amount of disbenefit would result from loss of food, shelter, and tree products that are currently harvested from the seasonal wetlands.

It is anticipated that the established crop marketing system will handle the increased crop production without any reduction in prevailing average price levels.

7.8.4 Summary Analysis

From a multi-criteria perspective (Table 7.13), the project is attractive:

- Benefits derive from increased production of both rice and non-rice crops.
- The net employment impact is positive; the employment impact for hired labourers is positive. This is mainly because the high value agricultural crops require more hired labourers.
- The rate of return is attractive.
- Economic returns to land owners and landless people are increased.
- Flood damage to homesteads and roads are reduced.
- Non-cereal production would be substantially increased.
- Gender equity of impacts is somewhat progressive.

- Socio-economic equity of impacts is somewhat progressive.

- The project responds to expressed public concerns.

The negative aspects of the project would be:

- Fish production would decrease.

- Conflicts between farmers and fishermen would continue although these could be mitigated to a degree through an appropriate community participation process.

- The project is partly dependent on central government for implementation.

- Summer wetland vegetation area and winter grazing areas decrease slightly; winter wetland vegetation area decreases by one-fifth.

- Flood levels outside the project would increase slightly.

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Table 7.12: Summary of Salient Data

Economic Rate of Return (ERR)	42			
Capital Investment (Tk million)	141			
Maximum O+M (Tk million / yr)	4			
Capital Investment (Tk/ha)	3,717			
Foreign Cost Component (%)	7			
Net Project Area (ha)	38,018			
Land Acquisition Required (ha)	86			

AGRICULTURAL IMPACTS		Present	FWO	FW
Incremental Net Econ Output (Tk million / yr)	47.3			
Cropping Intensity		2.0	2.0	2.0
Average Yield (tonnes/ha)		4.0	4.1	4.2
Average Gross Margins (Tk/ha)		15811	16062	16694
Owner Labour (md/ha)		109	109	108
Hired Labour (md/ha)		43	44	45
Irrigation (ha)		17946	19077	20246
Incremental Cereal Prod'n (' 000 tonnes / yr)	8			
Incremental Non-Cereal (' 000 tonnes / yr)	5			
Incremental Owner Labour (' 000 pd / yr)	-27			
Incremental Hired Labour (' 000 pd / yr)	+71			

FISHERIES IMPACTS		Flood plain	Beels	Channel/ River
Incremental Net Econ Output (Tk million / yr)	-0.2	-0.68	0	+0.47
Impacted Area (ha)		-500	0	+42
Average Gross Margins (Tk/ha)		770	28700	12250
Remaining Production on Impacted Area, %		0	0	0
Incremental Fish Production (tonnes / year)		-22	0	+7
Incremental Labour ('000 pd / yr)	-4	-14	0	+9

FLOOD DAMAGE BENEFITS				
Households Affected		7221		
Reduced Econ Damage Households (Tk M / yr)	3.9			
Roads/Embankments Affected -km		50		
Reduced Econ Damage Roads (Tk M / yr)	1.0			

OTHER IMPACTS				
Wetland Incr Net Econ Output (Tk million / yr)	-0.06			
Wetland Incremental Labour ('000 pd / yr)	-2.9			
Acquired Cult & Homestead Lands, Incr Net Econ Output (Tk million / yr)	-2.6			
Persons Displaced by Homestead Acquisition	-			

Table 7.13: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	42
EIRR, Increase Capital Costs by 20%	per cent	36.6
EIRR, Delay Benefits by Two Years	per cent	27
EIRR, Decrease in Benefits by 20%	per cent	36
Net Present Value	Tk ('000)	204803

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	+8	+4.5
Incremental Non-Cereal Production	tonnes	+5	+4
Incremental Fish Production	tonnes	-15	-2
Change in Floodplain Wetland/Fisheries Habitat	ha	-500	-3
Homesteads Displaced Due to Project Land Acquisition	homesteads	0	0
Homesteads Protected From Floods	homesteads	+7221	+3
Roads Protected From Floods	km	+18	+15
Owner Employment	million pd/yr	- .027	-0.32
Hired Employment (Agri+Fishing+Wetland)	million pd/yr	+0.071	+2

Qualitative Impacts (ranked from -5 ...0... +5)	
Impact	**Rank**
Road Transportation	+5
Navigation	+2
Flood Levels Outside Project Area	-1
Socioeconomic Equity	+2
Gender Equity	+2
Decentralized Organization and Management	-2
Responds to Public Concerns	+5
Conformity to Regional Strategy	+2

[1] Percent changes are calculated relative to future-without-project values.

[2] Includes incremental production foregone due to acquisition of cultivated land.

ANNEX A

TABLES

Table A.1: Meteorological Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature Max. (°C)	28.9	32.5	36.5	37.0	36.2	35.3	33.7	34.1	34.5	33.5	32.0	28.8
Min. (°C)	8.8	10.4	14.5	18.8	19.6	22.5	24.1	24.0	23.3	19.7	14.7	10.9
Mean (°C)	19.1	21.7	26.3	28.5	28.7	28.9	28.8	28.8	28.8	27.6	24.2	20.1
Humidity (max %)	84	85	83	86	91	96	96	95	96	94	89	85
Sunshine (hr/day)	8.4	8.8	8.5	8.4	7.8	5.0	4.5	5.7	5.8	7.6	8.2	8.5
Wind speed (m/sec)	1.46	1.73	2.05	2.54	2.17	2.12	2.12	2.06	1.79	1.62	1.51	1.55
Evapotranspi-ration (mm/month)	2.9	3.9	5.4	6.3	6.1	4.4	4.7	4.5	4.3	3.9	3.3	3.0

Source: BMD; Dhaka, Bangladesh.

Table A.2: Flood Discharges at Various Return Periods (m^3/sec)

River	Station and No	Return Period (Years)						
		2	5	10	20	25	50	100
Annual Monsoon Floods:								
Meghna	230 Bhairab Bazar	13,154	15,302	17,133	19,273	20,044	22,740	25,973
Old Brahmaputra	228.5 Nilukhirchar	2952	3579	3980	4353	4469	4821	5160
	230.1 Bhairab Bazar	551	769	900	1017	1052	1155	1250
Lakhya	179 Demra	2096	2307	2422	2518	2546	2624	2691
Pre-Monsoon Floods:								
Meghna	230 Bhairab Bazar	2997	3714	4071	4345	4421	4624	4787
Old Brahmaputra	228.5 Nilukhirchar	257	461	630	824	893	1132	1412

Source: NERP

Table A.3: Monsoon Flood Water Levels, m PWD

River	Location		Return Periods			
	Station	No	2	5	10	20
Lakhya	Trimohoni	9.5	7.93	8.38	8.63	8.83
	Lakhpur	177	6.86	7.24	7.45	7.62
	Demra	179	5.73	6.06	6.26	6.42
Old Brahmaputra	Toke	229	8.49	9.02	9.29	9.52
	Motkhola	230	8.45	8.84	9.08	9.31
	Bhairab Rly Bazar	230.1	6.54	6.98	7.22	7.42
Meghna	Narsingdi	274	5.88	6.26	6.48	6.68
Analysis						
Arial Khan	Katiadi	-	7.99	8.50	8.76	8.99
Arial Khan	Belabo	-	7.22	7.69	7.94	8.15
Binabaid Unit		-	7.61	8.10	8.35	8.57
Old Lakhya Unit		-	7.66	8.04	8.27	8.47

Source: NERP

Table A.4: Mean Monthly Discharges (m^3/sec)

Month	Gauge 273 Meghna at Bhairab Bazar			Gauge 228.5 Old Brahmaputra at Nilukhirchar		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	665.2	1105.6	1843.6	11.4	41.7	110.3
May	1520.7	2777.9	4321.0	54.9	279.0	644.6
June	3197.0	6755.0	13326.7	299.2	981.7	1984.6
July	6018.4	10697.6	16900.0	1272.5	2033.7	2886.8
Aug	8244.5	11650.3	16187.1	1056.9	1958.0	2882.9
Sept	7387.7	10689.8	16483.3	1173.8	1759.9	2765.0
Oct	4236.8	8258.0	11561.3	387.0	933.8	1344.3
Nov	1606.2	3414.9	5510.0	70.1	179.3	418.4
Dec	352.8	919.3	1836.1	28.9	60.9	166.4
Jan	75.3	369.5	721.7	19.2	35.1	88.7
Feb	80.6	263.9	451.5	13.8	23.8	56.9
Mar	161.9	360.4	587.9	9.1	19.0	59.9

Source: NERP

Table A.5 : Mean Monthly Water Levels (m PWD)

Month	Gauge 229 Old Brahmaputra at Toke			Gauge 230 Old Brahmaputra at Motkhola		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	1.61	1.92	2.45	1.77	2.07	2.67
May	2.30	3.13	4.39	2.57	3.41	4.74
June	3.07	5.18	6.95	3.56	5.44	7.04
July	6.14	7.28	8.75	6.41	7.30	8.04
Aug	6.05	7.59	8.91	7.05	7.66	8.34
Sept	6.24	7.27	8.56	6.34	7.28	8.53
Oct	4.14	5.74	6.69	4.64	5.91	6.75
Nov	2.09	2.94	3.99	2.54	3.20	4.24
Dec	1.55	1.93	2.33	1.78	2.15	2.74
Jan	1.30	1.50	1.72	1.45	1.76	2.31
Feb	1.17	1.34	1.51	1.35	1.58	1.99
Mar	1.29	1.43	1.63	1.44	1.62	1.96

Table A.5 (Cont'd): Mean Monthly Water Levels (m PWD)

Month	Gauge 177 Lakhya at Lakhpur			Gauge 230.1 Old Brahmaputra at Bhairab Rly Bridge		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Apr	1.66	1.88	2.32	1.74	2.06	2.65
May	2.23	2.79	3.67	2.20	2.85	3.67
June	2.83	4.25	5.43	2.68	4.23	5.34
July	5.07	5.83	6.35	4.57	5.78	6.77
Aug	5.30	6.31	7.31	5.33	6.20	7.18
Sept	5.24	6.09	7.19	5.21	5.93	7.12
Oct	3.74	4.94	5.70	3.86	4.94	5.76
Nov	2.17	2.75	3.36	2.27	2.97	3.72
Dec	1.62	1.88	2.23	1.73	1.95	2.46
Jan	1.30	1.47	1.66	1.38	1.56	2.11
Feb	1.13	1.33	1.49	1.22	1.40	1.62
Mar	1.30	1.43	1.67	1.23	1.51	1.83

Source: NERP

Table A.5 (Cont'd): Mean Monthly Water Level (m PWD)

Month	Gauge 274 Meghna at Narsingdi		
	Minimum	Mean	Maximum
Apr	1.52	1.86	2.32
May	2.01	2.59	3.27
June	2.63	3.73	4.71
July	4.23	5.06	5.86
Aug	4.79	5.52	6.50
Sept	4.58	5.31	6.38
Oct	3.43	4.37	5.07
Nov	2.02	2.66	3.26
Dec	1.47	1.78	2.23
Jan	1.23	1.38	1.66
Feb	1.12	1.27	1.44
Mar	1.14	1.36	1.62

Table A.6: Flood Depth Category for Various Return Period

Location/Units	Flood Depth in ha				
	F0	F1	F2	F3	Total
1:2 Year Monsoon Floods					
Old Lakhya	14699	4300	1050	350	20399
Binabaid	780	1100	900	1200	3980
Shibpur Area	18700	4500	2000	1000	26200
Total:	34179	9900	3950	2550	50579
1:5 Year Monsoon Floods					
Old Lakhya	13899	3500	2200	800	20399
Binabaid	680	700	800	1800	3980
Shibpur Area	17200	4800	3000	1200	26200
Total:	31779	9000	6000	3800	50579
1:10 Year Monsoon Floods					
Old Lakhya	11399	5400	2700	900	20399
Binabaid	480	710	790	2000	3980
Shibpur Area	15700	5500	3000	2000	26200
Total:	27579	11610	6490	4900	50579

Table A.7: Water Bodies in the Project Area

Thana	Total number of ponds	Combined pond area (ha)	Average pond size (ha)	Pond concentration (nos/km^2)	Beel Area (ha)
Old Lakhuya	1420	179	0.12	7.63	63
Binabaid	874	107	0.12	7.17	75
Shibpur	1569	198	0.12	6.76	49
Total	3836	484	0.12		187

Table A.8: Ground Water Recharge
(Narsingdi District Development Project)

