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)

PROJECT MONITORING PROGRAMME MANU RIVER FCDI PROJECT (1992-94)

Draft Final Report

November 1994

Shawinigan Lavalin (1991) Inc.
Northwest Hydraulic Consultants

in association with

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

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ACRONYMS AND ABBREVIATIONS

BFRSS	Bangladesh Fisheries Resources Survey System
BWDB	Bangladesh Water Development Board
CAS	Catch assessment survey
CBM	Community-based management
CIDA	Canadian International Development Agency
DOF	Department of Fisheries
DOFr	Department of Forestry
DRH	Department of Roads and Highways
FAP	Flood Action Plan
FCD	Flood control and drainage
FCS	Fishermen Cooperative Society
FRI	Fisheries Research Institute
GOB	Government of Bangladesh
GPS	Global positioning system
LIV	Local Improved Variety
LLOP	Lowest level of plantation
LV	Local Variety
MFL	Ministry of Fisheries and Livestock
MIWDFC	Ministry of Irrigation, Water Development and Flood Control
MLGRDC	Ministry of Local Government, Rural Development and Co-operatives
MOC	Ministry of Communication
MOL	Ministry of Land
MRP	Manu River FCDI Project
NERP	Northeast Regional Project
NFMP	New Fisheries Management Policy
PMP	Project Monitoring Program
SRP	Systems Rehabilitation Programme
WFP	World Food Programme

YEAR 1: May 1992 to April 1993

YEAR 2: May 1993 to May 1994

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GLOSSARY OF TERMS

aaratdar	Trader with a space for storing commodities
akai	Gleaning of submerged rice
barga	Share cropping
barman	Hindu sub-caste whose major profession is fishing
beel	Permanent shallow lake
bepari	Immigrant harvester of boro rice who generally lead a team of harvesters
bhagi	Immigrant harvester of boro rice
bigha	Local unit of land measurement (one bigha = 0.13 ha)
bisra	Area adjacent to homestead and intermediate in height between homestead and rice fields, on which winter vegetables are grown
boro	Rice grown in the winter dry season
chailya	A long grass grown in low land (Hematheria potensa)
chanda	Contribution
changari	Platform, especially made to dry fish
chhon (ululbinna)	A grass used to thatch house roof
chorergaon	Thief village
chukti	Seasonal lease of agricultural land with an agreed fixed amount of the produce to be paid after the harvest.
chula	Cooking place (oven)
dair/chhit	Terrace of shallow channel within rice field
dalal	Commission agent
debata gach	tree symbolizes god/goddess
deta	Rice straw
dhara	Bamboo mat
dhenki	Manually operated rice husking machine
doba	Smaller water body
ejmali	Jointly owned by co-sharers/villagers
firal	A person who claims himself spiritual to protect boro rice from hailstorms
gangail	Ridge of the Mora Surma River from village Gachia to Shyamarchar.
gola	Granary
haor	River back swamp
hati	Contiguous group of homesteads occupied by a social group sharing lineage and/or other factors.
jala	Seedings
jalachar	Seedbed
jalmohal	Fishing ground
kaiborta	Hindu sub-caste whose major profession is fishing
kamla	Wage labour
kanda	Ridges that are higher than the haor basin but lower than homestead land.
katha	Branches of trees or bamboo piles placed in water to provide shelter for fish.
ker	Local unit of land measurement (one ker = 0.12 ha)
khal	Small drainage channel
khas	Government-owned land.

khet	Agricultural land
khola fura	Collection of left-over rice from threshing ground.
khola	Drying space next to the homestead/ temporary fishing shed
koi/singra/pukal	Various water chest nuts
kossom	Buried tree, partly decomposed
lepa	Smearing a mixture of cow dung, soil, and water
londonee	Expatriate Sylhetis living in London (earning foreign exchange, absentee landlord)
mahajan	Local money/rice lender
maimol	Muslims whose major profession is fishing.
majhi	Boatman
maund	Local unit of measurement (one maund = 37.5 kg)
namasudra	Hindu sub-caste whose major profession is fishing
nikari	Fish retailer
nojorer bou	A wife married legally, but not accepted by the family.
paharadar	Guard
parishad	Council
patni	Hindu sub-caste whose major profession is boat plying
pon pratha	Dowry system
purdah	Seclusion
rangjama	Seasonal lease of agricultural land with an agreed advance cash
samity	Cooperative society
shail	A variety of boro rice
sinthal	A special kind of dry fish
tab	Bamboo poles to provide fish shelter
thana	Smallest administrative unit; below district (formerly upazila)
thankidar	Influential patron of the thieves.
ujaiya	Movement of fish against water current
uthan	Courtyard
zamindar	Feudal land lord
zirati	Immigrant cultivators

Bangla months:	From middle of	To middle of
Baishakh	April	May
Jaishthya	May	June
Ashar	June	July
Sravan	July	August
Bhadra	August	September
Ashwin	September	October
Kartik	October	November
Agrahayan	November	December
Poush	December	January
Magh	January	February
Falgun	February	March
Choitra	March	April

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 Kishorganj Seminar
- Proceedings of the Narsingdi Seminar
- Proceedings of the Habiganj Seminar
- Proceedings of the Netrokona Seminar
- Proceedings of the Sylhet Fisheries Seminar

Project Monitoring Program Reports
- PMP Shanir Haor Project
- ***PMP Manu River Project***

Pre-feasibility Studies
- Jadukata/Rakti River Improvement Project
- Baulai Dredging
- Mrigi River Drainage Improvement Project
- Kushiyara Dredging
- 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
- Improved Flood Warning

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APPENDICES

1. INTRODUCTION

1.1 General Program Objectives and Approach

The objective of the Project Monitoring Programme (PMP) is to monitor two flood control/drainage/irrigation (FCD/I) projects in the Northeast Region over a period of time, in enough detail to understand the real impacts of the projects. The general purpose is to create a basis for improved water resources planning and design through better understanding of the impacts of FCD/I projects.

Two projects were studied in the PMP; one partial flood control project (Shanir Haor) located in the deeply flooded area and one full flood control project (the Manu River FCDI Project) in the moderately flooded area. The Manu Project was selected as the full flood control site for the following reasons:

- It represents the largest single investment of any FCD/I project in the region;
- The project is plagued by several serious problems (public dissatisfaction and opposition; expected agricultural lands not brought into cultivation; huge operating costs; destruction of a major regional fishery);
- It is more complex than other full flood control projects in the region as it includes pumped drainage and a river barrage for irrigation. The feasibility of more widespread use of such measures in flood control projects in the region can be better assessed in a working example such as MRP.

Monitoring refers to ongoing, periodic observation and analysis in order to characterize the benefits and damages of an FCD/I project. Where possible these impacts are to be quantified. Observed parameters included project operation, water levels and flooding, cropping patterns and yield, fisheries yields, farm income, land ownership and terms of share cropping, nutritional indicators, domestic water supply/quality, and others.

The knowledge will be directed toward improving the two specific projects and other FCD/I projects more generally. Specific aspects to be addressed include the needs for, and means of achieving institutional and technical improvements in planning, design, construction, operation, and maintenance.

1.2 Specific Objectives

Physical: To evaluate the physical performance and physical impact of the project inside and outside the project area.

Operational: To evaluate the key operational parameters of the Manu Project and recommend changes that could optimize project benefits.

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Economic: To evaluate the impacts of the project on production sectors (agriculture, fisheries, forestry), services (navigation, health, education, communications), and infrastructure (roads, domestic water supply, energy supply).

Financial: To assess the economic efficiency of the investment of the project.

Planning: To formulate practical recommendations to solve FCDI-induced and related problems in the area impacted by the project.

Social: To evaluate the impacts of the project on human development and standard of living, including:

- employment and disposable income;
- literacy and education;
- health, nutrition and life expectancy;
- public empowerment, economic equity, gender equality, and freedom.

1.3 Methodology

Field monitoring was conducted from May 1992 to May 1994. This period included two hydrologic years, the first being relatively dry and the second having two major floods. The following parameters were monitored:

- water levels inside and adjacent to the project area;
- river morphology and sedimentation;
- engineering design, operation, and performance of the project;
- fisheries habitat, environment, migration, fishing practices, and production;
- agricultural practices and production;
- societal indicators (social, economic, social interaction, and human dynamics).

The monitoring relied heavily on direct observations and extensive interviews with local people. These observations were supported with direct quantitative measurement wherever possible (water levels, agricultural production, crop areas, fisheries production). Published data and statistics were compiled and analyzed to help determine the present conditions and the history of change within the project area. The monitoring and analysis were carried out by a multi-disciplinary team of specialists and other professionals.

The observations and other data were compiled, integrated, and analyzed to form a more complete understanding of the project impacts and to form this document.

1.4 Data base

The PMP used the following sources of primary and secondary data:

- direct observations;

- quantitative measurement (water levels inside and outside the project, crop area sampling, fish catch);
- extensive interviews with local people;
- published reports on project design and rehabilitation;
- available (limited) historical data on water levels within the project and adjacent rivers, agricultural production, and fisheries production.

1.5 Report Layout

The report has the following format:

Chapter 1 (this chapter) provides an introduction to the purpose and scope of the study;

Chapter 2, ***Project Description***, provides an overview of the Manu River Project, the setting, agriculture, fisheries, transportation, and wetland resources (further details are provided in the Annexes);

Chapter 3, ***Project Monitoring Program Fieldwork***, describes the scope of the field program;

Chapter 4, ***Chronology of Events and Project Impacts (1992-1994)***, provides a summary of the events and the observations that were made during the two years of monitoring (further details are provided in the Annexes to the report);

Chapter 5, ***Evaluation of Project Performance***, contains an evaluation of the project design, and operation and its impact on flooding, agriculture, fisheries, transportation, wetlands, and people. It also provides an assessment of the economic production of the project area for the two-year monitoring program and an evaluation of the changes which have resulted from the project;

Chapter 6, ***Recommendations for Improvement of the Manu Project***, outlines a plan for improving the Manu Project and its performance, including the need for a definitive feasibility study which will implement the principles of local involvement so as to optimize the provision of project benefits;

Chapter 7, ***Future Flood Control Projects***, makes several recommendations for planning and operating FCD/I projects based on the experience which has been gained in the Manu project.

The main report is followed by several annexes which provide further detail of the observations which were made in the monitoring program.

2. PROJECT DESCRIPTION

2.1 Location and Boundaries

The Manu River FCDI Project is situated immediately north of Maulvibazar, about 175 km northeast of Dhaka and 80 km southwest of Sylhet (Figure 1). Administratively, it falls within the Maulvibazar District and includes:

- Chandnighat, Akhikura, and Ekatuna union parishads of Maulvibazar Thana,
- Rajnagar, Mansurnagar, Uttar Bhagh, Panchgaon, Munshibazar, Fatehpur, and Tengra union parishads of Rajnagar Thana.

The municipal area of Maulvibazar is located mainly on the left bank of the Manu River and is outside the project area.

2.2 Project Infrastructure

The Manu River FCDI Project is a large and complex project that was conceived to protect about 241 km^2, and to irrigate 125 km^2, of agricultural land between the Kushiyara and Manu Rivers. The scheme was originally proposed in 1960 and was completed in 1983.

Details of the project history and infrastructure are provided in Annex I and a map of the principal infrastructure is provided in Figure 2.

This area was subjected to flood damage every year caused by floods in the two rivers. The project design report[1] cited three causes of flooding:

- backwater flooding from the Kushiyara River during the pre-monsoon period, from March to the middle of April, which flooded boro crops in the lower areas;
- overbank spilling from the Manu and Kushiyara Rivers which flooded *aus* and *aman* crops during the monsoon period;
- runoff from the Bhatera hills and the project area during times of heavy rainfall which contributed to the flooding and waterlogging of the low-lying areas.

It was reported in the design report that the project area had a deficit of rice production of about 20% and that the flood damage was about 40% of rice production. The rice shortage was projected to further increase with increasing population in the area. The stated objectives of the project were:

- to protect the area from floods;

[1]"Manu River Project Definite Project Report", Associated Consulting Engineers Ltd, October 1971.

- to provide irrigation facilities to offset the adverse effects of the dry season;
- to provide adequate drainage facilities to deal with monsoon runoff;
- to increase rice production by protecting the project area from flooding, by providing irrigation for winter crops, and by introducing improved agricultural practices and cropping patterns.

The project consists of a flood embankment extending along the right bank of the Manu from the southern end of the Bhatera Hills to Manumukh (Manu section), and along the left bank of the Kushiyara from the northern end of the Bhatera Hills to Manumukh (Kushiyara section).

The Kashimpur pumping station, located on the left bank of the Kushiyara about 3.5 km upstream of Manumukh, is used to drain the project area when the water levels are higher in the Kushiyara River than in the haor. Two drainage sluices which are also located at Kashimpur provide drainage by gravity whenever the river levels are lower than those in the haor.

The drainage system was intended to maintain water levels between elevations 3.5 m PWD and 6.9 m PWD. The pumps were supposed to operate whenever the project water levels rose above 4.1 m PWD.

A barrage across the Manu River 3.8 km upstream of Maulvibazar, diverts water into an irrigation system which supports 11,618 ha of gravity irrigation and 877 ha of LLP irrigation. The irrigation system was designed to irrigate the higher lands in the project area located between elevation 6.6 m and 11.1 m.

Unauthorized public cutting of the Manu embankment in 1984 and since 1990 has caused severe damage to the embankment and to the irrigation and drainage systems. During planning of the Project many people living along the right bank of the Manu refused to accept the proposed embankment setbank of 120 m (400 ft) from the river. The area is densely populated and many residents would have had to be re-located; since they were not threatened by flooding at the time, they refused to re-locate. Consequently, the alignment was altered, leaving many residences outside the project embankment. These unprotected areas have subsequently flooded, and people residing outside the embankment, along a 12.5 km length between Baliarbagh and Palpur, have responded by cutting the embankment to allow the flood waters to spill away from their area.

Flow through these cuts causes considerable damage to crops within the project area and overloads the capacity of the pump station and drainage sluices. In order to relieve flooding, farmers living within the project area have started to cut the Kushiyara section of the project embankment. The problem has been aggravated by the recent occurrence of severe floods plus rising flood stages due to increasing rainfall, confinement effects from project embankments and other embankments which are located further upstream.

About 23.7 km of secondary embankment have been built along the Manu right bank to further protect these areas, and this secondary embankment is constantly being strengthened and raised to protect vulnerable residences. Nevertheless, flooding has persisted in these areas and the residents continue to cut the embankment.

2.3 Topography and Drainage

The project encompasses an area of 24,076 ha. In addition it receives runoff from 6,000 ha of the Bhatera Hills located to the east. It is roughly trapezoidal in shape and it measures 22.8 km long (from southwest to northeast) and 14.8 km wide. It is bounded by the Kushiyara River on the north, the foot of the Bhatera Hills on the east, and the Manu River to the south and west.

Elevations within the project area range from below 4 m PWD at the centre of Kawadighi Haor to 12.5 m PWD at the foot of the Bhatera Hills and 433 m at the peak of the Bhatera Hills (Figure 3). The land forms a concave alluvial plain which slopes upward towards the Bhatera Hills and the surrounding river levees. River banks surrounding the project area are raised or "perched", having been formed by periodic overtopping during floods and deposition of the suspended bed material near the river. Flood water accumulates within the project area and the deeper haors.

There are about 50 *beels* (permanent water bodies) in the project area. These include the main haor (Boro Kawadighi) and a smaller group of beels (Chhoto Kawadighi). Other smaller beels are located in the northeast and northwest portions of the project area.

The area is dissected by numerous former distributaries of the Manu and tributaries of the Kushiyara and by many smaller drainage khals. Drainage water from most of the area is conveyed by natural drainage channels to Kawadighi Haor. From there it is discharged to the Kushiyara River through two drainage sluices at Kashimpur. When the water levels are higher in the river than in the haor (during flood stages and pre-monsoon floods) the sluices cannot drain and the Kashimpur pumping station is operated to drain the project area.

There are 21 *chhora* (small drainage channels) coming from Bhatera hills, of which 13 carry water throughout the year. This water is used for irrigating the land in Kawadighi Haor; about 60-70% of land in Chhoto Kawadighi Haor is irrigated by *chhora* water.

2.4 Soils

Soils of the project area are mostly floodplain deposits of grey, heavy silty clay loams on the ridges, and non-calcareous grey clays in the basins. The higher piedmont plains and valleys, which occupy 11% of the area, have soils ranging from sands to clay. The piedmont deposits are complex in pattern due to the irregular deposition of sediments of different textures during successive flash floods.

Permeability is slow in most soils except in the more loamy ridge soils close to the hills. Moisture-holding capacity is reduced by puddling of the surface layer and the formation of a strong ploughpan in soils which are used for transplanted rice cultivation. Except in beels, therefore, topsoil quickly becomes hard and dry after the end of the rainy season.

The organic content of the soil is moderate. Soil reaction ranges from strongly acidic to neutral. Levels of CEC and Zn are high while those of other essential nutrients are medium.

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2.5 Climate

Temperatures vary from about 6°C to 28°C in January to 23°C to 36°C during the period March to June. There is a significant diurnal fluctuation.

The mean annual rainfall over the project area, based on data from three local rainfall stations, is about 2,865 mm. The rainfall exhibits a seasonal pattern with up to 65% of the annual total experienced during the monsoon period from June to September. The period from December to March is significantly drier and has less than 5.5% of the annual total rainfall.

The relative humidity is high throughout the year, with daily averages ranging from 72 to 88%. The humidity is highest during the monsoon period from June to September.

The average wind speed varies from about 3.5 to 5.4 m/s with the highest speeds occurring between March and July.

Potential evapotranspiration rates reflect the seasonal patterns of rainfall and humidity. The highest rates of up to 4.9 mm/day during the pre-monsoon month of May while the lowest rate, 2.6 mm/day, occurs during the winter months of December and January.

2.6 Hydrology

The hydraulic performance of Manu Project is affected by the following factors:

- rainfall, evaporation, and infiltration at the haor surface;
- water levels in the Kushiyara River;
- water levels in the Manu River and embankment cuts in the Manu embankment;
- runoff from the Bhattera Hills;
- operation of regulators;
- operation of the pump station;
- cuts in the Kushiyara embankment.

The project covers an area of 240 km^2. It also receives direct runoff from 60 km^2 of the Bhatera Hills and, during floods, it receives spills from the Manu and Kushiyara Rivers.

The Kushiyara has a huge catchment area, 22,000 km^2, most of which is located in India. The Manu and Dhalai Rivers originate in the Lushai Hill range in India and together drain an area of 2,700 km^2, mostly from India. The Dhalai is the smaller of the two and drains an area of 865 km^2 into the Manu about 4.6 km upstream of the Manu barrage.

Drainage areas are summarized in Table 2.1.

The Manu derives most of its flow from rainfall during the monsoon season and from groundwater during the dry season. Throughout the entire rainy season from April to October the river stage fluctuates sharply, depending on rainfall intensity and duration. There can be as many as 8 to 9 peaks in this period, each of which can reach its maximum stage in a single day. A rise of 2 m or more is common and may persist for 3 to 5 days. Throughout the dry months the stage remains more-or-less uniform and decreasing except when the barrage gates are operated.

Historically the Manu River has spilled over its banks in the vicinity of the project, especially near Maulvibazar and for several kilometres upstream. The project embankments were intended to prevent these spill from occurring but they are cut during floods and the project area continues to flood. This spilled water collects within the project area and in Kawadighi Haor along with the local runoff from the project and from the Bhatera Hills.

Table 2.1: Drainage Areas (km^2)

River	India	Bangladesh	Total
Kushiyara	25,100	520	25,520
Manu	2,226	60	2,286
Dhalai	572	293	865
Project area		241	241
Bhatera Hills		60	60

Upstream of the project area the Manu River previously spilled eastward into Hakaluki Haor via the Phanai River, and westward into Hail Haor via the Gopla River. These overbank spills have been largely cut off by embankments which extend most of way to the Indian border. Embankments have also been constructed along the left bank upstream of Manu Railway Bridge but these embankments are breached during floods.

There is evidence that flood discharges in the Manu River have increased in recent years. A number of factors are involved:

- higher rainfall and increased variability of rainfall;
- deforestation in the tributary catchment which is mostly located in India;
- embankments in the Bangladesh and Indian portions of the catchment.

It is reasonable to expect that flood discharges and water levels will further increase as the embankments are strengthened and extended.

The Kushiyara River is the natural outlet from the haor. Before the project was implemented, high stages in the river would back up into Kawadighi Haor. The project embankments have blocked this natural outlet in order to prevent the backwater flooding. The project area is now drained by pumps during high river stages and by two drainage sluices whenever the river levels are lower than the haor levels.

2.7 River Morphology

The Manu River basin in India occupies a narrow valley between two prominent north-south trending anticlinal ridges. The lower portions of these ridges consist of poorly consolidated, often highly weathered Pleistocene and Pliocene-age sediments that are dissected and gullied by a network of headwater channels. The sediment production from these channels is high.

The Manu River carries a large sediment load which is evident in the numerous sand bars which occur in the river. From available (limited) data it is estimated that the average annual load is about 2.2 million tonnes/year upstream of the Dhalai River confluence and approximately 3 million tonnes/year downstream of the confluence. During the high-flow period from 1986 to 1991 the sediment load was double the average.

Channel dimensions do not increase downstream of the Dhalai confluence, in spite of the inflows from the Dhalai River and the effects of confinement by embankments. In fact the width actually decreases in the lower 5 km. This decrease is the result of the large overbank spills in this reach.

In spite of the large sediment loads it appears that the river is relatively stable and is neither aggrading nor degrading over time. The embankments have had a relatively minor effect on channel morphology; since 1983 the channel cross-section has increased by about 5% in area and 10% in surface width. These changes suggest that the channel has responded to increased flows and sediment loads by widening rather than by bed lowering.

2.8 Human Population

There are 42 villages in the project area having a population of 133,125 (estimated from 1991 census data). A sample survey which was undertaken in two villages, Panchgaon and Jahidpur, shows that the male population is slightly higher than the female population. More than one-third of the population are illiterate. Males have significantly more years of schooling than females, particularly at higher levels.

Agriculture is the occupation of most males, followed by service and wage labour. Most women work as housewives. Wild resources are generally collected by the children or female members of the households.

The area has a substantial fishermen population which has not been recorded in the household survey. According to preliminary observations, there are 2,840 *maimol* households and 463 *namasudra* households in the 42 villages of the study area.

2.9 Agriculture

The risk and uncertainty which are introduced by flooding and drainage problems have had a significant effect on the type of crops to be grown, sowing and transplantation time, use of inputs, and crop yields. More than 40% of the cultivated area is severely flooded (to a depth of more than 90 cm) which provides a major constraint to cropping in these areas. The deeply-flooded areas are single-cropped compared with an average cropping intensity of about 187% in the non-flooded areas. The average cropping intensity is 149%.

Details of the cropping pattern, cultivation practices, and constraints to production in the Manu Project area are provided in Annex D.

A wide range of crops are grown, but the major crop is rice which accounts for more than 98% of the total cropped area. Rice varieties include local and modern (high yielding) varieties, plus an improved variety called *pajam*. More than half of the cropped area is planted with local low-yielding rice varieties due to uncertainties caused by flooding and late post-monsoon drainage.

Transplanted aman is the major crop as indicated as follows:

Crop	Percent of cropped area
T aman	36%
Boro	31%
Aus	20%
Deepwater Aman	11%
Non-rice crops	2%

Cropped areas in early June 1993 including T. Aus and B. Aman crops are shown in Figure 4.

Aus and aman rice crops are damaged by flooding which results from public cutting of the embankments. Flood damage also occurs from natural causes in the low-lying areas and from runoff entering the project area from the Bhatera Hills.

Figure 5 shows the pattern of boro crops grown during the dry season of 1993. Some HYV crops are grown near the foot of the Bhatera Hills and are irrigated from creek runoff but most are grown in the lower areas near Kawadighi Haor. Low-yielding boro varieties are grown in the lowest areas near Kawadighi Haor where they require no irrigation.

One target of the Manu Project was to increase HYV boro production. This has been slow to develop, largely for two reasons:

- HYV boro requires better management and more inputs of labour, fertilizer, and irrigation than do the lower-yielding varieties. Consequently about half of the irrigable lands remain fallow in the boro season, much of which are owned by *Londonee* landowners (owners living oversees, primarily in London).

- It has been reported that water supply from the barrage to HYV boro land is delayed in the interest of the fishermen and lessees at a time when it is needed for transplanting of seedlings. Timely, assured, and regular supply of water are critical to HYV boro cultivation.

Agricultural production is also affected by drainage conditions. During the field visits and discussions with local people, it appeared that the project area has had problems with drainage congestion and water-logging, and that these problems have existed since its inception. The reasons are many and include recent heavy rainfall, repeated flooding of the project area, inadequate carrying capacity of drainage channels, and the lack of local drainage systems. There have also been complaints that the performance of the pumping station is inadequate and that the sluices have been left open during the pre-monsoon season to encourage fish migration. Some lands remain water-logged for a long period, which makes tillage difficult and delays or eliminates the next rabi crop. According to the farmers the water-logging reduces the productivity of soil due to leaching of plant nutrients.

There is little sign of crop diversification in the project area, with non-rice crops (mainly oilseeds, vegetables, and spices) representing only 2% of the total cropped area.

About 25% of the gross project area is not cultivated (beels, haors, homesteads, roads, embankments, and other non-agricultural areas).

Small farms are typically operated by their owners. Some large farmers also manage their farms by themselves and employ labourers on a seasonal or yearly basis; however share cropping is more common, particularly among the *Londonee* families.

2.10 Fisheries

The unique hydrologic conditions in the project area created a good fish habitat before establishment of the project. These conditions included:

- regular inflows of flood waters from the Manu and Kushiyara Rivers,
- easy migration between the Kushiyara River and Kawadighi Haor,
- extensive areas of water in Kawadighi Haor and 50 other water bodies,
- clear water in Kawadighi Haor which attracts migrating fish to spawn.

Kawadighi Haor, the main depression of the Project area, was formerly one of the most productive haors in the region. It had abundant stocks of large fish and was the best spawning ground of the region.

The fisheries in the area have virtually disappeared since the MRP was implemented and this decline is widely attributed to the impact of the project. Present production is reportedly less than 5% of the level which occurred previously. Consequently most of the fishermen have shifted from their hereditary profession. The remaining fishing occurs mainly at subsistence levels.

There were 2,500 "genuine" fishermen (people who are engaged full-time or primarily in fishing) in 1992 and 4,300 in 1993, a flood year which had greater fish stocks. Most of the fishermen live in 21 villages located around Kawadighi Haor, but there are also 13 other villages which have a significant number of fishermen families.

There is no prominent fish market within the Manu project area; most of the fish are marketed in Maulvibazar or in Rajnagar. During the dry season 600-700 *chhoira* or *nikari* (fish retailers) are active in purchasing fish in the Kawadighi Haor area. The majority of them are locals, but others come from Balaganj, Sherpur, and Maulvibazar.

There are 79 *jalmohals* (fishing grounds) in Kawadighi Haor, of which 53 are owned by the government and 26 are owned privately. Seventeen of the privately-owned *jalmohals* have silted up and are no longer leased out. Areas of these *jalmohals* are summarized in Table 2.2.

A substantial proportion of the active *jalmohals* are cultivated for *boro* crops during the dry season. However the silted-up jalmohals mostly remain fallow due to lack of drainage.

In each of the main *jalmohals* there are 10 to 15 groups of local fishermen and 2 to 4 groups coming from other areas, mainly from Fenchuganj and Habiganj. Each group is comprised of 10 to 15 persons.

Beel fishing takes place during the dry season from December to February. At the side of each *beel* or *jalmohal* a temporary *khola* (shed) is set up for harvesting of fish. Each *khola* contains 20 to 25 thatched rooms made of bamboo and straw to serve as temporary homes for the fishermen. Two rooms are kept for trading purposes. Each group makes its own house in the *khola* at their own expense.

Table 2.2: *Jalmohals* in the Manu Project area

Type	Number	Area (ha)
Public	53	911
Private:		
silted	17	185
active	9	127
Total	**79**	**1,223**

Women do not work at the *kholas* in Kawadighi Haor as most of the fishermen are hired locally. This practice is somewhat different from that in other parts of the Northeast region where fishermen are hired from greater distances and their families join them in the *kholas*.

Fresh fish are sold everyday in the *khola*. At the beginning, 70-80% of the total proceeds accrue to the lessee and 20-30% to the fishermen groups. As the volume of catch decreases over winter the fisherman's share increases and reaches a high of 50% in March/April.

The fishing community is dominated by the *maimol* (Muslin fishermen) who have formed 16 Fishermen Cooperative Societies (FCS's). There are no *mamasurda* (Hindu) FCS's. The *mamasurda* are allowed to catch fish during the monsoon season but not during the dry season since they do not belong to an FCS.

2.11 Forestry and Wetland Resources

Kawadighi Haor is an overwintering ground for migratory waterfowl which is of international importance. Birds arrive as early as August and leave at the end of April, with their populations peaking in December and January. The main migratory species are *feriya* (Garganey) and *lenjha* (Pintail). *Shorali* (Whistling Duck), a resident species, are common as well. Nesting of whiskered terns in Kawadighi Haor is the only known occurrence in Bangladesh.

Birds congregate mostly in Patasingra, Majherbandha, and Haowa beels.

Bird trappers of Shahpur, Noagaon, and Fenchuganj villages catch birds from the haor and sell them at Maulvibazar and Sherpur. Wild ducks sell for Tk 60-80 each. Amateur hunters, mostly *Londonees* or government officials, also hunt birds.

Eggs of nesting birds are collected by the local people and are either eaten or sold in the local market. In 1992 it is estimated that more than 2,000 eggs of different waterfowl species were collected.

Numerous wild plants grow in the haor and are consumed by the landless and the poor or are bartered or sold. Wetland trees (*koroch, barun, hijol, mandail*) occur in small numbers in the *kanda* and around the villages. *Nolkhagra* and *chailla* also occur and have been traditionally used for homestead protection.

Many species of trees and plants which once existed in the haor no longer occur there. Some species such as *pukol* became extinct.

2.12 Transportation

The topography, climate, flooding pattern, and network of waterways make water-based transportation navigation an important aspect of the project. Most of the people in the Manu Project are involved with navigation for their daily activities. Country boats are the only means of transport and communication in the vast interior of the project area, which is totally inaccessible by any sort of road during the monsoon season. Small boats are operated to carry passengers from one side of the haor to the other even during the dry season.

Water-based transportation fills the following roles in the Manu River Project:

- ***Access to regional markets:***
  Regional markets (Balagonj, Manumukh, Kaligonj, Hansapur, and Sherpur on the Kushiyara River and Kazirbazar and Maulvibazar on the Manu River) are reached mainly by water transport.

- ***Agricultural production:***
  Boats are used in every phase of agricultural production, from transportation of seedlings to marketing.

- ***Transport of passengers and cargo:***
  Boats are an important means of earning cash income by carrying commercial cargo and passengers. These boats carry seasonal fruits, housing materials, vegetables, bamboo, bamboo and cane products, and sand. Approximately 45 boats are engaged within the Project area for these purposes.

- ***Domestic Use:***
  Almost all rich households in the low lying areas have boats of their own for domestic use.

- ***Collection and transport of sand:***
  At least 250 labourers and 80 to 90 boats of Fatepur, Shahbazpur, Keola, Medinimohal, and Sonatiki villages are involved in collection and transportation of sand. They earn a good income from this activity.

- ***Fisheries:***
  About 2,500 boats are engaged in fishing in and around Kawadighi Haor.

- ***Gathering of fuel and wetland products:***
  People living in low-lying areas collect aquatic weeds (*Arail*, *Paura*, water hyacinth, water lily, *Kalmi*) by boat for use in protecting homesteads against erosion and for fodder for livestock.

3. PROJECT MONITORING PROGRAM FIELDWORK

3.1 Hydrology

Water levels were measured with staff gauges installed by PMP at the following locations:

STATION	RIVER	FROM	TO
Kamalpur	Kushiyara	23-May-92	21-Apr-94
Dhamai Chara	Dhamai Chara	23-May-92	31-May-94
Kazir Chalk	Manu River	1-Jun-92	30-May-94

Water level data was also collected from BWDB for staff gauges at the following locations:

- Kashimpur Pump Station (Kushiyara River & Kawadighi Haor)
- Manu Barrage (Manu River)
- Manu Bridge at Chandnighat (Manu River)

Daily rainfall data was collected from BWDB rain gauges at the following locations:

- Manumukh
- Maulvibazar
- Chandnighat

Daily pan evaporation data was collected from BWDB stations at:

- Srimangal
- Sylhet

The data which were collected are provided in Annex A.

3.2 River Morphology and Sedimentation

Morphological surveys were carried out to monitor ongoing channel changes on the Manu River and the Kushiyara River adjacent to the project area. The main purpose of these measurements was to monitor aggradation/degradation in the channel and on the floodplain. The table below lists the dates of surveys and site visits and the nature of the work that was carried out.

Table 3.1: River Survey Program on Manu River

Date	Work Carried Out
2-9 Aug 1992	Manu River channel surveys
20-25 Feb 1993	Manu River channel surveys, bed material samples
12-18 Mar 1993	Manu River cross sections
11-15 Apr 1993	Kushiyara River cross sections
13-16 June 1993	Manu River flood survey, longitudinal profile
8-10 Aug 1993	Manu River surveys and longitudinal profile

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The repeat cross section surveys were made by establishing permanent concrete hubs on each bank of the river and then surveying the channel with a portable echo sounder and tag line. Locations of all hubs were established by GPS measurements. A GPS was also used to carry out longitudinal profiles along portions of the Manu and Dhalai Rivers. Survey results are included in Appendix B.

3.3 Agriculture and livestock

Field work was carried out during Kharif II and Rabi seasons in 1992, Kharif I, Kharif II and Rabi seasons in 1993 and Kharif I season in 1994. Periodic visits to the project area were made by the NERP agricultural specialist, and some of the data was collected during these visits. However, most of the agricultural data was collected by the resident NERP social anthropology team with direction from the agricultural specialist.

Agricultural data are provided in Annex C.

3.4 Sociology

Two data collection teams were based at two different locations (Jahidpur and Panchgaon). Each team was composed of five field researchers. In the initial stage during August-October 1992, the field researchers underwent a process of practical orientation on concerned issues and were mainly involved in collecting bench-mark data. From December 1992, issues and processes were monitored on a monthly basis and field notes were sent to the NERP headquarters in Dhaka for compilation and analysis. Collection of monitoring data continued up to May 1994.

The following parameters were monitored:

- agriculture
- fisheries
- livestock
- employment
- migration
- water transportation
- health and sanitation
- flood
- irrigation and drainage
- coping strategies

Data were mainly obtained through informal interview, group discussion, and observation. Several key informants were also used as a source.

Results are provided in Annex C.

Table 3.2: Socioanthropology Data Collection in MRP

Year	Month	Date	Number of Field Staff
1992	August	1-31	12
	September	1-30	12
	October	1-31	12
	December	20-31	2
1993	January	1-31	2
	February	1-28	2
	March	1-31	3
	April	1-30	2
	May	1-31	2
	June	1-30	2
	July	1-31	2
	August	1-31	2
	September	1-30	3
	October	1-31	3
	November	1-30	3
	December	1-31	3
1994	January	1-31	4
	February	1-28	3
	March	1-31	3
	April	1-30	3
	May	1-15	3

3.5 Fisheries

Fisheries field work started in May 1992 and included catch assessment surveys, a frame survey, and sampling of fish stocks. Periodic field visits were made by the NERP fishery specialists (Table 3.3). Data, observations, and results are provided in Annex E.

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3.6 Forestry and Wetland Resources

The environmental team conducted the following investigations:

- survey of the floral composition of the wetland, homesteads, and fallow land;
- survey of the fauna (amphibia to mammals) in wetland, and homesteads;
- utilization of flora/floral products and fauna/faunal products by the local people;
- public attitude towards preservation and utilization of renewable biological resources.

Periodic visits to MRP were made by the NERP environmental team.

Results are provided in Annex F - Forestry, and Annex G - Biodiversity Inventory.

Table 3.3: Fisheries Data Collection in MRP

Period of Field Trip	Season	Hydrological Condition Inside Haor
16-18 May 92	Early monsoon	Water level increasing slowly
19-24 July 92		Partially flooded
25-31 Aug 92	Mid Monsoon	Partially flooded
22-30 Sep 92		Partially flooded
19-22 Oct 92	Late Monsoon	Flood receding
20-26 Dec 92	Dry Season	Water in beel
17-21 Jan 93		Water in beel
23-28 Feb 93		Water in beel
18-22 Apr 93		Water level increasing slowly
21-22 May 93	Early Monsoon	Water level increasing slowly.
28-30 June 93		Deeply flooded
01-03 July 93		Deeply flooded
01-05 August 93	Mid monsoon	Deeply flooded
26-29 Sep 93		Deeply flooded
14-18 Oct 93	Late Monsoon	Flood receding
01-05 Nov 93		Flood receding
28 Nov-03 Dec 93		Flood receding
24-28 Dec 93	Dry season	Water in beel
12-14 Jan 94		Water in beel
25-28 Feb 94		Water in beel
01-02 March 94		Water in beel
27-30 April 94		Increased rain water creates water logging
10-12 May 94	Early Monsoon	Increased rain water creates water logging

4. CHRONOLOGY OF EVENTS AND PROJECT IMPACTS (1992-94)

A summary of the observations which were made in the monitoring program is provided below. Further details are provided in the annexes to the report.

4.1 Summary of Water Levels and Flooding

Figure 6 shows the time graphs of water level in the project area, rainfall, pump operation, and Kushiyara River water levels. Water levels are provided for the Manu River at Maulvibazar in Figure 7. These water levels will be discussed briefly below and in further detail in the remainder of this section.

The monitoring period included two complete water years, 1992-93 and 1993-94, as well as the pre-monsoon season of 1994.

The first year had a mild monsoon season and little flooding. Heavy pre-monsoon rainfall caused river levels to rise abruptly but the project area was protected by the embankments and pumps and sustained only moderate damage. Water levels followed a typical season variation for the area, peaking in September inside the project area and in July outside the haor. Haor water levels rose from 4.1 m in May to 8.4 m in September, then declined rapidly to 4.3 m in December.

The second year had several pre-monsoon storms that caused river levels to rise substantially but the project area was protected by the embankments and the operation of the pumps. Monsoon rainfall was severe and caused severe flooding in June and July. The embankments were cut by the public in June and remained open through the remainder of the monsoon season, allowing massive quantities of water to spill through the project area. The peak water level reached 10.5 m within the project.

Unusually severe pre-monsoon rainfall occurred in April 1994 and caused the haor water levels to rise by about 2.5 m despite pumping at the pump station. Boro crop damage was extensive due to the pre-harvest flooding.

4.2 Pre-monsoon and Monsoon Period 1992

Water levels in Kawadighi Haor rose steadily (by 4.3 m) during this period and peaked in the middle of September at elevation 8.4 m. However the embankments and operation of the pump station kept the haor water level below that in the Kushiyara River, especially in the pre-monsoon and early monsoon season when water levels were as much as 3 m lower than river levels.

Pump operation was stopped on August 18 when the Kushiyara water levels had fallen enough to permit drainage through the sluice. Pumps were again started for brief periods when the Kushiyara River rose again (14-19 September and 16-25 October).

May 1992

In May the water level rose in the haor converting it into a large sheet of water. Aquatic grasses, mainly *parua*, were abundant. Some resident waterfowl (Pygmy Goose, Pheasant-tail Jacana, Watercock, Whiskered terns, etc.) and the migratory Blackwinged Stilts were in breeding plumage.

June/July 1992

Fingerlings of *rui* and *kalibaush* were caught near Sonapur by fishermen who thought that the fingerlings had entered through the leakage of the pump house. One *shakush* (Gangetic Stingray) weighting 150 kg was caught on 21 July at the confluence of the Manu and Kushiyara River. Local fishermen reported that ripe carp broodfish were caught from the Kushiyara River during this month. *Jatka* of different size groups were the main catch in the river.

Water levels increased, parua grass became less abundant, and *Nymphoides* bloomed. The water was less turbid than in the previous month. Some waterfowl (Whiskered tern, watercock, Pheasant-tail Jacana) had active nests.

Hatchlings of whiskered terns, watercock, and some migratory waders were observed. Water hyacinth was less abundant and *Nymphoides* were still flowering.

August 1992

The number of fish species and catch were greater in the river side than in the haor. Very little fishing was observed in the haor side compared with the river side.

The water level was a bit higher but the water mass was almost stagnant. Fishing activities increased this month. *Parua* grass started to die off. Almost all whiskered tern eggs hatched. Agricultural activities and collection of aquatic plants (*Nymphea, Hydrilla, Trapa* fruits) were in progress. Grasses (*parua* and *erali*) were being extracted for fodder.

People of the low-lying area used boats as the only means of internal transport and communication. The fishing community depended on boats for fishing as well as marketing their catch. People transported their rice crop, fuel, bamboo, sand, and other necessities by boat. They also collected water hyacinth, *paura*, and water lily as fodder. It was observed that some people had cleared off water hyacinth from the *b.aman* fields using their boats.

Seven cross sections were surveyed in the Manu River between Kazir Chalk and Manumukh to monitor morphological changes. Two cross-sections were located upstream of the Dhalai River and five were downstream.

September 1992

Jalmohal lease holders used their boats to guard their leased water bodies. Boats were used in fishing, fish retailing, sand carrying, and collection of wild natural resources. People in the villages marketed paddy and fetched drinking water by boat.

A fisherman reported that a large rui was caught at the embankment where it jumped out of the water near the outlet of the pump house. Closed water species were the most abundant species during this period.

The water level was a bit higher and more turbid because of rain which inundated marginal higher cultivable land. Collection of aquatic grasses was under way. Aquatic plants were decomposing. Agricultural activities increased in this month.

4.3 Post Monsoon Period Season: October to December 1992

Haor water levels receded rapidly, by about 4 m, as there was no rainfall in this period. Haor water levels remained higher than river water levels. Pumps were not operated as the water drained out of the haor through the sluice gates. During this period the haor water levels were as much as 1 m higher than the river level.

<u>October 1992</u>

Katari (b. aman) is grown extensively in Kawadighi haor. The main *katari* varieties are *gutak, dudhlaki, lathishail* and *ognilaki*.

Severe incidence of fish disease broke out in the haor during this period. About 75% of the fish were affected by the disease.

Breeding of resident waterfowl was over and new hatchlings were seen. Decomposition of aquatic plants was evident, and collection of aquatic plants continued. An increase in the number of both resident and migratory species of waterfowl attracted people to shoot ducks. Fishermen were seen using branches of *Cassia fistula* for katha (a type of fish trap) because of the scarcity of hizal and koroch branches.

<u>November 1992</u>

Many new activities began as the water level started to fall. Katari rice was being harvested and cattle grazing began on lands where water had receded. There was an increase in duck hunting. There was an increase in waterfowl species and numbers.

People from the low lying areas transported housing materials (tin, timber, concrete poles, bricks, bamboo products, cement, and sand) by boat. Lessees used boats to guard their water bodies. Fishing, fish retailing, and fish marketing were done by the fishing community. Some people collected weeds, earth, and drinking water by boats.

<u>December 1992</u>

Water level declined further and there was an increase in agricultural activities in the marginal cultivable areas. Pumps have been installed in the Akali Gang to pump water to the paddy fields and enhance fishing.

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Epizootic fish disease was observed in epidemic proportion and dead fishes were floating everywhere in the haor. Small and large fishes were equally infested. The waterbodies were covered with *Trapa* plants.

4.4 Dry Season: December 1992 to February 1993

Water levels in the haor fell approximately by 0.5 m during this period, mostly due to evaporation. There were only four or five days with rain in this period. The water levels were near the invert level of the sluice (3.8 to 4.1 m) and there was little outflow.

January 1993

In the early morning of 1 January 1993, water was released in canal RL4 near Panchgaon and flowed for the whole day. This resulted in flooding to a depth of 15 to 30 cm in some land adjacent to the canal. Farmers were concerned and many of them were seen to construct barriers in different places along the Rajnagar-Munshibazar road to prevent water from entering their land.

Lessees of different beels were recruiting the local fishermen for beel fishing. A large number of fishermen were working as *nikari* (retailers).

January/February 1993

Rainfall and the open sluice gates helped to drain out the stagnant water, reducing the viral fish infestation. A thin oily film was noticed on the surface of the water, probably from the decomposing dead fish or oil leakages from the pumps. It was observed that about 20-25% of the fish had disease in Kawadighi Haor, down from 75% in October to December. *Puti* were most affected but other affected species were *taki*, *magur*, *shing*, *gojar*, *koi*, *tengra*, and *meni*. Dead fish were seen floating in the beels. About 25-30% of the catch was diseased. Diseased fish were not sold in the market but are being dried to make *shutki* for sale in the lean season.

Local reports indicated that most of the traditional fishermen (about 80%) have entered other professions. In general fishing had been more profitable than other professions such as agriculture before establishment of the project. This shift has created heavier pressure on other professions.

There were higher numbers of migratory and resident waterfowl. Some mammals such as small mongoose and bandicot rats have bred and young ones were seen.

Women and their children were engaged in earthwork in some villages within the homesteads. Few women were employed in the earthwork for the BWDB.

Fishermen used boats to catch fish in the beels of Kawadighi haor. Lessees used boats to guard their jalmohals.

February 1993

Due to declining fish stocks many fishermen went to other *haors*. Five groups from Amirpur went to fish in Hakaluki Haor. Another two groups from Rokta went to Gurapur Haor near Balaganj.

Channel surveys in February showed that changes in the Manu River channel over the dry season were very small and were below the resolution of the surveys. As in the August survey the channel appeared to be devoid of bedforms such as dunes, which indicated that the rate of sediment transport was very low. Cross-sections are given in Annex B.

4.5 Pre-monsoon Period: February to April 1993

River water levels started to rise sharply in response to the onset of rainfall. The Project pumps were operated during this period and kept the haor water level relatively steady.

February 1993

Due to heavy rain from 17-22 February, 10-15% of the area under *boro* cultivation was flooded and seedlings were damaged.

March-April 1993

Nine cross sections of the Manu River made by BWDB in 1986 were replicated by the NERP sediment team. Comparisons indicated that only a small increase in cross-sectional area has occurred. Four cross sections which had been established by the Morphology Directorate of the BWDB in the late 1960s and had been resurveyed regularly through the 1970s were located and resurveyed. All cross-sections show some change but no significant trend was noticed. Details are provided in annex B.

Most fishermen were engaged in other economic sectors, mainly in agriculture. The lessees are installing the old *khata* in the beels. A very small number of fishermen were fishing commercially.

Not many boats were in use during this period.

April 1993

On 11 April crops were damaged by a hailstorm in the villages of Naichauri, Kalauri, Kathari, Akar Khal, Majher Chaila, Amirpur, Meghna, and Mithapur. On 26 April a wind storm damaged the crop which was already ripe. About 5% of the rice fell to the ground from ripe panicles. Due to runoff from the Bhatera hills in the last week of April and first week of May, 12-15% of the *boro* area was flooded and the crop was damaged in low-lying areas.

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4.6 Monsoon Period: May to September 1993

May 1993

Due to heavy rain (400 mm from May 2 to May 7), about 50% of the area under HYV *boro* was inundated. Water levels in the project area rose by 2.2 m from May 3 to May 7. Farmers of Kashempur, Islampur, Abdullahpur, Jahidpur, Shahpur, and other villages blame non-functioning of the pump house for this damage. They say that if the project cannot protect their crop, then why it is there? They say that they have made a mistake by depending on the project. Otherwise they would have transplanted their crop earlier so that it could be harvested earlier before the start of the monsoon. They also say that whenever there is bad weather, the water level rises in the haor and inundates their crop. When this happens the pump house always has power failures. Even if there is power, all pumps are not put in operation. Some of the pumps were not operational because the repair work in the pump house starts during the monsoon season, not in the dry season when the pumps are idle. Pump records confirm that the pump station was operated at substantially less than its capacity during this period.

The 3-vent sluice to the north of the pump house has been out of order since its installation. When the water level in the river rises, it enters (leaks) through the sluice even if its gates are closed. The amount of water that enters through this sluice gate is reportedly equal to the amount of water that can be pumped out by one pump. Despite repeated complaints no action has been taken to repair the sluice.

Among the local *aus* varieties grown in 1993, *murali, chengri* and *dhumail* were dominant. Among the HYVs, BR6, IR8 and BR1 were mostly being grown. BR6, locally termed as 532, was being grown in 50% of the area as HYV *aus*.

People residing on both sides of Rajnagar and Balaganj road used boats to transport boro crop after harvest. The fishing community used boats to catch fish as well as to transport paddy from their own or others land on a commercial basis. Field observation showed that boats saved substantial labour cost and time by transporting the harvest from the fields.

June 1993

In early June, 550 mm of rain fell in a 10-day period, of which 198 mm fell in one day (June 5-6). As a result, the Manu River flooded and the embankments were cut (see Figure 8), resulting in extensive flooding of the project area.

The water level in the Manu River rose rapidly on 7 June. The stretch of river upstream of the Dhalai confluence came under attack first. An area about 0.25 km upstream of Kadamhata Bazar went under water. The secondary dike was breached at 16 places from Kadamhata to Haripasha on 6 or 7 June. Many villages lying between the secondary dike and the main embankment were badly inundated. Almost all the villages in Monsurnagar union were flooded. All houses in Malikona, Shashmahal, Premnagar, Govindashree, Bakshikona, Tagarpur, Konagaon, Akua, Adnabaz, and Bhangarhat were inundated. All houses except ten were knee-deep or waist-deep in water in Rakta. People of these villages responded by cutting the main embankment at Ashrakapan and Bhangarhat, near Malikona, early on June 8 to get relief. These two breaches quickly eroded, one to 50 meters wide and the other to 100 meters.

The embankment was cut at several locations downstream of Maulvibazar early on 8 June. Shortly after midnight the people cut the secondary embankment near Baliakandi, 3 km downstream of Maulvibazar, to save the town from flooding. By morning people had also cut the main embankment in Dheopasha. People also cut the embankment at Sompashi, Noarai, Akhailkura, and Mirpur during the day. Two cuts were made in the secondary dike and the main embankment near Palpur and Mirpur villages (near Manumukh).

The largest cut was the one near Dheupasha, downstream of Maulvibazar.

At the time of cutting the embankment at Akhailkura, the villagers of Uluura inside the embankment came out to resist. After looking at the grave situation of the villages between the project embankment and the secondary embankment they went back without any resistance.

Despite the cuts on 8 June the water level in the Manu River did not fall substantially as the river discharges remained high. On 9 June the people cut the embankment at another place in Dheopasha near the cut of the previous day. This cut was about 30 to 40 meters long and helped to drain out water between the secondary dike and the embankment. Most of the houses were above flood level by the afternoon.

Due to the cuts in the Baliakandi dike the following villages between the secondary dike and the main embankment were submerged:

in Akhailkura union:	in Chandnighat union:
Kamargaon	Baliarbagh
Noarai	Baliakandi
Shahbazpur	Dheupasha
Akhailkura	Monrujpur
Dhonpur	Sompashi
Khargaon	
Mobarakpur	
Paguria	
Mirpur	
Palipur	
Amua	
Shewaijuri	
Chandpur	

Water levels within the project area rose sharply due to the heavy rainfall and the spills from the Manu River. By 11 am on 12 June the water level in the haor had risen to the point where it was the same as the Kushiyara water level. At 12:00 noon the BWDB staff opened the 6-vent sluice and the 3-vent sluice at Koradair but the water level continued to rise. The people of Antehori, Sonapur, Islampur, Kadipur, Jagatpur, and Mojaffarpur assembled to cut the embankment at Machhuakhali at a location where it had been cut in 1991. BWDB staff requested them to make the cut at a new location in order to minimize the erosion of the embankment, and they did. The water level in the haor continued to rise as a result of heavy rainfall between June 11 and June 13 and houses were going under water in the villages. Despite the request of the BWDB staff, the villagers then cut the embankment at the older location as a last resort to save their houses.

The Manu River peaked on 13 June about 0.5 m lower than the June 8 peak. After this, the water level in the haor began to fall.

In the early morning (4:00 am) on 13 June, the people living between the dike and the embankment cut the embankment at Bhangarhat, near the location where it had been cut on 8 June. BWDB staff, in collaboration with the administration, immediately filled the cut with sand bags.

Peak water levels were recorded as follows:

Location	Date	Water Level (m)
Manu River at Maulvi Bazar	June 8	13.25 m
	and June 13	12.73 m
Kawadighi Haor at pump station	June 15	10.27 m
Kushiyara River at pump station	June 16-17	9.79 m.

People living in the low areas of Kawadighi Haor were badly affected as the water rose. People transferred their livestock to higher areas by boat. Water buffalo swam to high land.

During the flood many boats were used to transport paddy, livestock, other household items, and people to safer places. However there was a scarcity of boats as many of the high land people had sold theirs. During the flood many people were compelled to take shelter on boats.

The cuts in the embankment temporarily restored the connections between the rivers and the haor in several places. At first the boats could not pass through the cuts because of the high current. However after the water levels had equalized and the cuts had scoured, the boats could pass freely. Boats could ply through the cuts at Machuakhali from 14 June to the end of November 1993.

With the recession of flood water in Rajnagar, Panchgaon, Ekatuna, Monsurnagar, Munshibazar and Tengra unions, farmers started preparing seed-beds for *shail* rice from 20 June. Land which was normally used for seed beds in Akhailkura union was still under water due to the cut in the dike near Baliakandi which was still open. Dheupasha village was still under water on 23 June.

Some people had to repair and rebuild their houses.

A water surface profile of the Manu was surveyed on June 15, 1993 from above the Dhalai River confluence to Manumukh. It was noted that the slope of the water surface was very flat upstream of the Dhalai River confluence where it appeared to be affected by backwater. The slope was noticeably steeper through the confined reach between Maulvibazar bridge and the barrage. At the time of the survey, water was spilling over the right bank near Kazir Bazar while the floodplain around Dakdhala Haor was deeply flooded and inter-connected with the river channel. (For flooded area see Figure 9).

A longitudinal profile was surveyed along the river centreline over a distance of 31 km during the flood. The channel was found to be flat and featureless in the backwater reach upstream of the Dhalai River confluence, and bed sediments were found to be primarily "mud" in this reach.

These features indicate that sediment transport rates were low in this reach and that deposition of fine sediment was occurring upstream of the confluence.

Large dunes were found on the bed of the river downstream of the Manu barrage where channel velocities were highest. Dunes were particularly prevalent downstream of the Maulvibazar bridge. The dunes averaged 2 m in height, were as high as 4 m, and had a wave length of about 60 m. These features are indicative of high bed-load transport, mobile bed conditions, and scour/fill occurring during floods. Therefore, previous claims that the bed of the Manu River cannot scour due to the presence of bedrock in the channel at Maulvibazar are clearly incorrect.

Comparison of June and February cross sections showed that considerable local re-distribution of sediment had taken place during the flood but the net change in cross-sectional area was very small. Just upstream of the Maulvibazar bridge the thalweg of the river shifted from the left bank to the right side of the river. At the downstream end of the river near Manumukh the river bed was scoured by about 1 m and the left bank was eroded by approximately 5 m.

July 1993

From 18 June to 17 July the water levels receded by less than 1 m. Heavy rainfall (500 mm over a 3-day period, of which 217mm fell on 20 July) caused a sudden rise in water level and renewed flooding.

The embankment cuts that had been made in June were still open and spilled into the haor. Ten of these cuts expanded by about 25%. About 90% of the earth was eroded along a 10 to 11 km stretch of the Kushiyara embankment. Many distressed families from low-lying villages of Antehori, Sunampur, and Islampur who had taken shelter on the embankment had to move to safer places.

People of Panchgaon, Bhumiura, and adjacent villages were stranded for two days. Many distressed families moved by boat from the low-lying area to the embankment to take shelter. Some people made banana rafts and as a result the price of banana plants increased from Tk 20 to Tk 50 per piece.

The Kushiyara embankment near Kashempur and Rashidpur eroded during the last week of July. Some people of Kashempur, Abdullahpur, and Rashidpur used these openings for transportation. Sixteen houses were washed away by wave action. The Rajnagar-Balagonj road went under water and it breached at several places. People were able to cross the road by boat through these breaches.

Flood conditions in five of the most severely affected villages are shown in Table 4.1:

Table 4.1: Flood levels in July 1993

Flood level (m)	Percentage of Homesteads Flooded				
	Panchgaon	Rokta	Sonateki	Ontehori	Sonapur
1+	10	5	15	50	45[1]
0.7-1	20	45	40	30	20
0.3-0.7	20	30	25	10	25
<0.3	45	15	10	9	8
No flood	5	5	10	1	2
Total	100	100	100	100	100

Source: Interview with villagers.

Roughly 80% of the transplanted *aus* land had severe crop damage; only 2% had a good harvest and another 18% had a moderately good harvest. Transplanted *aman* could not be planted on 35-40% of the available land. *Aman* seed-beds were damaged twice during the floods of June and July.

Most of the fishermen villages were badly flooded but the fishermen began trying to fish over the inundated area to take advantage of the greater fish abundance. Some fishermen from outside the project area (Sherpur, Dewangor, Shamshergonj) were also observed fishing inside Kawadighi Haor.

The income of almost all fishermen went up compared with the preceding year. All ponds were flooded and fish were abundant and cheap. On the whole it was observed that the fishermen were much better off than they were in the last year because of the abundance of fish.

The haor is regarded as open water in June and July and the fishermen can fish there freely. The Gargaon lease-holders were collecting a fee of Tk 100 per day from the fishermen who were using *tana jal* (nets). The lessees were exerting control over their jalmohals as well as the surrounding area so as to maximize their income during the coming dry season beel fishing.

<u>August 1993</u>

By August the level of the Manu River had dropped by approximately 3 m, and large localized deposits of sand could be seen on point bars and on the insides of bends. Approximately 20-30 cm of sand had been deposited on the floodplain upstream of the Dhalai River confluence. Closer to the confluence the right bank had eroded by 5 m while large quantities of fine sand had been deposited on the left bank. There was evidence of sand deposition in the channel at one section near the Dhalai confluence; other sections appeared to have either remained stable or have scoured.

Transplantation and broadcast of *aman* (mainly for seed production) continued into August due to the late recession of water.

During August, *afal* (stormy wind coming from the south-west accompanied by rainfall and flood wave) continued for three days. Fishermen could not use their boats at that time or catch fish.

Breaching of the embankment and flooding continued to be a blessing for the fishing community. Most of the people from the fishermen community (including those who had already changed to other professions) engaged in fishing during the monsoon season. Catches were 5 to 8 times greater than the last year. One fisherman from Rakta reported that he is now earning more than Tk 100 every day compared with Tk 15-20 last year. A group of fishermen set about 15 nets around the embankment breach at Machhuakhali.

September 1993

In September it was observed that few farmers used pesticides; instead many farmers posted bamboo sticks and branches of trees on the land so birds could perch and eat pests.

Fuel was scarce after the flood in almost all villages except Dheopasha. Some people in Antehori had cut down *koroch* trees or their branches for use as fuel. Poor households were cooking once a day to minimize the use of fuel. Some people were cutting dead trees and used these as firewood, as their timber is not suitable for making furniture. In Sonateki the fuel situation was less critical as the people were collecting firewood from the hills.

Because of heavy rainfall in the Bhatera hills and unplanned road constructed by the Union Parishad the eastern part of Kawadighi Haor suffered from water logging. People proposed new drainage channels and culverts through the road to drain out excess water. The farmers plan to build cross-dams on the drainage channels to irrigate boro crops. The channels can also be used as navigation routes during the harvesting period after the cross-dams are cleared.

In sample villages about 60% of the households were found busy in preparing homesteads and *bisra* for growing summer vegetables. The demand for labour had sharply declined.

4.7 Post Monsoon Period: October to mid-December, 1993

Haor and river water levels fell steadily by about 4 m from the beginning of October to the middle of December. By December 15 the haor water levels were nearly at the elevation of the sluice invert (4.1 m).

October

In October, people started broadcasting radish and *data* seeds, and began transplanting cauliflower, eggplant, cabbage, potato, and sweet potato. Vegetable cultivation could not be started in 10% of households in Dheupasha because of sand deposition on the *bisra* (vegetable plots).

Transplantation of aman was late in low-lying areas, such as the unions of Panchgaon, Munshibazar, Uttarbhag, and Fatehpur and about 15% of the land was attacked by pests. *T aman* did not grow well in an area of 0.75 km^2 at the two cuts in the embankment near Dheupasha village because of sand deposition.

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The fuel shortage continued. People were collecting *kolmi* plants from *kanda* and river banks and from their homestead areas to use as fuel after drying. About three-fourths of the households were using branches of *koroch* tree as fuel. In Sonateki about 90% of households were buying firewood from Munshibazar.

