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)

NARAYANGANJ-NARSINGDI FLOOD CONTROL AND DRAINAGE PROJECT

PRE-FEASIBILITY STUDY

Draft Final
February 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
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ACRONYMS AND ABBREVIATIONS

BBS	Bangladesh Bureau of Statistics
BFRSS	Bangladesh Fisheries Resource System Survey
BMD	Bangladesh Meteorological Department
BRDB	Bangladesh Rural Development Board
BWDB	Bangladesh Water Development Board
DAE	Department of Agricultural Extension
DPHE	Department of Public Health Engineering
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 Planning Organization
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
WASA	Water and Sewerage Authority

US $1 = Tk 38

MPO Land Classification Terminology

Class F0	Land inundated to a depth of less than 0.3 m
Class F1	Land inundated to a depth of between 0.3 m - 0.9 m
Class F2	Land inundated to a depth of between 0.9 m - 1.8 m
Class F3	Land inundated to a depth of more than 1.8 m
Class F4	Land inundated to a depth of more than 1.8 m and on which deepwater aman cannot be grown

EXECUTIVE SUMMARY

The districts of Narayanganj and Narsingdi are urbanized and densely populated, and include the Dhaka-Sylhet and the Dhaka-Chittagong corridors. Further urbanization and integration with the Dhaka mega-urban centre is expected.

In four of the last 10 years, floods from the Meghna and Lakhya Rivers have swept over the Narayanganj-Narsingdi area forcing thousands of people out of their dwellings, and causing extensive damage to infrastructure, agriculture, and aquaculture. The high floods overtop and damage the main roads linking Dhaka with Sylhet, Narsingdi, and Chittagong.

The purpose of this project is to protect homesteads and infrastructure from the monsoon floods of the Meghna and Lakhya Rivers, to promote development of high value and diversified agriculture, and to increase production of HYV monsoon season rice for the expanding Dhaka market.

There is a general public demand to provide the area with full flood protection and pump drainage and irrigation, modelled on the completed JICA Pilot scheme of the Narayanganj-Narsingdi Irrigation Project.

This study includes a comparative preliminary analysis of developments based on full flood control with (1) pump drainage and irrigation, and (2) with gravity drainage. The analysis showed that the pump drainage and irrigation option is economically less attractive, mainly because of high capital costs.

The solution proposed for this area is the completion of high flood embankments along the boundary rivers incorporating gravity drainage/flushing structures as required, and re-excavation of internal channels to improve drainage and availability of irrigation water.

At present, the existing high flood embankments and road/railway embankments cover 66 km of the total 108 km of the project boundary. To improve drainage and to complete embanking of the area the following works are required:

- construction of new embankments 42 km
- upgrading of road embankments 20 km
- re-excavation of channels 115 km
- construction of embankment structures:
  - pipes sluices 14
  - RCC Box Regulators 9
  - Navigation Lock/Regulator 1

The project would be implemented by BWDB at an estimated cost of about US$ 15.2 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 Kishoerganj 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
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
Surma-Kushiyara-Baulai Basin Project
Kushiyara-Bijna Inter-Basin Development Project
Dharmapasha-Rui Beel Project
Updakhali River Project
Sarigoyain-Piyain Basin Development

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1. INTRODUCTION

1.1 General Information

BWDB Division:	Dhaka O&M Division II
District:	Gazipur, Narsingdi, Narayanganj
Thanas:	Under Gazipur District: Kaliganj Under Narsingdi District: Narsingdi, Palash Under Narayanganj District: Araihazar, Badar, Rupganj, Shonargaon
MPO Planning Area:	18, 30
Gross Area:	40,560 ha
Net Area:	34,832 ha
Population:	781,482
Households	144,642

1.2 Scope and Methodology

This pre-feasibility study was undertaken intermittently over a period of four 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 economist. The Rapid Rural Appraisal (RRA) technique was followed for collecting primary data.

1.3 Data Base

Project analyses presented in this document was based mainly on secondary data supplemented by information obtained during field inspections and discussions with project area residents. Information and data sources used by the various analysts are as listed below.

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

Agricultural analysis: Data used from secondary sources included Land Resources Appraisal for Agricultural Development in Bangladesh (AEZ Reports) for soils and Water Resources Planning Organization (WARPO) for agricultural inputs. This being a pre-feasibility level study, Rapid Rural Appraisal (RRA) techniques were followed for collecting primary data on cropping pattern by land type, crop damage, and trends. An agronomist, accompanied by a multidisciplinary team, followed several traverses across the different land types in the project area. Groups of farmers were interviewed on each land type and information was collected on cropping patterns

and crop damage. This information was used to estimate cropping patterns by land type on a percentage basis. This was then used to compute areas under different cropping patterns on each land type developed by superimposing water level data on the area-elevation curve. Likewise data on crop damage were computed. Data on yield level of different crops both for damaged and damage-free conditions were collected and used in computing present production. Views of farmers were considered in making future projections for both future without (null option) and with project conditions.

***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 in Sylhet in June, 1992 and in Narsingdi in April, 1993.

***Wetland analysis*:** Topographic maps, local revenue department records, personal field observations and interviews with local people, and the *Wetland Specialist Study, NERP*.

***Socio-economic analysis*:** Published BBS data on demographic features, education and agriculture; reports of the Directorate of Public Health and Engineering, and the NERP data base on Population and Human Development, personal field observation and field interviews with various cross-sections of local people, the opinions and suggestions from various local level representatives including NGO personnel and the Honourable Members of the 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 directed towards water resource development in the area and Chapter 5 lists trends which are occurring and which will continue if no interventions are made. Chapter 6 reviews the water resource development options which were considered and Chapter 7 provides an analysis of the best (recommended) option. The annexes provide detailed information in support of the main body of the report.

2. BIOPHYSICAL DESCRIPTION

2.1 Location

The Narayanganj-Narsingdi Project Basin covers a gross area of 40,560 ha in Gazipur, Narsingdi and Narayanganj districts, between latitude 23° 35' and 23° 57' N, and longitude 90° 31' and 90° 44' E. The project area boundaries are defined by the Tongi-Narsingdi Railway line to the north, and by the Lakhya River to the east and by the Meghna River to the east (see Figure 1).

This study does not include the already developed Narayanganj-Narsingdi Irrigation Project area of about 4,300 ha (Block A-1 and Demonstration Unit) located in the west central part of the proposed Narayanganj-Narsingdi Project.

2.2 Climate

The project area experiences the sub-tropical monsoon climate typical of Bangladesh, but with variations due to its location and topography. Rainfall is the most significant and variable aspect of the climate, causing severe floods and flooding in summer and a shortage of water in some areas in winter.

2.2.1 Variations in Annual Rainfall

The variation of annual rainfall over the project area is best represented by data from the four rain gauges around the project area. The locations of these rain gauges are given in Table A1, and the data for 1961-90 is presented in Table A2.

The data show that annual rainfall varies from an average of 1695 mm/year in the east to 2668 mm/year in the north, or by 57% within the project area.

A regional analysis of annual rainfalls (NERP, 1993) has shown that mean annual rainfall for 1961-90 was 10% greater than that for 1901-30, and that the variability of annual rainfalls for 1961-90 was 1.95 times that for 1901-30. These disturbing trends have been reflected in increased floods and flooding in recent years, but it is not known whether they will continue into the future, level off, or be reversed. Climate modelling research being undertaken in the West suggests these trends, particularly that in variability of the annual rainfalls, will continue in the decades ahead.

There are four more or less distinct seasons in the project area relative to the annual cycle of water resource activity which reflects the seasonal distribution of annual rainfall. The seasons are shown in Table 2.1.

The most distinctive climatic events of the year are the onset and withdrawal of the monsoon. In the project area onset occurs on average on 1 June plus or minus about 4 days, and withdrawal occurs on average on 7 October plus or minus about 14 days. The average duration of the monsoon is 122 days, but it has varied from 112 days to 139 days.

The seasonal distribution of annual rainfall is shown in Table 2.2.

Table 2.1: Definition of Seasons in the Project Area

Season	Activity	Calendar Period
Dry	Irrigation	December through March
Pre-Monsoon	Flash Floods	April and May
Monsoon	Flooding	June through September
Post-Monsoon	Drainage	October and November

Table 2.2: Seasonal Distribution of Rainfall in the Project Area

Season	Percent of Annual Rainfall in Project Area	
	South (Munshiganj)	North (Narsingdi)
Dry	3	4
Pre-Monsoon	21	22
Monsoon	69	66
Post-Monsoon	7	8
Year	100	100

These figures show that the rainfall is heavily concentrated in the monsoon season, but more so in the north than in the south, and that the dry season is slightly more intense in the south than in the north.

2.2.2 Climatological Averages and Extremes

The climate of the project area as a whole is best represented by data for Dhaka, the nearest BMD climatological station, located west of the project area. Data are available for 1950-92 (43 years). The averages are given in Table A3, and the extremes of record in Table A4.

Annual sunshine hours average 7.3 hours/day, and average monthly sunshine hours range from a minimum of 4.2 hours/day in July to a maximum of 8.6 hours/day in February.

The mean annual temperature is 26.1°C, and average monthly temperatures range from a minimum of 19.1°C in January to a maximum of 29.0°C in June and August.

Monthly mean minimum temperatures range from 12.2°C in January to 26.2°C in July/August, and extreme minimum temperatures on record range from 4.5°C in February to 22.0°C in September

.

Monthly mean maximum temperatures range from 25.5°C in January to 34.3°C in April, and extreme maximum temperatures have ranged from 31.2°C in December to 42.3°C in April.

The annual mean humidity is 77%, and monthly averages range from 64% in March to 87% in July.

The annual mean wind speed is 7.3 km/hour from the south. Monthly average wind speeds range from 5.4 km/hour to 10.8 km/hour; the extreme gust of record is 167 km/hour. Winds are generally from the south-southeast during the monsoon season, and vary between southeast and west-northwest in the other seasons.

The mean annual rainfall is 2121 mm. Average monthly rainfalls range from 8 mm in January to 385 mm in June, and monthly rainfalls have ranged from 0 mm in November through March to as much as 856 mm in June. The extreme daily rainfall of record is 326 mm.

Potential evapotranspiration averages 1654 mm/year, and ranges from 100 mm (3.2 mm/day) in December to 188 mm (6.3 mm/day) in April.

The project area water balance shows an annual excess of 760 mm which runs off into the river system or recharges the aquifers. The monthly water balance is positive in May through October and reaches up to 332 mm/month in June, but during November through April the balance is negative reaching as low as -124 mm in March. The winter surface moisture deficit is generally met from residual soil moisture until February after which a demand for irrigation normally arises.

2.3 Land (Physiography)

2.3.1 General Description

The Narayanganj-Narsingdi area occupies the lowland floodplains of the Meghna and Old Brahmaputra Rivers. There are some scattered terraces which are extension of the Madhupur Tracts from the north. The project area is bordered by the Meghna and Lakhya Rivers from their confluence in the south to the Tongi-Narsingdi Railway line in the north. The Mora Brahmaputra River flows through the middle of the basin from north to south. The boundary rivers have along their banks alluvial deposit ridges which are a few meters higher than the internal part of the basin. In a few places the higher ridges are composed of older red clays which extend into the internal part of the project, mainly in the northern and central parts. The average ground elevation varies from below 3 m PWD to above 10 m PWD.

The ground surface slopes from the east and west boundary rivers towards the internal khals emptying into the Mora Brahmaputra, which drains into the Meghna at the southern end of the basin. The general land slopes from north to south and is low-lying. Local depressions with ground elevation below 3.0 m PWD are present all across the basin. Several east-west drainage/spill khals connect the Lakhya and the Meghna Rivers with the Brahmaputra and other north-south channels in the basin.

The area is densely populated with villages located mainly on higher grounds along the boundary rivers and scattered in the interior part on elevated ridges and along roads.

Project topography is shown in Figure 3.

2.3.2 Soils

The project area is covered by the Old and Young Brahmaputra floodplains.

The part of the Old Brahmaputra floodplain which is in 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 occurs 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 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, and is a complex landscape of ridges, basins and beels crossed by numerous rivers and abandoned channels. The young meander floodplain, covering the project area, is less irregular in relief than the active floodplain. Grey silty soils predominate on the ridges and grey clays 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

A small area to the north of the Tongi-Narsingdi railway drains into the project basin. The hydrological regime of the area is governed by the Meghna and Lakhya Rivers which essentially surround the project.

Historically spills from the Old Brahmaputra were carried downstream through Haridhana Nadi into the Mora Brahmaputra River which is the main drainage channel of the basin. Presently the Haridhana channel is silted below the Tongi-Narsingdi Railway, and only the upper catchment of the Daria Khal (about 2640 ha) located north of the railway drains into the project basin.

The general basin runoff pattern is from north to south through the central drainage channels, the Mora Brahmaputra River and Sunakhali-Daria Khal. There are several khals flowing in an east-west direction which connect the Meghna and Lakhya Rivers with the interior of the basin. These khals act as drainage and spill channels, depending on the water levels in the boundary rivers.

During high stages and when the Meghna and Lakhya are rising the whole basin runoff, including the inflow from the rivers, drain into the Mora Brahmaputra. During low stages small parts of the basin drain into the boundary rivers through the lateral khals.

The project lies in a tidal zone. The Meghna and Lakhya Rivers and internal channels of the Mora Brahmaputra River are tidally controlled (their water levels fluctuate according to the tides and the flows reverse twice daily).

The tides are stronger in the south and weaker in the north of the project. The hydrographs of the Lakhya at Demra (Gauge 179) and Narayanganj (Gauge 180), and of the Meghna River at Baidyar Bazar (Gauge 275) and Ferry Ghat (Gauge 275.5) show year-round tidal fluctuations; the tides vary from above 0.5 m during the dry season to below 0.1 m during the monsoon season. The hydrographs in the north, of the Lakhya at Ghorasal (Gauge 178) and of the Meghna at Narsingdi (Gauge 274) show strong tidal fluctuations, of about 0.4 m, between June and November; during the winter months the tides are from zero to a few centimetres.

2.4.2 Flooding

The area suffers mainly from monsoon season floods. The project rivers are not flashy, and pre-monsoon floods are rare. Normally the Meghna and Lakhya Rivers are low till June, and the pre-monsoon rainfall is too low to cause an accumulation of water over a larger area. Occasionally high rainfall in June, if it coincides with higher river levels, may cause flooding of lowlands.

The monsoon season floods which last from July to October cover almost the entire cultivable land in the project area. As the agriculture has adjusted to the flooding conditions, the monsoon season floods rather limit than damage agricultural production. However, abnormally high floods cause damage to agriculture.

The Meghna and the Lakhya Rivers are the main source of flood in the Narayanganj-Narsingdi area. Water enters the area from these rivers by overtopping their banks and through the open lateral spill/drainage channels, and by backflow from the Meghna through the Mora Brahmaputra channel.

As the average ground level in the project is low, in comparison to the monsoon flood levels in the Meghna and Lakhya Rivers, the floods limit the expansion of homesteads and infrastructure. In recent years, the high floods of 1986, 1987, 1988 and 1991 caused enormous devastation by flooding most of the homesteads and damaging industries, roads, and bridges. The Dhaka-Sylhet and Dhaka-Chittagong highway links were disrupted.

2.4.3 Drainage

The project's drainage pattern follows the land gradient, sloping from north to south and from the east and west boundaries towards the Mora Brahmaputra River flowing in the middle of the basin.

There are numerous low depressions scattered throughout the project. The internal khals collect the local drainage and flow to the Mora Brahmaputra which empties into the Meghna River at the southern end of the basin. Several of the khals join the Mora Brahmaputra with the Meghna and Lakhya Rivers. These khals also drain into the bordering rivers when the rivers are low.

The general slope of the area is low, and most of the internal channels are partly silted. Re-excavation of the khals including the Mora Brahmaputra channel would allow more rapid drainage and improve the early monsoon and post-monsoon flooding conditions.

2.4.4 Water Bodies

Open water bodies
About 1,030 ha (2.5%) of the project is under permanent water bodies, of which 360 ha are beels, and the remaining 670 ha are channels of which the Mora Brahmaputra River, Haridhana Nadi, Sonakhali, Nalla, and Daria Khals cover about 80%.

The larger beels are: Gridhan Bhuan, Galimpurar, Chanda Chira, Kusaba, Ludhurcharar, and Bhurumdir Beel. Most of the beels in the area are connected through khals with the Mora Brahmaputra or/and with the Meghna or Lakhya Rivers.

Closed water bodies
In addition to the open beels and khals there are about 2,480 ponds which are used for fish stocking and other household purposes. The ponds have a total area of 286 ha. Most of the ponds are inundated during high monsoon floods, particularly in the lower areas.

2.4.5 Surface Water Availability

The Meghna and Lakhya Rivers are the source of external inflows into the project area.

During the monsoon season these rivers supply water to the internal khals and the Mora Brahmaputra River all along their boundaries. The Mora Brahmaputra channel is connected with the Meghna River in the upper section near Narsingdi and at the outfall near Kalagahhia.

During the winter season backflows from the Meghna River enter the project from the south through the Mora Brahmaputra. The khals in the northern part of the area are silted and there is no inflow from the Meghna and Lakhya.

Meghna River
Within the project boundary, water levels in the Meghna River have been measured at Narsingdi (Gauge 274), Baidyar Bazar (Gauge 275), and at the Dhaka-Chittagong road bridge, formerly Ferry Crossing (Gauge 275.5). Discharges have been measured by BWDB at Bhairab Bazar (Gauge 273). The 21 years of record indicate a mean discharge of 4725 m^3/s, and a range of daily discharges from 2 to 19,800 m^3/s. As the Meghna River is a large tidal river, the low minimum flows are not an indication of the water availability in the river.

Lakhya River
Within the project boundary, the Lakhya River has been gauged at Ghorasal (Gauge 178), Demra (Gauge 179), and at Narayanganj (Gauge 180). Discharges have been measured by BWDB at Demra, but the yearly records are not complete. The estimated mean annual discharge in Lakhya at Narayanganj is 693 m^3/s (NERP). There is no reliable estimate of the low flow.

According to the National Water Plan (MPO), only 2 m^3/s is available in the Lakhya River during the dry season. The MPO estimate was based on present and planned water demands along the Lakhya River as follows: an irrigation demand by the Dhaka-Narayanganj-Demra and Narayanganj-Narsingdi Irrigation Projects of 24.5 m^3/s, a cooling water requirement for Palash power plant of 30 m^3/s, and a requirement for the WASA filtration plant of 10.5 m^3/s. The total demand is about 65 m^3/s. The minimum discharge in the Lakhya is lower than the measured discharge in the Old Brahmaputra at Nilukirchar upstream of the Lakhya (6.0 m^3/s). Clearly the

upper inflows to the Lakhya are not sufficient to meet present and future water demands. Lakhya River will have to rely on the tidal inflows from the Meghna River.

Details on water levels and discharges are provided in Annex A.

Table 2.3: Estimated Ground Water Recharge

Mode	Useable Recharge (Mm^3)	Available Recharge (Mm^3)
STW	6.03	4.22
DSSTW	23.99	17.00
DTW	95.71	67.65

Source: AST 1990

2.4.6 Ground Water

The estimated total usable ground water recharge within the project area is about 126 Mm^3. Of this, about 89 Mm^3 could be developed using shallow and deep tubewell force mode technology. About 21 Mm^3 could be developed using STW and DSSTW technologies and about 68 Mm^3 could be withdrawn using DTWs (Table 2.3).

2.5 Land/Water Interactions

2.5.1 Siltation

About 90% of the gross project area and almost all the cultivable lands are inundated annually by seasonal monsoon floods. However, there were no reports of problems with siltation over the cultivable land.

Serious siltation has taken place along the whole length of the Mora Brahmaputra River, which is the principal drain of the project basin, and in the internal khals draining into the Mora Brahmaputra. The siltation in the channels restricts the drainage of lowlands and prevents inflow of irrigation water during the dry season.

2.5.2 River Erosion

Erosion by the Meghna River is a major problem in the area. Both river bank erosion and erosion of roads and railway embankments occurs all along the eastern boundary of the project. An expensive brick mattressing is used to protect the Meghna embankment in the North Polder of Balushair Project. The embankment of the South Polder which was constructed without any protection has been washed away by wave action.

The river bank erosion rates are generally low. Erosion is due to the progressive migration of the river's meander pattern. This process is driven by secondary currents in the channel which deposit sediment on the convex side of the meander bend and scour material from the outer (concave) side of the bend. As a result, local sloughing and slow bank retreat are occurring at virtually each of the sharp bends in the river. The Meghna right bank erosion affects mainly homesteads which occupy the higher ridges along the river.

The earthen embankments are threatened by intense wave action. During the monsoon season vast areas of land along the Meghna River remain deeply flooded from July to October. In absence of natural land barriers or tree growth high waves form. The waves undermine the river

banks and cause extensive damage to roads and embankments constructed further away from the river.

2.5.3 Crop Damage

Field investigations have revealed that there is very little crop damage in the project area. Farmers reported that the high yielding varieties of boro rice are harvested before the arrival of flood water. This was confirmed by analysis of pre-monsoon water level data and the area-elevation data. The farmers of the project area did not report of any damage to local and high yielding varieties of aus and aman rice. It is apparent that restriction on crop choice due to flooding is a constraint and not damage to crops.

2.6 Wetlands and Swamp Forest

2.6.1 Natural Wetlands

Most of the wetlands are flat and shallow with very little perennial water bodies (beels). The total area of the perennial beels is about 360 ha which includes many small fragmented areas of less than five hectares. The relatively larger permanent water bodies are: Gridhan bhuan Beel, Galimpurar Beel, Chandal chira Beel, Kusaba Beel, Ludhurcharar Beel, and Bhurumdir Beel. The ecological characteristics of the wetlands are similar throughout the area with a luxuriant growth of aquatic plants in the monsoon season specially 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. Because of habitat degradation there is little wildlife.

2.6.2 Swamp Forest Trees

There are no swamp forests within the project area. Even individual swamp forest plants are not very common in the homestead lands.

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.

Settlements
The settlements in the project area are influenced by the proximity of urban cities like Dhaka and Narayanganj. Some of the Nation's major industrial complexes are situated along the bank of the Lakhya River. Bandar thana of Narayanganj district has the highest population density in the Northeast region and is mostly urbanised. Settlements in certain areas in Narsingdi, Baidyerbazar, Araihazar, and Rupganj thanas are comprised mostly of villages along roadsides and river/channel levees. Settlements are also located in the charlands along the Meghna River in Narsingdi, Araihazar, and Baidyerbazar thanas. Settlements on charlands are sparsely scattered, while roadsides and river banks are densely settled.

Table 3.1: Current Land Use

Use	Area (ha)
Cultivated (F0+F1+F2+F3)	34,832
Homesteads	3,075
Beels	360
Ponds	286
Channels	670
Hills	0
Fallow[1]	255
Infrastructure[2]	1,082
Total	40,560

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

Flood Damage to Housing
Homesteads in the project area are generally not affected by average monsoon flooding, except those situated on the char land and along the Meghna River bank. The homesteads of the char lands in Narsingdi, Araihazar, and Baidyerbazar thanas are affected by monsoon flooding. Many villages along the Meghna River and in the char areas are damaged by monsoon wave erosion. In Baidyerbazar and Araihazar thanas villages were reportedly eroded by the monsoon wave action of the Meghna River.

Coping Strategies
To avoid monsoon flooding, the homestead platforms of the lower lands including the charlands are raised one meter or more above natural ground level. People of the charlands take special measures to protect their homesteads from monsoon wave erosion. They construct boundary walls around their homesteads using locally available materials such as bamboo and grasses. Sometimes the poor grow water hyacinths around their homesteads to reduce wave intensity during the monsoon months and lessen erosion. Some well-off farmers put bricks around their homesteads for protection. But in many places, particularly along the Meghna River, residents are not able to protect their homesteads from erosion.

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	15.7	14.9	12.6	49.6	1.9	5.3	100.0
Female	17.8	17.0	12.8	46.4	1.3	4.7	100.0
Total	16.7	16.0	12.7	48.0	1.6	5.0	100.0

Source: BBS, 1981 Population Census

During years of unusually high floods (as happens in some years), the villagers make platforms inside their houses for living and storing their belongings. Some people shift their family members to safer places in cities or on higher lands. The use of country boats increases in times of severe high floods. At times of flooding the poor suffer the most.