Thana	Proj. fraction	Duty ha/Mm^3	Usable Recharge, Mm^3			Available Recharge, Mm^3		
			STW	DSSTW	DTW	STW	DSSTW	DTW
Katiadi	0.08	152	0.00	0.80	4.52	0.00	0.53	2.98
Bajitpur	0.03	136	0.00	0.16	1.25	0.00	0.13	1.04
Kuliarchar	0.35	156	0.46	2.07	9.84	0.46	2.07	9.84
Bhairab	0.09	135	0.00	1.34	5.76	0.00	1.21	5.18
Kapasia	0.08	138	0.69	1.19	3.55	0.52	0.91	2.71
Narshingdi	0.05	145	0.10	0.62	2.74	0.06	0.40	1.76
Palash	0.61	144	1.83	4.27	13.73	1.53	3.58	11.50
Shibpur	1.00	147	0.00	13.00	65.50	0.00	11.50	57.95
Monohardi	1.00	150	0.00	15.90	80.90	0.00	11.99	61.03
Belabo	1.00	161	1.40	8.80	50.00	1.32	8.32	47.25
Raipura	0.35	148	0.81	7.74	27.58	0.63	6.04	21.53
Total:			**5.28**	**55.88**	**265.36**	**4.53**	**46.66**	**222.77**

A.9: Present (AST 1991) Irrigation Statistics

Thana	Project Fraction	STW		DSSTW		DTW		MOSTI		LLP		Traditional (ha)
		(ha)	Number	(ha)	Number	(ha)	Number	(ha)	Number	(ha)	Number	
Kapasia	0.08	144	32	0	0	20	1	16	91	122	11	82
Belabo	1.00	2653	796	0	0	327	32	62	365	322	37	585
Monohordi	1.00	4575	864	0	0	1638	107	209	1393	212	16	764
Narsingdi	0.05	159	32	0	0	97	4	0	1	71	7	27
Palash	0.61	519	102	0	0	412	19	4	17	511	41	585
Raipura	0.35	2410	592	0	0	103	10	11	62	891	107	64
Shibpur	1.00	3966	836	0	0	1664	97	147	816	425	33	511
Bajitpur	0.03	76	12	0	0	44	3	0	0	77	5	31
Bhairab	0.09	293	55	0	0	9	1	0	1	85	8	37
Katiadi	0.08	362	66	0	0	134	7	11	95	49	3	42
Kuliarchar	0.35	1283	248	0	0	277	16	9	66	77	10	163
Total		**16441**	**3634**	**0**	**0**	**4726**	**297**	**469**	**2909**	**2842**	**278**	**2891**

Table A.10: Water Balance, Binabaid Unit

Iteams	Unit	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Rainfall	mm	8	20	57	145	280	395	382	322	286	162	31	10
Storage	ha-m	32	80	227	577	1114	1572	1520	1282	1138	645	123	40
Data :													
ETO	mm	103.99	123.02	172.45	188.03	175.18	137.66	138.46	140.37	129.28	132.42	113.09	100.09
KC factor		1.2	1.25	1.25	1.2	1.1	1.1	0.95	1.1	1.1	1.1	1.1	1.15
Deep Percolation	mm	77.5	70	77.5	75	31	30	0	0	0	0	30	62
Loses:													
Boro, 2246 ha	ha-m	280	345	484	507								
Aus, 593 ha	ha-m				134	114	90	78					
Aman, 2526 ha	ha-m								390	359	368	314	291
ETO (natural)	ha-m	119	140	197	215	200	157	158	160	148	151	129	114
Deep Percolation	ha-m	308	279	308	299	123	119	0	0	0	0	119	247
Total Loss:	ha-m	707	764	989	1154	438	366	236	550	507	519	563	652
Accumu Storage	ha-m	-676	-685	-763	-577	677	1206	1284	731	632	126	-439	-612

Table A.11: Design and Volume Estimates

Location	Distance (km)	Ground Elevation (m PWD)	Design Height (m PWD)	Embankment Height (m)	Volume (m3)
Old Brahmaputra at Arial Khan offtake (Katiadi)	0.0	9.8	9.89	0.10	0
	1.0	9.6	9.86	0.25	826
	2.0	8.4	9.83	1.44	6245
	3.0	8.1	9.79	1.71	12930
	4.0	6.6	9.76	3.20	26921
	5.0	6.4	9.73	3.32	40495
	6.0	6.6	9.70	3.14	39846
	7.0	6.6	9.66	3.10	37640
	8.0	6.6	9.63	3.07	37000
	9.0	6.9	9.60	2.73	33516
	10.0	6.7	9.57	2.82	31164
	11.0	6.3	9.53	3.28	36424
	12.0	6.6	9.50	2.94	37530
	13.0	6.6	9.47	2.91	33883
	14.0	5.8	9.44	3.67	41454
	15.0	5.9	9.41	3.55	47949
	16.0	5.7	9.37	3.67	47908
	17.0	6.0	9.34	3.39	46222
	18.0	4.7	9.31	4.61	57968
	19.0	5.6	9.28	3.63	60589
	20.0	5.8	9.24	3.45	46410
	21.0	6.0	9.21	3.26	42439
	22.0	6.6	9.18	2.62	34407
Old Brahmaputra at Arial Khan outfall (Belabo)	23.0	8.2	9.15	0.91	17133
	24.0	8.9	9.11	0.21	3467
	25.0	9.0	9.08	0.08	677
	26.0	9.2	9.05	-0.13	-78
			Average Height	2.48	820964
Arial Khan Offtake (Katiadi)	0.0	6.3	9.89	3.46	0
	1.0	7.7	9.84	2.15	32769
	2.0	7.9	9.79	1.86	18664
	3.0	9.8	9.74	-0.05	8178

Table A.11 (Cont'd): Design and Volume Estimates

Location	Distance (km)	Ground Elevation (m PWD)	Design Height (m PWD)	Embankment Height (m)	Volume (m3)
	4.0	7.7	9.69	2.00	9188
	5.0	6.7	9.64	2.93	26276
	6.0	6.3	9.59	3.34	38031
	7.0	7.5	9.54	2.01	30372
	8.0	7.2	9.49	2.32	21037
	9.0	6.0	9.45	3.43	33775
	10.0	5.1	9.40	4.27	53942
	11.0	4.7	9.35	4.61	68352
	12.0	7.2	9.30	2.13	46664
	13.0	7.2	9.25	2.08	20017
	14.0	7.0	9.20	2.18	20421
Arial Khan Outfall (Belabo)	15.0	7.7	9.15	1.49	16552
	16.0	7.7	9.10	1.44	11629
	17.0	7.6	9.05	1.42	11235
			Average Height	2.39	467103
Barachapra Project	1.0	8.7	9.89	1.19	0
	2.0	8.7	9.94	1.24	8921
	3.0	9.3	9.99	0.68	6621
	4.0	9.6	10.03	0.42	3168
	5.0	9.6	10.08	0.47	2422
	6.0	9.9	10.13	0.22	1810
	7.0	9.9	10.18	0.26	1172
	8.0	9.6	10.23	0.62	2447
High lands above Motkhola	9.0	9.6	10.28	0.67	3770
	10.0	9.9	10.32	0.41	3058
	11.0	11.1	10.42	-0.71	195
			Avegare Height		33584
				Grand Total:	1321650

Table A.12: Estimated Capital and O & M Costs

Item of Works	Quantity	Unit	Unit Price (tk)	Capital Cost (mtk)	O&M (%)	O&M Costs (mtk)
Full Flood Embankment	758600	m^3	37.44	22.7	6	1.36
Fine Dressing and Turfing	762000	m^2	3.04	2.3	1	0.02
Drainage Channel Re-excavation	1600000	m^3	25.74	41.2	3	1.24
Regulators:						
Two Vent (1.52m*1.63m)	3	unit	5000000	15.0	2	0.30
Land Acquisition	86	ha	200000	17.2		-
Project Buildings	-	-	-	-	3	-
BASE COST:				98.4		2.9
Physical Contingency 25%				24.6		0.73
SUB_TOTAL:				123.0		3.65
Engg & Admin 15%				18.58		0.55
TOTAL:				141.5		4.2
NET AREA (ha):				38155		
UNIT COST (Tk/ha):				3708		

Source : NERP

ANNEX B

FISHERIES MODEL

ANNEX B: FISHERIES MODEL

This annex briefly describes the model used to analyze fisheries impacts for the project.

The openwater fishery ecosystem is extremely complex. Impacts on production are assessed here using a highly simplified model. The limitations of the model mirror the limitations of the current understanding of and information about the system.

The major system processes about which some insight exists are:

- Migration access and timing. It seems to be accepted that:
  - a multiplicity of access points is desireable (i.e. that closing any or some channels is still deleterious,
  - the most important channels are those at the downstream end of the system (that with flood onset, fish mainly migrate upstream and onto the floodplain, and downstream out of the beels into the river), and
  - delay of flooding, as in partial flood control schemes, is highly disruptive

- Overwintering (dry season) habitat extent.

- Wet season habitat (floodplain grazing extent and duration). [It is expected that production also varies as a function of land type (F1, F2, F3) — probably such that shallower (F1, F2) land is more productive than deeper (F3) land — but as data to show this has been lacking it has been neglected from the model.]

- Habitat Quality. Habitat quality would include water quality, vegetation, and other conditions (presence of preferred types of substrate e.g. rocks, sand, brush). Water quality would appear to be most relevant during low volume/flow periods, and during the time of flood onset and recession when contaminants can disperse or accumulate.

- Spawning. Production outside the project area can also be impacted if habitats suitable for spawning within the project are adversely affected. It is believed that most of the region's fish production stems from spawning occurring in: mother fishery areas, which are those exhibiting extensive, well-interconnected, and varied habitats with good water quality; key beels; and river duars. Duars are somewhat a separate problem as they are located in rivers and larger channels, not on the floodplain.

The foregoing is represented quantitatively here as:

FWO production =

$$(R_0 * P_{R0}) + (B_0 * P_{B0}) + (W_0 * P_{W0})$$

FW production =

$$[M * Q * (R_1 * P_{R0})] + [M * Q * (B_1 * P_{B0})] + [M * (W_1 * P_{W0})]$$

Thus,

Impact = FW - FWO production =

$$\{ [(M * Q * R_1) - R_0] * P_{RO} \} +$$

$$\{ [(M * Q * B_1) - B_0] * P_{BO} \} +$$

$$\{ [(M * W_1) - W_0] * P_{WO} \}$$

where

sub-0 and sub-1 refer to FWO and FW respectively

R, B, and *W* are river/channel, beel, and floodplain (F1+F2+F3) areas, in ha

P is the unit FWO production in kg/ha for the respective habitats. Estimated regional average values are 175, 410, and 44 respectively.

M is the FW quality-weighted migration access remaining, relative to FWO conditions (range 0 to 1 for negative impacts, >1 for positive impacts)

Q is the FW acceptability of habitat/water quality relative to FWO conditions (range 0 to 1 for negative impacts; >1 for positive impacts).

A_M is the area of mother fishery and key beels affected times a factor (range 0 to 1 for negative impacts, >1 for positive impacts) reflecting the degree of degradation/enhancement

T is the estimated annual regional fish production attributable to spawning exported from mother fisheries/key beels (a constant of 50,000 tonnes, which is 50% of the total regional fish production of 100,000 tonnes)

A_T is the estimated regional mother fishery/key beel area (a constant of 100,000 ha).

Estimated values for this project are shown in Table B.1. Where standard values, established for the region or for a particular project type, are used, this is noted. Comments on project-specific values are also shown.

Table B.1: Fisheries Parameters

Var	Value	Stnd value?	Comments
M	1.0	0.8	Migration routes rehabilitated; water linkages with Meghna and Lakhya Rivers will be re-activated
Q	1.0	1.0	Water quality is expected to improve since drainage system will be re-activated
R_0	1700		
R_1	1742		About 90 km drainage channels will be re-excavated
B_0	187		
B_1	187		
W_0	14010		
W_1	13510		
P_{R0}	175	175	
P_{B0}	410	410	
P_{W0}	44	22	Based on NERP field estimates
A_M	—	100000	There is no "mother fishery" in this area.

ANNEX C

INITIAL ENVIRONMENTAL EXAMINATION

ANNEX C: INITIAL ENVIRONMENTAL EXAMINATION

C.1 Introduction

This Initial Environmental Examination (IEE) (pre-feasibility level Environmental Impact Assessment or EIA) follows the steps specified in the *Bangladesh Flood Action Plan Guidelines for Environmental Impact Assessment* (ISPAN, 1992). These steps are illustrated in Figure 2 of ISPAN (1992).