The fodder crisis declined gradually after 25 October as green grass started growing on *kanda* land and on *b aman* land in low-lying areas. By the end of October all cattle had been returned to their households from which they had been moved earlier during the flood.

November 1993

Harvesting was started at the beginning of November by a few farmers, and was in full swing by the end of the month. Harvesting was delayed in high lands which had been cultivated late. Immigration of labourers was 50-60% lower during the harvest of *t aman* in 1993 due to crop damage by successive floods. Harvesting of t.aman was mostly complete by December.

In many areas farmers were harvesting crops close to the ground to meet the need for fodder, as they had not been able to harvest rice during the aus season because of floods. Some farmers were using trucks to carry the harvested rice and straw from Munshibazar to Barkapon as they wanted to build up stocks of fodder. Under normal circumstances they would have threshed their crop in Munshibazar and carried only grain to Barkapon.

Seed-bed preparation for *boro* was 90% complete in November. Farmers reported that input costs would be minimal in the present year because aquatic weeds would not need to be removed and chemical fertilizer would not be needed.

The lessee of Karadair River started fishing during late October. Fishing started in some shallow beels during mid-November and was in full swing by the last week of November. Fishing continued actively in the various beels and khals of Chhoto Kawadighi Haor and Boro Kawadighi Haor. The catch of large fish increased significantly in Kawadighi Haor this year. At least 2,500 to 3,000 boats were being used to catch fish.

No fishing activity was observed in or around the Machuakhali cut. It was also observed that the outlet of the three-vent sluice was blocked with silt deposits.

December

Fishing by subsistence fishermen stopped when lease-holders took control of the *jalmohals* in December. Some fishermen would be able to get a sub-lease from the original lessee later.

4.8 Dry Season Mid-December 1993 to March 1994

Water levels in the project area continued to decline slowly. The water level fell below the invert level of the 6-vent sluice gate (4.1m PWD) on 20 January. Water levels declined very slowly after this date, mostly from evaporation, to an elevation of 3.8 m in late March 1994.

January 1994

In early January the gates of the barrage were raised at the request of a bamboo trader in order to increase the river discharge and thus to provide sufficient draft to allow the passage of 200,000 pieces of bamboo from Bekamora village. The bamboo trader thus saved Tk 1.3 lakhs in transportation and wage costs. However, farmers were deprived of irrigation water for some time and the boro transplantation was delayed.

Boro transplantation had started in low-lying areas near Kawadighi Haor. Boro transplantation was about 70% complete at Rokta where farmers were using water released from the barrage as well as water available from the Akali Gang. A part of Kawadighi Haor near Birunbaj, which is normally irrigated with runoff from Sutanoli Gang, was experiencing a water shortage. Transplantation was not well advanced in this area. The farmers of this area have used water from the project canals only once in the last five years. In highland areas farmers were still waiting for water from the irrigation canals and had not started planting.

Only one crop, boro, is grown in low-lying areas. About half of the households in this area (Medinimahal, Fatehpur, Antehori, and Kadipur villages) were having a shortage of rice even while other parts of the project area had just completed the aman harvest and had plenty. These poor people are forced to borrow rice for their own use and to pay it back five months later, at the end of the boro harvest, at about twice the market value.

Fishing in Patasingra Beel started from the beginning of January. Fishermen from Rakta, Gargaon, Amirpur, Kazirbazar, Antehori, Shahpur, Berkori, Abdalpur, Kalapur, Kubjargaon, and Fenchuganj were engaged in fishing. The quantity of catch, particularly of large fish, was much greater than in the previous year. Fish disease was also less prevalent than in the previous year. Fishing in all *beels* of Kawadighi Haor was going on.

Employment opportunities in the fisheries sector were greatly improved. Most of the efficient fishermen had been hired by the lessees. *Nikaries* (retailers) were getting enough fish to market through open auction and were making good profits.

The fuel shortage appeared to be over. Women of almost all households in Rokta were collecting cattle dung for fuel. Those who did not have any cattle of their own, collected dung from the *haor*. In Birunbaj and Barkapon, about four-fifths of the households bought fuel from the market. Most of the households in Munshibazar and Noyatilla collected firewood from the hills. In Antehori, the people mostly used *koroch* tree as firewood which was widely available in this village.

February/March 1994

The scale of agricultural activities decreased substantially in February. *Boro* transplanting in the low-lying areas of Kawadighi Haor was almost completed by the first week of February. In Sonateki 90% of the lands had already been planted to HYV boro and the remaining 10% was being prepared for transplantation. This had been facilitated by canal water. Land which had already been transplanted was being weeded. Water from the haor was pumped by LLP for irrigation until 25 March.

Preparation of land started in Rokta for cultivation of *katari* rice.

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In some areas farmers were still waiting for canal water to come in sufficient quantity. Transplanting had been delayed in Medinimahal, Dhulijura, Kewla, and Jamra due to the late release of water from the barrage.

Vegetable gardens were being irrigated once a week or once a fortnight, using water carried from ponds by earthen pot.

After the middle of March some farmers in high land areas started transplanting HYV *aus* seedlings. Ploughing for land preparation began in other high land areas for both *aus* and broadcast *aman*.

The wage for *aus* cultivation was Tk 40-50 plus one meal per day. The opportunities for wage employment in agriculture were still very limited.

Fishing in the beels was almost completed in February except in Patasingra and Salkatua where fishing continued on a contract basis up to the middle of March. The fishermen kept 30 to 50% of the catch. The number of *paikers* (retailers) had substantially decreased due to the reduced supply of fish.

Children continued to collect *kolmi* from the haor during the entire dry season up to March for use as fuel.

4.9 Pre-monsoon Period: April to May 1994

April 1994

Heavy rainfall from March 25 to 27 (280 mm at Maulvibazar) and April 1 (195mm) caused sharp rises in river and haor levels. Pump operation began on 26 March; however the haor levels still rose by about 2.3 m. Haor levels peaked at an elevation of 6.0 m, which was 2.4 m lower than the peak in the Kushiyara River (that is to say, the haor levels would have risen another 2.4 m if the embankments had not been in place). Almost all *boro* lands of Kawadighi Haor were submerged except those in higher areas.

The pump station was operated at about 50-60% of capacity during this period up to the end of April and again for two short periods in May. Pump operators said that the interruptions were due to mechanical troubles and power failure but the local people did not accept this explanation. Two out of three vents in the three-vent sluice were out of order and water was entering from the Kushiyara River into the haor.

It was felt by some people that the pump-house should have started operating from 15 March. However, the pump-house operators were retaining water to help fishermen catch fish in the beels while the market price of fish was high in late March.

Runoff from Bhatera hills also flooded several villages at the foot of the hills. About 80% of the *boro* crops in low-lying areas on the east side of Balaganj road were submerged.

People had started growing summer vegetables but the gardens were extensively damaged by heavy rain. The extent of the loss was estimated to be about 50% and reached 75% in some places.

Sowing of *katari* rice started in *Choitra*. Farm labourers involved in sowing were being paid Tk 30 plus one meal per day.

The fish catch in the haor dropped sharply. Some fishermen were still fishing with boats in Akali Nadi and a few other places.

<u>May 1994</u>

Harvesting of local and HYV boro was almost complete in May. *Katari* was being seeded by broadcast. Both local and HYV *aus* were being broadcasted or transplanted in high land areas.

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5. EVALUATION OF PROJECT PERFORMANCE (1992-94)

The following is an evaluation of the project and its impacts on the people. It is based on the information which is provided in the annexes to this report and which has been briefly summarized in preceding sections.

5.1 Water Management Issues in Manu Project

The key water management issues in the project area include:

- flooding of agricultural land and damage of crops;
- unauthorized embankment cuts causing flood damage;
- increasing flood discharges and water levels due to embankments and other causes;
- slow conversion to HYV varieties, partly due to flooding, drainage, and irrigation problems;
- destruction of the fishery in the project area which is widely attributed to the project;
- conflict between protected and unprotected owners;
- conflict between fishermen's and farmers' priorities.

5.1 Engineering Evaluation

Many of the problems with the design and operation of the project infrastructure are documented in Annex I. These are summarized below:

Embankments:

- A substantial area lies outside the project embankments and is unprotected, which leads to cutting of the embankment and flooding of the project during high river stages. This is one of the major issues for project rehabilitation.

People cut the embankments for the following reasons:

1. to reduce their flood damages by allowing the flood water to spill away from the Manu River,
2. To exert pressure on the authorities to upgrade the secondary dike and provide flood protection.

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- The original design was intended to provide protection against the 100-year flood which was estimated from historical water levels. In reality the flood discharges have been increasing as a result of the embankments cutting off the upstream overbank spills and as a result of watershed changes in India. There is reason to believe that the design flood discharges may be doubled and the flood water levels may be raised by 2 m or more if the embankments are fully strenthened and extended.

Drainage Pumps and sluices:

- The pumping plant was designed to be operated at full capacity whenever the project water levels rise above 4.1 m. In reality they are operated on a more selective and limited basis, which allows the water levels to rise higher than intended.

- The pumps and sluices are overwhelmed when the embankment cuts permit flood water to enter the project area. They were not designed nor are they intended to cope with this situation.

- There have been reports that the sluices are sometimes left open to accommodate the needs of the fishermen. There is also leakage around the sluice gates when they are closed. Maintenance is hampered by the lack of spare parts. The unused LLP inlets in the project embankment remain open which contributes to the additional water inflow to the protected area. These factors reduce the ability of the pump station to lower the project water levels.

Drainage Channels:

- Many sections of the drainage channels are badly silted due to the frequent overbank spills.

- Many of the drainage syphons have silted in and are blocked.

Irrigation System:

- Many of the canals are badly silted and have deteriorated due to the frequent overbank spills and public cuts to facilitate drainage.

- More turnouts are needed to supply irrigation water to the fields.

- Various structures need to be maintained and/or repaired.

- In some areas the borrow pits between the canal and the crop land need to be filled in to permit water to be taken to the crop land.

5.2 Drainage Problems

It was generally assumed in the design of the project that the existing drainage system was adequate, and the works for the most part included only drainage syphons to permit the existing drainage channels to cross the irrigation channels. There have been reports of inadequate drainage in places and these problems appear to be aggravated by deposition of silts during the overbank flood events. Many complaints originate from problems with drainage syphons at the foot of the Bhatera Hills.

Drainage congestion caused by roads:
The flow of monsoon water is obstructed by the Sonateki-Munshibazar road and the Rajnagar-Balaganj road. Another obstruction in the western side of the Rajnagar-Balaganj road has been causing flooding in Medinimahal and its surrounding areas. There are only six bridges or culverts along the Rajnagar-Balaganj road and this is reportedly not adequate.

The BWDB canal divided Chhoto Kawadighi haor into several parts. Due to late drainage, about 48 ha of land adjacent to Ulatuli Beel and 70 to 100 ha of land adjacent to Majherband Beel remained fallow in December 1992. It has been reported that the capacity of the outlet bridges and culverts is not sufficient for drainage (backup from downstream may also be involved).

Flooding due to Insufficient Syphon Capacity or Blocked Syphons:
In some places the irrigation canals have blocked the natural drainage route, especially along the foot of the Bhatera Hills. Although syphons have been provided to carry the drainage channel under the irrigation canal they often do not have sufficient capacity or are blocked with sediment. The locations of syphons are not always adequate to drain crop land to the canal. Consequently the people cut the dike to let water drain to the canal. In some places the dikes have eroded due to the high monsoon flows. Some instances that were observed were:

- Flooding occurs in about 50 to 55 villages on either side of the Asia Road between Rajnagar union and Munshibazar union. Syphons under the irrigation canal do not have enough capacity and obstruct the runoff from the Bhatera Hills. This flooding had never occurred before commissioning of the canal. Now the people cut the dike of the Rajnagar main canal and its branch canals in many areas to drain the flood water.

- Udna Chhara, a small stream from the Bhatera Hills, does not drain properly through the syphon under the canal. The crop was inundated by a few days of incessant rain and homesteads were submerged in Nandiura village. As a result the people cut the dike of the canal to drain the flood water. The dike on both sides of the canal was eroded for a length of 150-300 meters due to the increased flow, and the water overflowed to Udna Chhara. People feel that the problem could be solved if the syphon is made larger and the *chhara* is cleared of weeds.

- One farmer of Rajnagar cut the dike at one side of the Rajnagar canal to drain out water to the canal and thus save the boro crop on five *ker* land between Rajnagar and Konnigram.

- Water level rose up to 0.3-0.7 m above the homestead in Baligaon during the rainfall of May 2 to 4, 1993, even though there is a syphon for drainage. The people cut the dike of the canal to drain out the water.

- Kuchimura Chhara drains to Singua beel through a syphon under canal RL7R1. During incessant rain of May 2 to 4, water of Kuchimura Chhara could not pass

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through the syphon and it entered the canal, eroding its dike. An area of HYV *boro* which had been only partly harvested was damaged.

- Araiyar Khal passes to the south of Antehori and crosses the Manumukh main canal in two syphons. Due to a lack of drainage, crops were submerged during the incessant rain of early May 1993. Water of Machhuakhali Beel and Chatol Beel is drained through this khal. Farmers say that two syphons in the canal do not have enough capacity.

5.3 Flooding in Korayer Haor

Due to construction of embankments along the right bank of the Manu and left bank of the Dhalai, water now overflows into Korayer Haor, upstream of the confluence of the two rivers. This happens almost every year. The problem has been intensified by the siltation of Kata Gang which drains Korayer Haor.

5.4 Operation of the Pump Station

The project is large and complex and the principles of its operation are likely not apparent to most people. There seems to be a widespread perception that the pumps should be able to cope with flood inflows. In reality the capacity of the pumps is much less as compared to the peak rate of inflow into the haor, even if the embankments are not cut and if the pumps are running at their capacity, and as a result the haor will continue to store water (flood) and water levels will rise during heavy runoff. The pumps will, however, reduce the flood conditions over the duration of the monsoon if they are started early enough and are operated long enough. It is simply too late to start the pumps once the flood has started as they will require several weeks or months to empty the haor.

In principle the sluice gates are opened whenever the water levels inside the haor are higher than the water levels in the river, and flap gates on the sluices are supposed to prevent reverse flows. This does not always appear to be the case as there are reports that the sluice gates are left open during the pre-monsoon season. The actual operation of the gates is apparently not recorded.

5.5 Operation of Irrigation System

The design irrigation capacity of MRP is 12,000 ha, but presently only 18-20% of the area is irrigated.

Many farmers do not want to use canal water to grow *boro*, and in fact, they do not grow *boro*, because water is not available in time. For example, in the 1993-94 boro season the gates of the barrage were closed on 28 December. Water reached Antehori on January 14; as a result the farmers of Antehori were late in transplanting rice.

Irrigation data from the BWDB agricultural extension unit indicate that the project is unable to fully achieve its planned target of water supply to the boro area. The major causes for the low achievement were reported to be damage of irrigation structures by floods, insufficient workers to control the irrigation structures, and insufficient number of agricultural extension workers. Irrigation can be delayed for more than one week.

Some secondary irrigation canals do not supply enough water. MR1 and MR2 secondary canals were reportedly closed at the request of local representatives to BWDB mainly for the construction and repairing of roads around the canals under the Food for Works Program. Canals MR3, MR5, RL1 and RL3 also did not supply any water. MR6, RL2 and RL4 secondary canals supplied only part of their requirement.

5.6 Sedimentation in the Manu River

PMP observations indicate that the Manu River is relatively stable, even during the course of a major flood such as occurred in 1993. Although the bed is highly mobile downstream of Maulvibazar and although the river appears to be transporting large volumes of sediment, the channel is not experiencing notable siltation or aggradation/degradation. Therefore, operational problems which are associated with the Manu River FCDI Project and the tendency for increased flood levels in recent years on the Manu River cannot be attributed to morphologic changes or river sedimentation processes.

5.7 Public Perceptions Towards Embankments And Public Cuts

As might be expected, people have expressed different views regarding the project. Some people feel that the embankments have the following benefits:

- The *boro* and *b. aman* crops are saved from floods.
- The cropped area has increased as the people now feel safe against floods.
- The double-cropped area has increased. The area of *Aus* and t. aman has increased.
- Land where only *b.aman* was grown is now planted with local boro in some places due to supply of water from the canals.
- The cultivation of the HYVs has increased. The yield is 15-25 *maund* per *ker*.
- The embankment has increased the transport network by serving as a road.
- The borrow pits are being used for fish culture.
- Cattle can now graze year round whereas they were previously not able to during the monsoon.
- People can take shelter on the embankment during the time of floods.
- The embankment saves homesteads from wave action during the monsoon.
- People are planting trees, though in small numbers, along the embankment and are getting fruit and fuel wood from these.

Other people feel that cutting the embankments is to their benefit. Advantages of cutting embankments are perceived as follows:

- It allows the inflow of silt which increases the fertility of land.
- It increases fish production.

- Flowing water clears water hyacinth and other grasses from Machhuakhali Khal and saves labour expenses for land preparation to the extent of over Tk 200 per *ker*.
- Maulvibazar town is saved from flooding.
- Flooding is reduced for the people living between the river and the embankment.
- The quality of the water in the haor is improved.

5.8 Environmental Evaluation

High abundance of aquatic weeds:
Populations of aquatic weed have increased greatly due to stagnation of water in the haor and increased eutrophication from application of fertilizer. There are some benefits with respect to the nesting habitat for waterfowl and use of weeds as fodder, fuel, thatching and erosion control. Negative impacts are substantial; haor water quality is lowered by decomposition of plants, and outbreaks of fish disease are more common.

Loss of biodiversity:
Previously many different plants and grasses (*bon tulshi, chailla, paura* and *katachar*) were abundant in Kawadighi Haor and were collected by poor people to use as fuel and building materials. These grew in *kanda* (higher ridges) and other fallow lands. These plants have become scarce as *kanda* and other fallow lands and beels are being brought under cultivation, an indirect effect of the project.

The Kushiyara embankment restricts the natural movement of water between the haor and river. Migratory fish species cannot cross the embankment, and this restriction in fish migration has reduced the diversity and number of fish.

Over-exploitation of the wetland resources:
Inevitably, more people visit the haor area for agricultural activities. This brings the wetland resources, both flora and fauna, closer to human contact and exploitation. This has resulted in some of the resources being reduced to very low levels of viability or beyond the recoverable limit.

5.9 Social Evaluation

Improvement in the situation of farmers:
The situation of some farmers has improved after the implementation of the project. In Ontehori some farmers used to grow only one crop, b.aman. After the construction of the irrigation canal two crops are grown in high land, *boro* and b. aman. Cropping intensity has been increased in some lands. These people say that the embankment and the canal have benefitted them.

Destruction of livelihood of fishing community:
A large segment of the population living within the project area suffers from unemployment after the establishment of the project. Most fishing communities lost their sources of income as the fish production of the area dropped to a very low level. This has created pressure on other economic sectors for employment.

No incentive to grow boro despite irrigation facility:
Despite availability of water for irrigation the people of Akhailkura do not grow boro because the water is not available in time. A delay in planting would also delay the harvest and create extra costs and risks of late-season flooding.

Farmers still prefer to grow local varieties of rice for the following reasons:

- Local varieties do not require much fertilizer.
- The yield of HYV is significantly reduced if sowing is delayed; this is not the case for local varieties.
- If HYV aus is followed by HYV aman the yield is very low.
- Local variety rice is used in religious and social occasions such as *puja bhog* and marriage ceremonies.
- The market price of traditional varieties is higher.
- Local varieties are less vulnerable to pests.
- Local varieties can withstand prolonged dry weather.
- Traditional varieties need less plant care than the HYVs and consequently have lower costs. The cost of land preparation is 400-500 tk more per ker for HYV.
- Many owner farmers and share-croppers cannot afford to invest in HYVs.
- Poor farmers prefer local varieties for consumption as they get the harvest earlier.
- Traditional varieties taste better.
- Quality seed for traditional varieties are easily available.
- Seed preservation is easier.
- The straw of traditional varieties is better as cattle-feed and for roof-building material.

Even large farmers who grow HYVs for commercial purpose also grow local varieties for home consumption.

Lack of navigation infrastructure:
The project infrastructure (embankments, barrage, culverts) has created serious obstacles to boat transport. The growers have to share a large part of their produce with the harvesters due to the lack of an efficient transport system. The harvesters carry the cargo as head-loads for long distances and therefore charge higher shares for harvesting. Farmers of remote villages also face problems in marketing their agricultural products. To an extent the roads and waterways are complementary but this needs to be enhanced.

5.10 Conflicting Priorities of Various Groups

As might be expected the project benefits some people and harms the interests of others, and different groups have different views on how the project should be operated. These conflicts have not been resolved and indeed may not be possible to be resolved.

Conflict between farmers and fishermen:
Conflicts are occurring between fishermen and farmers regarding the operation of the project, resulting from the fact that the fishing season coincides with the boro cropping season. At the start of the boro season some farmers want to retain water for irrigation; at the end of the

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growing season the boro growers want lower water levels to facilitate harvest. Fishermen want just the opposite; they want speedy drainage at the start of the boro season to lower the water levels and to make catching fish easier and they want high levels later so that fish enter the haor. This conflict was observed in many areas, particularly in Rokta, Gargaon, Ontehori, Kadigaon, and Kalamollapur.

Conflict between high land and low land farmers:
Farmers in some low-lying areas of Kawadighi Haor want early drainage so that they can transplant boro in time while the farmers of high land areas want to retain water for irrigation. These conflicts of interest hinder the optimization of project benefits.

Conflict between people living inside the embankment and those living outside:
The homesteads which are located outside the embankment are subject to flooding almost every year and the residents blame the embankment. They cut the embankment in order to try to save their houses. The project will remain vulnerable until this problem is resolved. Rice crops are also damaged, either partly or fully. Some of this damage might occur even without the embankment. The affected villages are Mohonlal, Goria, Jivanganj, Shashmohan, Govindashree, Konagaon, Togorpur, Adnabaz, Syedernagar, Bhangarhat, Akua, Goneshpur, Ekamodhu, Kandirkul, Ujirpur, Haripasha, and Ibrahimpur.

Conflicts between navigation and agriculture:
Operation of the Manu barrage in order to facilitate navigation can cause problems for agriculture inside the project. In January 1994 the gates of the barrage were raised at the request of a bamboo trader and this deprived farmers of irrigation water at a critical time in the boro transplantation period.

5.11 Economic Evaluation

Economic data for the three primary sectors (agriculture, fisheries, and wetlands) are detailed in Appendix H. Estimates of production in the three sectors during the monitoring period are summarized in the accompanying tables and are discussed below:

Agriculture:
Agricultural products accounted for 97% of total haor output in 1992 and 93% in 1993. The total value of agricultural output was 12% lower in 1993. The main source of income for farmers was HYV crops. Agricultural output was lower in 1993 for the following reasons:

- cropping intensity was lower in 1993 due to heavy rainfall and flooding;
- most of the aman crop and some boro were inundated due to embankment cuts;
- yield of boro was lower;
- some non-rice areas could not be cropped due to water logging;
- supply of irrigation water was late and drainage was impeded.

Due to a lack of data the economic product values are based in part on parameters which were proposed by FPCO guide lines. These include input requirements except irrigation, input prices except labour and fertilizer, and crop prices. Livestock product values were not considered due to a lack of data.

Fisheries:
In 1992 fisheries products accounted for 2% of total haor outputs. More than nine-tenths of fish production originated from the monsoon flood fisheries. In 1993 fisheries output increased almost threefold but still represented only 6% of total output. This increase was the result of extremely high flood intensity caused by the embankment cuts, and increased migration of fish from the Kushiyara due to embankment breaching at Machuakhali. It is likely that the fisheries production would have been even higher if the breeching had occurred earlier, during the peak migration season.

Wetland Products:
Wetland products accounted for 0.6% of total haor output in 1992. Production was significantly lower in 1993 in spite of the wetter hydrologic conditions. Many wetland products such as medicinal plants, food, fencing materials, bio-fertilizers, and fish baits are extracted according to the level of needs of the local people; these needs vary from year to year and are only partly related to availability.

Several wetland products were lower in 1993 than 1992. Lower yields were recorded for all food products. Among the plant products, production of fuel, fodder, and green manure were lower. In the animal sector, frog and duck production decreased by 40%.

It is difficult to estimate the utilization of wetlands products since no records are kept and many of these products do not have established trade values. Many wetland products were not included. Consequently it is felt that wetlands products have a greater value, especially to poorer people, than their economic values would indicate.

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Table 5.1: Economic Production of Project Area in 1992

Net Project Area (ha)	10480	

AGRICULTURAL PRODUCTION			
Net financial value - Tk 000	335539		
Average Gross Margins - Tk/ha		15695	
Cost of Pump Station - Tk 000	5140		
Net Value of Agriculture - Tk 000	330400		

FISHERIES PRODUCTION		Flood plain	Beels
Net financial value - Tk 000	6983	6451	2180
Total Production - 000 (kg)		313	23
Average Gross Margins - Tk/ha		632	585

WETLAND PRODUCTION			
Net financial value - Tk 000	2096		-
Average Gross Margins - Tk/ha		205	-

NET ANNUAL INCOME - Tk 000	339433	

Table 5.2: Economic Production of Project Area in 1993

Net Project Area (ha)	10480		

AGRICULTURAL PRODUCTION			
Net financial value - Tk 000	296888		
Average Gross Margins - Tk/ha		15506	
Cost of operating Pump Station - Tk 000		5774	
Net Value of Agriculture - Tk 000	291114		

FISHERIES PRODUCTION		**Flood plain**	**Beels**
Net financial value - Tk 000	19600	13019	6581
Total Production - 000 (kg)		572	229
Average Gross Margins (Tk/ha)		1276	7900

WETLAND PRODUCTION			
Net financial value - Tk 000	1522		-
Average Gross Margins - Tk/ha		149	-

NET ANNUAL INCOME - Tk 000	312236		

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Table 5.3: Comparison of Net Financial Output

Sector	1992		1993		Change from 1992 to 1993	
	Tk 000	% of total	Tk 000	% of total	Tk 000	% change
Agriculture	330,400	97.3%	291,114	93.2%	- 39,286	- 11.9%
Fisheries	6,938	2.0%	19,600	6.3%	+ 12,662	+182.5%
Wetland	2,096	0.6%	1,522	0.5%	- 574	- 27.4%
TOTAL	**339,433**	**100%**	**312,236**	**100%**	**- 27,197**	**- 8.0%**

Interyear Comparison of Primary Sectors:
The total value of output was 8% lower in 1993 than in 1992. The principal reason for this difference was the impact on agriculture of severe flooding due to embankment cutting in June and July 1993.

As there is little overlap between the farming and fishing communities the incomes from these two sectors were differentially affected. Farming production suffered a significant reduction in 1993, while the fisheries sector experienced an economic boom due to the high flood intensity. The landless poor rely heavily on monsoon fishing for their livelihood and thus are benefited more by higher flood intensities.

The economic evaluation suggests several important conclusions:

- The fisheries and agriculture sectors do not fully complement one another insofar as a decrease in output from one sector is only partly offset by an increase in output from the other sector. The net effect under severe flood conditions is to decrease total haor output. Ideally the project would be more flexible and adaptable to variations in annual flood intensity.
- Severe flooding results in a net decrease in total haor output due to reduced agricultural output despite an increase in the fisheries sector.
- Wetland output is reduced under high flood intensities.

5.12 Effect of the Project on Production

Increased rice production:
Field studies and discussions with farmers suggest that rice crop production has increased substantially in the project area since its inception. The increase has resulted mainly from increased cropping intensity and switching to HYV's. Total HYV rice area has expanded significantly in all three seasons, but not to the extent that had been planned. Traditional deepwater aman varieties (*katari*) still occupy a significant area.

These reports are substantiated by the available data. Estimates of rice production, crop area, and average yield for 1981 and 1992/93 are compared in the following Table. For comparison the forecasts which were made at the time of the project design are also provided. These data indicate that the total production of rice has more than doubled, mostly due to increased yields. The crop area has increased slightly (by about 10%) while the average crop yields have increased substantially (by 120%).

The increase in crop area falls considerably short of the original forecast that crop areas would increase by about 50%. Yields have come close to the predicted increases, mostly due to introduction of higher-yielding varieties. The shortfall in crop areas and yields is mostly due to the limited success of irrigation in the higher areas of the project (87% of the forecasted rice production was predicted to be grown on irrigated land).

Table 5.4: Increase in Rice Production since 1981

	1981	1992-1993	Design Forecast
Annual rice production	26,000 Tonnes	62,000 Tonnes	91,000 Tonnes
Crop area	18,300 ha	20,000 ha	26,000 ha
Average yield	1.4 T/ha	3.1 T/ha	3.5 T/ha

Source: 1981 and design forecast - BWDB design report
1992-1993 - NERP estimates, average of 1992 and 1993 data

In view of the fact that the project continues to flood, it is not clear how much of these increases are the direct effect of project implementation.

The pre-project cropping pattern consisted exclusively of low yielding traditional rice varieties. After implementation of the project there has been a substantial increase in the area planted in HYV boro which has resulted in the decrease in aus lands in some areas. Farmers suggest that the area of higher-yielding transplanted aman has also increased.

In several villages, HYVs constitute a significant proportion of the boro crop. The situation is depicted in the following table:

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Table 5.5: Land Cropped Under Different Boro Varieties, 1992-93

Location/Zone	Percent of Boro Area (%)		
	HYV	LIV	LV
Zahidpur Shahpur Ontehori	75	15	10
Panchgaon	50	30	20
Sonateki Medinimahal	70	20	10
Billabari Fatehpur Shahbazpur	70	20	10
Middle Haor	5	40	55
Along Asia Road	90	10	0

Loss of economic benefits of haor fisheries:
It is widely reported that the fisheries have virtually disappeared since inception of the project and that this decline is largely due to blocking of the natural migration route from the Kushiyara River. Unfortunately the direct data with which to confirm this assertion (that is to say, fish surveys) do not exist for pre-project conditions. The indirect evidence all supports the hypothesis, including:

- public reports of previous fish abundance and its decline;
- switch of fishermen to other occupations in large numbers;
- threefold increase in productivity in 1993 when the Kushiyara embankment was cut and permitted fish to migrate;
- knowledge of the fish life cycle and local habitat conditions.

Other factors, such as intensive fishing and draining of the beels during the early years of the project may be involved.

The decline of the Kawadighi Haor fishery has resulted in severe loss in fish production and income to fishermen of Kawadighi Haor. In addition, because this area serves as the mother fishery for the lower Kushiyara/Kalni/Upper Meghna basin its destruction has a wider impact.

Changes in production levels of non-rice crops:
An increase in vegetable production has been observed in Shamra bazar, Borman, Akhailkura, Sonateki, and Dakshin bagh. Some crops which were grown before the commissioning of the project are now rarely cultivated. These include jute, linseed, ground nuts, and *paner bar*.

However, these changes are greater than could be explained by the changed flood regime and thus may be due to other causes.

Economic losses to navigation:
The project has caused significant economic losses to the navigation sector. Most of the highland people sold their boats after completion of the project, thinking (incorrectly) that the project would be free of flooding. But the reality is that the haor gets flooded almost every year, especially when the embankments are cut, and the people within the haor suffer badly due to lack of navigation support.

Big boats used to serve the interior areas of Kawadighi Haor but the project blocked navigation routes into and out of the haor. Now large mechanized boats can operate within the haor during the flood season only if the Kushiyara embankment is cut. Boats in the Manu River cannot cross the Manu barrage when it is closed in the winter.

Economic losses to wetland and wetland resources:
Significant losses have occurred in fisheries, biodiversity, and biomass productivity. This change is largely due to increased use of the land for agriculture. Although the value of these products is relatively small and difficult to quantify in economic terms, many people, especially the poor, depend on these wetland products.

6. RECOMMENDATIONS FOR IMPROVEMENT OF MANU RIVER FCDI PROJECT

6.1 Project Design and Operation

It is time to conduct a definitive review of the design and operation of the Manu Project in order to rationalize its design and to resolve the conflicting interests:

- the project has been in operation for several years and thus there is much information regarding its performance;
- certain aspects, such as boro cultivation, have evolved substantially during that time frame;
- the hydrologic operation of the project, especially of the drainage system, is complex and needs to be better defined and demonstrated to the layman;
- the operation of the project has been modified from time to time to try to accommodate the needs of various interests, but these have been made on an ad-hoc basis and need to be verified and formalized;
- the focus of the project has changed somewhat since its original inception which was heavily dependent on agricultural benefits; these are still important but other sectors need to be considered;
- various sectors such as agricultural drainage, fisheries, and transportation are experiencing a number of problems.

A multi-sectoral approach to project planning, operation, and management should be applied. The proposed framework should include the following:

- an integrated approach to resource management which optimizes the total benefit from agriculture, fisheries, livestock, and homestead-based activities;
- adequate protection of settlements in order to facilitate enhanced homestead-based economic activities and to improve the quality of life;
- access to safe water for all people;
- improved sanitation through adoption of appropriate settlement planning and acceptable sanitary standards for disposal of waste;
- flood preparedness infrastructure including flood shelters, emergency storage for essentials, and water supply;
- primary health care infrastructure to deal with common diseases and to respond to emergencies, particularly in times of flood;

- infrastructure for universal education with continuity and sustenance, at least up to the primary level;

- initiate local level planning in order to ensure public participation in all concerned matters.

A comprehensive hydrologic/modelling analysis of different alternatives to determine their effects on water levels and areas flooded is required. Based on a better understanding of the project hydrology and management options, the competing interests of various groups should be reconciled and resolved. The data that are presented in this report can be used as the starting point for analyzing the economic and social impacts of these alternatives, for resolving the various conflicts, and for optimizing the project output. Various project options are presented below for further evaluation through more detailed engineering studies, economic analysis, impact assessments, and dialogue with local residents.

6.2 Public Participation

The spirit of public participation should be institutionalized through formation of a beneficiaries' committee in the project area. Public participation should be encouraged and promoted for management of the project's operation as well as irrigation using the traditional water courses, *chhora*, haors, and beels.

The input of the people with respect to supply of water from the barrage and operation of the pump house is presently very limited due to the regulatory role of the BWDB. Public participation must be promoted if the operation of these components is to meet the needs of the benefitting people. This is very important for timely transplantation and harvesting of rice, particularly *boro*. If there is a forum of representatives, duly constituted by the affected people and acknowledged by the project's operating agency, a basis for participation and cooperation can be created.

Specific information of all the operation of the project as well as its impacts should be recorded by a monitoring team in order to quantify all the economic impacts.

People contribute funding toward closure of *chhora* to make best use of water coming from the Bhatera Hills. This should be further promoted.

6.3 Embankments

The project design needs to be revised. Unless the problem of flooding in the area between the secondary embankment and the main project embankment is solved the embankment will remain vulnerable to public cuts which will make it ineffective for preventing monsoon-season flooding. Higher rainfall in recent years, the confinement effects of embankments, and possibly deforestation of the Manu and Dhalai catchments, are resulting in higher peak flows in the Manu and this will likely lead to more frequent cutting of the project embankment. Some possible solutions are:

- divert the flood peaks from the Manu River as proposed in NERP's pre-feasibility study "Manu River Improvement Project", which has drawn heavily on the findings of this project monitoring program;
- raise and strengthen the secondary embankments which would then become the main embankment;
- provide pre-monsoon season protection only and allow the project to flood during the monsoon season through the Manu and Kushiyara embankments, perhaps using regulators, which would secure the primary agricultural benefits while increasing the fisheries production;

6.4 Regulators

The existing 3 vent regulator at Kashempur leaks badly and should be repaired as soon as possible or it should be abandoned completely. The purpose and function of this regulator are unclear as it was not part of the original design. It appears to have been operated in the first few years of the project to lower the winter levels in the haor, either for agriculture, for fishing, or to increase the available flood storage, but this is no longer done and the regulator may in fact be redundant.

6.5 Manu Barrage and Irrigation Works

The operation of the barrage should be scheduled to ensure the timely release of irrigation water into the project area as required by farmers. A better understanding is required among all parties as to the operation of the barrage and irrigation supply system in order to assure a timely supply of irrigation water.

People are presently constructing closures or cross-dams on various drainage channels to store water for irrigation. Because the cost of closures is high and re-occurs annually, farmers recommend the replacement of closures with sluice gates or regulators. Regulators should be considered at the locations shown in Table 6.1:

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Table 6.1: Possible Locations for Future Regulators

Location	Number of sites
Pabijuri Nadi	2
Oghar Khal	3
Machhua Nadi	3
Dhalidhara	2
Gulaidhara	2
Digla	1
Akali Nadi	3
Poukkar Khal	2
TOTAL	18

The Manu Barrage could be operated during the post-monsoon season to pass more water through the haor and thus reduce the incidence of fish disease. A larger regulator might be required at Kashimpur to drain the extra water and to allow the area to drain more rapidly in general.

6.6 Pump House and Drainage Works

A better understanding must be developed between the farmers and the pump and sluice gate operators about the role of the pump station in controlling haor water levels and the needs for water drainage. Repairing of pumps and sluice gates should be done during the dry season, not during the monsoon.

Other recommendations are provided below.

Water-logging in the Northeast Sector
It has been proposed by the people to extend the channel of Kuchimura Chhara from Charua Beel through Singua Beel to Munia Beel. Another channel is proposed from Singua beel to Nagri Khal. Kordair Khal would also be re-excavated.

Drainage in Kawadighi Haor
Almost all beel areas in Kawadighi Haor remain water-logged in the months of October to December. The staff operate the pump house to retain water at the request of the fisheries lease-holders which delays plantation of *boro*. This causes subsequent delays in harvesting when the crop becomes vulnerable to pre-monsoon flooding.

The low-lying areas were once connected by many natural channels which used to drain out water but now are closed due to siltation caused by repeated flooding. These include:

- Nolu Gang and Kalibarir Khal which used to drain most of the water coming through the *chhara* in Uttarbhag and Munshibazar to the Kushiyara;

- Pukuria Khal and Munia Gang, which used to drain part of the runoff from the Bhatera Hills and Panchgaon, Rajnagar, and Munshibazar unions;

- Machhuakhali Khal and Tolas Gang, which once drained most of the water from Ekatuna and Akhailkura unions;

- Noakhara Khal from Pukuria Beel to the Burijuri River, which is 3.3 m wide and 1.7 m deep but is not wide and deep enough to drain out the water from Pukuria beel (about 55 ha of land in Pukuria *beel* cannot be cultivated for *boro* due to water-logging);

- a channel between Burijuri beel and Munia gang.

All these *khals* and channels need re-excavation to improve drainage.

6.7 Fishpasses

The rehabilitation of Kawadighi Haor as both a productive fishery in its own right and a mother fishery of regional importance, ranks as one of the most important fishery development goals in the region. In order to accomplish this, timely migration of broodstock into and out of the haor during the pre-monsoon period needs to be assured. Accordingly it is recommended that a vertical-slot fishway be constructed through the Kushiyara embankment to allow migrating fish to move freely between the river and the haor. Other measures for promoting the fisheries and improved fisheries management, such as a fish hatchery or more active aquaculture, should be considered.

6.8 Navigation

The following measures should be considered as part of an integrated package to ameliorate conditions for navigation in and around MRP:

Navigation lock at Kashimpur
A navigation lock should be considered at Kashimpur to allow boats to pass to and from the Kushiyara River. This would allow many boats to operate through Kawadighi Haor, would generate employment for a large number of people, and would save substantial transport costs for the people in the haor.

Navigation pass at Bilbari
A navigation pass should be considered through the embankment across from Balagonj to allow country boats to enter into Kawadighi Haor during the monsoon season.

Re-excavation of existing canals within Kawadighi Haor
A good network of canals is needed within the haor for transportation of agricultural equipments, seedlings, fertilizer, and other goods. It is estimated that one boat transporting harvested paddy could save 25 to 50 maunds per day compared with transporting it by head loads as is presently done. Such canals would also fill a vital drainage function as discussed above. Some of the

existing canals within the haor can serve the purpose if they are extended and re-excavated (Table 6.2).

Table 6.2: Proposed work on Existing Canals

Channel	Length to be excavated
Munia river	12 km
Akali river	13 km
Kulainara	5 km
Machoa river	4 km
Lash river	10 km
Digola river	6 km
Koradair canal	2 km
Naria canal	2 km
Langua	5 km
Kodalia canal	4 km
Nagaria canal	3 km
Nalu river	1 km
Udna Gang	4 km
Bannaguri Khal	1 km
Kachinara Gang	2 km
TOTAL	**74 km**

The cost of re-excavation is estimated to be Tk 2,68,000 per km. Thus the total cost of re-excavating 74 km channels would be Tk 1.98 crore (about US$ 0.5 million).

Excavation of new canals
A number of new channels should be considered in order to improve navigation and irrigation. Any new channels should be identified by the local community through a local consultation process. If these new channels were built through local initiatives it may be possible to avoid high land acquisition costs. Possible new channels are listed in Table 6.3:

Table 6.3: Possible Future Channels

Location	Cost (Tk)
Ontohory - Jirarbond	2,295,000
Ontohory - Katasingra Bell	2,295,000
Biraimabad - Katasingra Beel	2,869,000
3 canals from Katasingra Beel	2,869,000
2 canals from Shalkatua Beel	2,869,000
Abdullahpur - Kapria Beel	573,000
4 Canals from Kapuia Beel	2,869,000
Shahpur - Dastika	2,295,000
Zahidpur - Dastika	1,147,000
Berkuri - Chail Beel	1,147,000
Bilbari - Chail Beel	1,147,000
Chail Beel - Munia Gang	1,147,000
Betagonj - Choto Bora Beel	2,869,000
Dhulijura - Bazbari to Chhilamak Beel	4,016,000
Total	**Tk 30,407,000**

The total estimated cost is about Tk. 3.04 crore (about US$ 0.75 million).

The proposed 2 km long canal between Ontohary and Jirarband paddy field would provide good access to navigation as well as irrigation for at least 60 ha of boro land. Six new canals linking Katasingra Beel with its surrounding agricultural land would provide transportation and navigation to 60 ha of land. The 2.5 km canal between Biraimabad and Katasingra would extend irrigation support to 80 ha of HYV boro land situated in the southern side of Katasingra Beel. Four new canals to connect Katasingra Beel with its surrounding agricultural land would benefit irrigation and navigation benefits to at least 200-240 ha of agricultural land. One canal would be excavated northwards from Katasingra and 3 canals spaced 0.75 km apart would be extended eastward.

Constructing the new canals would reduce the cost of transporting boro paddy and could increase the security of harvest. An efficient navigation network within the haor could save between 35,000 and 70,000 maunds of paddy, worth 50 to 110 lakh Taka, which is spent annually on transporting paddy from the field by hand. While certain costs are also incurred in water transport these are relatively small and, furthermore, some of the land owners own their own boats. Lack of a boat transport system contributes in failure to harvest the entire crop in the event of an untimely flood.

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Construction of these channels will also provide substantial benefits to fisheries and drainage.

6.8 Agriculture

Land Ownership and Tenancy
Policies supporting small farmers and share croppers should be introduced to reduce the dominance of absentee landowners in the project area. Many of these absentee land owners have little interest in improving cultivation practices. Many of them appoint tenants who are not interested in using new production technology because they would have to bear the large entire cost of labour, fertilizers, and other inputs while they would have to share the gains with the landowner. It is essential to promote a more effective use of the land in order to increase and diversify agricultural production if the project is to achieve its potential.

These policies could include:

- tax incentives for small owners;
- legislation to prohibit foreign ownership;
- tax incentives for land under crop or tax penalties for vacant land;
- subsidies of supplies and equipment which use new technologies.

It is acknowledged that such policies are quite general and universal in nature, and may be difficult to introduce.

Development of Farming Groups
Productive farming groups should be developed to fully exploit the natural and socio-economic conditions in the project area and to encourage economically productive farms, progressive farmers, and cooperative management. There is much opportunity to improve farming systems by providing guidance, encouragement, and support to farming groups.

Cooperative management of the project by farming groups must be encouraged for the effective use of land and irrigation water. The farm groups must be given the opportunities to plan and implement their own program, mobilize their own resources, and manage the project on a continuing basis. The farming groups need to be provided with loans for investment in livestock and poultry farming, non-rice crop production, and other productive farming. For example, assistance should be given to small farmers to obtain loans on a group liability basis.

Such programs will assist progressive farmers to improve their farm management. They will also help small farmers to increase the productivity of their land and will discourage them from selling land to absentee landowners. The farming groups could contract with the absentee farmers for the cultivation of their land. The farming groups can bring changes in the relationship between agriculture and non-agricultural sectors through diversification of agriculture.

Crop Selection
It is recommended that a programme of crop diversification be implemented in the project area. Rice production has been given the highest priority and as a consequence it has increased more rapidly than the production of non-rice crops. Crop diversification will improve production and could be a step toward promoting a market-oriented economy.

Crop rotation through diversification also contributes to the fertility of the soil and to the fight against parasites and diseases. Crop rotation ensures that the soil and water are used to their maximum because different plants have different needs. Some crops such as potatoes and carrots consume a lot of nitrates while others such as cereals need less. Some crops such as pulses produce nitrates. An improved and systematic rotation over 2 to 3 years would be beneficial.

There are good opportunities for crop diversification in the dry months when the lands presently remain fallow in many areas. Fallowing severely depletes the organic content of the soil.

Cultivation of vegetables, oilseeds, and pulses in the rabi season, followed by delayed transplantation of HYV boro in late February to early March, should be considered as one way to maintain and improve soil productivity. Unlike aus and aman, boro has an extended planting period from mid-December to mid-March. According to Bangladesh Agricultural University, late plantation of boro is practised in many areas in Bangladesh with no yield differences. Bangladesh Rice Research Institute has also released an HYV variety (BR 3) which is suitable for cultivation in all three crop seasons.

If a soil shows depletion of organic matter it would be wise to discourage cultivation of HYV boro rice. Instead farmers should be encouraged to follow the aus-aman cropping pattern and to include vegetable, oilseeds, and pulses in the rabi season. Studies should be carried out to identify potential local varieties.

Extension Services

Agricultural extension activities in the project area are carried out by the agricultural extension unit of the project and by the Department of Agricultural Extension. Distribution and adoption of modern technology should be the responsibility of a single organization, but there is no provision for integration between the two agencies.

Extension activities should be organized in consultation with the farmers in order to understand what has prevented them from achieving increases in cropped area and crop production. It could be followed by a series of pilot projects on a limited scale to organize the farmers gradually into small irrigation units. Formation of a body to ensure the coordination of the key services to achieve the goals should also be considered. There is a need to motivate, mobilize, and organize farmers into dynamic communities which will serve as the units for the agricultural development of the project area.

Credit

A credit system should be made available to small and marginal farmers, including share croppers, who represent a large part of the project. Few small and marginal farmers and share croppers have access to institutional credit. Farmers find it difficult to obtain credit from the bank; they have to go to the bank several times and then if credit is sanctioned they receive only 80% of the sanctioned amount. Not enough villages are covered by the Grameen Bank, and the coverage of institutional credit is negligible. Thus the farmers often resort to dealing with money lenders at exorbitant rates of interest.

Bureaucratic formalities complicate the loan application and few farmers can submit all the documents that the banks require. Two or three months are required to get loans from a bank and farmers cannot get the loan when they need it. The eligibility criteria exclude illiterate farmers.

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The gradual increase in HYV rice area suggests that some farmers are willing to use improved production practices and modern agricultural inputs if capital is available.

Crop production loans should be issued for the purpose of seasonal agricultural operations while medium term loans should be available for capital investment. This system will help the farmers after a successful year to repay crop production loans with interest. Crop production loans should cover fertilizers, seeds, and some cash money for labour costs. Agricultural diversification loan schemes should be established to enable credit institutes to provide farmers with loans for livestock, poultry, horticulture, and fish farming.

Preservation and Management of Seeds

Steps need to be taken to ensure an adequate and timely supply of seeds. Farmers in the project sometimes lose their seed stock due to inadequate knowledge of simple storage and preservation techniques. This should be addressed through extension programs. There is also shortage of seed supply after the crop is damaged by flood.

Seedling Age

Seedling nurseries should be established by the private sector in appropriate places. This would ensure timely supply of healthy seedlings. Seedlings are not always raised under appropriate and recommended agronomic practices. Use of aged, old, and unhealthy seedlings is very common especially in the boro season when seedlings are raised on seedbeds often situated far from the main fields. Excess seedlings, which become old and unhealthy, are frequently sold to other growers. Low prices of these seedlings attract small farmers. Use of old and unhealthy seedlings results in an increase of growing time.

Farming Technology

Farmers in the project area would require appropriate technologies in all aspects of the agricultural production system to replace the traditional methods. Simple machines and tools are required and these should use locally available materials so that farmers could easily afford them.

Use of Fertilizers

Appropriate fertilization and cropping patterns, improved crop management and cultivation practices, and efficient nutrient management should be introduced in the project area to sustain soil productivity and to reverse the decline in soil organic matter. In a natural system the nutrient inputs, deposition, and losses are balanced without the involvement of fertilizers. This is possible because nothing is harvested from the system. However in an agricultural system as in the project area the harvest is exported from the crop area. Thus fertilizers are very important in renewing the supply of nutrients.

All nutrient sources, not just commercially produced fertilizers, should be involved in efficient nutrient management. This includes nitrogen from mineralization of organic matter, from fixing by legumes, and from manure.

A strategy is needed to encourage farmers in the use of technologies that will increase productivity while conserving the soil. It has been estimated that, in general, only about 30-40% of the applied nitrogen from inorganic water-soluble fertilizer is utilized by growing plants; the remainder being lost through volatilization, leaching, or denitrification. Application of sufficient quantities of biological fertilizer along with chemical fertilizers increases the efficiency of both and reduces the loss of applied nitrogen by 60-70%. It also improves the physical and biological conditions of the soil. Bangladesh Rice Research Institute, Bangladesh Agricultural Research Institute, and Bangladesh Agricultural University have indicated that *dhaincha* (green manuring) substantially increases rice yield.

Drainage
Improvement in drainage is required to reduce crop losses and to bring a large area under cultivation. Drainage improvement would increase the confidence of farmers and would help in the adaption of modern technologies. Detailed investigation of soils, water-logging, and drainage problems is required.

Irrigation
Existing irrigation facilities must be utilized more efficiently by developing farm level canals and improved irrigation management systems in conjunction with improved cultural practices. Some possible initiatives are:

- pilot projects by the agriculture extension unit to examine field level problems associated with irrigation;

- organised efforts to construct field channels to supply water to the fields;

- a strong linkage between water users and the supply agency to promote the efficient operation and management of the irrigation system;

- model farms to motivate farmers.

Marketing
In order to promote cooperative group marketing the supply of marketing information should be expanded. This will help to provide alternative marketing channels to the farmers and to improve the efficiency of the marketing system.

Rice is often sold from the farmers' house to *beparis* (millers or traders). The price is a little better in the Maulvibazar rice market but few farmers in the low-lying areas can sell in the market due to poor or non-existent road communication, high transport cost, and complicated payment mechanisms. Therefore, local agents buy from the field and receive 2 to 3% commission for their services from buyers.

An improved crop marketing system should be established in order that the expanding crop production can be handled without causing a significant reduction in prevailing price levels. The export potential for fine and aromatic varieties of rice which are grown in the Manu Project should be developed. Access to export markets through existing *Londonee* trading companies should be explored.

Livestock Production
The production of forage and green fodder should be increased. An increase in rice yields would free up some land for forage production. More productive and nutritive forage can be grown. Rice herbage can be produced in the deepwater aman area.

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Increased forage production together with better livestock management can improve the supply of draft animals, increase dairy production, and raise family farm incomes. Forage such as maize can also be an important ingredient of poultry feed.

6.4 Fisheries

Allocation of Fishing Rights
Only genuine fishermen should be allocated rights for beel fishing in the dry season. The rights of non-genuine and subsistence fishermen to fish in the haor during the monsoon should also be guaranteed, and harassment from *parahadars* (guards) should be stopped.

Enhancement of Kawadighi Haor Fishery
Restoration of the Kawadighi Haor to a reasonable level of productivity requires several interrelated measures:

- Ensure the migration of broodfish from the Kushiyara River through a fishpass into the haor during the pre-monsoon season.
- Enforce a closed season on fishing in the haor during the pre-monsoon period in order to allow breeding to take place.
- Ban the use of small-mesh fishing gear such as *kona jal* and *current jal*.
- Ensure that fish are able to migrate via the fishpass and the sluice gates from the haor back into the Kushiyara River during the late monsoon.
- Flush the haor with adequate volumes of river water during the dry season to prevent stagnation of the water and to prevent severe outbreaks of fish disease.
- Ban the practice of dewatering the beels and harvesting all the fish.
- Ban the practice of annual pile fishing.
- Re-instate the three year harvesting regime.

Pond Production
Flood protection measures should be provided to prevent the fish ponds inside the project area from being flooded out. Although there are ponds in every village in Kawadighi Haor, pisciculture is not done in all the ponds. The ponds are submerged during floods and all fish are lost to the floodplain. The risk of flooding is too great for the available profit margin.

Provision of Credit
A system of credit for fishermen to buy gear and boats should be introduced. There is almost no provision of credit for the fishermen at present.

Improved Processing and Marketing of Fish
There is a need to improve the marketing of fresh fish from Kawadighi Haor. Fish from Kawadighi Haor can be sent to any one of several markets including Dhaka. The haor is close

to an urban center, Maulvibazar, and has ready access to a good road network and therefore to other urban centres. This suggests that processing by sun-drying should not be necessary as this reduces the fishermen's profits to a minimum. Improvements should be made in keeping and transporting live fish. Provision of ice for fresh fish marketing appears to be feasible.

6.5 Villages

Flood proofing homestead mounds

Raising the homestead mounds by one to two meters in villages which are vulnerable to flooding is highly recommended. Based on observations which were made during the 1993 monsoon flood, villages in the following unions need attention:

Unions totally flooded

- Monsurnagar
- Ekatuna
- Fatehpur
- Panchgaon
- Akhailkura

Unions partly flooded

- Rajnagar
- Tengra
- Munshibazar
- Uttarbhag
- Chandnighat

Domestic water supply

There should be more tube-wells to ensure access to safe water by all. Many women who usually fetch water are restricted from moving beyond a short distance outside their homestead. There should be at least one public tube-well in each *hati* (contiguous group of homesteads). These tube-wells should be properly maintained so that water is always available. Maintenance should be performed by a users' committee. The DPHE in cooperation with the local government should formulate guiding principles to govern the location of public tube-wells, formation of maintenance committees, and training for maintenance.

Improved sanitation

All homesteads should have water-sealed latrines of acceptable standard. The existing programme of the DPHE with respect to distributing rings and slabs for sanitary latrines should be expanded so that all households are covered. Motivation and some investment are required to encourage the development of sanitary habits in homesteads. Necessary flood-proofing measures such as raising of homestead platforms and extending homestead areas should be taken so that all households will have a secure place to construct a latrine.

Social services

Primary health care: The existing infrastructure for primary health care should be improved to effectively cover all households. This needs increased investment in the thana health complex and the union family welfare centre including provision of more skilled staff and extension workers. During flood times a mobile team of health workers is needed.

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Education: There should be at least one primary school in each village so that it remains accessible to children in all seasons.

6.6 Environment

Afforestation

There is a need to initiate an afforestation program using water tolerant trees (*hizal*, *koroch*, and *mandar*). Planting of trees around the homesteads will protect the villages from wave action, erosion, high winds. The trees will also be a source of fuel, employment, and income. Nurseries of these trees should be developed in conjunction with the Forest Department or DAE.

Harvesting of Wild Plants and Animals

Programs for sustainable harvest of wetland products need to be developed. A system should be developed for quantification and assessment of the wild resources which are utilized by the local people. Management of the resource should be improved through the involvement of local users. Research needs to be carried out for improving the quality and increased production of some wetland products (*singra, khei, kheichur, and murta*). Research and artificial breeding program for some species of wetland-dependent animals (*sona bang, sundi kasim, jat kasim*), which are economically important and are exported for consumption as food, should be attempted.

These programs will generate employment and will create awareness of the importance of wetland resources among the local people.

Protection of Wildlife

Shooting and trapping any wildlife is prohibited under the Bangladesh Wildlife (Preservation) Act, 1973 Amendment. Despite this Act many people are engaged in hunting and trapping, particularly of migratory ducks during the winter months. The Wildlife Act should be publicized more effectively and should be supported by pragmatic steps in enforcement of the law and application of punitive measures. Local committees need to be formed.

Programmes need to be developed to monitor waterfowl abundance and to assess hunting pressure. Endangered and threatened species need to be identified and hunting bans should be imposed on these species.

Enhancing Biodiversity

A programme should be initiated in environmental education and awareness building. A local consultation centre should be established to advise and educate the local people on various environmental issues and on how to make the best use of the available wetland resources. Selected wetland areas should be designated as sanctuaries and should be protected from human interference. The possibility of re-introducing lost species also needs to be considered.

6.7 Institutional Strengthening

Strengthening of the local government institution with adequate planning and financial authority is required. Horizontal linkage among all concerned parties (BWDB, DPHE, LGED, DOF, DLS, and the local government) is necessary.

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7. FUTURE FULL FLOOD CONTROL PROJECTS

7.1 Local Level Planning Process

Participation of the impacted people is increasingly being recognized as a key element for successful implementation of any development initiative. The people need to be involved not merely after implementation of a project, but also at the planning stage.

This focus is conditioned by the following principles:

- The dynamics of rural life should be understood before starting any viable planning for the betterment of rural society.
- Development is a process which should not be imposed from outside.
- Area residents probably know best how to cope with situations affecting them, while outsiders can best act as 'catalysts' using their knowledge and expertise to stimulate the local population to initiate activities - especially those involving novel methods and approaches.
- The environment of the residents (village, haor, surrounding rivers) of a particular project needs to be well understood before advocating any remedy.
- Emphasis should be given to human populations - their experiences, perceptions and practices.
- Infrastructure development should follow people's needs.

A successful planning strategy should evolve around the following elements:

- Demand for interventions by the people themselves;
- Scrutiny of all possible options proposed by the people or in consultation with the people;
- Scrutiny of all positive and negative impacts on different sections of the population that are expected to result from the implementation of a project;
- Dialogue between different sections of the population having different or conflicting interest in order to have a decision preferably on the basis of general consensus;
- Ownership of the project by the people who have a vested interest in taking care of the infrastructure.

For such a strategy to evolve, development efforts should be integrated with the local level planning process through strengthening existing local government institutions. A workable arrangement may encompass, among others, the following:

- A project committee should participate in the decision-making in all phases, that is, in planning, construction, and maintenance.
- This committee, as a statutory body of the impacted people, should own the project and participate in the financing of construction, operation, and maintenance.
- An effective horizontal linkage between this committee and all concerned specialized agencies should be established through necessary administrative reforms.

7.2 Defining Project Objectives

FCDI projects must be designed with a view toward:

- ensuring food supplies;
- securing farmers incomes;
- conserving the natural environment;
- changing the relationship between agriculture and the non-agricultural sectors through diversification.

The planning process must include a comprehensive program for flood control, drainage improvement, irrigation, and land utilization. In addition, other important parameters must be considered including:

- infrastructural improvement, development of farming groups, credit system, effective agricultural extension services, and streamlined marketing facilities;
- integration of crops, fishery, livestock, and forestry into the farming system;
- special consideration of sensitive and strategic fisheries environments (such as mother fisheries);
- consideration of all resources available (actual and potential) within and outside the prescribed project area;
- exclusion of high risk areas from cropping, such as low areas adjacent to beels, by sharp demarkation from any agricultural development initiative
- provision for fisheries development in the low areas;

- production of natural commodities which have high commercial value or provide food security and survival value for poor people.

7.3 Baseline Field Studies

Physical, technical, institutional, and socio-economic constraints in the project area should be studied extensively. Farmers' knowledge of irrigation management, non-rice crop production, homestead development, post-harvest technology, and seed production and storage should be studied and evaluated. This would help to organize effective extension activities and training for farmers. Infrastructure, all resources, people's involvement and interests, socio-economic trends, hydrological regime, and constraints should all be studied extensively. Farmers, fishermen and other professional's interest should be studied including their alternative opportunities relating with the project initiatives.

7.4 Review of Community-based Management

The potential for installing a community-based project management system should be explored. Possibly a pilot project should be considered which would include the following activities:

- detailed description and economic and institutional analysis of the existing ownership and management regime at MRP;
- evaluation of examples of community-based FCDI project ownership and management regimes elsewhere in Bangladesh and in other countries in the region;
- discussion with MRP area residents of various options for a new management regime;
- cost/benefit analysis of options;
- preparation of an implementation plan based on MRP area resident preference and the results of the cost/benefit analysis.

If the results of the pilot project appear attractive, a full feasibility study should be undertaken to examine the prospect for transfer of the management of the project to the project users.