3.1.2 Demographic Characteristics

The total population of the project area is estimated to be about 781,480 of whom 366,460 are female. The gender ratio is calculated to be 113 (males to 100 females). The total households are estimated to be 144,642 within 826 villages. The population increased by 33.9% between 1981 and 1991. The cohort distribution for males is: 30.6% are below 10 years of age, 49.6% are between 15 and 54 years of age, and 5.3% are above 60 years of age. The corresponding distribution for females is 34.5%, 46.4%, and 4.7% (see Table 3.2).

The average population density is 1,927 persons per km^2, with density ranging from a maximum of 4,668 persons per km^2 in Bandar thana to 1243 persons per km^2 in Kaliganj thana. The average household size in the area is estimated to be 5.4 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

According to the 1981 census, the literacy of the population at five years of age and above varied from 16.2% in Araihazar thana to 31.5% in Palash thana. The corresponding figures for females were 10.1% 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, and for Narayanganj district the rate is 32.59%.

According to the 1981 census, school attendance in the project area for all children five to nine years of age varies from 16.3% in Araihazar thana to 31.9% in Palash thana. Attendance for females in this age cohort in these two thanas varies from 13.9% to 29.2% respectively. Attendance for all youths between the ages of five and 24 is 15.6% 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 Araihazar, Rupganj and Baidyer Bazar thanas, have no primary schools. The average number of primary schools per 10,000 population is estimated to be 3.7 for Narsingdi district, while for Narayanganj district it is 2.9 (BANBEIS, 1990).

Access to Health Services

The district headquarters of Narsingdi, Gazipur, and Narayanganj have hospital facilities. Similarly, all thanas have hospital facilities located at their headquarters. 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 Narayanganj district there is one hospital for 260,642 persons and one doctor for every 17,376 persons. One hospital bed is meant for 11,947 people in Narsingdi district, 4,303 people in Narayanganj district, and 9,790 people for Gazipur district. Because of the area's proximity to Dhaka, many people can afford health services in Dhaka. Immunization coverage of children below two years of age is low for the project area. The rate varies from 14% in Kaliganj thana to 27% in Rupganj 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 Narayanganj districts, such figures are 135 and 194 respectively. In 1990, 96% of the households had access to potable water in the district of Narsingdi. For the other two districts of Gazipur and Narayanganj, such percentages are recorded as 90% and 97% respectively. It is noted that most tube wells are located in the houses of the rich. This results in the poor having very limited access to potable water.

Sanitation

Specific information on sanitation facilities is not available at the project level. During field reconnaissance, it was noted that open space defecation is a common practice in the rural villages, 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, people generally defecate in running water using hanging latrines. The use of sanitary latrines (ring and slab) is increasing in the area, especially in villages near to thana headquarters and industrial complexes.

[1] DPHE, 1991-92

3.1.4 Employment and Wage Rates

Village employment opportunities are mainly limited to agricultural activities. The major crop in the area is HYV boro and t.aman. Employment for men for t. aman crops mainly consists of transplanting which occurs between July and August, and harvesting which occurs in late November and December. For HYV boro cultivation there are two employment peaks: transplantation in January-February, and harvesting in May-June.

The wage rates for male agricultural labourers varies from Tk 40 to 60 with three meals per day during peak agricultural months. During months when there is no agriculture work, the wage rate varies from Tk 30 to 40 per day. Employment scope reduces significantly during monsoon months for the poor of the char areas. However, it is reported that the poor people get employment in the weaving factories year-round, especially in Narsingdi, and Araihazar, thanas. Most of them work on a contract basis and earn a daily income which varies from Tk 40 to Tk 80 for men. The women generally work in these looms on a weekly contract and earn an income which varies from Tk 50 to Tk 100 per week. Many women also work during slack time on hand embroidery of clothes on a contract basis.

Employment of the poor in vegetables cultivation is also common in the area, especially in Palash, Araihazar and Narsingdi thanas. The average daily income from these activities varies from Tk 30 to Tk 50 with three meals for men and Tk 20 to Tk 25 without meals for women. Employment is also available in mills and factories in and around the area. Many of them are employed on a permanent basis.

During months when employment opportunities are limited, some poor people migrate to the districts headquarters within the project area as well as Dhaka city to work as rickshaw pullers, construction workers, or sometimes in household activities. A few poor women are employed for the Rural Maintenance Program of CARE, and a limited number of women migrate to Dhaka city to perform household work.

There is in-migration into the project area, mainly from Mymensingh, Kishoreganj, and Comilla districts. They mainly stay seasonally to work on cultivation and harvesting of rice crops.

3.1.5 Land Ownership Pattern

Land ownership is extremely skewed in the project area. Nearly 59.0% of the households are landless (with cultivable land less than 0.2 ha). Among the landless, about 2.2% have no homesteads of their own. If the definition of landless includes landholdings up to 0.4 ha, the proportion of households included increases by about 10%. 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 30.8%, 9.2%, and 1.0% respectively.

Most of the land is available for cultivation. Land not available for cultivation includes deeper wetlands, char land, and community pastures. The price of agricultural land varies from Tk 20,000 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 the major tenurial system in the area. The large as well as absentee land owners including the traders who own agricultural lands generally share out their land to tenants for operation. The share cropping system is that one half of the produce is received by the land owners whether they provide inputs or not. For local rice crops and jute, the land owners provide no input costs, while for HYV rice, mustard and rabi crops, the land owners pay 50% of the cost of inputs and receive 50% of the crops. The leasing out of land for advance cash (pattani) is also practised on a small scale in the area. The usual rate for leasing varies from Tk. 500 to Tk. 1200 per bigha (0.12 ha) depending on the quality of the land and this is paid in advance to the land owner for one year. Landless people have very little access to land under this tenurial arrangement due to their inability to provide the cash after which they must still purchase other agricultural inputs.

3.1.7 Fishermen

There are mainly two types of fishermen, traditional and non-traditional, who catch fish for generating an income.

Traditional fishermen live on fishing and have been engaged in the profession for generations. The jalmohals are generally leased out to them through their cooperatives. However, the rich among them, act as the financiers and appropriate most of the profits from the catch while the poor catch fish on a regular basis and sell the fish for their survival. Some traditional fishermen also work as fishing labourers. There are an estimated 1,500 to 2,500 traditional fishermen households in the project area. Additional information on fishing practices is given in Section 3.5.1.

The non-traditional fishermen are mainly an emerging group from the landless and poor agriculturists. They fish in open water especially during monsoon months and sell their catch. Such non-traditional fishermen are increasing and nearly 5-7% of the households, especially from the char areas, are reportedly engaged in catching fish.

Another group of people who catch fish but should not be referred to as "fishermen" are the residents of the area. They do not sell the fish but catch for their own family consumption. Sometimes they culture fish in ponds for their own consumption as well as for selling.

3.1.8 Situation of Women

Women play an important role in producing vegetables in the project area. Their role in agricultural production is also important, especially in the post harvesting activities. Women's contribution, however, tends to be devalued and under reported. A large number of women, especially from the Narsingdi, Palash and Araihazar thanas work for the hand/power looms. Some poor women are reported to be working outside their homes, mainly for the Rural Maintenance Programme of CARE, and in activities like collecting fuel and wild vegetables. The women of the char areas work in nearby agricultural fields in cultivation of winter rabi crops and vegetables. The village women generally work in the post-harvesting activities of rice crops, especially drying, winnowing, par-boiling and storing of rice. Most woman prefer working on homestead gardening, raising poultry/ducks, and other household works.

3.1.9 Urbanization

The districts of Narsingdi and Narayanganj are the two most densely populated districts and the most urbanized areas in the Northeast region.

In addition to the thana headquarters, there are several growth centres along the Dhaka-Sylhet corridor which are rapidly becoming urbanized. Some of these are as follows:

- Tarabo (Rupganj thana)
- Bhulta (Rupganj thana)
- Kanchan (Rupganj thana)
- Madhabdi (Narsingdi thana)
- Shekher Char (Narsingdi thana)
- Panchdona (Narsingdi thana)

This area has a very high concentration of modern manufacturing establishments. The area's proximity to Dhaka, better transport network, and the high social mobility of the people make it an attractive environment for the development of the manufacturing sector. Data on manufacturing establishments in the project area for the year 1989/90 are given in Table 3.3.[1]

With increasing urbanization, land use and cropping patterns are changing rapidly. While more lands are being put to industrial use, high value crops, particularly vegetables, are replacing traditional field crops.

Table 3.3: Manufacturing Sector in the Project Area

Thana	Manufacturing Establishments (with 10 or more workers)	Persons employed
Narsingdi	384	12,958
Palash	33	16,050
Bandar	136	13,598
Sonargaon	137	7,025
Araihazar	74	6,453
Rupganj	500	32,555
Total	**1,264**	**88,639**

Source: BBS

[1]. NERP, Study on Urbanisation, 1993.

This area is expected to be more urbanized in the near future and its integration with the Dhaka mega-urban field will be accelerated because of its strategic location. A sharp rise in urban population in this zone in the initial period will result from in-migration from villages, as well as from transformation of some rural and semi-urban settlements into new urban centres along the Dhaka-Sylhet and the Dhaka-Chittagong corridors.

It is likely that Narsingdi municipality, which is the second-largest city in the Northeast region, will not expand rapidly, as there are many other urban areas and growth centres in the area which will grow in the near future. It is expected that the major growth centres in the area which are now discrete units will soon be integrated into a larger chain and become part of the greater Dhaka city. Already, a part of this area has been officially included in the "Dhaka Statistical Metropolitan Area" (SMA). The entire Bandar thana has been treated as an urban area in the 1991 census.

3.1.10 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 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, opinion and suggestions were sought at a one-day seminar held at the District Headquarters of Narsingdi in April, 1993. Participants at the seminar included the Honourable Members of the Parliament, District and Thana level officials, Union Parishad Chairmen, representatives from village level organizations, and NGOs. These are described below.

Problems

Seasonal inundation of most of the agricultural land by monsoon flooding limits the cultivation of monsoon crops in the project area. Farmers reported that the aus and aman crops cultivated at certain locations are affected by monsoon floods. Such flood waters generally enter into the area by overtopping the banks of the Lakhya and Meghna Rivers. The monsoon rice crops are also damaged by water hyacinths, especially in the char lands along the Meghna River in Narsingdi, Araihazar and Baidyer bazar thanas. Sometimes, the pre-monsoon flood waters from the greater Sylhet district damages the early kharif crops, such as sweet potato, chili, and ground nuts in the char lands along the Meghna River. If the upstream pre-monsoon flooding is severe, the local and HYV boro crops of the above thanas are also damaged. However, in other areas, the HYV boro is harvested before the seasonal monsoon flooding and no damage of to crops was reported.

Marketing of high value winter crops appears attractive due to the area's proximity to Dhaka city. However, due to inadequate irrigation facilities, the expansion of winter cropping is limited. Farmers reported that a lack of irrigation water was also a problem for cultivating HYV boro crops. Further, the land preparation for the rabi crops is costly, and sometimes is delayed because the land has to be first cleared of water hyacinth, which has grown in the area during the monsoon season. Such land clearing also delays the cultivation of local boro in many pockets. The silting up of the internal channels and smaller rivers including the Mora Brahmaputra River has reduced the water retention capacity of these rivers/channels. This has reduced the supply of water for winter irrigation and increased overbank spilling during the monsoon months.

Local residents, especially in Araihazar, Baidyerbazar, and Narsingdi thanas stated that damage to homesteads along the Meghna River bank and in the char lands by monsoon flooding and wave erosion is a serious problem. Many villages in these areas are found badly damaged by wave erosion.

Pond aquaculture fisheries is expanding in the area. Reportedly the ponds are frequently overtopped by peak monsoon floods. Poor fishermen expressed their concerns about the leasing system of the beels and the rivers. They complained that the some local influential people generally dominate when the jalmohals are being leased. The poor fishermen said that they are deprived of the use of the jalmohals. The fishermen stated that the silting up of beels and rivers has reduced fish production. Industrial pollution was cited as another important factor in the reduction in fish production in the project area. The fishermen also considered that the development of infrastructure such as roads, embankments, and closing of smaller rivers/channels had obstructed fish migration and thus reduced fish production.

Local people reported that the reduced depth of some of the rivers, including the Lakhya, Mora Brahmaputra, and channels of the Meghna River was a constraint to year-round navigation.

Suggestions

Numerous suggestions were put forward by local people. However, some suggestions are meant for very small and localised issues. The most common suggestions were:

- Re-excavate the Lakhya River from Lakhpur of Shibpur thana to Narayanganj, and the Mora Brahmaputra River from Kaligachia to Kendua khal of Rupganj thana via Sonargaon and Araihazar.
- Complete the Balushair-Meghna embankment project by constructing a road-cum-embankment from Balushair to Gopaldi bazar.
- Construct a sluice gate on the Mora Brahmaputra to stop the backflow of flood water from the Meghna River. The site for the sluice gate should be selected upstream of the Langal Bundh to maintain a regular flow of water in the *Mela* (religious bathing) site.
- Stop over bank spilling from the Meghna and Lakhya Rivers during the monsoon season.
- Prevent spreading of water hyacinth to save aus and aman crops, especially in char land along the Meghna River.
- Protect the Lakhya River from industrial wastes
- All the jalmohals in the project area be leased to fishermen only.
- Develop the following fisheries as fish sanctuaries and preserve them for increasing fish production:
  - Nunertek fishery (Baidyerbazar thana)
  - Kalpaharia beel (Araihazar thana)

- Rupsichanpara in the Lakhya River under Rupganj thana

- Banks of beels and embankments along river/channel sides should be brought under an afforestation programme.

- Allow the poor and subsistence fishermen to catch fish in open water, especially during monsoon months.

3.1.11 Local Initiatives

Information on specific local initiatives to avert flood-related problems in the project area were not collected during the field visit. However, people stated that it is their traditional practice to organize local people to counteract crisis which arise as a result of floods and drainage congestion.

3.2 Water Resources Development

3.2.1 Flood Control, Drainage and Irrigation

The existing water developments in the Narayanganj-Narsingdi area include two flood control, drainage and irrigation projects, one flood control and drainage project, re-excavation of khals, and several hydraulic structures constructed in peripheral embankments under different programs. These are as follows.

Demonstration Unit of the Narayanganj-Narsingdi Irrigation Project
It is a full flood control, drainage and irrigation project which was constructed in 1981-84 under the assistance of the Japan International Agency (JICA) as part of Phase I of the Narayanganj-Narsingdi Irrigation Project. It covers a gross area of about 1,300 ha and is located on the eastern side of the Dhaka-Sylhet Road between Demra and the Gopalpur road crossing. The project had been designed for full flood protection with a new high embankment on the eastern side, and pump drainage and irrigation facilities. The irrigation water was to be supplied by a pump station on the Lakhya River with three reversible type pumps each with 1.06 m^3/s capacity.

During the 1987 monsoon flood the eastern embankment breached and the entire project area was flooded. The project failed to provide sufficient irrigation water for boro crops as the elevation of the pump intake was too high.

Block A-1, of Narayanganj-Narsingdi Irrigation Project
The project was also constructed as part of Phase I of the Narayanganj-Narsingdi Irrigation Project under a JICA grant. The construction work started in December 1989 and the project was declared complete in December, 1993. It covers a gross area of about 3,000 ha located between the Demonstration Unit on the east and the Lakhya River on the west. The project includes a complete internal drainage and irrigation system, and high flood embankments/roads. Block A-1 borders the Demonstration Unit which is to the east across the Dhaka-Sylhet Road. For flood protection, the two projects are separated by a RCC flood wall constructed along the Dhaka-Sylhet Road (Figure 4). A 4-unit pumping station (1.88 m^3/s each) is used for drainage and for supply of irrigation water from the Lakhya River.

The Block A-1 canal system has been designed to supply winter irrigation water to the Demonstration Unit.

Balushair Embankment Project (North Polder)

The project covers a gross area of about 400 ha in the northeastern corner of the study area bordered by the Dhaka-Narsingdi Road to the north, and high flood embankments to the east and south. Gravity drainage is effected through three regulators; one draining into the Meghna River and two into Baniar Khal (north). The project was constructed by BWDB in 1973-86 and was designed for full flood protection. The project cost was high as brick matressing was provided on the Meghna embankment to protect it from wave action. With limited gravity drainage there is a small improvement in flood conditions inside the embanked area.

Re-excavation of Internal Khals

Re-excavation of internal khals is carried out by local bodies and by BWDB under WFP. The local bodies undertake minor works which usually affect small areas.

To remove drainage congestion in the northern part of the project in 1990/92 BWDB re-excavated and linked Daria and Nella Khals with the Sonakhali Khal which drains into Mora Brahmaputra. As no water control structures were constructed on these khals the area drains quickly into the Brahmaputra at the end of monsoon, and presently the area suffers from overdrainage.

Embankment Structures

The existing hydraulic structures along the Lakhya River are: the six-vent 0.9 m dia. Ghagra Sluice and two-vent 1.5 x 1.8 m Kendua Regulator. There are also two pipe sluices and a one-vent 1.5 x 1.8 m Rupsi Regulator, but these are within the Narayanganj-Narsingdi Irrigation Project, Block A-1 embankment.

Along the Meghna there are three RCC Box Regulators in the North Polder of Balushair Project and two RCC Box Regulators on khals in the South Polder. Embankments in the South Polder have not been constructed.

In addition to the above structures, there are a large number of pipe and box culverts constructed by local bodies in roads and local dikes around the project periphery.

3.2.2 Irrigation

About 14,040 ha or 40% of the project cultivated area is under irrigation. About half of the land is irrigated with surface water out of which 33.6% is pump irrigation (LLPs) and 15.4% is traditional irrigation.

Ground water is used to irrigate 7146 ha or about 50% of the irrigation in the project area. Shallow and deep tubewells are used for extraction of the irrigation ground water. In 1991 about 20% of the sunk DTWs were out of operation, as compared with 5% of the STWs.

The status of irrigation in the Narayanganj-Narsingdi area is summarized in Table 3.4.

Table 3.4: 1991 Irrigated Area

Item	Mode of Irrigation				
	STW	DTW	LLP	Traditional	Total
Area (ha)	4146	3000	4722	2172	14040
Number	756	105	331	-	1192
% of Total	29.5	21.4	33.6	15.5	100

Source: AST (1991)

3.3 Other Infrastructure

The Narayanganj-Narsingdi area has a well developed road network. There are about 120 km of metalled road, about 65 km of unmetalled roads and an estimated 80 km of village roads in the project area. The main roads are the Dhaka-Sylhet and Dhaka-Chittagong Highways, and the Narsingdi road. All the metalled roads, and unmetalled roads with improved surface are all-season roads, but during the extreme floods large sections of the roads are overtopped and damaged. The Sylhet and Chittagong highways were overtopped in 1984, 1986, 1987, 1988 and in 1991. The Dhaka-Chittagong Highway has recently been widened and raised to above the high flood level.

Along the northern boundary of the project runs the Tongi-Narsingdi (Dhaka-Sylhet) railway line. The project is bisected by the high N-M Railway embankment crossing the basin from southwest to northeast (between Narayanganj and Narsingdi). Presently the N-M embankment is used as a road; sections of the road have a metalled surface, while some improvement works are ongoing in other sections.

3.4 Agriculture

The hydrologic regime dictates the crop production practices in the project area. Present cropping patterns reflect the farmer's efforts to adjust his crop production practices with the hydrologic regime.

Flood depth on 54 percent of the cultivated area exceeds 1.8 meter (F3 land type) imposing a restriction on monsoon season cropping. Local and high yielding varieties of boro rice are grown in these area after the recession of flood waters in the winter season. Flood-free conditions in the pre-monsoon season have led to a dominance of high yielding varieties of boro rice which is presently grown on 95 percent of the cultivated area under a F3 land type. Local varieties of boro rice are grown on the remaining five percent of the cultivated area on this land type.

The area flooded between 0.9 to 1.8 meter (F2 land type) in the monsoon season constitutes 33 percent of the cultivated area in the Narayanganj-Narsingdi Project. Local varieties of broadcast aman with ability to elongate with a gradual rise in flood level are grown on 65 percent of the

cultivated area, either singly or in sequence with rabi crops including wheat and potato. After the recession of flood water mustard is grown prior to growing high yielding varieties of boro rice on about 30 percent of the cultivated area of this land type. Single high yielding varieties of boro are grown on the remaining five percent of cultivated area.

The area flooded up to 0.3 meter (F0 land type) and between 0.3 to 0.9 meter (F1 land type) constitutes one and 12 percent of the cultivated area, respectively. Double cropping is practiced on most of these areas except in a small area where there are three crops per year. These include local varieties of broadcast aus, high yielding varieties of transplanted aus and jute in the early kharif season grown in sequence with local and high yielding varieties of transplanted aman in the monsoon season. High yielding varieties of boro rice are grown in sequence with local and high yielding varieties of transplanted aman where irrigation facilities are available. Cropping patterns on these land types also include rabi crops preceded by jute or high yielding varieties of aus.

Cropping patterns, presently practiced on different land types in the project, are presented in Table 3.5.

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

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. Homesteads located in flood-free areas have dense vegetation cover. These include different types of trees namely jack fruit, mango, guava, litchi, coconut, betel nut, bamboo, banana, papaya, and so on providing fruit, fuel, and building materials. Homesteads located at lower lying elevations are deprived of this benefit. Most of the vegetables consumed by the family are produced in the kitchen garden, adjacent to the homestead.

The present level of inputs used in Narayanganj-Narsingdi Project is low for local varieties and moderate for high yielding varieties of crops. Yield levels of crops vary depending on the level of input use and flood vulnerability. As flood damage to crops is not common in the project area, separate yield data under damaged conditions were not collected.

Present crop production data are presented in Table 3.6.

Table 3.5: Present Cropping Patterns
(Areas in ha)

Cropping Pattern	F0		F1		F2		F3		Total Area
	Area	%	Area	%	Area	%	Area	%	
orchard	18	5	0						18
sugarcane	10	3	0		0				11
b aman-fallow					3401	30	0		3401
fallow-l boro					0		942	5	942
fallow-hyv boro	0		0		566	5	17907	95	18473
b aus-lt aman-rabi	0		214	5	0		0		214
jute-wheat	0		300	7	0		0		300
hyv aus-wheat	0		342	8	0		0		342
hyv aus-rabi	36	10	0		0		0		36
hyv aus-lt aman	55	15	0		0		0		55
hyv aus-hyv aman	80	22	0		0		0		80
lt aman-wheat	0		214	5	0		0		214
lt aman-rabi	36	10	0		0		0		36
lt aman-hyv boro	0		2141	50	0		0		2141
hyv aman-wheat	0		642	15	0		0		642
hyv aman-rabi	91	25	0		0		0		91
hyv aman-hyv boro	36	10	428	10	0		0		464
mustard-hyv boro	0		0		3401	30	0		3401
b aman-wheat	0		0		907	8	0		907
b aman-potato	0		0		1927	17	0		1927
b aman-rabi	0		0		1134	10	0		1134
Total	366		4281		11336		18849		34832

Table 3.6: Present Crop Production

Crop	Area (ha)	Yield (t/ha)	Production (t)
b aus	214	1.25	267
hyv aus	514	3.75	1929
b aman	7368	1.75	12895
lt aman	2660	2.15	5719
hyv aman	1279	3.95	5051
l boro	942	2.25	2120
hyv boro	24479	4.55	111381
Paddy			139364
wheat	2405	2.05	4930
potato	1927	12.00	23125
pulses	227	0.85	193
oilseeds	4157	0.75	3117
spices	75	2.25	170
vegetables	454	9.25	4197
rabi crops			
jute	300	1.65	494
sugarcane	11	45.00	494
orchard	18	15.00	274

3.5 Fisheries

3.5.1 Floodplain fishery

There are 22 important permanent and seasonal beels in the project area of which the following are the most important for fish production: Gridhan Bhuan Beel, Galimpurar Beel, Chandal chira Beel, Kusaba Beel, Ludhurcharar Beel and Bhurumdir Beel. Beels serve as overwintering refuges for the species present in the area. During the monsoon season, water from the Brahmaputra and Lakhya Rivers flows to the area through open khals, breached dykes, and by overtopping the rivers banks. Most of the beels are isolated basins. Some beels are interlinked with each other by narrow channels and fish can move freely between the rivers, channels, beels, and floodplain.

3.5.2 Species present in the area

Of the 155 species identified in the region, about 50-55 species inhabit the project area. The most common of these species are listed in Table 3.7.