Much of the information required for the IEE/EIA appears in the main body of the study. The section and chapter references given below cite this information.

C.2 Alternative 1: Proposed Flood Control and Drainage Improvement Project

C.2.1 Project Design and Description (Step 1)

As in Section 7.3, Project Description.

C.2.2 Environmental Baseline Description (Step 2)

As in Chapter 2, Biophysical Description, and Chapter 3, Settlement, Development, and Resource Management.

C.2.3 Scoping (Step 3)

Technical:

Literature review: Presented in Chapter 4, Previous Studies.

Local community: As described in Section 3.1.9, People's Perception.

C.2.4 Bounding (Step 4)

Physical:

Gross area: 50,600 ha.
Impacted (net) area: 38010 ha.
Impacted area outside project: No adverse impact outside the project area.

Temporal:

Preconstruction: years 0 through year 3 (see Table 7.6).
Construction: year 1 through year 3 (see Table 7.6).
Operation: year 3 through year 20.
Abandonment: after year 20.

Cumulative impacts:

With other floodplain infrastructure: With project upland flooding to the existing projects (Barachapa and Kanchikata Khal projects) will be reduced. Existing Kakon Nadi project will also get better drainage facilities.
With pre-existing no-project trends. Described in Chapter 5.

C.2.5 Field Investigations (Step 5)

Field investigations were limited to seven to ten days of informal reconnaissance by a multi-disciplinary team.

20

C.2.6 Impact Assessment (Step 6)

At this level of detail, a screening matrix (Table C.1) was filled out by the project team. Impacts are designated by:

+	positive impact
-	negative impact
•	neutral impact (such as conversion from one productive land use to another)
?	insufficient information to designate

Impacts are discussed in Section 7.8.

C.2.7 Quantify and Value Impacts (Step 7)

Quantification and evaluation of impacts is documented in Section 7.7, 7.8 and Tables 7.8, 7.9, and 7.11 through 7.13.

C.2.8 Environmental Management Plan (Step 8)

At a pre-feasibility level, this section focuses on "identification of broad management options and major constraints" (p. 28, ISPAN, 1992).

Mitigation and enhancement. Documented in Section 7.3.

Compensation. Mandated requirements for land acquisition must be adhered to. Beyond this, consideration should be given to:

- In-kind rather than cash compensation for households whose homestead land is taken.

- Compensation for persons other than landowners who are impacted negatively by land acquisition and construction/infrastructure-related land use changes. Example: project implementation could be made contingent upon successful resettlement of squatters displaced from embankment/structure sites under local initiative; local communities could work with NGOs to accomplish this.

Monitoring. There is a need to define monitoring needs and methodologies at regional, institutional (BWDB), and projects levels. This exercise should reflect (i) the need for greater people's participation in all project activities, which would include monitoring project function and opportunities for discussion with BWDB and (ii) the need for greater emphasis on operation and maintenance, of which monitoring can play an important role.

People's participation. There is a need at regional, institutional, and project levels to maintain enthusiasm for people's participation, and to develop effective and efficient public participation modalities.

Disaster management (contingency planning). Once the flood protection is operational, investment in agriculture will likely rise. This increases the total amount of farmers' assets that are at risk should an extreme flood event occur or the embankment fail for any reason. Currently in Bangladesh, these risks are borne by individual investors (in this case farmers). Unsustainable solutions (such as government subsidy of crop insurance) should be avoided however.

EMP institutionalization. Arrangements for sharing EMP responsibility between BWDB and local people would need to be worked out. Project implementation should be contingent upon agreement on this matter between BWDB and local people.

Residual impact description. This should be generated as part of the feasibility-level EIA.

Reporting and accountability framework. At a national or regional scale, there is a need to develop satisfactory reporting/accountability arrangements involving BWDB and DOE, probably through an Environmental Cell within BWDB linked to DOE. At the project level, the client committee and local BWDB staff should develop reporting/accountability arrangements satisfactory to themselves. Project implementation should be contingent upon development of satisfactory arrangements at the local level, at a minimum.

Budget estimates. These should be generated as part of the feasibility study.

Environmental Screening Matrix

Screening matrix PHASE	Normal/ Abnormal	Activity / Important Environmental Component	Land Use	Agri-culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Preconstruction	Normal	Surveys & instrumentation: landmark, topographic, benchmark, hydrologic, climatic, socio-economic, land use, natural resource										
		Land acquisition										
		People's participation activities		+	+				+			
	Abnormal											
Construction	Normal	Site preparation: vegetation removal, infrastructure removal/relocation, resettlement, levelling, temporary structure installation (access roads, godowns, accommodations, garages and parking sites, cooking and eating facilities, waste disposal sites, water supply, drainage, sanitary facilities)							+			
		Canal excavation: labor and materials mobilization, crossdam construction, spoil transport, spoil disposal							+			
		Embankment construction: labor and materials mobilization, topsoil removal, soil taking and transport, compaction, turfing, paving							+			
		Structure (sluice gate, culvert, pump house, and so on) construction: labor and material mobilization, de-watering, excavation, pile driving, foundation works, structure construction, earthwork filling, turfing, paving										
		Tube well installation: boring, distribution facilities, electrification N/A										
	Abnormal	Suspension of construction before completion, construction delays		—	—				—			
		Incorrect construction practices or techniques										

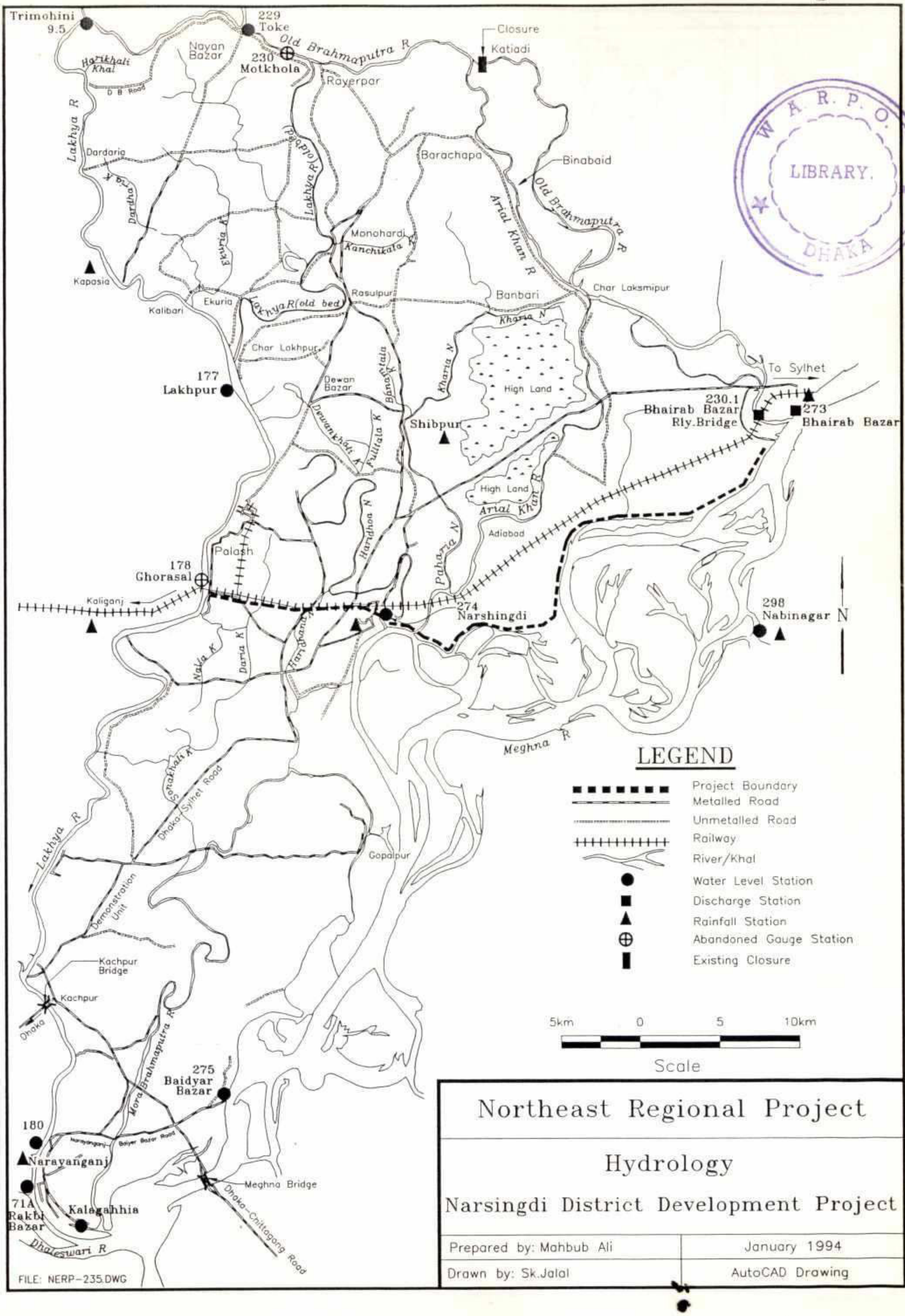
Environmental Screening Matrix

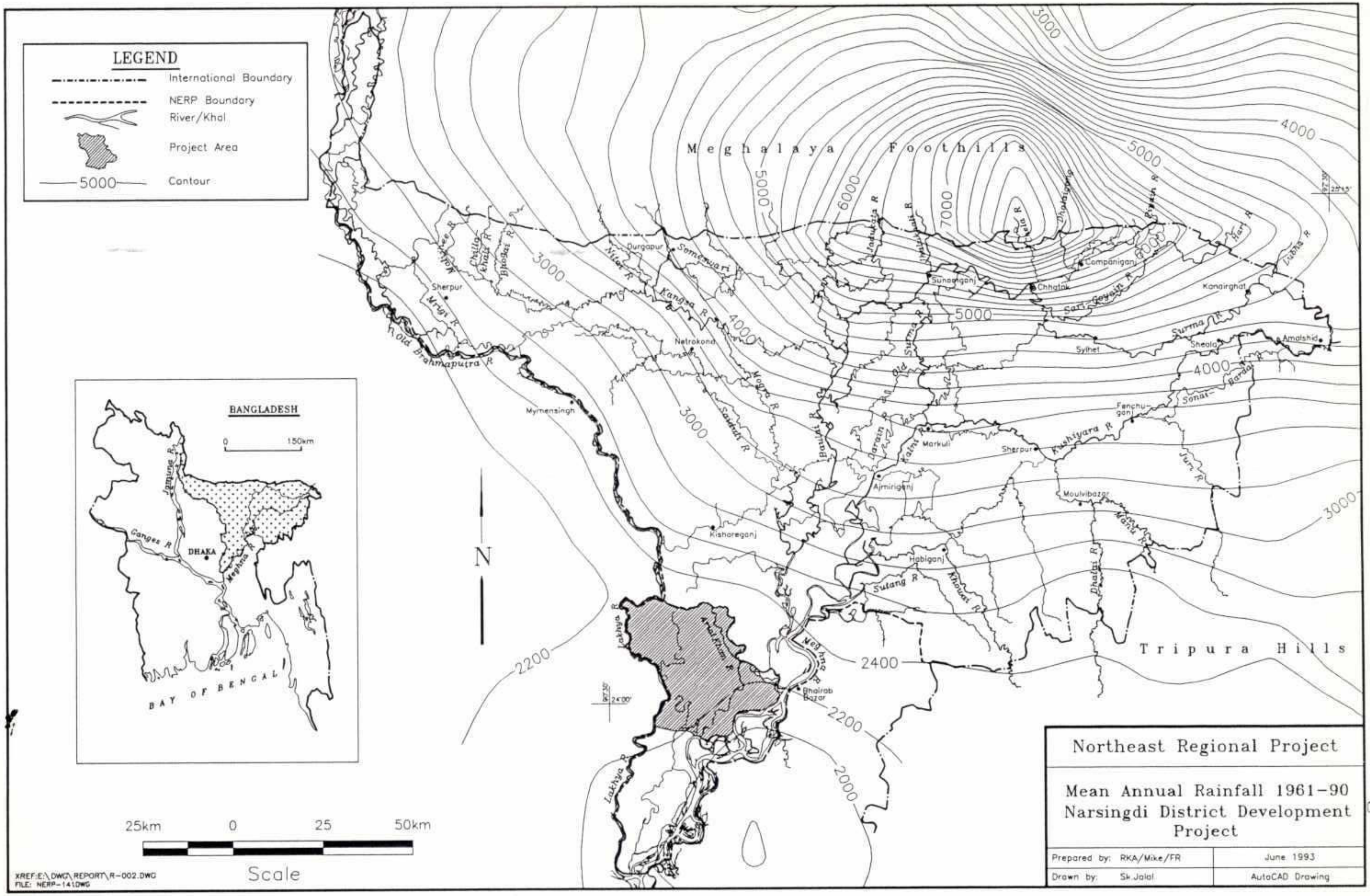
Screening matrix PHASE	Normal/ Abnormal	Activity	Important Environmental Component	Land Use	Agri-culture	Fisheries	Water Quality	Water Quantity	Human Health	Social Issues	Wild Plants & Animals	Hazards	Other
Construction (continued)	Abnormal (cont'd)												
Operation	Normal	Pre-monsoon flood protection			+	∓		+				+	
		Monsoon flood protection			+	±		+				+	
		Surface water irrigation	N/A		+								
		Ground water irrigation	N/A										
		Drainage		+	+	+		+					
		Agriculture: operation of institutions, extension, credit, seed distribution, fertilizer and pesticide storage and use, farmer groups						±		+			
		Water management: activities of BWDB, subproject implementation committee, local water user groups, structure committees and guards								+			
	Abnormal (relative to FWO, not FW normal)	Pre-monsoon flooding (due to extreme event, infrastructure failure)		−	−	±	−	−	−	−		−	
		Monsoon flooding (due to extreme event, infrastructure failure)		−	−	−	−	−	−	−		−	
		Embankment overtopping			−								
		Under- and over-drainage		−	−				−	−			
		Improper operation (public cuts, mistiming of scheduled O&M events etc)											
		Riverbed aggradation/degradation											
Abandonment	Normal	Re-occupation of infrastructure sites											
		Reclamation of materials											
	Abnormal												