7.5 Embankments

The construction of the embankment must be done in such a way that it is accepted by the project people so that cutting of the project embankment does not occur. The confinement effect should be reduced by providing long set back distance, and the people living outside the project should be relocated. Where embankments are to be provided on both sides of a river, the minimum set back distance shall be determined from the width of floodway required to pass the design flood under confined conditions. Provision in the design must be made for the flow that is presently escaping the river completely by overbank spills.

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7.6 Fishpasses

Adequate provision for fishpasses and fish-friendly regulators must be made in FCDI projects to facilitate fish migration and to improve the general quality of the fisheries environment. Whenever feasible, consideration should be given to excluding sensitive fishery environments from the project area entirely.

7.7 Navigation and Transportation

Navigation by rivers and canals has considerable importance in FCDI project areas. Any comprehensive development plan for FCDI projects must include navigation passes and canals, otherwise the cost of socio-economic activities will remain very high and act as a brake on economic development of the area. The use of embankments as roads and footpaths is an important function which should be improved and integrated with the transportation network as part of a comprehensive and carefully planned project-wide transportation system.

7.8 Environmental Components

Attention should be given to the management of biodiversity and wild resources through habitat management or restoration programmes (including afforestation). Favourable water quality standards should be maintained in order to optimize production.

7.9 Social Components

In order to facilitate effective functioning of the infrastructure and to optimize project benefits, the project should have enough provision for the following:

Need assessment:
There should be a project committee comprising representatives of the impacted people, specialized agencies and the local government for assessment of the need of the people, such as water supply, drainage, retention for fishing or transplantation, and so on. An activity calendar based on existing practices with some element of flexibility responding to emergencies should be devised and maintained by the committee.

Conflict resolution:
It is likely that there would be conflict of interests among different sections of beneficiaries in any project. The project committee should handle all such conflicts carefully in order to attain maximum possible benefits from the infrastructure.

7.10 Economic Components

The possibility of beneficiaries paying for the services they receive from the project should be reviewed. A separate fund for operation and maintenance should be created to meet the expenses. Financial participation of the people will give them a sense of belonging to the project and consequently they would feel obliged to take care of the infrastructure. The people who are negatively impacted by the project in its day to day operation should receive adequate compensation from this fund.

Alternate job options need to be created for the people who are negatively impacted by the project in its day to day operation.

7.11 Project Operation and Maintenance

Beneficiaries should be responsible for operation and maintenance of most components of the project. This can be done through the above-mentioned project committee in the impacted area. Separate sub-committees can function to deal with separate structures or parts of the same structure. The project should belong to the people in every sense of the term.

All the structures should be adequately maintained. Any faults should be repaired in the dry season to prevent leakage and to keep structures fully functional. There should be adequate power supply to pumps, and drainage water should be free from any debris in order to maintain high efficiency of pumps. Inlet and outlet channels of the structures should be re-excavated if silted up. The internal drainage channels should also be maintained.

7.12 Impact Monitoring

Adequate provisions should be made for routine monitoring of a project following its construction, with regard to the following:

- functioning of the infrastructure;
- performance of the impacted economic activities;
- management practices;
- livelihood pattern of the people;
- social institutions and processes;
- biodiversity and natural products.

Guidelines for optimizing the project benefits will evolve from routine monitoring, which should be the task of the project coordination committee. Results of monitoring should be transmitted to the wider audience on a regular basis.

For each FCDI project BWDB should have a program to monitor hydrological changes in both the inside and outside of the project, so that other GOB Departments can use this data in their sectoral monitoring studies. Because fisheries is an economic sector that is completely water resource-determined, it would be most useful to analyze the changes in fish production by comparison with changes in flood intensity from year to year. Fish size and species diversity should be monitored by the DOF along with changes in floodplain and beel production levels and fishing effort.

For all FCDI projects there should be data collection facilities in order to record the project impacts, otherwise economic internal rates of return cannot be verified.

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7.13 Ongoing Dynamic Optimization

The PMP study clearly indicates that an FCDI project is never 'finished', in the same way that a bridge project is considered finished once construction is completed and the bridge is put into commission. This is especially true for a large and complex project such as MRP. FCDI projects create environments which attempt to balance a complexity of human needs and negative impacts, and this balance is ever changing.

An FCDI project is thus at any point in time always far from being perfect. This axiom is easily supported by the number of complaints that are levelled against FCDI projects throughout the Northeast region by project area residents. The imperfections may originate in part from faulty initial planning and design such as ignoring the needs of some of the impacted area resident groups and failing to select development objectives which address all economic sectors. However, other imperfections arise after the project has been commissioned:

- from unpredictable changes in remote variables (rainfall, land use, and other developments in the catchment area),
- from changes in the needs and development objectives of project area residents themselves, as they respond to the ever changing mix of personal, regional, national, and international social and economic driving forces.

Under such pressure, a FCDI project cannot remain a static item of infrastructure, but must undergo a continuous process of evaluation and modification in order to optimize its outputs and impacts. New construction and decommissioning of redundant structures is required from time to time. The role of users in project ownership and management will similarly not remain static. Institutional flexibility and local initiative will remain the keys to achieving continuous project success.

APPENDIX A

HYDROLOGICAL DATA

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APPENDIX A : HYDROLOGICAL DATA

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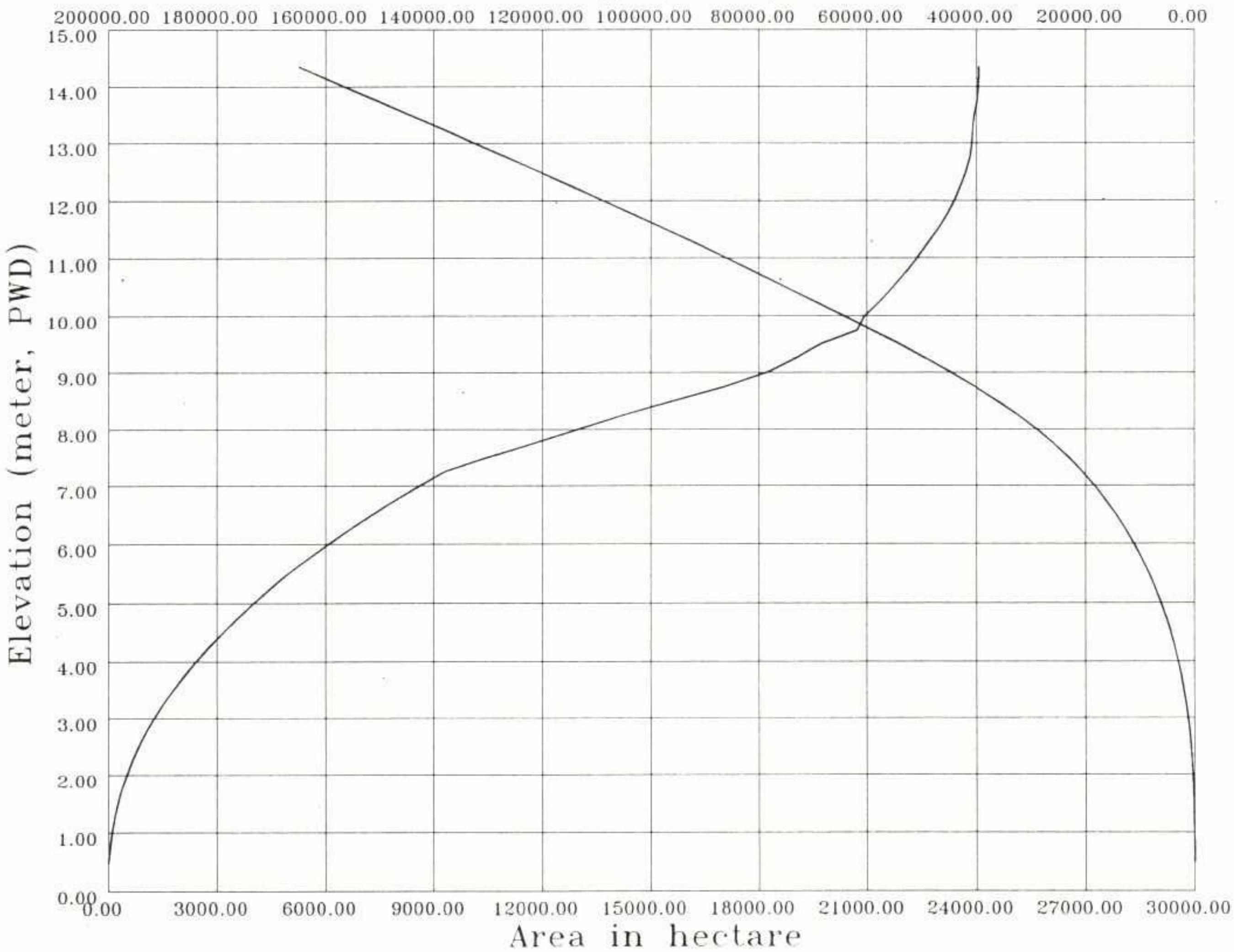
Figure A1

MANU PROJECT



Elev. (m Pwd)	Area (ha)	Storage (ha-m)
0.50	0	0.100
0.75	55	4.682
1.00	105	24.395
1.25	175	59.044
1.50	264	113.476
1.75	374	192.804
2.00	506	302.368
2.25	660	447.715
2.50	838	634.580
2.75	1040	868.866
3.00	1266	1156.632
3.25	1517	1504.088
3.50	1794	1917.578
3.75	2098	2403.578
4.00	2427	2968.684
4.25	2784	3619.612
4.50	3169	4363.186
4.75	3581	5206.339
5.00	4022	6156.104
5.25	4491	7219.613
5.50	4989	8404.092
5.75	5517	9716.858
6.00	6075	11165.316
6.25	6663	12756.956
6.50	7281	14499.350
6.75	7930	16400.150
7.00	8610	18467.087
7.25	9296	20704.850
7.50	10464	23173.482
7.75	11734	25946.796
8.00	12976	29034.280
8.25	14212	32431.632
8.50	15583	36154.789
8.75	16993	40225.544
9.00	18206	44624.551
9.25	19010	49276.186
9.50	19714	54116.381
9.75	20738	59127.866
10.00	20935	64291.669
10.25	21349	69577.096
10.50	21709	74959.215
10.75	22056	80429.733
11.00	22374	85983.423
11.25	22662	91612.810
11.50	22948	97313.921
11.75	23184	103060.362
12.00	23400	108903.381
12.25	23559	114773.248
12.50	23709	120681.702
12.75	23824	126623.358
13.00	23874	132585.841
13.25	23899	138557.266
13.50	23944	144537.669
13.75	24015	150532.537
14.00	24052	156540.904
14.25	24069	162555.978
14.35	24076	164963.224

Note : SRP Data

FILE: LARRY-A1.DWG

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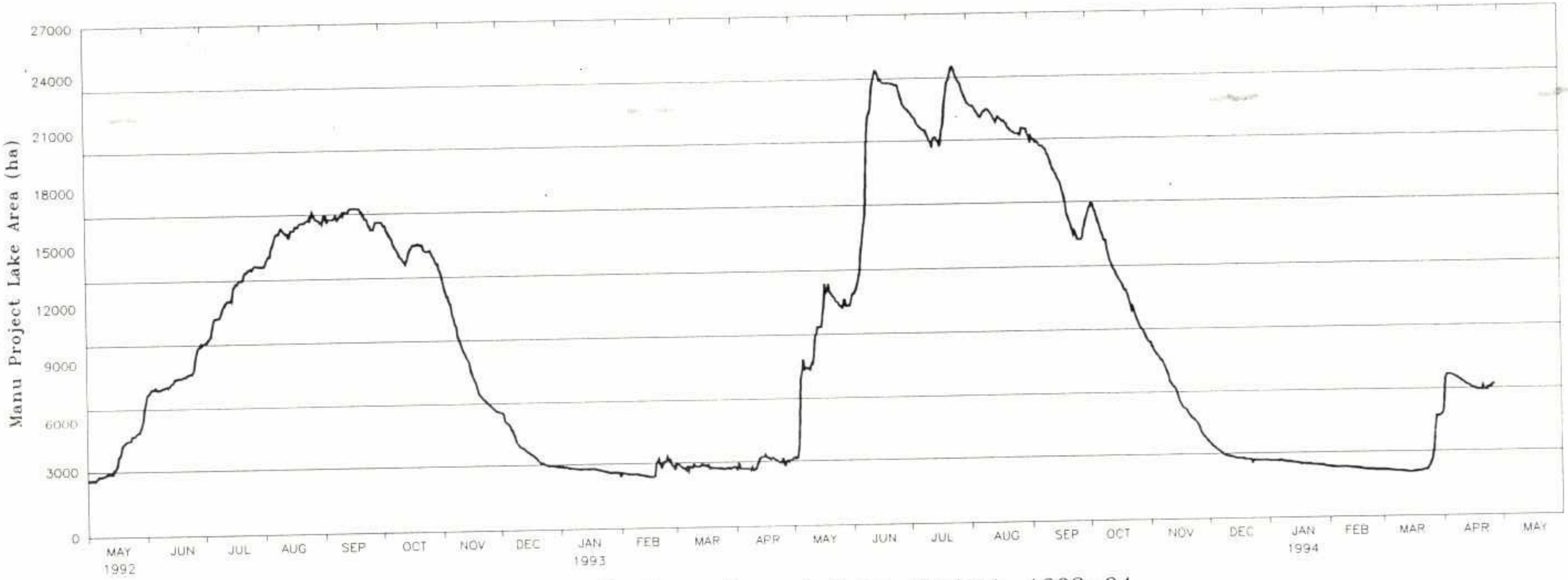


Hydraulic Operation of Manu Project, 1992–94

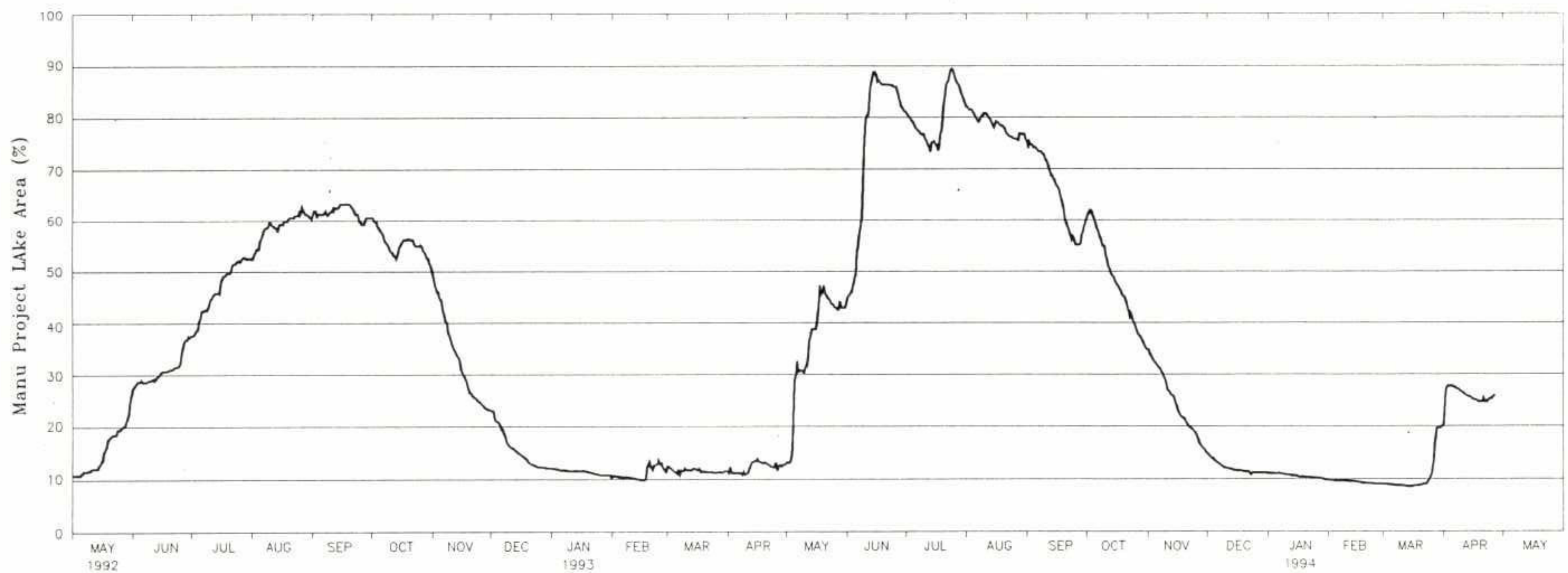
Note : Derived from NERP water level data
and SRP area-elevation curve

Northeast Regional Project	
Manu River FCDI Project Area Flooded, 1992–94	
Prepared by: MEI	June 1994
Computer Drafting by: SK	AutoCAD Drawing

FILE: LARRY-A2.DWG

Figure A2

Figure A3



Hydraulic Operation of Manu Project, 1992–94

Note : Derived from NERP water level data
and SRP area–elevation curve

Northeast Regional Project

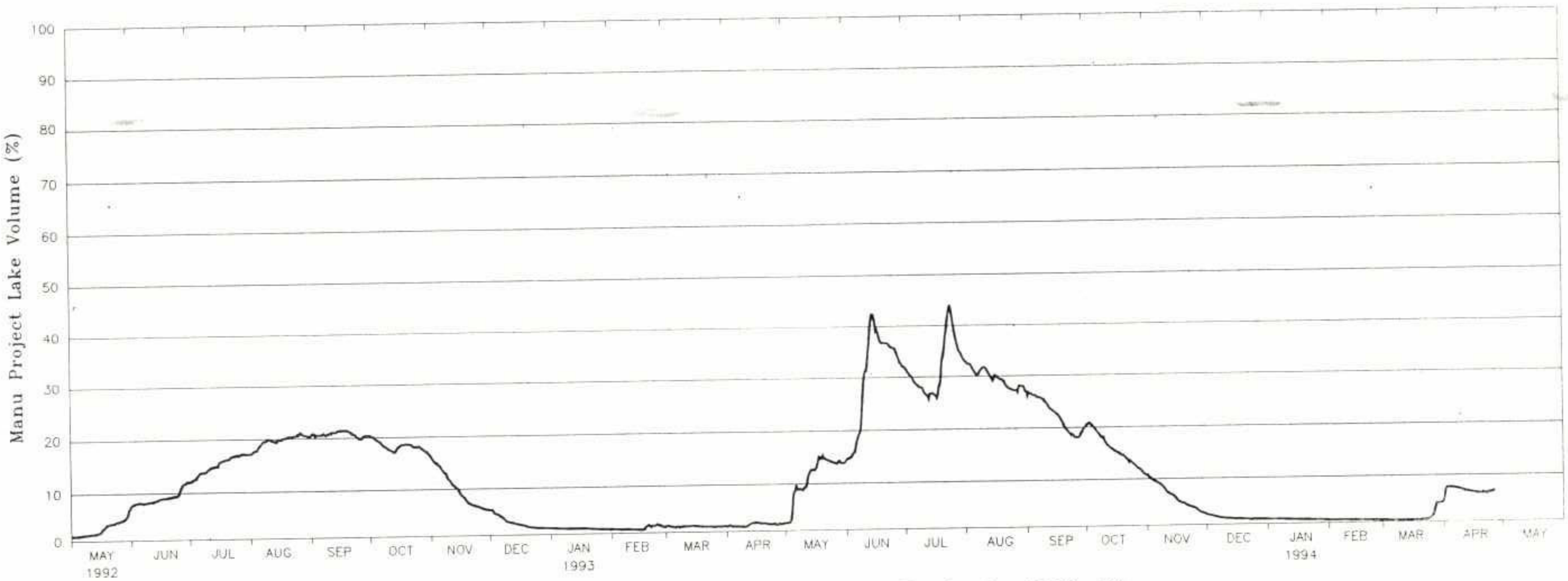
Manu River FCDI Project

Percent Area Flooded, 1992–94

Prepared by: MEI	June 1994
Computer Drafting by: SK	AutoCAD Drawing

FILE: LARRY–A3.DWG

Figure A4



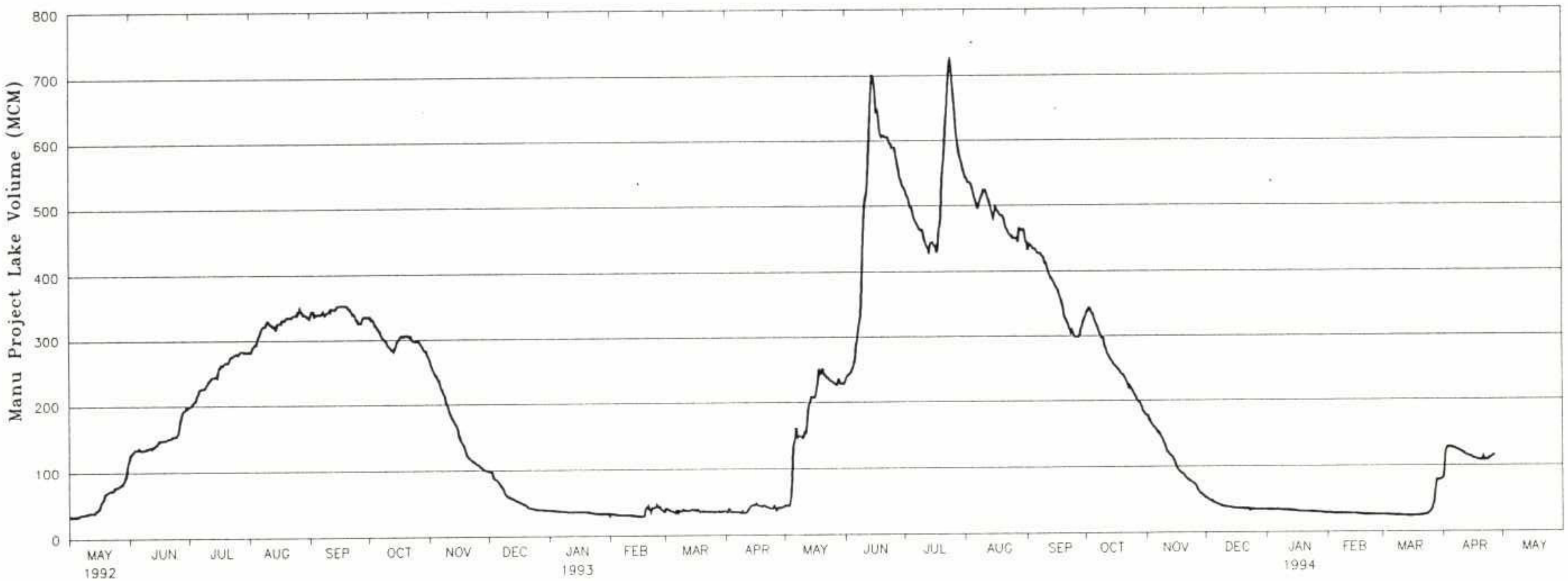
Hydraulic Operation of Manu Project, 1992–94

Note : Derived from NERP water level data
and SRP area-elevation curve

Northeast Regional Project	
Manu River FCDI Project	
Percent Volume Flooded, 1992–94	
Prepared by: MEI	June 1994
Computer Drafting by: SK	AutoCAD Drawing

FILE: LARRY-A4.DWG

Figure A5



Hydraulic Operation of Manu Project, 1992–94

Note : Derived from NERP water level data and SRP area–elevation curve

Northeast Regional Project	
Manu River FCDI Project Volume Flooded, 1992–94	
Prepared by: MEI	June 1994
Computer Drafting by: Sk	AutoCAD Drawing

FILE: LARRY-A5.DWG

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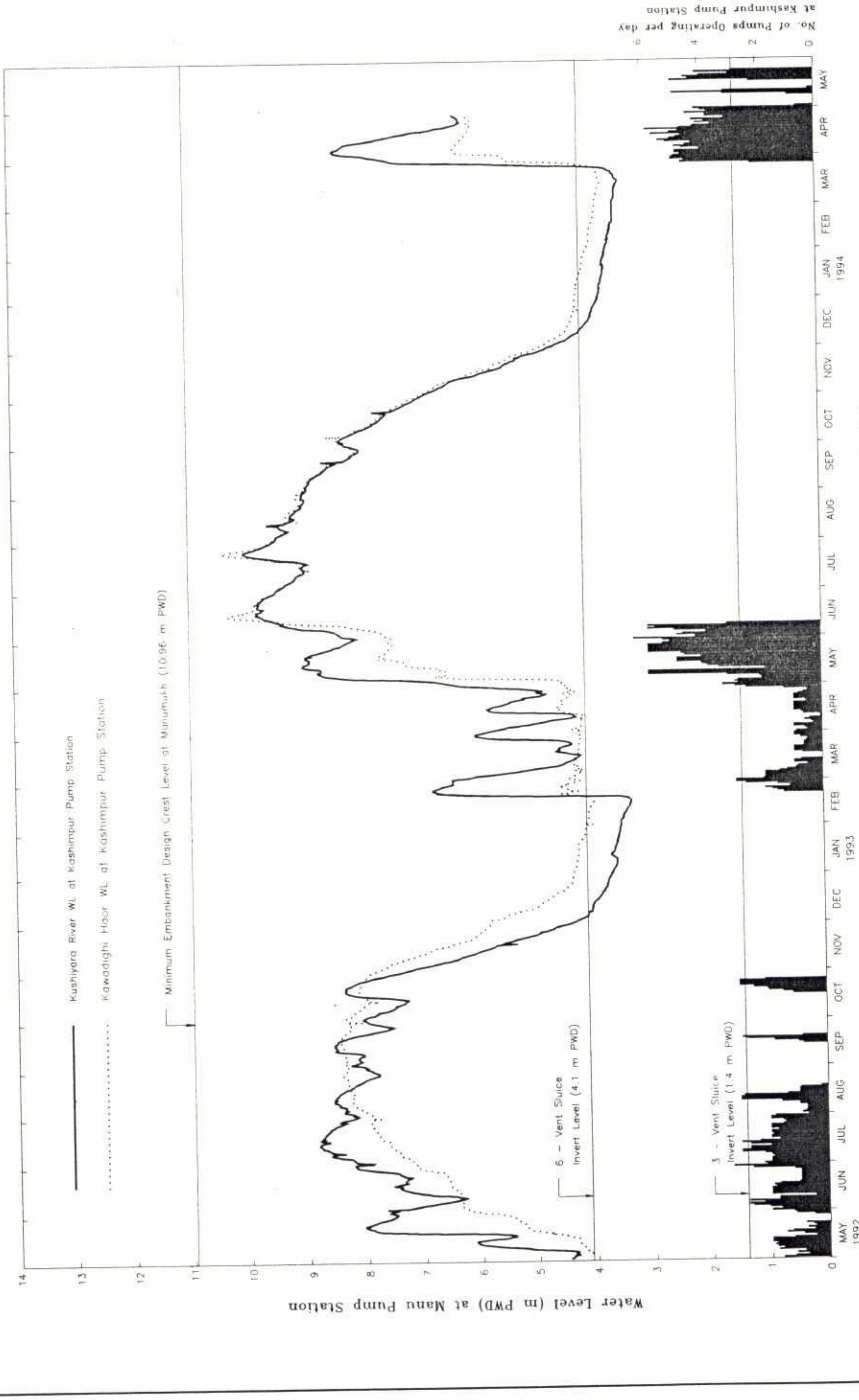
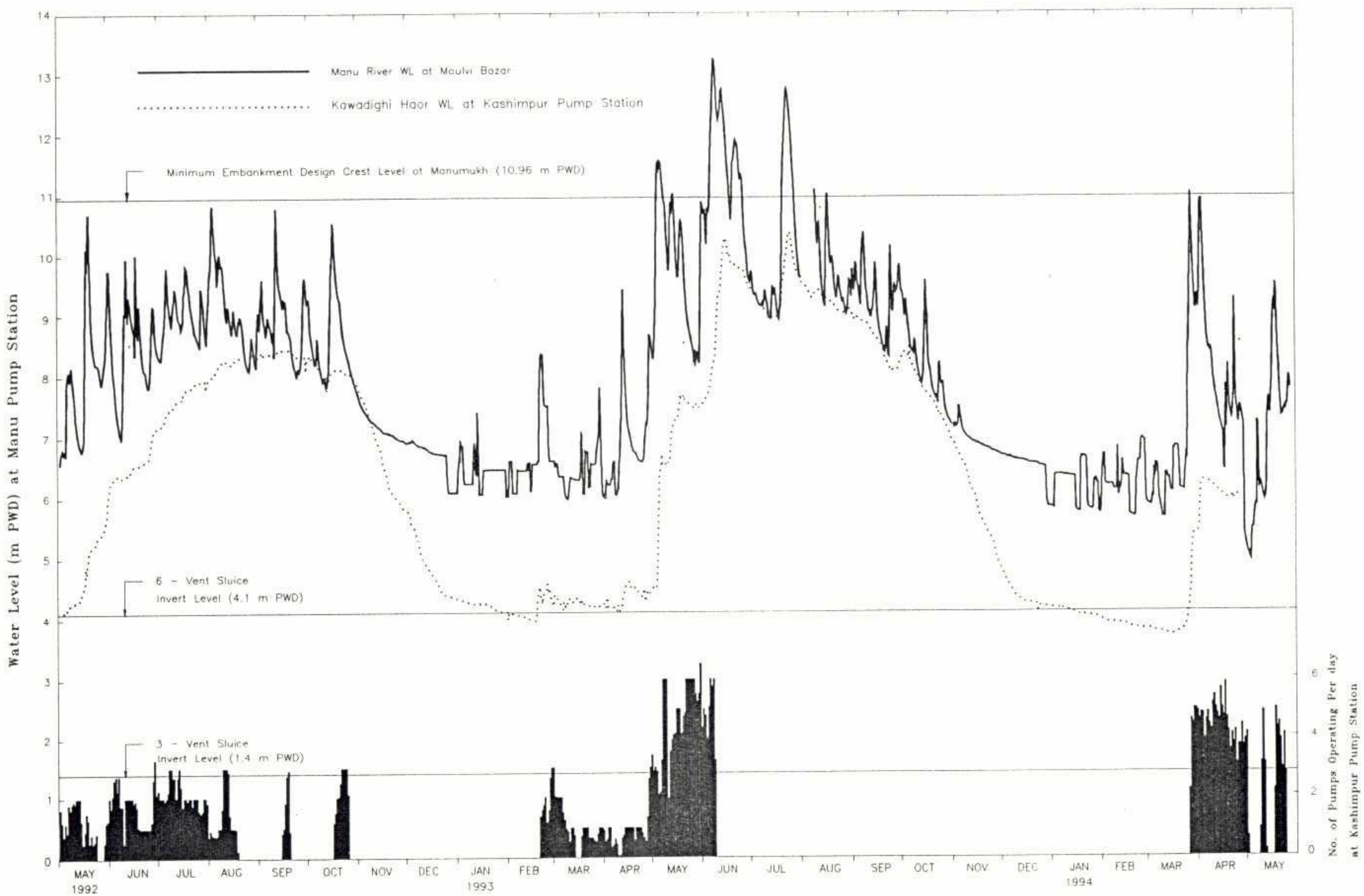
Figure A6



Hydraulic Operation of Manu Project, 1992–94

FILE : LARRY-A6.DWG

Figure A7



Hydraulic Operation of Manu Project, 1992-94

FILE : LARRY-A7.DWG

FILE : LARRY-A6.DWG

Project Monitoring Program
MANU RIVER FCDI PROJECT

Rainfall (mm) at Manumukh (Stn. No. R119)

	1992												1993												1994				
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0.00	13.00	3.00	0.00	0.00	19.00	5.00	4.00	105.00	0.00	0.00	0.00	0.00	27.00	0.00	0.00	14.00	10.00	35.00	17.00	7.00	0.00	8.00	0.00	0.00	2.00	0.00	56.00	0.00
2	0.00	0.00	5.00	0.00	2.00	0.00	8.00	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.00	0.00	6.00	6.00	60.00	73.00	0.00	0.00	0.00	1.00	0.00	65.00	0.00
3	0.00	5.00	0.00	0.00	4.00	0.00	16.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.00	8.00	57.00	21.00	6.00	3.00	0.00	0.00	0.00	3.00	0.00	8.00	0.00
4	0.00	0.00	0.00	0.00	16.00	0.00	21.00	2.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	27.00	7.00	5.00	24.00	21.00	9.00	25.00	0.00	0.00	0.00	0.00	10.00	12.00
5	0.00	0.00	0.00	0.00	14.00	0.00	18.00	87.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.00	28.00	22.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.00	218.00	6.00	9.00	13.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00
7	0.00	0.00	0.00	0.00	10.00	1.00	0.00	35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	27.00	11.00	6.00	7.00	54.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00
8	0.00	0.00	0.00	0.00	2.00	17.00	24.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	36.00	2.00	54.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	13.00
9	0.00	0.00	0.00	0.00	7.00	0.00	13.00	19.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.00	25.00	15.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	11.00	2.00	33.00	0.00	27.00	1.00	0.00	0.00	23.00	0.00	0.00	16.00	142.00	16.00	16.00	26.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	4.00	0.00	1.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	3.00	28.00	112.00	0.00	28.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	17.00	9.00	0.00	0.00	19.00	0.00	0.00	0.00	0.00	0.00	71.00	90.00	53.00	9.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00
13	0.00	0.00	0.00	0.00	0.00	0.00	11.00	0.00	1.00	99.00	0.00	0.00	0.00	0.00	0.00	0.00	32.00	5.00	3.00	0.00	24.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
14	0.00	0.00	0.00	0.00	0.00	0.00	3.00	34.00	77.00	2.00	0.00	0.00	0.00	12.00	0.00	0.00	0.00	0.00	56.00	0.00	1.00	2.00	0.00	0.00	0.00	0.00	27.00	0.00	10.00
15	0.00	0.00	0.00	0.00	5.00	11.00	0.00	4.00	3.00	29.00	0.00	0.00	0.00	0.00	27.00	1.00	0.00	15.00	1.00	3.00	4.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	61.00
16	0.00	0.00	0.00	0.00	30.00	0.00	105.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	2.00	77.00	6.00	27.00	28.00	0.00	18.00	0.00	0.00	2.00	0.00	30.00	0.00	9.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	16.00	6.00	0.00	0.00	0.00	0.00	0.00	7.00	17.00	22.00	16.00	4.00	10.00	0.00	0.00	0.00	7.00	0.00	0.00	9.00	7.00
18	0.00	0.00	0.00	0.00	26.00	2.00	17.00	1.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.00	15.00	112.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00
19	0.00	0.00	60.00	7.00	0.00	4.00	4.00	16.00	0.00	0.00	0.00	0.00	0.00	60.00	0.00	0.00	3.00	60.00	148.00	36.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	3.00	0.00
20	0.00	0.00	29.00	16.00	0.00	6.00	8.00	18.00	0.00	0.00	0.00	0.00	0.00	6.00	12.00	30.00	2.00	27.00	176.00	13.00	0.00	3.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
21	0.00	0.00	0.00	0.00	11.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	34.00	0.00	0.00	0.00	0.00	194.00	5.00	12.00	0.00	0.00	0.00	0.00	0.00	2.00	21.00	0.00
22	0.00	13.00	0.00	10.00	0.00	0.00	44.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	26.00	168.00	3.00	0.00	0.00	0.00	0.00	0.00	24.00	0.00	6.00	4.00
23	0.00	0.00	0.00	12.00	0.00	7.00	9.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.00	1.00	25.00	0.00	0.00	0.00	0.00	4.00	0.00	2.00	8.00
24	0.00	0.00	0.00	5.00	0.00	2.00	17.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.00	32.00	4.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
25	5.00	0.00	0.00	0.00	0.00	34.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.00	0.00	0.00	2.00	16.00	76.00	0.00	0.00	0.00	0.00	0.00	54.00	45.00	2.00
26	0.00	0.00	0.00	0.00	3.00	110.00	1.00	30.00	28.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	2.00	0.00	0.00	9.00	17.00	0.00	0.00	0.00	0.00	0.00	51.00	38.00	11.00
27	0.00	0.00	0.00	2.00	2.00	8.00	22.00	0.00	32.00	0.00	0.00	0.00	0.00	0.00	28.00	31.00	0.00	0.00	0.00	30.00	71.00	0.00	0.00	0.00	0.00	0.00	105.00	21.00	3.00
28	0.00	0.00	0.00	4.00	24.00	0.00	4.00	5.00	37.00	0.00	0.00	0.00	0.00	2.00	0.00	93.00	47.00	0.00	5.00	71.00	122.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00
29	0.00	3.00	0.00	0.00	2.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	4.00	37.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
30	0.00		0.00	0.00	13.00	0.00	0.00	0.00	12.00	0.00	1.00	0.00	0.00		0.00	0.00	5.00	20.00	0.00	12.00	0.00	0.00	0.00	0.00	0.00		18.00	0.00	9.00
31	0.00		0.00		0.00		8.00	0.00		0.00		0.00	0.00		0.00		14.00		35.00	1.00		0.00		0.00	11.00		0.00		2.00
Sum	5.00	34.00	97.00	56.00	186.00	240.00	404.00	357.00	426.00	183.00	1.00	0.00	23.00	142.00	77.00	299.00	788.00	752.00	1175.00	446.00	516.00	185.00	33.00	0.00	20.00	43.00	294.00	295.00	217.00

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Project Monitoring Program
MANU RIVER FCDI PROJECT

Rainfall (mm) at Moulvi Bazar (Stn. No. R122)

	1992												1993												1994				
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0.00	30.00	6.00	0.00	2.00	0.00	6.00	14.00	23.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	3.00	5.70	30.00	3.00	2.00	0.00	4.00	0.00	0.00	2.00	0.00	195.00	0.00
2	0.00	0.00	66.00	0.00	30.00	0.00	7.00	13.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	3.00	25.00	0.00	0.00	0.00	0.00	2.00	0.00	50.00	0.00
3	0.00	0.00	0.00	0.00	10.00	0.00	13.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	117.50	20.00	4.00	2.00	4.00	3.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	25.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	172.00	15.00	4.00	25.00	23.00	2.00	4.00	0.00	0.00	0.00	0.00	0.00	10.00
5	0.00	0.00	0.00	0.00	0.00	0.00	102.00	35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.00	30.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.60	198.00	1.00	0.00	92.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
7	0.00	0.00	0.00	14.00	2.00	0.00	0.00	77.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.50	39.00	1.00	1.00	2.00	10.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
8	0.00	2.00	0.00	0.00	2.00	6.00	2.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.00	0.00	130.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.00
9	0.00	0.00	0.00	0.00	4.00	3.00	5.00	22.00	46.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	31.00	20.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	12.00	0.00	0.00	0.00	34.00	0.00	0.00	35.00	45.00	2.00	2.00	5.00	3.40	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	3.00	2.00	5.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.00	119.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	2.00	5.00	0.00	0.00	13.00	0.00	0.00	0.00	0.00	0.00	35.00	44.00	40.00	4.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00
13	0.00	0.00	3.00	0.00	0.00	20.00	14.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.00	22.00	13.00	0.00	46.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
14	0.00	0.00	0.00	0.00	0.00	15.00	0.00	2.00	12.00	40.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	55.00	0.00	10.00	8.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00
15	0.00	13.00	0.00	0.00	25.00	16.00	7.00	3.00	4.00	3.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	19.50	2.00	0.00	2.00	3.60	0.00	0.00	0.00	0.00	37.00	0.00	42.00
16	0.00	0.00	0.00	0.00	90.00	2.00	17.00	6.00	0.00	35.20	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	20.00	23.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	12.00	10.00
17	0.00	0.00	0.00	0.00	0.00	3.00	0.00	3.00	36.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	15.00	10.00	2.00	10.00	2.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	27.00	43.00	10.20	7.00	2.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	50.00	15.00	10.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	14.00	0.00	20.00
19	0.00	0.00	23.00	0.00	0.00	0.00	3.00	32.50	0.00	0.00	0.00	0.00	0.00	45.00	0.00	0.00	2.00	60.00	34.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	15.00	28.00	0.00	0.00	2.00	3.00	0.00	0.00	0.00	0.00	0.00	13.50	34.30	37.00	14.00	54.20	217.00	9.00	25.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	3.00	0.00	0.00	4.00	0.00	4.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	1.00	0.00	201.00	3.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
22	0.00	4.00	0.00	0.00	0.00	16.00	35.00	0.00	0.00	0.00	0.00	0.00	0.00	41.00	0.40	0.00	0.00	13.00	130.00	0.00	0.00	0.00	0.00	0.00	0.00	14.00	0.00	2.00	0.00
23	0.00	0.00	0.00	9.00	0.00	12.00	0.00	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.80	0.00	45.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	2.00
24	0.00	0.00	0.00	0.00	0.00	0.00	15.60	2.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	10.00	4.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
25	0.00	6.00	0.00	0.00	0.00	10.50	0.00	2.00	25.00	0.00	2.00	0.00	0.00	0.00	0.00	22.30	0.00	7.00	0.00	3.00	4.00	0.00	0.00	0.00	0.00	0.00	140.00	14.00	13.00
26	0.00	0.00	0.00	0.00	21.00	15.00	0.00	6.00	45.00	0.00	0.00	0.00	0.00	0.00	2.30	0.00	0.00	5.00	3.50	1.00	15.00	0.00	0.00	0.00	0.00	0.00	45.00	20.00	20.00
27	0.00	0.00	0.00	0.00	3.00	45.00	16.00	2.00	21.00	0.00	0.00	0.00	0.00	0.00	52.00	53.40	5.00	2.00	0.00	7.00	2.00	0.00	0.00	0.00	0.00	0.00	95.00	8.00	2.00
28	0.00	0.00	0.00	12.00	6.00	0.00	15.00	7.00	47.60	0.00	0.00	0.00	0.00	0.00	0.00	114.00	50.00	0.60	0.00	28.00	95.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	36.00	0.00	0.60	0.00	3.00	0.00	0.00	0.00	0.00		0.00	0.00	2.00	2.00	0.00	34.80	60.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
30	0.00		0.00	0.00	143.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	25.00	5.00	1.00	10.00	3.00	0.00	0.00	0.00	0.00		45.00	0.00	0.00
31	0.00		0.00		0.00		4.00	0.00		0.00		0.00	0.00		0.00		32.00		0.00	0.00		0.00		0.00	5.00		0.00		10.00
SUM	0.00	58.00	113.00	63.00	433.00	216.50	290.40	280.70	290.60	91.20	2.00	0.00	34.00	114.00	100.00	301.70	842.80	757.00	769.30	326.60	463.40	31.60	8.00	0.00	7.00	30.00	378.00	322.00	222.00

Project Monitoring Program
MANU RIVER FCDI PROJECT

Rainfall (mm) at Chandbagh (Stn. No. R104)

	1992												1993												1994				
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0.00	0.00	4.00	0.00	0.00	22.00	0.00	0.00	18.00	11.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	162.00	68.00	12.00	30.00	0.00	5.00	0.00	0.00	0.00	0.00	60.00	
2	0.00	21.00	0.00	0.00	0.00	0.00	28.00	63.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.00	28.00	0.00	26.00	11.00	66.00	0.00	0.00	0.00	10.00	0.00	5.00	
3	0.00	0.00	0.00	0.00	18.00	0.00	18.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	116.00	0.00	8.00	52.00	0.00	5.00	3.00	0.00	0.00	0.00	0.00	0.00	
4	0.00	0.00	0.00	0.00	19.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5	0.00	0.00	0.00	0.00	2.00	0.00	65.00	51.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.00	110.00	3.00	0.00	56.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
6	0.00	0.00	0.00	0.00	0.00	0.00	3.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	53.00	114.00	9.00	2.00	28.00	6.00	0.00	0.00	0.00	0.00	2.00	48.00	
7	0.00	0.00	0.00	0.00	3.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.00	34.00	4.00	71.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8	0.00	8.00	0.00	4.00	0.00	12.00	37.00	32.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	7.00	0.00	5.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
9	0.00	0.00	0.00	0.00	25.00	7.00	0.00	21.00	39.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.00	0.00	52.00	0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00	
10	0.00	0.00	0.00	0.00	20.00	9.00	0.00	30.00	23.00	0.00	0.00	0.00	51.00	0.00	0.00	32.00	15.00	23.00	15.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
11	0.00	0.00	0.00	0.00	18.00	10.00	39.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	86.00	74.00	112.00	11.00	0.00	4.00	56.00	0.00	0.00	0.00	0.00	0.00	0.00	
13	0.00	0.00	0.00	0.00	0.00	0.00	30.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	30.00	16.00	0.00	5.00	9.00	0.00	0.00	0.00	0.00	38.00	0.00	
14	0.00	0.00	0.00	0.00	4.00	0.00	5.00	0.00	15.00	21.00	0.00	0.00	0.00	35.00	0.00	0.00	0.00	0.00	43.00	6.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
15	0.00	0.00	0.00	0.00	5.00	69.00	0.00	18.00	0.00	72.00	0.00	0.00	0.00	0.00	12.00	0.00	0.00	0.00	13.00	74.00	0.00	14.00	0.00	0.00	0.00	0.00	64.00	0.00	
16	0.00	0.00	0.00	0.00	77.00	0.00	70.00	4.00	0.00	39.00	0.00	0.00	0.00	9.00	0.00	0.00	67.00	0.00	0.00	4.00	21.00	0.00	0.00	0.00	7.00	0.00	18.00	8.00	
17	0.00	0.00	0.00	0.00	3.00	0.00	0.00	57.00	0.00	28.00	0.00	0.00	0.00	8.00	0.00	0.00	40.00	24.00	34.00	0.00	0.00	11.00	0.00	0.00	0.00	0.00	0.00	7.00	
18	0.00	0.00	0.00	0.00	73.00	9.00	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.00	20.00	114.00	33.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
19	0.00	0.00	91.00	36.00	0.00	0.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00	90.00	0.00	0.00	0.00	67.00	200.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	36.00	23.00	0.00	4.00	12.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.00	192.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00	
21	0.00	0.00	0.00	10.00	23.00	14.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	190.00	12.00	0.00	0.00	0.00	0.00	0.00	21.00	10.00	0.00	
22	0.00	9.00	0.00	34.00	0.00	10.00	52.00	0.00	0.00	0.00	0.00	0.00	0.00	33.00	4.00	0.00	0.00	7.00	171.00	2.00	46.00	0.00	0.00	0.00	0.00	7.00	2.00	2.00	
23	0.00	0.00	2.00	36.00	0.00	0.00	20.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	14.00	0.00	
24	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.00	24.00	9.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	26.00	13.00	
25	0.00	6.00	0.00	0.00	0.00	0.00	0.00	21.00	55.00	0.00	0.00	0.00	0.00	0.00	0.00	31.00	0.00	0.00	3.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	37.00	
26	0.00	0.00	0.00	0.00	26.00	160.00	0.00	61.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.00	59.00	7.00	22.00	36.00	0.00	0.00	0.00	0.00	0.00	163.00	6.00	
27	0.00	0.00	0.00	0.00	0.00	54.00	0.00	0.00	23.00	0.00	0.00	0.00	0.00	0.00	34.00	34.00	0.00	15.00	0.00	92.00	63.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	
28	0.00	0.00	0.00	11.00	0.00	0.00	25.00	6.00	19.00	0.00	0.00	0.00	0.00	0.00	0.00	152.00	37.00	15.00	0.00	20.00	80.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	
29	0.00	0.00	0.00	0.00	0.00	0.00	8.00	0.00	8.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	14.00	0.00	0.00	17.00	0.00	0.00	0.00	0.00		17.00	0.00	
30	0.00		0.00	0.00	105.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	15.00	9.00	9.00	0.00	0.00	0.00	0.00	0.00	6.00		0.00	0.00	
31	0.00		0.00		0.00		0.00	0.00		0.00		0.00	0.00		0.00		19.00		4.00	26.00		0.00		0.00	0.00		46.00		
SUM	0.00	44.00	133.00	154.00	421.00	384.00	462.00	411.00	232.00	191.00	0.00	0.00	51.00	184.00	50.00	359.00	761.00	974.00	1155.00	536.00	432.00	167.00	8.00	0.00	13.00	55.00	407.00	198.00	

Project Monitoring Program
MANU RIVER FCDI PROJECT

Adjusted Pan Evaporation (mm) at Srimangal (Stn. No. E36)

	1992												1993												1994				
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	2.03	1.84	3.05	5.08	4.06	4.68	4.06	2.36	3.84	5.00	3.05	1.02	1.02	2.03	1.52	4.06	3.05	5.68	3.05	2.03	3.97	2.98	7.52	3.05	1.52	5.00	2.54	2.84	5.08
2	2.03	2.03	3.05	5.06	2.30	5.08	4.68	2.53	5.08	3.05	3.05	1.02	1.02	2.03	2.03	4.06	3.05	1.92	3.05	2.03	3.41	2.00	3.05	3.05	1.52	6.95	2.54	7.62	4.06
3	2.03	2.36	3.05	5.08	1.46	5.08	3.22	2.73	6.10	3.56	3.05	1.02	1.02	2.54	2.03	4.06	6.16	4.68	3.05	5.00	2.86	1.70	2.03	2.54	1.52	3.00	3.05	1.87	6.60
4	2.03	3.05	3.56	5.08	0.00	6.10	3.05	4.06	6.10	3.56	3.05	1.52	1.02	2.54	2.03	4.57	6.61	7.62	3.05	2.38	2.90	1.40	1.87	2.03	1.52	2.03	3.05	5.08	7.11
5	2.54	3.05	3.56	6.10	0.00	6.10	4.68	2.73	5.38	4.06	3.05	1.52	1.52	2.54	2.03	4.57	7.04	4.02	3.05	2.81	3.05	3.05	2.54	2.03	1.52	2.03	3.05	5.08	2.86
6	2.54	3.05	3.56	6.10	3.05	6.10	4.06	2.95	5.08	4.06	2.54	1.52	1.52	2.54	2.03	5.08	2.70	7.62	3.74	3.98	4.68	3.05	2.54	2.03	1.52	2.03	3.05	5.06	5.08
7	2.03	2.54	4.06	6.10	4.68	6.10	4.06	5.30	5.08	3.05	2.54	1.52	1.52	2.54	3.05	5.06	3.05	4.68	2.38	2.86	2.97	2.98	2.54	2.03	1.52	2.03	3.05	4.86	6.10
8	2.03	0.44	4.06	6.10	3.56	2.84	4.06	1.87	1.40	3.05	2.54	1.52	1.02	2.54	3.05	5.08	0.96	7.62	4.06	3.42	3.05	3.48	2.54	2.03	1.52	2.03	3.05	6.10	3.05
9	1.52	2.03	4.06	6.60	4.60	4.22	2.90	4.68	3.76	3.05	2.54	1.52	1.02	3.05	3.05	4.92	3.05	7.62	3.76	3.98	4.06	3.48	2.54	2.03	1.52	5.00	3.05	6.10	5.08
10	2.03	2.03	4.06	6.60	3.00	3.05	7.62	5.94	4.68	3.05	2.54	1.52	1.44	3.05	3.05	4.68	0.84	4.55	4.06	2.86	4.06	3.82	2.54	2.03	1.52	1.52	3.05	6.10	6.10
11	2.03	2.54	4.06	6.60	6.60	4.76	2.38	5.08	2.44	3.05	2.54	1.52	1.02	3.56	3.05	4.06	6.06	5.50	4.06	2.82	4.06	2.97	2.54	2.03	1.02	1.52	2.54	6.60	2.87
12	2.03	2.54	4.06	7.11	6.60	2.79	3.00	6.60	2.38	4.00	2.54	1.52	1.02	3.56	4.06	6.54	4.00	3.70	5.08	5.00	2.76	4.06	2.54	2.54	1.02	1.52	2.54	6.60	3.84
13	1.52	2.54	4.06	7.11	6.60	3.33	3.46	7.11	3.05	2.92	2.54	1.52	1.02	3.56	4.06	4.00	4.68	1.82	7.62	4.06	3.33	4.06	2.54	2.54	2.03	1.52	2.38	6.60	2.89
14	1.52	2.54	6.97	7.11	7.11	2.34	4.46	5.36	2.86	1.84	2.54	1.52	1.52	4.76	4.06	3.05	4.06	4.06	3.76	4.06	3.90	3.74	3.05	2.54	2.03	2.03	3.05	7.11	6.60
15	1.02	2.84	5.08	7.11	5.08	7.62	3.05	1.52	5.08	3.65	2.54	1.52	1.52	4.68	3.74	4.06	4.06	7.00	3.98	2.89	4.06	2.84	3.05	2.54	1.02	2.03	4.06	7.11	7.62
16	1.02	2.03	5.08	6.10	7.62	1.89	3.00	2.00	4.06	3.65	2.54	1.52	1.52	2.38	3.56	4.06	6.17	5.94	3.90	7.62	4.06	3.00	3.05	2.03	1.02	2.03	4.06	7.11	7.19
17	1.02	2.54	5.59	6.10	6.52	4.50	4.68	2.84	4.84	5.46	2.54	1.52	1.52	3.05	3.56	4.06	4.68	4.68	3.48	3.05	4.06	3.05	3.05	2.03	3.97	2.54	4.06	7.11	2.84
18	1.02	2.54	5.59	6.10	7.01	4.68	4.18	5.30	3.05	2.03	3.05	2.03	2.03	3.05	3.56	4.06	4.68	2.86	3.48	5.97	5.08	3.05	3.05	2.03	1.52	2.54	0.92	3.87	7.62
19	2.03	2.54	7.62	7.62	1.52	4.00	3.48	2.92	5.08	2.03	3.05	2.03	2.03	4.68	3.05	4.06	3.87	7.62	7.62	2.89	5.08	2.03	2.54	2.03	1.52	2.54	3.56	6.10	5.08
20	2.03	3.05	3.05	4.60	3.05	2.92	3.48	2.38	5.08	2.03	2.54	2.03	2.03	2.38	3.05	5.08	4.46	4.68	6.15	2.89	4.44	2.03	2.54	2.03	1.52	2.54	4.06	3.86	5.08
21	2.03	3.05	3.05	2.34	3.05	5.08	3.40	4.00	5.08	2.54	2.54	2.03	1.52	2.03	4.00	5.08	3.05	4.06	6.15	2.98	4.79	3.05	2.54	2.03	1.52	2.54	4.06	5.00	6.10
22	2.03	3.05	4.06	5.08	2.54	2.76	3.56	5.08	5.08	2.54	2.54	2.03	1.52	4.70	2.03	5.08	5.08	2.92	6.15	2.00	4.06	3.05	2.54	2.03	1.52	4.76	4.06	3.05	6.60
23	2.54	2.03	4.06	4.12	2.54	3.05	3.90	5.08	2.03	2.54	2.54	2.03	1.52	2.54	5.97	5.08	5.08	3.00	4.66	3.05	4.68	3.05	2.54	2.03	1.52	1.79	4.06	2.90	6.60
24	2.54	2.03	5.08	4.66	3.05	4.00	5.08	5.08	3.05	3.05	2.03	2.03	1.52	2.03	2.54	3.50	5.08	0.95	1.52	5.46	3.05	2.54	2.54	2.03	1.52	2.03	4.06	4.06	3.87
25	2.54	2.03	5.08	4.06	3.90	7.46	6.10	4.76	2.38	3.05	5.00	2.03	1.52	2.03	2.54	5.66	6.10	2.92	1.52	2.38	3.05	2.54	2.54	1.52	1.52	2.03	3.74	4.06	3.86
26	2.54	2.54	6.10	6.10	3.48	9.28	6.10	4.68	2.30	3.05	1.52	2.03	2.03	2.03	2.03	3.05	6.10	3.05	3.84	2.30	3.05	2.54	2.54	1.52	1.52	2.03	3.42	2.38	7.62
27	2.54	2.54	6.10	6.10	3.48	3.56	4.04	5.08	4.68	3.05	2.03	2.03	2.03	2.03	4.18	5.95	7.11	4.06	3.05	2.38	5.00	2.54	2.54	1.52	1.02	2.54	3.24	2.86	6.60
28	2.54	3.05	6.10	6.97	2.76	3.56	3.05	5.08	7.62	3.05	2.03	2.03	2.03	2.03	4.06	7.38	7.11	4.06	4.06	2.84	4.68	2.54	2.54	1.52	1.02	2.54	3.05	6.10	6.60
29	2.54	3.05	6.10	6.10	3.48	5.08	3.05	2.03	2.03	3.56	2.03	1.52	2.03		4.06	1.52	5.08	4.68	4.06	5.98	7.62	2.54	2.54	1.52	1.02		3.05	6.60	7.11
30	2.54		6.10	3.45	3.16	5.08	3.00	5.08	3.05	3.05	1.52	1.52	2.03		4.06	3.05	4.68	3.86	5.08	2.54	2.92	2.54	2.54	1.52	1.02		3.88	7.11	7.11
31	2.54		6.10		2.84		7.38	6.10		3.05		1.02	2.03		4.06		4.68		5.08	2.54		2.03		1.52	5.00		3.56		6.10
SUM	62.99	71.51	145.14	172.47	118.70	137.06	126.24	128.35	121.71	98.66	78.15	50.73	47.13	30.48	99.17	134.58	142.42	137.45	127.59	107.06	118.77	87.73	83.05	64.01	50.12	72.73	100.90	156.93	170.93

Note: Missing values found by interpolation between adjacent values
All values >7.62mm reduced to 7.62mm

Project Monitoring Program

MANU RIVER FCDI PROJECT

Adjusted Pan Evaporation (mm) at Sylhet (Stn. No. E38)