3.5.3 Duar Fishery

There are no important duars in the project area. Most of the broodfish overwinter in the Meghna River.

3.5.4 Sources of fish and breeding

It is generally understood that early rain, thunder, flooding, temperature, grassy or rocky land influence spawning of freshwater fish. If conditions are favourable, during the flooding time, fish migrate from beels to adjacent grassy areas, to the rivers, and vice-versa. Except for major carp, Pangus, and Ilish, most of the smaller species breed in the local floodplains during the monsoon season. Localized breeding migration can be seen for Fali, Koi, Singi, Magur, Puti, Chanda, Tengra, Gulsha, Kholisha, Bheda, Lati, and some other smaller varieties fish. Sonakhali khal and Galimpur area are reported as fish breeding places within the project area. Within the project area, species composition of capture fishery is dominated by chotomaach (75-85%) followed by catfish (10-15%) and carp (3-5%).

Table 3.7: Major Fish Species in the Narayanganj-Narsingdi Area

BARAMACH	CHOTOMACH
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, Batashi, Chapila, Keski, Tara baim, Gutum, Cirka, Kaikka, Shilon, Ek Tuitta, Chanda, Icha .

3.5.5 Production Trends

Presently, fin fish production in the project area is estimated at 1,700 tonnes per year (Table 3.8).

Table 3.8: Present Fish Production

Regime	Area (ha)	Production Rate (kg/ha)	Total Production (mt)
Beel	360	410	147.6
Floodplain	34446	35	1206.6
Pond	670	175	117.3
Channel	286	800	228.8
Total	35762		1700.0

Fish production in the area has reportedly declined by 30-40% over the last ten years. The identified causes of decline in fish production are:

- Beels infilling with sediment. This results in a decline in beel area and water depth and hence a reduction in the water hectare-months.
- Overfishing and loss of fish habitat.
- Fewer reproductive fish stock due to indiscriminate use of some gear (current jal, kona ber jal etc).
- Increased fish mortality due to fish disease caused by water pollution in the beels, particularly during the month of December and January.
- Reduced fish habitat because of agriculture encroaching onto fish producing beels.
- Leasing of smaller beels to outsiders which encourages overfishing by complete de-watering. Previously, when most of the small beels were kept under common village use the overwintered stock were maintained in those beels.
- Lack of proper extension services for the pond owners to develop culture based fish farming in the existing ponds.
- The absence of strong leadership, poor communication facilities, and inadequate infrastructure prevents the fishing community from adequately defending its interests.
- The short term leasing system combined with insufficient security of lease renewal encourages over exploitation of the jalmohals.

3.5.6 Fishing practice

Floodplain

Open water fisheries are the major source of fish in the area (floodplain 71%, beels 9%, channels 7%, and ponds 13%). Subsistence fishing occurs mainly during the monsoon season and large-scale beel fishing occurs from December to March. Except for the pile fishery, most beel fishing is done on an annual basis.

Piles are not maintained as a part of the biological management of the fishery resource, but for annual fishing. The installation of katha is common. Since hizal and koroch trees are scarce in the area, shawra and mango tree branches are widely used. Kathas are installed in the months of August and September during the time when the water recedes from the floodplain.

Closed Water

Pond fish culture practices are different here than in other parts of the country. Most ponds are located in the flood prone areas and owners usually do not release fingerling into their ponds. Ponds are used to trap varieties of fish from the floodplains and in most cases katha is installed during the flood recession time. In some cases supplementary feed is placed in the pond to attract more fish. 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.

3.6 Navigation

The project area is enclosed by two large rivers which are navigable year-round; the Meghna River (BWITA Class 1 route) on the east and south, and by the Lakhya River (BWITA Class 2 route) on the west. In the interior, the Mora Brahmaputra River traverses the area from north to south.

The Meghna River is the main international river transport route connecting the Northeast region with the Bay of Bengal. Large boats ply both the rivers during the monsoon season. During the winter, however, only smaller size boats can use the Lakhya River due to siltation. The Mora Brahmaputra channel is badly silted and it is only used by local cargo and passenger boats during the monsoon season. The most important landing centres within and close to the project area are, Narsingdi, Bhairab Bazar, and Ashuganj along the Meghna River, and Narayanganj, Demra, Palash, and Ghorasal along the Lakhya River.

During the monsoon months, small boats are used for transportation between villages located in the lower areas and in the char lands. The importance of this river traffic is decreasing as the road network in the area is developing. Furthermore, construction of roads and embankments along rivers and channels has disrupted the traditional navigation routes across the flood plains.

3.7 Wetland Resources Utilization and Management

The natural wetland products in the project area are used primarily as fodder and as house thatching material. Village people are dependent on these materials, particularly during the monsoon season when much of the grazing grounds are inundated. 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 their own requirement by themselves. Therefore, estimation of their value was made primarily considering their replacement value and from data collected in other projects. The wetland productive area is mostly F3 land which remains fallow in the summer. The project wetland area is estimated at about 19,000 ha, and its annual production value could reach up to Tk 0.76 million per year,

considering a unit rate of 40 Tk per ha. The estimated annual employment is about 19,000 pd (at 1 pd per ha).

The second important use of wetland products is as biofertilizer or green manure, for which all the herbs and grasses growing in the wetlands are used. The farmers living around these lands use them instead of chemical fertilizer and thus maintain the fertility of their land. Right after the monsoon season farmers start to gather the soft aquatic plants and stack them in the field to decompose. The decomposed material is used as green fertilizer. The production area, economic value, and employment in gathering is more or less the same as for fodder.

Another important use of these resources is fuel wood. Due to the high scarcity of fuel wood around the homesteads people are becoming increasingly dependant on wetland products for fuel. All woody shrubs as well as grasses are used for this purpose.

Other uses of the wetlands are:

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

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

These common property resources are important to the poor, who are the most likely to engage in wetland gathering, to eat wetland food in times of scarcity, and to depend on income from wetland products. Fodder and building materials tend to be collected by men, and food and medicinal materials tend to be collected by women.

4. PREVIOUS STUDIES

4.1 Narayanganj-Narsingdi Irrigation Project

A study of water resources development in the Narayanganj-Narsingdi area was undertaken by the Japan International Cooperation Agency (JICA), and a feasibility report on the Narayanganj-Narsingdi Irrigation Project was issued in July 1978. The study covered the entire Narayanganj-Narsingdi area of about 60,000 ha, located between the Lakhya and Meghna Rivers south of the Tongi-Narsingdi railway line. The report recommended development of 45,182 ha with provision for full flood control, drainage and irrigation with 3 pumping stations. The proposed plan (Plan B) recommended implementation of the project in two phases. The area was sub-divided along the N-M railway embankment: Phase I was north of the railway line and covered an area of 28,986 ha, and Phase II was south of the railway embankment and covered an area of 16,194 ha.

As a follow up, JICA developed 4,300 ha of land within the Phase I area. A 1,300 ha Demonstration Unit was constructed in 1981-84, and a 3,000 ha Block A-1 was constructed in 1989-93.

4.2 Balushair Embankment Project

The project covers an area of about 900 ha in the northeastern corner of the study area between the Meghna and Old Brahmaputra Rivers. In 1973-86 BWDB developed the Northern Polder of the project (400 ha) by constructing three regulators and high embankments along the Meghna River and Baniar Khal. Only two regulators were constructed in the South Polder. It is planned to include the South Polder in the EIP Programme. A decision on its inclusion has been deferred pending the outcome of the NERP study.

4.3 Lakhya River Development

In 1991 National Water Plan, MPO (WARPO) prepared a report regarding water availability and demand for the Lakhya River including existing and planned projects along both the banks.

The study shows that about 2 m^3/sec is available during the winter months. Present and planned water demand along the Lakhya River includes irrigation, cooling water, navigation and domestic and industrial water supplies. Irrigation water demand including the Dhaka-Narayanganj-Demra and the 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; about 22 m^3/sec is withdrawn by the Palash power plant. Dhaka WASA has proposed a water filtration plant at Demra with a capacity of about 200 mgd or 10.52 m^3/sec. The total water demand is about 65 m^3/sec. As the Lakhya River has negligible upland flows during the winter months this suggests that the existing and planned projects along the river will have to rely on back flows from the Meghna River.

4.4 Lakhya-Meghna Project

In 1991 MPO prepared a plan for development of the 109,000 ha area bounded by the Old Brahmaputra River in the north, Lakhya River in the west, and Meghna River in the east and south.

The proposed project was divided into two units along the Tongi-Narsingdi railway line. Only flood control and gravity drainage is recommended for the northern unit, which is targeted for development during the fifth and sixth Five Years Plan periods. Flood control, drainage and pump irrigation is recommended for the southern unit, which covers the Narayanganj-Narsingdi project area.

5. WITHOUT-PROJECT TRENDS (NULL OPTION)

Certain trends are occurring in the project area. These trends provide some indication of what the future in the project area will be if no intervention is undertaken:

- Net population growth: Population growth in the project area, including in-migration, during the period 1981-91 averaged 3.39% per annum. The future growth is predicted to decline to 2.5% by the year 2000 and to 2.00% in 2015. Based on these assumptions, the project population will increase from 781,482 in 1991, to 1,014,687 in 2000, and 1,413,309 in year 2015.

- Current trends in agricultural production would continue, in the absence of any intervention. Local varieties of transplanted aman would continue to be replaced by high yielding varieties of transplanted aman on the F0 land type. High yielding varieties of boro area are expected to increase with the expansion of irrigation facilities. The future without project cropping patterns are presented in Tables 5.1.

  Analysis of the historical data shows that the yield level of individual varieties have not changed over time. A change in production has come mainly from shifts in variety. Without any change in the flood regime levels of input use are not expected to change. Crop production under future without project condition are presented in table 5.2.

- Floodplain fisheries production: Observations of past fish production trends indicate that production is declining by 1-3% per year. The decline is due to present management practices which include overfishing of brood stock. It is suggested that great increases in fish production are possible through the introduction of non-structural interventions under improved biological management of the fishery. Lacking any specific information about future developments in fisheries, for the purpose of this study, it is assumed that the FWO project openwater production is equal to present production.

- River course changes: The Meghna River erosion occurs along the entire eastern bank from Narsingdi to Baidyar Bazar. The erosion process appears to be mainly the result of wave action, and a combination of progressive evolution of the meander pattern and wave action along the concaved sections of the channel. The river bank shifting is rather slow, but high waves during the prolonged monsoon season and inundation of vast areas cause extensive damage to any unprotected earthworks like roads, flood embankments, and raised homesteads. Without major preventive works, the erosion and damaging effects of the river will continue.

  There is no river erosion problem along the Lakhya boundary. Wave action is small. The banks of the Lakhya channel are high and the river water is sheltered

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from wind exposure. Siltation occurring in the Lakhya River channel is independent of the works in the project area.

- Loss of arable land to settlement: By the year 2015 the number of households is expected to increase by about 130,000, which will require about 2,600 ha of land.

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	18	5	0						18
sugarcane	11	3	0		0				11
b aman-fallow					2834	25	0		2834
fallow-l boro					0		377	2	377
fallow-hyv boro	0		0		1134	10	18472	98	19606
b aus-lt aman-rabi	0		214	5	0		0		214
jute-wheat	0		300	7	0		0		300
hyv aus-wheat	0		342	8	0		0		342
hyv aus-rabi	36	10	0		0		0		36
hyv aus-lt aman	36	10	0		0		0		36
hyv aus-hyv aman	99	27	0		0		0		99
lt aman-wheat	0		214	5	0		0		214
lt aman-rabi	18	5	0		0		0		18
lt aman-hyv boro	0		2141	50	0		0		2141
hyv aman-wheat	0		642	15	0		0		642
hyv aman-rabi	110	30	0		0		0		110
hyv aman-hyv boro	36	10	428	10	0		0		464
mustard-hyv boro	0		0		3401	30	0		3401
b aman-wheat	0		0		907	8	0		907
b aman-potato	0		0		1927	17	0		1927
b aman-rabi	0		0		1134	10	0		1134
Total	366		4281		11336		18849		34832

Table 5.2: Crop Production Under Future Without Project Condition

Crop	Area (ha)	Yield (t/ha)	Production (t)
b aus	214	1.25	267
hyv aus	514	3.75	1929
b aman	6802	1.75	11903
lt aman	2624	2.15	5640
hyv aman	1315	3.95	5196
l boro	377	2.25	848
hyv boro	25612	4.55	116533
Paddy			142317
wheat	2405	2.05	4930
potato	1927	12.00	23125
pulses	227	0.85	193
oilseeds	4157	0.75	3117
spices	75	2.25	170
vegetables	453	9.25	4197
jute	300	1.65	494
sugarcane	11	45.00	494
orchard	18	15.00	274

6. WATER RESOURCES INFRASTRUCTURE DEVELOPMENT OPTIONS

6.1 Summary of Problems

The problems within the project area were described in earlier sections of this report. They are summarized here as follows: seasonal inundation of most of the agricultural land by monsoon floods originating from the surrounding Lakhya and Meghna Rivers, damage of homesteads and infrastructure by peak floods spilling from the boundary rivers, and silting of internal channels. Normally during the pre-monsoon season the water levels in the surrounding rivers are low, but due to inadequate drainage boro crops grown in the lowlands are flooded by accumulated local runoff.

The proximity of the project area to the Dhaka market, combined with the soils and land topography, makes the area suitable for the production of high value winter crops and culture fisheries. However, the expansion of winter cropping is limited due to an inadequate irrigation water supply caused by siltation of the internal channels. The expansion of culture fisheries is restricted by flood hazard. The existing fish ponds are frequently overtopped by peak monsoon floods. At the end of the monsoon season, land preparation for rabi crops and boro rice is delayed because vast areas have to be cleared of water hyacinth, which thrives in the project area during the monsoon season.

The present agriculture, which has evolved to accommodate the monsoon floods, is based mainly on dry season rabi and boro rice crops. Damage during the monsoon season is mainly to infrastructure and communication systems in the affected areas. However, with improved flood protection and drainage there is a potential for expansion of both the winter and the monsoon season cropping.

There have been significant investments in infrastructure within the proposed project area including roads and embankments. These investments can be used for flood management if incorporated with additional hydraulic structures.

6.2 Water Resources Development Options

Over 80% of the project basin is flooded during the monsoon season in average years. Close to 100% of the basin is flooded when there are higher than 1 in 5-year floods in the Lakhya and Meghna Rivers. Due to the relatively flat topography and high rainfall, the scope for reducing the monsoon season flood area by means of gravity drainage is limited, but the project can successfully be protected against the destructive higher frequency peak floods. A better degree of protection can be achieved with pumped drainage, as presently provided in the Block A-1 and the Demonstration Unit of JICA Project.

There is a high level of infrastructural development in the project area at present. Further development of infrastructure (including industries), agriculture, and fisheries is needed but high monsoon floods are restricting development. The impacts of the monsoon floods, however, can

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be mitigated. Water resources planning needs to focus on protecting the area against the high monsoon floods. Proposed work would include the protection of infrastructure and culture fisheries, and the development of agriculture based on an improved flood regime and improved irrigation water availability.

There are two basic options for water resources development in the project area:

- Developments based on full flood protection by means of flood control embankments and pump drainage of the excess rainfall; and
- Developments based on partial flood protection by means of flood control embankments and gravity drainage of excess rainfall when water levels in the surrounding rivers permit.

To review the different options, three alternative development plans were studied as follows.

Plan 1 *Full Flood Control with Pump Drainage and Irrigation.* This plan is basically the Plan B, Phase I, of the JICA Narayanganj-Narsingdi Irrigation Project (1978). The studied area does not include the areas of the Demonstration Unit (1300 ha) and the Block A-1 (3000 ha) which has been commissioned in December 1993. Basically the JICA designs were followed in the project analysis. The infrastructure requirements have been updated taking into account the works carried out since 1978, the cropping patterns have been revised, and the costs estimates adjusted to the June 1991 price level.

Plan 2 *Partial Flood Control and Gravity Drainage.* High flood embankments and road/railway embankments will protect the area from the inflow of external floods and regulators will be used for gravity drainage. The area of this development is identical with the area of Plan 1.

Plan 3 *Partial Flood Control and Gravity Drainage.* The technical concept of this plan is the same as in Plan 2 but it covers a larger area. This plan basically covers the area of the Plan B, Phase I and Phase II, of the JICA Narayanganj-Narsingdi Irrigation Project (1978), excluding the 4,300 ha already developed as separate units.

The analysis of the three options reveal that the Economic Rate of Return for Plan 1 is 11%, which is below the required value of 12% (Table 6.1). This indicates that the development of pump drainage and irrigation system is not economical, due mainly to the high capital cost of irrigation systems with central pumping facilities.

By providing only flood protection and gravity drainage a lower investment is needed and the development appears economic. The area can be developed in one or two phases. The analysis indicates that Plan 3 - development of the whole project area as one unit - has a lower EIRR. However the investment cost is low and the increase in the production of high value crops is high.

Table 6.1: Comparison of Development Options

Item	Development Options		
	Plan 1 (FCD&I)	Plan 2 (FCD)	Plan 3 (FCD)
Area: Gross (ha) Net (ha)	24700 21411	24700 21411	40560 34832
Capital Investment (Mil Tk)	1725	265	576
Unit Cost (Tk/ha)	80547	12365	16545
Incr Net Econ Output (Mil Tk)	211	61	115
Incr Cereal Production ('000 t)	35	14	12
Incr Non-Cereal Production ('000 t)	23	7	36
Flood Damage Benefits (Mil Tk)	20	20	32
Open Fisheries Losses: (t) (Mil Tk)	651 16	379 10	707 19
Net Present Value (Mil Tk)	77	219	314
EIRR	**11.0%**	**29.7%**	**25.8%**

Preliminary field investigations have revealed that both social and technical difficulties may be encountered in constructing and maintaining the flood embankment along the Meghna River. It may be feasible to implement the project in two phases, by first developing the Plan 2 area while works could be carried out to secure the Meghna embankment from erosion with plantations or other means. Both FCD plans, Plan 2 and Plan 3, are recommended for analysis at feasibility level.

The project description presented in Chapter 7 is based on Plan 3, which future development of the whole project area.

The structural requirements and cost estimates for the above three plans are presented in Annexes A and B.

7. PROPOSED FLOOD PROTECTION and DRAINAGE PROJECT

7.1 Rationale

This plan provides for protection against high monsoon floods and improved drainage in an area of 40,560 ha, confined by the Meghna and Lakhya Rivers from their confluence in the south to the Tongi-Narsingdi Railway line in the north. Flood protection will be achieved by constructing about 42 km of new embankments and utilizing the existing embankments and road and railway embankments along the remaining 66 km of the project boundary.

Re-excavation of 115 km of existing channels will prevent water logging in lowland areas and improve post-monsoon drainage. The re-excavated channels will also enhance LLP irrigation and improve internal navigation routes.

As a result of project implementation the homesteads and infrastructure will be protected from high floods and the area of flood free arable land will increase by about 6,000 ha.

7.2 Objectives

The objectives of the Narayanganj-Narsingdi Project are:

- to increase production of high value winter crops and vegetables;
- to protect homesteads, infrastructure, and communication systems from high monsoon floods;
- to increase production of HYV aman and HYV aus crops;
- to protect from flooding and create conditions for expansion of culture fisheries in the area.

7.3 Description

The proposed project area encompasses the natural drainage basin of the lower Mora Brahmaputra River. The Brahmaputra channel is silted near the Tongi-Narsingdi Railway crossing and the upper part of the basin drains into the Meghna at Narsingdi.

Each year high monsoon floods overtop the banks of the Meghna River along the eastern boundary of the project. Occasionally floods from Lakhya River enter the project area along its western boundary. Out of approximately 98 km of rivers along the project boundary about 56 km are already embanked with high embankments and road/railway embankments.

On the western side of the project, the Lakhya River flood waters enter the area through the unembanked section from Kendua to Ghorasal in the north and through four culverts in the

Dhaka-Chittagong Road, and three culverts in the N-M Embankment in the south. Inflow through the two main spill/drainage channels in the north is checked by the existing 2-vent 1.5 x 1.8 m Kendua Regulator and 6-vent 0.9 m dia. Ghagra Regulator.

On the eastern side, the Meghna River flood waters enter the area by overbank spills between Badiyar Bazar and Gopalpur (unembanked 20 km), through the open northern and southern channels of the Baniar Khal, and through open culverts in the road between Gopalpur and the Balushair Project embankment.

In the south, water enters the area by backflows through the Mora Brahmaputra channel and through the open road culverts. The Mora Brahmaputra is the main drain of the area as well as the main source of water for winter irrigation.

The project design concept is to prevent the entry of external waters into the area during the monsoon season with high flood embankments, and to provide gravity drainage of local runoff through hydraulic structures and main drainage channels.

In general, the flood protection works include the completion of flood embankments along the Meghna and Lakhya Rivers, some upgrading of existing roads, and the closing of the openings in roads and embankments with hydraulic structures. For the improvement of drainage it is proposed to re-excavate major internal khals.

In the south the project boundary could be aligned with the Narayanganj-Baidyar Bazar Road. However, to preserve the important Hindu religious grounds at Langal Bundh along the Mora Brahmaputra River the project boundary has been shifted upstream to the Mora Brahmaputra bridge on the Dhaka-Chittagong Road (Figure 9).

7.3.1 Flood Protection

Embankments
The following embankment works are required to complete empoldering of the Narayanganj-Narsingdi Project area.

- Construction of new high embankments (42.6 km):
  - along the left bank of Lakhya River from Tongi-Narsingdi Railway to the existing embankment of Block A-1 near Kendua (20.1 km),
  - connecting the embankment to the Mora Brahmaputra Regulator at Dhaka-Chittagong Road crossing (2.0 km),
  - along the right bank of Meghna River from Baidyar Bazar to Gopalpur Road (20.5 km).
- Upgrading of roads to flood embankments (20.0 km):
  - Narayanganj-Badiyar Bazar Road (7.0 km),
  - Langal Bundh Road along the right bank of Mora Brahmaputra (4.0 km),
  - Gopalpur-Narsingdi Road (9.0 km).

The degree of embankment protection has been increased for this project to a 1 in 50-year flood, because of the high population density and the present and potential infrastructure and industrial developments in the area.

Alignment of the Lakhya embankment should have a minimum set back distance of 60.0 m. To reduce the risk of embankment erosion by wave action, it is proposed to construct the Meghna embankment along the right bank of the Gopalpur Khal. The new embankment would join the Gopalpur road and N-M railway embankment. Tree wind breaks could be planted in the area between the Meghna and the Gopalpur Khal.

The embankment section has been designed to utilize the crest of the dyke as a roadway. The embankment-roadway would likely be developed by the Roads and Highways Department, therefore, the cost of pavement has not been included in the project cost analysis.

Table 7.1 Embankment Design Crest Elevations

Locations	Section (km)	Crest Level (m PWD)
Lakhya River		
Ghorasal, T-N Rlwy Emb.	0	8.10
Kendua, Block A-1 Emb.	20.1	7.76
Nabiganj	46.0	7.55
Mora Brahmaputra River		
Dhaka-Chittagong Road	53.0 55.0	7.85 7.85
Meghna River		
Baidyar Bazar	61.0	7.85
N-M Rlwy Emb.	85.5	8.05
Narsingdi	98.0	8.13

Crest levels of the embankments are designed for the 1:50-year flood levels with freeboards of 0.91 m for the Lakhya embankment, and 1.22 m for the Meghna embankment.

The proposed embankment cross section is 6.00 m crest width, with side slopes of 1(v):2.5(h) and 1(v):3(h) on country and river side respectively.

Embankment design crest elevations are shown in Table 7.1. Longitudinal profiles of the proposed embankments are shown in Figures 10, 11,and 12.

Structures for Flood Control and Drainage

To check the flood inflow into the project area through the open khals it is proposed to construct 24 hydraulic structures: 14 Pipe Sluices, 9 RCC Box Regulators and 1 Navigation Lock with Regulator. All the structures are designed for drainage and flushing. The structures which drain into the Lakhya and Brahmaputra Rivers will be attached to existing culverts and road bridges. The Meghna River structures will be on open khals or attached to the existing road bridges.

The Brahmaputra Navigation Lock should be constructed on the northern side of the Dhaka-Chittagong Road. With the structure location upstream of the bridge the present water conditions in the Mora Brahmaputra River along the Langal Bundh, the Hindu religious site, will not be altered.