ANNEX D

FIGURES

Figure 1


Trimohini
9.5
229
Toke
Closure
Katiadi
Nayan Bazar
Harikhali Khal
D B Road
230
Motkhola
Old Brahmaputra R
Rayerpar
Lakhya R
Dardaria
Barachapa
Binabaid
Old Brahmaputra R
Lakhya R (old bed)
Ekuria K
Monohardi
Kanchikata K
Arial Khan R
Kapasia
Rasulpur
Banbari
Char Laksmipur
Ekuria
Kalibari
Lakhya R (old bed)
Kharia N
Char Lokhpur
High Land
To Sylhet
177
Lakhpur
Dewan Bazar
230.1
Bhairab Bazar
Rly. Bridge
273
Bhairab Bazar
Shibpur
High Land
Arial Khan R
Adiabad
Palash
178
Ghorasal
Kaliganj
274
Narshingdi
298
Nabinagar
N
Paharia N
Haridhoa N
Naila K
Dara K
Meghna R
Lakhya R
Sonakhali K
Dhaka-Sylhet Road
Gopalpur
Demonstration Unit
Kachpur Bridge
Kachpur
Dhaka
Mora Brahmaputra R
275
Baidyar Bazar
180
Narayanganj
Narayanganj-Baidyar Bazar Road
Meghna Bridge
71A
Rakbi Bazar
Kalagachhia
Dhaleswari R
Dhaka-Chittagong Road
FILE: NERP-235.DWG
LEGEND
Project Boundary
Metalled Road
Unmetalled Road
Railway
River/Khal
Water Level Station
Discharge Station
Rainfall Station
Abandoned Gauge Station
Existing Closure
5km 0 5 10km
Scale
Northeast Regional Project
Hydrology
Narsingdi District Development Project
Prepared by: Mahbub Ali
January 1994
Drawn by: Sk.Jalal
AutoCAD Drawing



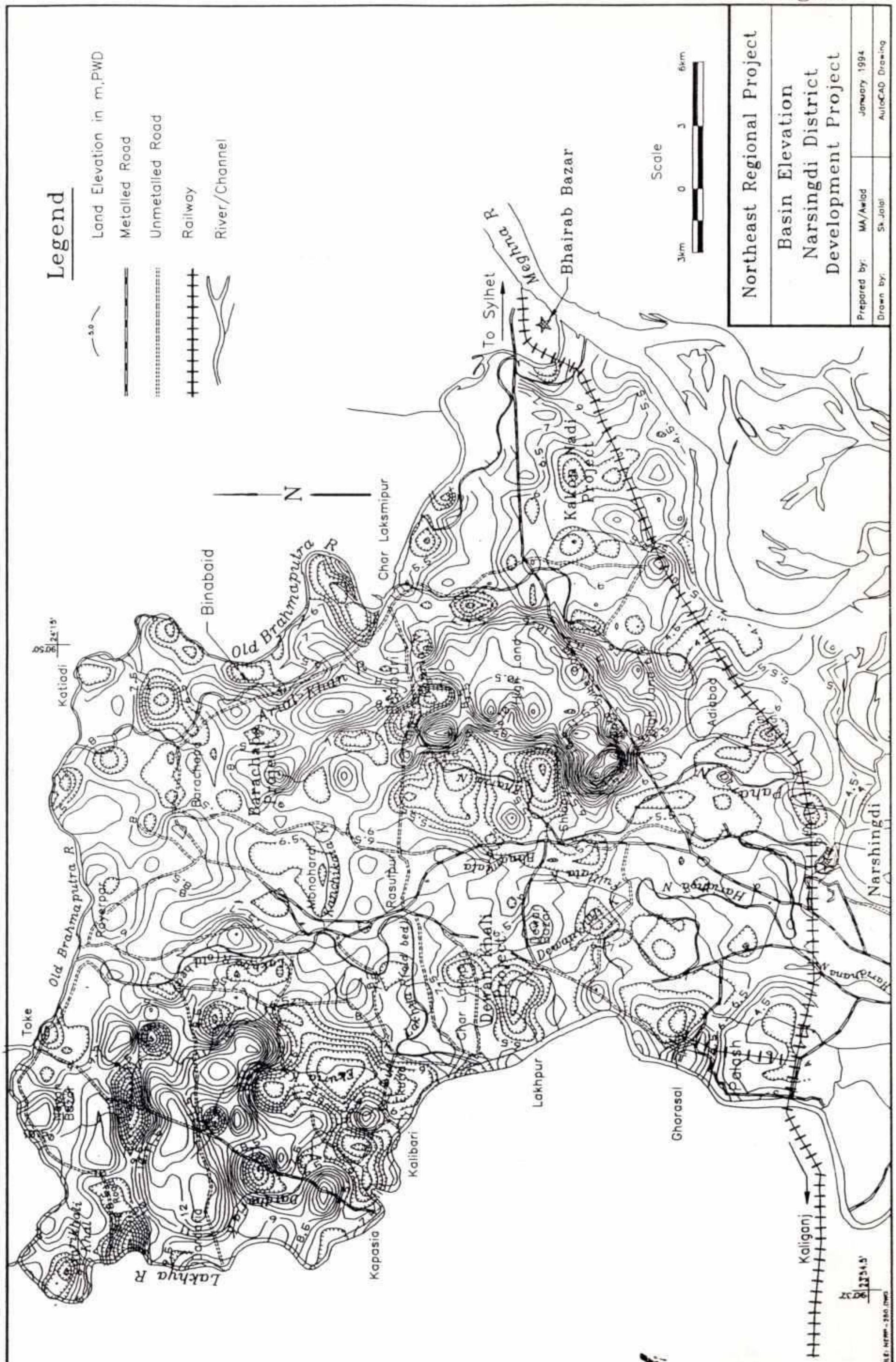
Northeast Regional Project

Mean Annual Rainfall 1961-90
Narsingdi District Development Project

Prepared by: RKA/Mike/FR	June 1993
Drawn by: Sk.Jalal	AutoCAD Drawing

Figure 2

Figure 3



Legend
Land Elevation in m.PWD
Metalled Road
Unmetalled Road
Railway
River/Channel
Scale
3km 0 3 6km
Northeast Regional Project
Basin Elevation
Narsingdi District
Development Project
Prepared by: MA/Awlad
January 1994
Drawn by: Sk.Jalal
AutoCAD Drawing
Old Brahmaputra R
Binabaid
Char Laksmipur
Katiadi
Toke
Lakhya R
Kapasia
Kalibari
Lakhpur
Ghorasal
Palash
Kaliganj
Narshingdi
Adiabad
Bhairab Bazar
To Sylhet
Meghna R
Rasulpur
Barachapa Project
Dewan Khali Project
Katera Nadi Project

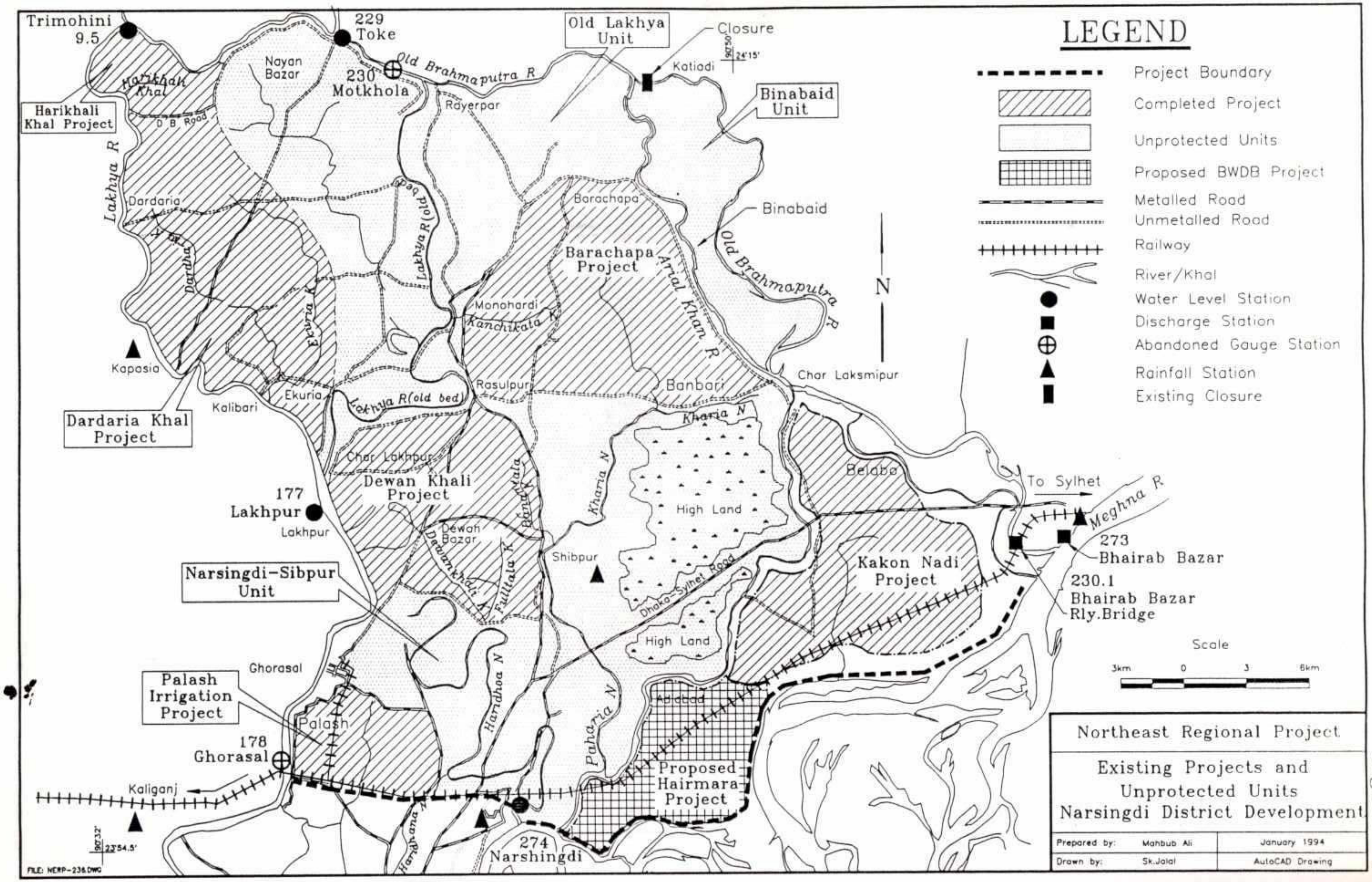

LEGEND
Project Boundary
Completed Project
Unprotected Units
Proposed BWDB Project
Metalled Road
Unmetalled Road
Railway
River/Khal
Water Level Station
Discharge Station
Abandoned Gauge Station
Rainfall Station
Existing Closure
N
Scale
3km 0 3 6km
Northeast Regional Project
Existing Projects and Unprotected Units Narsingdi District Development
Prepared by: Mahbub Ali
January 1994
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-238.DWG
Trimohini 9.5
229 Toke
230 Motkhola
Old Lakhya Unit
Closure
Katiadi
Binabaid Unit
Binabaid
Harikhali Khal Project
Nayan Bazar
Old Brahmaputra R
Rayerpar
D B Road
Lakhya R
Dardaria
Barachapa
Barachapa Project
Arial Khan R
Old Brahmaputra R
Lakhya R(old bed)
Monohardi
Kanchikata K
Kapasia
Ekuria
Rasulpur
Banbari
Char Laksmipur
Kalibari
Dardaria Khal Project
Lakhya R(old bed)
Kharia N
Char Lakhpur
Dewan Khali Project
Belabo
177 Lakhpur
Lakhpur
Dewan Bazar
Dewankhali
Fullala K
Kharia N
High Land
To Sylhet
Meghna R
273 Bhairab Bazar
230.1 Bhairab Bazar Rly.Bridge
Shibpur
Dhaka-Sylhet Road
Kakon Nadi Project
Narsingdi-Sibpur Unit
High Land
Ghorasal
Palash Irrigation Project
Palash
Haridhoa N
Paharia N
Abidbad
178 Ghorasal
Proposed Hairmara Project
Kaliganj
Haridhana N
274 Narshingdi