	1992												1993												1994				
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	3.05	7.62	3.56	5.08	5.59	3.76	2.38	5.20	1.26	4.90	4.06	3.56	3.05	3.35	3.56	6.10	2.87	6.11	6.24	5.08	1.90	5.08	5.08	5.08	5.08	0.94	4.83	4.78	
2	3.56	1.92	4.06	5.59	3.33	5.08	2.36	6.14	4.57	4.57	4.06	3.56	3.56	3.05	4.06	6.10	6.10	2.38	3.81	4.74	6.85	7.11	4.57	5.08	5.08	1.43	5.08	6.66	
3	2.03	1.90	3.56	5.59	1.42	5.08	5.14	1.90	5.71	4.06	4.57	3.56	3.56	3.56	4.06	5.59	3.78	3.49	5.08	4.57	2.87	5.08	5.08	4.57	4.57	0.94	5.59	2.40	
4	2.54	3.56	3.56	5.08	5.88	5.59	5.24	6.58	4.57	2.00	4.57	3.56	3.05	3.56	3.56	5.59	6.48	2.96	2.84	3.32	4.06	4.28	5.08	5.08	4.57	4.06	5.59	7.62	
5	2.54	3.56	3.56	5.59	3.83	5.59	3.28	5.65	3.22	4.57	4.57	3.05	3.05	3.05	4.06	6.10	7.62	6.17	3.25	3.33	5.08	5.08	4.57	5.08	4.06	4.06	5.08	5.08	
6	2.03	3.56	3.56	5.20	5.08	5.08	4.01	5.77	3.10	4.06	4.06	3.56	3.05	3.56	4.06	5.59	6.45	3.88	2.86	3.33	2.38	5.08	4.57	4.57	4.06	4.57	4.57	4.28	
7	2.03	3.56	3.05	5.08	5.92	5.08	2.36	7.62	6.07	4.06	4.06	4.06	3.56	3.56	4.06	5.59	5.09	5.73	3.35	4.34	1.92	5.59	4.57	4.57	4.06	4.57	4.57	5.08	
8	2.54	3.05	3.56	5.22	5.08	5.41	4.22	5.20	4.44	4.57	4.57	3.56	3.56	4.06	3.56	5.08	5.08	5.08	5.08	5.45	1.43	1.89	5.08	5.08	4.57	4.57	5.08	4.24	
9	2.54	3.05	3.56	5.08	5.59	5.08	7.14	7.00	6.02	4.57	4.57	3.56	3.35	3.56	3.56	5.22	4.57	3.82	3.35	5.09	7.62	5.08	5.06	4.57	4.06	4.06	5.59	4.57	
10	2.54	3.05	4.06	5.59	6.65	6.14	3.68	6.08	2.86	4.06	4.06	4.06	5.70	3.56	4.06	5.17	5.63	5.68	5.08	3.79	5.59	5.59	4.57	4.57	4.06	1.90	5.59	4.57	
11	3.05	3.05	4.06	5.08	4.94	5.08	5.68	5.08	1.50	4.06	4.06	3.56	3.56	4.06	4.06	3.81	5.58	3.50	3.25	4.57	4.06	5.59	5.08	5.08	4.57	4.06	6.10	4.06	
12	3.05	3.56	3.56	5.08	5.59	5.26	0.77	4.57	7.62	1.00	4.06	3.56	3.05	3.56	3.56	5.25	3.76	2.44	3.97	5.59	5.08	5.59	4.57	5.08	4.57	4.57	5.59	4.57	
13	3.05	3.56	3.56	5.08	5.59	4.93	6.57	5.08	2.90	3.81	4.06	3.56	3.05	3.56	4.06	5.08	6.71	2.95	4.70	5.59	7.16	5.59	4.57	5.08	4.57	4.57	5.59	4.57	
14	3.05	3.05	3.79	5.59	5.08	0.44	5.57	5.68	7.62	0.51	4.57	3.05	3.56	2.86	4.57	5.08	3.12	5.08	4.66	5.08	5.08	5.08	4.57	4.57	4.06	4.57	8.08	4.06	
15	3.05	3.05	3.05	5.08	2.26	4.19	2.38	3.81	6.07	7.62	4.57	3.05	3.56	7.12	6.62	5.08	5.59	5.59	3.36	3.35	2.38	5.08	5.08	4.57	4.57	4.06	1.43	4.57	
16	3.05	3.05	3.56	5.59	5.70	5.08	3.34	6.57	4.57	3.79	4.57	3.56	3.56	3.56	3.56	5.08	4.26	5.59	3.33	2.50	5.24	1.98	4.57	5.08	7.06	4.06	8.14	5.08	
17	2.54	2.54	4.06	5.59	4.37	4.57	3.32	7.62	4.71	1.00	4.57	3.05	3.05	3.05	4.06	5.58	5.24	4.55	3.32	5.08	3.38	5.08	4.06	4.57	3.32	4.57	4.96	5.22	
18	2.54	3.05	4.06	5.59	6.28	3.28	6.57	4.71	5.57	4.57	4.06	3.05	3.56	5.72	4.06	4.57	6.49	2.00	5.31	6.17	5.59	5.08	4.06	4.57	4.06	4.57	2.78	5.08	
19	3.05	3.56	7.09	4.94	4.06	4.57	6.07	5.57	4.57	4.57	4.06	3.05	3.56	5.58	4.06	4.06	5.08	0.80	7.62	5.24	5.08	5.59	4.57	4.06	4.06	5.08	4.57	7.16	
20	3.05	3.56	7.42	5.08	5.08	4.57	4.30	7.62	4.57	4.06	3.56	3.56	3.05	3.56	4.06	5.08	1.41	6.14	4.78	5.70	5.08	5.08	4.06	4.57	4.57	4.57	6.98	3.32	
21	3.05	3.05	2.38	5.08	4.34	4.01	7.62	4.90	4.57	4.73	3.56	3.56	3.05	3.56	4.57	5.59	5.59	2.78	7.62	2.38	5.59	5.08	4.06	4.57	4.06	5.08	6.66	6.65	
22	3.05	6.81	3.56	3.23	5.59	4.57	7.62	4.57	4.57	1.50	3.56	3.05	3.05	5.24	3.78	5.59	6.10	4.93	3.81	1.43	5.59	4.57	4.57	4.57	4.06	3.32	5.08	6.19	
23	2.54	3.05	5.78	4.44	5.59	3.32	2.86	7.56	4.06	3.56	4.06	3.05	3.05	3.05	4.74	6.10	6.10	5.08	2.77	5.71	4.50	4.57	4.57	4.06	4.57	1.90	3.28	5.08	
24	2.54	3.05	4.06	5.08	5.08	3.40	2.84	2.90	4.06	4.06	3.56	3.05	3.05	3.56	4.06	4.36	5.59	2.38	2.40	2.86	5.08	5.08	5.08	4.06	4.57	4.57	1.98	6.44	
25	2.54	3.05	4.06	5.08	5.59	1.56	5.08	4.28	2.36	4.06	3.56	3.05	3.56	3.56	3.56	4.01	5.59	5.08	5.08	1.92	5.08	5.08	4.57	4.57	4.06	5.08	2.40	6.62	
26	2.54	3.56	4.06	4.06	5.08	4.78	5.08	1.41	1.43	4.57	3.56	3.05	3.05	3.05	3.35	3.78	2.86	1.90	5.08	5.59	3.33	4.57	4.57	4.57	4.57	5.08	4.94	3.81	
27	3.05	3.56	4.57	4.06	5.08	3.02	6.08	3.78	6.14	4.06	3.56	3.56	3.05	3.56	5.17	4.42	5.59	3.32	5.59	5.68	5.69	4.57	4.57	5.08	4.06	5.08	6.38	4.27	
28	3.56	4.06	5.08	3.82	2.36	4.57	7.06	5.23	5.58	4.57	3.56	3.05	3.05	3.56	4.06	2.86	3.35	0.90	5.08	4.74	7.62	5.08	4.06	5.08	4.06	4.57	7.62	5.08	
29	3.56	3.56	5.08	5.08	8.01	5.08	5.06	4.57	4.28	4.06	4.06	3.05	3.05		4.06	4.28	6.10	7.14	7.14	2.21	5.00	5.08	4.57	5.08	4.06		5.08	5.59	
30	3.56		5.08	5.08	5.08	2.94	4.57	4.57	2.86	4.06	4.06	3.05	3.56		4.06	5.59	3.30	2.24	7.12	5.08	3.79	5.08	4.57	4.57	4.57		7.57	5.59	
31	3.05		5.08		5.08		4.64	4.57		4.57		3.56	3.05		3.56		6.14		1.43	5.08		5.08		5.08	0.94		5.08		
SUM	87.88	100.55	129.09	150.81	154.19	131.12	142.91	161.82	131.47	120.27	122.43	104.14	103.61	106.58	126.27	151.36	157.19	119.67	138.37	134.60	139.10	153.44	138.68	146.81	133.24	110.50	161.83	152.29	

Note: Missing values found by interpolation between adjacent values

All values >7.62mm reduced to 7.62mm

Project Monitoring Program

MANU RIVER FCDI PROJECT

Manu Project Pumping Station Water Levels (m PWD)

DAY	TIME	1992 MAY U/S	MAY D/S	JUNE U/S	JUNE D/S	JULY U/S	JULY D/S	AUGUST U/S	AUGUST D/S	SEPTEMBER U/S	SEPTEMBER D/S	OCTOBER U/S	OCTOBER D/S	NOVEMBER U/S	NOVEMBER D/S	DECEMBER U/S	DECEMBER D/S
1	07:00	4.12	4.48	6.22	7.53	7.16	7.93	7.93	8.23	8.35	8.02	8.32	8.05	7.79	7.23	5.76	4.30
	17:00	4.12	4.45	6.25	7.47	7.16	7.91	7.93	8.20	8.38	8.09	8.32	8.05	7.76	7.18	5.76	4.28
2	07:00	4.12	4.42	6.25	7.68	7.18	8.20	7.98	8.23	8.38	8.26	8.35	8.00	7.71	7.13	6.76	4.24
	17:00	4.12	4.42	6.28	7.32	7.16	8.20	7.99	8.29	8.38	8.26	8.29	7.99	7.68	7.10	5.75	4.22
3	07:00	4.12	4.42	6.31	7.23	7.23	8.23	8.00	8.40	8.32	8.17	8.29	7.96	7.65	7.01	5.58	4.18
	17:00	4.13	4.33	6.34	7.16	7.23	8.23	8.02	8.40	8.35	8.17	8.23	7.67	7.62	6.97	5.55	4.15
4	07:00	4.12	4.37	6.34	7.07	7.26	8.26	8.02	8.38	8.35	8.11	8.23	7.64	7.62	6.86	5.53	4.13
	17:00	4.12	4.39	6.34	7.01	7.28	8.28	8.02	8.34	8.35	8.08	8.23	7.80	7.58	6.80	5.52	4.10
5	07:00	4.12	4.36	6.34	6.86	7.35	8.46	8.09	8.37	8.35	8.11	8.20	7.77	7.55	6.74	5.50	4.09
	17:00	4.18	4.36	6.37	6.81	7.36	8.61	8.11	8.37	8.35	8.12	8.20	7.77	7.55	6.66	5.47	4.09
6	07:00	4.18	4.51	6.34	6.71	7.42	8.61	8.14	8.37	8.35	8.14	8.17	7.65	7.47	6.62	5.41	4.09
	17:00	4.24	4.63	6.34	6.63	7.44	8.63	8.16	8.37	8.35	8.14	8.17	7.62	7.44	6.51	5.36	4.09
7	07:00	4.24	5.08	6.33	6.52	7.44	8.60	8.20	8.48	8.37	8.11	8.12	7.56	7.41	6.48	5.35	4.09
	17:00	4.24	5.15	6.34	6.45	7.44	8.60	8.22	8.48	8.38	8.11	8.11	7.55	7.35	6.40	5.27	4.02
8	07:00	4.24	5.24	6.34	6.37	7.45	8.38	8.23	8.48	8.35	8.05	8.08	7.50	7.33	6.38	5.23	4.02
	17:00	4.24	5.49	6.34	6.31	7.44	8.63	8.23	8.51	8.34	8.03	8.08	7.48	7.32	6.33	5.15	4.02
9	07:00	4.27	5.73	6.36	6.25	7.45	8.63	8.23	8.51	8.35	8.05	8.06	7.47	7.19	6.29	5.06	4.02
	17:00	4.27	5.79	6.36	6.34	7.47	8.66	8.25	8.57	8.37	8.08	8.05	7.47	7.16	6.26	5.01	4.01
10	07:00	4.27	5.94	6.37	6.43	7.50	8.69	8.26	8.57	8.37	8.20	8.02	7.42	7.10	6.19	4.98	4.01
	17:00	4.30	6.01	6.37	6.45	7.53	8.69	8.26	8.57	8.38	8.37	8.00	7.39	7.09	6.17	4.95	4.01
11	07:00	4.33	6.07	6.39	6.89	7.56	8.73	8.26	8.54	8.40	8.52	7.99	7.35	7.01	6.10	4.92	4.01
	17:00	4.33	6.07	6.39	6.92	7.56	8.73	8.25	8.57	8.38	8.54	7.99	7.32	6.98	6.07	4.91	4.01
12	07:00	4.33	6.10	6.37	7.07	7.59	8.60	8.25	8.55	8.41	8.51	7.56	7.30	6.92	6.02	4.89	3.99
	17:00	4.33	6.10	6.40	7.10	7.59	8.81	8.25	8.64	8.41	8.51	7.77	7.29	6.91	5.96	4.89	3.96
13	07:00	4.33	5.98	6.40	7.24	7.61	8.83	8.23	8.54	8.40	8.52	7.94	7.26	6.67	5.93	4.86	3.98
	17:00	4.33	5.91	6.43	7.26	7.61	8.83	8.23	8.51	8.40	8.54	7.93	7.26	6.83	5.88	4.83	3.98
14	07:00	4.33	5.73	6.45	7.33	7.61	8.81	8.20	8.51	8.43	8.55	7.96	7.41	6.80	5.84	4.82	3.96
	17:00	4.44	5.56	6.45	7.35	7.61	8.78	8.20	8.49	8.43	8.54	8.00	7.47	6.76	5.79	4.79	3.95
15	07:00	4.46	5.52	6.49	7.41	7.62	8.69	8.26	8.48	8.44	8.55	8.05	7.62	6.72	5.75	4.77	3.92
	17:00	4.48	5.41	6.52	7.44	7.61	8.66	8.26	8.44	8.44	8.54	8.05	7.88	6.59	5.72	4.75	3.92
16	07:00	4.57	5.41	6.52	7.41	7.70	8.80	8.26	8.41	8.44	8.51	8.08	8.05	6.55	5.69	4.73	3.90
	17:00	4.57	5.43	6.54	7.41	7.74	8.81	8.26	8.40	8.44	8.51	8.08	8.19	6.49	5.67	4.71	3.89
17	07:00	4.82	5.73	6.54	7.56	7.74	8.75	8.26	8.38	8.44	8.51	8.11	8.26	6.46	5.32	4.69	3.87
	17:00	4.74	5.76	6.54	7.50	7.77	8.78	8.29	8.35	8.44	8.49	8.11	8.29	6.43	5.56	4.68	3.87
18	07:00	4.91	7.10	6.54	7.47	7.77	8.76	8.29	8.29	8.44	8.44	8.11	8.32	6.39	5.53	4.66	3.86
	17:00	4.94	7.21	6.54	7.35	7.77	8.75	8.29	8.28	8.44	8.41	8.11	8.35	6.33	5.47	4.62	3.84
19	07:00	5.12	7.77	6.55	7.32	7.79	8.75	8.29	8.26	8.44	8.35	8.12	8.35	6.25	5.40	4.62	3.84
	17:00	5.12	7.87	6.55	7.35	7.80	8.73	8.31	8.23	8.44	8.32	8.12	8.35	6.20	5.37	4.59	3.84
20	07:00	5.17	7.90	6.57	7.35	7.80	8.72	8.32	8.22	8.43	8.26	8.11	8.34	6.13	5.30	4.53	3.81
	17:00	5.18	7.91	6.57	7.35	7.80	8.72	8.32	8.20	8.41	8.23	8.11	9.35	6.13	5.24	4.51	3.81
21	07:00	5.21	8.00	6.57	7.32	7.80	8.69	8.32	8.14	8.41	8.14	8.11	8.35	6.10	5.19	4.47	3.80
	17:00	5.23	8.02	6.57	7.32	7.82	8.69	8.32	8.14	8.38	8.08	8.11	8.34	6.07	5.12	4.45	3.80
22	07:00	5.23	8.05	6.60	7.26	7.87	8.67	8.32	8.09	8.36	7.99	8.11	8.29	6.05	5.09	4.45	3.78
	17:00	5.24	8.02	6.60	7.24	7.68	8.64	8.32	8.08	8.35	7.91	8.08	8.26	6.04	5.01	4.46	3.76
23	07:00	5.24	8.06	6.62	7.38	7.88	8.64	8.34	8.05	8.35	7.87	8.06	8.23	6.02	4.97	4.42	3.76
	17:00	5.24	7.98	6.62	7.36	7.88	8.64	8.34	8.03	8.35	7.77	8.05	8.22	6.01	4.94	4.42	3.75
24	07:00	5.34	7.98	6.62	7.44	7.90	8.60	8.34	7.99	8.32	7.68	8.05	8.19	5.98	4.91	4.39	3.75
	17:00	5.34	7.90	6.63	7.44	7.90	8.58	8.34	7.97	8.29	7.65	8.05	8.16	5.96	4.91	4.39	3.75
25	07:00	5.35	7.87	6.66	7.47	7.91	8.57	8.35	7.91	8.29	7.59	8.05	8.11	5.94	4.80	4.37	3.75
	17:00	5.35	7.84	6.68	7.48	7.91	8.54	8.35	7.88	8.26	7.56	8.05	8.05	5.94	4.76	4.36	3.73
26	07:00	5.38	7.77	6.83	7.62	7.90	8.49	8.38	7.84	8.26	7.53	8.06	7.99	5.91	4.74	4.36	3.73
	17:00	5.40	7.71	6.91	7.77	7.91	8.48	8.41	7.79	8.26	7.59	9.05	7.94	5.86	4.69	4.36	3.73
27	07:00	5.43	7.65	7.00	7.93	7.93	8.41	8.38	7.77	8.26	7.68	6.02	7.91	5.87	4.66	4.36	3.73
	17:00	5.43	7.59	7.06	8.02	7.94	8.38	8.38	7.77	8.29	7.74	8.00	7.84	5.85	4.65	4.36	3.73
28	07:00	5.44	7.59	7.09	8.14	7.94	8.48	8.35	7.84	8.32	7.85	7.99	7.74	5.82	4.58	4.36	3.72
	17:00	5.52	7.53	7.10	8.19	7.94	8.48	8.35	7.87	8.32	7.90	7.97	7.67	5.81	4.54	4.36	3.72
29	07:00	5.55	7.53	7.10	8.20	7.93	8.38	8.35	7.90	8.32	7.96	7.94	7.62	5.79	4.45	4.34	3.70
	17:00	5.64	7.50	7.15	8.22	7.93	8.32	8.34	7.91	8.08	7.97	7.93	7.59	5.79	4.42	4.34	3.70
30	07:00	5.70	7.50	7.13	8.20	7.77	8.26	8.34	7.94	8.32	7.99	7.93	7.47	5.78	4.37	4.33	3.69
	17:00	5.93	7.58	7.15	8.22	7.93	8.23	8.32	8.00	6.32	8.02	7.88	7.42	5.78	4.36	4.33	3.69
31	07:00	6.05	7.92			7.93	8.17	8.32	8.02			7.87	7.35			4.33	3.67
	17:00	6.10	7.59			7.93	8.16	8.31	7.99			7.84	7.30			4.33	3.67

DAY	TIME	1993 JANUARY U/S	JANUARY D/S	FEBRUARY U/S	FEBRUARY D/S	MARCH U/S	MARCH D/S	APRIL U/S	APRIL D/S	MAY U/S	MAY D/S	JUNE U/S	JUNE D/S	JULY U/S	JULY D/S	AUGUST U/S	AUGUST D/S	SEPTEMBER U/S	SEPTEMBER D/S	OCTOBER U/S	OCTOBER D/S	NOVEMBER U/S	NOVEMBER D/S	DECEMBER U/S	DECEMBER D/S
1	07:00	4.33	3.66	4.10	3.61	4.39	6.42	4.16	5.73	4.50	8.43	7.56	8.32	9.42	9.44	9.51	9.48	8.99	6.53	8.31	8.28	6.91	8.83	4.76	4.56
	17:00	4.33	3.66	4.10	3.51	4.39	6.39	4.16	5.70	4.51	6.49	7.58	8.34	9.41	9.42	9.51	9.48	8.92	8.92	8.35	8.26	6.91	6.80	4.74	4.54
2	07:00	4.31	3.64	4.09	3.51	4.36	6.16	4.34	5.59	4.48	6.55	7.59	8.35	9.37	9.37	9.46	9.45	8.98	8.90	8.35	8.26	6.83	6.75	4.69	4.51
	17:00	4.31	3.64	4.09	3.51	4.33	6.10	4.33	5.55	4.48	6.63	7.59	8.37	9.38	9.39	9.47	9.44	8.96	8.90	8.38	8.34	6.63	6.74	4.68	4.46
3	07:00	4.31	3.63	4.08	3.51	4.31	6.04	4.18	5.46	4.50	6.71	7.62	8.38	9.33	9.34	9.47	9.44	8.96	8.92	8.38	8.34	6.77	6.68	4.63	4.44
	17:00	4.30	3.63	4.07	3.49	4.28	5.98	4.18	5.44	4.62	6.92	7.62	8.41	9.31	9.31	9.47	9.44	8.95	8.92	8.37	8.32	6.75	6.66	4.62	4.42
4	07:00	4.30	3.61	4.07	3.48	4.24	5.76	4.18	5.26	4.89	7.13	7.68	8.43	9.28	9.30	9.45	9.42	8.93	8.90	8.32	8.31	6.72	6.62	4.62	4.36
	17:00	4.30	3.61	4.05	3.46	4.24	5.64	4.15	5.21	5.53	7.39	7.70	8.48	9.28	9.30	9.42	9.39	8.93	8.90	8.32	8.29	6.69	6.59	4.56	4.32
5	07:00	4.28	3.60	4.05	3.46	4.21	5.49	4.18	5.03	6.33	8.08	7.77	8.54	9.25	9.25	9.39	9.34	8.93	8.89	9.28	8.26	6.68	6.55	4.54	4.31
	17:00	4.28	3.60	4.05	3.46	4.19	5.43	4.13	5.01	6.42	8.23	7.77	8.58	9.21	9.24	9.38	9.33	8.92	8.89	8.26	8.25	6.65	6.52	4.53	4.30
6	07:00	4.27	3.58	4.05	3.46	4.15	5.27	4.18	4.91	6.49	8.38	8.00	8.69	9.16	9.21	9.33	9.30	8.90	8.87	8.22	8.19	6.62	6.49	4.50	4.27
	17:00	4.27	3.58	4.05	3.44	4.26	5.21	4.18	4.83	6.71	8.43	8.02	8.99	9.16	9.18	9.30	9.28	8.89	8.86	8.20	8.17	6.59	6.46	4.48	4.25
7	07:00	4.27	3.58	4.05	3.44	4.27	5.12	4.18	4.76	6.52	8.61	8.14	9.09	9.15	9.15	9.27	9.24	8.89	8.86	8.17	8.14	6.59	6.45	4.45	4.24
	17:00	4.27	3.58	4.05	3.44	4.15	5.01	4.13	4.71	6.52	8.56	8.19	9.13	9.13	9.15	9.27	9.22	8.89	8.86	8.14	8.11	6.55	6.42	4.44	4.22
8	07:00	4.27	3.58	4.05	3.41	4.27	4.94	4.15	4.57	6.55	8.67	8.26	9.27	9.12	9.13	9.31	9.28	8.89	8.86	8.11	8.08	6.51	6.40	4.41	4.18
	17:00	4.27	3.58	4.05	3.41	4.25	4.80	4.12	4.45	6.65	8.72	8.32	9.27	9.10	9.12	9.34	9.30	8.87	8.84	6.06	6.05	6.49	6.39	4.39	4.16
9	07:00	4.25	3.58	4.05	3.41	4.24	4.69	4.22	4.36	6.54	8.75	6.60	9.34	9.09	9.12	9.37	9.36	8.86	6.63	8.06	6.00	6.43	6.36	4.36	4.12
	17:00	4.25	3.58	4.04	3.40	4.24	4.59	4.15	4.31	6.52	5.75	6.90	9.39	9.09	9.10	9.37	9.36	8.66	8.83	8.06	8.00	6.39	6.33	4.34	4.12
10	07:00	4.24	3.58	4.04	3.40	4.33	4.54	4.12	4.25	6.51	8.69	9.15	9.33	9.09	9.09	9.41	9.39	8.61	8.78	8.05	7.93	6.33	6.26	4.34	4.10
	17:00	4.24	3.61	4.02	3.36	4.30	4.51	4.15	4.30	6.60	8.69	9.30	9.37	9.05	9.07	9.41	9.39	8.51	8.76	7.96	7.91	6.26	6.23	4.33	4.10
11	07:00	4.24	3.63	4.02	3.38	4.27	4.47	4.15	4.30	6.63	8.69	9.37	9.45	9.01	9.04	9.41	9.39	8.78	8.73	7.93	7.87	6.17	6.16	4.33	4.09
	17:00	4.24	3.64	4.02	3.37	4.27	4.45	4.19	4.30	6.62	8.70	9.37	9.48	8.99	8.99	9.39	9.59	8.76	8.72	7.90	7.85	6.16	6.10	4.31	4.07
12	07:00	4.25	3.67	4.02	3.35	4.27	4.41	4.34	4.50	5.60	8.36	9.48	9.53	8.98	8.96	9.36	9.31	8.72	8.69	7.85	7.80	6.14	5.98	4.30	4.06
	17:00	4.25	3.67	4.01	3.35	4.27	4.37	4.36	4.73	7.04	5.96	9.66	9.57	8.95	8.96	9.34	9.26	8.70	8.66	7.84	7.79	6.10	5.93	4.30	4.04
13	07:00	4.25	3.67	3.99	3.35	4.27	4.33	4.48	5.49	7.12	8.99	9.83	9.63	8.93	8.96	9.31	9.25	8.67	8.64	7.80	7.74	6.07	5.88	4.30	4.02
	17:00	4.25	3.66	3.99	3.34	4.27	4.30	4.51	5.57	7.16	9.01	10.03	9.86	8.99	8.95	9.28	9.22	8.67	8.63	7.79	7.74	6.07	5.87	4.30	4.02
14	07:00	4.25	3.63	3.99	3.34	4.33	4.28	4.53	5.75	7.26	8.99	10.20	9.68	8.98	8.99	9.24	9.18	8.64	8.61	7.77	7.71	6.04	5.82	4.27	4.01
	17:00	4.24	3.63	3.98	3.34	4.33	4.27	4.54	5.76	7.26	8.99	10.27	9.71	8.98	8.99	9.22	9.15	8.64	8.61	7.76	7.70	5.99	5.79	4.27	3.99
15	07:00	4.24	3.61	3.96	3.32	4.30	4.24	4.54	5.79	7.25	8.93	10.27	9.73	8.99	9.01	9.19	9.12	8.61	8.58	7.73	7.65	5.91	5.72	4.25	3.98
	17:00	4.24	3.61	3.96	3.32	4.31	4.22	4.54	5.75	7.26	8.90	10.23	9.79	8.99	9.02	9.22	9.12	8.60	8.57	7.71	7.65	5.88	5.70	4.25	3.98
16	07:00	4.24	3.61	3.96	3.34	4.30	4.21	4.60	5.72	7.26	8.89	10.14	9.77	8.96	8.98	9.28	9.19	8.58	8.57	7.70	7.62	5.79	5.61	4.25	3.96
	17:00	4.24	3.61	3.96	3.35	4.27	4.18	4.54	5.70	7.30	8.90	10.00	9.79	8.96	8.98	9.27	9.19	8.57	8.54	7.58	7.61	5.73	5.55	4.25	3.95
17	07:00	4.25	3.61	3.96	3.37	4.31	4.34	4.51	5.61	7.42	8.89	10.03	9.79	8.93	9.95	9.25	9.19	8.54	8.52	7.67	7.61	5.69	5.50	4.25	3.93
	17:00	4.25	3.60	3.96	3.43	4.31	4.39	4.51	5.56	7.47	8.89	10.00	9.74	8.90	8.90	9.24	9.18	8.52	8.51	7.65	7.59	5.68	5.47	4.25	3.93
18	07:00	4.24	3.60	3.99	3.54	4.21	4.42	4.50	5.50	7.68	8.93	9.91	9.69	8.95	8.93	9.22	9.16	8.48	8.44	7.64	7.56	5.62	5.44	4.25	3.93
	17:00	4.24	3.60	4.30	4.80	4.21	4.56	4.48	5.44	7.59	8.96	9.86	9.68	9.10	8.98	9.21	9.15	8.46	8.43	7.82	7.55	5.61	5.44	4.24	3.92
19	07:00	4.24	3.58	4.42	5.64	4.24	4.60	4.47	5.40	7.51	8.96	9.83	9.66	9.12	9.05	9.21	9.12	8.41	8.38	7.59	7.53	5.59	5.41	4.24	3.92
	17:00	4.22	3.58	4.47	6.17	4.22	4.59	4.50	5.40	7.51	8.96	9.82	9.71	9.21	9.15	9.21	9.12	8.38	8.64	7.58	7.51	5.59	5.41	4.22	3.90
20	07:00	4.22	3.58	4.53	6.43	4.22	4.54	4.61	5.34	7.68	8.87	9.83	9.77	9.50	9.45	9.18	9.10	8.29	8.26	7.55	7.50	6.55	5.37	4.22	3.90
	17:00	4.21	3.57	4.38	6.71	4.22	4.54	4.48	5.29	7.62	8.90	9.83	9.77	9.57	9.45	9.18	9.09	8.28	8.25	7.56	7.62	5.50	5.34	4.22	3.90
21	07:00	4.21	3.57	4.38	6.66	4.22	4.56	4.45	5.18	7.59	8.87	9.82	9.76	9.56	9.56	9.12	9.06	8.25	8.22	7.53	7.74	5.48	5.30	4.22	3.90
	17:00	4.19	3.57	4.24	6.71	4.22	4.53	4.41	5.12	7.59	8.83	9.82	9.74	9.77	9.63	9.10	9.24	8.23	8.20	7.50	7.42	5.44	5.29	4.22	3.90
22	07:00	4.18	3.57	4.41	6.77	4.21	4.48	4.42	5.19	7.56	8.75	9.82	9.74	9.94	9.77	9.09	9.01	8.20	8.17	7.45	7.39	5.40	5.21	4.22	3.89
	17:00	4.18	3.57	4.39	6.77	4.21	4.44	4.41	5.06	7.56	8.72	9.82	9.77	10.00	9.82	9.07	8.99	8.17	8.14	7.44	7.36	5.38	5.21	4.22	3.89
23	07:00	4.15	3.55	4.44	6.72	4.21	4.36	4.37	4.88	7.55	8.66	9.80	9.74	10.18	9.91	9.06	9.01	8.14	8.14	7.36	7.33	5.37	5.20	4.12	3.87
	17:00	4.15	3.55	4.45	6.72	4.21	4.34	4.36	4.85	7.53	8.61	9.77	9.73	10.27	9.97	9.05	9.01	8.11	8.11	7.41	7.30	5.35	5.21	4.12	3.87
24	07:00	4.15	3.55	4.47	6.83	4.22	4.34	4.36	4.79	7.51	8.54	9.77	9.71	10.37	9.98	9.04	8.99	8.14	8.11	7.38	7.27	5.32	5.14	4.18	3.87
	17:00	4.15	3.55	4.57	6.63	4.19	4.36	4.34	4.77	7.51	8.51	9.74	9.71	10.38	10.00	9.04	8.99	8.12	8.09	7.35	7.24	5.30	5.12	4.19	3.87
25	07:00	4.13	3.54	4.48	6.55	4.19	4.41	4.47	4.89	7.50	8.49	9.74	9.69	10.32	9.98	9.02	8.98	8.06	8.05	7.32	7.21	5.27	5.09	4.18	3.88
	17:00	4.12	3.54	4.44	6.51	4.19	4.47	4.48	4.94	7.48	8.46	9.74	9.66	10.24	9.95	9.02	8.96	8.06	8.03	7.29	7.18	5.24	5.03	4.18	3.86
26	07:00	4.12	3.54	4.48	6.43	4.19	4.57	4.28	4.85	7.47	8.38	9.74	9.66	10.11	9.89	9.02	8.95	8.06	8.00	7.26	7.16	5.18	4.97	4.18	3.84
	17:00	4.12	3.54	4.36	6.40	4.19	4.69	4.27	4.83	7.47	8.35	9.69	9.66	10.05	9.86	9.02	8.95	8.06	7.99	7.24	7.13	5.12	4.89	4.19	3.84
27	07:00	4.12	3.52	4.30	6.42	4.21	5.55	4.39	4.94	7.45	8.32	9.65	9.60	9.92	9.79	9.02	8.95	8.06	7.99	7.18	7.09	5.03	4.85	4.18	3.83
	17:00	4.12	3.52	4.30	6.42	4.21	5.75	4.42	5.06	7.45	8.31	9.60	9.59	9.86	9.77	8.99	8.95	8.06	7.99	7.16	7.06	4.98	4.80	4.18	3.83
28	07:00	4.12	3.52	4.21	6.40	4.22	5.88	4.42	5.26	7.53	8.26	9.57	9.54	9.79	9.71	9.10	8.98	8.08	8.02	7.15	7.03	4.95	4.75	4.18	3.81
	17:00	4.12	3.52	4.21	6.40	4.19	5.93	4.37	5.55	7.53	8.25	9.51	9.51	9.74	9.68	9.10	8.99	8.16	8.09	7.13	7.01	4.92	4.73	4.18	3.81
29	07:00	4.12	3.52			4.19	6.01	4.42	5.72	7.47	8.20	9.50	9.48	9.68	9.65	9.09	8.99	8.17	8.11	7.09	6.98	4.68	4.66	4.18	3.80
	17:00	4.12	3.52			4.21	6.01	4.42	6.01	7.47	8.13	9.47	9.47	9.66	9.63	9.09	8.98	8.23	8.16	7.06	6.97	4.86	4.68	4.18	3.80
30	07:00	4.12	3.51			4.22	6.01	4.44	6.25	7.47	8.14	9.44	9.45	9.63	9.59	9.09	8.99	8.26	8.23	7.00	6.94	4.83	4.65	4.18	3.78
	17:00	4.12	3.51			4.24	5.93	4.45	6.33	7.47	6.12	9.44	9.45	9.60	9.56	9.09	8.99	8.28	8.25	6.97	6.91	4.77	4.60	4.18	3.78
31	07:00	4.12	3.51			4.24	5.85			7.47	8.08			9.56	9.53	9.02	8.98			6.94	6.87			4.18	3.78
	17:00	3.98	3.51			4.24	5.81			7.50	8.12			9.54	9.51	8.98	8.95			6.92	6.84			4.18	3.78

DAY	TIME	1994 JANUARY U/S	JANUARY D/S	FEBRUARY U/S	FEBRUARY D/S	MARCH U/S	MARCH D/S	APRIL U/S	APRIL D/S	MAY U/S	MAY D/S
1	07:00	4.15	3.76	3.96	3.63	3.81	3.51	5.46	7.87		
	17:00	4.16	3.76	3.95	3.63	3.81	3.51	5.75	7.93		
2	07:00	4.16	3.76	3.95	3.63	3.81	3.51	6.16	8.20		
	17:00	4.18	3.76	3.93	3.63	3.81	3.51	6.20	8.28		
3	07:00	4.18	3.75	3.93	3.61	3.81	3.49	6.25	8.35		
	17:00	4.16	3.75	3.93	3.81	3.90	3.49	6.25	8.35		
4	07:00	4.16	3.75	3.92	3.60	3.80	3.48	6.25	8.38		
	17:00	4.16	3.75	3.92	3.60	3.78	3.48	8.25	6.38		
5	07:00	4.15	3.75	3.92	3.60	3.78	3.46	5.25	8.34		
	17:00	4.15	3.75	3.92	3.61	3.78	3.46	6.25	8.29		
6	07:00	4.15	3.73	3.92	3.60	3.78	3.46	6.23	8.26		
	17:00	4.18	3.75	3.92	3.56	3.78	3.48	6.23	8.25		
7	07:00	4.15	3.75	3.92	3.60	3.76	3.46	6.22	8.23		
	17:00	4.15	3.75	3.92	3.60	3.76	3.48	5.20	8.20		
8	07:00	4.15	3.75	3.92	3.60	3.76	3.48	6.19	8.19		
	17:00	4.15	3.75	3.92	3.60	3.76	3.48	5.19	8.16		
9	07:00	4.13	3.73	3.92	3.56	3.76	3.46	6.17	8.05		
	17:00	4.13	3.73	3.92	3.56	3.76	3.48	6.16	7.96		
10	07:00	4.12	3.72	3.92	3.57	3.78	3.46	6.14	7.84		
	17:00	4.12	3.72	3.92	3.57	3.75	3.46	6.13	7.79		
11	07:00	4.12	3.72	3.92	3.57	3.75	3.46	6.11	7.65		
	17:00	4.12	3.72	3.90	3.57	3.75	3.46	6.11	7.64		
12	07:00	4.12	3.72	3.90	3.57	3.75	3.44	6.08	7.53		
	17:00	4.12	3.72	3.90	3.55	3.73	3.44	6.08	7.50		
13	07:00	4.05	3.70	3.90	3.55	3.73	3.44	6.05	7.39		
	17:00	4.09	3.70	3.89	3.55	3.72	3.43	6.05	7.36		
14	07:00	4.09	3.70	3.89	3.55	3.72	3.41	6.04	7.29		
	17:00	4.09	3.70	3.89	3.55	3.72	3.41	6.04	7.19		
15	07:00	4.09	3.69	3.89	3.55	3.72	3.41	6.02	7.09		
	17:00	4.09	3.69	3.89	3.55	3.72	3.41	6.01	7.06		
16	07:00	4.07	3.69	3.87	3.54	3.72	3.44	5.99	6.96		
	17:00	4.07	3.69	3.87	3.54	3.73	3.46	5.98	6.80		
17	07:00	4.05	3.69	3.87	3.51	3.75	3.48	5.98	6.71		
	17:00	4.04	3.69	3.87	3.51	3.75	3.48	5.98	6.65		
18	07:00	4.05	3.69	3.86	3.51	3.75	3.48	5.96	6.62		
	17:00	4.05	3.67	3.84	3.51	3.75	3.48	5.94	6.46		
19	07:00	4.05	3.67	3.84	3.51	3.75	3.48	5.94	8.37		
	17:00	4.04	3.67	3.84	3.51	3.76	3.51	5.94	6.34		
20	07:00	4.04	3.67	3.84	3.51	3.76	3.51	5.94	5.26		
	17:00	4.04	3.67	3.83	3.51	3.76	3.52	5.94	6.22		
21	07:00	4.04	3.70	3.83	3.51	3.76	3.52	5.94	6.19		
	17:00	4.04	3.69	3.83	3.51	3.80	3.57	6.01	6.17		
22	07:00	4.04	3.70	3.83	3.51	3.80	3.60	5.94	6.13		
	17:00	4.04	3.70	3.83	3.51	3.81	3.60	5.94	6.13		
23	07:00	4.02	3.70	3.83	3.51	3.81	3.66	5.96	6.19		
	17:00	4.02	3.70	3.83	3.51	3.81	3.73	5.94	6.16		
24	07:00	4.02	3.69	3.83	3.51	3.89	4.04	5.99	6.16		
	17:00	4.02	3.69	3.81	3.51	3.92	4.16	5.99	6.16		
25	07:00	4.02	3.65	3.81	3.51	3.99	4.88	6.01	6.15		
	17:00	4.02	3.67	3.81	3.51	4.10	5.06	6.01	6.19		
26	07:00	4.02	3.67	3.81	3.51	4.15	5.49	6.05	6.23		
	17:00	4.01	3.66	3.81	3.51	4.36	5.78	6.05	6.25		
27	07:00	4.01	3.66	3.81	3.51	4.50	6.48	6.07	5.28		
	17:00	4.01	3.66	3.81	3.51	4.98	7.16				
28	07:00	4.01	3.66	3.81	3.51	5.18	7.35				
	17:00	4.01	3.66	3.81	3.51	5.37	7.38				
29	07:00	3.99	3.66			5.37	7.42				
	17:00	3.98	3.64			5.37	7.47				
30	07:00	3.96	3.64			5.37	7.56				
	17:00	3.96	3.64			5.38	7.62				
31	07:00	3.96	3.64			5.41	7.74				
	17:00	3.96	3.64			5.41	7.79				

24

Project Monitoring Program
MANU RIVER FCDI PROJECT

Manu River Water Level (m PWD) at Chandnighat

1992 (W.L.)

DAY	TIME	MAY	JUNE	JULY	AUGUST	SEPT	OCTOBER	NOVEMBER	DECEMBER
1	06:00	6.57	9.27	8.32	9.60	8.76	9.28	7.65	6.90
	18:00	6.67	8.90	8.29	9.72	9.25	9.13	7.60	6.90
2	06:00	6.73	8.64	8.27	9.80	9.23	8.75	7.56	6.92
	16:00	6.76	8.33	8.27	10.70	9.60	8.65	7.53	6.92
3	06:00	6.82	8.11	8.37	10.63	9.10	8.56	7.50	6.91
	18:00	6.72	7.95	8.56	10.55	8.92	8.47	7.48	6.92
4	06:00	6.75	7.82	8.70	10.32	8.85	8.38	7.45	6.95
	18:00	6.73	7.62	8.76	10.16	8.75	8.28	7.43	6.94
5	06:00	6.70	7.45	9.06	9.98	8.65	8.20	7.41	6.92
	16:00	7.78	7.35	9.50	9.89	8.76	8.20	7.39	6.91
6	06:00	8.02	7.25	9.80	9.50	8.87	8.20	7.37	6.89
	18:00	8.08	7.15	9.47	9.64	8.91	8.63	7.35	6.88
7	06:00	8.00	7.05	9.25	9.95	8.85	8.52	7.33	6.87
	19:00	7.92	7.02	9.12	10.02	8.80	8.32	7.31	6.86
8	06:00	8.09	6.96	9.00	9.82	8.76	8.15	7.29	6.85
	18:00	8.16	7.03	8.92	9.80	8.65	8.09	7.27	6.85
9	06:00	7.93	7.62	8.82	9.63	8.57	8.03	7.25	6.64
	16:00	7.62	9.25	9.00	9.68	8.74	7.95	7.25	6.64
10	06:00	7.70	9.05	9.16	9.49	8.32	7.85	7.25	6.64
	16:00	7.50	9.00	9.28	9.34	9.50	7.97	7.24	6.63
11	06:00	7.30	9.95	9.45	9.10	10.79	7.96	7.22	6.83
	16:00	7.18	9.35	9.36	9.94	10.60	7.90	7.21	6.83
12	06:00	7.06	8.90	9.23	8.90	9.80	7.82	7.19	6.82
	18:00	7.00	9.32	9.10	9.15	9.50	7.63	7.18	6.81
13	06:00	6.90	9.24	8.95	9.09	9.48	7.96	7.17	6.80
	18:00	6.86	9.15	8.93	8.93	9.40	8.10	7.16	6.79
14	06:00	6.82	9.02	8.90	8.85	9.34	8.87	7.16	6.77
	18:00	6.78	8.92	8.85	8.76	9.24	9.10	7.14	6.76
15	06:00	6.72	8.85	8.78	8.70	9.12	9.88	7.12	6.76
	18:00	6.63	8.77	9.82	8.95	9.28	9.80	7.11	6.75
16	06:00	6.98	8.72	8.92	9.10	9.19	10.55	7.09	6.74
	18:00	7.60	9.35	9.35	8.92	9.13	10.38	7.06	6.74
17	06:00	9.27	10.02	9.42	8.86	9.25	10.10	7.07	6.73
	18:00	10.12	9.17	9.82	8.73	8.95	9.85	7.07	6.73
18	06:00	9.75	8.73	9.80	8.70	8.76	9.65	7.07	6.73
	16:00	10.45	8.63	9.75	8.70	8.74	9.50	7.07	6.72
19	06:00	10.70	9.17	9.66	8.92	8.72	9.36	7.06	6.72
	18:00	10.05	8.96	9.44	8.89	8.69	9.32	7.06	6.72
20	06:00	9.47	9.65	9.35	8.97	8.64	9.27	7.05	6.72
	18:00	8.99	8.45	9.20	8.95	8.48	9.23	7.05	6.72
21	06:00	8.66	8.29	9.06	8.89	8.35	9.05	7.04	6.71
	16:00	8.52	9.15	9.00	8.80	8.26	8.87	7.04	6.71
22	06:00	8.40	8.11	8.92	8.62	8.16	8.73	7.03	6.71
	16:00	8.30	8.08	8.86	8.46	8.13	8.64	7.03	6.71
23	06:00	8.21	8.07	8.74	9.33	8.09	8.56	7.01	6.70
	18:00	8.21	7.98	8.70	8.25	8.03	8.50	7.00	6.70
24	06:00	8.20	7.88	9.67	8.18	7.96	8.43	6.99	6.70
	18:00	8.19	7.82	8.63	8.13	8.12	8.36	6.98	6.70
25	06:00	8.18	7.82	8.59	9.10	8.12	8.33	6.97	6.70
	18:00	8.10	7.86	8.55	8.09	8.08	8.28	6.96	6.25
26	06:00	8.02	8.14	8.52	8.19	8.14	8.23	6.95	6.06
	18:00	7.91	8.60	8.46	8.44	8.23	8.17	6.95	6.07
27	06:00	7.86	9.04	9.45	8.65	8.48	8.10	6.95	6.07
	18:00	7.92	9.17	9.40	8.60	8.90	8.05	6.94	6.07
28	06:00	8.05	9.13	9.24	8.45	9.50	8.00	6.94	6.07
	18:00	8.18	8.80	9.10	8.35	9.62	7.96	6.94	6.07
29	06:00	8.24	8.60	8.90	8.25	9.50	7.91	6.93	6.07
	18:00	8.50	8.48	8.70	8.18	8.37	7.87	6.92	6.07
30	06:00	8.87	8.40	8.80	8.14	9.20	7.82	6.81	6.07
	18:00	9.30	8.36	8.53	8.74	9.22	7.78	6.90	6.07
31	06:00	9.74		9.10	9.05		7.74		6.07
	18:00				8.85		7.70		6.07

1993 (W.L.)

DAY	TIME	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	OCTOBER
1	06:00	6.40	9.01	6.60	5.96	8.30	10.82	9.72		9.54	9.38
	18:00	6.59	6.60	6.50	5.96	8.27	10.70	9.60		9.39	9.30
2	06:00	6.55	6.60	6.59	6.29	8.46	10.73	9.42		9.56	9.18
	16:00	6.94	6.60	6.56	6.23	8.96	10.74	9.34		9.86	8.97
3	06:00	6.84	6.60	6.55	6.20	9.24	10.42	9.33		9.81	9.19
	18:00	6.84	6.06	6.36	6.20	10.75	10.17	9.33		9.56	9.25
4	06:00	6.84	6.06	6.34	6.19	11.33	10.76	9.34		9.48	9.03
	18:00	6.33	6.06	6.34	6.19	11.55	10.75	9.29		9.41	8.86
5	06:00	6.22	6.06	6.34	6.30	11.37	10.73	9.23		9.26	8.77
	16:00	6.22	6.06	6.34	6.30	11.58	11.03	9.18		9.15	8.65
6	06:00	6.22	6.06	6.34	6.54	11.65	11.66	9.16		9.78	8.51
	18:00	6.22	6.45	6.34	6.56	11.50	12.17	9.15		10.21	8.43
7	06:00	6.22	6.44	6.20	6.60	11.30	12.44	9.14		10.29	8.39
	19:00	6.22	6.44	6.03	6.06	11.14	12.95	9.14		10.37	8.38
8	06:00	6.22	6.44	5.99	6.03	10.95	13.25	9.20		10.06	8.36
	18:00	6.22	6.44	5.97	6.03	10.90	13.17	9.16		9.62	8.58
9	06:00	6.22	6.44	5.96	6.10	10.80	13.04	9.23	11.09	9.41	8.57
	16:00	6.22	6.44	5.93	6.12	10.44	12.70	9.40	10.76	9.34	8.36
10	06:00	6.22	6.44	6.11	6.55	10.17	12.42	9.33	10.35	9.15	8.23
	16:00	6.75	6.44	6.30	6.66	9.95	12.28	9.22	10.17	9.05	8.13
11	06:00	6.90	6.44	5.33	7.17	9.73	12.24	9.17	10.51	9.05	8.06
	16:00	6.50	6.44	6.33	7.33	9.94	12.31	8.97	10.53	8.97	7.99
12	06:00	6.37	6.44	6.31	8.70	10.25	12.46	8.94	10.16	8.96	7.93
	18:00	6.37	6.57	6.30	9.42	10.85	12.70	8.94	9.76	9.09	7.89
13	06:00	7.40	6.44	6.29	9.53	10.98	12.73	8.93	9.52	9.05	7.85
	18:00	6.94	6.57	6.29	8.27	10.57	12.55	9.19	9.36	9.32	7.91
14	06:00	6.04	6.57	6.29	7.90	11.02	12.44	9.48	9.25	9.43	8.08
	18:00	6.04	6.10	6.29	7.59	10.66	12.29	9.37	9.18	9.85	8.56
15	06:00	6.04	6.10	6.28	7.33	10.28	12.09	9.32	9.13	9.68	9.18
	18:00	6.04	6.55	6.26	7.20	9.96	11.90	9.44	10.03	9.22	9.56
16	06:00	6.04	6.56	6.26	7.10	9.70	11.58	9.30	10.93	8.96	9.17
	18:00	6.45	6.56	6.28	7.06	9.63	11.40	9.15	11.01	8.85	8.98
17	06:00	6.45	6.56	6.46	6.96	9.63	11.24	9.02	10.74	8.77	8.32
	18:00	6.45	6.55	7.05	6.92	10.02	10.90	8.94	10.31	8.69	8.16
18	06:00	6.46	6.55	7.03	6.85	10.50	10.80	8.92	9.96	8.63	8.12
	16:00	6.46	6.56	6.06	6.80	10.56	10.58	9.05	9.83	8.56	8.03
19	06:00	6.46	6.60	6.05	6.75	10.53	10.95	9.20	9.94	8.49	7.89
	18:00	6.46	6.60	6.05	6.74	10.38	11.53	9.65	9.95	8.44	7.80
20	06:00	6.46	7.63	6.76	6.73	10.10	11.57	11.05	9.84	8.39	7.74
	18:00	6.46	8.30	6.75	6.73	9.75	11.70	11.47	9.61	8.36	7.70
21	06:00	6.46	8.34	6.74	6.69	9.46	11.86	11.78	9.42	8.61	7.67
	16:00	6.46	8.29	8.74	6.66	9.25	11.90	12.10	9.32	8.79	7.62
22	06:00	6.46	8.36	6.14	6.61	9.08	11.85	12.33	9.27	8.51	7.65
	16:00	6.46	7.75	6.33	6.60	8.95	11.85	12.70	9.45	8.33	7.61
23	06:00	6.45	7.52	6.15	6.59	8.85	11.68	12.74	9.64	8.31	7.53
	18:00	6.46	7.61	6.55	6.59	8.77	11.46	12.69	9.59	9.55	8.15
24	06:00	6.46	7.50	6.54	6.56	8.70	11.25	12.50	9.42	10.14	8.21
	18:00	6.46	7.50	6.54	6.56	8.65	11.30	12.37	9.36	9.48	7.91
25	06:00	6.46	7.50	6.54	6.60	8.56	11.35	12.20	9.27	9.06	7.85
	18:00	6.46	6.90	6.54	6.65	8.49	11.23	11.98	9.19	9.04	7.86
26	06:00	6.46	6.60	6.55	6.92	8.45	10.86	11.74	9.27	9.44	7.89
	18:00	6.46	6.60	6.56	7.05	8.20	10.52	11.45	8.19	9.51	7.72
27	06:00	6.46	6.60	6.77	7.24	8.42	10.25	11.23	9.11	9.34	7.53
	18:00	6.46	8.60	6.85	7.21	8.15	10.13	10.86	9.04	9.46	7.43
28	06:00	6.46	6.60	7.00	7.32	8.40	10.05	10.60	9.01	9.39	7.38
	18:00	6.46	6.60	7.05	7.78	8.36	8.80	10.35	9.07	9.58	7.33
29	06:00	6.46		7.80	8.68	9.28	9.65	10.12	9.19	9.78	7.30
	18:00	6.46		7.20	6.65	8.23	9.58	8.93	9.59	9.82	7.27
30	06:00	6.46		6.65	6.53	8.20	9.55	9.78	9.55	9.59	7.25
	18:00	6.01		6.07	6.44	9.35	9.64	8.66	9.49	9.39	7.21
31	06:00	6.01		6.00		10.48		9.62	9.29		7.19
	18:00	6.01		5.99		10.88		9.60	8.75		7.18

1993 (W.L.) – 1994

DAY	TIME	NOVEMBER 1993 W.L.	DECEMBER 1993 W.L.	JANUARY 1994 W.L.	FEBRUARY 1994 G.R	FEBRUARY 1994 W.L.	MARCH 1994 G.R	MARCH 1994 W.L.	APRIL 1994 G.R	APRIL 1994 W.L.	MAY 1994 G.R	MAY 1994 W.L.
1	06:00	7.17	6.68	5.81	1.63	6.53	0.96	5.86	9.10	9.10	0.16	5.06
	18:00	7.15	6.68	5.81	1.78	6.68	0.96	5.86	9.42	9.42	0.15	5.05
2	06:00	7.19	6.67	5.80	1.78	6.68	0.95	5.85	10.82	10.62	0.10	5.00
	16:00	7.15	6.67	6.34	1.31	6.21	0.95	5.85	10.90	10.90	0.06	4.96
3	06:00	7.16	6.67	6.35	1.28	6.18	0.95	5.85	10.90	10.90	0.04	4.94
	18:00	7.18	6.66	6.35	1.28	6.18	1.10	6.00	10.45	10.45	0.56	5.46
4	06:00	7.19	6.65	6.35	1.26	6.16	1.09	5.99	10.01	10.01	0.57	5.47
	18:00	7.49	6.65	6.35	1.27	6.17	1.57	6.47	9.60	9.60	0.57	5.47
5	06:00	7.45	6.65	6.35	1.28	6.18	1.40	6.30	9.25	9.25	0.78	5.68
	16:00	7.33	6.64	6.35	1.28	6.18	1.63	6.53	6.92	8.82	0.90	5.80
6	06:00	7.24	6.65	6.35	1.28	6.18	1.63	6.53	8.70	8.70	0.96	5.86
	18:00	7.14	6.65	6.35	1.28	6.19	1.63	6.53	8.56	8.56	0.95	5.85
7	06:00	7.09	6.63	6.35	1.28	6.18	1.58	6.48	8.45	8.45	7.23	7.23
	19:00	7.05	6.62	6.35	1.20	6.10	1.04	5.94	8.46	8.46	7.19	7.19
8	06:00	7.04	6.62	6.34	1.20	6.10	1.02	5.92	8.41	8.41	1.20	6.10
	18:00	7.01	6.62	6.34	1.20	6.10	0.93	5.83	8.43	8.43	1.26	6.16
9	06:00	7.00	6.61	6.34	1.20	6.10	0.87	5.77	6.36	6.36	1.30	6.20
	16:00	6.98	6.61	6.34	1.34	6.24	0.75	5.65	8.17	8.17	1.25	6.15
10	06:00	6.97	6.61	6.34	1.91	6.81	0.75	5.65	7.98	7.98	1.20	6.10
	16:00	6.96	6.61	6.34	1.10	6.00	0.75	5.65	7.88	7.88	1.10	6.00
11	06:00	6.95	6.60	6.33	1.16	6.06	0.75	5.65	7.75	7.75	1.07	5.97
	16:00	6.94	6.60	6.33	1.23	6.13	1.47	6.37	7.67	7.67	1.03	5.93
12	06:00	6.93	6.60	6.33	1.20	6.10	1.47	6.37	7.59	7.59	1.06	5.96
	18:00	6.91	6.60	6.33	1.36	6.26	1.47	6.37	7.60	7.60	1.34	6.24
13	06:00	6.91	6.60	6.33	1.69	6.59	1.39	6.29	7.42	7.42	7.25	7.25
	18:00	6.90	6.60	6.33	1.52	6.42	1.36	6.26	7.33	7.33	7.53	7.53
14	06:00	6.90	6.59	6.32	1.42	6.32	1.39	6.29	7.25	7.25	7.62	7.52
	18:00	6.89	6.59	6.32	1.43	6.33	1.21	6.11	7.20	7.20	7.38	7.38
15	06:00	6.88	6.58	6.32	1.43	6.33	1.17	6.07	7.14	7.14	7.35	7.35
	18:00	6.88	6.58	5.79	1.42	6.32	1.17	6.07	7.09	7.09	7.64	7.64
16	06:00	6.67	6.57	5.76	1.43	6.33	1.17	6.07	2.14	7.04	7.95	7.95
	18:00	6.87	6.57	5.75	1.41	6.31	1.86	6.76	1.56	6.46	6.65	8.65
17	06:00	6.86	6.56	5.74	1.41	6.31	1.88	6.78	1.52	6.42	9.10	9.10
	18:00	6.85	6.55	5.74	0.80	5.70	1.92	6.82	7.83	7.83	9.26	9.26
18	06:00	6.85	6.55	5.74	0.79	5.69	1.92	6.82	7.12	7.12	9.03	9.03
	16:00	6.83	6.55	6.56	0.78	5.68	1.92	6.82	7.57	7.57	9.50	9.50
19	06:00	6.83	6.55	6.65	0.78	5.68	1.92	6.82	8.17	8.17	9.30	9.30
	18:00	6.83	6.55	6.65	0.77	5.67	1.91	6.81	7.67	7.87	6.76	6.76
20	06:00	6.82	6.55	6.65	0.76	5.66	1.63	6.53	7.61	7.51	6.33	6.33
	18:00	6.81	6.54	6.65	0.78	5.66	1.22	6.12	7.39	7.39	6.11	6.11
21	06:00	6.81	6.54	6.64	0.79	5.69	1.21	6.11	7.31	7.31	7.72	7.72
	16:00	6.80	6.54	6.64	1.33	6.23	1.20	6.10	7.26	7.26	7.48	7.48
22	06:00	6.80	6.54	6.62	1.48	6.38	1.20	6.10	7.45	7.45	7.31	7.31
	16:00	6.79	6.54	5.80	1.67	6.57	1.20	6.10	7.74	7.74	7.32	7.32
23	06:00	6.79	6.53	5.81	1.67	6.57	1.19	6.09	9.26	9.26	7.34	7.34
	18:00	6.78	6.53	5.80	1.67	6.57	1.45	6.35	8.03	8.03	7.42	7.42
24	06:00	6.77	6.51	5.76	1.69	6.59	1.63	6.53	7.61	7.61	7.45	7.45
	18:00	6.76	6.51	5.78	2.01	6.91	1.83	6.73	7.41	7.41	7.40	7.40
25	06:00	6.75	6.50	5.78	2.05	6.95	1.71	6.61	7.27	7.27	7.50	7.50
	18:00	6.74	6.50	5.77	2.05	6.95	8.45	8.45	7.20	7.20	7.50	7.50
26	06:00	6.75	6.50	5.79	2.03	6.93	8.60	8.60	7.40	7.40	7.80	7.80
	18:00	6.74	6.50	6.24	2.02	6.92	9.33	8.33	7.49	7.49	7.98	7.98
27	06:00	6.73	6.49	6.26	2.01	6.91	10.48	10.48	7.43	7.43	7.93	7.93
	18:00	6.73	6.49	6.25	1.08	5.98	11.02	11.02	7.36	7.36	7.76	7.76
28	06:00	6.72	6.48	6.29	0.99	5.89	10.45	10.45	7.27	7.27		
	18:00	6.71	5.94	6.20	0.98	5.88	10.03	10.03	7.19	7.19		
29	06:00	6.71	5.86	6.20			9.74	9.74	0.50	5.40		
	18:00	6.70	5.83	5.73			9.38	9.38	0.40	5.30		
30	06:00	6.69	5.83	5.92			9.12	9.12	0.32	5.22		
	18:00	6.68	6.83	5.71			8.09	9.09	0.24	5.14		
31	06:00		5.82	5.82			9.30	9.30				
	18:00		5.82	6.45			9.33	8.33				

Project Monitoring Program

MANU RIVER FCDI PROJECT

Manu River Water Level (m PWD) at Kazir Chalk (NERP Station)