The drainage requirement of the Narayanganj-Narsingdi Project basin, including about 26 km^2 of the Daria Khal catchment located north of the Tongi-Narsingdi Railway line, is about 190 m^3/s; using an estimated 38 mm per day drainage index. The total drainage capacity of the proposed new structures is about 232 m^3/s. The capacity of the existing regulators draining into Lakhya is 14 m^3/s and into Meghna is about 30 m^3/s, which gives a combined total of about 276 m^3/s. The additional drainage capacity is required for local drainage.

The drainage capacity of structures draining into the Mora Brahmaputra River at the low end of the basin is 174 m^3/s which is adequate to drain the project runoff, assuming that during rising stages of the rivers about 90% of the basin will drain through the Mora Brahmaputra.

The proposed structures are listed in Table 7.2, and their locations are shown in Figure 9.

Drainage Channels

A provision has been made for re-excavation of 115 km of internal channels; 60 km of the Mora Brahmaputra channel, and 55 km of other internal khals. Re-excavation and deepening of the channels by an average 1 to 1.5 m will remove drainage congestion and improve post-monsoon drainage. During the dry season there will be more water in the interior of the project accessible for LLP irrigation.

Table 7.2: Proposed Structures

Location	Type	Size (Nos)	Design Q (m^3/s)
Structures draining into Lakhya River			
D-C Road	Fl/Dr Regulator Pipe Sluice	1-vent 1.5 x 1.8 m (2) 2-vent 0.9 m Dia. (2)	8.0 4.0
N-M Rlway Embankment	Pipe Sluice Pipe Sluice	1-vent 0.9 m Dia. (2) 2-vent 0.9 m Dia. (2)	2.0 4.0
Structures draining into Mora Brahmaputra River			
Langal Bundh	Fl/Dr Regulator Pipe Sluice	1-vent 1.5 x 1.8 m (2) 1-vent 0.9 m Dia. (2)	8.0 2.0
Brahmaputra River	Lock + Regulator	6.0 m Lock + 6-vent 2.0 x 6.0 m Dr Reg.(1)	54.1 108.2
D-C Road	Pipe Sluice	1-vent 0.9 m Dia. (2)	2.0
Structures draining into Meghna River			
Meghna Embankment	Pipe Sluice Fl/Dr Regulator Fl/Dr Regulator Fl/Dr Regulator	1-vent 0.9 m Dia. (4) 1-vent 1.5 x 1.8 m (2) 2-vent 1.5 x 1.8 m (2) 3-vent 1.5 x 1.8 m (1)	4.0 8.0 16.0 12.0
Total:		**24 Nos**	**232.3**

7.3.2 Impact on Flooding

As a result of the flood protection measures the area will be free of peak floods and the average level of the monsoon season inundation will be reduced by 0.74 m. As a result, the area of flood-free land (F0) will increase by about 6000 ha while the area of deeply flooded land (F3) will decrease by about 14,000 ha.

Drainage improvement works will eliminate water logging in low-lying areas during the pre-monsoon season and reduce the post-monsoon drainage period. The areas under different depths of flooding under the present, FWO, and FW conditions are shown in Table 7.3.

7.3.3 Expected Benefits

The benefits expected from the project which relate to agriculture are described below. Flood control would reduce monsoon season water level in the project area. Drainage improvements would also contribute towards improving the hydrologic regime for crop production and make the land available for cultivation early in the rabi season.

Cropping patterns are expected to be impacted by the improvements in hydrologic regime. Drainage improvements and protection from floods would encourage farmers to extend cultivation of high yielding varieties of aus, aman, and boro with provision of irrigation. There would be corresponding reduction in area under local varieties of aus and broadcast aman rice. Timely availability of land for cultivation early in the rabi season would create an opportunity of increasing rabi crop cultivation with residual soil moisture. High value agricultural crops are also expected to be grown with irrigation facilities in the rabi season. Good all-weather road communication and proximity of the project area to Dhaka city make marketing of agricultural produce easier. Cropping patterns under future with project condition are presented in Table 7.4, and the projected crop production is presented in Table 7.5.

Annual cereal and non-cereal crop production and per person availability are given in Section 7.8

Other major benefits are protection from flood damage of homesteads and infrastructures, and aquaculture. The pond fisheries production is expected to increase substantially when the area is protected from flooding.

Table 7.3: Area by Depth of Flooding

Flood Depth (m)	Gross Area (ha)		Net Area (ha)	
	Pre-Project	Post-Project	Pre-Project	Post-Project
< 0.30	4778	10512	366	6030
0.30-0.90	4567	6190	4281	5904
0.90-1.80	11336	18222	11336	18222
> 1.80	19879	5636	18849	4550
Total	40560	40560	34832	34706

Table 7.4: Cropping Patterns For With-Project Condition
(Areas in ha)

Cropping Pattern	F0		F1		F2		F3		Total Area
	Area	%	Area	%	Area	%	Area	%	
orchard	42	0.7	0						42
sugarcane	18	0.3	0		0				18
fallow-hyv boro	0		0		11662	64	3185	70	14847
b aus-lt aman-rabi	0		177	3	0		0		177
jute-wheat	0		295	5	0		0		295
hyv aus-wheat	361	6	472	8	0		0		834
hyv aus-potato	904	15	0		0		0		904
hyv aus-rabi	1025	17	1417	24	0		0		2442
lt aman-wheat	0		295	5	0		0		295
lt aman-rabi	60	1	0		0		0		60
lt aman-hyv boro	904	15	1771	30	0		0		2676
hyv aman-wheat	241	4	590	10	0		0		831
hyv aman-potato	181	3	0		0		0		181
hyv aman-rabi	844	14	0		0		0		844
hyv aman-hyv boro	1447	24	886	15	0		0		2333
mustard-hyv boro	0		0		1458	8	1365	30	2823
b aman-wheat	0		0		1458	8	0		1458
b aman-potato	0		0		1822	10	0		1822
b aman-rabi	0		0		1822	10	0		1822
Total	6030		5904		18222		4550		34706

Table 7.5: Future Crop Production for With-Project Condition

Crop	Area (ha)	Yield (t/ha)	Production (t)
b aus	177	1.25	221
hyv aus	4181	3.75	15678
b aman	5102	1.75	8928
lt aman	3208	2.15	6898
hyv aman	4190	3.95	16549
hyv boro	22678	4.55	103186
Paddy			151461
wheat	3714	2.05	7613
potato	2908	12.00	34891
pulses	802	0.85	681
oilseeds	4239	0.75	3179
spices	267	2.25	601
vegetables	2860	9.75	27885
jute	295	1.65	487
sugarcane	18	45.00	814
orchard	42	15.00	633

7.3.4 Mitigation Measures Incorporated

The project will have a negative effect on openwater fisheries resulting mainly from restrictions in fish migration due to embankments and structures. Provision of fish passes incorporated into embankment structures would lessen the disruption. But the continuous inflow through the passes would reduce the area's flood protected agricultural land and increase conflict between fisheries and agriculture. This issue needs to be studied further during the feasibility study.

7.4 Project Operation and Maintenance

The proposed regulator structures (RCC Box Regulators) will be equipped with slide gates; the smaller pipe sluices with automatic flap gates. The regulator gates should be closed in the pre-monsoon when the river levels start to rise, and open at the end of monsoon. Sometimes the gates may need to be open during the monsoon season if the water level on the country side rises above the river side level, which may occur following a heavy rainfall over the basin. The pipe sluices only require regular inspection.

Operation of the navigation lock will be dictated by traffic requirements.

The structures with slide gates should be attended by operators appointed on a permanent basis. These operators may also be in charge of the pipe sluices which should be inspected on a regular basis and following peak floods.

It is proposed that a single Project Operation Unit (POU) be formed for the purpose of operation and maintenance of the Narayanganj-Narsingdi Project. The POU should have on its staff a hydrologist/hydraulic engineer, an agronomist, a fisheries specialist, and representatives of local bodies, field monitors, and structure operators.

The field monitors would be responsible for inspecting project components (embankments, channels and structures) and for monitoring water levels. They would relay the information to the central office through a separate communication system set up for the project. The central office would analyze the information and transmit orders to the structure operators.

The maintenance works like repair of embankments and structures, and re-sectioning of drainage channels should be the responsibility of the POU.

To function properly, the POU should have the authority to make decisions independently of the BWDB Division of the project area.

7.5 Organization and Management

During the early part of the feasibility study process, a client group would need to be organized to oversee project development. The client group would be composed of representatives from the local farming community, fishing community, and would include relevant thana-level technical officers. The group would ensure that the problems of the area are clearly understood and adequately reflected in the feasibility work and that the technical solutions 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 exercise. They would also be informed as to details of designs being proposed by BWDB design engineers which designs, in the end, would require their approval. 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 would be responsive to the client group described above. The general tasks include completion of final designs, preparation of tenders, pre-qualification of contractors, contract awards and construction supervision. The general

management of BWDB activities would be under the Executive Engineer, Dhaka O&M, Division I. Construction supervision would be carried out by sub-divisional field staff with offices in Dhaka and Narsingdi.

During the construction phase, BWDB would be responsible for establishing a Project Operation Unit (see above) to undertake project operation and maintenance activities. The POU would liaise with the various agencies responsible for providing services to the project community including agriculturalists and fishermen.

Bangladesh Rural Development Board (BRDB) is responsible for assisting with command area development through farmers' training and by 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.

7.6 Cost Estimates

Total project costs are estimated at Tk 576.31 million. A summary of total costs is presented in Table 7.6 with details provided in Annex B.

Estimates of land required and of the physical work to be undertaken are based on preliminary designs and lay-out plans using four inch to one mile topographic maps and historic hydrologic data.

Land costs reflect the current prices obtained from field interviews: land along the Lakhya River was priced at Tk 740,000 per ha, land for the Meghna embankment and for re-excavation of channels in the lowlands was priced at Tk 400,000 per ha. Earthwork costs are based on the BWDB Schedule of Rates for Dhaka Circle indexed to June 1991 prices. Structure costs are based on preliminary line drawings and parametric costs developed for the region. These were also indexed to June 1991 prices in accordance with FPCO Guidelines for Project Assessment.

Table 7.6 Capital Cost Summary

Item	Cost ('000 Tk)
Embankments	172799
Channels	53282
Structures	91700
Buildings	4750
Land Acquisition	78380
Base Cost	400911
Physical Contingencies	100228
Subtotal	501139
Study Costs	75171
TOTAL	576310
Net Area (ha)	34832
Unit Cost (Tk/ha)	16545

Notes: 1. Physical Contingencies are 25% of Base Costs

2. Study Costs are 15% of the Subtotal and include the cost of an EIA and preparation of an Environmental Management Plan.

7.7 Project Phasing and Disbursement Period

Five years are required to implement the project. One year (year zero) is required for completion of feasibility studies and conducting field surveys. Preparation of detail designs should start in year one and be completed in year three. Land acquisition should commence in year one, be implemented in phases preceding construction, and completed in year three. Construction activities should start in year one and be completed in year four. An itemized implementation schedule is shown in Table 7.7.

Table 7.7: Implementation Schedule

Activity	Year (% Completion)				
	0	1	2	3	4
Preconstruction Activities					
Feasibility Study	100				
Engineering Investigation	100				
Detail Designs	100	60	30	10	
Land Acquisition	30	40	30		
Construction Activities					
Construction of Embankments		20	30	30	20
Re-excavation of Channels			30	30	40
Construction of Structures			30	30	40
Project Buildings				100	

7.8 Evaluation

7.8.1 Environmental

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

Table 7.8: Food Availability Indicators
grams/person/day

Food Group	Present (1993)	FW (2000)	FW (2015)	FWO (2015)
Cereals	277	251	180	167
Non-Cereals	105	183	131	62
Fish	6	3	2	3

Agriculture

The annual grain crop production (paddy + wheat) is expected to increase by 11,828 tonnes from 147,247 tonnes (future without) to 159,075 tonnes as a result of the project, an increase of 8%. The cereal production increase implies a per person increase in cereal availability from 167 (FWO) to 180 (FW) gm per person per day, an increase of 8%. Current Bangladesh average consumption is 440 gm per person per day. Non-cereal production is expected to increase by 35,687 tonnes, from 32,054 tonnes (FWO) to 67,779 (FW) tonnes, an increase of 111%. This results from a 4,224 ha increase in area cultivated to non-cereals from 7,165 ha to 11,389 ha. It indicates an increase in the availability of non-cereals from 62 to 131 grams per person per day (Table 7.8).

Fisheries

The proposed project is a full flood control and drainage improvement project. The area will be enclosed with high embankments and the hydraulic structures gates will remain closed for most of the monsoon season and only local runoff will accumulate over the project floodplain area. The floodplain area will be reduced from 34,466 ha (FWO) to 28,676 ha (FW), a reduction of 17%. The migration to and from the surrounding rivers will be cut off and the floodplain inundation period will reduce. These changes will result in an overall reduction in openwater fish production.

The project should have a positive impact on aquaculture, as with flood protection the pond fisheries are expected to expand. Detailed fishery development designs were not carried out under this study and possible benefits have not been included in the project economic analysis. Impacts on open water fisheries production were assessed using a simplified model that represents the major system processes. These factors include migration, overwintering habitat extent, wet season habitat, habitat quality, and spawning habitat. The basis for this model is summarized in Annex C. A summary of outputs are provided in Table 7.9.

The analysis indicated that the total annual open water fisheries production impact from the project will be negative. Assuming the pond production remains the same, total annual fish production (beel + floodplain + channel + pond) would decrease from 1700 tonnes (FWO) to 993 tonnes (FW), which represents a reduction of about 42%. This implies a decrease in fish availability per person due to the project from 3 (FWO) to 2 (FW) gm per person per day (Table 7.8).

Table 7.9: 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	34466	1206.6	28676	17206	-604	-20462
Beels	360	147.6	360	216	-59	-3527
Channels	670	117.3	702	421	-44	-2799
Ponds	286	228.8	286	286	0	0
Totals	35762	1700.3	30024	18129	-707	-26788

Homestead flooding

Homestead flood damage would be eliminated. Due to the lack of reliable data on the extension and cost of homestead flood damage, a simple model based on inundation level and the house value according to landholding category was used. There are about 144,642 homesteads in the area, and the average plinth level is at about the 1:5 year flood level. About 43% of homesteads are inundated by an average 23 and 50 cm during the 1:10 to 1:20 year floods respectively. The estimated annualized economic value of the homesteads damage is about Tk 29 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. While it is clear that animals do graze on such areas, 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.

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

The impact of the project would be a decrease in winter grazing area by 98%, increase in winter wetland area by 5%, and decrease in summer wetland area by 23%.

There would be no impact on swamp forest as it has already disappeared from the Narayanganj-Narsingdi area.

An approximate estimate of economic and employment impacts of the project on wetland plant and animal production is given below.

Assuming an annual economic production of Tk 100 per hectare for both summer and winter wetland areas gives a total annual loss of Tk 560,000 per year. Assuming 1.0 pd/ha-yr for harvesting, the employment impact would -5,600 pd per year.

Table 7.10: Floodplain Grazing and Wetland Changes

Land Type	Winter Grazing Area			
	FWO	FW	Change	%
sc/wf F0	135	0	-135	
sc/wf F1	0	0	0	
sc/wf F2	2834	0	-2834	
Fallow Highland	75	75	0	
Total	3044	75	-2969	-98

Land Type	Winter Wetland			
sc/wf F3	0	0		
F4, Beel, Channel	1210	1242	32	
Total	1210	1242	32	5

Land Type	Summer Wetland			
wc/sf F1	0	0	0	
wc/sf F2	4535	13120	8585	
wc/sf F3	18849	4550	-14299	
F4, Beel, Channel	1210	1242	32	
Total	24594	18912	-5682	-23

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.

Land Use

Land use changes are summarized in Table 7.11. A total of 156 ha of land (about 0.4% of the project gross area) will be required for the project infrastructure (including re-excavation of channels). Of this:

- 126 ha will be taken from cultivated area. Assuming average yields and that this is all under rice, this corresponds to incremental cereal production foregone of about 479 tonnes per year or about 4% of total incremental cereal production.

- 30 ha will be taken from homestead area. This is about 1% of total homestead area, which implies that 1,500 households or about 8,100 persons will be displaced. Also, homestead garden agricultural production from these sites will be lost. Roughly estimating homestead garden area at 20% of the homestead area, and the garden production at Tk 1000 per decimal or Tk 200,000 per ha, this comes to about Tk 1.2 million per year.

Transportation/navigation
The project will protect the internal roads from annual floods and there should be no disruption in the Dhaka-Sylhet and Dhaka-Chittagong road communication. The proposed embankments are designed with a six metre crest width to accommodate vehicular traffic which would improve the road network within the project.

The total length of existing roads in the project is about 185 km of which 140 km is flood affected. Assuming 15% of the affected roads are damaged and the repair cost is Tk 190,000/km, the annual benefit of flood protection is Tk 2.8 million.

Re-excavation of major drainage channels will enhance the internal navigation which will benefit from improved channel sections and an extended navigability period. Water links with boundary rivers will be cut off, except for the Mora Brahmaputra River, on which a navigation lock is proposed.

Table 7.11: Land Use Changes

Use	Change in Area (ha)
Cultivation	- 126
Homesteads	- 30
Beels	
Ponds	
Channels	+ 32
Fallow[1]	
Infrastructure[2]	+ 124

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

Higher flood levels
The project will not affect the Meghna River flood levels, which has a wide floodway. The Lakhya River flows in a confined channel which is already embanked, with the exception of about a 20 km section with high river banks downstream of Ghorasal. As this section overtops only during extreme floods there is a possibility of an increase in high flood levels in the future.

7.8.2 Social

The key areas of social impact for this project are described below.

Employment
There will be an overall decrease in employment of 223,000 person-days per year. This is composed of:

- an increase in agricultural labour employment of 1,013,000 pd/yr:
  - owner-labour employment + 632,000 pd/yr, of which very roughly 20% is post-harvest processing activities traditionally done by women of the household.
  - hired labour + 381,000 pd/yr, of which about 10% is for post-harvest processing traditionally done by women hired in (mainly by larger farmers) for the purpose.

- a net decrease in employment opportunities for landless people of 1,236,000 pd/yr, mainly in fishing labour due to reduced openwater fish production. In addition to this, there would be a corresponding loss in support activities such as net-making and post-catch processing (mainly drying) much of which is done by women.

Displacement impacts due to land use changes
Households whose homestead land is acquired, for proper cash compensation, by the project may have difficulty relocating. This is because suitable homestead lands are so scarce that availability of replacement land for purchase is not assured.

Two mitigation options bear consideration. Embankments could be constructed with berms at strategic locations to support homesteads. Alternatively, provision could be included for the construction of raised housing platforms to facilitate relocation. The experience of BWDB in resettling landless people on embankments in the Cyclone Protection Project may be relevant to the requirements of this project area.

Conflicts
With flood protection there will be expansion of pond fisheries at the expense of agriculture.

Households that are left outside the embankment along the Meghna River could also be a source of conflict. When water levels are high, river side residents may cut the embankment in an attempt to relieve flooding in their area. Detailed settlement surveys will be required to assess the magnitude of this problem.

Equity
The net equity impact would appear to be *regressive*. Who benefits?

- Landowners, in proportion to landholdings, benefit directly from investment in agriculture production. This is the main benefit (78% in economic terms) of the project and its distribution is quite *regressive*.

Who loses?

- Families dependent upon fishing labour. These families are mainly landless and tend to be poorer than average. *Regressive.*

- Families displaced from their homesteads by project land acquisition. Insofar as more wealthy families can influence infrastructure siting/alignment, this is *regressive*.

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

Gender Equity
The net equity impact would appear to be *regressive*. While employment opportunities for women are expected to increase in agriculture, they will decrease in fisheries, and in wetland gathering. Given that overall employment is expected to decrease, it is also reasonable to assume that employment for women will decrease by a proportionate amount.

Table 7.12: Qualitative Impact Scoring

Qualitative Impact	Impact Sign	True=1 False=0					Score
		Sensitive	Magnitude	Immediate	Sustainable Pos Impact/ Irreversible Neg Impact	No Mitigation Required/ Possible	
Ecological Character of Wetlands	-1	1	1	1	0	0	-3
Regional Biodiversity	-1	0	0	0	1	1	-2
Road Transportation	1	1	1	1	0	1	+4
Navigation	-1	1	1	1	0	0	-3
Flood Levels Outside Project Area	-1	0	0	1	1	0	-2
Conflicts	-1	0	0	0	0	1	-1
Socioeconomic Equity	1	0	0	0	1	1	+2
Gender Equity	1	1	0	0	1	1	+3

The adverse effects of acquiring 30 ha of homestead land (1,500 households involving an estimated 4,000 females) will be substantial given that most village women spend most of their lives within the homestead and are responsible for homestead-based productive tasks.

Qualitative Impact Scoring

The qualitative criteria shown in Table 7.12 are scored on an 11 level scale of -5 to +5. Scoring of those criteria that are impacts (some are not, like "responds to public concerns") is shown in Table 7.14. The scoring procedure is analogous to that used in the FAP 19 EIA case studies, but simplified to eliminate half-point scores (1.5, 2.5, 3.5, etc). Here, 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.

7.8.3 Economic

The project has an economic rate of return of 25.8%, which compares well to the required rate of 12% as prescribed by government. It is a medium sized investment project, at Tk 576 million, and the unit cost is reasonable at Tk 16,545 per hectare. It covers a large geographic area of 40,560 ha located close to Dhaka. The rate of return remains above the required 12% under different economic scenarios (a 20% increase in capital costs would reduce the rate of return to 22.1%), and a delay in benefits by two years would reduce the ERR to 18.1%.

The foreign costs associated with the project are low, at 7% (excluding FFW contributions). Donor funding considerations would clearly need to include funding local costs.

The benefits of the project relate to agriculture and protection of homesteads and infrastructure. The agricultural benefit is mainly from increased production of high value crops.

The openwater fish production would decrease by an estimated 48% of future-without-project production. The value of the loss in fish production would amount to about 16% of the value of incremental agricultural output.

The disbenefits that result from loss of food, shelter, and products that are currently harvested from the seasonal wetlands are very small though they impact the population group which is most vulnerable to a loss in resources.

A summary of salient data in provided in Table 7.13.

It is anticipated that the established crop marketing system will handle incremental crop production without any reduction in prevailing average price levels. Assuming the current annual growth in the demand for grain remains at about 3%, the increased cereal production is unlikely to present any marketing difficulties.

A significant caution is that the economic benefits are based largely on assumed shifts in cropping patterns, and if this did not occur, the project would not be viable. Lessons of the past have shown that producers have not always responded as predicted, and this case warrants special efforts in predicting producer responses.

7.8.4 Summary Analysis

From a multi-criteria perspective (Table 7.14), the project is not attractive:

- A number of households would lose their homestead land to project land acquisition.
- Conflicts between farmers and fishermen, and between families living within and outside the embankment, would increase.
- The net employment impact is negative.
- The project has a high dependency on central government for implementation.
- There would be a decline in fisheries production.

The positive aspects of the project would be:

- Benefits derive from agriculture 78%, flood protection of households 19%, and savings in maintaining existing infrastructure 3% (of total benefits).
- The project would not adversely affect regional biodiversity.
- Rate of return is acceptable.
- Substantial increase in high value crop production (mainly vegetables for the Dhaka market).

- Increased economic returns to land owners.
- Increase in cereal production.
- Project responds to some public concerns.