Figure 4

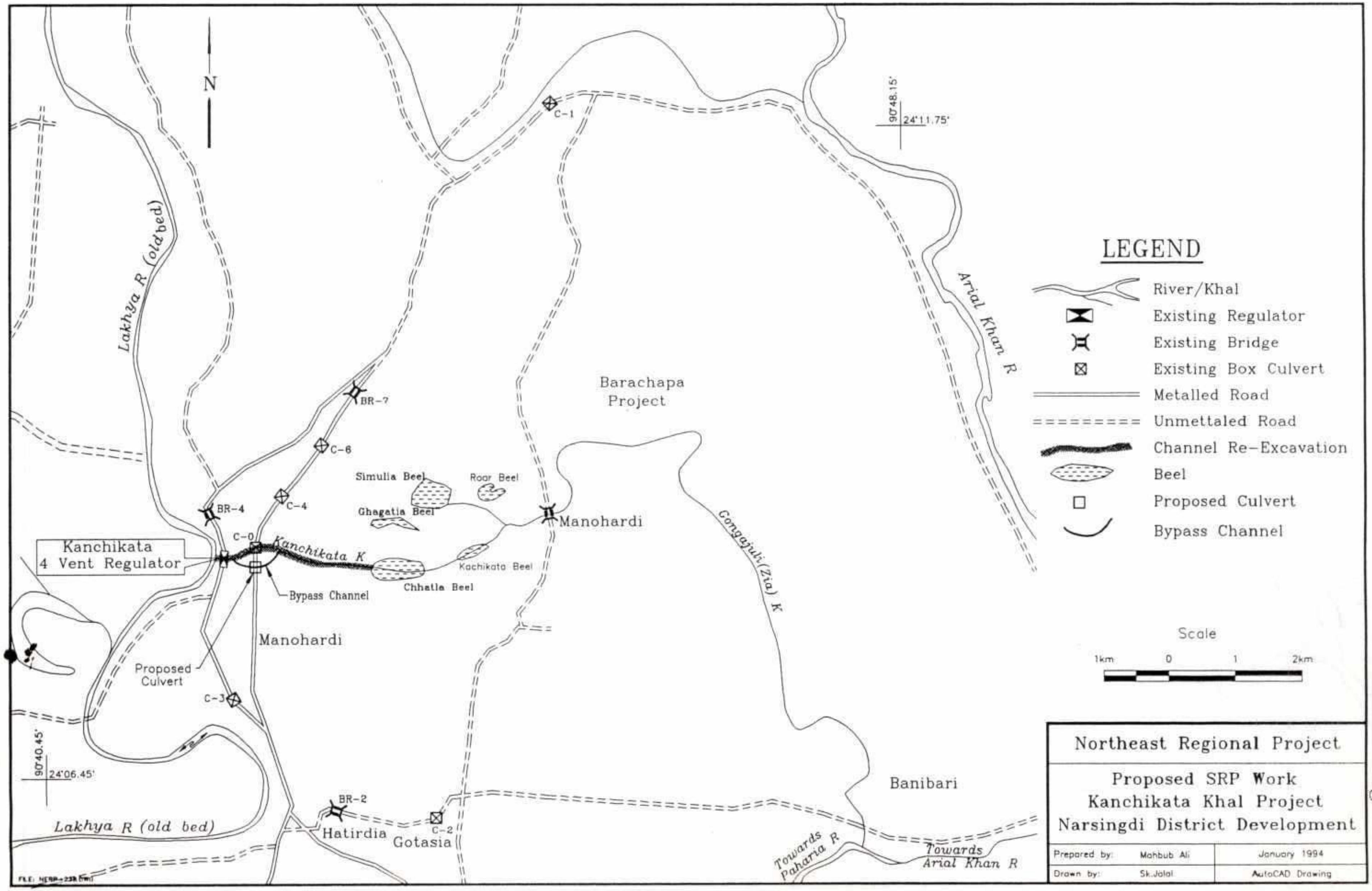
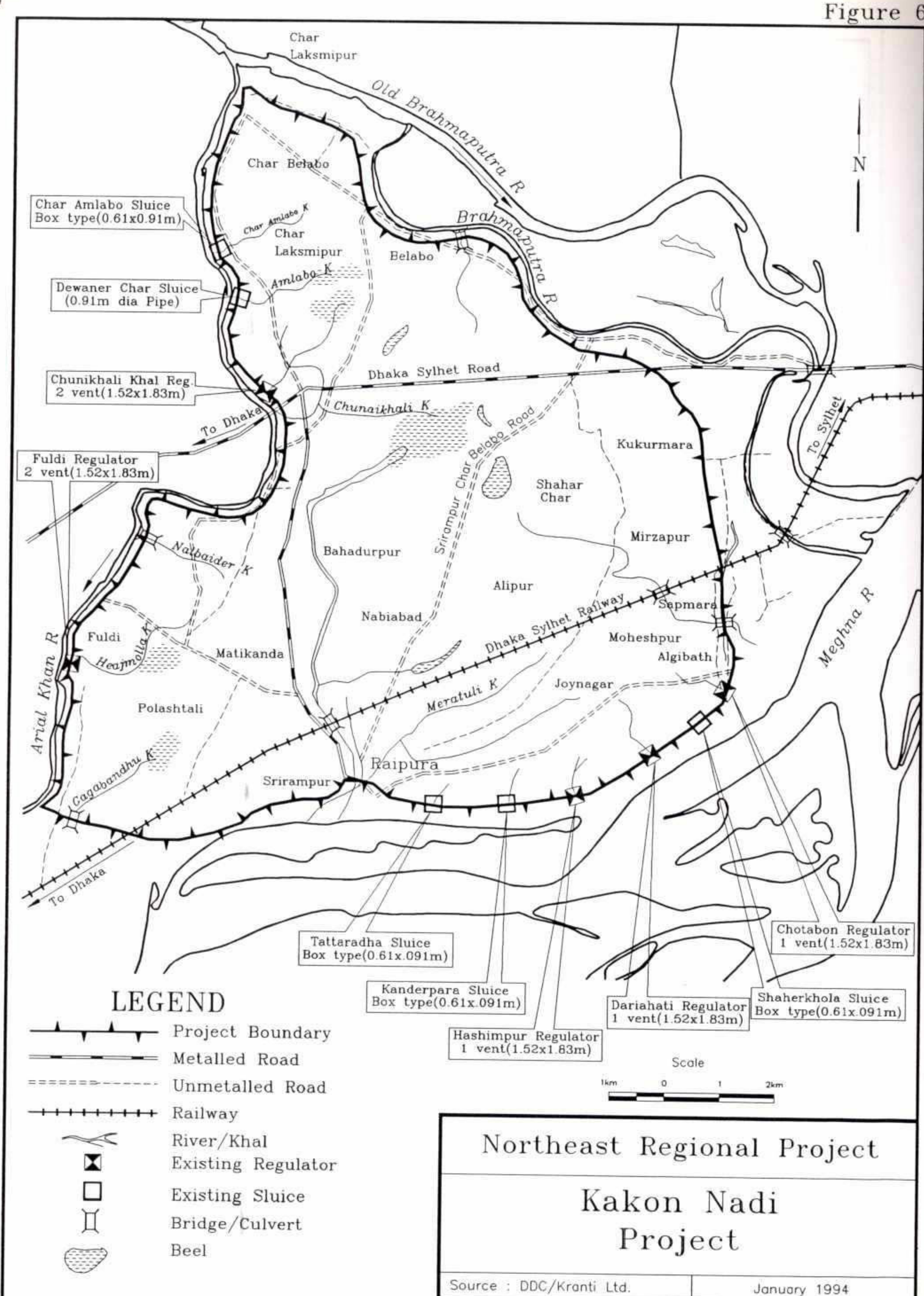

N
Lakhya R (old bed)
Kanchikata
4 Vent Regulator
BR-4
C-0
Kanchikata K
Bypass Channel
Manohardi
Proposed Culvert
C-3
BR-7
C-6
C-4
C-1
Simulia Beel
Roar Beel
Ghagatia Beel
Chhatla Beel
Kachikata Beel
Manohardi
Barachapa Project
Gongajuli (Zia) K
Arial Khan R
90°48.15'
24°11.75'
90°40.45'
24°06.45'
BR-2
C-2
Hatirdia
Gotasia
Lakhya R (old bed)
Banibari
Towards Paharia R
Towards Arial Khan R
LEGEND
River/Khal
Existing Regulator
Existing Bridge
Existing Box Culvert
Metalled Road
Unmettaled Road
Channel Re-Excavation
Beel
Proposed Culvert
Bypass Channel
Scale
1km 0 1 2km
Northeast Regional Project
Proposed SRP Work
Kanchikata Khal Project
Narsingdi District Development
Prepared by: Mahbub Ali
January 1994
Drawn by: Sk.Jalal
AutoCAD Drawing

Figure 5

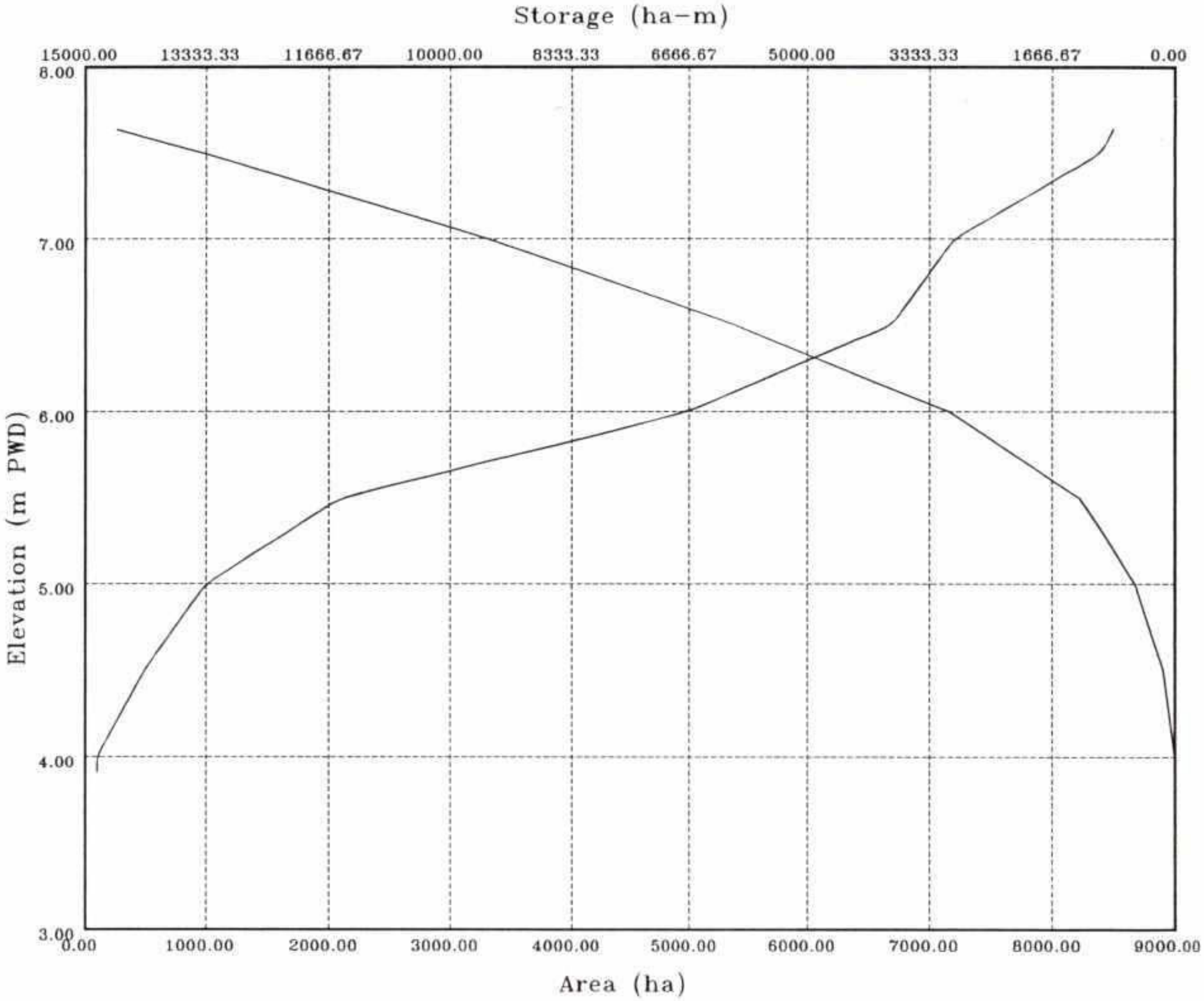
Figure 6



Northeast Regional Project	
Kakon Nadi Project	
Source : DDC/Kranti Ltd.	January 1994
Drawn by: Sk.Jalal	AutoCAD Drawing