DAY	TIME	1992 MAY G.R	MAY W.L	JUNE G.R	JUNE W.L	JULY G.R	JULY W.L	AUGUST G.R	AUGUST W.L	SEPT	OCTOBER G.R	OCTOBER W.L	NOVEMBER G.R	NOVEMBER W.L	DECEMBER G.R	DECEMBER W.L
1	07:00	-	-	-	-			1.25	13.38		1.27	13.40	0.07	12.19	0.56	11.57
	05:00	-	-	-	-			0.86	12.99		0.90	13.03	0.05	12.17	0.58	11.67
2	07:00	-	-	-	-			1.47	13.60		0.60	12.73	0.03	12.15	0.59	11.68
	05:00	-	-	-	-						0.54	12.67	0.01	12.14	0.63	11.72
3	07:00	-	-	-	-						0.21	12.34	0.97	12.06	0.64	11.73
	05:00	-	-	-	-			1.60	13.73		0.13	12.26	0.95	12.04	0.66	11.74
4	07:00	-	-	-	-			1.19	13.32		0.06	12.19	0.94	12.03	0.65	11.74
	05:00	-	-	-	-			0.96	13.09		-0.04	12.09	0.93	12.02	0.64	11.73
5	07:00	-	-	-	-	0.15	12.28	0.54	12.67		-0.03	12.10	0.92	12.01	0.61	11.70
	05:00	-	-	-	-	1.04	13.17	0.44	12.57		0.74	12.87	0.91	12.00	0.69	11.68
6	07:00	-	-	-	-	0.67	12.80	0.39	12.52		1.47	13.60	0.90	11.99	0.58	11.67
	05:00	-	-	-	-	0.30	12.43	0.90	13.03		1.53	13.66	0.89	11.98	0.57	11.66
7	07:00	-	-	-	-			0.72	12.85		1.06	13.19	0.86	11.95	0.56	11.65
	05:00	-	-	-	-			0.60	12.73		0.86	12.99	0.85	11.94	0.56	11.65
8	07:00	-	-	-	-			0.34	12.47		0.70	12.83	0.84	11.93	0.55	11.64
	05:00	-	-	-	-			0.56	12.69		0.64	12.77	0.83	11.92	0.55	11.54
9	07:00	-	-	-	-			0.51	12.64		0.50	12.63	0.82	11.91	0.56	11.64
	05:00	-	-	-	-			0.41	12.54		0.45	12.58	0.82	11.91	0.54	11.63
10	07:00	-	-	-	-	0.28	12.41	0.20	12.33		0.68	12.81	0.81	11.90	0.54	11.63
	05:00	-	-	-	-	0.58	12.71	0.04	12.17		0.89	13.02	0.80	11.89	0.53	11.62
11	07:00	-	-	-	-	0.34	12.47				0.57	12.70	0.79	11.88	0.53	11.62
	05:00	-	-	-	-						0.40	12.53	0.78	11.87	0.52	11.61
12	07:00	-	-	-	-			0.92	13.05		0.32	12.45	0.77	11.86	0.51	11.60
	05:00	-	-	-	-			0.59	12.72		0.34	12.47	0.76	11.85	0.51	11.60
13	07:00	-	-	-	-			0.10	12.23		1.49	13.62	0.75	11.84	0.51	11.60
	05:00	-	-	-	-			0.04	12.17		1.80	13.93	0.74	11.83	0.50	11.66
14	07:00	-	-	-	-			0.16	12.29		1.32	13.45	0.73	11.82	0.50	11.59
	05:00	-	-	-	-			0.22	12.35		2.14	14.27	0.73	11.82	0.50	11.59
15	07:00	-	-	-	-	0.06	12.19	0.10	12.23		2.80	14.93	0.72	11.81	0.49	11.69
	05:00	-	-	-	-	0.52	12.65	0.04	12.17		2.46	14.59	0.71	11.80	0.48	11.57
16	07:00	-	-	-	-	0.46	12.59				2.99	15.12	0.70	11.79	0.46	11.57
	05:00	-	-	-	-	0.15	12.28				2.97	15.10	0.69	11.78	0.48	11.57
17	07:00	-	-	-	-	0.42	12.55				2.24	14.37	0.68	11.77	0.48	11.67
	05:00	-	-	-	-	0.52	12.65				1.90	14.03	0.68	11.77	0.49	11.57
18	07:00	-	-	-	-	0.29	12.42				1.63	13.76	0.68	11.77	0.47	11.67
	05:00	-	-	-	-	0.17	12.30				1.47	13.60	0.68	11.77	0.47	11.56
19	07:00	-	-	-	-	0.42	12.55				1.17	13.30	0.68	11.77	0.47	11.56
	06:00	-	-	0.29	12.42	0.36	12.49	0.07	12.20		1.07	13.20	0.68	11.77	0.47	11.55
20	07:00	-	-	0.13	12.26	0.11	12.24	0.19	12.32		1.52	13.66	0.68	11.77	0.46	11.65
	05:00	-	-	0.02	12.15	0.16	12.29	0.21	12.34		1.46	13.59	0.66	11.77	0.46	11.65
21	07:00	-	-	-	-			0.13	12.26		1.05	13.18	0.67	11.76	0.46	11.55
	05:00	-	-	-	-						0.98	13.11	0.67	11.76	0.46	11.55
22	07:00	-	-	-	-						0.89	13.02	0.67	11.76	0.45	11.55
	05:00	-	-	-	-						0.80	12.93	0.66	11.75	0.45	11.54
23	11:00	-	-	-	-						0.69	12.82	0.66	11.75	0.45	11.54
	05:00	-	-	-	-						0.61	12.74	0.65	11.74	0.44	11.54
24	07:00	-	-	-	-						0.55	12.68	0.64	11.73	0.45	11.54
	05:00	-	-	-	-						0.51	12.64	0.63	11.72	0.44	11.53
25	07:00	-	-	-	-						0.57	12.70	0.62	11.71	0.44	11.53
	05:00	-	-	-	-						0.48	12.61	0.63	11.72	0.43	11.52
26	07:00	-	-	-	-						0.37	12.50	0.64	11.73	0.44	11.53
	05:00	-	-	-	-						0.32	12.45	0.63	11.72	0.44	11.63
27	07:00	-	-	0.19	12.32	0.52	12.65				0.28	12.41	0.64	11.73	0.50	11.59
	05:00	-	-	0.27	12.40	1.17	13.29				0.26	12.39	0.64	11.73	0.54	11.63
28	07:00	-	-	-	-	0.71	12.84				0.22	12.35	0.61	11.71	0.77	11.85
	05:00	-	-	-	-	0.41	12.54				0.20	12.33	0.61	11.70	0.96	12.05
29	07:00	-	-	-	-						0.17	12.30	0.60	11.69	0.20	12.33
	05:00	-	-	-	-						0.15	12.28	0.59	11.66	0.42	12.55
30	07:00	-	-	-	-			0.70	12.83		0.12	12.25	0.58	11.68	0.50	12.63
	05:00	-	-	-	-			0.29	12.42		0.11	12.23	0.56	11.67	0.55	12.68
31	07:00	-	-					0.49	12.62		0.09	12.22			0.63	12.76
	05:00	-	-			0.77	12.90				0.06	12.21			0.66	12.78

DAY	TIME	1993 JANUARY G.R	JANUARY W.L	FEBRUARY G.R	FEBRUARY W.L	MARCH G.R	MARCH W.L	APRIL G.R	APRIL W.L	MAY G.R	MAY W.L	JUNE G.R	JUNE W.L	JULY G.R	JULY W.L	AUGUST G.R	AUGUST W.L
1	07:00	0.68	12.81	0.70	12.83	0.20	12.33	0.55	12.68	0.85	12.98	2.40	14.53	1.45	13.58	1.30	13.43
	05:00	0.68	12.81	0.75	12.88	0.14	12.27	0.61	12.74	0.91	13.04	2.32	14.45	1.34	13.47	1.28	13.41
2	07:00	0.68	12.81	0.78	12.91	0.36	12.49	0.62	12.75	1.30	13.43	2.29	14.42	1.25	13.38	1.21	13.34
	05:00	0.67	12.80	0.85	12.98	0.50	12.63	0.64	12.77	1.62	13.75	2.27	14.40	1.27	13.40	1.14	13.27
3	07:00	0.32	12.45	0.86	12.99	0.61	12.74	0.66	12.79	1.70	13.83	2.13	14.26	1.09	13.22	1.10	13.23
	05:00	0.28	12.41	0.82	12.95	0.66	12.79	0.68	12.81	2.15	14.28	1.96	14.09	0.98	13.11	1.30	13.43
4	07:00	0.23	12.36	0.76	12.89	0.72	12.85	0.67	12.80	0.98	16.11	2.40	14.53	0.83	12.96	1.22	13.35
	05:00	0.32	12.45	0.77	12.90	0.74	12.87	0.68	12.81	1.00	16.13	2.34	14.47	0.82	12.95	0.99	13.12
5	07:00	0.44	12.57	0.82	12.95	0.76	12.89	0.63	12.76	0.89	16.02	2.60	14.73	0.85	12.96	0.83	12.96
	05:00	0.48	12.61	0.81	12.94	0.75	12.88	0.60	12.73	0.92	16.05	2.75	14.88	0.89	13.02	0.76	12.89
6	07:00	0.56	12.69	0.82	12.95	0.72	12.85	0.56	12.69	0.69	15.82	0.04	16.17	0.87	13.00	0.73	12.86
	05:00	0.59	12.72	0.81	12.94	0.71	12.84	0.51	12.64	0.52	15.65	0.31	16.44	0.90	13.03	0.70	12.83
7	07:00	0.66	12.79	0.80	12.93	0.72	12.85	0.42	12.55	0.40	15.53	0.27	16.40	0.86	12.99	0.69	12.82
	05:00	0.72	12.85	0.79	12.92	0.75	12.88	0.44	12.57	0.36	15.49	0.33	16.46	0.80	12.93	0.68	12.81
8	07:00	0.76	12.89	0.78	12.91	0.82	12.95	0.50	12.63	0.30	15.43	0.37	16.50	1.04	13.17	1.57	13.70
	05:00	0.77	12.90	0.78	12.91	0.84	12.97	0.56	12.69	0.24	15.37	0.35	16.48	1.30	13.43	2.46	14.59
9	07:00	0.78	12.91	0.75	12.89	0.87	13.00	0.60	12.73	2.73	14.86	0.26	16.39	1.47	13.60	2.70	14.83
	05:00	0.79	12.92	0.75	12.88	0.88	13.01	0.63	12.76	2.58	14.61	0.09	16.22	1.56	13.69	2.33	14.46
10	07:00	0.82	12.95	0.74	12.87	0.89	13.02	0.65	12.78	2.53	14.56	0.80	15.93	1.32	13.45	1.89	14.02
	05:00	0.81	12.94	0.75	12.86	0.89	13.02	0.66	12.79	2.13	14.26	0.76	15.89	1.15	13.28	1.92	14.05
11	07:00	0.68	12.81	0.72	12.85	0.89	13.02	0.67	12.80	1.48	13.61	0.86	15.99	0.88	13.01	2.31	14.44
	05:00	0.69	12.82	0.74	12.87	0.84	12.97	0.73	12.86	1.92	14.05	0.88	16.01	0.70	12.83	2.40	14.53
12	07:00	0.70	12.83	0.79	12.92	0.80	12.93	1.87	14.00	2.60	14.73	0.04	16.17	0.68	12.81	1.94	14.07
	05:00	0.72	12.85	0.80	12.93	0.81	12.94	1.89	14.02	2.48	14.61	0.15	16.28	0.66	12.79	1.69	13.82
13	07:00	0.15	12.28	0.82	12.95	0.81	12.94	1.17	13.30	2.52	14.65	0.99	16.12	0.89	13.02	1.42	13.55
	05:00	0.15	12.28	0.81	12.94	0.82	12.95	0.95	13.08	2.55	14.68	0.94	16.07	1.65	13.78	1.26	13.39
14	07:00	0.24	12.37	0.77	12.90	0.82	12.95	0.48	12.61	2.42	14.55	0.85	15.98	1.73	13.86	1.05	13.18
	05:00	0.31	12.44	0.79	12.92	0.83	12.96	0.25	12.38	2.35	14.48	0.82	15.95	1.70	13.83	0.96	13.09
15	07:00	0.49	12.62	0.83	12.96	0.85	12.98	0.96	12.08	1.92	14.05	0.31	15.44	1.66	13.79	0.76	12.89
	05:00	0.54	12.67	0.86	12.99	0.92	13.05	0.92	12.02	1.74	13.87	0.23	15.36	1.88	14.01	2.73	14.86
16	07:00	0.65	12.78	0.89	13.02	0.95	13.08	0.68	11.96	1.70	13.83	0.09	15.22	1.32	13.45	2.96	15.09
	05:00	0.66	12.79	0.86	13.01	0.90	13.03	0.78	11.88	1.62	13.75	0.04	15.17	1.18	13.31	0.18	15.31
17	07:00	0.88	12.81	0.82	12.95	0.82	12.95	0.66	11.76	1.65	13.78	2.62	14.75	0.89	13.02	2.67	14.60
	05:00	0.88	12.81	0.80	12.93	0.76	12.89	0.64	11.74	1.85	13.98	2.45	14.58	0.84	12.97	2.40	14.53
18	07:00	0.68	12.81	0.79	12.92	0.70	12.83	0.60	11.70	1.97	14.10	2.12	14.25	0.81	12.94	2.19	14.32
	05:00	0.68	12.81	0.79	12.92	0.74	12.87	0.57	11.67	2.09	14.22	2.14	14.27	0.78	12.91	2.03	14.16
19	07:00	0.68	12.81	0.78	12.91	0.79	12.92	0.55	11.65	2.10	14.23	2.95	15.08	1.05	13.18	1.89	14.02
	06:00	0.67	12.80	0.79	12.92	0.82	12.95	0.54	11.64	2.04	14.17	0.19	15.32	1.12	13.25	2.24	14.37
20	07:00	0.66	12.79	1.27	13.40	0.86	12.99	0.52	11.62	1.85	13.98	0.29	15.42	0.52	15.65	2.03	14.16
	05:00	0.65	12.78	1.22	13.35	0.80	12.93	0.56	11.66	1.74	13.87	0.45	15.69	0.59	15.72	1.86	13.99
21	07:00	0.66	12.79	1.25	13.38	0.68	12.81	0.56	11.66	1.54	13.67	0.72	15.85	0.82	15.95	1.64	13.77
	05:00	0.64	12.77	1.12	13.25	0.72	12.85	0.57	11.67	1.49	13.62	0.66	15.79	0.89	16.02	1.52	13.65
22	07:00	0.62	12.75	0.94	13.07	0.79	12.92	0.46	11.56	1.09	13.22	0.62	15.75	0.94	16.07	1.61	13.74
	05:00	0.61	12.74	0.64	12.77	0.82	12.95	0.46	11.56	1.00	13.13	0.48	15.61	1.00	16.13	1.70	13.63
23	11:00	0.60	12.73	0.48	12.61	0.84	12.97	0.45	11.55	0.96	13.09	0.35	15.48	0.96	16.09	1.79	13.92
	05:00	0.59	12.72	0.42	12.55	0.86	12.99	0.44	11.54	0.90	13.03	0.17	15.30	0.90	16.03	1.88	14.01
24	07:00	0.58	12.71	0.26	12.41	0.89	13.02	0.42	11.52	0.69	12.62	2.90	15.03	0.79	15.92	1.59	13.72
	05:00	0.56	12.69	0.24	12.37	0.83	12.96	0.40	11.50	0.52	12.69	0.22	15.35	0.74	15.87	1.44	13.67
25	07:00	0.55	12.68	0.16	12.21	0.66	12.79	0.40	11.50	0.43	12.66	0.12	15.26	0.42	15.55	1.32	13.49
	05:00	0.55	12.58	0.12	12.25	0.63	12.76	0.54	11.64	0.39	12.52	0.04	15.17	0.21	15.34	1.28	13.41
26	07:00	0.53	12.66	0.02	12.15	0.59	12.72	0.84	11.94	0.32	12.46	2.44	14.57	2.96	15.09	1.26	13.39
	05:00	0.53	12.66	0.10	12.23	0.60	12.73	0.94	12.04	0.48	12.61	2.20	14.33	2.79	14.92	1.24	13.37
27	07:00	0.52	12.65	0.27	12.40	0.81	12.74	0.97	12.07	0.50	12.63	2.10	14.23	2.53	14.66	1.09	13.22
	05:00	0.51	12.64	0.32	12.45	0.63	12.76	0.94	12.04	0.47	12.60	2.02	14.15	2.48	14.61	0.98	13.11
28	07:00	0.50	12.63	0.28	12.41	0.65	12.78	0.95	12.06	0.47	12.60	1.82	13.95	2.18	14.31	0.94	13.07
	05:00	0.48	12.61	0.25	12.38	0.61	12.74	0.99	12.09	0.47	12.60	1.70	13.83	1.96	14.09	0.92	13.05
29	07:00	0.44	12.57			0.31	12.44	1.58	13.71	0.47	12.60	1.34	13.47	1.72	13.85	1.34	13.47
	05:00	0.42	12.55			0.15	12.28	1.42	13.55	0.46	12.59	1.28	13.41	1.61	13.74	1.66	13.79
30	07:00	0.38	12.51			0.86	11.96	1.15	13.28	1.19	13.32	1.20	13.33	1.50	13.63	1.52	13.65
	05:00	0.42	12.55			0.07	12.20	1.38	13.51	2.06	14.19	1.49	13.62	1.44	13.57	1.42	13.55
31	07:00	0.55	12.68			0.33	12.46			2.63	14.76			1.35	13.48	1.72	13.85
	05:00	0.58	12.71			0.46	12.59			0.32	15.45			1.32	13.45	1.78	13.91

DAY	TIME	1993 SEPT G.R	SEPT W.L	OCTOBER G.R	OCTOBER W.L	NOVEMBER G.R	NOVEMBER W.L	DECEMBER G.R	DECEMBER W.L	1994 JANUARY G.R	JANUARY W.L	FEBRUARY G.R	FEBRUARY W.L	MARCH G.R	MARCH W.L	APRIL G.R	APRIL W.L	MAY G.R	MAY W.L
1	07:00	1.76	13.89	1.40	13.53	0.10	12.23	0.61	11.71	0.12	12.25	0.37	12.50	0.27	12.40	1.46	13.59	0.69	11.79
	05:00	1.74	13.87	1.45	13.58	0.12	12.25	0.61	11.71	0.20	12.33	0.35	12.48	0.32	12.45	2.15	14.25	0.68	11.78
2	07:00	1.99	14.12	1.52	13.55	0.09	12.22	0.61	11.71	0.42	12.55	0.26	12.39	0.39	12.52	2.82	14.95	0.67	11.77
	05:00	2.10	14.23	1.57	13.70	0.07	12.20	0.60	11.70	0.41	12.54	0.18	12.31	0.44	12.57	2.98	15.11	0.66	11.76
3	07:00	1.90	14.03	1.70	13.63	0.12	12.25	0.60	11.70	0.40	12.53	0.14	12.27	0.49	12.62	2.62	14.75	0.65	11.75
	05:00	1.75	13.88	1.65	13.78	0.19	12.32	0.59	11.65	0.39	12.52	0.19	12.32	0.50	12.63	2.26	14.39	0.63	11.73
4	07:00	1.59	13.72	1.22	13.35	0.41	12.54	0.59	11.69	0.38	12.51	0.28	12.41	0.51	12.64	2.12	14.25	0.62	11.72
	05:00	1.46	13.59	1.09	13.22	0.36	12.49	0.59	11.69	0.37	12.50	0.36	12.49	0.49	12.62	2.04	14.17	0.61	11.71
5	07:00	1.28	13.41	1.03	13.16	0.27	12.40	0.59	11.69	0.37	12.50	0.45	12.58	0.46	12.59	1.93	14.06	0.66	11.76
	05:00	1.16	13.29	0.92	13.05	0.18	12.31	0.57	11.67	0.36	12.49	0.49	12.62	0.36	12.49	1.81	13.94	0.82	11.92
6	07:00	2.00	14.13	0.81	12.94	0.16	12.29	0.57	11.67	0.37	12.50	0.50	12.63	0.30	12.43	1.65	13.78	0.88	11.98
	05:00	2.26	14.39	0.74	12.87	0.13	12.26	0.57	11.67	0.37	12.50	0.51	12.64	0.29	12.42	1.14	13.27	0.92	12.02
7	07:00	2.36	14.49	0.66	12.79	0.09	12.22	0.57	11.67	0.37	12.50	0.52	12.65	0.28	12.41	0.84	12.97	0.95	12.05
	05:00	2.37	14.50	0.62	12.75	0.03	12.16	0.57	11.57	0.37	12.50	0.53	12.66	0.26	12.39	0.58	12.71	0.96	12.06
8	07:00	2.03	14.16	1.25	13.38	0.96	12.06	0.57	11.67	0.37	12.50	0.49	12.62	0.28	12.41	0.60	12.73	0.84	11.94
	05:00	1.80	13.93	1.28	13.41	0.90	12.00	0.57	11.67	0.36	12.49	0.50	12.63	0.36	12.49	0.62	12.75	0.77	11.87
9	07:00	1.75	13.88	0.97	13.10	0.88	11.98	0.56	11.66	0.36	12.49	0.52	12.65	0.46	12.59	0.64	12.77	0.73	11.83
	05:00	1.59	13.72	0.89	13.02	0.87	11.97	0.56	11.66	0.34	12.47	0.53	12.66	0.47	12.60	0.32	12.45	0.70	11.80
10	07:00	1.34	13.47	0.66	12.79	0.86	11.96	0.56	11.66	0.33	12.46	0.24	12.37	0.48	12.61	0.24	12.37	0.67	11.77
	05:00	1.22	13.35	0.55	12.68	0.85	11.95	0.56	11.66	0.32	12.45	0.29	12.42	0.49	12.62	0.10	12.23	0.66	11.76
11	07:00	1.34	13.47	0.46	12.59	0.85	11.95	0.56	11.66	0.30	12.43	0.32	12.45	0.50	12.63	0.04	12.17	0.70	11.80
	05:00	1.23	13.36	0.40	12.53	0.82	11.92	0.56	11.65	0.29	12.42	0.35	12.48	0.52	12.65	0.96	12.09	0.72	11.82
12	07:00	1.52	13.65	0.35	12.48	0.81	11.91	0.55	11.65	0.28	12.41	0.41	12.54	0.50	12.63	0.94	12.04	0.75	11.85
	05:00	1.43	13.56	0.30	12.43	0.79	11.89	0.55	11.65	0.27	12.40	0.45	12.59	0.48	12.61	0.92	12.02	0.12	12.25
13	07:00	1.33	13.46	0.32	12.45	0.77	11.87	0.55	11.65	0.25	12.38	0.41	12.54	0.42	12.55	0.91	12.01	0.42	12.55
	05:00	1.43	13.56	0.39	12.52	0.78	11.88	0.55	11.65	0.23	12.36	0.36	12.49	0.38	12.51	0.90	12.00	0.56	12.69
14	07:00	1.99	14.12	0.58	12.71	0.77	11.87	0.54	11.64	0.22	12.35	0.31	12.44	0.37	12.50	0.85	11.98	0.60	12.73
	05:00	2.27	14.40	1.12	13.25	0.76	11.86	0.53	11.63	0.21	12.34	0.27	12.40	0.36	12.49	0.82	11.92	0.42	12.55
15	07:00	2.04	14.17	1.91	14.04	0.76	11.86	0.53	11.63	0.20	12.33	0.24	12.37	0.40	12.53	0.74	11.84	0.36	12.51
	05:00	1.57	13.70	2.00	14.13	0.77	11.87	0.53	11.63	0.19	12.32	0.21	12.34	0.49	12.62	0.70	11.80	0.40	12.53
16	07:00	1.23	13.36	1.39	13.52	0.76	11.86	0.53	11.63	0.28	12.41	0.18	12.31	0.54	12.67	0.72	11.82	1.10	13.23
	05:00	1.07	13.20	1.09	13.22	0.75	11.85	0.53	11.63	0.49	12.62	0.16	12.29	0.55	12.68	0.80	11.90	1.50	13.63
17	07:00	0.93	13.06	0.82	12.95	0.74	11.84	0.52	11.62	0.48	12.61	0.26	12.39	0.52	12.65	0.89	11.99	1.98	14.11
	05:00	0.86	12.99	0.72	12.85	0.73	11.83	0.52	11.62	0.50	12.63	0.30	12.43	0.49	12.62	0.96	12.06	1.69	14.02
18	07:00	0.74	12.87	0.64	12.77	0.72	11.82	0.52	11.62	0.58	12.71	0.34	12.47	0.46	12.59	0.36	12.49	1.35	13.48
	05:00	0.67	12.80	0.58	12.71	0.73	11.83	0.52	11.62	0.59	12.72	0.38	12.51	0.41	12.54	0.85	12.98	1.98	14.12
19	07:00	0.60	12.73	0.49	12.62	0.74	11.84	0.52	11.62	0.44	12.57	0.48	12.61	0.26	12.39	0.89	13.02	1.68	13.81
	06:00	0.54	12.67	0.39	12.52	0.73	11.83	0.52	11.62	0.40	12.53	0.49	12.62	0.19	12.32	0.62	12.75	1.12	13.25
20	07:00	0.50	12.63	0.31	12.44	0.73	11.83	0.51	11.61	0.37	12.50	0.55	12.68	0.16	12.29	0.49	12.62	0.92	13.05
	05:00	0.46	12.59	0.29	12.42	0.72	11.82	0.51	11.61	0.29	12.42	0.56	12.69	0.09	12.22	0.42	12.55	0.67	12.80
21	07:00	1.38	13.51	0.26	12.39	0.72	11.82	0.51	11.61	0.21	12.34	0.57	12.70	0.21	12.34	0.32	12.45	0.52	12.55
	05:00	1.29	13.42	0.28	12.41	0.72	11.82	0.61	11.61	0.15	12.28	0.57	12.70	0.32	12.45	0.26	12.39	0.32	12.45
22	07:00	0.70	12.83	0.26	12.39	0.71	11.81	0.50	11.60	0.12	12.25	0.55	12.65	0.34	12.47	0.69	12.82	0.26	12.39
	05:00	0.62	12.75	0.29	12.42	0.70	11.80	0.52	11.60	0.07	12.20	0.50	12.63	0.36	12.49	0.95	13.08	0.22	12.35
23	11:00	0.72	12.85	0.81	12.94	0.70	11.80	0.50	11.60	0.14	12.27	0.47	12.60	0.38	12.51	0.69	12.82	0.24	12.37
	05:00	1.99	14.12	1.10	13.23	0.69	11.79	0.49	11.59	0.20	12.33	0.51	12.64	0.42	12.55	0.52	12.65	0.29	12.42
24	07:00	2.13	14.26	0.83	12.96	0.69	11.79	0.49	11.59	0.30	12.43	0.65	12.78	0.45	12.58	0.36	12.49	0.31	12.44
	05:00	1.86	13.99	0.68	12.81	0.68	11.78	0.48	11.58	0.36	12.49	0.60	12.73	0.49	12.62	0.32	12.45	0.37	12.50
25	07:00	1.40	13.53	0.74	12.87	0.68	11.78	0.48	11.58	0.44	12.57	0.49	12.62	0.55	12.66	0.30	12.43	0.38	12.51
	05:00	1.52	13.65	0.66	12.79	0.67	11.77	0.48	11.58	0.51	12.64	0.14	12.27	0.85	12.98	0.29	12.42	0.39	12.52
26	07:00	2.04	14.17	0.60	12.73	0.66	11.76	0.47	11.57	0.54	12.67	0.06	12.19	1.24	13.37	0.27	12.40		
	05:00	2.00	14.13	0.48	12.61	0.65	11.75	0.47	11.57	0.55	12.68	0.84	11.94	1.39	13.52	0.30	12.43		
27	07:00	1.80	13.93	0.36	12.49	0.64	11.74	0.46	11.56	0.55	12.58	0.75	11.85	1.73	13.86	0.26	12.39		
	05:00	1.85	13.98	0.25	12.38	0.64	11.74	0.46	11.56	0.57	12.70	0.72	11.82	1.98	14.11	0.24	12.37		
28	07:00	1.88	13.81	0.19	12.32	0.64	11.74	0.47	11.57	0.46	12.59	0.92	12.02	1.36	13.49	0.14	12.27		
	05:00	1.76	13.89	0.15	12.28	0.63	11.73	0.49	11.56	0.49	12.62	0.14	12.27	1.35	13.48	0.08	12.21		
29	07:00	1.84	13.97	0.13	12.26	0.63	11.73	0.51	11.61	0.45	12.58			1.42	13.55	0.92	12.02		
	05:00	1.63	13.76	0.11	12.24	0.62	11.72	0.53	11.63	0.48	12.61			1.44	13.57	0.85	11.96		
30	07:00	1.46	13.59	0.09	12.22	0.62	11.72	0.55	11.85	0.50	12.63			1.36	13.49	0.76	11.86		
	05:00	1.43	13.56	0.06	12.19	0.62	11.72	0.58	11.68	0.55	12.68			1.40	13.53	0.71	11.81		
31	07:00			0.05	12.18			0.83	11.93	0.51	12.64			1.45	13.58				
	05:00			0.03	12.16			0.94	12.04	0.46	12.59			1.49	13.62				

ZERO VALUES(m GTS): 11.67m R3; 10.64m R4

Project Monitoring Program
MANU RIVER FCDI PROJECT

Dhamai Chara Water Level (m PWD) at Road Crossing (NERP Station)

1992

Day	TIME	MAY G.R	MAY WL	JUNE G.R	JUNE WL	JULY G.R	JULY WL	AUGUST G.R	AUGUST WL	SEPT G.R	SEPT WL	OCTOBER G.R	OCTOBER WL	NOVEMBER G.R	NOVEMBER WL	DECEMBER G.R	DECEMBER WL
1	07:00	–	–	0.61	9.88	0.43	9.70	0.50	9.77	0.73	10.00	0.48	9.79	0.43	9.70	0.43	9.70
	05:00	–	–	–		0.50	9.77	0.46	9.73	0.47	9.74	0.47	9.74	0.43	9.70	0.42	9.69
2	07:00	–	–	–		0.45	9.72	0.96	10.25	0.47	9.74	0.47	9.74	0.43	9.70	0.43	9.70
	05:00	–	–	–		0.46	9.70	0.59	9.86	0.45	9.72	0.46	9.73	0.43	9.70	0.42	9.69
3	07:00	–	–	–		0.50	9.77	0.54	9.81	0.45	9.72	0.45	9.72	0.43	9.70	0.43	9.70
	05:00	–	–	–		0.50	9.77	0.51	9.78	0.45	9.72	0.45	9.72	0.42	9.69	0.42	9.69
4	07:00	–	–	–		0.50	9.77	0.47	9.74	0.44	9.71	0.45	9.72	0.43	9.70	0.43	9.70
	05:00	–	–	–		0.50	9.77	0.49	9.72	0.43	9.70	0.45	9.72	0.42	9.69	0.42	9.69
5	07:00	–	–	–		0.10	9.37	0.65	9.92	0.58	9.85	0.45	9.72	0.43	9.70	0.43	9.70
	05:00	–	–	–		0.06	9.33	0.64	9.91	0.47	9.74	0.45	9.72	0.43	9.70	0.43	9.70
6	07:00	–	–	–		0.50	9.77	0.52	9.79	0.48	9.75	0.45	9.72	0.43	9.70	0.44	9.71
	05:00	–	–	–		0.44	9.71	0.63	9.90	0.44	9.71	0.45	9.72	0.42	9.69	0.43	9.70
7	07:00	–	–	–		0.48	9.75	0.51	9.78	0.46	9.73	0.44	9.71	0.43	9.70	0.43	9.70
	05:00	–	–	–		0.20	9.47	0.50	9.77	0.44	9.71	0.43	9.70	0.42	9.69	0.43	9.70
8	07:00	–	–	–		0.40	9.67	0.50	9.77	0.46	9.73	0.43	9.70	0.43	9.70	0.42	9.69
	05:00	–	–	–		0.49	9.76	0.65	9.92	0.45	9.72	0.43	9.70	0.43	9.70	0.42	9.69
9	07:00	–	–	0.69	9.92	0.47	9.74	0.52	9.79	0.61	9.88	0.43	9.70	0.43	9.70	0.43	9.70
	05:00	–	–	–		0.45	9.72	0.60	10.07	0.50	9.77	0.43	9.70	0.42	9.69	0.43	9.70
10	07:00	–	–	0.56	9.85	0.20	9.47	0.54	9.81	0.60	9.87	0.43	9.70	0.43	9.70	0.47	9.74
	05:00	–	–	–		0.04	9.31	0.49	9.76	0.48	9.75	0.43	9.70	0.42	9.69	0.46	9.73
11	07:00	–	–	–		0.07	9.34	0.48	9.75	0.46	9.73	0.43	9.70	0.43	9.70	0.43	9.70
	05:00	–	–	–		0.19	9.46	0.46	9.73	0.47	9.74	0.43	9.70	0.43	9.70	0.42	9.69
12	07:00	–	–	0.60	9.87	0.50	9.77	0.46	9.73	0.46	9.73	0.43	9.70	0.43	9.70	0.43	9.70
	05:00	–	–	0.71	9.98	0.10	9.37	0.46	9.73	0.45	9.72	0.47	9.74	0.43	9.70	0.42	9.69
13	07:00	–	–	0.69	9.96	0.48	9.75	0.46	9.73	0.46	9.72	0.54	9.81	0.43	9.70	0.42	9.69
	05:00	–	–	–		0.49	9.76	0.46	9.73	0.44	9.71	0.51	9.78	0.43	9.70	0.42	9.69
14	07:00	–	–	–		0.49	9.76	0.45	9.72	0.71	9.98	0.48	9.75	0.43	9.70	0.42	9.69
	05:00	–	–	–		0.50	9.77	0.44	9.71	0.55	9.82	0.57	9.84	0.43	9.70	0.42	9.69
15	07:00	–	–	–		0.44	9.71	0.48	9.75	0.50	9.77	0.56	9.83	0.43	9.70	0.41	9.68
	05:00	–	–	–		0.48	9.75	0.48	9.75	0.46	9.73	0.67	9.94	0.43	9.70	0.41	9.68
16	07:00	–	–	–		0.30	9.57	0.46	8.73	0.45	9.72	0.77	10.04	0.43	9.70	0.41	9.68
	05:00	–	–	–		0.37	9.64	0.70	9.97	0.44	9.71	0.52	9.79	0.43	9.70	0.40	9.67
17	07:00	–	–	–		0.50	9.77	0.79	10.06	0.73	10.00	0.53	9.80	0.43	9.70	0.41	9.68
	05:00	–	–	–		0.50	9.77	0.48	9.75	0.50	9.77	0.48	9.75	0.42	9.69	0.40	9.67
18	07:00	–	–	–		0.10	9.37	0.47	9.74	0.46	9.73	0.46	9.73	0.43	9.70	0.42	9.69
	05:00	–	–	–		0.07	9.34	0.46	9.73	0.45	9.72	0.45	9.72	0.43	9.70	0.41	9.68
19	07:00	–	–	0.51	9.78	0.49	9.76	0.47	8.74	0.45	9.72	0.46	9.73	0.44	9.71	0.41	9.66
	05:00	–	–	0.44	9.71	0.50	9.77	0.48	9.75	0.44	9.71	0.46	9.73	0.42	9.69	0.40	9.57
20	07:00	–	–	0.44	9.71	0.01	9.26	0.47	9.74	0.44	9.71	0.46	9.73	0.43	9.70	0.42	9.69
	05:00	–	–	0.44	9.71	0.05	9.32	0.46	9.73	0.43	9.70	0.45	9.72	0.42	9.69	0.42	9.68
21	07:00	–	–	0.48	9.75	0.02	9.29	0.46	9.73	0.43	9.70	0.46	9.73	0.43	9.70	0.41	9.68
	05:00	–	–	0.47	9.74	0.37	9.64	0.45	9.72	0.43	9.70	0.47	9.74	0.42	9.69	0.40	9.67
22	07:00	–	–	0.46	9.73	0.01	9.28	0.45	9.72	0.43	9.70	0.47	9.74	0.43	9.70	0.41	9.68
	05:00	–	–	0.45	9.72	0.18	9.45	0.44	9.71	0.43	9.70	0.47	9.74	0.42	9.69	0.40	9.67
23	11:00	–	–	0.44	9.71	0.50	9.77	0.46	9.73	0.43	9.70	0.46	9.73	0.44	9.71	0.41	9.68
	05:00	–	–	0.44	9.71	0.50	9.77	0.45	9.72	0.43	9.70	0.43	9.70	0.42	9.69	0.40	9.67
24	07:00	–	–	0.43	9.70	0.48	9.75	0.45	8.72	0.43	9.70	0.45	9.72	0.43	9.70	0.41	9.68
	05:00	–	–	0.43	9.70	0.47	9.74	0.62	9.89	0.42	9.69	0.45	9.72	0.42	9.69	0.40	9.67
25	07:00	–	–	0.49	9.76	0.47	9.74	0.48	9.76	0.47	9.74	0.45	9.72	0.43	9.70	0.42	9.69
	05:00	0.58	9.85	0.49	9.76	0.46	9.73	0.48	9.75	0.46	9.73	0.44	9.71	0.42	9.69	0.41	9.68
26	07:00	–		1.36	10.63	0.46	9.73	0.88	10.15	0.48	9.75	0.44	9.71	0.43	9.70	0.42	9.69
	05:00	0.59	9.86	0.96	10.23	0.45	9.72	0.51	9.78	0.50	9.77	0.44	9.71	0.42	9.69	0.41	9.68
27	07:00	–		0.67	9.94	0.46	9.73	0.51	9.78	0.52	9.79	0.44	9.71	0.43	9.70	0.42	9.69
	05:00	–		0.53	9.80	0.47	9.74	0.47	9.74	0.68	9.95	0.44	9.71	0.43	9.70	0.41	9.68
28	07:00	0.74	10.01	0.50	9.77	0.48	9.75	0.47	9.74	0.50	9.77	0.44	9.71	0.42	9.69	0.43	9.70
	05:00	0.57	9.84	0.46	9.73	0.50	9.77	0.46	9.73	0.50	9.77	0.44	9.71	0.43	9.70	0.41	9.88
29	07:00	0.68	9.95	0.46	9.73	0.47	9.74	0.46	8.73	0.48	9.75	0.44	9.71	0.43	9.70	0.41	9.68
	05:00	0.59	9.86	0.45	9.72	0.44	9.71	0.45	9.72	0.47	9.74	0.43	9.70	0.42	9.69	0.40	9.67
30	07:00	0.76	10.03	0.44	8.71	0.45	9.72	0.47	9.74	0.46	9.73	0.43	9.70	0.43	8.70	0.42	9.69
	05:00	0.60	9.87	0.43	9.70	0.44	9.71	0.47	9.74	0.52	9.79	0.43	9.70	0.42	9.69	0.40	9.67
31	07:00	–				0.50	9.77	0.46	9.73			0.43	9.70			0.41	9.68
	06:00							0.45	9.72							0.40	9.67

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Day	TIME	JANUARY G.R	JANUARY WL	FEBRUARY G.R	FEBRUARY WL	MARCH G.R	MARCH WL	APRIL G.R	APRIL WL	MAY G.R	MAY WL	JUNE G.R	JUNE WL	JULY G.R	JULY WL	AUGUST G.R	AUGUST WL	SEPT G.R	SEPT WL	OCTOBER G.R	OCTOBER WL	NOVEMBER G.R	NOVEMBER WL
1	07:00	0.41	9.68	0.41	9.68	0.41	9.66	0.44	9.71	0.45	9.72	1.17	10.44	0.64	9.91	0.61	9.88	0.70	8.97	0.50	9.77	0.46	9.75
	05:00	0.40	9.67	0.40	9.67	0.40	9.67	0.43	9.70	0.43	9.70	0.81	10.08	0.63	9.90	0.54	9.91	0.88	10.15	0.46	9.73	0.45	9.72
2	07:00	0.40	9.67	0.42	9.69	0.40	9.67	0.44	9.71	0.43	9.70	0.61	9.88	0.54	9.81	0.55	9.92	0.84	10.11	0.73	10.00	0.44	9.71
	05:00	0.40	9.67	0.42	9.69	0.40	9.67	0.43	9.70	0.42	9.69	0.53	9.80	0.53	9.80	0.53	9.80	0.78	10.05	0.86	10.13	0.41	9.68
3	07:00	0.41	9.68	0.41	9.68	0.40	9.67	0.43	9.70	1.89	11.16	0.62	9.89	0.58	9.85	0.67	9.94	0.68	9.95	0.88	9.95	0.40	9.67
	05:00	0.40	9.67	0.40	9.67	0.39	9.66	0.42	9.69	1.02	10.29	0.59	9.86	0.86	10.13	0.60	9.87	0.50	9.77	0.51	9.78	0.39	9.66
4	07:00	0.41	9.68	0.42	9.69	0.40	9.67	0.43	9.70	0.65	9.92	1.23	10.50	0.68	9.95	0.57	9.84	0.53	9.80	0.47	9.74	0.39	9.66
	05:00	0.40	9.67	0.41	9.68	0.39	9.66	0.42	9.69	0.58	9.85	0.76	10.03	0.65	9.92	0.68	9.95	0.46	9.75	0.49	9.72	0.37	9.64
5	07:00	0.40	9.67	0.42	9.69	0.39	9.66	0.44	9.71	0.62	9.89	1.19	10.46	0.59	9.86	0.59	9.86	0.70	9.97	0.46	9.73	0.37	9.64
	05:00	0.40	9.67	0.42	9.69	0.38	9.65	0.42	9.69	0.76	10.03	1.35	10.62	0.56	9.63	0.76	10.03	0.51	9.78	0.46	9.72	0.36	9.63
6	07:00	0.40	9.67	0.42	9.69	0.39	9.66	0.42	9.69	0.60	9.67	1.47	10.74	0.56	9.83	0.62	9.89	1.06	10.33	0.45	9.72	0.35	9.62
	05:00	0.40	9.67	0.41	9.88	0.39	9.66	0.41	9.68	0.70	9.87	2.30	11.57	0.55	9.82	0.55	9.82	0.62	9.89	0.43	9.70	0.33	9.60
7	07:00	0.40	9.67	0.41	9.68	0.39	9.66	0.42	9.69	0.58	9.85	0.58	9.85	0.54	9.81	0.57	9.84	0.75	10.02	0.44	9.71	0.34	9.61
	05:00	0.34	9.61	0.40	9.67	0.39	9.66	0.41	9.68	0.73	10.00	0.51	9.78	0.54	9.81	0.76	10.03	0.51	9.79	0.41	9.88	0.33	9.60
8	07:00	0.43	9.70	0.41	9.68	0.40	9.67	0.41	9.68	0.56	9.83	1.90	11.17	0.50	9.77	0.71	9.98	0.55	9.82	0.40	9.67	0.33	9.60
	05:00	0.41	9.68	0.40	9.67	0.40	9.67	0.40	9.67	0.51	9.78	1.82	11.09	0.50	9.77	0.80	10.07	0.50	9.77	0.40	9.67	0.32	9.59
9	07:00	0.45	9.72	0.40	9.67	0.40	9.67	0.40	9.67	0.68	9.95	1.48	10.75	0.57	9.84	0.72	9.99	0.54	9.81	0.39	9.66	0.33	9.60
	05:00	0.46	9.73	0.40	9.67	0.40	9.67	0.39	9.66	0.52	9.79	0.69	9.96	0.59	9.86	0.61	9.86	0.47	9.74	0.38	9.65	0.32	9.59
10	07:00	0.49	9.76	0.42	9.69	0.41	9.68	0.40	9.67	0.59	9.86	0.90	10.17	0.50	9.77	0.62	9.89	0.49	9.76	0.40	9.67	0.32	9.59
	05:00	0.44	9.71	0.41	9.68	0.41	9.68	0.41	9.68	0.51	9.78	0.68	9.95	0.50	9.77	0.56	9.63	0.48	9.75	0.39	9.66	0.31	9.58
11	07:00	0.42	9.69	0.43	9.70	0.42	9.69	0.48	9.75	0.84	10.11	0.71	9.96	0.50	9.77	0.96	10.23	0.62	9.89	0.41	9.68	0.32	9.59
	05:00	0.41	9.68	0.42	9.69	0.42	9.69	0.87	10.14	0.54	9.81	1.02	10.29	0.62	9.89	0.64	9.91	0.53	9.80	0.40	9.67	0.31	9.58
12	07:00	0.42	9.69	0.42	9.69	0.43	9.70	0.48	9.75	1.10	10.37	0.85	10.12	0.63	9.90	0.65	9.92	0.57	9.84	0.81	10.08	0.31	9.58
	05:00	0.40	9.67	0.41	9.68	0.43	9.70	0.44	9.71	0.64	9.91	0.67	9.94	0.58	9.85	0.58	9.85	0.52	9.79	0.52	9.79	0.31	9.58
13	07:00	0.40	9.67	0.43	9.70	0.43	9.70	0.42	9.69	0.64	9.91	0.63	9.90	0.50	9.77	0.59	9.86	0.60	9.87	0.88	9.96	0.31	9.58
	05:00	0.43	9.70	0.43	9.70	0.43	9.70	0.42	9.69	0.58	9.85	0.63	9.90	0.49	9.76	0.52	9.79	0.52	9.79	0.50	9.77	0.31	9.58
14	07:00	0.01	9.78	0.50	9.77	0.44	9.71	0.41	9.68	0.48	9.75	0.66	9.93	0.60	9.87	0.54	9.91	0.50	9.77	0.50	9.77	0.32	9.59
	05:00	0.09	9.86	0.45	9.72	0.44	9.71	0.40	9.67	0.46	9.73	0.75	10.02	0.50	9.77	0.51	9.78	0.45	9.72	0.48	9.75	0.31	9.56
15	07:00	0.15	9.92	0.42	9.69	0.45	9.72	0.40	9.67	0.46	9.73	0.61	9.88	0.50	9.77	0.53	9.80	0.45	9.72	0.49	8.76	0.31	9.58
	05:00	0.18	9.95	0.42	9.69	0.44	9.71	0.39	9.66	0.45	9.72	0.65	9.92	0.50	9.77	0.52	9.79	0.47	9.74	0.47	9.74	0.30	9.57
16	07:00	0.26	10.03	0.43	9.70	0.45	9.72	0.39	9.66	0.71	9.98	0.96	10.23	0.50	9.77	0.56	9.83	0.57	9.84	0.47	9.74	0.31	9.58
	05:00	0.31	10.06	0.42	8.69	0.44	9.71	0.35	9.66	0.78	10.05	0.63	8.90	0.49	9.76	0.54	9.81	0.76	10.03	0.46	9.73	0.30	9.57
17	07:00	0.35	10.12	0.56	9.83	0.44	9.71	0.35	9.66	0.53	9.80	0.67	9.94	0.49	9.76	0.79	10.06	0.57	9.84	0.47	9.74	0.30	9.57
	05:00	0.34	10.11	0.46	9.73	0.44	9.71	0.38	9.66	0.78	10.05	0.64	9.91	0.49	9.76	0.70	9.97	0.50	8.77	0.44	9.71	0.29	9.56
18	07:00	0.36	10.13	0.44	9.71	0.44	9.71	0.39	9.66	0.66	9.93	0.80	10.07	1.69	10.96	0.66	9.95	0.48	9.75	0.45	9.72	0.30	9.57
	05:00	0.35	10.12	0.43	9.70	0.43	9.70	0.38	9.65	0.56	9.83	0.72	9.99	0.80	10.07	0.60	9.97	0.47	8.74	0.42	9.69	0.30	9.57
19	07:00	0.33	10.10	0.49	9.76	0.44	9.71	0.38	9.65	0.50	9.77	1.34	10.61	1.00	10.27	0.69	9.96	0.47	9.74	0.42	9.68	0.30	9.57
	05:00	0.32	10.09	0.44	9.71	0.43	9.70	0.38	9.65	0.45	9.72	1.48	10.75	1.67	10.94	0.66	9.93	0.46	9.73	0.41	9.88	0.29	9.56
20	07:00	0.34	10.11	0.47	9.74	0.44	9.71	0.38	9.65	0.49	9.76	1.06	10.33	1.70	10.97	0.62	9.88	0.46	9.73	0.40	9.67	0.29	9.56
	05:00	0.31	10.08	0.43	9.70	0.43	9.70	0.38	9.65	0.46	9.73	0.67	9.94	1.09	10.36	0.61	9.88	0.45	9.72	0.38	9.65	0.29	9.56
21	07:00	0.28	10.05	0.42	9.69	0.44	9.71	0.39	9.66	ND	ND	0.69	9.96	1.36	10.63	0.73	10.00	0.46	9.73	0.38	9.66	0.30	9.57
	05:00	0.27	10.04	0.41	9.68	0.44	9.71	0.38	9.65	ND	ND	0.75	10.02	1.13	10.40	0.66	9.93	0.46	9.73	0.37	9.64	0.29	9.56
22	07:00	0.29	10.06	0.59	9.86	0.44	9.71	0.40	9.67	ND	ND	0.74	10.01	0.73	10.00	0.65	9.92	0.46	9.73	0.38	9.66	0.29	9.56
	05:00	0.29	10.06	0.44	9.71	0.44	9.71	0.39	9.66	ND	ND	0.62	9.89	0.82	10.09	0.65	9.92	0.45	9.72	0.36	9.63	0.28	9.55
23	11:00	0.50	9.77	0.46	9.75	0.43	9.70	0.39	9.66	0.46	9.73	0.65	9.92	0.67	9.94	0.83	10.10	0.45	9.72	0.36	9.63	0.29	9.56
	05:00	0.49	9.76	0.43	9.70	0.43	9.70	0.39	9.66	0.46	9.73	0.61	9.88	0.71	9.99	0.71	9.98	0.45	9.72	0.35	9.62	0.29	9.56
24	07:00	0.44	9.71	0.44	9.71	0.44	9.71	0.40	9.67	0.45	9.72	0.68	9.95	0.76	10.03	0.73	10.00	0.46	9.73	0.35	9.62	0.30	9.57
	05:00	0.43	9.70	0.44	9.71	0.43	9.70	0.39	9.66	0.44	9.71	0.66	9.93	0.78	10.05	0.64	9.91	0.44	9.71	0.34	9.61	0.29	9.56
25	07:00	0.44	9.71	0.43	9.70	0.46	9.73	0.59	9.85	0.44	9.71	0.86	9.93	0.79	10.06	0.60	9.87	0.45	9.72	0.34	9.61	0.29	9.56
	05:00	0.43	8.70	0.42	9.69	0.49	9.76	0.41	9.68	0.43	9.70	0.71	9.98	0.70	9.97	0.59	9.86	0.44	9.71	0.39	9.86	0.28	9.55
26	07:00	0.43	9.70	0.42	9.68	0.47	9.74	0.40	9.67	0.78	10.05	0.69	9.96	0.61	9.88	0.68	9.95	0.48	9.75	0.35	9.62	0.29	9.56
	05:00	0.43	9.70	0.41	9.68	0.48	9.75	0.39	9.66	0.64	9.91	0.62	9.89	0.57	9.64	0.61	9.88	0.61	9.86	0.34	9.61	0.29	9.56
27	07:00	0.43	9.70	0.44	9.71	0.44	9.71	1.59	10.86	0.54	9.81	0.61	9.88	0.56	9.83	0.90	10.17	0.84	10.11	0.34	9.61	0.30	9.57
	05:00	0.42	9.69	0.45	9.72	0.43	9.70	0.67	9.94	0.51	9.78	0.66	9.93	0.55	9.82	0.88	10.15	0.65	9.92	0.32	9.59	0.29	9.56
28	07:00	0.43	9.70	0.44	9.71	0.44	9.71	0.58	9.85	0.59	9.86	0.68	9.95	0.55	9.82	0.92	10.19	1.62	10.89	0.33	9.60	0.29	9.56
	05:00	0.42	9.69	0.43	9.70	0.43	9.70	0.49	9.76	0.63	9.90	0.64	8.91	0.54	8.81	0.76	10.03	0.71	9.98	0.32	8.59	0.28	9.56
29	07:00	0.44	9.71			0.44	9.71	0.46	9.73	0.84	10.11	0.65	9.92	0.54	9.81	0.68	9.96	0.67	9.84	0.33	9.60	0.29	9.56
	05:00	0.43	9.70			0.43	9.70	0.45	9.72	0.78	10.05	0.62	9.89	0.52	9.79	0.62	9.89	0.60	9.97	0.31	9.59	0.29	9.56
30	07:00	0.44	9.71			0.44	9.71	0.43	9.70	1.18	10.45	0.64	9.91	0.52	9.79	0.64	9.91	0.47	9.74	0.32	9.59	0.28	9.56
	05:00	0.42	9.69			0.44	8.71	0.43	9.70	0.72	8.99	1.52	10.79	0.52	9.79	0.63	9.90	0.46	9.73	0.31	9.58	0.28	9.55
31	07:00	0.43	9.70			0.44	9.71			0.55	9.82			0.56	9.83	0.60	9.87			0.31	9.58		
	06:00	0.42	9.69			0.43	9.70			0.67	9.94			0.54	9.81	0.66	9.93			0.30	9.57		

1993–1994

Day	TIME	DECEMBER (1993) G.R	DECEMBER (1993) WL	JANUARY (1994) G.R	JANUARY (1994) WL	FEBRUARY G.R	FEBRUARY WL	MARCH G.R	MARCH WL	APRIL G.R	APRIL WL	MAY G.R	MAY WL
1	07:00	0.30	9.57	0.26	9.53	0.30	9.57	0.28	9.55	2.03	11.30	0.24	9.51
	05:00	0.29	9.56	0.25	9.52	0.28	9.55	0.21	9.48	0.50	9.77	0.23	9.50
2	07:00	0.29	9.56	0.24	9.51	0.23	9.50	0.23	9.50	0.70	9.97	0.23	9.50
	05:00	0.29	9.56	0.25	9.52	0.24	9.51	0.21	9.46	0.27	9.54	0.22	9.49
3	07:00	0.29	9.56	0.23	9.50	0.22	9.49	0.25	9.52	0.19	9.46	0.25	9.52
	05:00	0.29	9.56	0.23	9.50	0.21	9.48	0.25	9.52	0.26	9.55	0.21	9.48
4	07:00	0.30	9.57	0.24	9.51	0.23	9.50	0.23	9.50	0.64	9.91	0.27	9.54
	05:00	0.29	9.56	0.23	9.50	0.23	9.50	0.21	9.48	0.25	9.52	0.23	9.50
5	07:00	0.29	9.56	0.25	9.52	0.21	9.46	0.22	9.49	0.24	9.51	0.24	9.51
	05:00	0.28	9.55	0.24	9.51	0.25	9.52	0.21	9.48	0.23	9.50	0.22	9.49
6	07:00	0.29	9.56	0.24	9.51	0.24	9.51	0.24	9.51	0.28	9.59	0.23	9.50
	05:00	0.29	9.56	0.22	9.49	0.26	9.53	0.23	8.50	0.22	9.49	0.23	9.50
7	07:00	0.29	9.56	0.26	9.53	0.21	9.48	0.26	9.53	0.26	9.53	0.25	9.52
	05:00	0.28	9.55	0.24	9.51	0.23	9.50	0.21	9.48	0.26	9.53	0.22	9.49
8	07:00	0.29	9.56	0.27	9.54	0.24	9.51	0.23	9.50	0.70	9.97	0.23	9.50
	05:00	0.29	9.56	0.23	9.50	0.22	9.49	0.21	9.48	0.26	9.53	0.22	9.49
9	07:00	0.30	9.57	0.28	9.55	0.27	9.54	0.21	9.48	0.29	9.56	0.24	9.51
	05:00	0.30	9.57	0.24	9.51	0.23	9.50	0.28	9.55	0.23	9.50	0.28	9.55
10	07:00	0.30	9.57	0.25	9.52	0.26	9.53	0.24	9.51	0.27	9.54	0.23	9.50
	05:00	0.29	9.55	0.23	9.50	0.21	9.46	0.23	9.50	0.23	9.50	0.21	9.46
11	07:00	0.29	9.56	0.26	9.53	0.26	9.53	0.28	9.55	0.28	9.55	0.24	9.51
	05:00	0.28	9.55	0.24	9.51	0.23	9.50	0.21	9.48	0.24	9.51	0.22	9.49
12	07:00	0.28	9.55	0.25	9.52	0.22	9.49	0.22	9.49	0.31	9.58	0.27	9.54
	05:00	0.28	9.55	0.23	9.50	0.21	9.48	0.25	9.52	0.23	9.50	0.24	9.51
13	07:00	0.28	9.55	0.27	9.54	0.22	9.49	0.23	9.50	0.24	9.51	0.29	9.56
	05:00	0.27	9.54	0.23	9.50	0.22	9.49	0.21	9.48	0.23	9.50	0.25	9.52
14	07:00	0.29	9.56	0.24	9.51	0.23	9.50	0.22	9.49	0.25	9.52	0.29	9.56
	05:00	0.27	9.54	0.23	9.50	0.21	9.48	0.21	9.48	0.23	9.50	0.24	9.51
15	07:00	0.28	9.55	0.25	9.52	0.22	9.49	0.31	9.58	0.40	9.67	0.26	9.55
	05:00	0.27	9.54	0.24	9.51	0.21	9.46	0.24	9.51	0.23	9.50	0.24	9.51
16	07:00	0.29	9.56	0.28	9.55	0.23	9.50	0.32	9.59	0.25	9.52	0.25	9.52
	05:00	0.28	9.55	0.23	9.50	0.22	9.49	0.21	9.48	0.23	9.50	0.23	9.50
17	07:00	0.28	9.56	0.24	9.51	0.24	9.51	0.30	9.57	0.24	9.51	0.29	9.56
	05:00	0.26	9.53	0.23	9.50	0.21	9.46	0.28	9.55	0.23	9.50	0.26	9.53
18	07:00	0.36	9.63	0.27	8.54	0.23	9.50	0.35	9.62	0.25	9.52	0.27	9.54
	05:00	0.30	9.57	0.22	8.49	0.21	9.48	0.22	9.48	0.25	9.56	0.24	9.51
19	07:00	0.29	9.56	0.26	8.53	0.25	9.52	0.29	9.56	0.23	9.50	0.26	9.53
	05:00	0.28	9.55	0.25	9.52	0.22	9.49	0.38	9.65	0.23	9.50	0.24	9.51
20	07:00	0.28	9.55	0.24	9.51	0.23	9.50	0.38	9.65	0.26	9.53	0.26	9.55
	05:00	0.26	9.53	0.23	9.50	0.23	9.50	0.29	9.56	0.23	9.50	0.27	9.54
21	07:00	0.27	9.54	0.26	9.53	0.22	9.49	0.39	9.66	0.26	9.55	0.26	9.53
	05:00	0.26	9.53	0.24	9.51	0.21	9.46	0.30	9.57	0.24	9.51	0.25	9.52
22	07:00	0.29	9.56	0.24	9.51	0.28	9.55	0.29	9.56	0.24	9.51	0.29	9.56
	05:00	0.27	9.54	0.21	9.46	0.35	9.62	0.23	9.50	0.23	9.50	0.26	9.53
23	11:00	0.28	9.55	0.27	9.54	0.29	9.56	0.34	9.61	0.26	9.53	0.28	9.55
	05:00	0.26	9.53	0.27	9.54	0.24	9.51	0.23	9.50	0.25	9.52	0.27	9.54
24	07:00	0.29	9.56	0.28	9.55	0.22	8.49	0.31	9.58	0.28	9.55	0.28	9.55
	05:00	0.27	9.54	0.23	9.50	0.21	9.48	0.23	9.50	0.23	9.50	0.27	9.54
25	07:00	0.29	9.56	0.26	9.53	0.22	9.49	0.38	9.65	0.26	9.53	0.27	9.54
	05:00	0.27	9.54	0.22	9.48	0.26	9.53	0.26	9.53	0.23	9.50	0.27	9.54
26	07:00	0.28	9.55	0.25	9.52	0.21	9.48	0.50	9.77	0.28	9.55	0.29	9.56
	05:00	0.27	9.54	0.24	9.51	0.23	9.50	0.17	9.94	0.23	9.50		
27	07:00	0.29	9.56	0.26	9.53	0.23	9.50	0.10	9.37	0.24	9.51		
	05:00	0.27	9.54	0.24	9.51	0.21	9.48	0.29	9.56	0.23	9.50		
28	07:00	0.27	9.54	0.27	9.54	0.22	9.49	0.23	9.50	0.23	9.50		
	05:00	0.26	9.53	0.22	9.49	0.21	9.48	0.22	9.49	0.22	9.49		
29	07:00	0.29	9.56	0.26	9.53			0.24	9.51	0.25	9.52		
	05:00	0.18	9.45	0.25	9.52			0.25	9.52	0.23	9.50		
30	07:00	0.19	9.46	0.26	9.53			0.38	9.65	0.24	9.51		
	05:00	0.17	9.44	0.23	9.50			0.29	8.56	0.23	9.50		
31	07:00	0.26	9.53	0.31	9.58			0.28	9.55				
	06:00	0.24	9.51	0.29	9.56			0.28	9.56				

ZERO VALUE (m GTS): 8.812

Project Monitoring Program
MANU RIVER FCDI PROJECT

Manu Barragé Water Levels (m PWD)