Table 7.13: Summary of Salient Data

Economic Rate of Return (ERR)	26%			
Capital Investment (Tk million)	576			
Maximum O+M (Tk million / yr)	17			
Capital Investment (Tk/ha)	16545			
Foreign Cost Component	7			
Net Project Area (ha)	34832			
Land Acquisition Required (ha)	156			

AGRICULTURAL IMPACTS		Present	FWO	FW
Incremental Net Econ Output (M Tk / yr)	114.63			
Cropping Intensity		1.4	1.4	1.6
Average Yield (tonnes/ha)		3.7	3.8	4.1
Average Gross Margins (Tk/ha)		17856	18125	17884
Owner Labour (md/ha)		121	122	117
Hired Labour (md/ha)		47	48	48
Irrigation (ha)		28109	28676	29643
Incremental Cereal Prod'n (' 000 tonnes / yr)	12			
Incremental Non-Cereal (' 000 tonnes / yr)	36			
Incremental Owner Labour (' 000 pd / yr)	632			
Incremental Hired Labour (' 000 pd / yr)	381			

FISHERIES IMPACTS		Flood plain	Beels	Channels
Incremental Net Econ Output (M Tk / yr)	-18.75	-14	-2	-2
Impacted Area (ha)		28676	360	702
Average Gross Margins (Tk/ha)		1278	28700	12250
Remaining Production on Impacted Area, %		60%	60%	60%
Incremental Fish Production (tonnes / year)	-707	-604	-59	-44
Incremental Labour ('000 pd / yr)	-1231	-1209	-7	-15

FLOOD DAMAGE BENEFITS				
Households Affected ('000)	62.5			
Reduced Econ Damage Households (M Tk / yr)	28.97			
Embankments/Roads Affected (km)	140			
Reduced Econ Damage Roads (M Tk / yr)	2.79			

OTHER IMPACTS				
Wetland Incr Net Econ Output (M Tk / yr)	-0.56			
Wetland Incremental Labour ('000 pd / yr)	-5.6			
Acquired Cult & Homestead Lands, Incr Net Econ output (M Tk / yr)	-1.6			
Persons Displaced by Homestead Acquisition	8100			

Table 7.14: Multi-Criteria Analysis

Economic		
Indicator	**Units**	**Value**
Economic Internal Rate of Return (EIRR)	per cent	25.8
EIRR, Increase Capital Costs by 20%	per cent	22.1
EIRR, Delay Benefits by Two Years	per cent	18.1
EIRR, Decrease in Agr/Fish Production by 20%	per cent	22.9
Net Present Value	'1000 Tk	313737

Quantitative Impacts			
Indicator	**Units**	**Value**	**Percent[1]**
Incremental Cereal Production[2]	tonnes	6920	8.0
Incremental Non-Cereal Production	tonnes	35687	111.0
Incremental Fish Production	tonnes	-707	-41.6
Change in Floodplain Wetland/Fisheries Habitat	ha	-5790	-16.8
Homesteads Displaced Due to Land Acquisition	homesteads	1500	1.0
Homesteads Protected From Floods	homesteads	62500	43.0
Roads Protected From Floods	km	140	75.0
Meghna Flood Levels (monsoon)	m	NC	
Lakhya Flood Levels (monsoon)	m	+0.1	
Owner Employment	million pd/yr	+0.63	11.0
Hired Employment (Agri+Fishing+Wetland)	million pd/yr	-0.85	18.0

Qualitative Impacts (ranked from -5 ...0... +5)	
Impact	**Rank**
Ecological Character of Wetlands (Beels)	-3
Regional Biodiversity	-2
Road Transportation	+4
Navigation	-3
Flood Levels Outside Project Area	-2
Conflicts	-1
Socioeconomic Equity	+2
Gender Equity	+3
Decentralized Organization and Management	-3
Responds to Public Concerns	+2
Conformity to Regional Strategy	+4

[1] Percent changes are calculated relative to future-without-project values of: total production of cereal, non-cereal, and fisheries; total floodplain area; total number of homesteads (for displacement due to land acquisition); Lakhya water levels; and total employment for owners and hired labourers.

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

ANNEX A

ENGINEERING DATA AND ANALYSIS

ANNEX A: ENGINEERING DATA AND ANALYSIS

A.1 Climatic Data

The weather stations within the Narayanganj-Narsingdi Project area are listed in Table A1. The monthly averages of the climatic parameters are presented in Tables A2 and A3, and the extremes of records in Table A4.

Table A1: Weather Stations Relevant to The Narayanganj-Narsingdi Project Area

Name of Station	Number	Location Relative to Project Area
Dhaka	R-009	Outside, west central
Narsingdi	R-076	Peripheral, to the northeast
Bancharanpur	R-351	Outside, east central
Munshiganj	R-365	Outside, to the south

Table A2: Average Rainfall in the proximity of Narayanganj-Narsingdi Project Area 1961-90 (mm)

Period	Dhaka (W)	Narsingdi (NE)	Bancharanpur (E)	Munshiganj (S)
January	8	7	3	4
February	21	18	14	17
March	61	54	46	44
April	153	201	138	162
May	288	385	260	289
June	283	510	293	430
July	379	504	350	417
August	307	436	271	384
September	307	309	204	258
October	165	188	101	134
November	36	34	34	33
December	13	12	7	5
Year	2121 (125%)	2668 (157%)	1695 (100%)	2159 (127%)

Table A3: Climatological Averages
Dhaka, 1950-92

Month	Sunshine (hrs)	Temperature			Humidity (%)
		Mean Max (°C)	Mean Min (°C)	Mean (°C)	
Jan	8.2	25.5	12.2	19.1	71
Feb	8.6	28.4	14.9	21.8	65
Mar	8.5	32.6	19.9	26.4	64
Apr	8.3	34.3	23.5	28.8	77
May	7.8	33.0	24.7	28.9	79
Jun	5.1	31.7	26.0	29.0	85
Jul	4.2	31.1	26.2	28.8	87
Aug	5.6	31.3	26.2	29.0	85
Sep	5.6	31.5	25.9	28.9	85
Oct	7.5	31.1	23.7	27.6	80
Nov	8.4	29.0	18.5	24.0	74
Dec	8.3	26.2	13.6	20.1	74
Year	7.3	34.3	12.2	26.1	77

Month	Wind		Rain (mm)	PET (mm)	Surplus/ Deficit
	Speed (km/hr)	Direction			
Jan	5.7	SW	8	104	-96
Feb	7.3	WSW	21	123	-102
Mar	7.6	SW	61	172	-111
Apr	10.8	S	153	188	-35
May	9.2	S	288	175	113
Jun	8.9	SSE	283	138	245
July	8.9	SSE	379	138	241
Aug	8.9	SSE	307	140	167
Sep	7.3	SSE	307	129	178
Oct	5.7	SE	165	132	33
Nov	5.4	SE	36	113	-77
Dec	5.7	SSE	13	100	-87
Year	7.3	S	2121	1652	469

Source: BMD
BARC for Potential Evapotranspiration (PET)

Table A4: Climatic Extremes of Record Dhaka, 1950-1992

Month	Daily Temperature		Monthly Rainfall		Maximum Daily	
	Max (°C)	Min (°C)	Max (mm)	Min (mm)	Rainfall (mm)	Wind Speed (km/hr)
Jan	34.2	5.6	99	0	99	93
Feb	36.6	4.5	95	0	53	94
Mar	40.6	10.4	189	0	73	93
Apr	42.3	15.6	275	17	174	130
May	40.6	18.4	621	69	231	96
Jun	38.4	20.4	856	161	189	94
Jul	35.2	21.7	690	184	326	167
Aug	35.9	21.0	540	92	165	167
Sep	35.3	22.0	496	91	257	94
Oct	38.8	10.4	568	29	116	133
Nov	33.3	10.6	131	0	102	128
Dec	31.2	6.7	86	0	50	50
Period	42.3	4.5	856	0	326	167

Source: BMD

A.2 Topographic Data

For the planning purpose, the project area has been divided into two sub-areas, with the division line along the N-M Railway embankment (similarly as in the feasibility report of the JICA Narayanganj-Narsingdi Irrigation Project, 1978). The area north of the railway corresponds to the Phase I area but without the areas of Demonstration Unit and Block A-1, and the area south of the railway embankment corresponds to the Phase II area of the JICA Project, but with the southern boundary shifted from the Badyar Bazar road to the Langal Bundh and Dhaka-Chittagong Road).

In this report the Plan 1 and Plan 2 developments, which cover the same area, refer to the Phase I area and the Plan 3 refers to a combined area of the Phase I and Phase II. A general topography of the project area is shown in Figure 3.

The Area-Elevation and Storage Volume Relations for the project study areas are given in Table A5.

Table A5: Basin Elevation vs Area-Storage Volume Relation

Elevation (m PWD)	Area (ha)	Storage (ha-m)	Elevation (m PWD)	Area (ha)	Storage (ha-m)
Plan 1 and 2 (Phase I)			(Phase II)		
2.3	130	0	2.3	380	0
2.9	1220	410	2.9	1220	490
3.5	5980	2610	3.5	4450	2220
4.1	12110	8120	4.1	13240	7610
4.7	16320	16790	4.7	14250	15990
5.3	20020	27860	5.3	15390	25020
5.9	22440	40800	5.9	15760	34520
6.6	23930	54940	6.6	15810	44140
7.2	24640	69740	7.2	15860	53790
7.8	24660	84770	7.8	15860	63460
8.4	24670	99800	8.4	15860	73130
9.0	24680	114850	9.0	15860	82800
9.6	24690	129890	9.6	15860	92460
10.2	24700	144950	10.2	15860	102130
Plan 3 (Phase I + Phase II)					
2.3	510	0	6.6	39740	99080
2.9	2440	900	7.2	40500	123530
3.5	10430	4820	7.8	40520	148230
4.1	25350	15730	8.4	40530	172930
4.7	30570	32770	9.0	40540	197650
5.3	35410	52880	9.6	40550	222350
5.9	38200	75320	10.2	40560	247080

A.3 Hydrological Data

The hydrological regime in the Narayanganj-Narsingdi area is governed by upper flows and by the tidal water levels in the Meghna and Lakhya Rivers. Good hydrological records are available from the gauging stations maintained on the boundary rivers, but there are no hydrometric stations inside the project basin. The project stations listed in Table A6 are shown in Figure 4.

Table A6: Narayanganj-Narsingdi Project Hydrometric Stations

Station No.	Name of Station	Type of Observations	Latitude (N)	Longitude (E)
Lakhya River				
178	Ghorasal	S	23°56.83'	90°37.50'
179	Demra	S,Q	23°43.60'	90°30.53'
180	Narayanganj	S	23°37.82'	90°31.03'
Meghna River				
274	Narsingdi	S	23°55.09'	90°43.76'
275	Badyar Bazar	S	23°38.88'	90°37.58'
275.5	Meghna Ferry Ghat	S	23°36.07'	90°37.38'

Table A7: Recorded Discharges along the Lakhya, 1964-91

Station	Years of Record	Mean (m^3/s)	Minimum (m^3/s)	Maximum (m^3/s)	Range (m^3/s)
Demra	18	NA	NA	2257	NA

Table A8: Recorded Discharges along the Meghna, 1964-91

Station	Years of Record	Mean (m^3/s)	Minimum (m^3/s)	Maximum (m^3/s)	Range (m^3/s)
Bhairab Bazar	20	4725	2.0	19800	19798

Table A9: Recorded Water Levels along the Lakhya, 1964-91

Station	Years of Record	Mean (m PWD)	Minimum (m PWD)	Maximum (m PWD)	Range (m)
Ghorasal	15	3.22	0.61	7.19	6.58
Demra	26	3.02	0.48	6.60	6.12
Narayanganj	17	2.84	0.62	6.23	5.61

Table A10: Recorded Water Levels along the Meghna, 1964-91

Station	Years of Record	Mean (m PWD)	Minimum (m PWD)	Maximum (m PWD)	Range (m)
Bhairab Bazar	27	3.94	0.74	7.66	6.92
Narsingdi	27	3.08	0.64	6.90	6.26
Badyer Bazar	25	2.87	0.14	6.98	6.84
Meghna Ferry Ghat	24	2.87	0.49	6.19	5.70

Table A11: Monthly Distribution of Mean Discharges and Water Levels Meghna at Bhairab Bazar

Period	Discharge (m^3/s)	Volume		Water Level (m PWD)
		MCM	%	
Apr	1105.6	2865.7	1.9	2.11
May	2777.9	7439.2	5.0	2.88
Jun	6259.8	16225.4	10.9	4.23
Jul	10618.1	28435.3	19.1	5.82
Aug	11759.7	31492.5	21.1	6.23
Sep	10686.4	27699.1	18.6	5.97
Oct	7994.8	21410.1	14.4	4.97
Nov	3278.7	8498.4	5.7	2.99
Dec	919.3	2461.9	1.7	1.97
Jan	396.5	989.5	0.7	1.54
Feb	263.9	638.4	0.4	1.42
Mar	360.4	965.2	0.6	1.55
Year	4725.3	149120.7	100.0	3.49

A.3.1 Flood Frequency Analysis

The flood frequency analysis for the stations bordering the project are summarized in Tables A12 to A14.

Table A12: Flood Discharges along the Lakhya (m^3/s)

Station	Return Period (Years)						
	2	5	10	20	25	50	100
Annual (Monsoon) Series:							
Demra	2096	2307	2422	2518	2546	2624	2691
Pre-Monsoon Series:							
Demra	NA	NA	NA	NA	NA	NA	NA

Table A13: Flood Water Levels along the Lakhya (m PWD)

Station	Return Period (years)						
	2	5	10	20	25	50	100
Annual (Monsoon) Floods:							
Ghorasal	6.46	6.75	6.91	7.05	7.08	7.19	7.29
Demra	5.73	6.06	6.26	6.42	6.47	6.61	6.74
Narayanganj	5.47	5.80	6.04	6.29	6.37	6.64	6.93
Pre-Monsoon Floods:							
Ghorasal	2.84	3.27	3.50	3.70	3.76	3.92	4.06
Demra	2.68	3.02	3.23	3.44	3.50	3.69	3.87
Narayanganj	2.40	2.68	2.84	2.99	3.40	3.17	3.29

Table A14: Flood Water Levels along the Meghna (m PWD)

Station	Return Period (years)						
	2	5	10	20	25	50	100
Annual (Monsoon) Floods:							
Narsingdi	5.88	6.26	6.48	6.68	6.74	6.91	7.06
Badyer Bazar	5.48	5.82	6.06	6.30	6.38	6.63	6.89
Meghna Ferry Ghat	5.45	5.73	5.90	6.05	6.30	6.21	6.33
Pre-Monsoon Floods:							
Narsingdi	2.70	3.01	3.18	3.31	3.35	3.47	3.56
Badyer Bazar	2.59	2.90	3.06	3.17	3.20	3.29	3.35
Meghna Ferry Ghat	2.56	2.92	3.12	3.28	3.33	3.46	3.57

A.3.2 Water Balance and Basin Water Level Analyses

A simplified water balance calculations were carried out to determine the with project water levels in the project basin. The analysis presented in Table A15 are based on the average monthly rainfall over the project catchment and the monthly evapotranspiration data from Dhaka weather station. Seepage into the basin through embankments and evapotranspiration crop factors were omitted, on the assumption that their values would approximately balance one another.

Table A15: Narayanganj-Narsingdi Project Water Balance

Month	Basin Rainfall (mm)	ETP (mm)	R-ETP (mm)	Soil Loss (mm)	Excess Rain (mm)	Cumulative Runoff (ha-m)	
						Plan 1,2	Plan 3
Jan	5.5	104.0	-98.5		0	0	0
Feb	17.4	123.0	-105.6		0	0	0
Mar	48.7	172.5	-123.8		0	0	0
Apr	181.9	188.0	-6.1		0	0	0
May	332.0	175.2	156.8	150.0	6.8	190	290
Jun	470.1	137.7	332.4	150.0	182.4	5170	81800
Jul	460.7	138.7	322.0		322.0	13980	22090
Aug	410.2	140.4	269.8		269.8	21360	33740
Sep	283.2	129.3	153.9		153.9	25560	40390
Oct	161.0	132.4	28.5		28.5	26340	41630
Nov	33.0	113.1	-80.1		0	0	0
Dec	8.8	100.1	-91.3		0	0	0
Year	2413.6	1654.0	759.5		963.4	26340	41630

Note: (1) Plan 1 and Plan 2 refer to 24,700 ha project area north of the N-M Railway embankment with a total catchment area of 27,340 ha.

(2) Plan 3 refers to the whole project area of 40,560 ha with a total catchment area of 43,200 ha.

The water levels in the embanked project area were obtained by superimposing the values of the cumulative monthly runoff on the elevation-storage volume curves. Adjustments were for drainage through structures when the outside water levels permit.

The future with project water levels in the embanked project area are given in Table A16.

Table A16: Narayanganj-Narsingdi Basin FW Project
Water Levels (m PWD)

Item	May	Jun	Jul	Aug	Sep	Oct
Plan 1 and Plan 2 Area (24,700 ha)						
Basin WL (m PWD)	2.70	3.60	4.55	4.90	**5.10**	4.23
Gravity Drainage	Yes	Yes	No	No	Yes	Yes
Project Impact	**5.10 - 5.75 = -0.65 m**					
Plan 3 Area (40,560 ha)						
Basin WL (m PWD)	2.55	3.50	4.30	4.70	**4.94**	4.10
Gravity Drainage	Yes	Yes	No	No	No	Yes
Project Impact	**4.94 - 5.68 = -0.74 m**					

Note: The "Project Impact" represents the difference between the present and the future with project average annual flood levels. The present levels refer to the water levels at the center of the basin derived from interpolation of the 1:2-y annual flood levels for Narsingdi and Baidyar Bazar stations.

A.4 Drainage Channels

Drainage channels can be sized for the pre-monsoon flood, the monsoon flood or for post-monsoon evacuation of the water accumulated in the basin during the monsoon season.

In the Narayanganj-Narsingdi Project area the pre-monsoon rainfall runoff is small and the highest runoff occurs in July and August. During these months however, the boundary rivers are high and normally there is no gravity drainage from the basin. Therefore, the project drainage channels (similarly as the drainage structures) are designed for the monsoon season rainfall runoff, and their capacities are verified for the post-monsoon drainage, which is controlled by the outfall river hydrograph. Taking into account future loss of channel capacity due to siltation, the channels should be provided with capacities 20% to 50% higher than those of the drainage structures. (As per BWDB recommendation drainage structures should have sufficient capacity to allow drainage of the basin at such rate that the difference between the basin and the falling river water levels does not exceed 0.15 m). Also the channels, if required, should have sufficient section for navigation and for supply of irrigation water.

Most of the channels in the Narayanganj-Narsingdi Project area have sufficient width but are silted and dry up during the winter months. The high bed levels delay the post-monsoon drainage and hamper the access of water for LLP irrigation.

Since surveyed sections of the existing channels are not available the proposed improvement works are based on field inspections and information provided by the local people.

To improve the drainage, irrigation and the local navigation in the Narayanganj-Narsingdi area, a provision has been made for re-excavation of 115 km of internal channels; 60 km of the Mora

Brahmaputra channel (including the section downstream of the Dhaka-Chittagong road bridge) and 55 km of other internal khals. The channels have variable bed widths. For the purpose of cost estimate, the Brahmaputra channel would be re-excavated to an average bed width of 15.0 m and deepened by about 1.5 m; and average bed width of 10.0 m and 1.0 m excavation depth were provided for re-excavation of other channels.

A.5 Flood Embankments

The project area is proposed to be enclosed with flood embankments and road/railway embankments. The channel openings including the existing bridges and culverts will be closed with hydraulic structures.

The following embankment works are required to complete the enclosure of the Narayanganj-Narsingdi Project area.

- Construction of new high embankments (42.6 km):
  - along the left bank of Lakhya River from T-N Railway to the existing embankment of Block A-1 near Kendua (20.1 km),
  - connecting embankment to the Mora Brahmaputra Lock cum Regulator at D-C Road crossing (2.0 km),
  - along the right bank of Meghna River from Badyar Bazar to Gopalpur Road (20.5 km).
- Upgrading of roads to flood embankment (20.0 km):
  - Narayanganj-Badyar Bazar Road (7.0 km),
  - Langal Bundh Road along the right bank of Mora Brahmaputra (4.0 km),
  - Gopalpur-Narsingdi Road (9.0 km).

Taking into account the high population density, the present and potential infrastructure and industrial developments in the project area it is proposed to construct embankments designed for protection against the 1 in 50-year annual flood.

Alignment of Embankments

Flood embankments are constructed at a certain distance from river banks which is called an embankment set back distance. The purpose of the embankment set back is to ensure a reasonable degree of protection against river erosion and against foundation failure. River erosion is governed by natural channel development processes, and it intensifies with increases in flow velocity and wind exposure. Detailed analysis are required to determine the progressive channel erosion under both the natural conditions and in a confined channel with embankments. Also the volume of earthworks and resettlement of homesteads which usually are constructed close to the river are taken into account.

A 60 m embankment set back distance is proposed for the Lakhya River which has stable channel.

The Meghna right bank is exposed to high winds which cause strong wave erosion and the river channel is shifting. To reduce the risk of embankment erosion by wave action, it is proposed to construct the Meghna embankment along the right bank of the Gopalpur Khal. See Figure 9.

The new embankment would join the Gopalpur road and N-M Railway embankment. Tree wind breaks could be planted in the area between the Meghna and the Gopalpur Khal.

Embankment Cross Sections

The embankment section has been designed to utilize the crest of the dike as a roadway. The embankment roadway could be developed in future by Road Department, therefore, the cost of pavement has not been included in the project capital cost.

Crest levels of the embankments are designed above the 1:50-year flood levels with added freeboard of 0.91 m for the Lakhya embankment, and of 1.22 m for the Meghna embankment.

The same cross sections are proposed for the Lakhya and Meghna embankments:

- crest width 6.00 m
- side slope (C/S) 1:2.5
- side slope (R/S) 1:3

Table A17: Embankment Design Crest Elevations

Locations	Section (km)	Crest Level (m PWD)
Lakhya River		
Ghorasal, T-N Rlwy Emb.	0	8.10
Kendua, Block A-1 Emb.	20.1	7.76
Nabiganj	46.0	7.55
Mora Brahmaputra River		
Dhaka-Chittagong Road	53.0 55.0	7.85 7.85
Meghna River		
Badyar Bazar	61.0	7.85
N-M Rlway Emb.	85.5	8.05
Narsingdi	98.0	8.13

The embankment design crest elevations are given in Table A17, and the longitudinal profiles are shown in Figure 10 to Figure 12.

A.6 Structures

To check the flood inflow into the project area through the open khals it is proposed to construct 24 hydraulic structures: 14 Pipe Sluices, 9 RCC Box Regulators and 1 Navigation Lock with Regulator. All the structures are designed for drainage and flushing. The structures draining into the Lakhya and Brahmaputra Rivers will be attached to existing culverts and road bridges. The Meghna structures will be on the open khals or attached to the existing road bridges.

The Brahmaputra Navigation Lock should be constructed on the northern side of the D-C Road. With the structure location upstream of the bridge the present water conditions in the Mora Brahmaputra River along the Langal Bundh, the Hindu religious site, will not be altered.

The drainage requirement of the Narayanganj-Narsingdi Project basin, including about 26 km^2 of the Daria Khal catchment located north of the T-N Rlway line is about 190 m^3/s. (Estimate based on a 5-day, 10-year return period storm with 38 mm average drainage index). The total drainage capacity of the proposed new structures is 232.3 m^3/s, and capacity of the existing regulators draining into Lakhya is 14 m^3/s and into Meghna is about 30 m^3/s, which gives a combined total of about 276 m^3/s. The extra discharge capacity has been provided on account of local drainage requirement.

The drainage capacity of structures draining into the Mora Brahmaputra River at the low end of the basin is 174 m^3/s which is adequate to drain the project runoff, assuming that during rising stages of the bounday rivers about 90% of the basin will drain through the Brahmaputra.

The proposed structures are listed in Table A18, and their locations are shown in Figure 9, Development Plan 3.

Table A18: Proposed Structures (Plan 3)

Location	Type	Size (Nos)	Design Q (m^3/s)
Structures draining into Lakhya River			
D-C Road	Fl/Dr Regulator Pipe Sluice	1-vent 1.5 x 1.8 m (2) 2-vent 0.9 m Dia. (2)	8.0 4.0
N-M Rlway Embankment	Pipe Sluice Pipe Sluice	1-vent 0.9 m Dia. (2) 2-vent 0.9 m Dia. (2)	2.0 4.0
Structures draining into Mora Brahmaputra River			
Langal Bundh	Fl/Dr Regulator Pipe Sluice	1-vent 1.5 x 1.8 m (2) 1-vent 0.9 m Dia. (2)	8.0 2.0
Brahmaputra River	Lock + Regulator	6.0 m Lock + 6-vent 2.0 x 6.0 m Dr Reg.(1)	54.1 108.2
D-C Road	Pipe Sluice	1-vent 0.9 m Dia. (2)	2.0
Structures draining into Meghna River			
Meghna Embankment	Pipe Sluice Fl/Dr Regulator Fl/Dr Regulator Fl/Dr Regulator	1-vent 0.9 m Dia. (4) 1-vent 1.5 x 1.8 m (2) 2-vent 1.5 x 1.8 m (2) 3-vent 1.5 x 1.8 m (1)	4.0 8.0 16.0 12.0
Total:		24 Nos	232.3

The structural requirements for the development Plan 1 and Plan 2 are provided in Annex B, Cost Estimate.