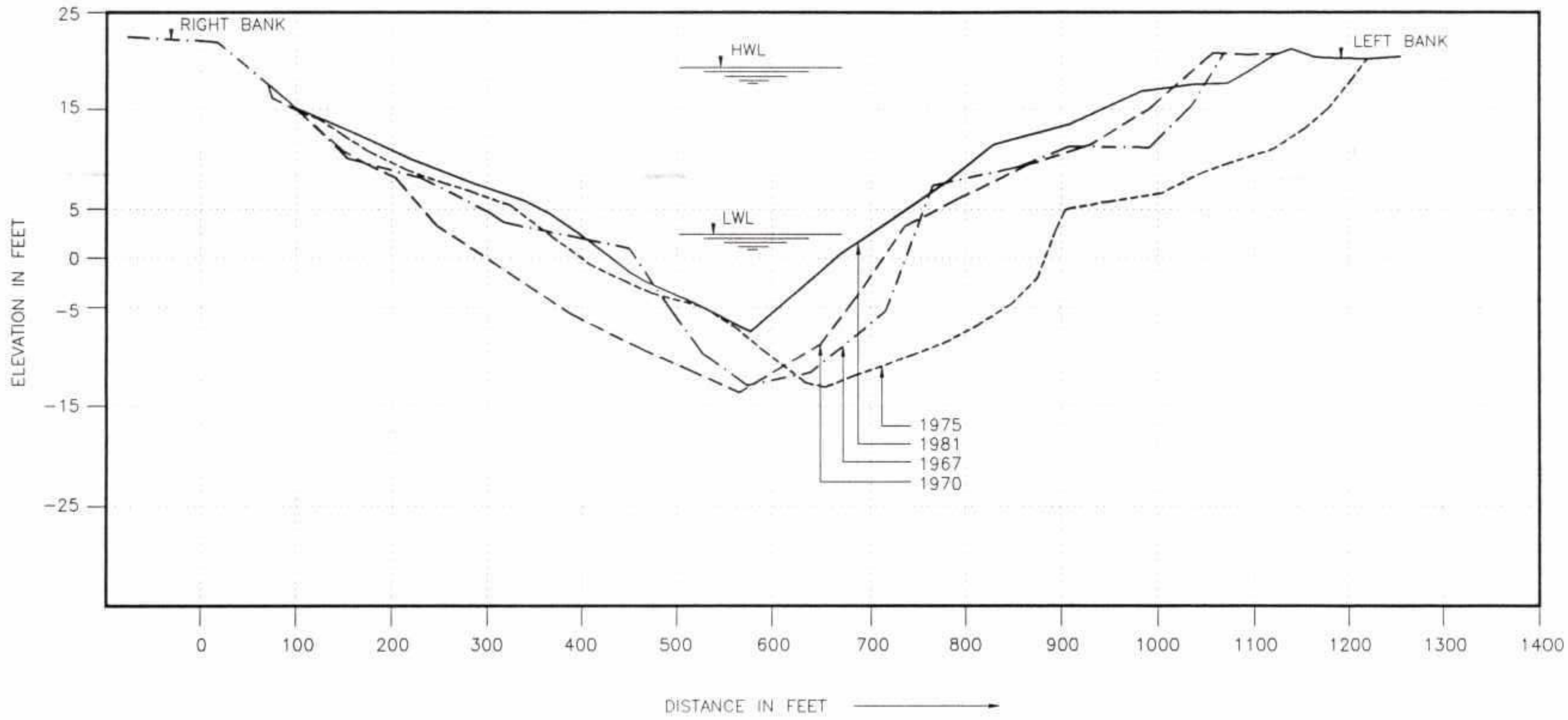
Figure 7

AREA ELEVATION AND STORAGE VOLUME CURVE
KAKON NADI PROJECT



Data:

Elevation (m PWD)	3.91	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	7.64
Area (ha)	99.903	99.903	499.515	999.031	2097.964	4995.153	6693.505	7193.020	8391.857	8491.760
Volume (ha−m)	0.000	8.991	158.846	533.482	1307.731	3081.010	6003.175	9474.806	13371.025	14552.879



SOURCE:MPO(IWTA Hydrographic Survey Map)

Northeast Regional Project

Cross Section of Lakhya River at Demra

Prepared by:	MA	January 1994
Drawn by:	Mamun	AutoCAD Drawing

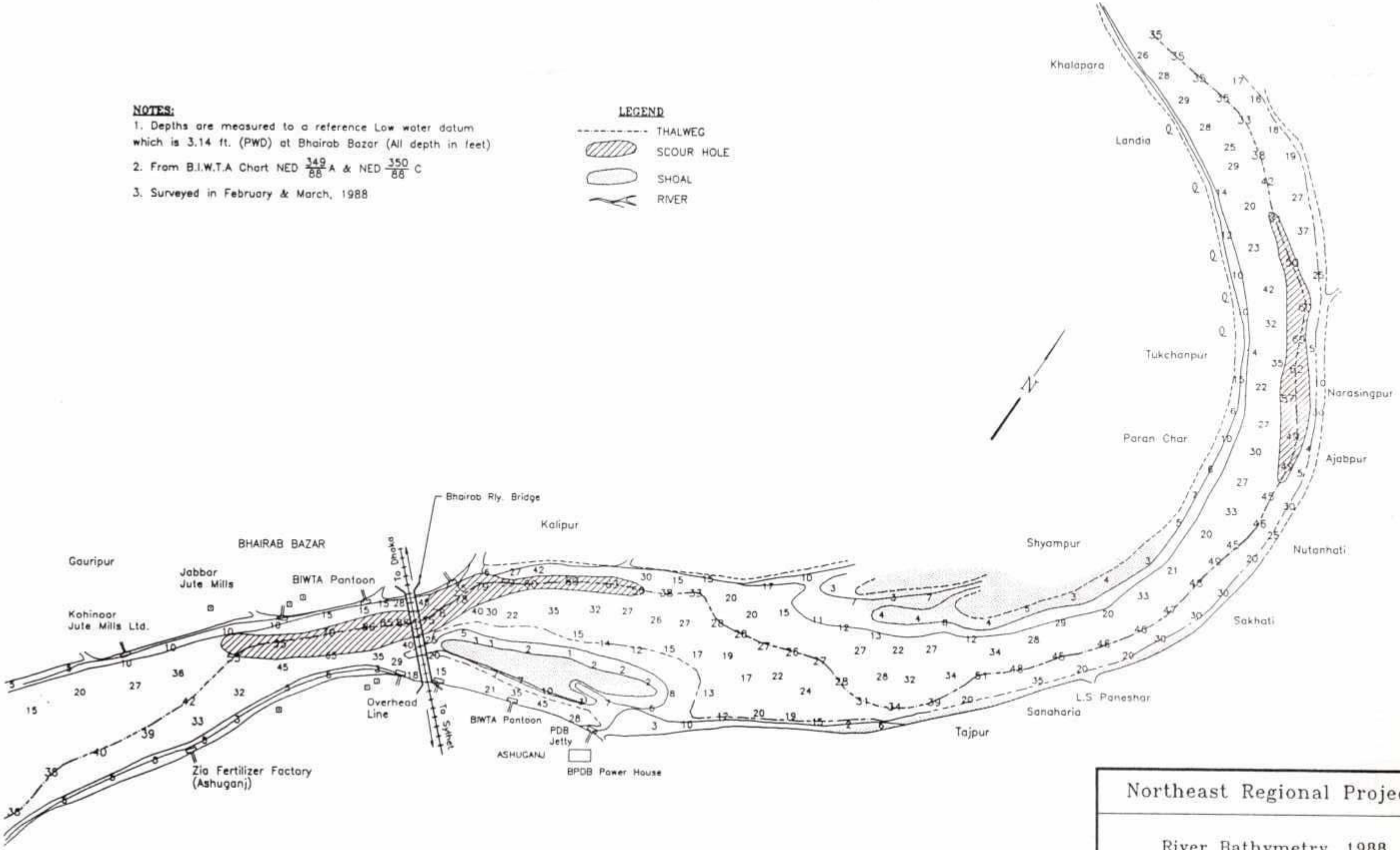
FILE: NERP-769.DWG

Figure 8

Figure 9

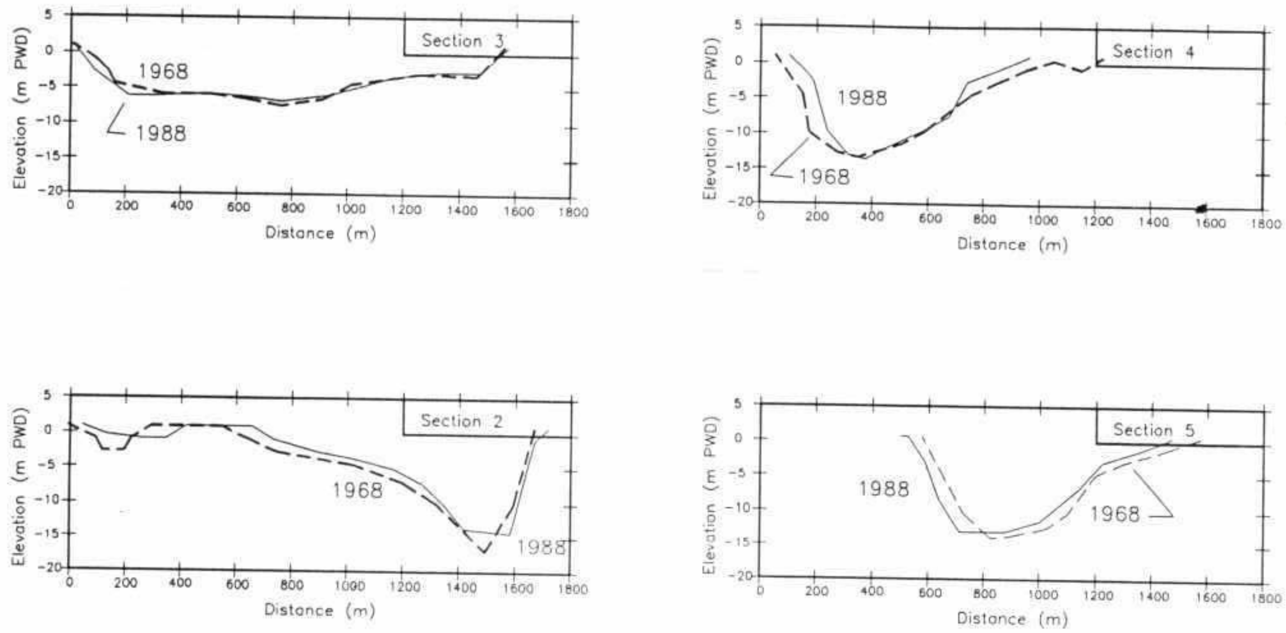
NOTES:

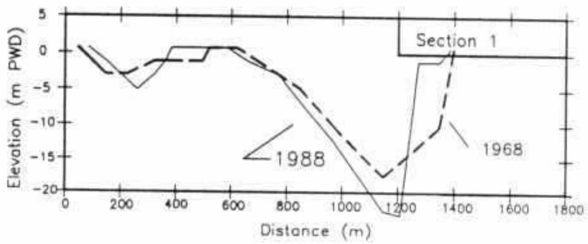
1. Depths are measured to a reference Low water datum which is 3.14 ft. (PWD) at Bhairab Bazar (All depth in feet)
2. From B.I.W.T.A Chart NED $\frac{349}{88}$ A & NED $\frac{350}{88}$ C
3. Surveyed in February & March, 1988

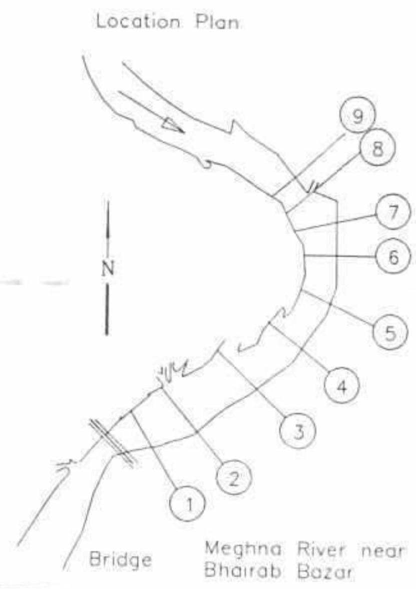


Northeast Regional Project			
River Bathymetry, 1988 Meghna River Near Bhairab Bazar			
Prepared by:	MA	January 1994	
Drawn by:	Mamun	AutoCAD Drawing	

FILE: NERP-77.DWG







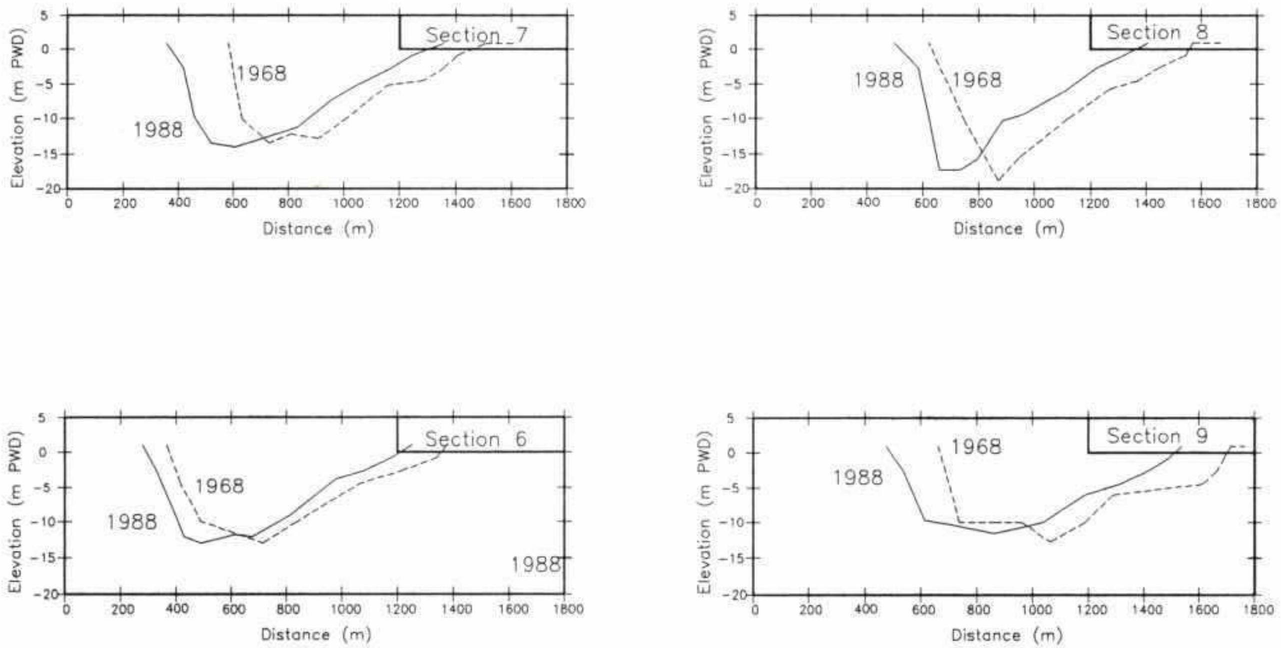
Notes:
1. All cross sections viewed downstream
2. Cross sections surveyed by BIWTA
3. Bed level information based on BIWTA navigation chart S 118/68 D and S 349/88A

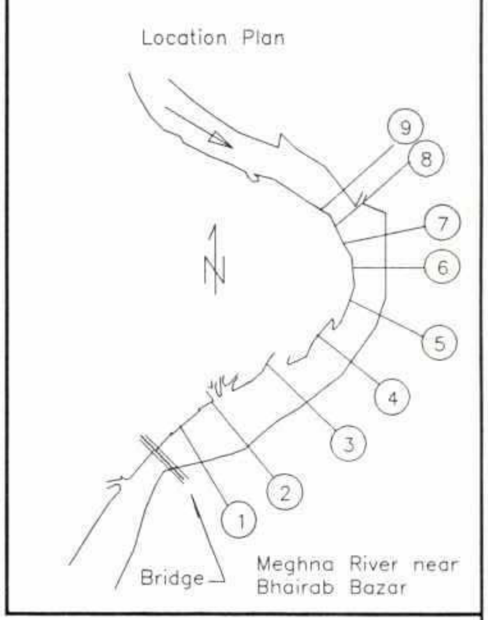
Northeast Regional Project			
Morphological Studies Meghna River (Sections 1 to 5)			
Prepared by:	DMc	January 1994	
Drawn by:	Momun	AutoCAD Drawing	

Figure 10

FILE: NERP-767.DWG

Figure 11





Notes:
1. All cross sections viewed downstream
2. Cross sections surveyed by BIWTA
3. Bed level information based on BIWTA navigation chart S 118/68 D and S 349/88A

Northeast Regional Project			
Morphological Studies Meghna River (Sections 6 to 9)			
Prepared by:	DMc	January 1994	
Drawn by:	Mamun	AutoCAD Drawing	

FILE: NERP-788.DWG

207

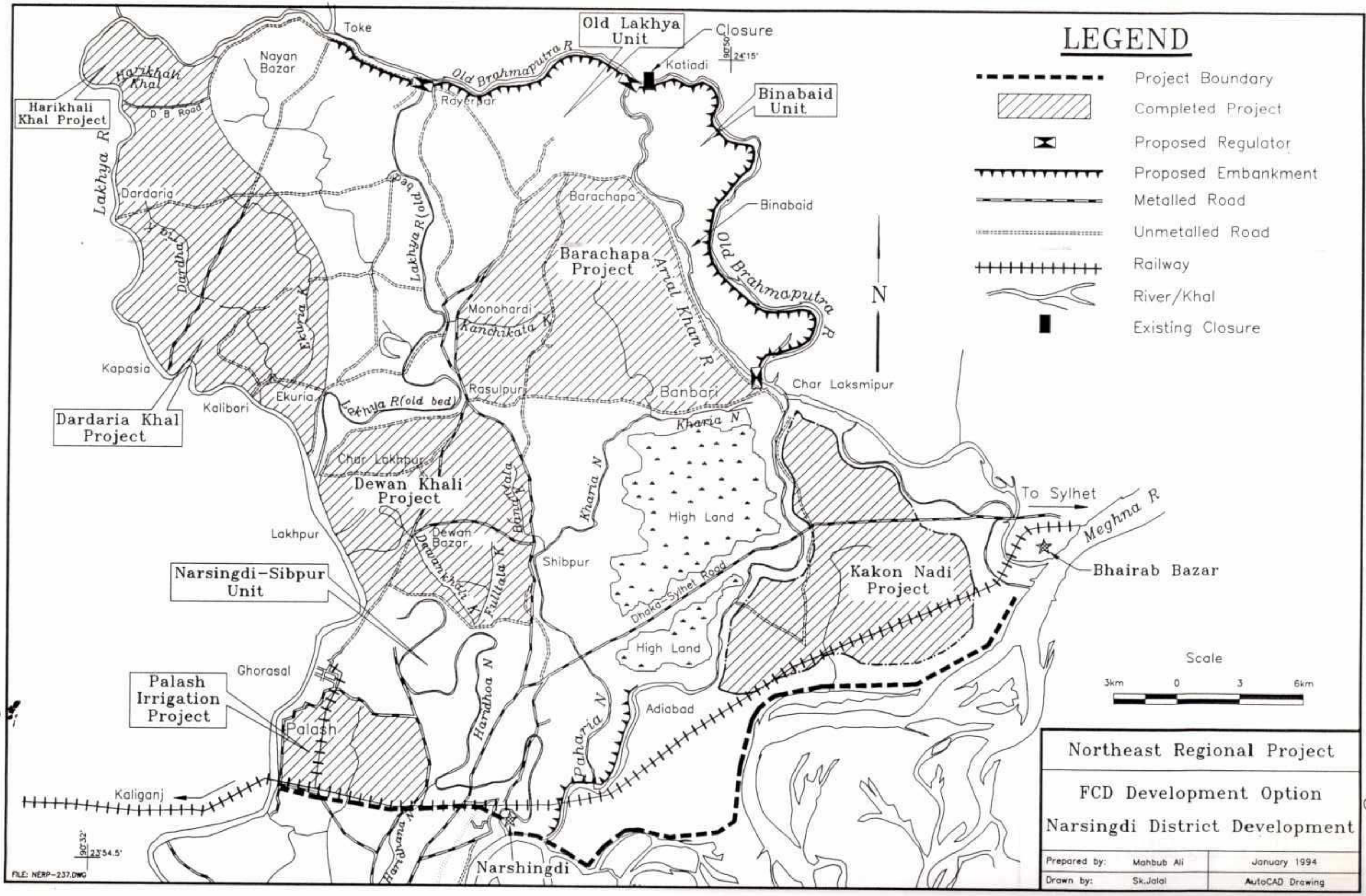
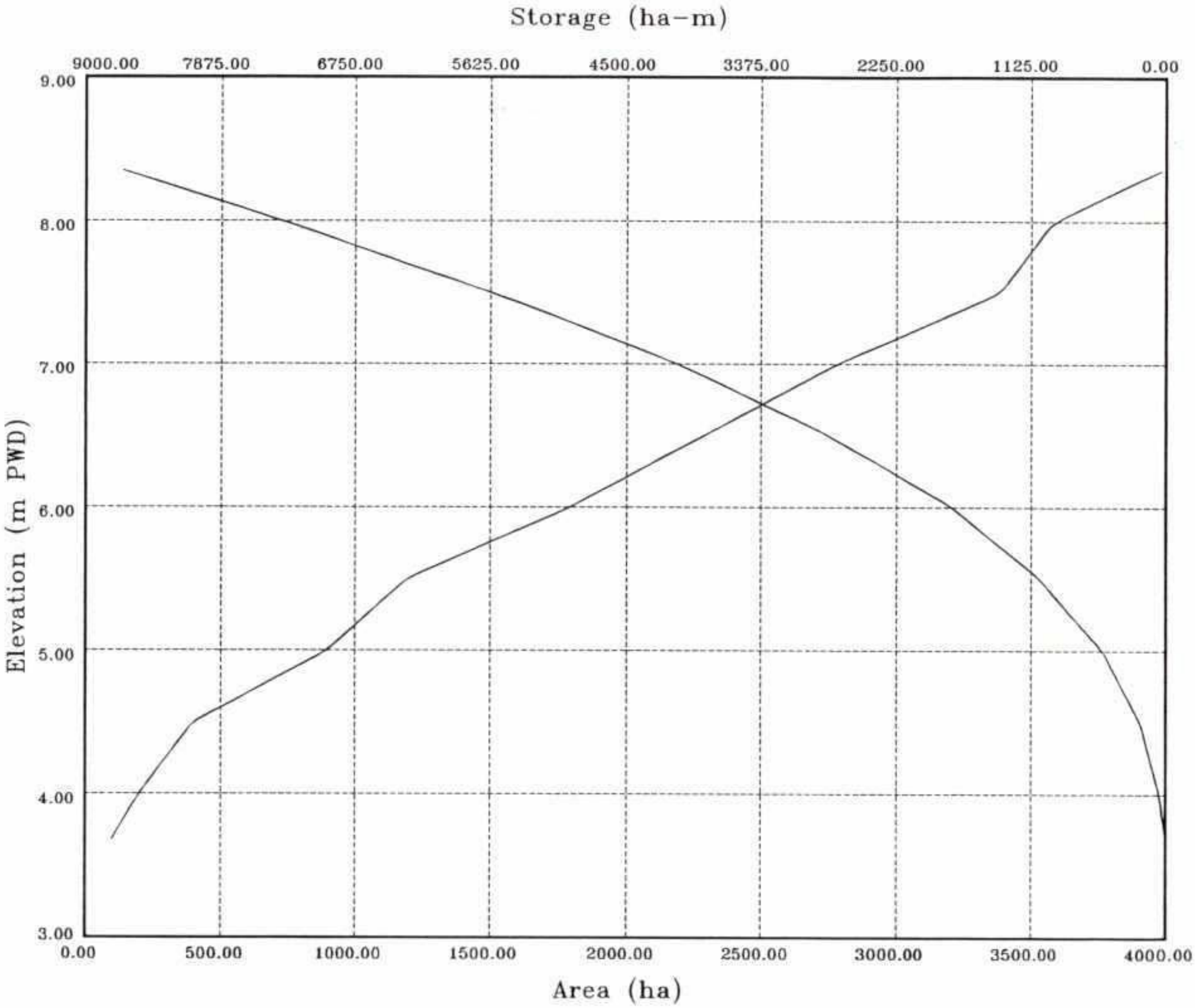