1992

DAY	TIME	MARCH U/S	MARCH D/S	APRIL U/S	APRIL D/S	MAY U/S	MAY D/S	JUNE U/S	JUNE D/S	JULY U/S	JULY D/S	AUGUST U/S	AUGUST D/S	SEPTEMBER U/S	SEPTEMBER D/S	OCTOBER U/S	OCTOBER D/S	NOVEMBER U/S	NOVEMBER D/S	DECEMBER U/S	DECEMBER D/S
1	6	11.85		12.05				10.06	9.82	8.51	8.26	10.16	9.94	8.91	8.68	8.91	8.67	7.47	7.23	7.26	7.01
	18	12.01		12.09				10.00	9.76	8.51	8.26	10.06	9.82	10.46	10.22	9.61	9.36	7.44	7.20	7.26	7.01
2	6	11.37		12.11				9.76	9.51	9.48	9.23	10.49	10.25	10.78	10.53	9.46	9.21	7.44	7.20	7.26	7.01
	18	11.47		12.08				9.76	9.51	9.48	9.23	11.28	11.04	10.16	9.91	9.33	9.09	7.41	7.17	7.26	7.01
3	6	11.51		12.05				9.76	9.58	9.69	9.45	11.47	11.22	9.76	9.51	9.15	8.91	7.41	7.17	7.26	7.01
	18	11.47		[illegible]				9.76	9.51	9.69	9.54	11.13	10.89	9.67	9.42	9.03	8.78	7.41	7.17	7.26	7.01
4	6	11.60		11.99				9.45	9.21	8.94	9.69	10.98	10.73	9.67	9.42	8.87	8.61	7.38	7.14	7.26	7.01
	18	11.87		11.96				9.45	9.21	9.00	8.75	10.52	10.28	9.67	9.42	8.75	8.51	7.38	7.14	7.26	7.01
5	6	11.92		12.01				9.15	8.91	9.30	9.06	10.40	10.16	9.67	9.42	8.63	8.39	7.35	7.11	7.26	7.01
	18	11.92		12.05				9.15	8.91	8.61	8.36	10.16	9.91	9.67	9.42	8.39	8.14	7.35	7.11	7.26	7.01
6	6	11.89		12.08				9.84	9.60	10.37	10.12	10.06	9.82	9.67	9.42	8.54	8.30	7.35	7.11	7.26	7.01
	18	11.80		12.11				9.84	9.60	10.16	10.16	9.94	9.70	9.67	9.42	9.09	8.84	7.35	7.11	7.26	7.01
7	6	11.80		12.05				8.54	8.30	9.58	9.33	10.46	10.22	9.67	9.42	8.94	8.69	7.35	7.11	7.26	7.01
	18	11.89		12.01				8.54	8.30	9.30	9.06	10.49	10.25	9.67	9.42	8.69	8.45	7.35	7.11	7.26	7.01
8	6	12.05		12.05				8.09	7.84	9.27	9.03	10.34	10.09	9.67	9.42	8.54	8.30	7.35	7.11	7.26	7.01
	18	11.96		12.05				8.08	7.84	9.15	8.91	10.26	10.03	9.67	9.42	8.42	8.17	7.35	7.11	7.26	7.01
9	6	11.74		12.05				8.33	8.09	9.00	8.75	10.28	10.03	9.76	9.51	8.33	8.09	7.35	7.11	7.26	7.01
	18	11.74		12.01				8.38	8.14	9.12	8.87	10.19	9.91	9.78	9.55	8.33	8.09	7.35	7.11	7.26	7.01
10	6	11.86		11.98				8.54	8.30	9.09	8.84	9.61	9.36	10.46	10.22	8.26	8.02	7.35	7.11	7.26	7.01
	18	11.95		12.01				9.15	8.91	9.00	8.76	9.85	9.61	10.52	10.28	8.26	8.02	7.35	7.11	7.26	7.01
11	6	12.01		11.96				10.22	9.97	9.86	9.61	9.45	9.21	11.13	10.88	8.11	7.87	7.35	7.11	7.26	7.01
	18	12.11		11.95				9.91	9.67	9.88	9.64	9.30	9.06	11.44	11.19	8.11	7.87	7.35	7.11	7.26	7.01
12	6	12.14		11.89				9.85	9.61	9.88	9.64	9.97	9.72	11.59	11.34	8.05	7.81	7.35	7.11	7.26	7.01
	18	12.14		11.86				9.88	9.64	9.88	9.64	9.91	9.67	10.92	10.68	8.05	7.81	7.35	7.11	7.26	7.01
13	6	12.11		11.83				9.76	9.51	9.88	9.64	9.45	9.21	9.91	9.67	8.54	8.30	7.35	7.11	7.26	7.01
	18	12.11		11.63				9.64	9.39	9.88	9.64	9.15	8.91	9.83	9.58	8.45	8.21	7.35	7.11	7.26	7.01
14	6	12.11		11.89				9.61	9.36	9.88	9.64	9.03	8.78	9.64	9.39	8.39	8.15	7.32	7.08	7.26	7.01
	18	12.11		11.92				9.61	9.36	9.88	9.64	8.97	8.72	9.59	9.33	9.91	9.67	7.32	7.08	7.26	7.01
15	6	12.11		11.98				9.67	9.42	9.86	9.64	9.15	8.91	9.79	9.55	10.61	10.37	7.32	7.08	7.26	7.01
	18	12.11		12.01				9.61	9.39	9.88	9.64	9.27	8.72	9.73	9.48	10.46	10.22	7.32	7.08	7.26	7.01
16	6	12.11		12.08				10.00	9.76	9.91	9.67	9.42	9.18	9.55	9.30	10.46	10.22	7.32	7.08	7.26	7.01
	18	12.11		12.05				10.52	10.28	9.85	9.61	9.30	9.06	9.39	9.15	10.46	10.22	7.32	7.08	7.26	7.01
17	6	12.11		12.01		9.81	9.67	10.61	10.37	9.86	9.64	9.24	9.00	9.30	9.06	10.46	10.22	7.32	7.08	7.26	7.01
	18	12.11		12.01		10.80	10.25	9.76	9.51	9.85	9.61	9.00	8.75	9.30	9.06	10.46	10.22	7.32	7.08	7.26	7.01
18	6	12.08		12.05		10.37	10.12	9.30	9.06	9.97	9.73	8.97	8.72	9.27	9.03	10.09	9.85	7.32	7.08	7.26	7.01
	18	12.05		12.05		11.44	11.19	9.45	9.21	9.91	9.67	9.00	8.75	9.15	8.91	9.97	9.73	7.32	7.08	7.26	7.01
19	6	12.11		12.08		11.34	11.10	9.79	9.55	9.94	9.70	9.06	8.81	9.09	8.84	9.73	9.48	7.22	7.08	7.26	7.01
	18	12.08		12.05		10.52	10.28	9.30	9.06	9.91	9.67	8.97	8.72	8.94	8.69	9.64	9.39	7.32	7.08	7.26	7.01
20	6	11.98		12.09		9.91	9.67	9.18	8.94	9.70	9.46	9.15	8.91	8.79	8.54	9.55	9.30	7.32	7.08	7.26	7.01
	18	11.86		12.08		9.61	9.36	9.00	8.75	9.45	9.21	9.33	9.09	8.66	8.42	9.55	9.30	7.32	7.08	7.26	7.01
21	6	11.37		12.05		9.00	9.75	8.84	8.60	8.84	8.60	9.15	8.91	8.60	8.36	9.33	9.09	7.32	7.08	7.26	7.01
	18	11.50		12.05		8.84	8.60	8.60	8.36	8.60	8.36	9.03	8.78	8.54	8.30	9.12	8.87	7.32	7.08	7.26	7.01
22	6	11.74		11.86		9.66	9.42	8.60	8.36	8.60	8.36	8.84	8.60	8.48	8.23	9.06	8.81	7.32	7.08	7.26	7.01
	18	11.56		11.80		8.54	8.30	8.61	8.36	8.60	8.36	8.72	8.48	8.42	8.17	8.87	8.63	7.32	7.08	7.26	7.01
23	6	11.01		11.68		8.39	8.14	8.54	8.30	8.54	8.30	8.63	8.39	8.39	8.14	8.69	8.45	7.29	7.05	7.26	7.01
	18	10.73		10.22		8.39	8.14	8.54	8.30	8.54	8.30	8.45	8.20	8.26	8.02	8.63	8.39	7.29	7.05	7.26	7.01
24	6	10.83		8.05		8.51	8.26	8.39	8.14	8.39	8.14	8.39	8.14	8.20	7.96	8.60	8.36	7.29	7.05	7.26	7.01
	18	11.13		8.08		8.45	8.20	8.17	8.02	8.26	8.02	8.39	8.14	8.20	7.96	8.57	8.33	7.29	7.05	7.26	7.01
25	6	11.08				8.39	8.14	8.26	8.02	8.26	8.02	8.39	8.14	8.39	8.14	8.57	8.33	7.29	7.05	7.26	7.01
	18	11.53				8.33	8.08	8.26	8.02	8.26	8.02	8.39	8.14	8.69	8.45	8.54	8.30	7.29	7.05	8.54	7.01
26	6	11.63				8.23	7.98	8.33	8.08	8.33	8.08	8.46	8.23	8.64	8.60	8.51	8.26	7.29	7.05	9.51	
	18	11.74				8.23	7.98	8.15	6.81	9.15	8.91	8.75	8.51	9.15	8.91	8.48	8.23	7.29	7.05	10.06	
27	6	11.80				8.30	8.05	9.51	9.27	9.51	9.27	9.06	8.81	9.30	9.06	8.39	8.14	7.29	7.05	10.37	
	18	11.83				8.36	8.11	8.70	9.45	9.70	9.45	8.84	8.89	9.67	9.42	8.33	8.09	7.29	7.05	10.70	
28	6	11.83				8.39	8.14	9.36	9.12	9.36	9.12	8.61	8.57	10.06	9.82	8.23	7.99	7.29	7.05	10.98	
	18	12.01				8.54	8.30	9.09	8.84	9.09	8.84	8.60	8.36	10.16	9.91	8.20	7.96	7.29	7.05	11.16	
29	6	11.77				8.60	8.36	8.84	8.60	8.33	9.08	8.51	8.26	10.06	9.82	8.14	7.90	7.29	7.05	11.37	
	18	11.80				8.94	8.69	8.75	8.51	9.09	8.84	8.51	8.26	9.94	9.70	8.08	7.84	7.29	7.05	11.53	
30	6	11.86				9.30	9.06	8.63	8.39	8.97	8.72	9.39	9.15	9.73	9.48	8.02	7.78	7.29	7.05	11.68	
	18	11.92				9.76	9.51	8.57	8.33	8.84	8.60	9.30	9.06	9.82	9.58	7.90	7.66	7.29	7.05	11.77	
31	6	11.98				10.22	9.97			8.81	8.57	9.58	9.33			7.78	7.53			11.88	
	18	12.01				10.18	9.81			9.70	9.45	9.30	9.06			7.59	7.35			11.89	

1993

DAY	TIME	JANUARY U/S	FEBRUARY U/S	MARCH U/S	APRIL U/S	MAY U/S	JUNE U/S	JULY U/S	AUGUST U/S	SEPTEMBER U/S
1	6	11.89	11.92	11.37	11.83	8.94	11.41	9.87	8.73	9.78
	18	11.89	11.92	11.47	11.85	8.84	11.34	9.08	8.84	9.84
2	6	11.80	12.01	11.62	11.83	9.58	11.37	9.45	9.61	9.88
	18		12.05	11.77	11.86	9.64	11.25	9.31	9.49	10.16
3	6	11.53	12.05	11.85	11.89	10.03	10.98	9.58	9.42	10.12
	18	11.44	12.05	11.82	11.89	11.00	10.83	9.46	9.51	9.85
4	6	11.44	12.01	11.92	11.89	11.55	11.44	9.21	9.61	9.73
	18	11.60	12.01	11.96	11.86	12.11	11.37	9.16	8.84	9.64
5	6	11.62	12.05	11.96	11.86	12.08	11.37	8.30	9.46	9.61
	18	11.68	12.05	12.01	11.83	12.17	11.93	9.24	9.26	9.39
6	6	11.77	12.05	11.95	11.80	12.17	12.35	9.33	9.30	10.09
	18	11.80	12.05	11.98	11.74	12.08	12.75	9.24	9.24	10.52
7	6	11.86	12.06	11.95	11.68	11.92	13.48	9.21	9.33	10.61
	18	11.92	12.01	11.98	11.68	11.71	13.57	9.15	9.21	10.73
8	6	11.58	12.01	12.09	11.71	11.44	13.81	9.20	8.82	10.37
	18	11.98	12.01	12.08	11.77	11.31	13.54	9.27	11.10	9.88
9	6	11.98	12.01	12.11	11.83	11.38	13.72	9.42	11.47	8.73
	18	11.98	11.96	12.11	11.83	11.19	13.42	9.61	11.10	9.61
10	6	12.01	11.96	12.11	11.86	10.61	13.08	9.58	10.64	9.35
	18	11.98	11.85	12.11	11.92	10.56	12.96	9.48	10.37	9.24
11	6	11.89	11.92	12.11	11.86	10.09	12.90	9.27	10.73	9.27
	18	11.86	11.96	12.11	11.95	10.57	12.93	9.15	10.86	9.18
12	6	11.92	11.98	12.05	11.47	11.47	13.08	9.09	10.40	9.18
	18	11.60	12.05	12.09	9.58	11.53	13.30	9.00	10.00	9.15
13	6	11.60	12.06	12.08	9.09	11.27	13.36	9.03	9.67	9.27
	18	11.28	12.05	12.05	8.84	11.47	13.22	9.21	9.51	9.55
14	6	11.44	12.01	12.09	8.39	11.50	13.11	9.49	9.39	9.70
	18	11.53	12.05	12.06	8.03	11.44	12.90	9.72	9.00	9.85
15	6	11.71	12.05	12.08	7.96	10.73	12.66	9.64	9.24	9.97
	18	11.77	12.11	12.05	7.90	10.61	12.35	9.55	10.22	9.49
16	6	11.83	12.06	12.11	7.84	9.87	12.01	9.48	11.10	9.21
	18	11.89	12.11	12.11	7.75	8.78	11.63	9.55	11.34	9.06
17	6	11.89	12.08	12.05	7.53	9.94	11.68	9.33	11.07	9.00
	18	11.88	12.08	11.92	7.53	10.06	11.13	9.15	10.58	6.94
18	6	11.89	12.09	11.80	7.47	10.56	12.98	9.27	10.22	8.87
	18	11.89	12.05	11.95	7.50	11.13	10.83	8.39	10.00	8.75
19	6	11.89	12.01	12.01	7.44	11.34	11.37	9.87	10.19	8.69
	18	11.89	11.49	12.05	7.47	11.38	11.77	9.85	10.19	8.60
20	6	11.89	12.05	12.06	7.47	10.37	12.11	11.74	10.09	8.54
	18	11.89	12.01	12.01	7.44	10.34	12.17	12.05	9.86	8.63
21	6	11.88	11.83	11.92	7.41	8.84	12.47	12.44	9.01	8.87
	18	11.86	11.71	11.89	7.38	9.45	12.47	12.75	9.48	9.06
22	6	11.96	10.92	11.96	7.35	9.27	12.41	13.02	9.48	8.78
	18		11.07	12.05	7.32	9.09	12.36	13.30	9.67	8.57
23	6	11.83	11.37	12.05	7.29	9.00	12.20	13.39	9.88	8.39
	18	11.80	11.37	12.09	7.32	8.91	11.85	13.39	10.12	8.51
24	6	11.80	11.28	12.05	7.35	9.84	11.71	13.20	9.64	10.52
	18	11.80	11.28	12.01	7.32	8.78	11.83	13.11	9.55	9.85
25	6	11.80	11.31	11.92	7.32	8.69	11.68	12.81	9.49	9.42
	18	11.77	11.25	11.96	7.92	8.66	11.47	12.66	9.47	9.39
26	6	11.77	11.16	11.80	7.32	6.63	11.10	12.23	8.48	9.82
	18	11.77	11.28	11.90	7.44	10.01	10.76	11.99	8.38	9.89
27	6	11.74	11.47	11.80	7.50	9.63	10.46	11.65	8.30	9.70
	18	11.74	11.56	11.83	7.59	9.15	10.37	11.31	9.21	9.82
28	6	11.74	11.50	11.80	7.99	8.66	10.09	10.85	9.18	9.73
	18	11.71	11.44	11.83	8.05	8.45	9.81	11.34	8.21	9.94
29	6	11.68		11.44	6.98	6.54	9.82	10.31	9.39	10.16
	18	11.65		11.19	9.30	6.60	9.73	10.19	8.81	10.22
30	6	11.82		11.07	9.03	8.87	9.67	9.84	8.82	9.84
	18	11.68		11.28	8.81	9.00	9.78	9.85	8.73	8.73
31	6	11.77		11.53		11.13		9.76	9.82	
	18	11.83		11.65		11.44		9.70	10.03	

1993–1994

DAY	TIME	OCTOBER U/S	OCTOBER D/S	NOVEMBER U/S	NOVEMBER D/S	DECEMBER U/S	DECEMBER D/S	JANUARY U/S	JANUARY D/S	FEBRUARY U/S	FEBRUARY D/S	MARCH U/S	MARCH D/S	APRIL U/S	APRIL D/S	MAY U/S	MAY D/S
1	6	9.64	9.42	7.84	7.72	7.63	7.41	11.53	6.65	11.80	7.04	11.68	6.34	9.42	9.18	7.41	7.15
	18	9.61	9.39	7.88	7.76	7.50	7.38	11.59	6.56	11.68	7.04	11.77	6.34	9.77	9.51	7.35	7.10
2	6	8.51	9.33	7.88	7.75	7.53	7.41	11.77	6.69	11.84	7.04	11.80	6.34	11.34	[illegible]	7.35	7.10
	18	9.30	9.12	7.90	7.76	7.50	7.39	11.80	6.28	11.52	6.71	11.56	6.34	11.37	[illegible]	7.32	7.07
3	6	9.51	9.33	7.90	7.76	7.52	7.41	11.80	6.71	11.77	6.68	11.92	6.34	11.40	11.12	7.33	7.07
	18	9.61	9.42	7.81	7.78	7.50	7.36	11.80	6.71	11.80	6.68	11.95	6.40	10.61	[illegible]	7.25	7.04
4	6	9.33	9.15	7.87	7.75	7.50	7.40	11.80	6.71	11.92	6.68	11.92	6.43	10.42	[illegible]	7.30	[illegible]
	18	9.23	9.03	9.14	7.59	7.46	7.37	11.60	6.71	11.71	6.68	11.92	6.63	10.03	9.78	7.36	[illegible]
5	6	9.09	8.92	8.20	6.35	7.50	7.36	11.60	6.71	11.86	6.66	11.74	6.77	8.63	8.39	7.47	7.19
	18	9.00	8.84	8.11	7.96	7.49	7.37	11.90	6.71	11.96	6.68	11.93	6.92	9.27	9.02	7.63	7.26
6	6	8.87	8.72	7.93	7.91	7.49	7.36	11.90	6.71	11.89	6.68	11.65	6.92	9.09	8.78	7.58	7.32
	18	8.74	9.59	7.81	7.68	7.47	7.35	11.80	6.71	11.89	6.68	11.65	6.90	[illegible]	[illegible]	7.56	7.37
7	6	8.78	8.63	7.78	7.66	7.49	7.37	11.80	6.71	11.92	6.68	11.75	6.92	8.75	8.48	7.60	7.53
	18	8.72	8.57	7.67	7.55	7.47	7.35	11.90	6.71	11.92	6.68	11.71	9.46	9.78	8.51	7.71	7.47
8	6	8.74	8.60	7.75	7.82	7.47	7.25	11.79	6.68	11.92	6.66	11.86	6.46	8.63	[illegible]	7.59	7.35
	18	8.54	8.75	7.69	7.50	7.46	7.34	11.79	6.71	11.92	6.69	11.90	6.34	9.97	9.63	7.53	7.28
9	6	8.91	8.75	7.69	7.56	7.46	7.35	11.77	6.86	11.92	6.98	11.95	6.34	8.72	8.48	7.50	7.23
	18	8.81	8.69	7.66	7.53	7.44	7.35	11.77	6.71	11.92	6.68	11.89	6.34	8.43	8.2	7.47	7.19
10	6	8.66	8.54	7.66	7.53	7.46	7.34	11.74	6.68	11.66	7.07	11.95	6.34	9.26	8.02	7.44	7.19
	18	8.45	8.33	7.62	7.50	7.44	7.32	11.71	6.71	11.71	6.48	11.98	6.34	8.11	7.97	7.36	7.41
11	6	8.36	8.23	7.62	7.49	7.44	7.34	11.71	6.68	11.53	6.62	11.89	6.49	8.00	7.74	7.35	7.38
	18	8.20	8.08	7.56	7.44	7.44	7.32	11.65	6.69	11.94	6.62	11.95	6.74	7.96	7.71	7.32	7.04
12	6	8.29	8.11	7.59	7.47	7.44	7.32	11.69	6.68	11.92	6.62	11.80	6.77	7.84	7.69	7.30	7.04
	18	8.17	8.05	7.56	7.44	7.44	7.30	11.69	6.68	11.86	6.98	11.83	6.77	7.79	7.56	7.63	7.39
13	6	8.25	8.14	7.56	7.44	7.44	7.32	11.69	6.68	11.77	6.98	11.77	6.74	7.74	7.5	7.84	7.59
	18	8.30	8.17	7.53	7.40	7.43	7.30	11.68	6.68	11.71	6.99	11.77	6.77	7.66	7.47	8.08	7.84
14	6	8.45	8.33	7.53	7.41	7.43	7.32	11.65	6.99	11.71	6.77	11.80	6.71	7.62	7.41	8.05	7.80
	18	9.91	8.72	7.49	7.37	7.41	7.29	11.65	6.89	11.69	6.74	11.74	6.71	7.62	7.41	7.92	7.66
15	6	9.58	6.39	7.47	7.35	7.43	7.30	11.62	6.68	11.65	6.77	11.92	9.59	7.59	7.36	7.83	7.68
	18	9.89	9.79	7.44	7.30	7.41	7.29	11.65	6.62	11.65	6.74	11.83	6.82	7.58	7.33	8.17	7.90
16	6	9.43	9.24	7.44	7.32	7.41	7.30	11.73	6.59	11.89	8.74	11.22	6.89	7.53	7.31	8.01	8.70
	18	9.09	8.94	7.40	7.27	7.41	7.29	11.92	6.59	11.92	6.74	11.85	6.92	9.12	6.88	9.01	8.94
17	6	8.75	8.60	7.41	7.29	7.41	7.29	11.89	6.55	11.58	6.74	11.84	7.13	8.96	8.68	9.66	9.42
	18	8.57	8.42	7.38	7.26	7.40	7.27	11.95	6.65	11.65	6.31	11.86	7.13	10.40	9.26	9.35	9.57
18	6	8.54	8.39	7.38	7.26	7.41	7.29	12.01	6.68	11.74	6.31	11.65	7.13	7.99	7.44	9.54	9.27
	18	8.45	8.30	7.35	7.23	7.40	7.27	12.01	6.74	11.86	6.31	11.77	7.13	8.14	7.9	10.03	9.76
19	6	8.45	8.30	7.35	7.23	7.40	7.27	11.97	7.01	11.89	6.31	11.46	7.13	8.62	8.44	9.83	9.57
	18	8.36	8.23	7.32	7.20	7.38	7.26	11.89	7.01	11.94	6.31	11.52	7.10	9.40	8.14	8.60	9.39
20	6	8.26	8.14	7.32	7.20	7.40	7.27	11.80	7.01	11.98	6.31	11.49	6.83	8.05	7.6	8.78	8.54
	18	8.20	8.08	7.29	7.17	7.36	7.26	11.74	7.01	11.99	6.31	11.46	6.85	7.63	7.05	8.44	8.20
21	6	8.35	8.17	7.28	7.17	7.40	7.25	11.86	7.01	12.07	6.71	11.60	6.65	7.87	7.52	8.91	7.96
	18	8.20	8.08	7.25	7.44	7.40	7.27	11.47	7.01	12.01	6.71	11.62	6.65	7.64	7.59	7.69	7.74
22	6	8.33	8.20	7.29	7.17	7.42	7.30	11.34	7.01	12.00	6.93	11.77	6.62	9.02	7.77	7.93	7.69
	18	8.22	8.10	7.26	7.14	7.38	7.28	11.37	7.01	11.94	6.99	11.72	6.85	8.26	8.02	7.80	7.56
23	6	8.29	8.14	7.26	7.14	7.36	7.26	11.54	6.37	11.89	6.95	11.53	6.63	8.81	8.57	7.90	7.65
	18	8.63	8.48	7.21	7.09	7.38	7.28	11.65	6.34	11.89	6.95	11.80	6.62	8.54	8.26	7.99	7.74
24	6	8.66	8.51	7.23	7.11	7.38	7.28	11.74	6.34	12.01	6.95	11.65	7.10	8.17	7.9	8.03	7.74
	18	8.54	8.42	7.14	7.01	7.37	7.26	11.83	6.34	12.01	7.26	11.37	7.10	7.87	7.71	7.87	7.70
25	6	8.49	8.36	7.14	7.01	7.38	7.26	11.86	6.34	11.84	7.26	11.10	6.80	7.84	7.56	8.08	7.84
	18	8.42	8.30	7.08	6.95	7.35	7.23	11.92	6.34	11.74	7.26	10.70	8.78	7.77	7.5	8.08	7.84
26	6	8.45	8.33	7.05	6.82	7.35	7.23	11.95	6.71	11.55	7.26	11.07	8.90	7.97	7.68	8.44	8.20
	18	8.39	8.23	7.01	6.89	7.32	7.20	11.99	6.80	11.34	7.26	10.18	9.81	8.05	7.77	8.38	8.14
27	6	8.14	8.02	7.01	6.98	7.35	7.23	11.99	6.77	11.13	7.23	11.07	10.82	7.99	7.71	8.35	8.11
	18	9.05	7.93	6.98	6.86	7.32	7.20	11.95	6.77	11.22	6.34	11.62	11.37	7.90	7.65	8.26	8.02
28	6	7.99	7.87	7.01	6.89	7.35	7.23	11.89	6.68	11.40	6.34	10.89	10.73	7.84	7.59	8.05	7.80
	18	7.93	7.81	6.98	6.88	8.45	7.01	11.92	6.71	11.55	6.34	10.52	10.27	7.74	7.5		
29	6	7.96	7.84	6.98	6.86	9.48	6.86	11.89	6.68			10.18	9.94	7.65	7.38		
	18	7.88	7.75	6.95	6.83	10.03	6.74	11.99	6.50			9.95	9.48	7.56	7.28		
30	6	7.87	7.75	6.95	6.83	10.49	6.71	11.93	6.68			9.42	9.21	7.47	7.23		
	18	7.81	7.69	6.82	6.80	10.80	6.65	11.98	6.62			9.48	9.24	7.44	7.19		
31	6	7.78	7.66			11.10	6.65	11.96	6.66			9.69	9.45				
	18	24.66	24.26			11.34	6.65	11.85	6.65			9.73	9.48				

Project Monitoring Program
MANU RIVER FCDI PROJECT

Cumulative Pumping Hours of Manu Project Pump Station

DAY	1992																	
	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS
1	1.96	47	1.63	39	1.67	40	2.00	48	0.92	22	0.00	0	0.00	0	0.00	0	0.00	0
2	1.42	34	1.21	29	2.08	50	2.00	48	0.79	19	0.00	0	0.00	0	0.00	0	0.00	0
3	0.67	16	0.75	18	2.63	63	2.00	48	0.75	18	0.00	0	0.00	0	0.00	0	0.00	0
4	0.33	8	1.17	28	2.75	66	1.92	46	0.75	18	0.00	0	0.00	0	0.00	0	0.00	0
5	0.00	0	0.88	21	2.25	54	2.00	48	0.75	18	0.00	0	0.00	0	0.00	0	0.00	0
6	0.00	0	1.79	43	2.75	66	2.21	53	1.00	24	0.00	0	0.00	0	0.00	0	0.00	0
7	0.00	0	1.63	39	1.75	42	3.00	72	1.00	24	0.00	0	0.00	0	0.00	0	0.00	0
8	0.00	0	1.83	44	1.75	42	3.00	72	1.63	39	0.00	0	0.00	0	0.00	0	0.00	0
9	0.00	0	1.92	46	0.50	12	2.71	65	3.00	72	0.00	0	0.00	0	0.00	0	0.00	0
10	0.54	13	1.83	44	2.00	48	2.71	65	3.00	72	0.00	0	0.00	0	0.00	0	0.00	0
11	1.13	27	2.00	48	2.00	48	2.00	48	3.00	72	0.00	0	0.00	0	0.00	0	0.00	0
12	0.71	17	2.00	48	2.00	48	2.71	65	2.88	69	0.00	0	0.00	0	0.00	0	0.00	0
13	0.96	23	2.00	48	2.00	48	3.00	72	1.42	34	0.00	0	0.00	0	0.00	0	0.00	0
14	0.75	18	1.25	30	2.00	48	2.38	57	1.00	24	0.83	20	0.00	0	0.00	0	0.00	0
15	0.76	18	0.50	12	1.83	44	1.71	41	1.00	24	1.00	24	0.00	0	0.00	0	0.00	0
16	0.00	0	0.92	22	1.92	46	2.00	48	1.00	24	1.83	44	1.17	28	0.00	0	0.00	0
17	0.00	0	1.50	36	1.71	41	2.00	48	0.96	23	2.75	66	1.50	36	0.00	0	0.00	0
18	0.00	0	1.29	31	1.04	25	1.92	46	0.25	6	2.92	70	2.00	48	0.00	0	0.00	0
19	0.36	9	0.54	13	1.00	24	2.00	48	0.00	0	0.88	21	2.04	49	0.00	0	0.00	0
20	0.33	8	0.79	19	1.00	24	2.00	48	0.00	0	0.00	0	2.50	60	0.00	0	0.00	0
21	0.75	18	0.50	12	1.00	24	1.75	42	0.00	0	0.00	0	3.00	72	0.00	0	0.00	0
22	0.33	8	0.58	14	1.00	24	2.00	48	0.00	0	0.00	0	3.00	72	0.00	0	0.00	0
23	0.88	21	0.83	20	1.00	24	2.00	48	0.00	0	0.00	0	3.00	72	0.00	0	0.00	0
24	2.00	48	0.00	0	1.00	24	2.00	48	0.00	0	0.00	0	3.00	72	0.00	0	0.00	0
25	1.63	39	0.00	0	1.00	24	1.58	38	0.00	0	0.00	0	2.13	51	0.00	0	0.00	0
26	2.00	48	0.00	0	1.21	29	1.50	36	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
27	1.46	35	0.00	0	2.63	63	1.58	38	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
28	0.88	21	0.54	13	3.29	79	2.00	48	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
29	1.46	35	1.17	28	2.13	51	2.00	48	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
30	1.63	39	1.25	30	2.25	54	1.83	44	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
31			2.00	48			0.71	17	0.00	0			0.00	0			0.00	0
SUM		550		823		1275		1541		602		245		560		0		0

DAY	1993																							
	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No. of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No. of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No. of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS
1	0.00	0	0.00	0	2.04	49	0.54	13	2.88	69	5.00	120	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
2	0.00	0	0.00	0	2.00	48	0.63	15	3.00	72	4.79	115	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
3	0.00	0	0.00	0	2.00	48	1.00	24	2.88	69	4.00	96	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
4	0.00	0	0.00	0	2.00	48	1.00	24	2.08	50	5.08	122	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
5	0.00	0	0.00	0	2.00	48	0.33	8	2.17	52	6.00	144	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
6	0.00	0	0.00	0	1.50	36	0.42	10	3.25	78	5.75	138	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
7	0.00	0	0.00	0	1.25	30	0.83	15	6.00	144	6.00	144	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
8	0.00	0	0.00	0	0.96	23	0.46	11	6.00	144	3.25	78	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
9	0.00	0	0.00	0	0.88	21	0.08	2	6.00	144	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
10	0.00	0	0.00	0	0.54	13	0.08	2	1.96	47	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
11	0.00	0	0.00	0	1.00	24	0.67	16	3.54	85	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
12	0.00	0	0.00	0	1.00	24	0.75	18	3.96	95	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
13	0.00	0	0.00	0	0.75	18	1.00	24	4.13	99	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
14	0.00	0	0.00	0	0.00	0	1.00	24	4.17	100	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
15	0.00	0	0.00	0	0.00	0	1.00	24	5.00	120	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
16	0.00	0	0.00	0	0.00	0	1.00	24	6.00	120	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
17	0.00	0	0.00	0	0.71	17	1.00	24	5.00	120	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
18	0.00	0	0.00	0	1.00	24	1.00	24	4.17	100	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
19	0.00	0	0.00	0	1.00	24	0.58	14	4.75	114	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
20	0.00	0	1.35	33	1.00	24	1.00	24	4.68	117	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
21	0.00	0	1.58	38	1.00	24	1.00	24	6.00	144	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
22	0.00	0	1.75	42	0.67	16	1.00	24	6.00	144	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
23	0.00	0	2.00	48	0.67	16	1.00	24	6.00	144	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
24	0.00	0	1.17	28	0.67	16	0.83	20	6.00	144	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
25	0.00	0	1.58	38	0.58	14	0.67	16	6.00	144	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
26	0.00	0	2.67	64	0.54	13	0.54	13	6.00	144	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
27	0.00	0	3.00	72	0.79	19	1.33	32	5.50	132	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
28	0.00	0	3.00	72	1.00	24	2.63	63	5.25	126	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
29	0.00	0			1.00	24	3.00	72	5.50	132	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
30	0.00	0			1.00	24	3.42	82	6.50	156	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
31	0.00	0			0.92	22			4.38	105			0.00	0	0.00	0			0.00	0			0.00	0
SUM		0		435		731		710		3454		957		0		0		0		0		0		0

DAY	1994									
	JAN		FEB		MAR		APR		MAY	
	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No of Pump	CUM PUMP HRS	No. of Pump	CUM PUMP HRS
1	0.00	0	0.00	0	0.00	0	4.64	111		
2	0.00	0	0.00	0	0.00	0	4.83	116		
3	0.00	0	0.00	0	0.00	0	4.82	116		
4	0.00	0	0.00	0	0.00	0	3.95	95		
5	0.00	0	0.00	0	0.00	0	4.60	111		
6	0.00	0	0.00	0	0.00	0	4.85	116		
7	0.00	0	0.00	0	0.00	0	4.47	107		
8	0.00	0	0.00	0	0.00	0	4.27	102		
9	0.00	0	0.00	0	0.00	0	5.16	124		
10	0.00	0	0.00	0	0.00	0	5.40	130		
11	0.00	0	0.00	0	0.00	0	5.01	120		
12	0.00	0	0.00	0	0.00	0	4.80	115		
13	0.00	0	0.00	0	0.00	0	4.63	111		
14	0.00	0	0.00	0	0.00	0	5.65	136		
15	0.00	0	0.00	0	0.00	0	5.00	120		
16	0.00	0	0.00	0	0.00	0	4.72	113		
17	0.00	0	0.00	0	0.00	0	5.83	140		
18	0.00	0	0.00	0	0.00	0	4.68	112		
19	0.00	0	0.00	0	0.00	0	4.21	101		
20	0.00	0	0.00	0	0.00	0	3.57	86		
21	0.00	0	0.00	0	0.00	0	4.11	99		
22	0.00	0	0.00	0	0.00	0	3.80	91		
23	0.00	0	0.00	0	0.00	0	4.23	101		
24	0.00	0	0.00	0	0.00	0	3.10	75		
25	0.00	0	0.00	0	0.00	0	3.74	90		
26	0.00	0	0.00	0	2.23	53				
27	0.00	0	0.00	0	4.63	111				
28	0.00	0	0.00	0	4.50	108				
29	0.00	0			4.98	120				
30	0.00	0			4.96	119				
31	0.00	0			4.86	117				
SUM		0		0		628		2738		

Project Monitoring Program

MANU RIVER FCDI PROJECT

Volume Pumped by Manu Project Pump Station (in Million m3)

DAY	1992 APR No. of Pump	APR VOL	MAY No. of Pump	MAY VOL	JUN No. of Pump	JUN VOL	JUL No. of Pump	JUL VOL	AUG No. of Pump	AUG VOL	SEP No. of Pump	SEP VOL	OCT No. of Pump	OCT VOL	NOV No. of Pump	NOV VOL	DEC No. of Pump	DEC VOL
1	1.96	0.72	1.63	0.60	1.67	0.61	2.00	0.73	0.92	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1.42	0.52	1.21	0.44	2.08	0.77	2.00	0.73	0.78	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.67	0.24	0.75	0.28	2.63	0.96	2.00	0.73	0.75	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.33	0.12	1.17	0.43	2.75	1.01	1.92	0.70	0.75	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.88	0.32	2.25	0.63	2.00	0.73	0.75	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	1.79	0.66	2.75	1.01	2.21	0.81	1.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	1.63	0.60	1.75	0.64	3.00	1.10	1.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	1.83	0.67	1.75	0.64	3.00	1.10	1.63	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	1.92	0.70	0.50	0.18	2.71	0.99	3.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.54	0.20	1.83	0.67	2.00	0.73	2.71	0.99	3.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	1.13	0.41	2.00	0.73	2.00	0.73	2.00	0.73	3.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.71	0.26	2.00	0.73	2.00	0.73	2.71	0.99	2.88	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.96	0.35	2.00	0.73	2.00	0.73	3.00	1.10	1.42	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.75	0.28	1.25	0.46	2.00	0.73	2.38	0.67	1.00	0.37	0.83	0.31	0.00	0.00	0.00	0.00	0.00	0.00
15	0.75	0.26	0.50	0.18	1.83	0.67	1.71	0.63	1.00	0.37	1.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.92	0.34	1.92	0.70	2.00	0.73	1.00	0.37	1.83	0.67	1.17	0.43	0.00	0.00	0.00	0.00
17	0.00	0.00	1.50	0.55	1.71	0.63	2.00	0.73	0.96	0.35	2.75	1.01	1.50	0.55	0.00	0.00	0.00	0.00
18	0.00	0.00	1.29	0.47	1.04	0.38	1.92	0.70	0.25	0.09	2.92	1.07	2.00	0.73	0.00	0.00	0.00	0.00
19	0.38	0.14	0.54	0.20	1.00	0.37	2.00	0.73	0.00	0.00	0.86	0.32	2.04	0.75	0.00	0.00	0.00	0.00
20	0.33	0.12	0.79	0.29	1.00	0.37	2.00	0.73	0.00	0.00	0.00	0.00	2.50	0.92	0.00	0.00	0.00	0.00
21	0.75	0.26	0.50	0.18	1.00	0.37	1.75	0.64	0.00	0.00	0.00	0.00	3.00	1.10	0.00	0.00	0.00	0.00
22	0.33	0.12	0.56	0.21	1.00	0.37	2.00	0.73	0.00	0.00	0.00	0.00	3.00	1.10	0.00	0.00	0.00	0.00
23	0.86	0.32	0.83	0.31	1.00	0.37	2.00	0.73	0.00	0.00	0.00	0.00	3.00	1.10	0.00	0.00	0.00	0.00
24	2.00	0.73	0.00	0.00	1.00	0.37	2.00	0.73	0.00	0.00	0.00	0.00	3.00	1.10	0.00	0.00	0.00	0.00
25	1.63	0.60	0.00	0.00	1.00	0.37	1.58	0.58	0.00	0.00	0.00	0.00	2.13	0.78	0.00	0.00	0.00	0.00
26	2.00	0.73	0.00	0.00	1.21	0.44	1.50	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	1.46	0.54	0.00	0.00	2.63	0.96	1.58	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.88	0.32	0.54	0.20	3.29	1.21	2.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	1.46	0.54	1.17	0.43	2.13	0.78	2.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	1.63	0.60	1.25	0.46	2.25	0.83	1.83	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31			2.00	0.73			0.71	0.26	0.00	0.00			0.00	0.00			0.00	0.00
SUM		8.42		12.59		19.51		23.58		9.21		3.75		8.57		0.00		0.00

DAY	1993 JAN No. of Pump	JAN VOL	FEB No. of Pump	FEB VOL	MAR No. of Pump	MAR VOL	APR No. of Pump	APR VOL	MAY No. of Pump	MAY VOL	JUN No. of Pump	JUN VOL
1	0.00	0.00	0.00	0.00	2.04	0.75	0.54	0.20	2.88	1.06	5.00	1.64
2	0.00	0.00	0.00	0.00	2.00	0.73	0.63	0.23	3.00	1.10	4.79	1.76
3	0.00	0.00	0.00	0.00	2.00	0.73	1.00	0.37	2.88	1.06	4.00	1.47
4	0.00	0.00	0.00	0.00	2.00	0.73	1.00	0.37	2.08	0.77	5.08	1.87
5	0.00	0.00	0.00	0.00	2.00	0.73	0.33	0.12	2.17	0.80	6.00	2.20
6	0.00	0.00	0.00	0.00	1.50	0.56	0.42	0.15	3.25	1.18	5.75	2.11
7	0.00	0.00	0.00	0.00	1.25	0.46	0.63	0.23	6.00	2.20	6.00	2.20
8	0.00	0.00	0.00	0.00	0.96	0.35	0.48	0.17	6.00	2.20	3.25	1.19
9	0.00	0.00	0.00	0.00	0.88	0.32	0.06	0.03	6.00	2.20	0.00	0.00
10	0.00	0.00	0.00	0.00	0.54	0.20	0.08	0.03	1.98	0.72	0.00	0.00
11	0.00	0.00	0.00	0.00	1.00	0.37	0.67	0.24	3.54	1.30	0.00	0.00
12	0.00	0.00	0.00	0.00	1.00	0.37	0.75	0.28	3.96	1.45	0.00	0.00
13	0.00	0.00	0.00	0.00	0.75	0.28	1.00	0.37	4.13	1.51	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.37	4.17	1.53	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.37	5.00	1.84	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.37	5.00	1.64	0.00	0.00
17	0.00	0.00	0.00	0.00	0.71	0.26	1.00	0.37	5.00	1.84	0.00	0.00
18	0.00	0.00	0.00	0.00	1.00	0.37	1.00	0.37	4.17	1.53	0.00	0.00
19	0.00	0.00	0.00	0.00	1.00	0.37	0.56	0.21	4.75	1.74	0.00	0.00
20	0.00	0.00	1.38	0.50	1.00	0.37	1.00	0.37	4.88	1.79	0.00	0.00
21	0.00	0.00	1.56	0.55	1.00	0.37	1.00	0.37	6.00	2.20	0.00	0.00
22	0.00	0.00	1.75	0.64	0.67	0.24	1.00	0.37	6.00	2.20	0.00	0.00
23	0.00	0.00	2.00	0.73	0.67	0.24	1.00	0.37	6.00	2.20	0.00	0.00
24	0.00	0.00	1.17	0.43	0.57	0.24	0.83	0.31	6.00	2.20	0.00	0.00
25	0.00	0.00	1.58	0.58	0.58	0.21	0.67	0.24	6.00	2.20	0.00	0.00
26	0.00	0.00	2.67	0.98	0.54	0.20	0.54	0.20	6.00	2.20	0.00	0.00
27	0.00	0.00	3.00	1.10	0.79	0.29	1.33	0.49	5.50	2.02	0.00	0.00
28	0.00	0.00	3.00	1.10	1.00	0.37	2.63	0.96	5.25	1.93	0.00	0.00
29	0.00	0.00			1.00	0.37	3.00	1.10	5.50	2.02	0.00	0.00
30	0.00	0.00			1.00	0.37	3.42	1.25	6.50	2.39	0.00	0.00
31	0.00	0.00			0.92	0.34			4.38	1.61		
SUM		0.00		6.66		11.15		10.86		52.85		14.61

DAY	1993 JUL No. of Pump	JUL VOL	AUG No. of Pump	AUG VOL	SEP No. of Pump	SEP VOL	OCT No. of Pump	OCT VOL	NOV No. of Pump	NOV VOL	DEC No. of Pump	DEC VOL	1994 JAN No. of Pump	JAN VOL	FEB No. of Pump	FEB VOL	MAR No. of Pump	MAR VOL	APR No. of Pump	APR VOL	MAY No. of Pump	MAY VOL
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.64	1.70		
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.83	1.77		
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.82	1.77		
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.85	1.45		
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.60	1.69		
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.85	1.78		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.47	1.64		
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.27	1.57		
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.16	1.89		
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.40	1.98		
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.01	1.84		
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.80	1.76		
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.63	1.70		
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.65	2.07		
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	1.84		
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.72	1.73		
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.65	2.16		
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.65	1.72		
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.21	1.55		
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.57	1.31		
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.11	1.51		
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.83	1.40		
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.23	1.55		
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.10	1.14		
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74	1.37		
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.23	0.82				
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.63	1.70				
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	1.65				
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			4.98	1.83				
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			4.96	1.82				
31	0.00	0.00	0.00	0.00			0.00	0.00			0.00	0.00	0.00	0.00			4.68	1.79				
SUM		0.00		0.00		0.00		0.00		0.00		0.00		0.00				9.61		41.90		

APPENDIX B

RIVER MORPHOLOGY AND SEDIMENT DATA

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APPENDIX B : RIVER MORPHOLOGY AND SEDIMENT DATA

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B.1 RIVER MORPHOLOGY AND SEDIMENTATION

Morphology

The Manu River can be sub-divided into three main reaches:

- upper Manu River in Tripura State, India;
- middle reach, from the Bangladesh border to Dhalai River confluence;
- lower Manu River from Dhalai River confluence to its junction with Kushiyara River.

The Upper Manu River occupies a narrow valley between two prominent north-south trending anticlinal ridges. The lower portions of these ridges consist of poorly consolidated, often highly weathered Pleistocene and Pliocene-age sediments (Dihing and Dupi Tila Formation) that are dissected and gullied by a network of headwater channels that form a dendritic drainage pattern. It appears sediment production from these channels is high. The Upper Manu River flows in a confined, irregularly meandering channel and displays large sandy point bars, mid-channel bars and side-bars, which suggests the river is transporting substantial sand-loads

Downstream of the border, the Manu River flows in a north-westerly direction, across the strike of the anticlines, and breaks through a gap between the ridges below Hashimpur. The channel turns westwards and is confined by the Bhatera Hills on its right bank and bordered by Dakdhala Haor on its left. However, there are indications that the river has followed other courses in the past:

- Old channel scars and partially infilled paleo-channel leads off from the present channel just upstream of the Manu railway bridge and follows the east side of the Bhatera Hills into Hakaluki Haor;

- A second former channel appears to lead off to the north from the present channel near Kazir Bazar (just upstream of the Dhalai confluence) and flows along the west side of the Bhatera Hills towards the Kushiyara River near Fenchuganj.

The present-day Manu River has a highly sinuous, regular meander pattern in this reach. A comparison of 1990 SPOT satellite photos with 1:40,000 scale maps derived from 1952 air photos showed there has been localized channel shifting due to progressive meander migration and two apparently natural cutoffs. Bed material samples collected by NERP indicate the channel is composed of medium-fine sand (D_{50} of 0.2 mm). Typical channel dimensions are summarized

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in the table. The channel has an average top width of 103 m and an average cross sectional area of 410 m^2 (at approximately bankfull stage).

Table B1: Typical Channel Dimension

Reach (km from Manumukh)	1985/86 Survey		1993 Survey	
	Area (m^2)	Width (m)	Area (m^2)	Width (m)
2.65 - 2.9	396	79	416	88
18 - 20.8	527	103	545	114

The Dhalai River enters the left bank of the Manu River just downstream of Dakdhala Haor. Immediately downstream, the left (south) bank of the Manu River is confined by the Balishiri Hills, and Pleistocene-age weathered sandstone can be seen outcropping in the left bank in some locations. The river turns northwards near Moulvibazar and flows in an irregular, low sinuosity channel until joining the Kushiyara River near Manumukh. In spite of inflows from the Dhalai River and other tributaries, the channel dimensions remain virtually unchanged in this reach, with the width actually decreasing in the lower 5 km. The reach is affected by embankments on both banks which have been continuously constructed and upgraded since the early 1980's.

Sediment Transport

Suspended sediment concentration has been periodically measured by BWDB at the Manu Railway bridge in several years. Measurements in 1977 and 1984 covered moderately high flow conditions and were used to establish a sediment rating curve. A regression equation of the log-transformed values gave the following relation between daily water discharge (Q) and daily sediment load (G_s, in tonnes/day).

$$G_s=0.54Q^{2.015}$$

The daily loads were summed to estimate the annual suspended load in each year between 1981-1991 using the available discharge data at the gauging station. The computed annual load averaged about 2.2 million tonnes/year, and reached over 5 million tonnes/year during high flood years such as 1988 or 1991. Furthermore, the annual load during the period 1986-1991 was approximately double the average load between 1981-1985, due to the high flood magnitudes that have occurred in recent years.

No estimates of sediment loads are available for the Dhalai River. Assuming the additional loads are proportional to the increased flood discharges, it is expected the sediment loads on the Manu River below the confluence would be approximately 40 % larger (around 3 million tonnes/year).

Channel Stability and Trends

Assessment of channel changes and trends has been based on comparisons of historic maps and satellite images, analysis of hydrometric data and a comparison of channel cross sections and surveys. The most useful information to assess vertical changes (degradation/aggradation) in the

Manu River upstream of the Dhalai River are the historic stage-discharge measurements collected by BWDB at the Manu Railway bridge. A comparison of these rating curves, in the form of a "specific guage" plot, shows trends in water levels for certain specified discharges (in this case the selected discharges were 100, 200 and 400 m^3/s). It can be seen that there has been virtually no change over the period 1965-1991 at the lower discharges and a decrease over time (0.6 m over 25 years) at the highest discharge. The decrease in levels at the higher flows suggests the channel section has increased by widening rather than by bed lowering.

River cross sections were surveyed by BWDB downstream of Moulvibazar in 1985 and repeated by NERP in February 1993. The BWDB surveys were concentrated in two locations - six cross sections near Palpur (3 km upstream of Manamukh) and five cross sections near Moulvibazar town (18-20 km upstream of Manamukh). Comparison of the channel sections at the two sites, and changes in the average bankfull geometry between 1985-1993, indicate there has been only minor changes to the overall channel properties over the last 18 years. The river's top width has increased by about 10% in both reaches, and the average channel area at bankfull stage has increased by 3-5%. This suggests that the impact of embankment construction on channel geometry has not been pronounced. Furthermore, it appears the lower portion of the Manu River (from Moulvibazar to Manamukh) is a relatively stable transport reach, that is neither aggrading nor degrading over time.

Further details are provided in the following sections.

B.2 MANU CROSS SECTIONS

The NERP sediment team has collected some information on 26 different cross-sections (x-s) of the Manu River. These sections were made by BWDB, SWMC and NERP. Although there appear to be a significant number of cross-sections there are several reasons why they do not provide as much information as desired. First, they only cover two periods in time; the BWDB cross-sections were all made in 1986 or 85 and the SWMC and NERP cross-sections were made between 1991 and 1993. Secondly, they cover only a small portion of the river. Although, the newer sections (SWMC & NERP) are spread out over the length of the river, the older (BWDB) cross-sections are concentrated to two very short distances near Moulvibazar and Palpur (see Figure 1). For these reasons we only have a very limited view of the changes that have occurred in the river over the last 8 years.

BWDB vs NERP cross-sections

As mentioned above there are 2 main sets of BWDB cross-sections - the Palpur set (chainage 2.65 - 2.9) and the Moulvibazar set (chainage 18.0 - 21.0). The Palpur cross-sections (see figure 2) were first surveyed by BWDB in 1986 in conjunction with a bank revetment project at a river bend that was to close to the MRP embankment. NERP re-surveyed the area in March 1993. Although it is certain the same bend in the river was re-surveyed, it is doubtful that the section lines match exactly. NERP surveyed two full section in the bend and three partial sections of the river only. A combination of all 5 sections was used to make 'best-fit' cross-sections which match the old BWDB cross-sections.

The distance between the cross-sections is very short (less than 200 m), so it is difficult to make any definite conclusions. However, the sections seem to show that the scour hole in the bend has deepened (as can be expected when the river is confined by a such a revetment project). When a profile of the sections is made (see figure 3a) the upstream sections seems to indicate that some deposition has occurred. A comparison of cross-sectional area (figure 3b) indicates that there is an increase in area at the bend (scour hole) and a decrease in area in the upstream section. The top widths increase in all but one section; the average increased by about 10 m or 12% (Table B1).

The second set of cross-sections from BWDB contained a series of 11 cross-sections near Moulvibazar town. Again it was difficult to determine the exact locations of the original cross-sections, as no permanent markers were left. Five cross-sections within the same reach were resurveyed (see fig 4). It was attempted to match 4 of the cross-sections exactly (18.07, 20.3, 20.55, 20.77) to the 1986 sections. However, section 18.88 was establish by NERP in 1992 and is compared to the nearest BWDB section (19.10).

Here again, the elevation profile (figure 5) indicates a small amount of deposition. Figure 6 shows a significant increase in area, and top width, as one moves downstream of the barrage. However, the cross-sectional area of the two sections nearest the barrage has decreased. The average cross-sectional area in 1993 was about 3.5% greater than in 1986.

NERP August vs NERP February cross-sections

There has been some difficulty in measuring the cross-sections accurately and consistently both times. A discrepancy in elevation, and distances,between hubs existed at most of the 7 cross-sections. These have all been checked and remeasured to determine the "true" measurements. The cross-sections have been correspondingly adjusted to fit the "true" measurements. The cross-sectional drawings (figure 7) seems to indicate that there is little change in between the August and February cross-sections. It might have been expected that the upstream section would have silted in during the dry season (because water is stored behind the dam for irrigation), but the slight change that has occurred seems to indicate the opposite (see figure 8a). The plot of cross-sectional area (figure 8b) show some erratic behaviour but his may be due to incorrect, or inconsistent bankfull designations. The bankfull data is given in Table B2 but it is difficult to draw any conclusions from it.

NERP vs. SWMC cross-sections

It has been difficult to compare the SWMC cross-sections with NERP cross-sections. Though the original intention was so make a direct comparison it has proven difficult because at only 2 stations are the sections lines within 500 m of each other (x-sec 0.10 and x-sec 18.88). A comparison of the two sets of cross-sections is given graphically in figures 9, and 10 and in tabular form in Table B3. The profiles (figure 9) seem to be match closely. The cross-sectional areas seem to vary greatly so that it is difficult to make a comparison, even for the two where the lines are close together.

Water Levels

Water level data has been collected from the three stations on the Manu river - at the railway bridge, at Moulvibazar town, and at Manumukh. The Manumukh data from 1982 to 1989 was calculated by adding 0.4 m to the Sherpur gauge reading (on the Kushiyara River) and adding 0.4 m. Some of the above cross-sections were used to make an overall river profile. A water profile was plotted overtop using the water elevations of various years (see figures 11-15). The following years are plotted; 1964 (first year of data), 1968 (a typical pre-project flood year), 1976(max. pre-project flood), 1988 (max recorded flood) 1990 (typical post-project flood year).

A Comparison of Rating Curves

Rating curves were plotted (figures 16-20) using the water level and discharge at Moulvibazar town. The discharge at Moulvibazar was calculated by adding the discharge measurements made at the Manu Railway bridge (gauge 201) and at Kamalganj (Dhalai river - gauge 67). The water levels are from station gauge 202 (Moulvibazar town).

The rating curve for 1990 is very similar to the rating curves of the 1960s and 70s. However in the late 1980s the water levels seems to be unusually high, even at low discharges. This phenomena is most pronounced in 1988. A possible explanation is that there was some construction work on the river at this time. But apparently the works constructed were "wash-out" in the 1988 flood.

Effects of Embankments

Calculations were made using Manning's equation to determine the effects of moving the embankments back from the river edge. Figure 21 gives the results graphically. Using all the above cross-section data, a typical cross-section was established. The bankfull discharge of this section was determined to be 700 m^3/s. The average max annual flood at the Manu Barrage was calculated at 750 m^3/s; the average annual pre-monsoon flood is 430 m^3/s. The highest recorded flood was 1242 m^3/s, in 1991. A 'Q' value of 1200 m^3/s was used in the calculation. Results indicate the water level would rise about 0.65 m if the embankments were put right on the edge. The velocity would increase from 0.9 to 1.65 m/s

B.3 KUSHIYARA CROSS SECTIONS

The NERP sediment team re-surveyed four cross sections on the Kushiyara River. These were originally established by the Morphology Directorate of BWDB in the late 60s and surveyed throughout the 1970s. The NERP sections have been plotted overtop of the original sections. The cross-sections and the location plan are given in figure 22. A table giving the bankfull data is given in Table B4.

It was relatively easy to locate the cross-sections again. It could also be assumed that, even though our survey accuracy is not very good, it is comparable to that of the Morphology Directorate. (On the drawings they give distances and elevations on each monument for each year the section was surveyed; on some of the monuments the distances at a single monument vary by more than 100 ft (30 m) and some elevations vary by half a foot (0.15 m).)

<u>Kus #1</u> cross-section is located just south of the Manu irrigation project's pump station. This cross-sectional drawing indicates that the river has moved about 200 m. Though a comparison of satellite photos and the 1:50,000 scale maps,as well as the sounding charts do not such a significant river shift in the area. This cross-section was an unusual one because there was a lot of construction in the area (pump station and canal) since the last survey. Also, this was the only section where we did not find any monuments, and this is the longest of all the section (almost twice as the length of the other cross-sections). Therefore the movement which appears to have occurred in the cross section may only be due to difficulty in finding the original survey points. The bankfull area has not increased, and is, in fact, lower than the 1978 area.

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Kus #2 was easy to locate since all 3 monuments were still in place. The 1993 section retains the same basic shape as all the previous sections though the bankfull area show some increase. No significate changes were noticed.

Kus #3 section is located at the Balaganj hospital. The section drawing indicates that the top width remains about the same but the bed level has risen. There is a corresponding decrease in bankfull area. The sounding charts confirm that in this short stretch of the river the thalweg elevations have risen, though there is no obvious reason for this (such as a loop-cut).

Kus #4 section still had 2 good monument on the left bank, but no monument on the right bank was found. The bankfull area and top width have both increased from the previous surveys. The 1993 section seems to have moved to the right. This seems plausible since the location plan indicates a similar shift in the river.

Overall no major trend of morphological changes can be found in the Kushiyara River near the Manu River project since 1978.

B.4 MANU RIVER PROFILE SURVEY

NERP sediment team made longitudinal surveys of the Manu River on June 14 and August 9 - 10, 1994. The findings are summarized here.

Water Levels for the 15th of June were collected from various points along the river (see Table B5). The slope was calculated for each section (column 4), and then with respect to Manumukh, or the pump station (columns 5-7). There appears to be some discrepancy between the water levels at Manumukh (or x-sec 7) and the pump station (PS). The PS recorded values were 9.74, upstream, and 9.22, downstream (upstream being the haor side). Our value, at x-sec 7, downstream of the PS, is higher than both at 9.8 m PWD.

It is noticed that the slope between the bridge (or x-sec 5) and the barrage is rather steep (0.000218). This appears in our earlier data as well though the reason for such a steep slope remains unclear. The slope upstream of the Dhalai River is very shallow (0.000064). This is confirmed by field observations of a flat slope and slow current.

Water reading for the August survey were also recorded (Table B6). The slope between Dhalai and Kazir Chalk are steeper than during the June survey. However, the slope between Kazir Chalk and Manu Railway Bridge is flatter.

Longitudinal Profile The echo-sounder print-out was first digitized into an *Autocad* drawing; then a program was written in *Q-Basic* to scale the digitized drawing.

Figures 23 and 24 are plots of the river bed profile recorded in June. Each figure gives half of the profile along with a location plan. The numbers given on the profiles correspond to the "marks" made on the original print-out. The "marks" help give our position along the river; the marks are all shown on the location plan. The breaks in the profile line are due to breaks made in the original survey or are caused by a faulty digitizing table which "skips" in certain locations.

It can be seen that upstream of the barrage the bed becomes much smoother. Would this also indicate that the slope is shallower and that there is, therefore, less sediment movement?

Longitudinal Profile for the August survey are shown in figure 25. The first, shows the Manu River from the Barrage to Kazir Chalk. The upstream section of the June 1993 survey has been included on this drawing for comparison. The river bed upstream of the Dhalai junction appears to be much "smoother" in the June profile than the August profile. This would suggest that there was more sediment movement in August. The survey fix marks on the location plan seem to indicate a new bend in the river between fix numbers 36 and 43. (The channel plotted in the location plan is taken from the 1990 satellite photos.)

Figure 26 gives a profile of the about the first kilometre of the Dhalai River. The profile reveals that the Dhalai is about 2 meters higher than the Manu right at the mouth. The bed rises slowly for the first half kilometre and then begins to drop again. The area around the mouth of the Dhalai has caused great confusion on past surveys; it appear that there were three mouths to the Dhalai. The most westerly is the channel which has just recently been abandoned, though at higher water levels it still connects the Dhalai to the Manu. The middle channel is now the primary channel of the Dhalai. The easterly channel is actually a khal that goes to Daldala Beel.

<u>Sediment Dunes</u> could be seen clearly in several sections of the profile. These were plotted separately, at a different scale. Figures 27 and 28 show the sections between profile marks 18 to 23, 38 to 42, and between 36 and 37, of the June survey. The last section was recorded while allowing the boat to drift with the current. The average height of the dunes in these drawings is about 2.0 m. A wavelength of 60 m seems to be the most common.

In August the sediment dunes, though less impressive than those recorded in the June survey, were noticed on both the Manu and the Dhalai. The most interesting dunes on the Manu occur between fix marks 33 and 43. Here the dunes are less than a meters in height and very short in length. In the rest of the channel actual dunes can be seen in only a few places but the river bed is "rough" almost the entire length.

On the Dhalai some dunes over 1.5 m can be seen near fix mark number 9. Here again the bottom seems rough though no real dunes in most places.

<u>Cross-Sections</u> were surveyed on the same days as the profile surveys. Three sections on the June survey and 4 in August. In June NERP sections #7, #6, and #5, also know by there chainage as X-Sec 0.10, X-Sec 10.05 and X-Sec 18.88, respectively were surveyed. The cross-section drawings are given in figure 29. The most interesting section is #5 where the thalweg appears to have shifted to the opposite side of the river. Field observations in February and June confirm this. It is assumed that this occurred because of the bank revetments constructed earlier this year, just upstream of the this cross-section.

The four remaining Cross-Sections on the Manu River were surveyed in August. These are shown in the figure 30. Generally there does not appear to be any aggradation in the main channel. Though some aggradation appears to have occurred on the banks, especially in cross-sections 3 & 4. At cross-section 3 the right bank was washed-out so it is difficult to tie this side of the section to previous surveys. Cross-section 4 appears to have experience the most significant changes. The river bed has flattened and apparently the right bank has also experienced some erosion.