A.7 Fisheries

Table A19: Narayanganj-Narsingdi Project Fisheries

Type of Water Body	Area (ha)			Rate of Production (kg/ha)
	Present	FWO	FW	
Floodplain	34466	34466	28676	35
Beels	360	360	360	410
River/Channel	670	670	702	175
Pond	286	286	286	800

Note: FW Project open water production rates decreased approximately by 40%. See model in Annex C.

Table A20: Fish Production in the Narayanganj-Narsingdi Project Area (tones/year)

Year	Floodplain	Beels	Channels	Ponds	Total
Present	1206.3	147.6	117.3	228.8	1700.0
FWO	1206.3	147.6	117.3	228.8	1700.0
FW	602.2	88.6	73.7	228.8	993.3

Note: Pond production assumed to remain constant.

Table A21: Fisheries Employment ('000 Person Days)

Year	Floodplain	Beels	Channels	Ponds	Total
Present	2413.2	18.5	39.1	25.4	2496.2
FWO	2413.2	18.5	39.1	25.4	2496.2
FW	1204.4	11.1	24.6	25.4	1265.5

The direct fisheries employment estimates are based on the following labor requirement: **Beel** - 1 person day per 8 kg fish; **Floodplain** - 1 person day per 0.5 kg fish; **Pond** - 1 person day per 9 kg fish; **River/Channel** - 1 person day per 3 kg fish.

ANNEX B

ENGINEERING COST ANALYSIS

ANNEX B: ENGINEERING COST ANALYSIS

The physical requirements of project works along with the itemized cost estimates prepared in accordance with the FPCO Guidelines For Project Assessment, May 1992, are provided in the following sections. The Plan 1 estimates are given in Section B.1, the Plan 2 estimates in Section B.2 and the Plan 3 estimates are given in Section B.3 of this Annex. The total capital costs of the alternative developments are summarized at the end of each section.

B.1 Plan 1: Flood Control, Pump Drainage and Irrigation Project (Gross Area 24,700 ha)

Table B1.1: Earthworks - Flood Embankments

Item	Quantity	Rate (Tk)	Amount ('000 Tk)
Lakhya River Flood Embankments			
Construction of New Embankments from T-N Rlway to Block A-1 boundary, 20.1 km			
- Earth fill (h = 0-3 m)	430220 m^3	37.44	16107.44
- Royalty	430220 m^3	21.06	9060.43
- Turfing	361400 m^2	3.04	1098.65
Re-sectioning of Roads/Embankments, 12.0 km			
- Earth fill	267600 m^3	40.95	10958.22
- Royalty	267600 m^3	21.06	5635.66
- Turfing	252300 m^2	3.04	766.99
Total: - Earth fill - Royalty - Turfing	 697820 m3 697820 m3 613700 m^2		 27065.66 14696.09 1865.64
Total:			**43627.39**

Source: NERP Estimates.

Note: Cost of khal closures included in the cost of embankments

Table B1.2: Earthworks - Irrigation Canals

Item	Quantity	Rate (Tk)	Amount ('000 Tk)
Construction of Main and Secondary Canals			
- Excavation	1021000 m^3	18.72	19113.12
- Earth fill	1531000 m^3	37.44	57320.64
- Royalty	510000 m^3	21.06	10740.60
- Turfing	1900000 m^2	3.04	5776.00
Total:			**92950.36**

Table B1.3: Earthworks - Drainage Channels

Item	Quantity (m^3)	Rate (Tk)	Amount ('000 Tk)
Re-excavation of Mora Brahmaputra - Haridhana River			
L = 30.0 km, average excavation b = 10.0 m, d = 1.5 m, s = 1:1.5	551250	25.74	14189.18
Re-excavation of Other Internal Khals			
L = 20.0 km, average excavation b = 10.0 m, d = 1.0 m, s = 1:1.5	229960	21.06	4843.00
Re-excavation of Channels Draining to Pumping Stations			
L = 15.0 km, average excavation b = 10.0 m, d = 1.5 m, s = 1:1.5	267000	25.74	6872.58
Total:	**1048210**		**25904.76**

Table B1.4: Structures

Location	Type	Size (Nos)	Unit Cost ('000 Tk)	Total Cost ('000 Tk)
(1) Structures appurtenant to gravity drainage system				
Structures draining into Mora Brahmaputra River				
N-M Rlway Emb/Road	Fl/Dr Reg. Fl/Dr Reg.	1-vent 1.5 x 1.8 m (1) 2-vent 1.5 x 1.8 m (1)	3500 5000	3500 5000
Brahmaputra River	Fl/Dr Reg.	6-vent 1.8 x 2.4 m (1)	12500	12500
Structures draining into Meghna River				
N-M Rlway Emb/Road	Fl/Dr Reg. Fl/Dr Reg.	2-vent 1.5 x 1.8 m (1) 3-vent 1.5 x 1.8 m (1)	5000 6000	5000 6000
(2) Structures appurtenant to irrigation system				
Irrigation water distribution and bridges and culverts			Updated JICA Est.	198000
Total:				**230000**

Table B1.5: Pumping Stations

Location / Item	Size / No.	Total Cost ('000 Tk)
Pumping Station No. 1	30 m^3/s	328000
Pumping Station No. 2	35 m^3/s	369000
Transmission Line	5.0 km	2250
Transformer	2 nos.	1800
Total:		**701050**

Table B1.6: Project Buildings

Item	Quantity	Rate ('000 Tk)	Amount ('000 Tk)
Project office	1	1000	1000
Staff quarters	1	2000	2000
Pumping station office/ staff quarters	2	1000	2000
Regulator khalashi shed	4	250	1000
Total:	**8**		**6000**

Table B1.7: Land Acquisition

Item	Area (ha)	Rate ('000 Tk)	Amount ('000 Tk)
Irrigation Canals	97.0	500	48500
Lakhya River Embankment, 20.1 km	35.0	740	25900
Re-sectioning of Roads/Embankments, 12.0 km	14.0	500	7000
Re-excavation of Channels	34.0	400	13600
Structures and Buildings	7.0	740	5180
Total:	**187.0**		**100180**

Table B1.8: Capital Cost Summary - Plan 1

Item	Cost ('000 Tk)
Embankments/Roads	43627.4
Irrigation Canals	92950.4
Channels	25904.8
Structures	230000.0
Pumping Stations	701050.0
Project Buildings	6000.0
Land Acquisition	100180.0
BASE COST	1199712.6
Physical Contingencies (25%)	299928.2
SUBTOTAL	1499640.8
Study Cost (15%)	224946.1
TOTAL:	**1724589.9**

US$ 45.38 Million

B.2 Plan 2: Flood Control and Gravity Drainage Project (Gross Area 24,700 ha)

Table B2.1: Earthworks - Flood Embankments

Item	Quantity	Rate (Tk)	Amount ('000 Tk)
Lakhya River Flood Embankments			
Construction of New Embankments from T-N Rlway to Block A-1 boundary, 20.1 km			
- Earth fill (h = 0-3 m)	430220 m^3	37.44	16107.44
- Royalty	430220 m^3	21.06	9060.43
- Turfing	361400 m^2	3.04	1098.65
Re-sectioning of Roads/Embankments, 12.0 km			
- Earth fill	267600 m^3	40.95	10958.22
- Royalty	267600 m^3	21.06	5635.66
- Turfing	252300 m^2	3.04	766.99
Total: - Earth fill - Royalty - Turfing	 697820 m3 697820 m3 613700 m^2		 27065.66 14696.09 1865.64
Total Embankments:			**43627.39**

Note: Cost of khal closures included in the cost of embankments

Table B2.2: Earthworks - Excavation

Item	Quantity (m^3)	Rate (Tk)	Amount ('000 Tk)
Re-excavation of Mora Brahmaputra - Haridhana River			
L = 30.0 km, average excavation b = 10.0 m, d = 1.5 m, s = 1:1.5	551250	25.74	14189.18
Re-excavation of Other Internal Khals			
L = 25.0 km, average excavation b = 10.0 m, d = 1.0 m, s = 1:1.5	287500	21.06	6054.75
Total:	**8387500**		**20243.93**

Table B2.3: Structures

Location	Type	Size (Nos)	Unit Cost ('000 Tk)	Total Cost ('000 Tk)
Structures draining into Lakhya River				
D-C Road	Fl/Dr Reg. Pipe Sluice	1-vent 1.5 x 1.8 m (2) 2-vent 0.9 m Dia. (2)	3500 900	7000 1800
Structures draining into Mora Brahmaputra River				
N-M Rlway Emb/Road	Pipe Sluice Fl/Dr Reg. Fl/Dr Reg.	2-vent 0.9 m Dia. (2) 1-vent 1.5 x 1.8 m (1) 2-vent 1.5 x 1.8 m (1)	900 3500 5000	1800 3500 5000
Brahmaputra River	Lock + Fl/Dr Reg.	4.0 m Lock + 12-vent 1.8 x 2.4 m Reg.(1)	37600	37600
Structures draining into Meghna River				
N-M Rlway Emb/Road	Fl/Dr Reg. Fl/Dr Reg.	2-vent 1.5 x 1.8 m (1) 3-vent 1.5 x 1.8 m (1)	5000 6000	5000 6000
Total Structures:		**11 Nos**		**67700**

Table B2.4: Project Buildings

Item	Quanty	Rate ('000 Tk)	Amount ('000 Tk)
Project office/quarters (500 m^2)	1	2500	2500
Storage/Residence of lock operator	1	500	500
Khalashi shed (with 2 and 3-vent 1.5 x 1.8 m Reg)	2	250	500
Total:	**4**		**3500**

Table B2.5: Land Acquisition

Item	Area (ha)	Rate ('000 Tk)	Amount ('000 Tk)
Lakhya River Embankment, 20.1 km	35.0	740	25900
Re-sectioning of Roads/Embankments, 12.0 km	14.0	500	7000
Re-excavation of Channels	30.0	400	12000
Structures and Buildings	6.0	700	4200
Total:	85.0		49100

Table B2.6: Capital Cost Summary - Plan 2

Item	Quantity	Cost ('000 Tk)
Embankments/Roads	32.1 km	43627.4
Channels	55.0 km	20243.9
Structures	11 Nos.	67700.0
Buildings	4 Nos	3500.0
Land Acquisition	85.0 ha	49100.0
BASE COST		184171.3
Physical Contingencies (25%)		46042.8
SUBTOTAL		230214.1
Study Cost (15%)		34532.1
TOTAL:		**264746.2**

US$ 6.97 Million

B.3 Plan 3: Flood Control and Gravity Drainage (Gross Area 40,560 ha)

Table B3.1: Earthworks - Flood Embankments

Item	Quantity	Rate (Tk)	Amount ('000 Tk)
Lakhya River Flood Embankments			
Construction of New Embankments from T-N Rlway to Block A-1 boundary, 20.1 km			
- Earth fill (h = 0-3 m)	430220 m^3	37.44	16107.44
- Royalty	430220 m^3	21.06	9060.43
- Turfing	361400 m^2	3.04	1098.65
Mora Brahmaputra River Regulator Ring Dike			
Construction of New Embankment u/s of D-C Road Bridge, 2.0 km			
- Earth fill (h = 0-6 m)	292680 m^3	43.29	12670.11
- Royalty	292680 m^3	21.06	6163.84
- Turfing	278930 m^2	3.04	847.95
Meghna River Embankment			
Construction of New Embt from Badya Bazar to N-M Rlway, 24.5 km			
- Earth fill (h = 0-4 m)	1634100 m^3	40.95	66916.40
- Royalty	1634100 m^3	21.06	34414.15
- Turfing	780360 m^2	3.04	2372.29
Re-sectioning of Roads/Embankments, 16.0 km			
- Earth fill	356800 m^3	40.95	14611.00
- Royalty	356800 m^3	21.06	7514.21
- Turfing	336400 m^2	3.04	1022.65
Total: - Earth fill - Royalty - Turfing	 2713800 m3 2713800 m3 1757090 m^2		 110304.95 57152.63 5341.54
Total Embankments:			**172799.12**

Note: Cost of khal closures included in the cost of embankments

Table B3.2: Earthworks - Excavation

Item	Quantity (m^3)	Rate (Tk)	Amount ('000 Tk)
Re-excavation of Mora Brahmaputra - Haridhana River			
L = 60.0 km, average excavation b = 15.0 m, d = 1.5 m	1552500	25.74	39961.35
Re-excavation of Other Internal Khals			
L = 55.0 km, average excavation b = 10.0 m, d = 1.0 m	632500	21.06	13320.45
Total:	2185000		53281.80

Table B3.3: Structures

Location	Type	Size (Nos)	Unit Cost ('000 Tk)	Total Cost ('000 Tk)
Structures draining into Lakhya River				
D-C Road	Fl/Dr Reg. Pipe Sluice	1-vent 1.5 x 1.8 m (2) 2-vent 0.9 m Dia. (2)	3500 900	7000 1800
N-M Rlway Emb.	Pipe Sluice Pipe Sluice	1-vent 0.9 m Dia. (2) 2-vent 0.9 m Dia. (2)	550 900	1100 1800
Structures draining into Mora Brahmaputra River				
Brahmaputra R/B Emb.	Fl/Dr Reg. Pipe Sluice	1-vent 1.5 x 1.8 m (2) 1-vent 0.9 m Dia. (2)	3500 550	7000 1100
Brahmaputra River	Lock + Reg.	6.0 m Lock + 6-vent 2.0 x 6.0 m Dr Reg.(1)	45600	45600
D-C Road	Pipe Sluice	1-vent 0.9 m Dia. (2)	550	1100
Structures draining into Meghna River				
Meghna Embankment	Pipe Sluice Fl/Dr Reg. Fl/Dr Reg. Fl/Dr Reg.	1-vent 0.9 m Dia. (4) 1-vent 1.5 x 1.8 m (2) 2-vent 1.5 x 1.8 m (2) 3-vent 1.5 x 1.8 m (1)	550 3500 5000 6000	2200 7000 10000 6000
Total Structures:		**24 Nos**		**91700**

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Table B3.4: Project Buildings

Item	Quantity	Rate ('000 Tk)	Amount ('000 Tk)
Project office (200 m^2)	1	1000	1000
Staff quarters (500 m^2)	1	2500	2500
Office/Residence of lock operator	1	500	500
Khalashi shed (with 2 and 3-vent 1.5 x 1.8 m Reg)	3	250	750
Total:	**6**		**4750**

Table B3.5: Land Acquisition

Item	Area (ha)	Rate ('000 Tk)	Amount ('000 Tk)
Lakhya River Embankment, 20.1 km	35.0	740	25900
Mora Brahmaputra Ring Dike, 2.0 km	7.8	500	3900
Meghna River Embankment	69.3	400	27720
Re-excavation of Channels	32.9	400	13160
Structures and Buildings	11.0	700	7700
Total:	**156.0**		**78380**

Table B3.6: Capital Cost Summary - Plan 3

Item	Quantity	Cost ('000 Tk)
Embankments/Roads	62.6 km	172799.1
Channels	115.0 km	53281.8
Structures	24 Nos.	91700.0
Buildings	6 Nos	4750.0
Land Acquisition	156.0 ha	78380.0
BASE COST		405660.9
Physical Contingencies (25%)		101415.2
SUBTOTAL		507076.1
Study Cost (15%)		76061.4
TOTAL:		**583137.5**

US$ 15.35 Million

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 FCD 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: 40,560 ha.

Impacted (net) area: 34,832 ha.

Impacted area outside project: High frequency peak monsoon flood levels could increase slightly (0.1 - 0.2 m) in the upper reaches of Lakhya River due to the embankment confinement; the lower reach of the river is already embanked. Completion of embanking of the right bank of the Meghna is not likely affect the river flood levels.

Temporal:

Preconstruction: years zero through year three (see Table 7.7).

Construction: year one through year four (see Table 7.7).

Operation: year four through year thirty.

Abandonment: Not applicable.

Cumulative impacts:

With other floodplain infrastructure: This will be looked in the Feasibility Study in context of the Regional Plan.

With pre-existing no-project trends. Described in Chapter 5.

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C.2.5 Field Investigations (Step 5)

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

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 openwater fisheries production impacts were estimated with a simplified model. The limitations of the model mirror the limitations in our current understanding of and information about the system. Results of the analysis are summarized below and Table 7.14 of the main report (multi-criteria analysis).

The major system processes about which we have some insight are:

- Migration access and timing. It seems to be accepted that:
  - a multiplicity of access points is desirable (i.e. that closing any or some channels is still deleterious),
  - the most important channels are those at the downstream end (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 suspected 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 is lacking it has been neglected in the model.]
- Habitat quality. Habitat quality would include water quality, vegetation, and other conditions (presence of preferred types of substrata e.g. sand, rocks, brush). Water quality would appear to be most relevant during low volume/flow periods, and during the times 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 =

$$\{[(M * Q * R_1) - R_0] * P_{R0}\} +$$

$$\{[(M * Q * B_1) - B_0] * P_{B0}\} +$$

$$\{[(M * W_1) - W_0] * P_{W0}\}$$

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 200, 550, 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.

Estimated values for this project are shown in the Table C1. 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 C1: Fisheries Indicators

Var	Value	Stnd value	Comments
M	0.6	1	
Q	1	1	
R_0	670		
R_1	702		Re-excavation of internal channels
B_0	360		
B_1	360		
W_0	34466		
W_1	28676		Reduced area and depth of monsoon flooding
P_{R0}	175	200	BFRSS average yields for Dhaka and Narsingdi Districts
P_{B0}	410	550	
P_{W0}	35	44	
A_M	0		

The total annual openwater fisheries production impact is - 707 tonnes, which is about 42% of the FWO annual production of 1,700 tonnes. This implies decrease in the openwater-source fish availability from 3 to 2 gm per person per day after the project implementation.

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 7.3.5.

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.

Table C2: 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										
	Abnormal	Suspension of construction before completion, construction delays										
		Incorrect construction practices or techniques										
Construction (continued)	Abnormal (cont'd)											

Table C2: 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
Operation	Normal	Pre-monsoon flood protection	•	+	–	•				•	+	
		Monsoon flood protection	+	+	–	•	–	+	•	•	+	
		Surface water irrigation		+								
		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

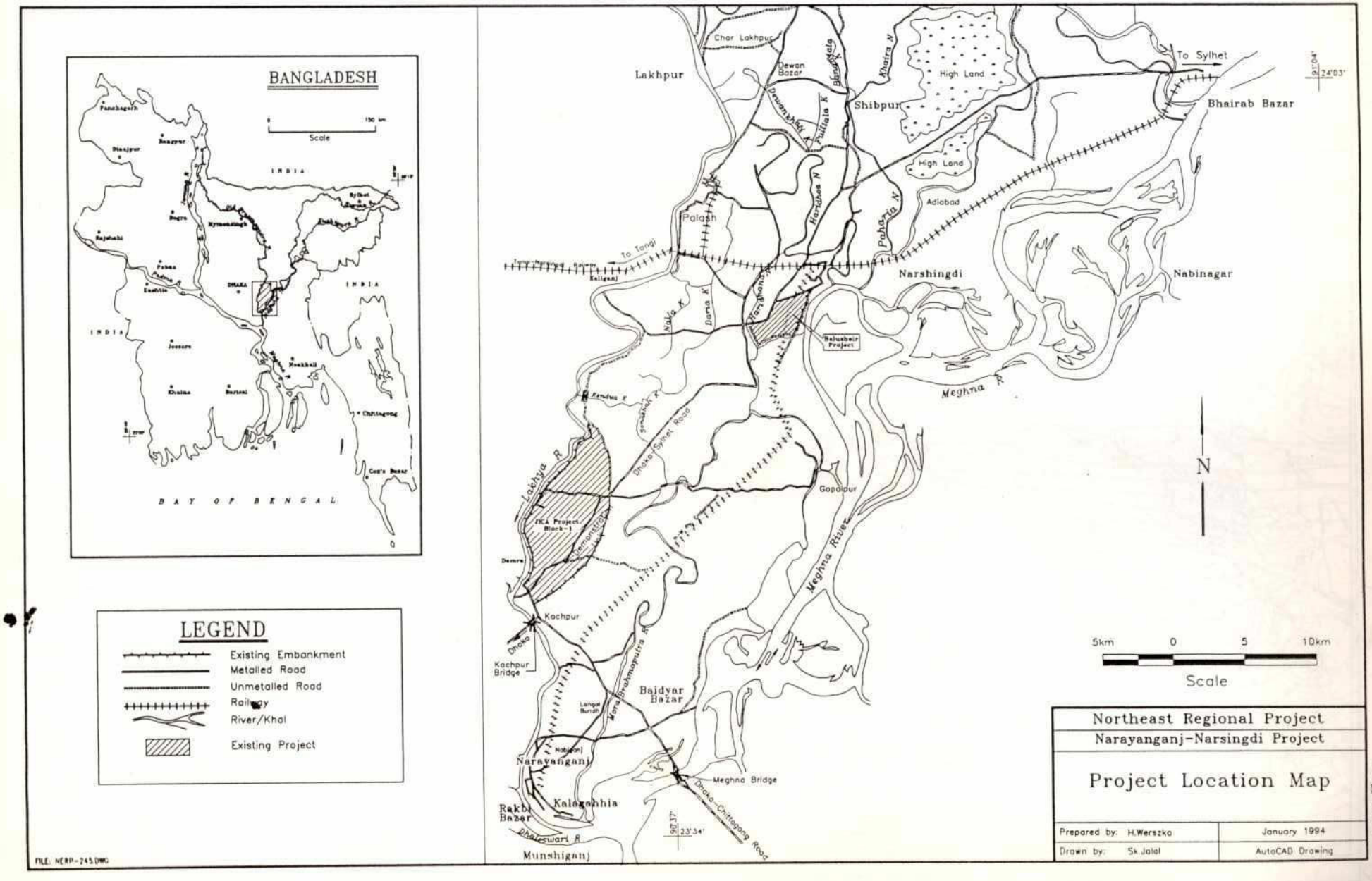

BANGLADESH
Scale
INDIA
INDIA
INDIA
BAY OF BENGAL
DHAKA
Chittagong
Cox's Bazar
Jessore
Khulna
Barisal
Rajshahi
Pabna
Kushtia
Rangpur
Dinajpur
Sylhet
Mymensingh
Comilla
Noakhali
LEGEND
Existing Embankment
Metalled Road
Unmetalled Road
Railway
River/Khal
Existing Project
Lakhpur
Char Lakhpur
Dewan Bazar
Shibpur
High Land
High Land
To Sylhet
Bhairab Bazar
Adiabad
Palash
To Tangi
Kaliganj
Narshingdi
Nabinagar
Baluabair Project
Meghna R
Gopalpur
Meghna River
ITCA Project Block-I
Demra
Kachpur
Dhaka
Kachpur Bridge
Bajdyar Bazar
Narayanganj
Meghna Bridge
Dhaka-Chittagong Road
Rakhi Bazar
Kalagachhia
Dhaleswari R
Munshiganj
Dhaka-Sylhet Road
N
5km 0 5 10km
Scale
Northeast Regional Project
Narayanganj-Narsingdi Project
Project Location Map
Prepared by: H.Werszko
January 1994
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: NERP-245.DWG