Figure 12

AREA ELEVATION AND STORAGE VOLUME CURVE

BINABAID UNIT



Data:

Elevation (m PWD)	Area (ha)	Volume (ha−m)
3.68	99.566	0.000
4.00	199.132	47.792
4.50	398.264	197.141
5.00	896.094	520.730
5.50	1194.792	1043.452
6.00	1792.188	1790.197
6.50	2290.018	2810.748
7.00	2787.848	4080.215
7.50	3385.244	5623.488
8.00	3584.376	7365.893
8.35	3982.640	8690.120

Figure 14

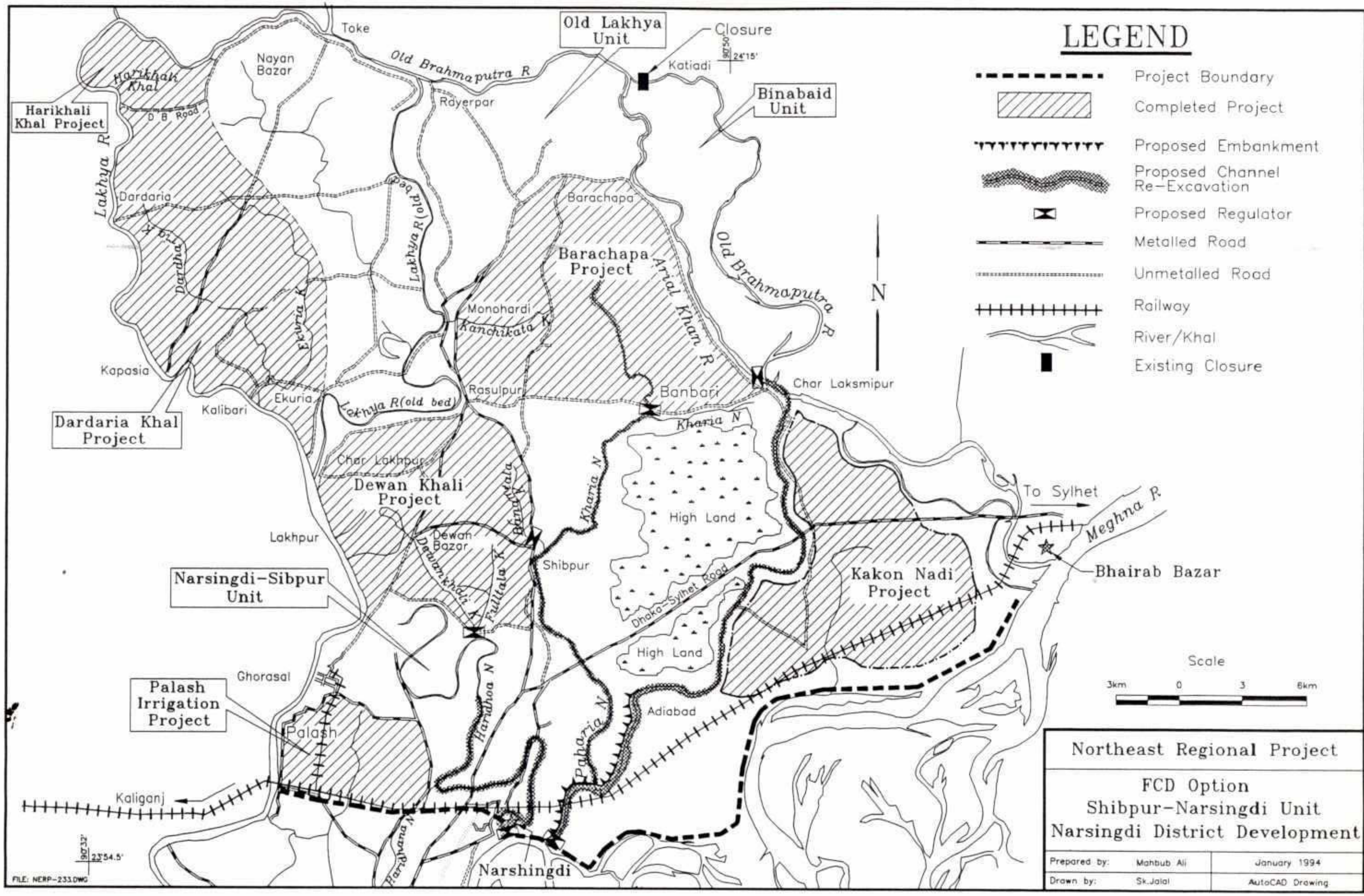
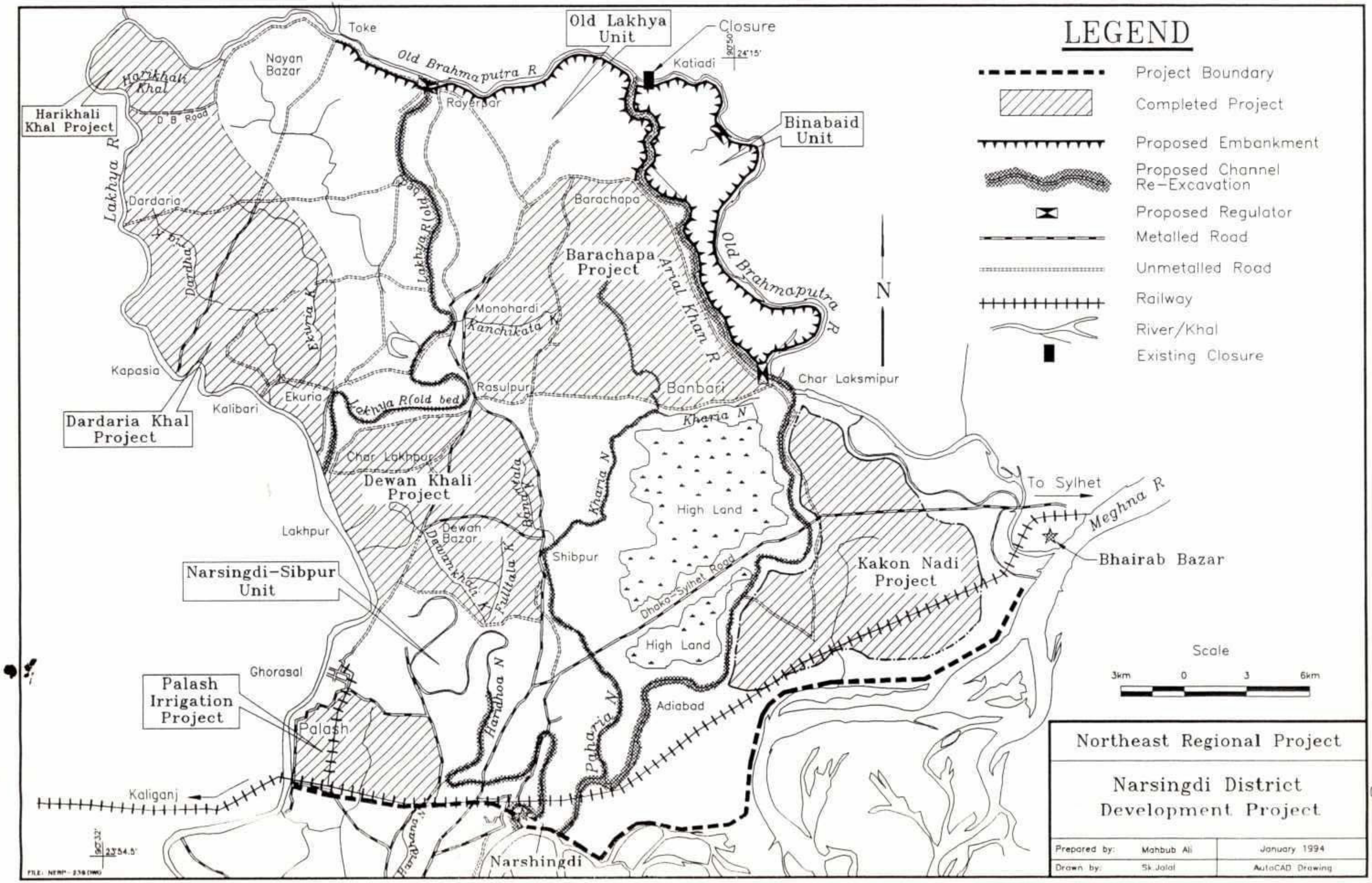

LEGEND
Project Boundary
Completed Project
Proposed Embankment
Proposed Channel Re-Excavation
Proposed Regulator
Metalled Road
Unmetalled Road
Railway
River/Khal
Existing Closure
N
Scale
3km 0 3 6km
Old Lakhya Unit
Closure
Katiadi
Binabaid Unit
Harikhali Khal Project
Dardaria Khal Project
Barachapa Project
Dewan Khali Project
Narsingdi-Sibpur Unit
Palash Irrigation Project
Kakon Nadi Project
Toke
Nayan Bazar
Old Brahmaputra R
Rayerpar
Harikhali Khal
D B Road
Lakhya R
Dardaria
Dardha K
Ekuria K
Kaposia
Ekuria
Kalibari
Lakhya R(old bed)
Monohardi
Kanchikata K
Rasulpur
Barachapa
Arial Khan R
Old Brahmaputra R
Char Laksmipur
Banbari
Kharia N
Char Lakhpur
Lakhpur
Dewan Bazar
Dewan khali K
Fulltala K
Banartala K
Shibpur
High Land
Dhaka-Sylhet Road
Ghorasal
Palash
Haridhoa N
Paharia N
Adiabad
Kaliganj
Haridhana N
Narshingdi
To Sylhet
Meghna R
Bhairab Bazar
Northeast Regional Project
FCD Option
Shibpur-Narsingdi Unit
Narsingdi District Development
Prepared by: Mahbub Ali
January 1994
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-233.DWG

Figure 15



LEGEND
Project Boundary
Completed Project
Proposed Embankment
Proposed Channel Re-Excavation
Proposed Regulator
Metalled Road
Unmetalled Road
Railway
River/Khal
Existing Closure
N
Scale
3km 0 3 6km
Northeast Regional Project
Narsingdi District Development Project
Prepared by: Mahbub Ali
January 1994
Drawn by: Sk Jalal
AutoCAD Drawing
Old Lakhya Unit
Closure
Katiadi
Binabaid Unit
Toke
Nayan Bazar
Old Brahmaputra R
Rayerpar
Harikhali Khal
D B Road
Harikhali Khal Project
Lakhya R
Dardaria
Dardaria K
Ekuria K
Lakhya R(old bed)
Barachapa
Barachapa Project
Arial Khan R
Monohardi
Kanchikata K
Rasulpur
Banbari
Char Laksmipur
Kharia N
Kapasia
Ekuria
Kalibari
Dardaria Khal Project
Char Lakhpur
Dewan Khali Project
Dewan Bazar
Dewankhali K
Fulltala K
Banartala K
High Land
Shibpur
Lakhpur
Narsingdi-Sibpur Unit
Dhaka-Sylhet Road
To Sylhet
Meghna R
Bhairab Bazar
Kakon Nadi Project
Ghorasal
Palash Irrigation Project
Palash
Haridhoa N
Paharia N
Adiabad
Kaliganj
Narshingdi
Haridhana N
FILE: NERP - 236.DWG