Table B1: BWDB Cross Section Data

COMPARISON 0F 1985 TO 1993

BWDB CROSS–SECTION BANKFULL DATA – 1985/6

SEC #	CHAINAGE km	BF ELEV	AREA	TW	DEPTH	BED ELEV	THALWEG
1	2.65	8.96	404.46	81.72	4.95	4.01	0.14
2	2.70	8.96	385.49	71.48	5.39	3.57	0.14
3	2.75	8.37	365.51	83.70	4.37	4.00	0.75
4	2.80	8.93	390.56	77.11	5.06	3.87	1.97
5	2.85	9.01	395.94	77.13	5.13	3.88	1.97
6	2.88	9.15	432.52	81.10	5.33	3.82	1.97

Avg =	395.75	78.71	5.04

P.O.	17.07	11.31	481.71	105.06	4.59	6.72	5.16
17	17.88	11.17	544.78	104.16	5.23	5.94	5.09
11	19.30	11.17	477.82	98.59	4.85	6.32	4.60
10	19.55	11.53	532.18	97.80	5.44	6.09	4.60
9	19.77	11.13	598.16	111.85	5.35	5.78	4.33

Avg =	526.93	103.49	5.09

NERP'S RE–SURVEY OF BWDB CROSS–SECTIONS – 1993

NAME	CHAINAGE	BF ELEV	AREA	TW	DEPTH	BED ELEV	THALWEG
XS 2.65 FEB	2.65	8.98	542.73	101.70	5.34	3.64	1.11
XS 2.70 FEB	2.70	8.98	440.86	81.90	5.38	3.60	0.14
XS 2.75 FEB	2.75	8.98	452.07	80.41	5.62	3.36	0.19
XS 2.80 FEB	2.80	9.83	368.50	90.61	4.07	5.76	2.77
XS 2.85 FEB	2.85	9.83	368.49	90.62	4.07	5.76	2.77
XS 2.90 FEB	2.90	9.83	327.46	85.62	3.82	6.01	3.10

Avg =	416.69	88.48	4.72
+/– %	5.29	12.41	–6.42

XS 17.07 FEB	17.07	11.58	629.28	132.60	4.75	6.83	5.91
XS 17.88 FEB	17.88	11.78	558.53	115.96	4.82	6.96	4.31
XS 19.30 FEB	19.30	11.17	477.82	98.59	4.85	6.32	4.60
XS 19.55 FEB	19.55	10.64	503.26	112.65	4.47	6.17	5.12
XS 19.77 FEB	19.77	11.37	556.38	112.71	4.94	6.43	5.34

Avg =	545.05	114.50	4.76
+/– %	3.44	10.64	–6.44

Table B2: NERP Cross Section Data

NERP CROSS-SECTIONS BANKFULL DATA

NAME	CHAINAGE	BF ELEV	AREA	TW	DEPTH	BED EL	THALWEG
0.10 AUG	0.1	8.65	517.05	98.06	5.27	3.38	1.79
9.05 AUG	9.05	10.89	550.40	101.21	5.44	5.45	4.38
17.88 AUG	17.88	13.57	735.70	122.80	5.99	7.58	4.13
23.84 AUG	23.84	12.7	541.76	144.62	3.75	8.95	6.23
24.25 AUG	24.25	12.78	379.58	96.89	3.92	8.86	5.92
35.62 AUG	35.62	14.24	408.00	133.55	3.05	11.19	7.83
39.16 AUG	39.16	15.18	370.73	73.81	5.02	10.16	6.09

	AREA	TW	DEPTH
Avg =	500.46	110.14	4.63
U/S Avg =	425.02	112.22	3.94
D/S Avg =	601.05	107.36	5.57

NAME	CHAINAGE	BF ELEV	AREA	TW	DEPTH	BED EL	THALWEG
0.10 FEB	0.1	9.04	535.12	99.06	5.40	3.64	2.46
9.05 FEB	9.04	10.78	469.05	97.07	4.83	5.95	4.49
17.88 FEB	17.88	11.78	558.53	115.96	4.82	6.96	4.31
23.84 FEB	23.84	12.64	542.34	119.60	4.53	8.11	6.63
24.25 FEB	24.25	12.26	308.72	83.75	3.69	8.57	6.13
35.62 FEB	35.62	14.24	453.13	131.37	3.45	10.79	7.12
39.16 FEB	39.16	15.46	410.53	75.72	5.42	10.04	5.74

	AREA	TW	DEPTH
Avg =	468.20	103.22	4.59
U/S Avg =	428.68	102.61	4.27
D/S Avg =	520.90	104.03	5.02

Table B3: SWMC Cross Section Data

SWMC CROSS-SECTIONS - BANKFULL DATA

SEC #	SWMC km	NERP km	BF ELEV	AREA	TW	DEPTH	BED EL.	THALWEG
1	0	54.2	19.90	562.58	95.50	5.89	14.01	12.15
2	10	46.6	16.81	589.51	139.53	4.22	12.59	11.04
3	19.5	35.05	14.77	408.81	90.32	4.53	10.24	9.10
4	28.5	24.25	12.68	554.20	110.08	5.03	7.65	5.50
5	28.7	23.84	13.21	586.85	113.55	5.17	8.04	6.27
6	36.5	17.88	11.06	453.48	106.44	4.26	6.80	5.51
7	54.75	0.1	9.20	606.78	135.52	4.48	4.72	1.09
			Avg =	537.46	112.99	4.80		

NERP CROSS-SECTIONS BANKFULL DATA

NAME	CHAINAGE	BF ELEV	AREA	TW	DEPTH	BED EL	THALWEG
0.10 FEB	0.1	9.04	535.12	99.06	5.40	3.64	2.46
9.05 FEB	9.04	10.78	469.05	97.07	4.83	5.95	4.49
17.88 FEB	17.88	11.78	558.53	115.96	4.82	6.96	4.31
23.84 FEB	23.84	12.64	542.34	119.60	4.53	8.11	6.63
24.25 FEB	24.25	12.26	308.72	83.75	3.69	8.57	6.13
35.62 FEB	35.62	14.24	453.13	131.37	3.45	10.79	7.12
39.16 FEB	39.16	15.46	410.53	75.72	5.42	10.04	5.74
			Avg =	468.20	103.22	4.59	

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Table B4: Bankfull Data of Cross Sections on the Kushiyara River

Bankfull Data of Cross–sections on the Kushiyara River

Section	BF Elev	Area	Top Width	Depth	Avg Bed El	Thalweg
Kus#1–69	8.72	1420.19	170.16	8.35	0.37	–5.93
Kus#1–72	8.72	1336.42	214.40	6.23	2.49	–7.30
Kus#1–73	8.72	1347.96	163.89	8.22	0.50	–8.63
Kus#1–78	8.72	1649.03	262.09	6.29	2.43	–5.83
Kus#1–93	8.72	1428.93	212.32	6.73	1.99	–5.02
Kus#2–69	9.31	1569.31	207.00	7.58	1.73	–8.25
Kus#2–72	9.31	1507.43	155.33	9.70	–0.39	–8.50
Kus#2–73	9.31	1523.07	182.80	8.33	0.98	–9.87
Kus#2–78	9.31	1541.52	171.68	8.98	0.33	–5.43
Kus#2–93	9.31	1644.51	178.06	9.24	0.07	–6.81
Kus#3–69	9.40	1713.55	177.38	9.66	–0.26	–5.16
Kus#3–72	9.40	1738.88	198.20	8.77	0.63	–5.96
Kus#3–73	9.40	1668.42	248.90	6.70	2.70	–9.11
Kus#3–78	9.40	1792.30	188.64	9.50	–0.10	–5.34
Kus#3–93	9.40	1659.76	190.71	8.70	0.70	–1.98
Kus#4–69	9.53	1022.00	110.09	9.28	0.25	–4.36
Kus#4–72	9.53	1225.71	135.26	9.06	0.47	–6.80
Kus#4–73	9.53	1274.20	145.53	8.76	0.77	–8.23
Kus#4–78	9.53	1342.01	125.23	10.72	–1.19	–7.32
Kus#4–93	9.53	1370.26	147.10	9.32	0.21	–6.52

Table B5: Water Levels for Manu River, June 1993

Water Levels for Manu River Profile Survey – June 14, 1993							
STATION	Chainage–km	BM ELEV	W/L (m PWD)	Slope/Sect	Slope/MM	Slope/Pump	Slope/Pump
PUMP STATION	0		9.74/9.22				
X–SEC 7, MM	0	9.7	9.8				
X–SEC 6	10.05	12.05	11.01	0.000120	0.000120	0.001096	0.001096
BRIDGE	18.5		12.35	0.000159	0.000138	0.000668	0.000668
X–SEC 5	18.88	13.57	12.41	0.000158	0.000138	0.000657	0.000657
BARRAGE	21.95	–	13.08	0.000218	0.000149	0.000596	0.000596
DHALI R.	25	14.27	13.55	0.000154	0.000150	0.000542	0.000542
KAZIR CHALK	40.2		15.96	0.000159	0.000153	0.000397	0.000397
RWY BRIDGE	55.2		17.85	0.000126	0.000146	0.000323	0.000323
			avg slope =	0.000156	0.000142	0.000611	0.000611

008

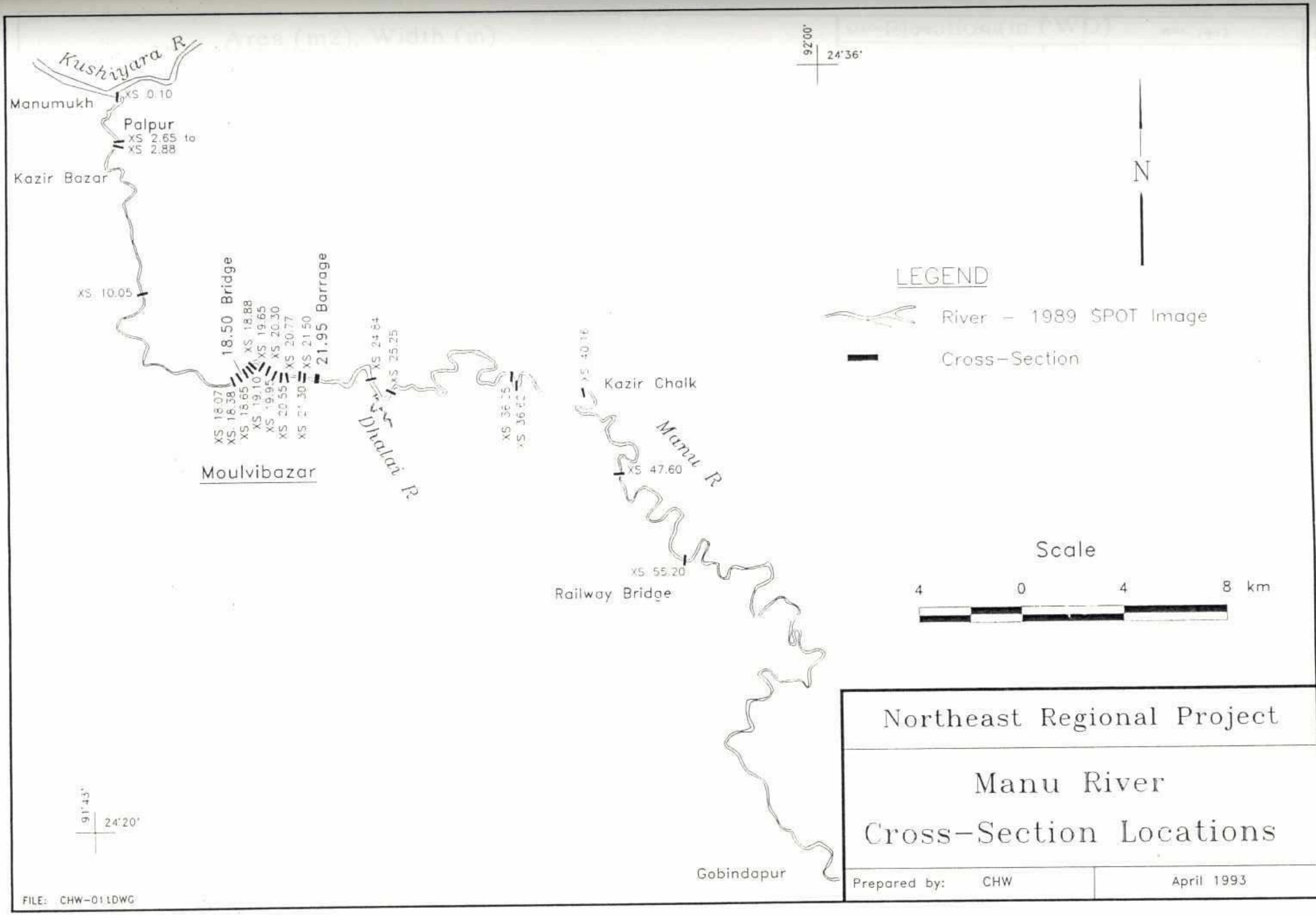
Table B6: Water Levels for Manu River, August 1993

Water Levels for Manu River Profile Survey – August 9 & 10, 1993

STATION	Chainage–km	W/L (m PWD)	W/L (m PWD)	Slope/Sect	Slope/Sect	Slope/Barr	Slope/Barr	Slope/Pump
		Aug 9	Aug 10	Aug 9	Aug 10	Aug 9	Aug 10	
PUMP STATION	0	9.36	9.37					
BRIDGE	18.5	10.94	10.23	0.000085	0.000046			0.000553
BARRAGE	21.95	10.76	10.03	–0.000052	–0.000058			0.000457
X–SEC 4	24.85	11.37		0.000210		0.000210		0.000000
X–SEC 3	25.25	11.42		0.000125		0.000200		0.000000
X–SEC 2	36.62		12.25		0.000151		0.000151	0.000335
X–SEC 1	40.16		12.9		0.000184		0.000158	0.000321
KAZIR CHALK	40.2	13.61	12.99	0.000146	0.000207	0.000156	0.000162	0.000323
RWY BRIDGE	55.2	16.33		0.000181				0.000000
			avg slope =	0.000116	0.000106	0.000189	0.000157	0.000249

Dec

Figure 1

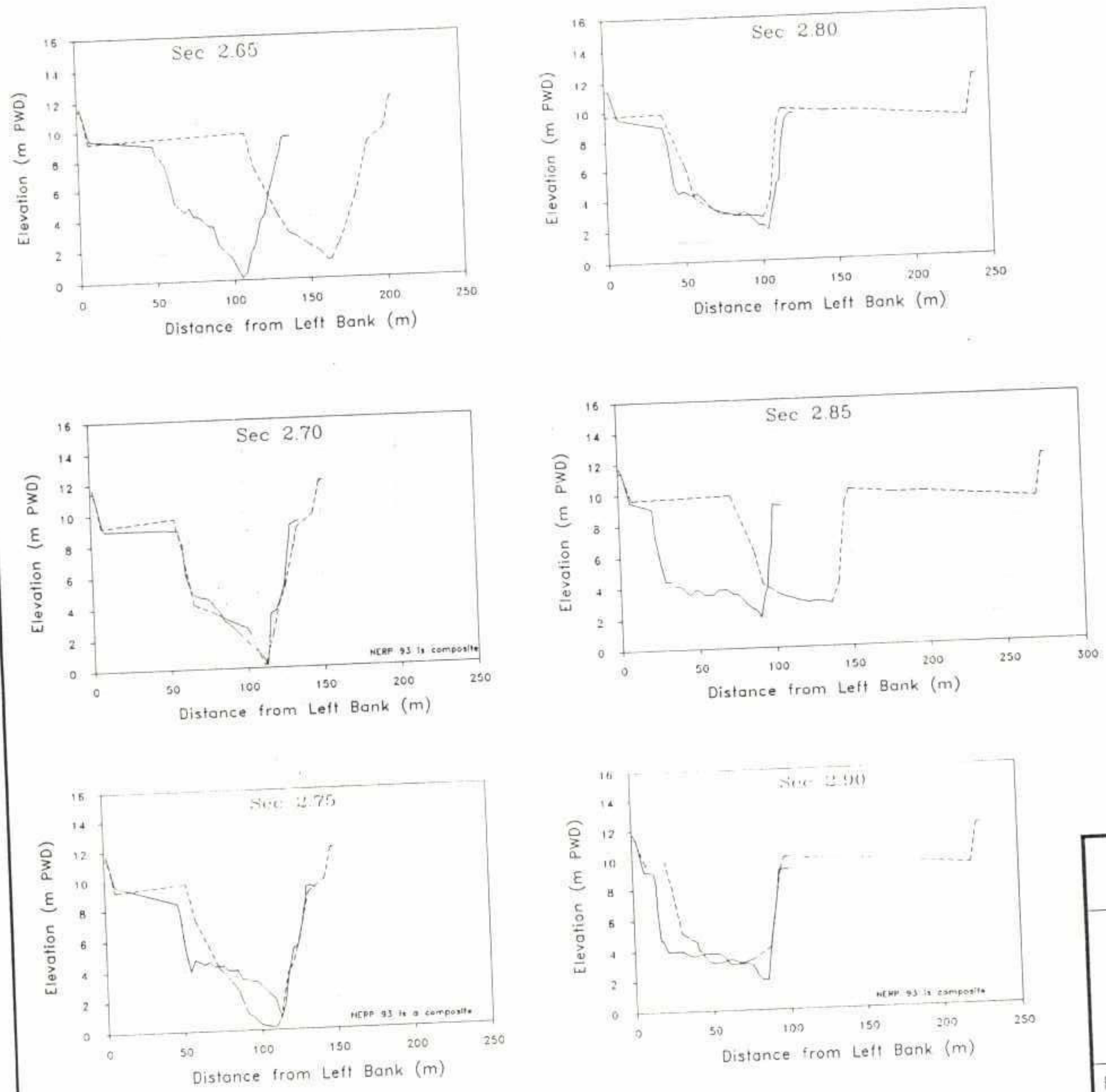


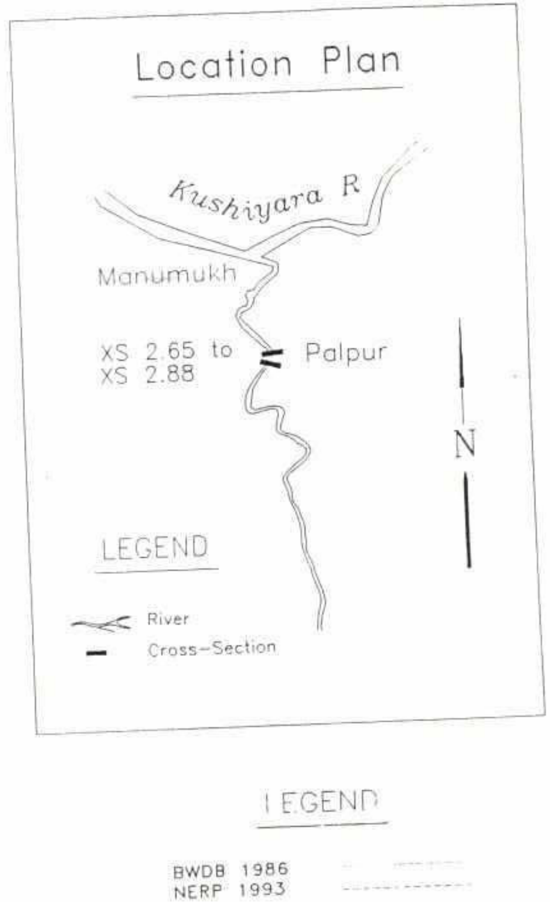
Northeast Regional Project

Manu River

Cross-Section Locations

Prepared by: CHW | April 1993





Northeast Regional Project

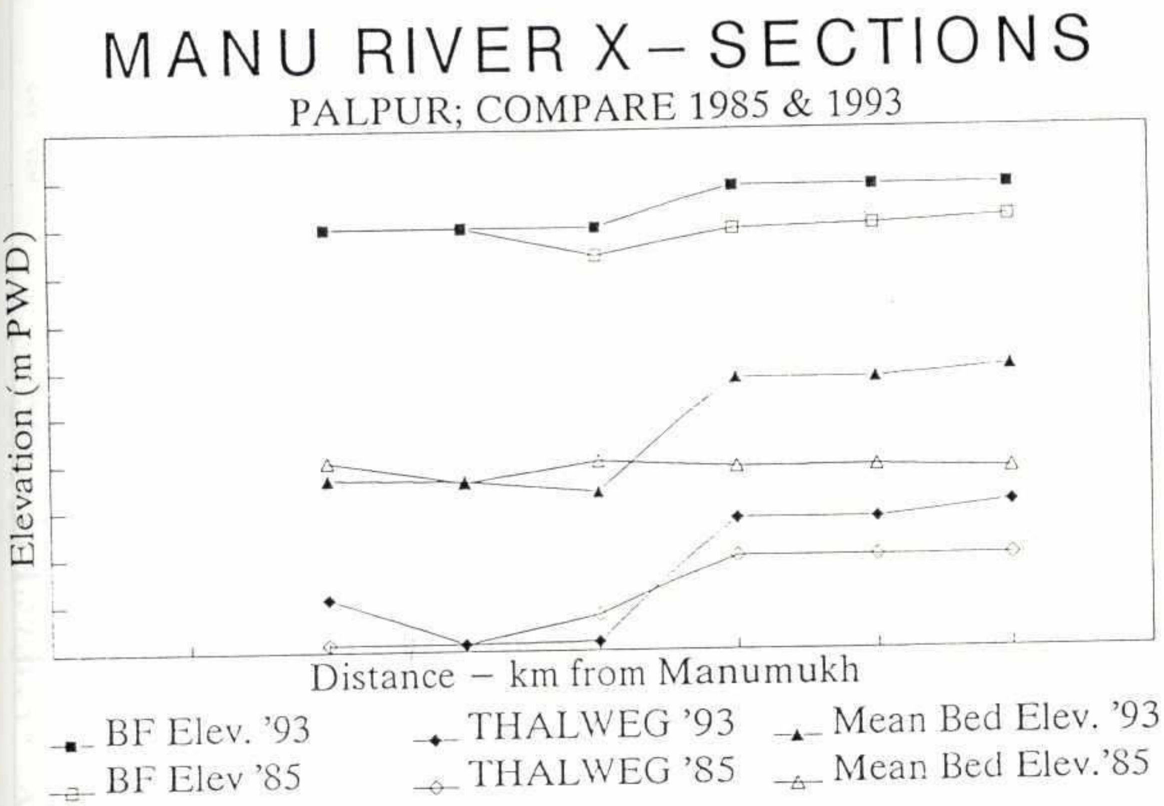
Manu River

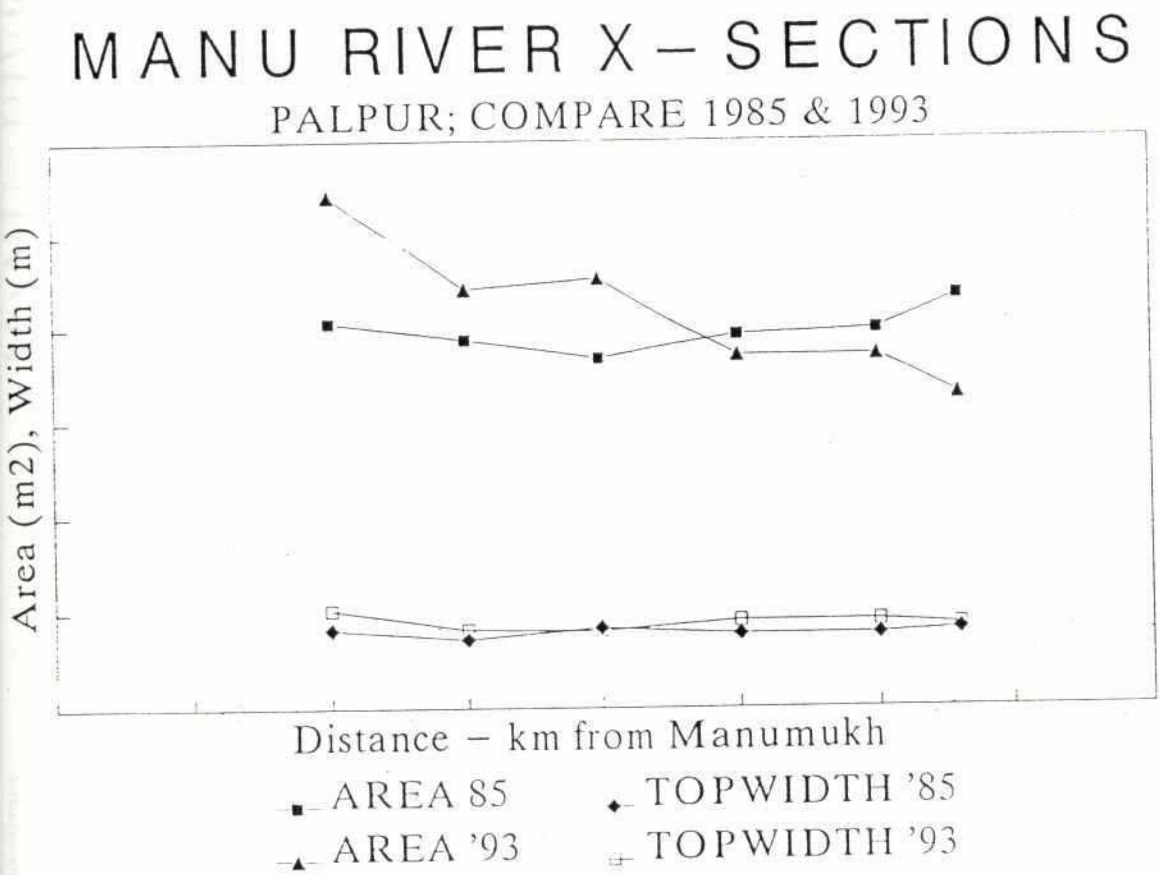
Palpur Cross-Section

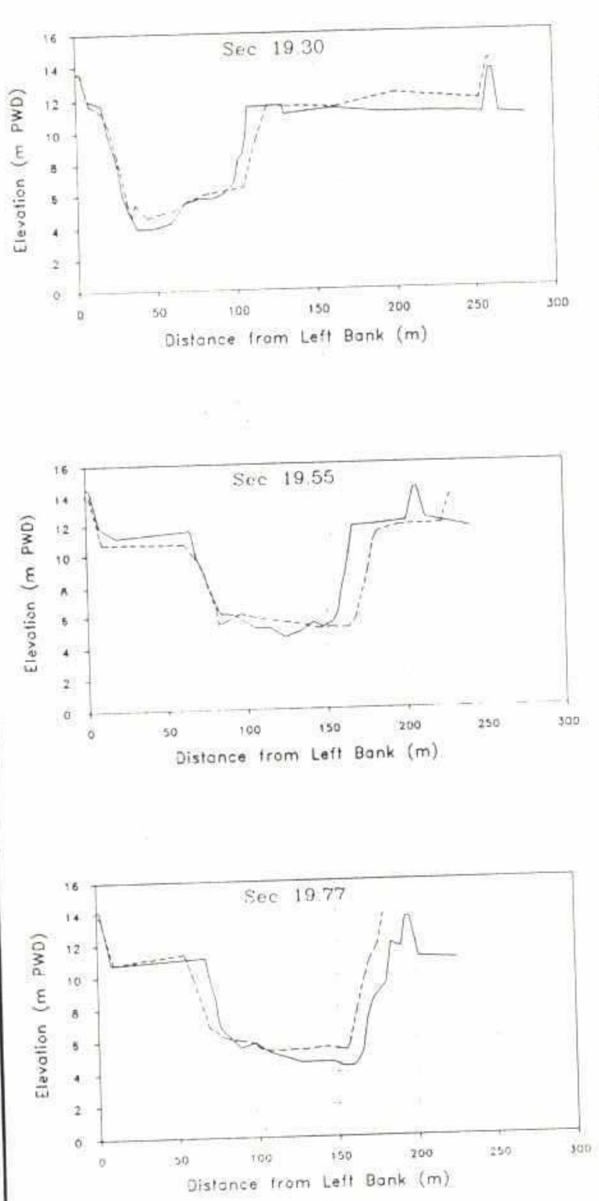
Prepared by: CHW | May 1993

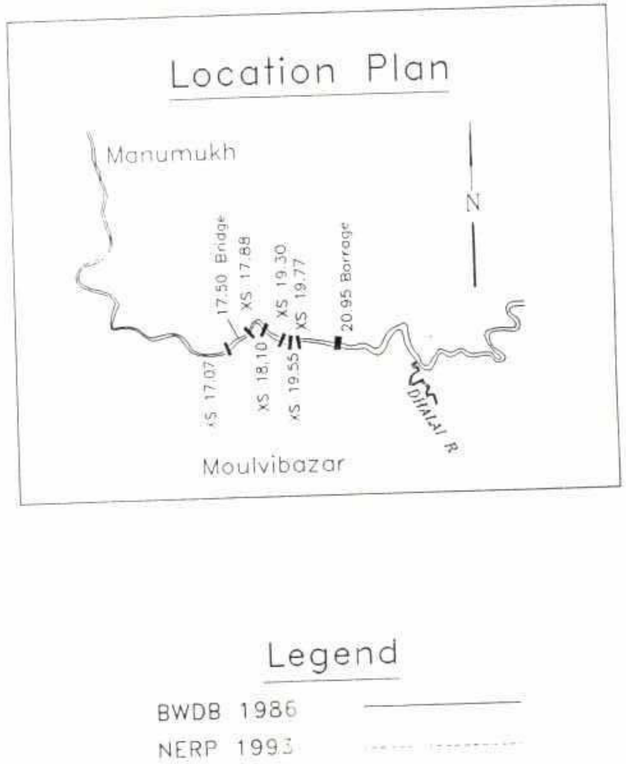
FILE: CHW-013.DWG

Figure 3


MANU RIVER X-SECTIONS
PALPUR; COMPARE 1985 & 1993
Elevation (m PWD)
Distance - km from Manumukh
BF Elev. '93
BF Elev '85
THALWEG '93
THALWEG '85
Mean Bed Elev. '93
Mean Bed Elev.'85


MANU RIVER X-SECTIONS
PALPUR; COMPARE 1985 & 1993
Area (m2), Width (m)
Distance - km from Manumukh
AREA 85
AREA '93
TOPWIDTH '85
TOPWIDTH '93





Northeast Regional Project

Manu River Cross-Sec. near Moulvibazar

Prepared by: CHW-014 | May 1993

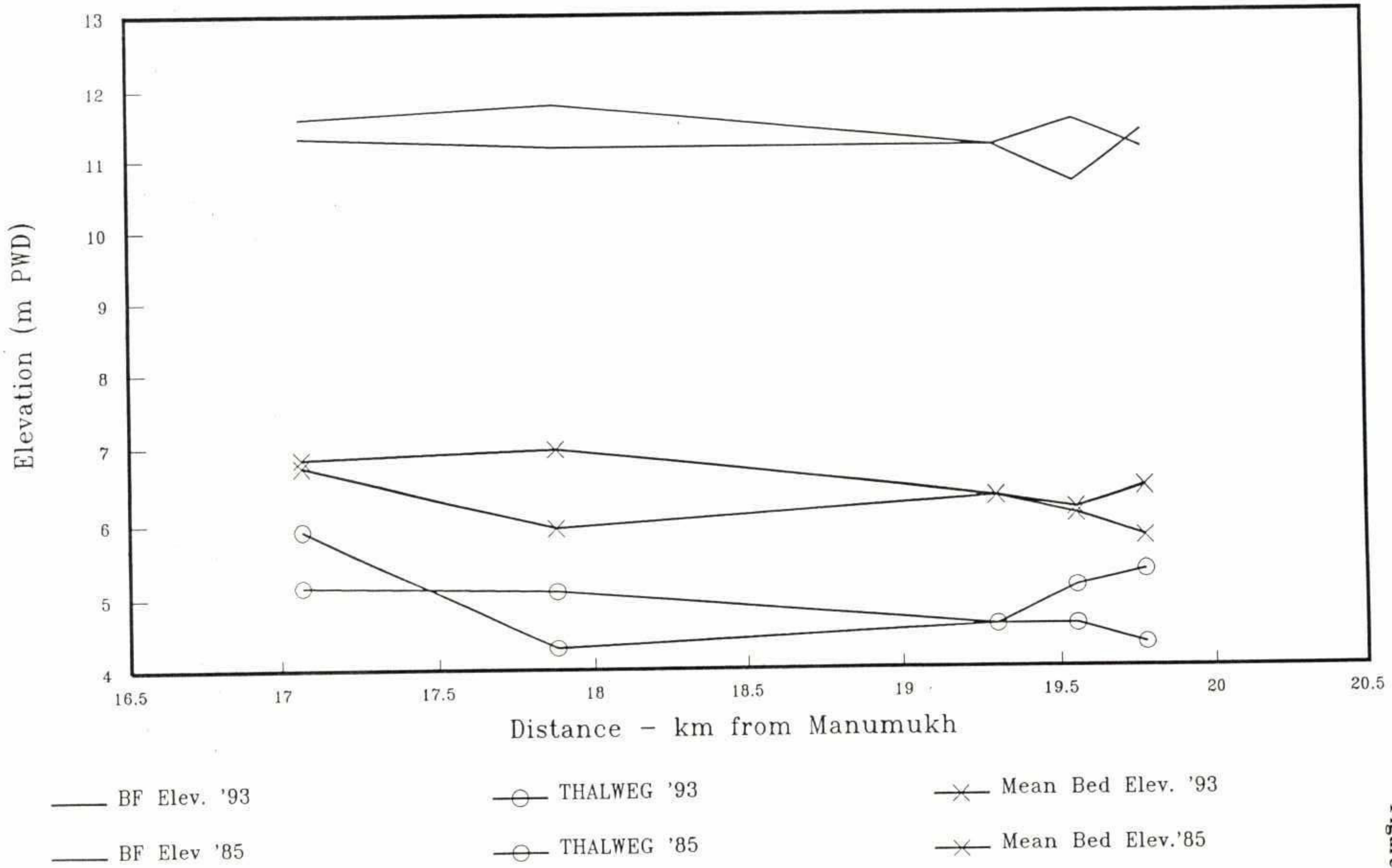
Figure 4

FILE: CHW-014.DWG

Figure 5

MANU RIVER X-SECTIONS

MOULVIBAZAR; COMPARE 1985 & 1993



MANU RIVER X-SECTIONS

MOULVIBAZAR; COMPARE 1985 & 1993

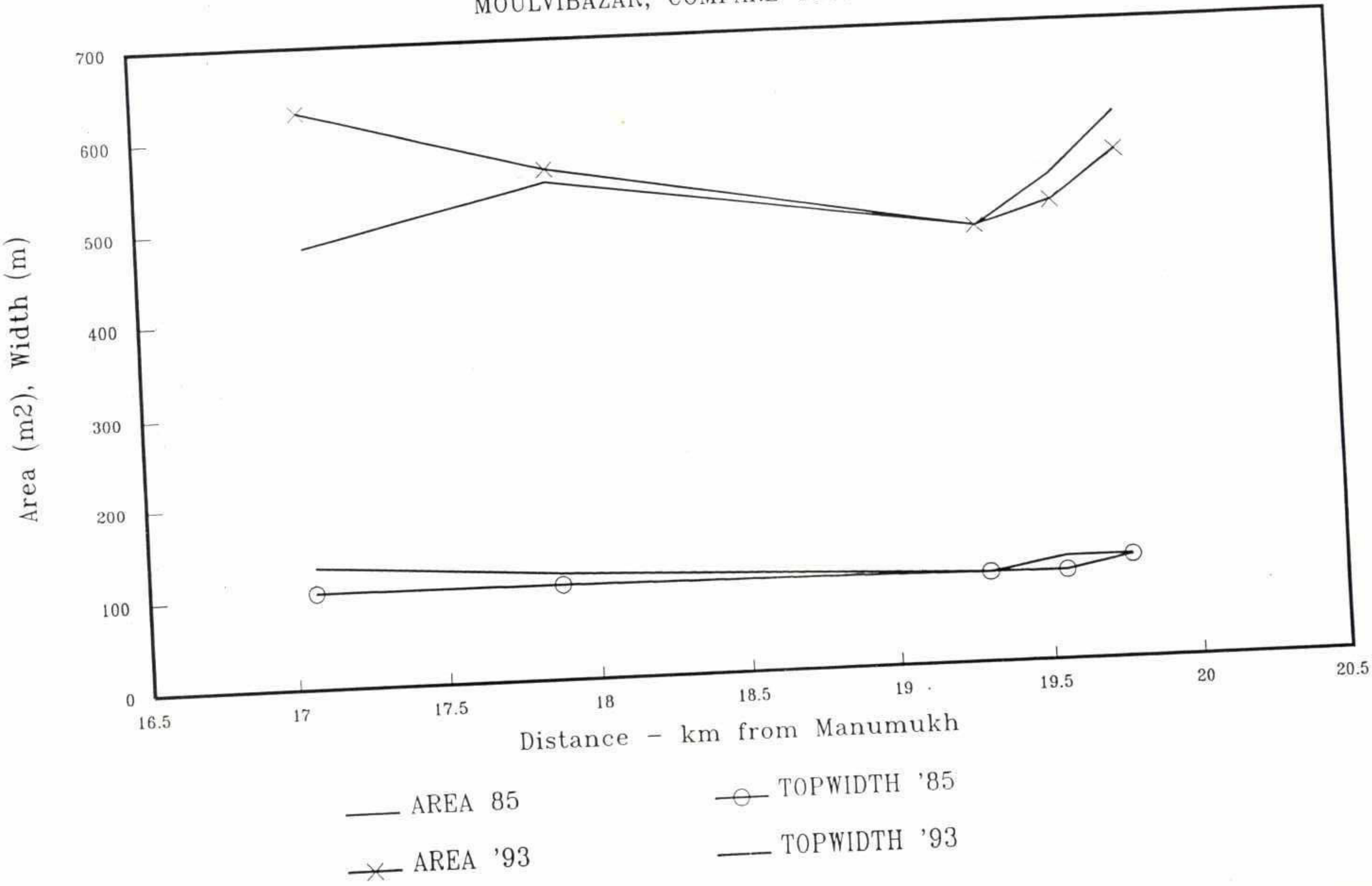
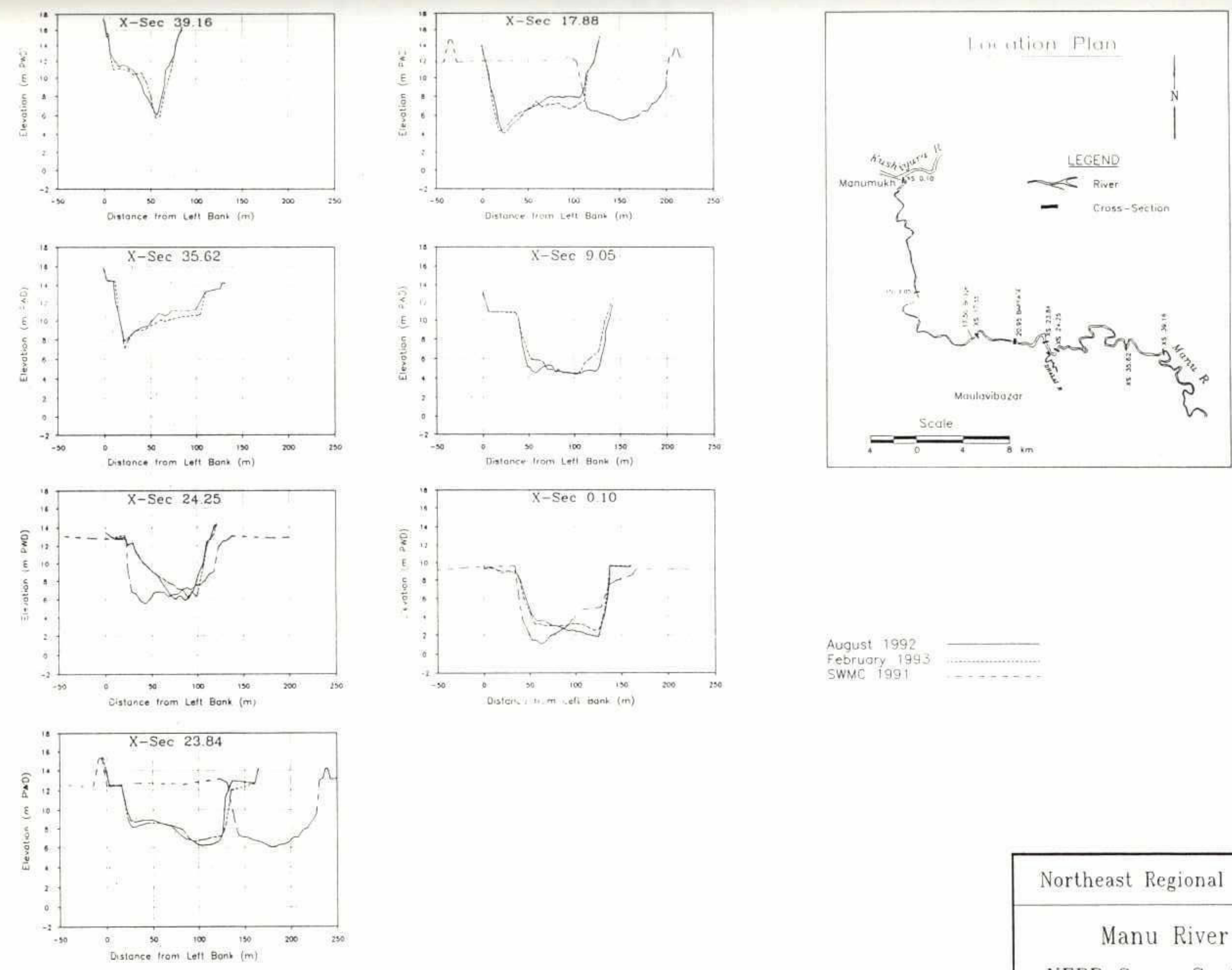


Figure 6

022

Figure 7



Northeast Regional Project

Manu River

NERP Cross-Sections

Prepared by CHW | April 1993

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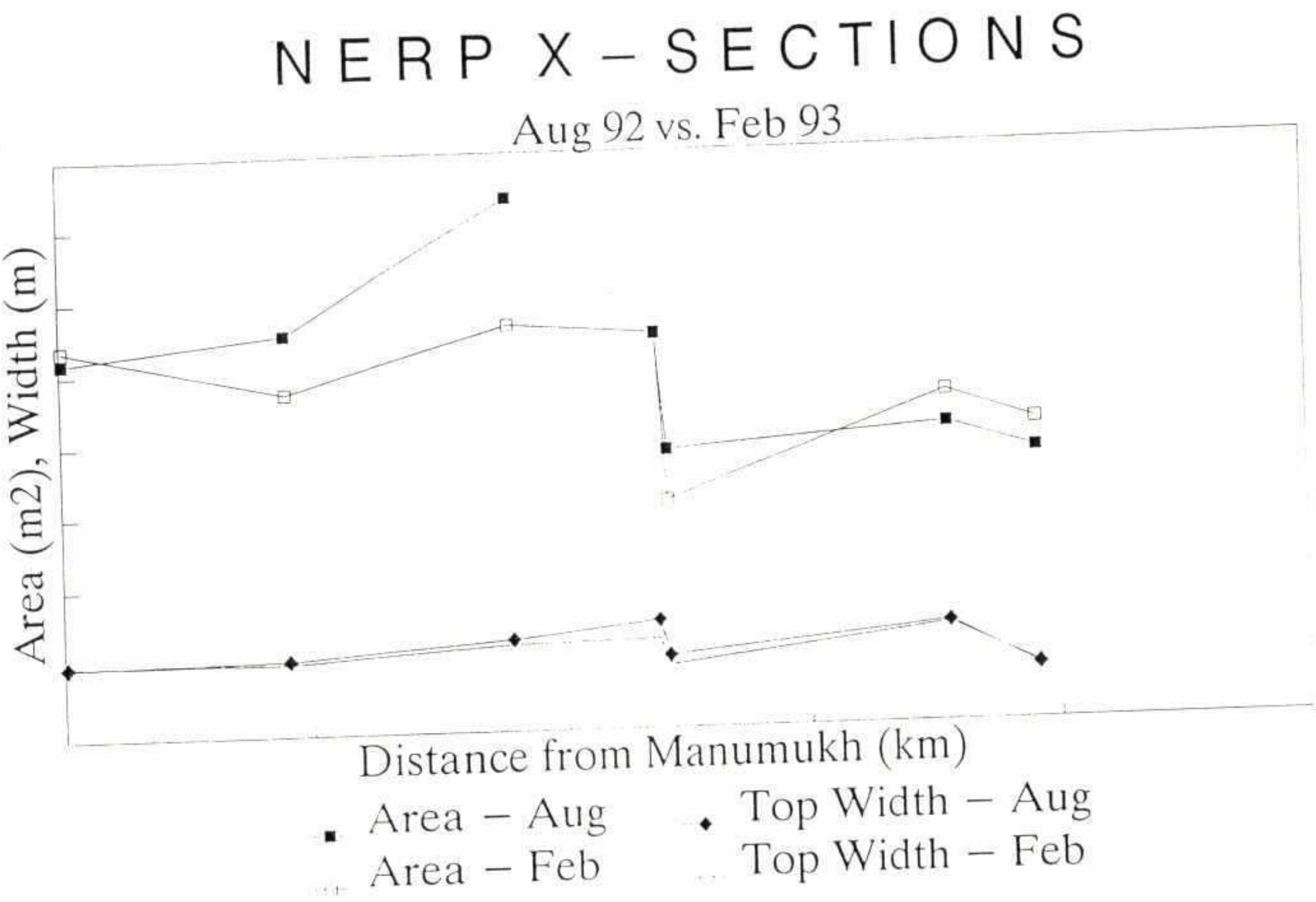
Figure 8


NERP X-SECTIONS
Aug 92 vs. Feb 93
Area (m2), Width (m)
Distance from Manumukh (km)
Area - Aug
Area - Feb
Top Width - Aug
Top Width - Feb

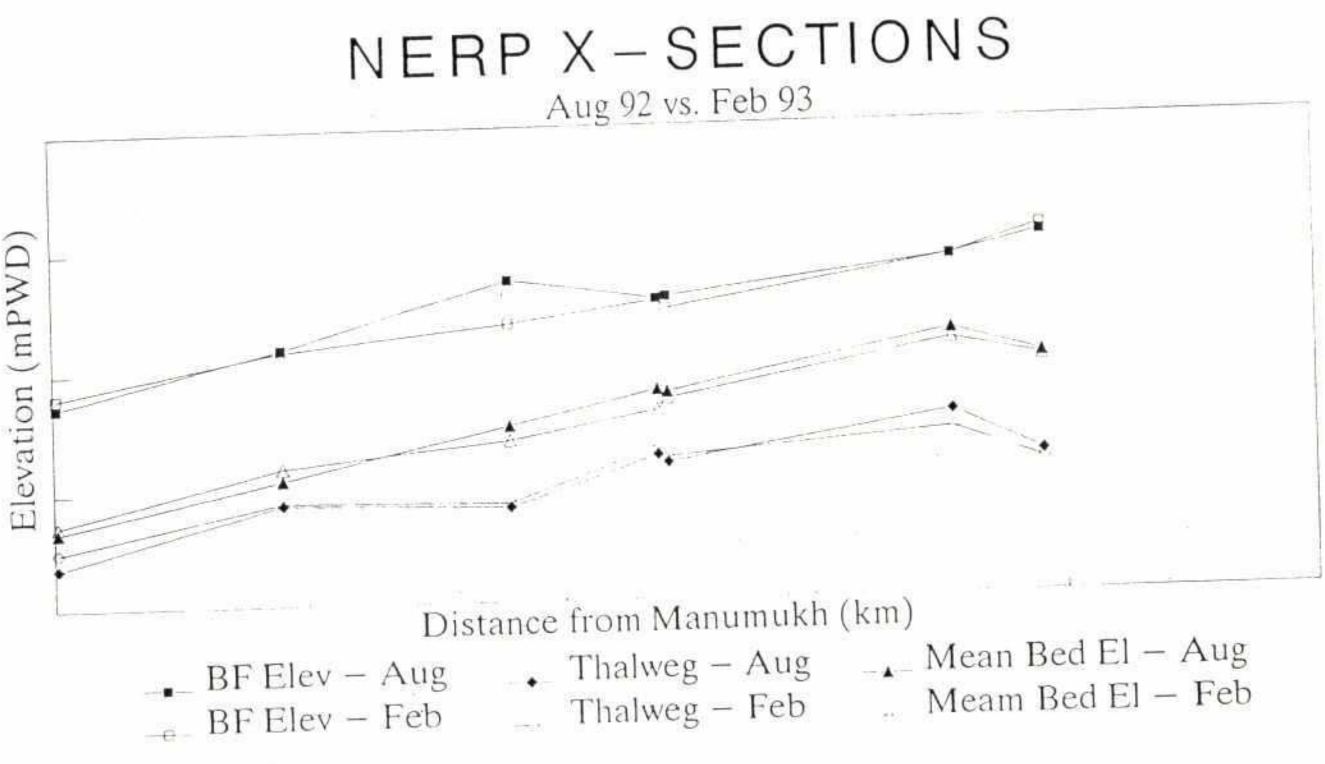

NERP X-SECTIONS
Aug 92 vs. Feb 93
Elevation (mPWD)
Distance from Manumukh (km)
BF Elev - Aug
BF Elev - Feb
Thalweg - Aug
Thalweg - Feb
Mean Bed El - Aug
Meam Bed El - Feb

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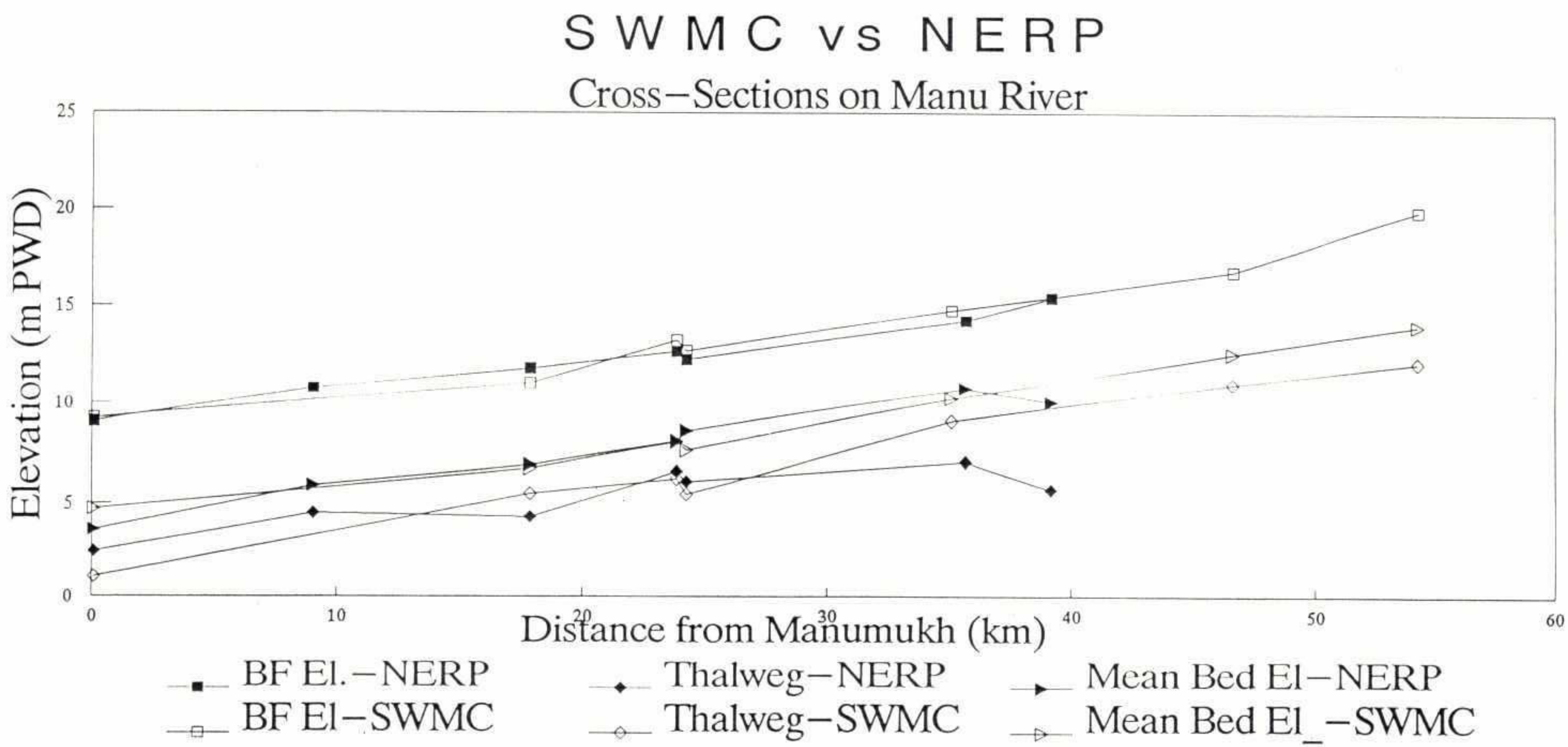
Figure 9


S W M C vs N E R P
Cross−Sections on Manu River
Elevation (m PWD)
0
5
10
15
20
25
Distance from Manumukh (km)
0
10
20
30
40
50
60
BF El.−NERP
BF El−SWMC
Thalweg−NERP
Thalweg−SWMC
Mean Bed El−NERP
Mean Bed El_−SWMC

22D

Figure 10

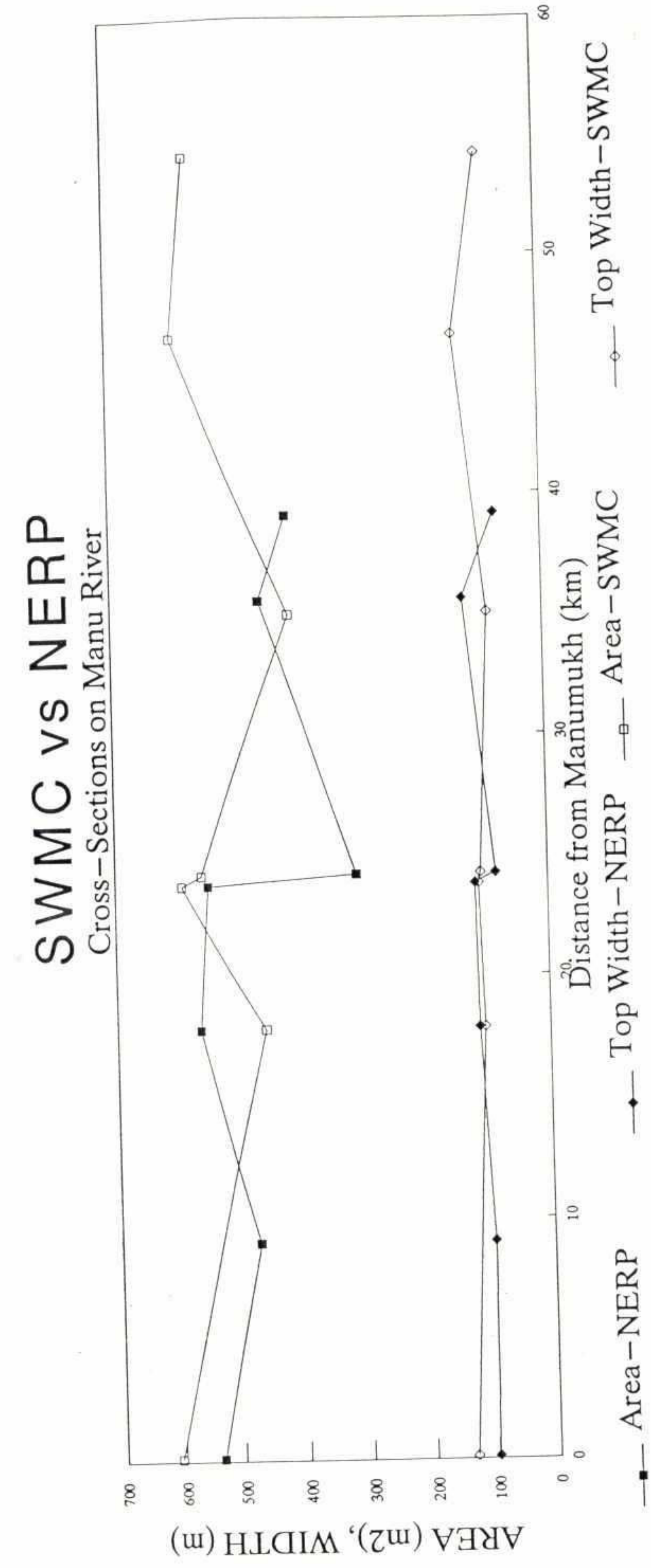
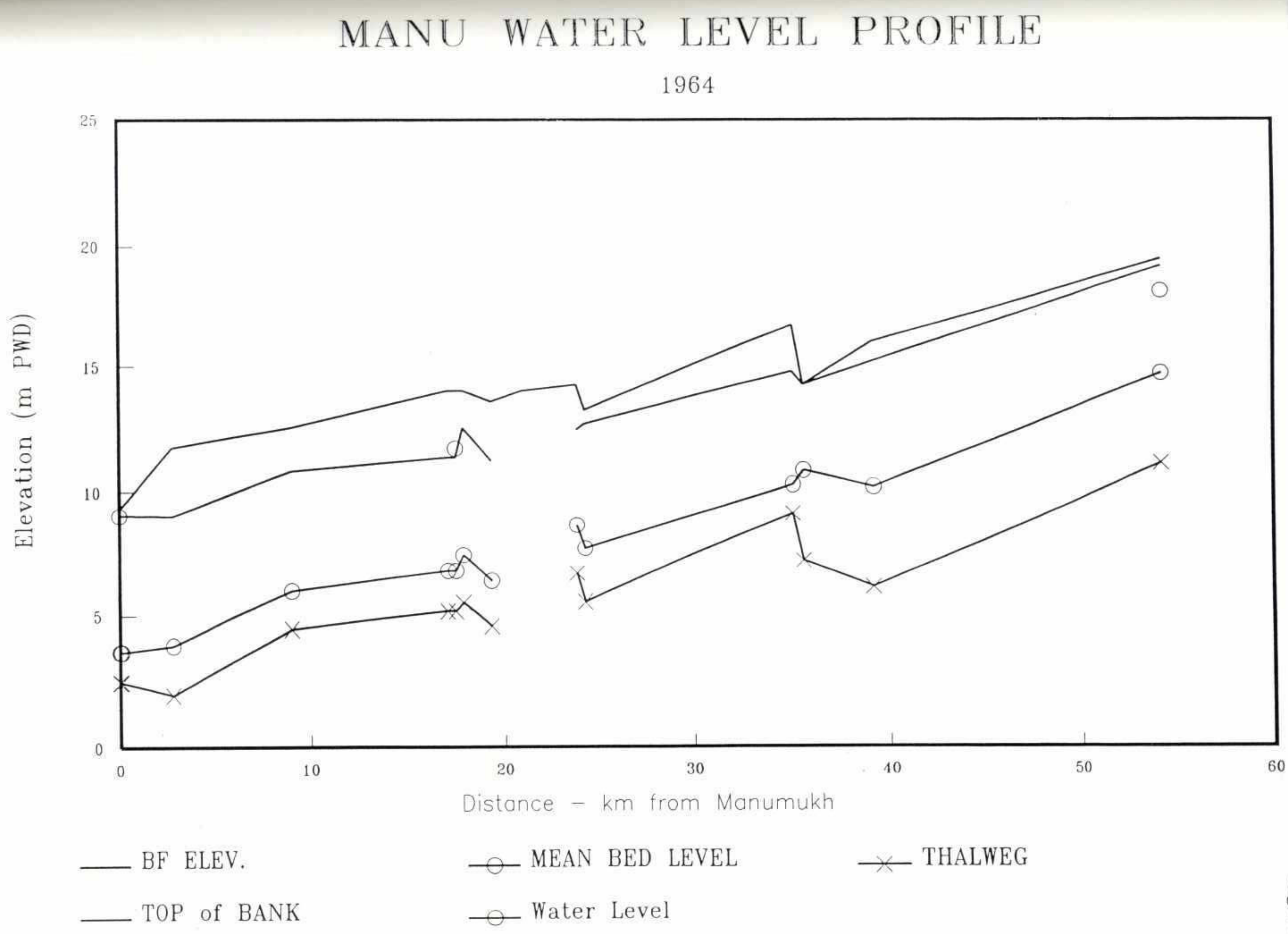


Figure 11



MANU WATER LEVEL PROFILE
1964
Elevation (m PWD)
25
20
15
10
5
0
0
10
20
30
40
50
60
Distance - km from Manumukh
BF ELEV.
TOP of BANK
MEAN BED LEVEL
Water Level
THALWEG