Figure 1

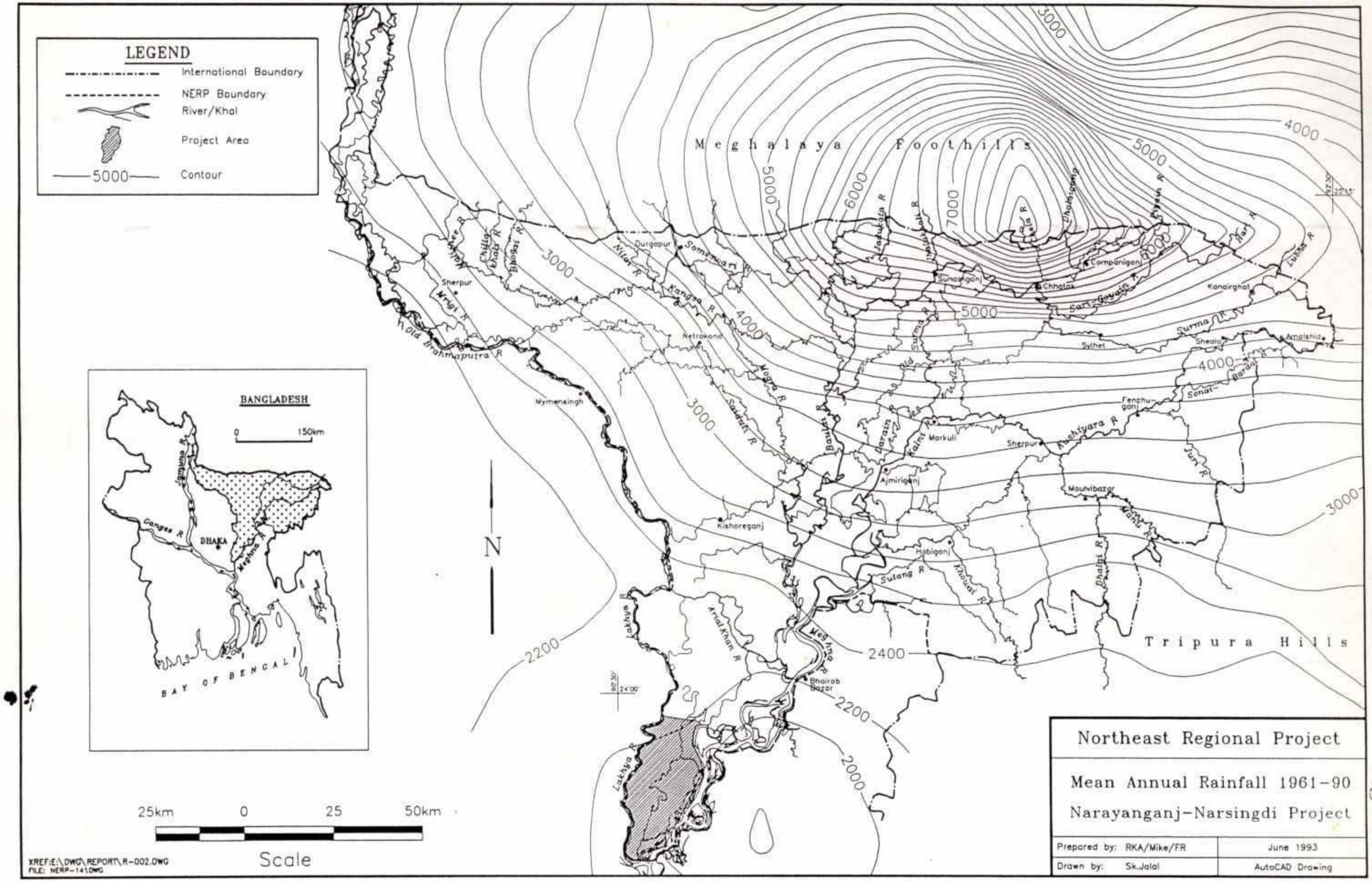
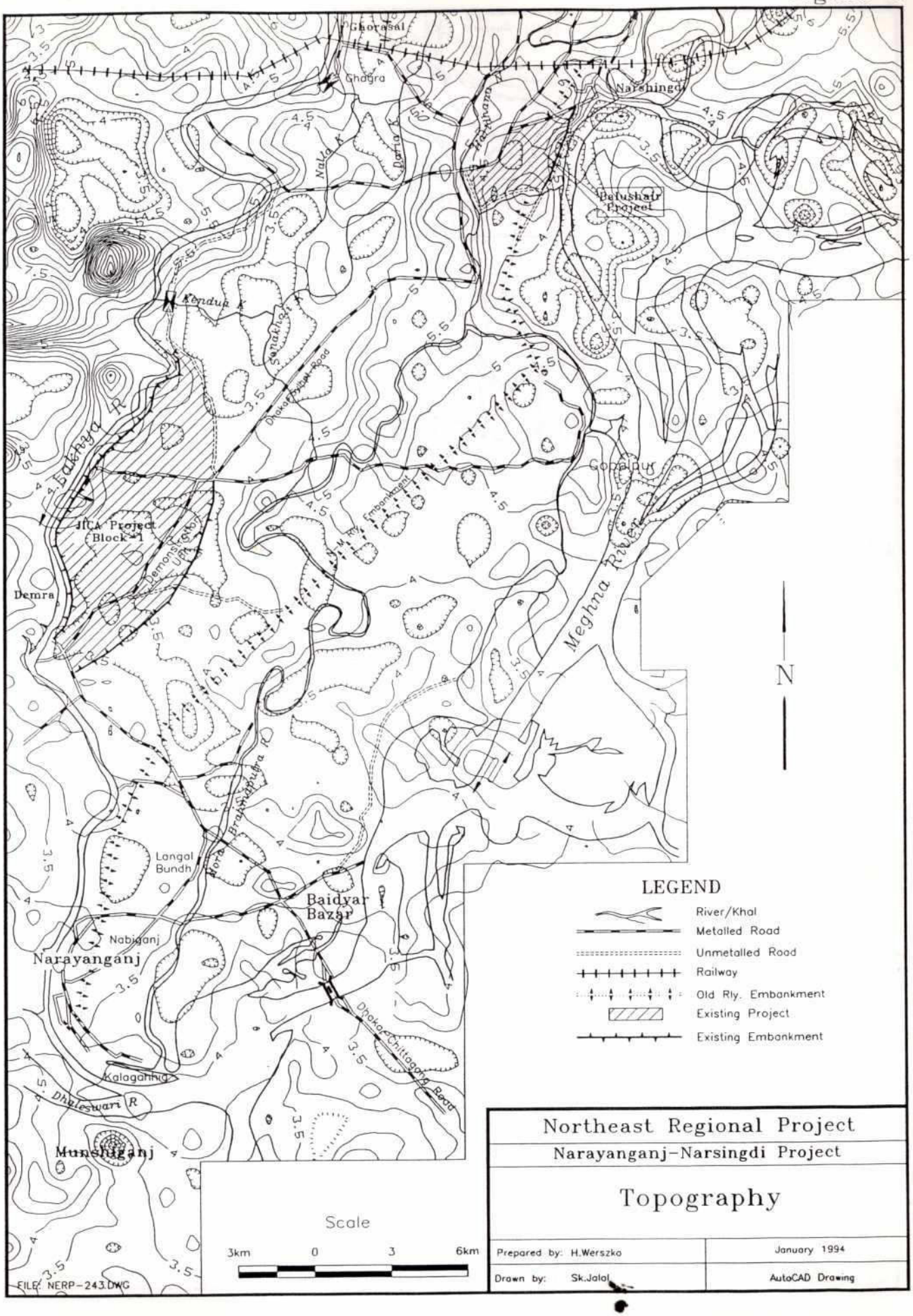
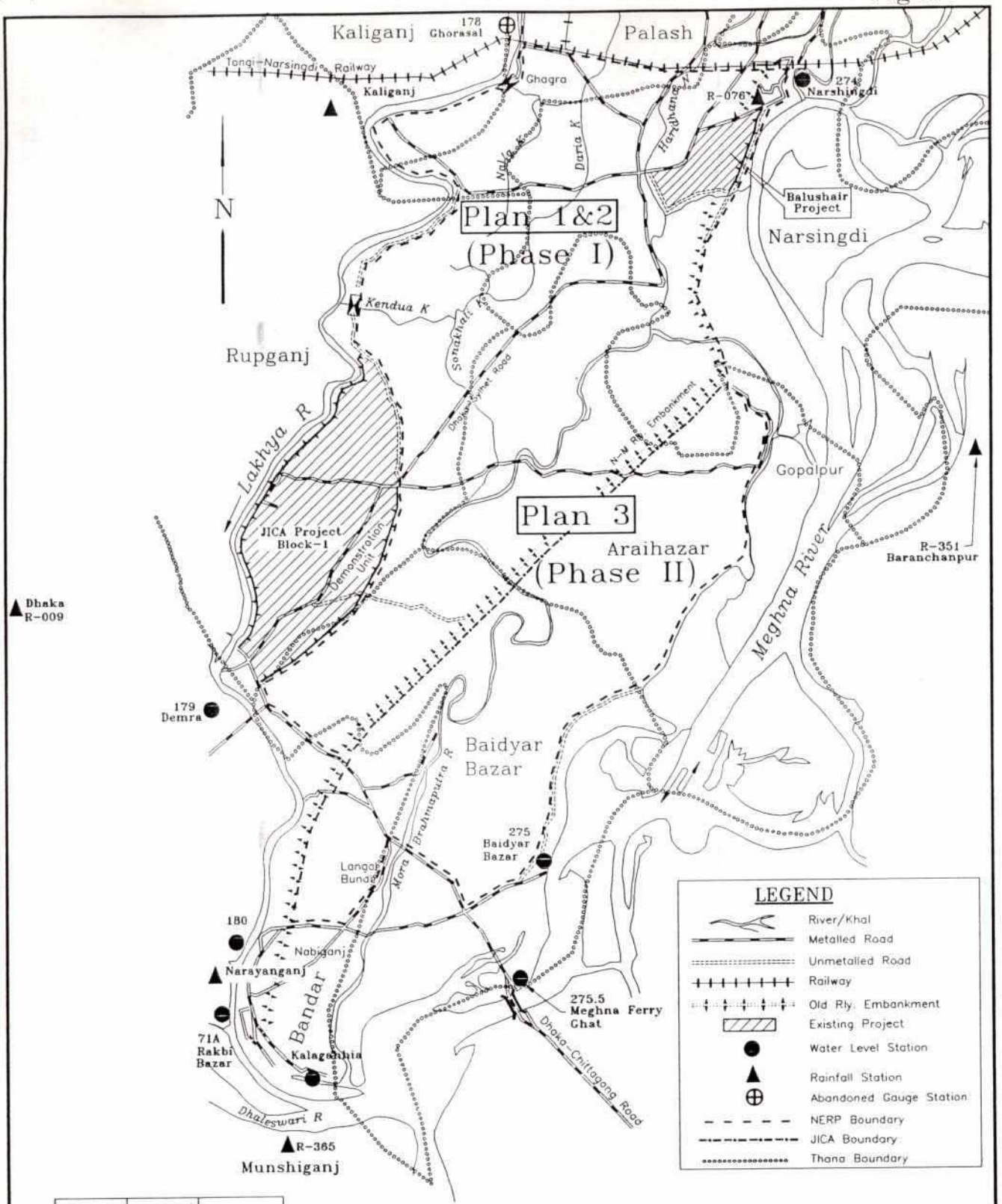

LEGEND
International Boundary
NERP Boundary
River/Khal
Project Area
5000
Contour
Meghalaya Foothills
Tripura Hills
BANGLADESH
0
150km
DHAKA
Jamuna R
Ganges R
Meghna R
BAY OF BENGAL
N
Durgapur
Sherpur
Mymensingh
Netrokona
Kishoreganj
Sunamganj
Chhatak
Companiganj
Kanairghat
Sylhet
Sheala
Amalshid
Fenchuganj
Sherpur
Markuli
Ajmiriganj
Moulvibazar
Habiganj
Bhairab Bazar
Old Brahmaputra R
Mrigi R
Meghna R
Arial Khan R
Lakhya R
Surma R
Kushiyara R
Old Surma R
Sari Goyain R
Someswari R
Kangsa R
Mogra R
Saiduli R
Baulai R
Dharain R
Kalni R
Sutang R
Khowai R
Dhalai R
Manu R
Juri R
Sonai Bardal R
Lubha R
Hari R
Piyain R
Jadukata R
Bhogai R
Nitai R
Chillia Khali R
Malijhee R
7000
6000
5000
4000
3000
2400
2200
2000
25km
0
25
50km
Scale
Northeast Regional Project
Mean Annual Rainfall 1961–90
Narayanganj–Narsingdi Project
Prepared by: RKA/Mike/FR
June 1993
Drawn by: Sk.Jalal
AutoCAD Drawing
XREF:E:\DWG\REPORT\R-002.DWG
FILE: NERP-141.DWG

Figure 2

Figure 3


Ghorasal
Ghagra
Narshingdi
Belushatr Project
Kendua
Sonakhar
Dhaka-Tangail Road
Gopalpur
Bakhya R
JICA Project Block-1
Demonstration Farm
Demra
Embankment
Meghna River
N
Langal Bundh
Nabiganj
Narayanganj
Baidyar Bazar
Dhaka-Chittagong Road
Kalagachia
Dhaleswari R
Munshiganj
LEGEND
River/Khal
Metalled Road
Unmetalled Road
Railway
Old Rly. Embankment
Existing Project
Existing Embankment
Scale
3km 0 3 6km
FILE: NERP-243.DWG
Northeast Regional Project
Narayanganj-Narsingdi Project
Topography
Prepared by: H.Werszko
January 1994
Drawn by: Sk.Jalal
AutoCAD Drawing



NERP	Plan 1&2	Plan 3
JICA	Phase I	Phase I&II
Area (ha)	24,700	40,560

Scale

3km 0 3 6km

FILE: NERP-246.DWG

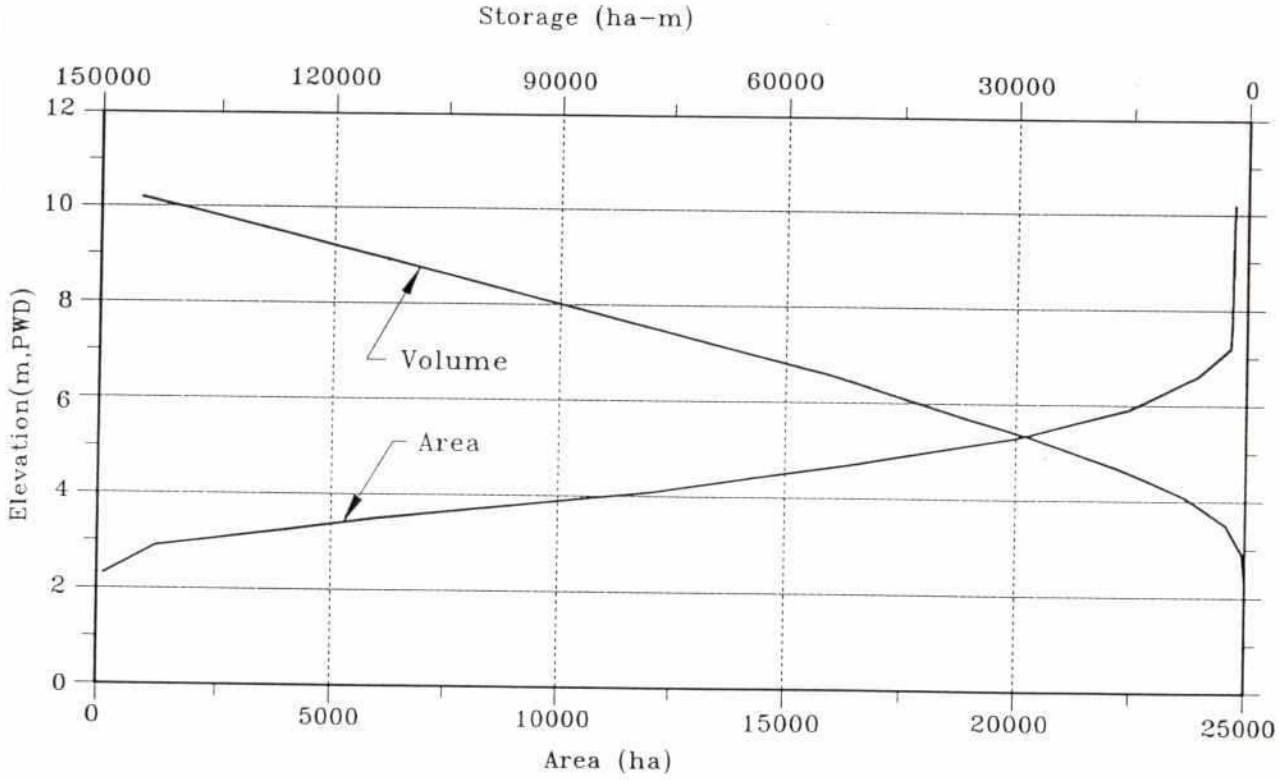
Northeast Regional Project

Narayanganj-Narsingdi Project

Development Planning Area

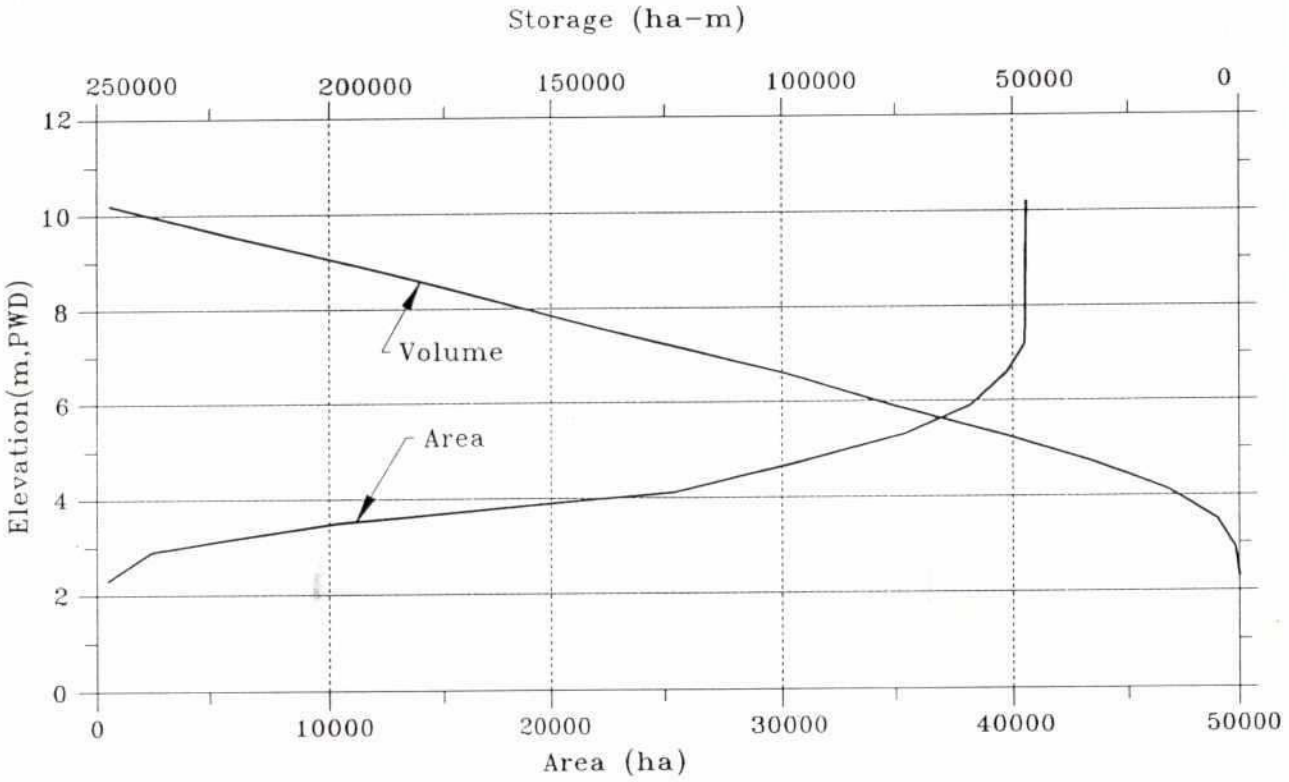
Prepared by: H.Werszko	January 1994
Drawn by: Sk.Jalal	AutoCAD Drawing

Elevation vs Area/Capacity Relation Plan 1 and 2



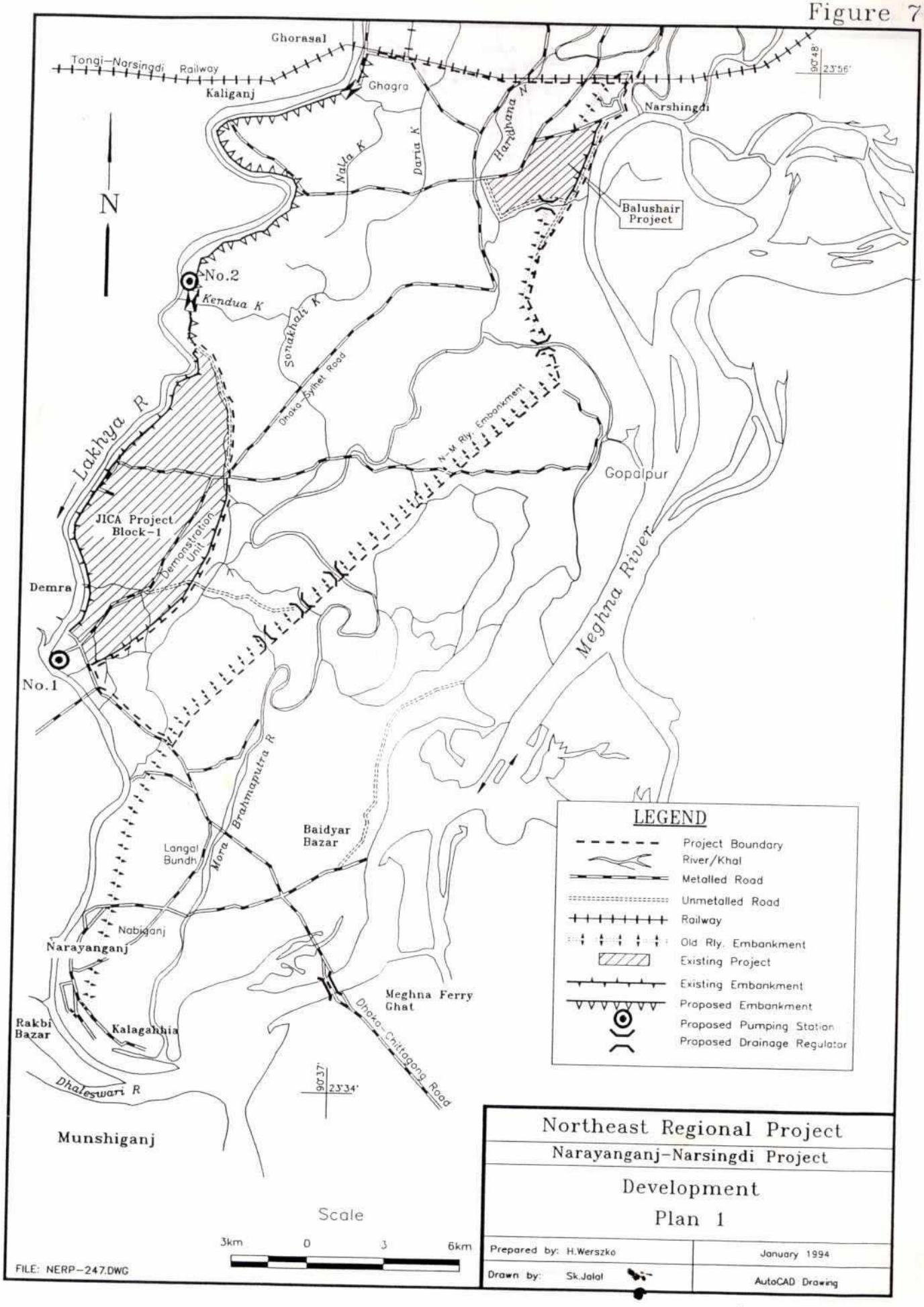
Northeast Regional Project	
Elevation vs Area/Capacity Relation Plan 1 and 2 N-N Project	
Prepared by: H.Werszko	January 1994

Elevation vs Area/Capacity Relation Plan 3



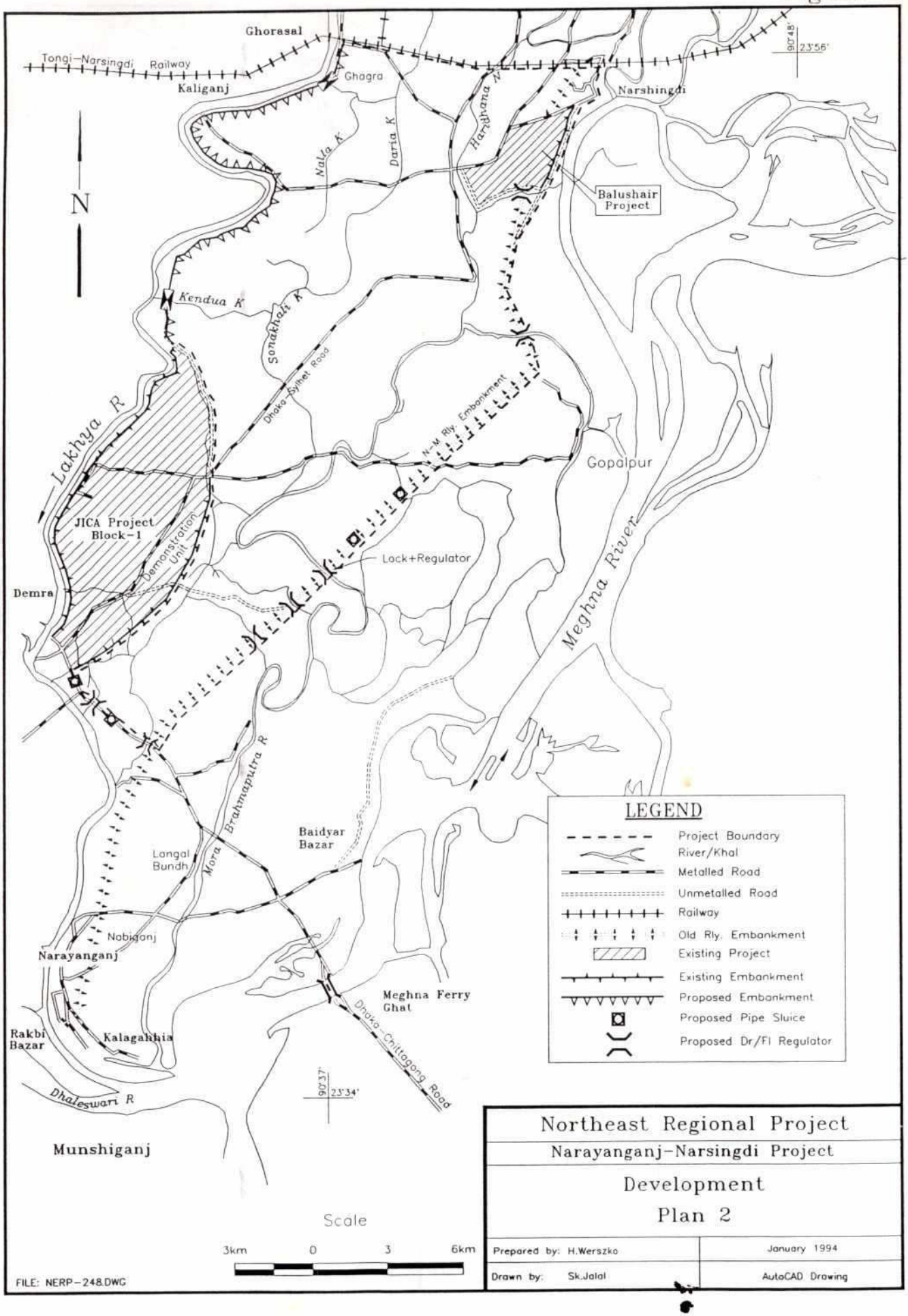
Northeast Regional Project	
Elevation vs Area/Capacity Relation Plan 3 N-N Project	
Prepared by: H.Werszko	January 1994

Figure 7



Northeast Regional Project	
Narayanganj–Narsingdi Project	
Development Plan 1	
Prepared by: H.Werszko	January 1994
Drawn by: Sk.Jalal	AutoCAD Drawing

Figure 8



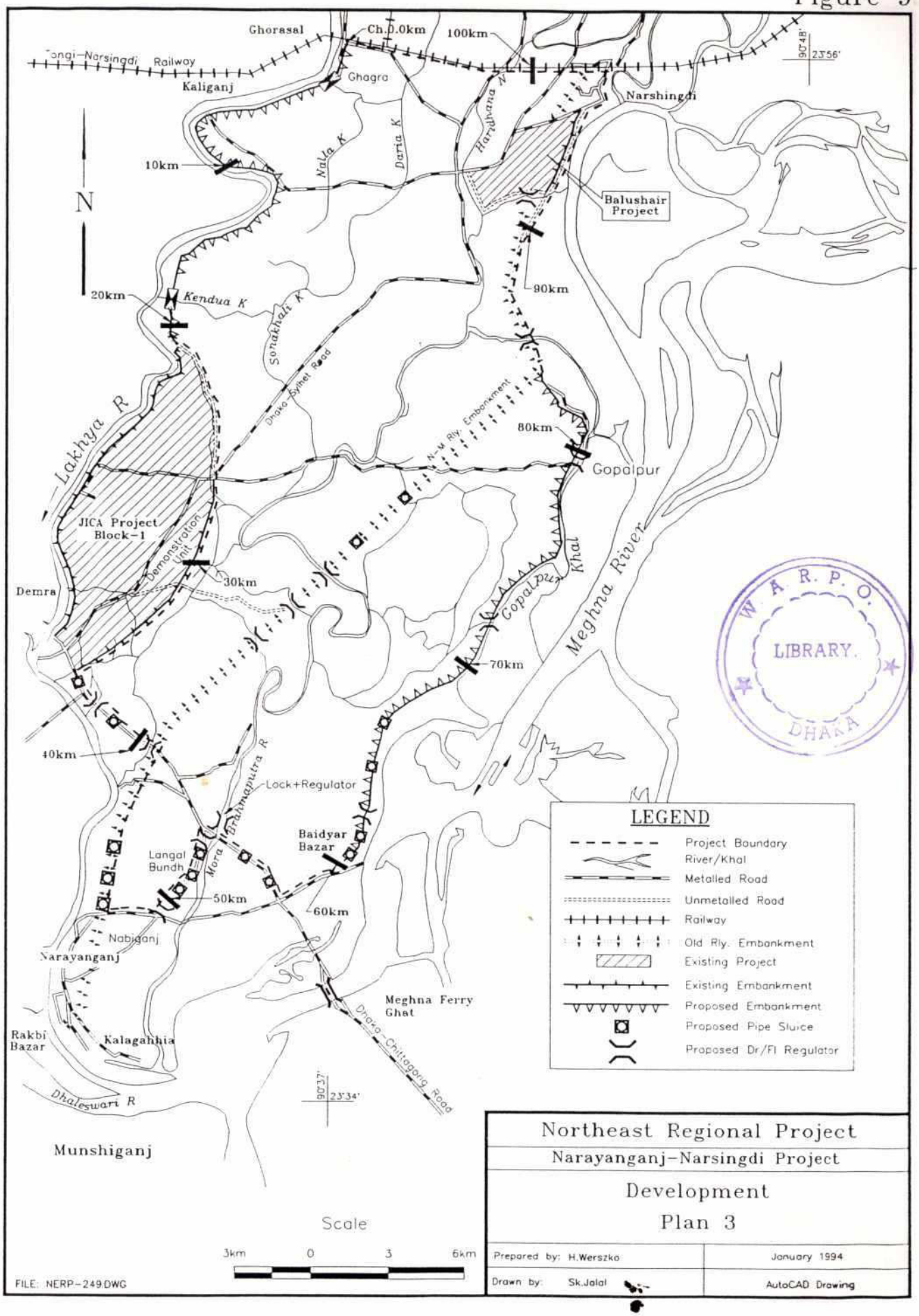
Northeast Regional Project

Narayanganj–Narsingdi Project

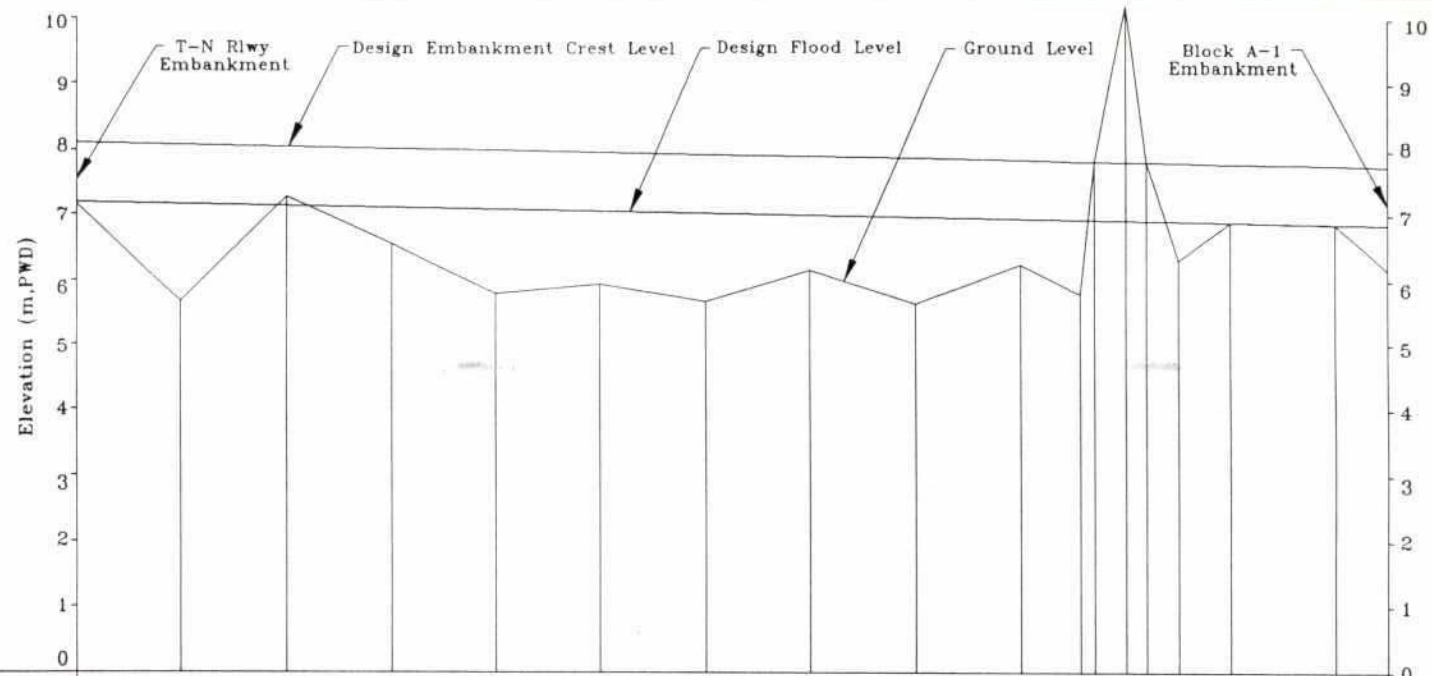
Development Plan 2

Prepared by: H.Werszko	January 1994
Drawn by: Sk.Jalal	AutoCAD Drawing

Figure 9



Northeast Regional Project	
Narayanganj–Narsingdi Project	
Development Plan 3	
Prepared by: H.Werszko	January 1994
Drawn by: Sk.Jalal	AutoCAD Drawing



Datum Line																			
Existing Bank Level	7.16	5.67	7.28	6.55	5.79	5.94	5.67	6.16	5.64	6.25	5.79	7.84	10.21	7.83	6.31	6.89	6.86	6.16	
Design Crest Level	8.10	8.07	8.05	8.02	8.00	7.97	7.94	7.92	7.90	7.87	7.84	7.84	7.83	7.83	7.82	7.80	7.78	7.76	
Design Flood Level (1:50-yr)	7.19																6.85		
Distance (km)	0.00	1.61	3.22	4.83	6.44	8.05	9.66	11.27	12.88	14.49	15.30	15.62	16.10	16.42	16.91	17.71	19.32	20.13	

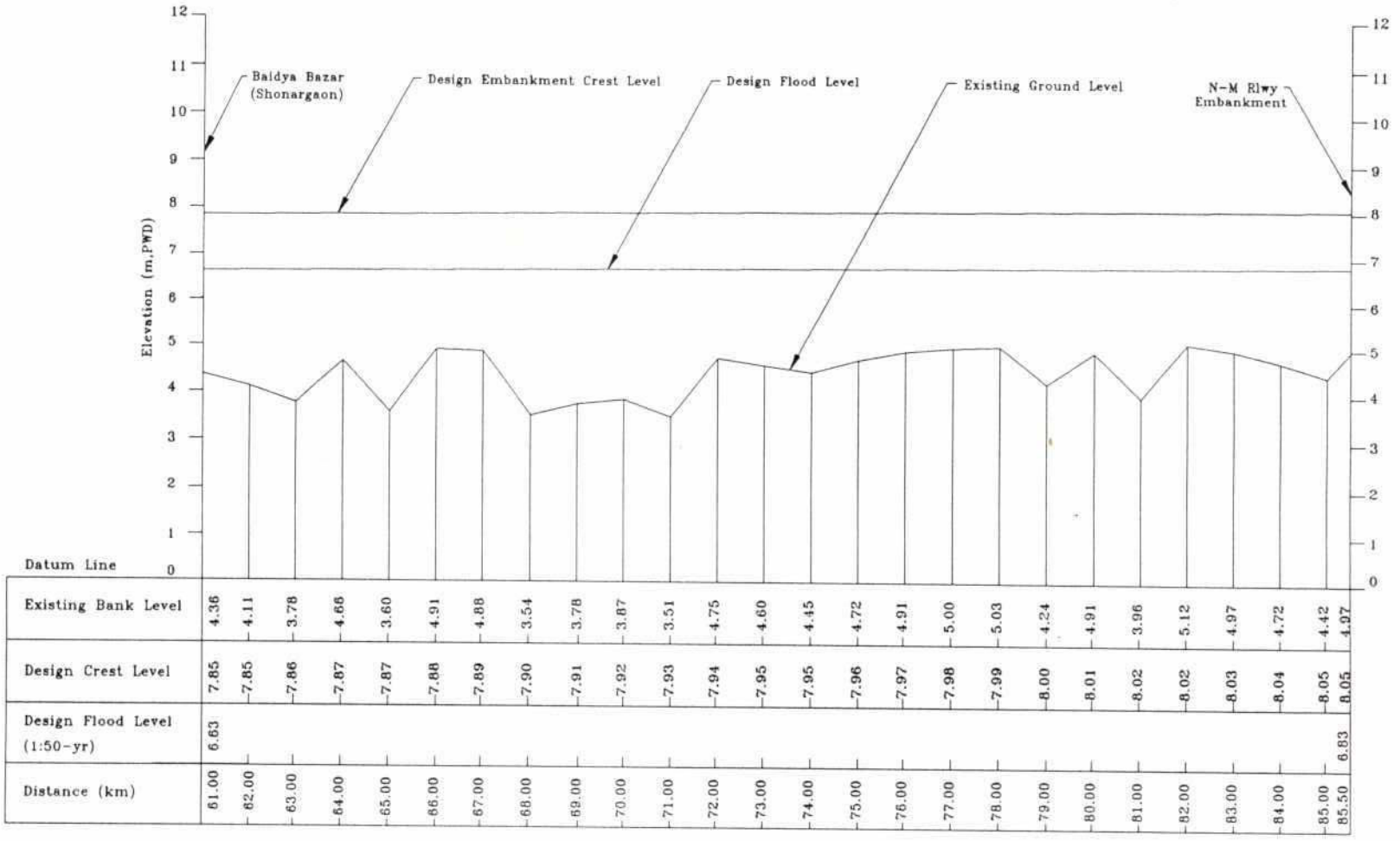
Northeast Regional Project

Lakhya River
Left Embankment

Prepared by: H.Werszko | January 1994

FILE: Lakhya .DWG

Figure 10



Distance (km)	Existing Bank Level	Design Crest Level	Design Flood Level (1:50-yr)
61.00	4.36	7.85	6.63
62.00	4.11	7.85	
63.00	3.78	7.86	
64.00	4.66	7.87	
65.00	3.60	7.87	
66.00	4.91	7.88	
67.00	4.88	7.89	
68.00	3.54	7.90	
69.00	3.78	7.91	
70.00	3.87	7.92	
71.00	3.51	7.93	
72.00	4.75	7.94	
73.00	4.60	7.95	
74.00	4.45	7.95	
75.00	4.72	7.96	
76.00	4.91	7.97	
77.00	5.00	7.98	
78.00	5.03	7.99	
79.00	4.24	8.00	
80.00	4.91	8.01	
81.00	3.96	8.02	
82.00	5.12	8.02	
83.00	4.97	8.03	
84.00	4.72	8.04	
85.00	4.42	8.05	6.63
85.50	4.97	8.05	

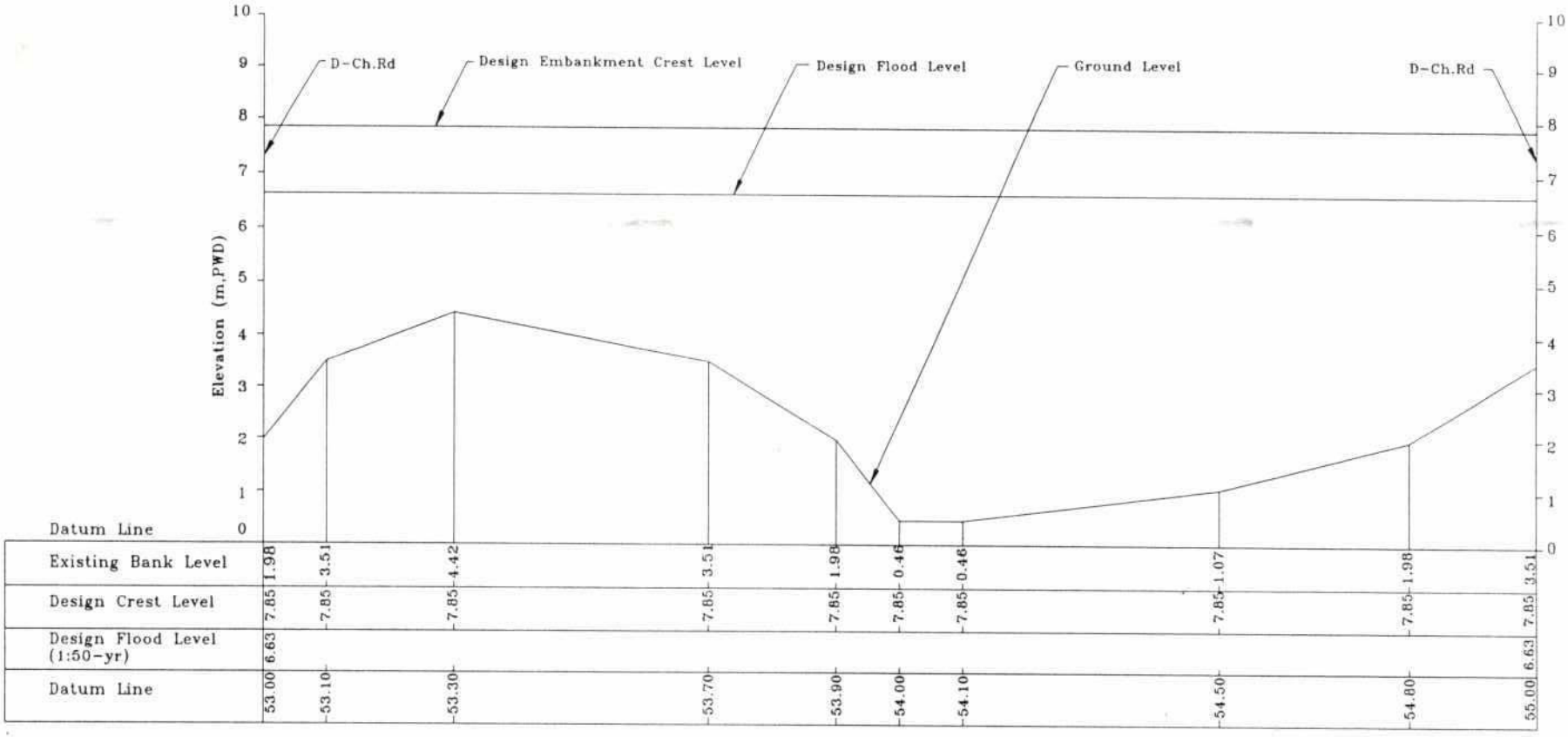
Northeast Regional Project

Meghna River
Right Embankment

Prepared by: H.Werszko | January 1994

FILE: Meghna.DWG

Figure 11



Existing Bank Level	1.98	3.51	4.42	3.51	1.98	0.46	0.46	1.07	1.98	3.51
Design Crest Level	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85
Design Flood Level (1:50-yr)	6.63									6.63
Datum Line	53.00	53.10	53.30	53.70	53.90	54.00	54.10	54.50	54.80	55.00

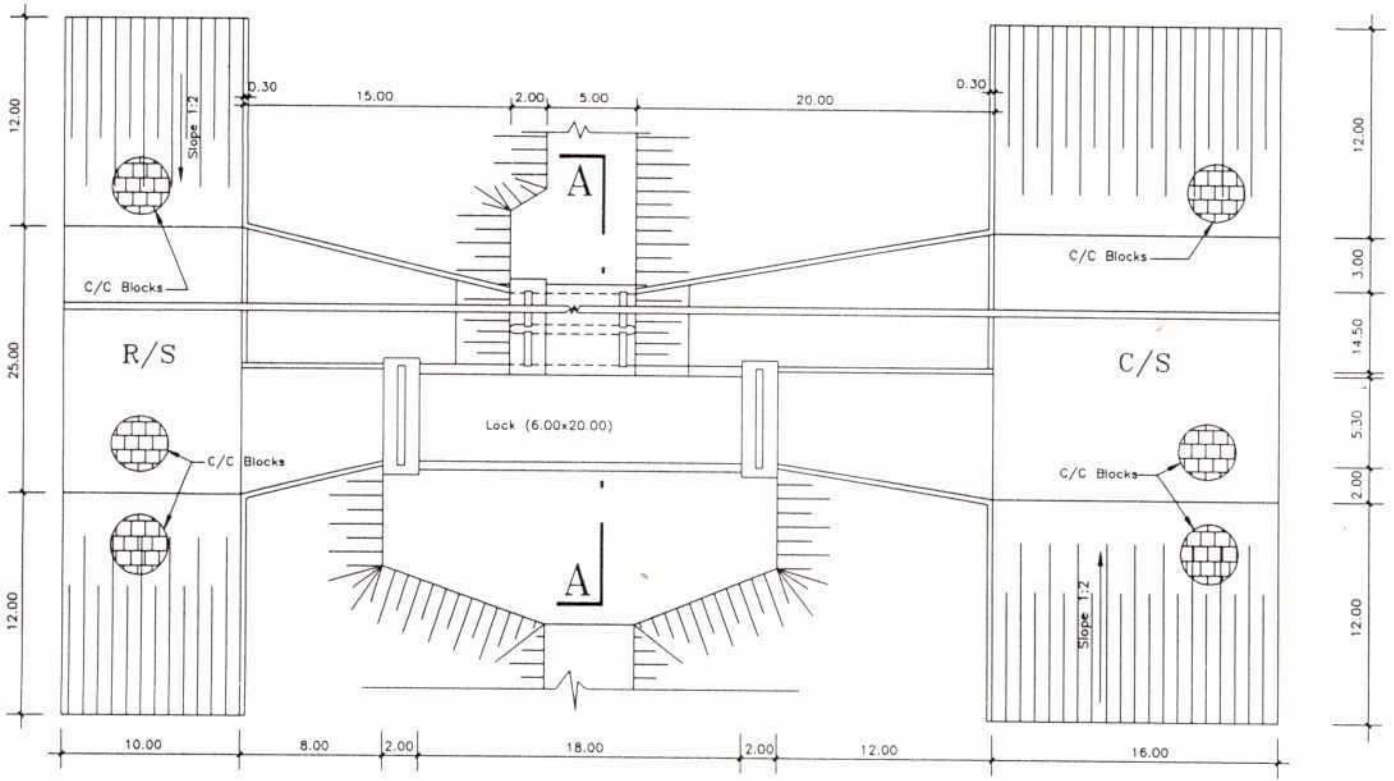
Northeast Regional Project

Mora Brahmaputra River Ring Dike

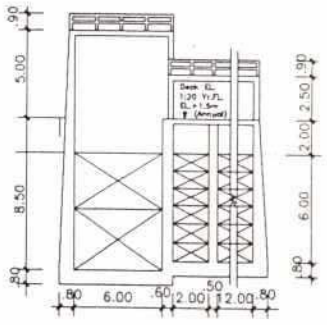
Prepared by: H.Werszko | January 1994

FILE: Brahma.DWG

Figure 12



Plan



Section: A–A

Scale

5m 0 5 10m

Northeast Regional Project	
Narayanganj–Narsingdi Project	
Mora Brahmaputra River Lock cum Regulator	
Prepared by: H.Werszko	January 1994
Drawn by: Sk.Jalal	AutoCAD Drawing

Figure 13