MANU WATER LEVEL PROFILE

1968

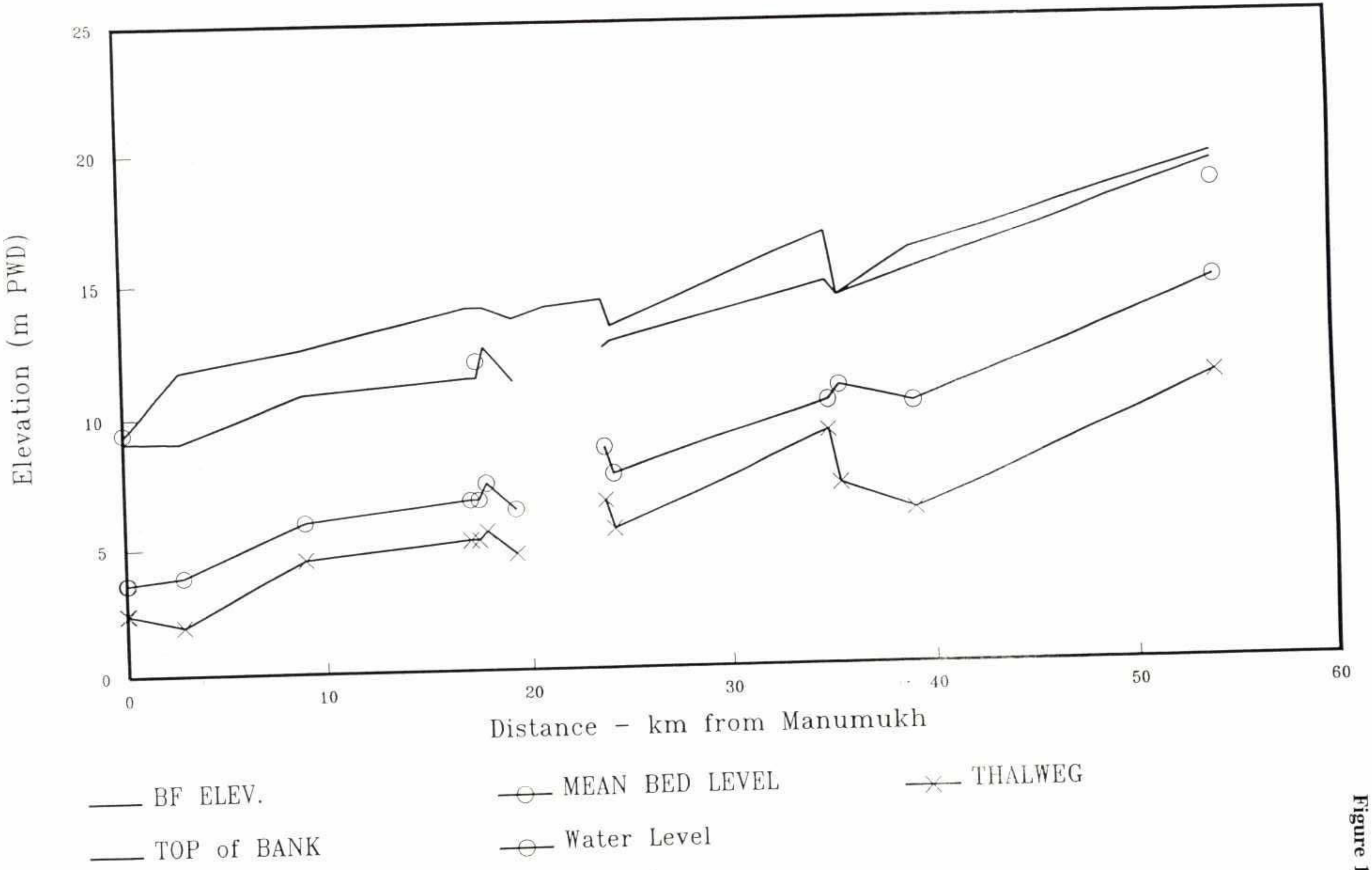


Figure 12

MANU WATER LEVEL PROFILE

1976

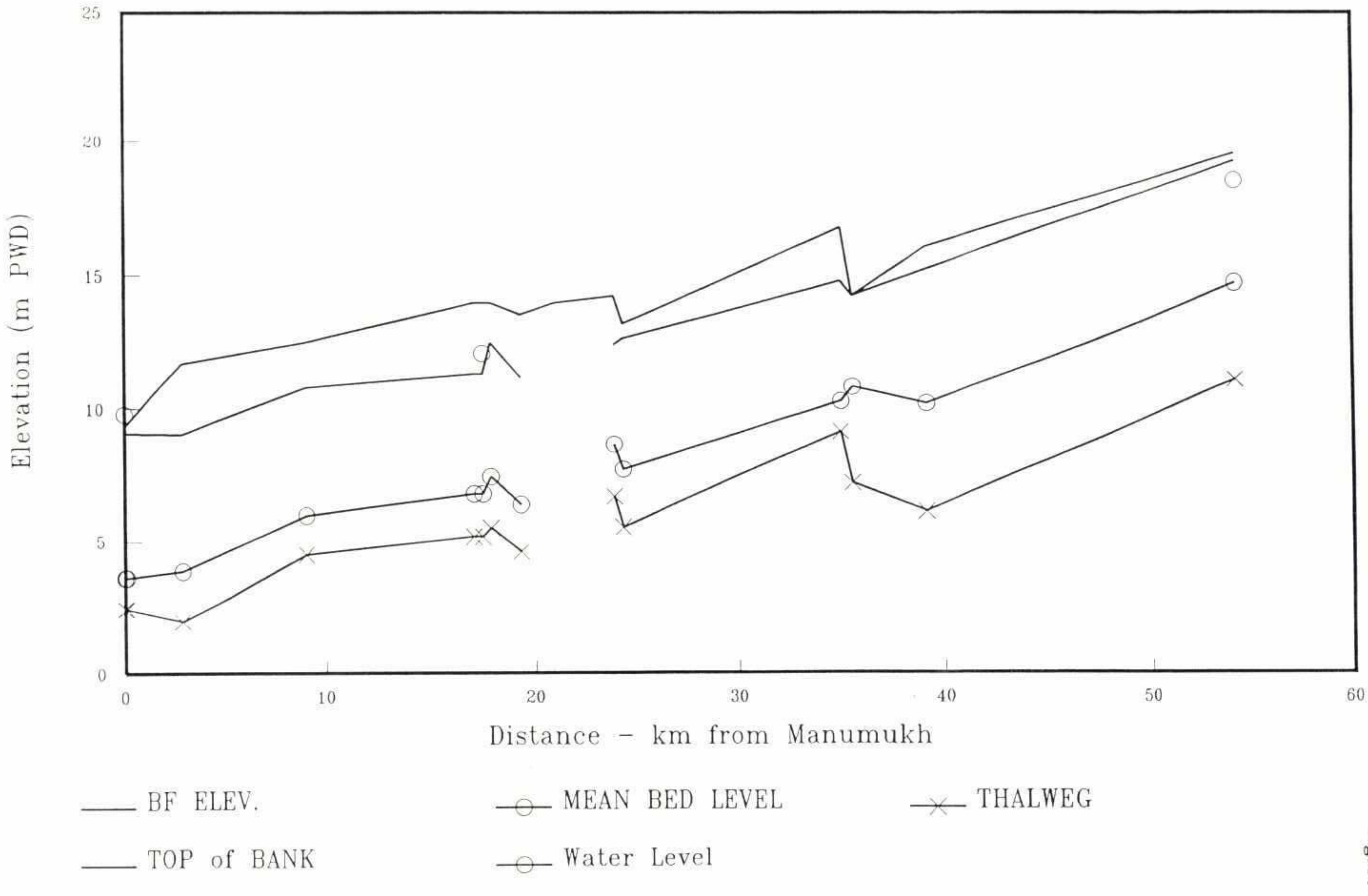


Figure 13

027

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MANU WATER LEVEL PROFILE

1988

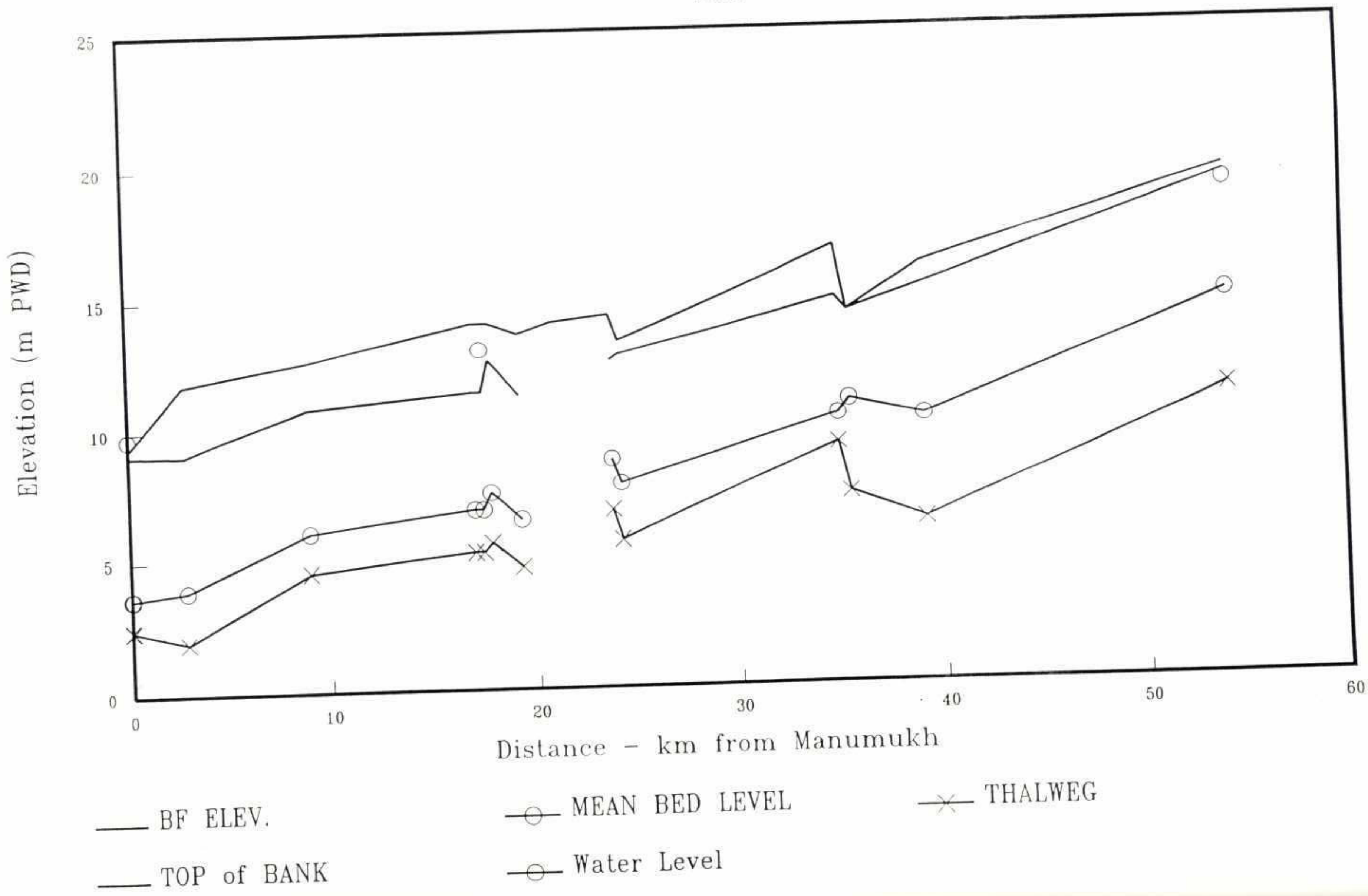
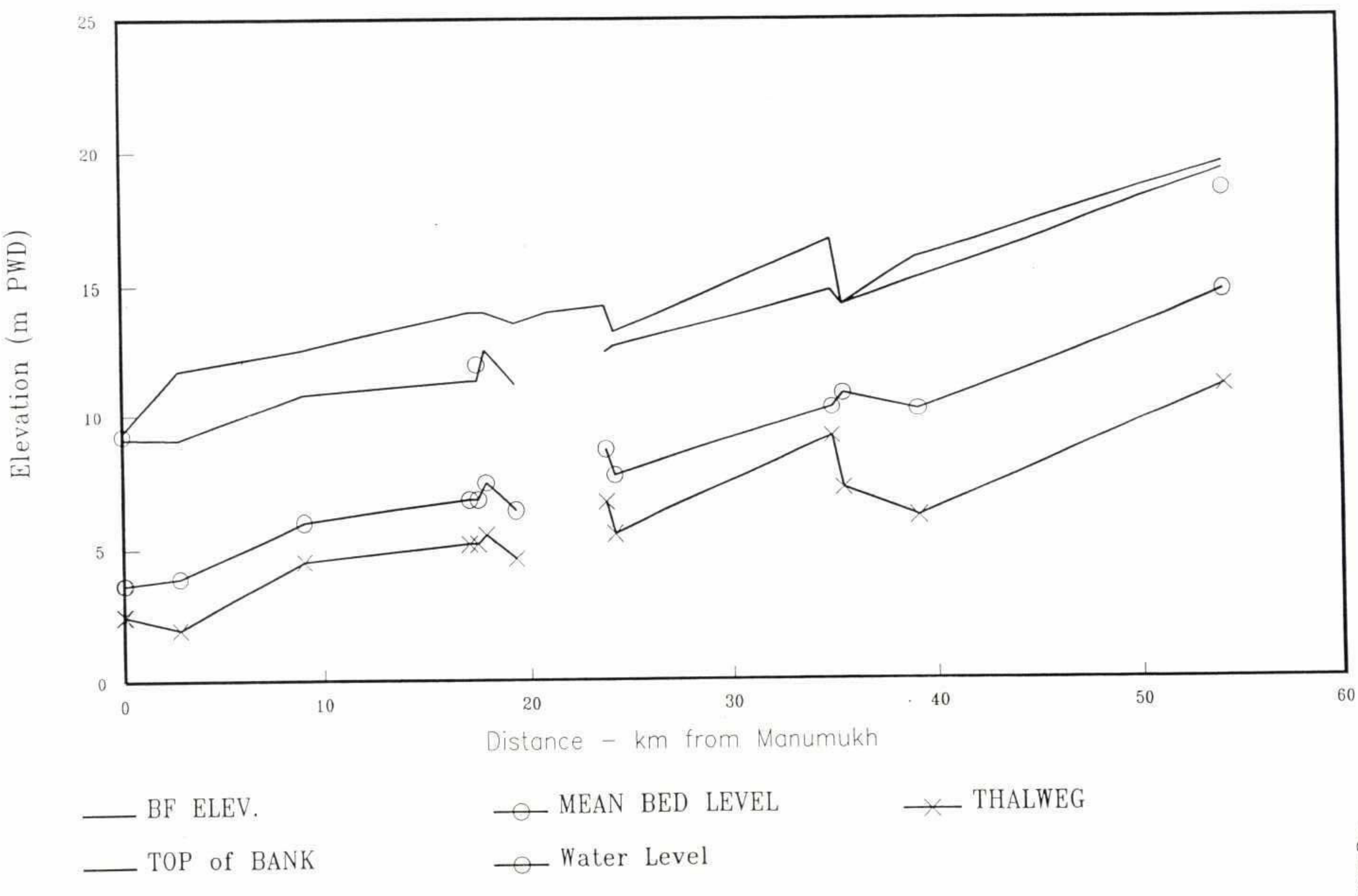


Figure 14

MANU WATER LEVEL PROFILE

1990



060

Figure 15

262

Figure 16

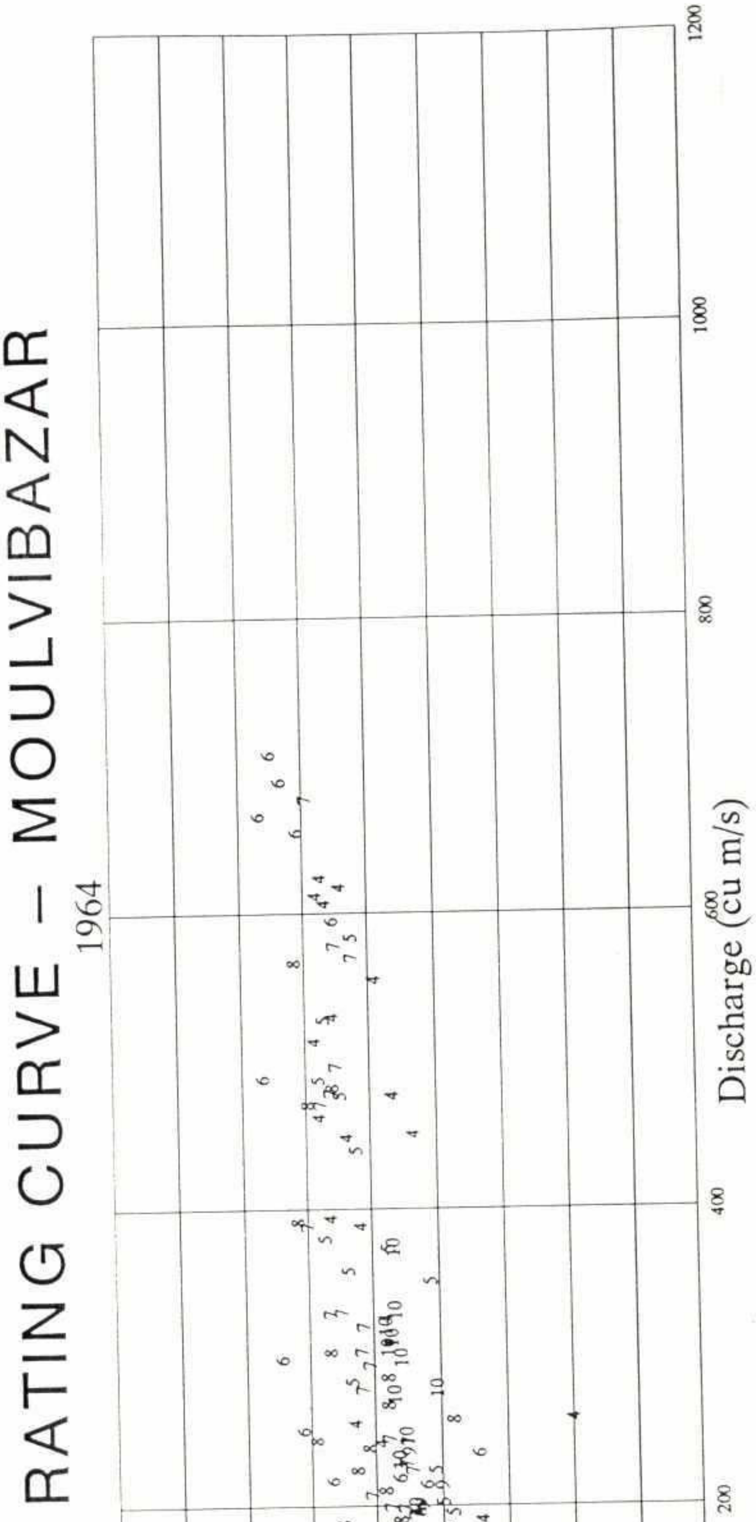
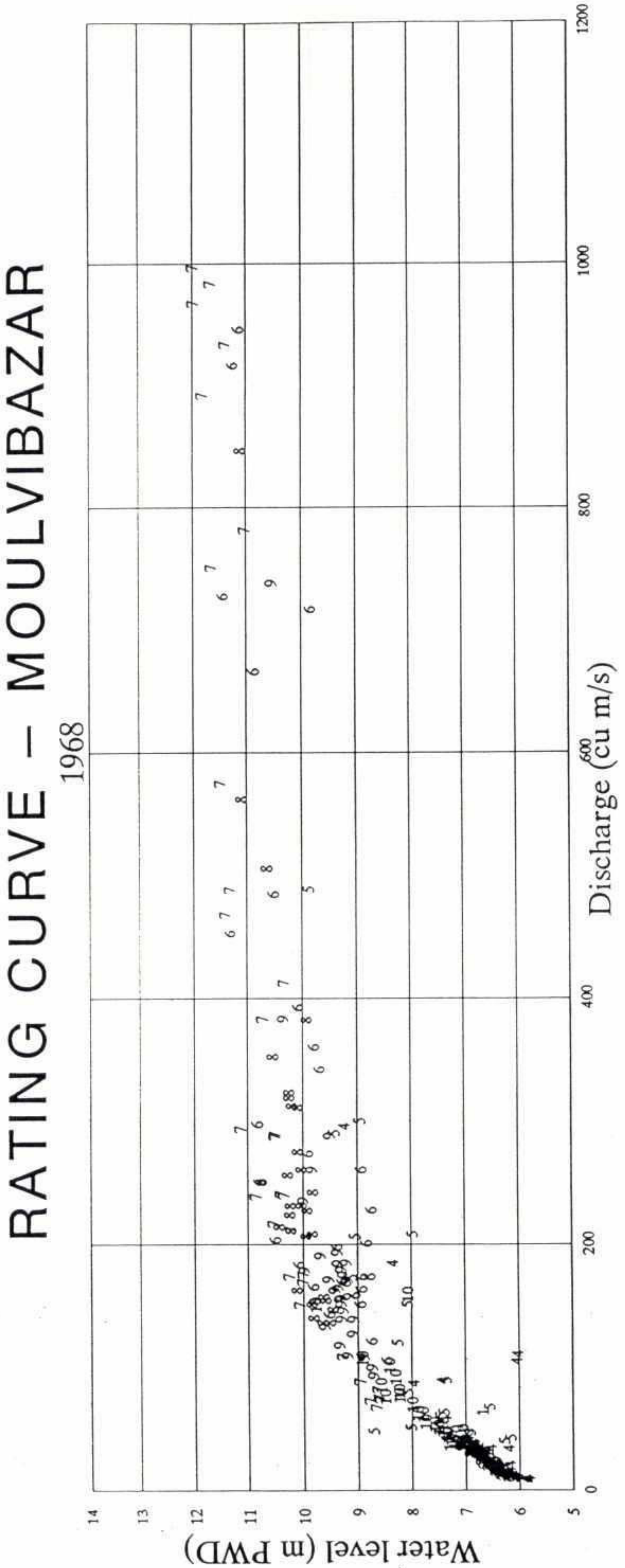


Figure 17


RATING CURVE – MOULVIBAZAR
1968
Water level (m PWD)
Discharge (cu m/s)
5
6
7
8
9
10
11
12
13
14
0
200
400
600
800
1000
1200

266

Figure 18

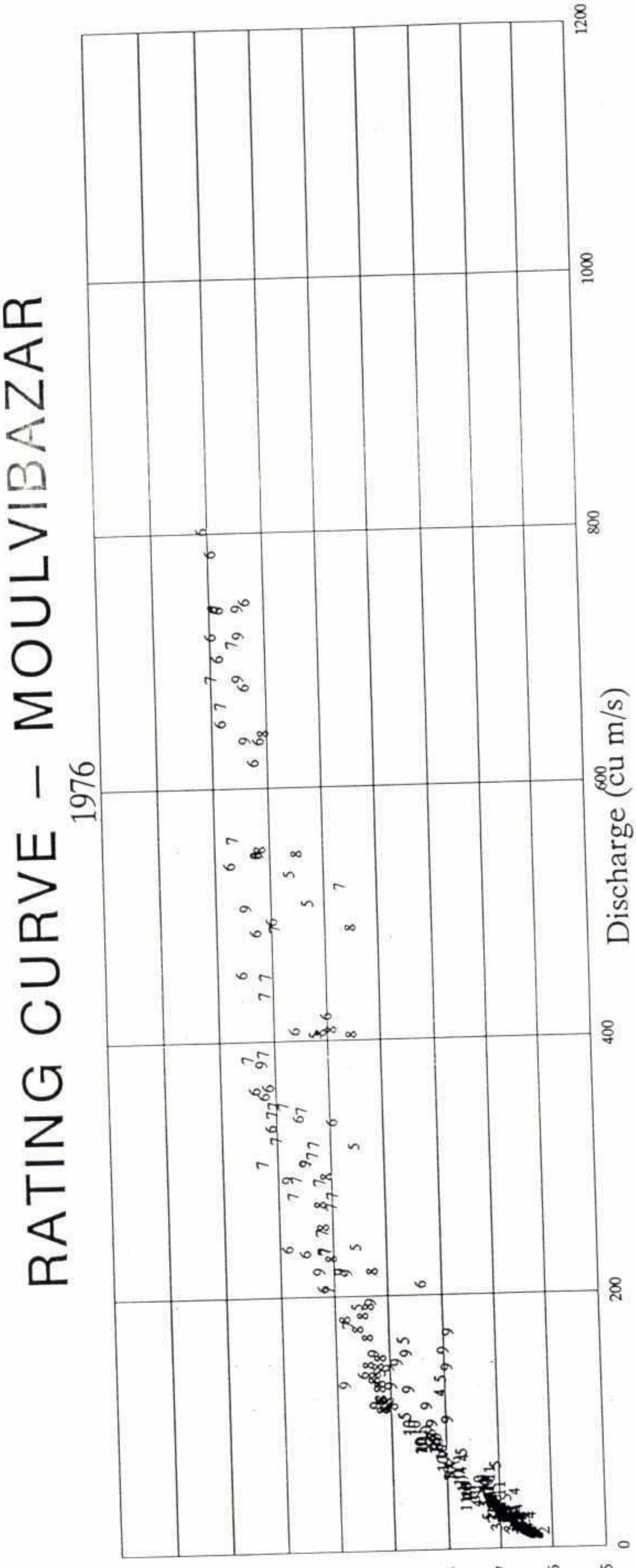


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Figure 19

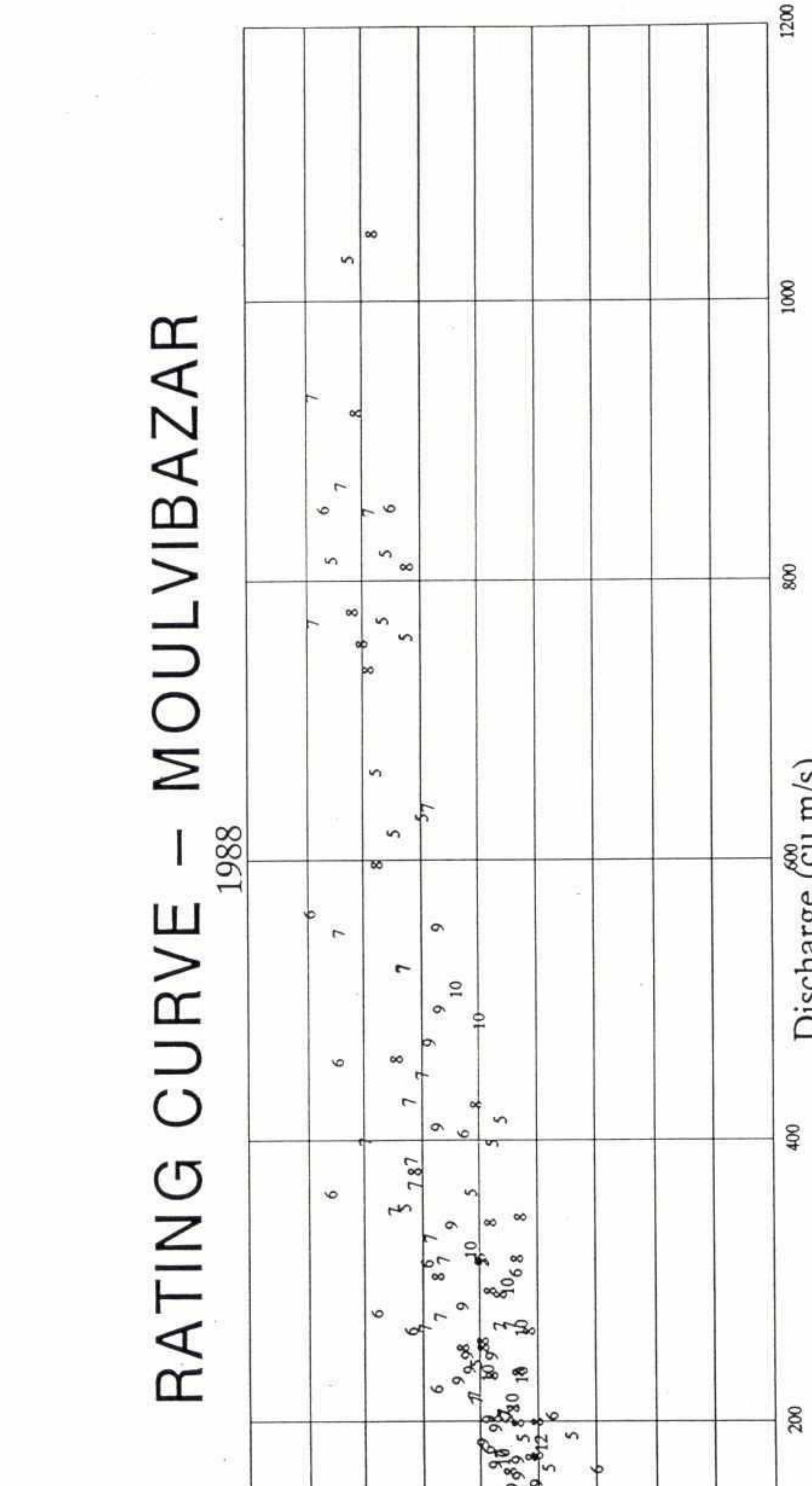


Figure 20

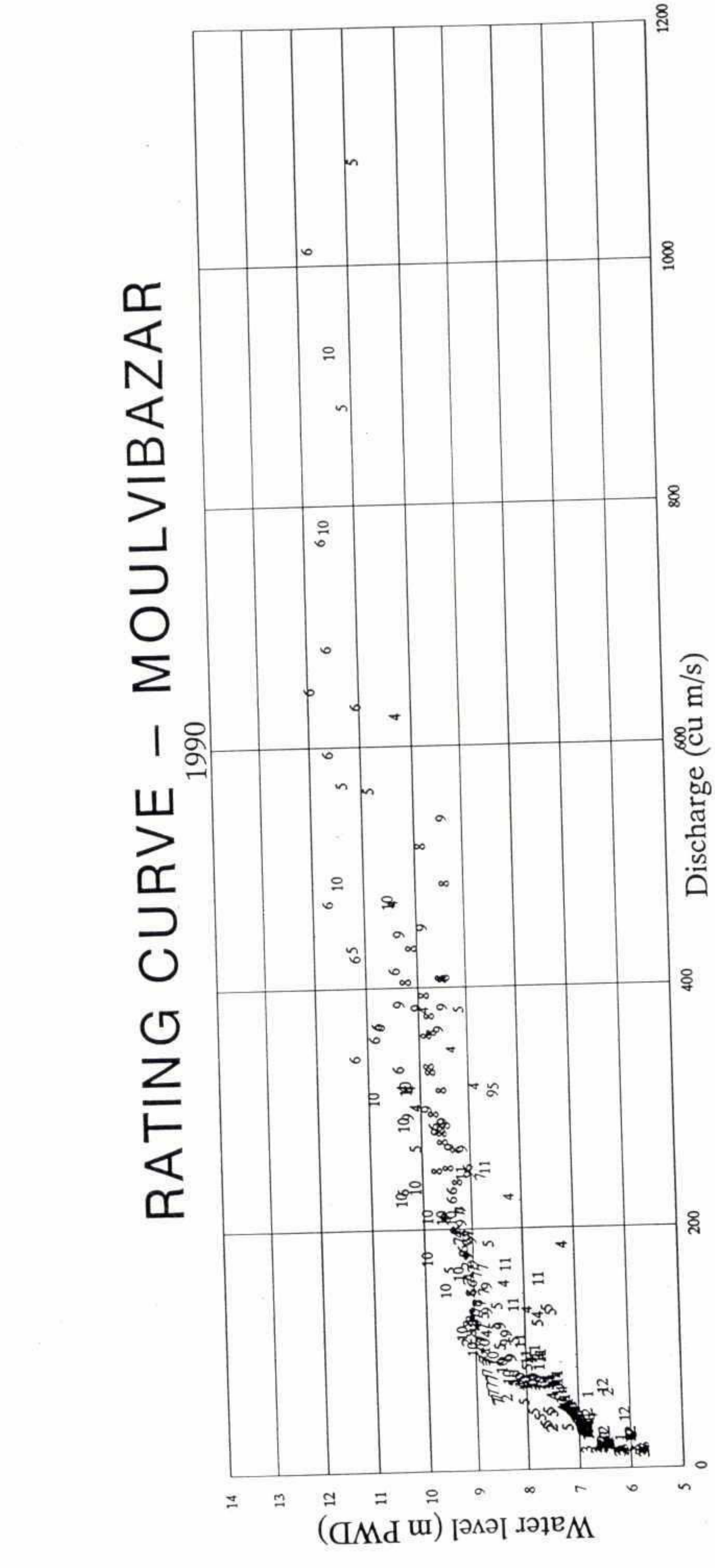
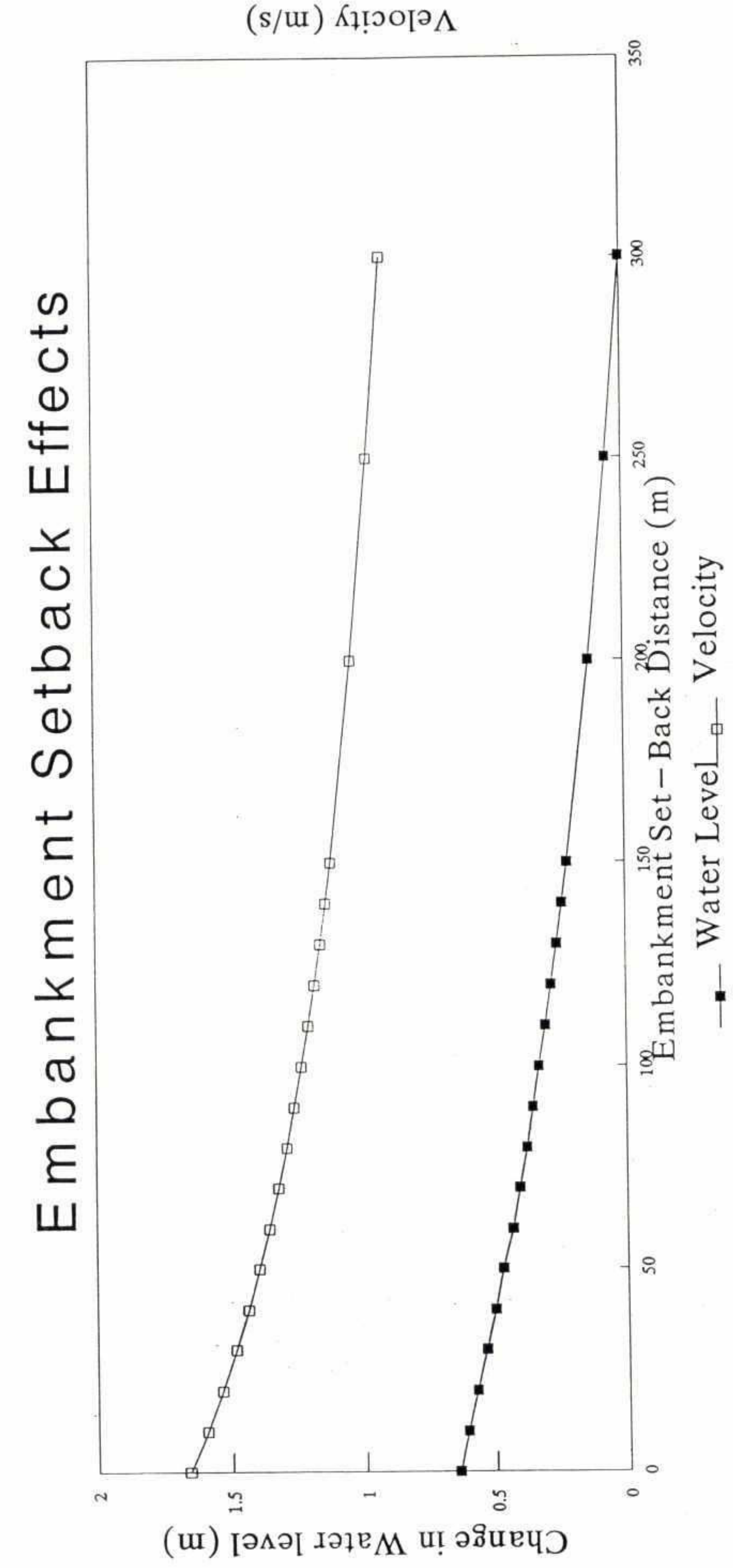

RATING CURVE – MOULVIBAZAR
1990
Water level (m PWD)
Discharge (cu m/s)
0
200
400
600
800
1000
1200
5
6
7
8
9
10
11
12
13
14

Figure 21



Embankment Setback Effects
Change in Water level (m)
Velocity (m/s)
Embankment Set-Back Distance (m)
Water Level
Velocity
0
0.5
1
1.5
2
0
50
100
150
200
250
300
350

369

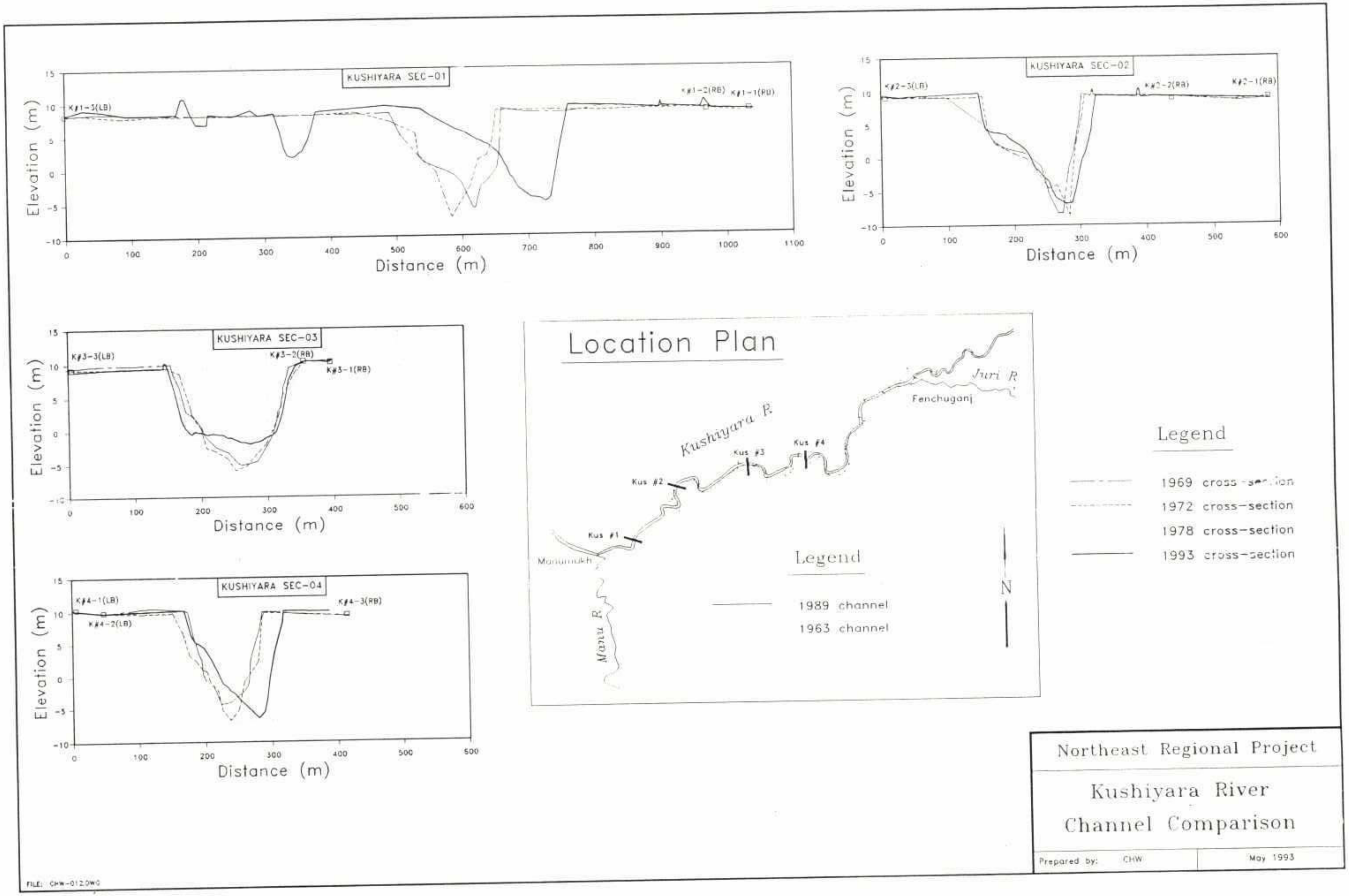


Figure 22

Figure 23

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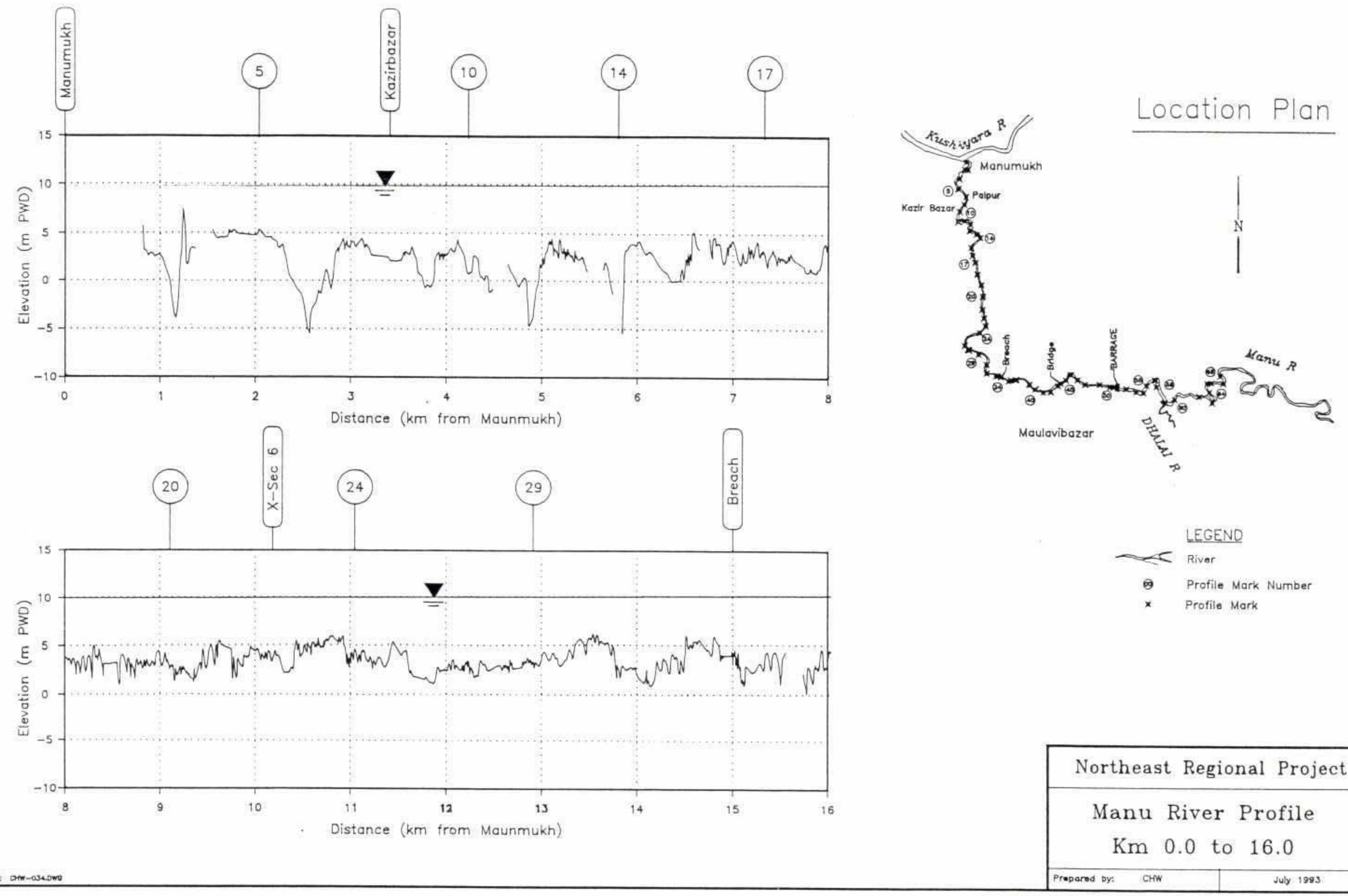
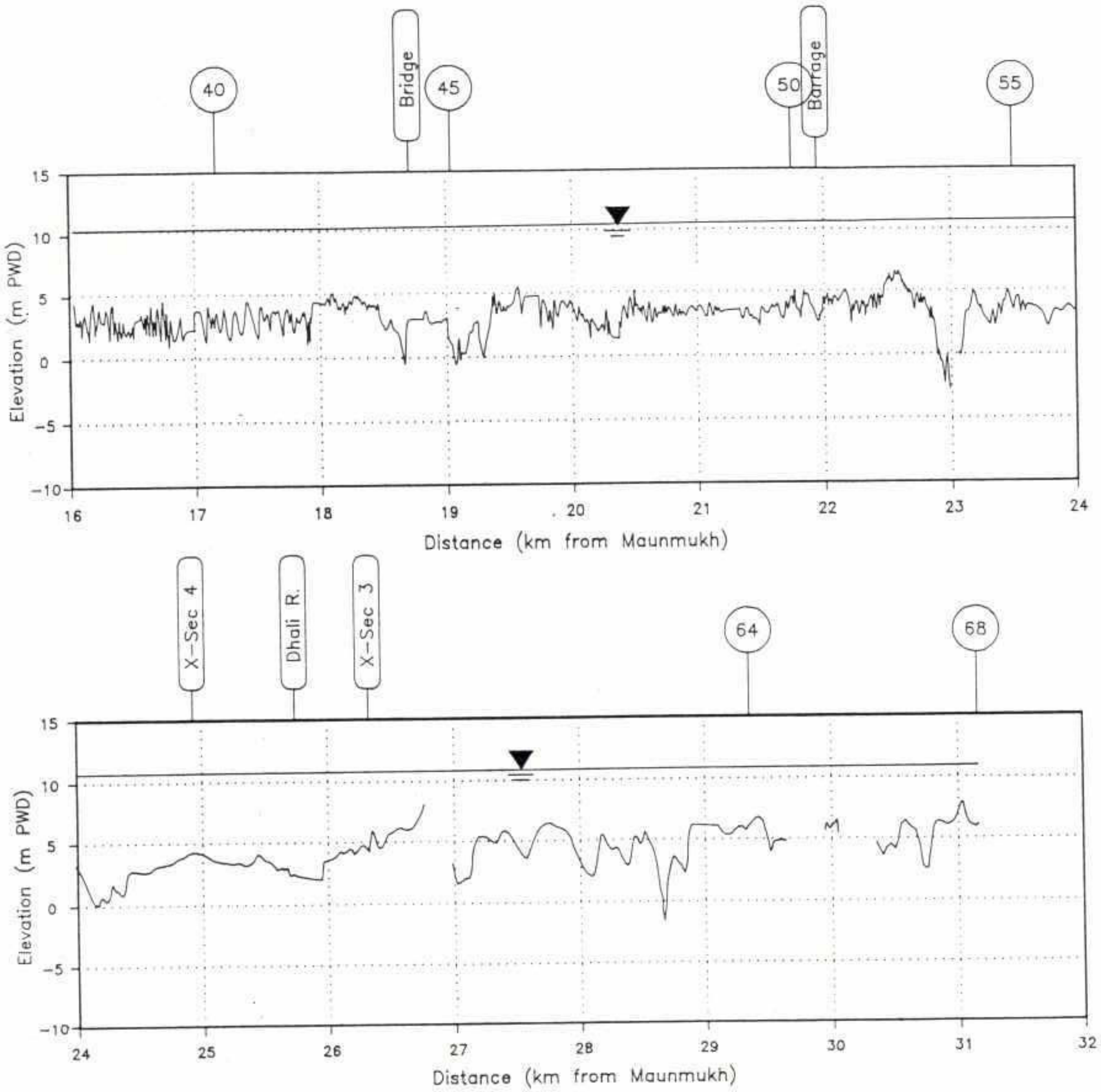


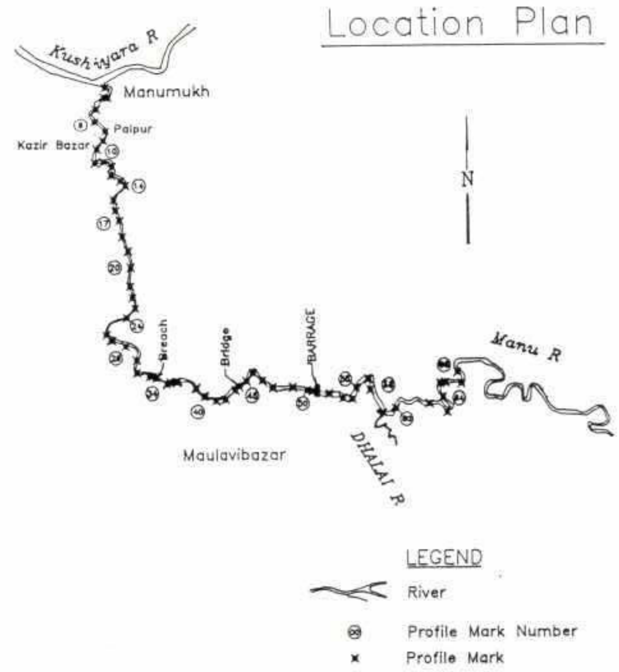
Northeast Regional Project

Manu River Profile
Km 0.0 to 16.0

Prepared by: CHW | July 1993

Figure 24





Northeast Regional Project

Manu River Profile
Km 16.0 to 32.0

Prepared by: CHW | July 1993

FILE: CHW-035.DWG

280

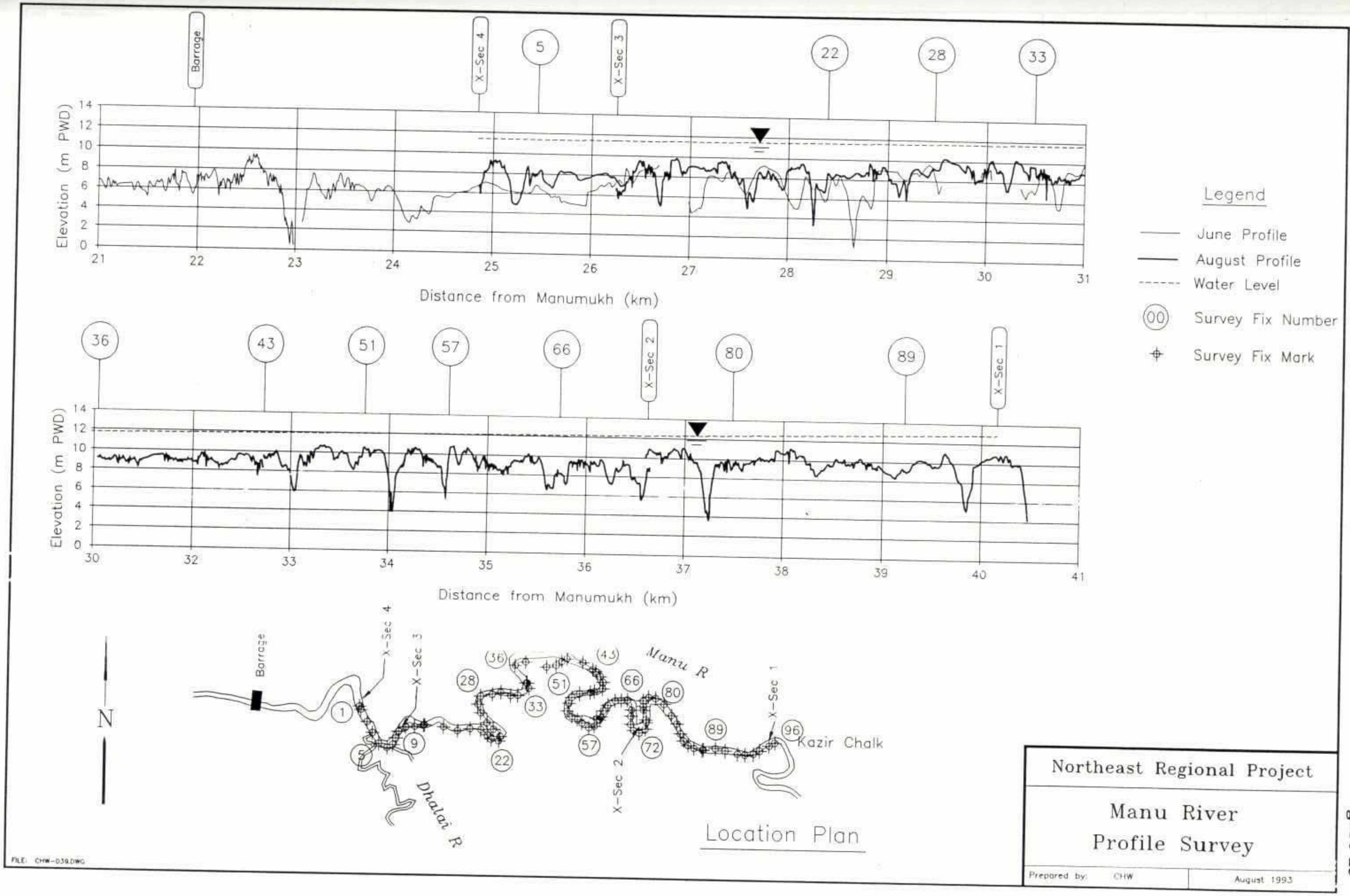


Figure 25

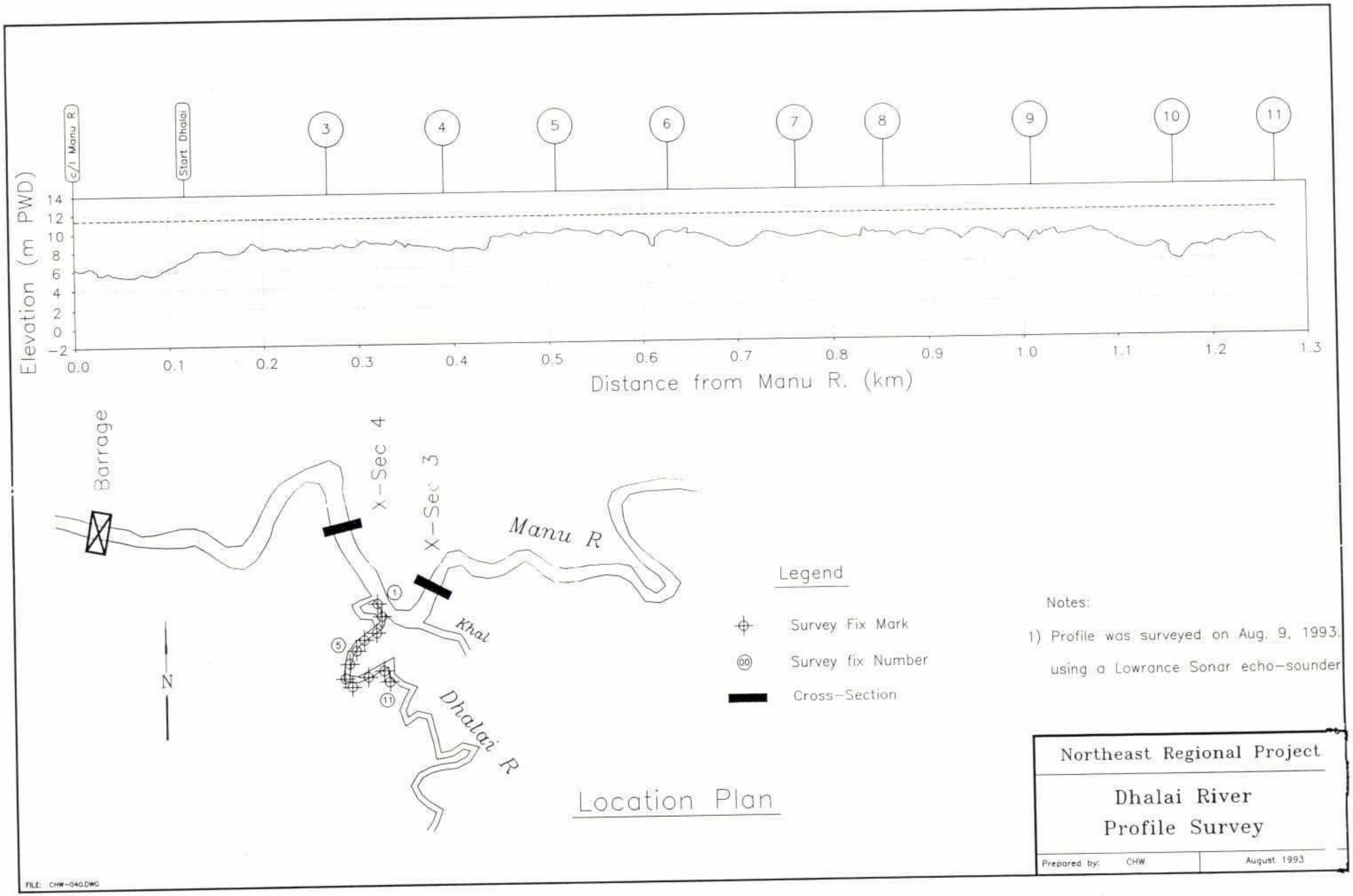
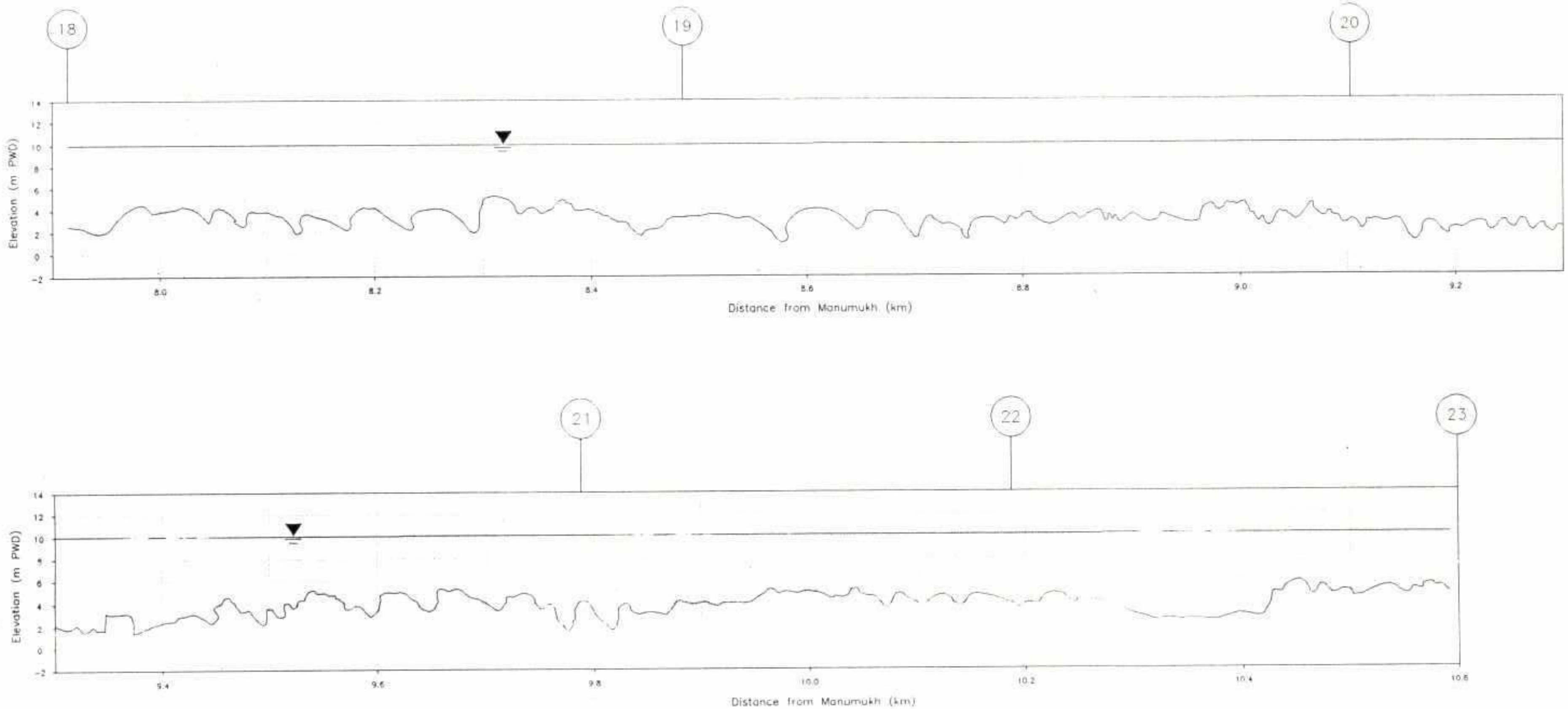

c/l Manu R
Start Dhalai
3
4
5
6
7
8
9
10
11
Elevation (m PWD)
14
12
10
8
6
4
2
0
-2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
Distance from Manu R. (km)
Barrage
X-Sec 4
X-Sec 3
Manu R
Khal
Dhalai R
N
Legend
Survey Fix Mark
Survey fix Number
Cross-Section
Location Plan
Notes:
1) Profile was surveyed on Aug. 9, 1993.
using a Lowrance Sonar echo-sounder
Northeast Regional Project
Dhalai River
Profile Survey
Prepared by: CHW
August 1993
FILE: CHW-040.DWG

Figure 26

Figure 27



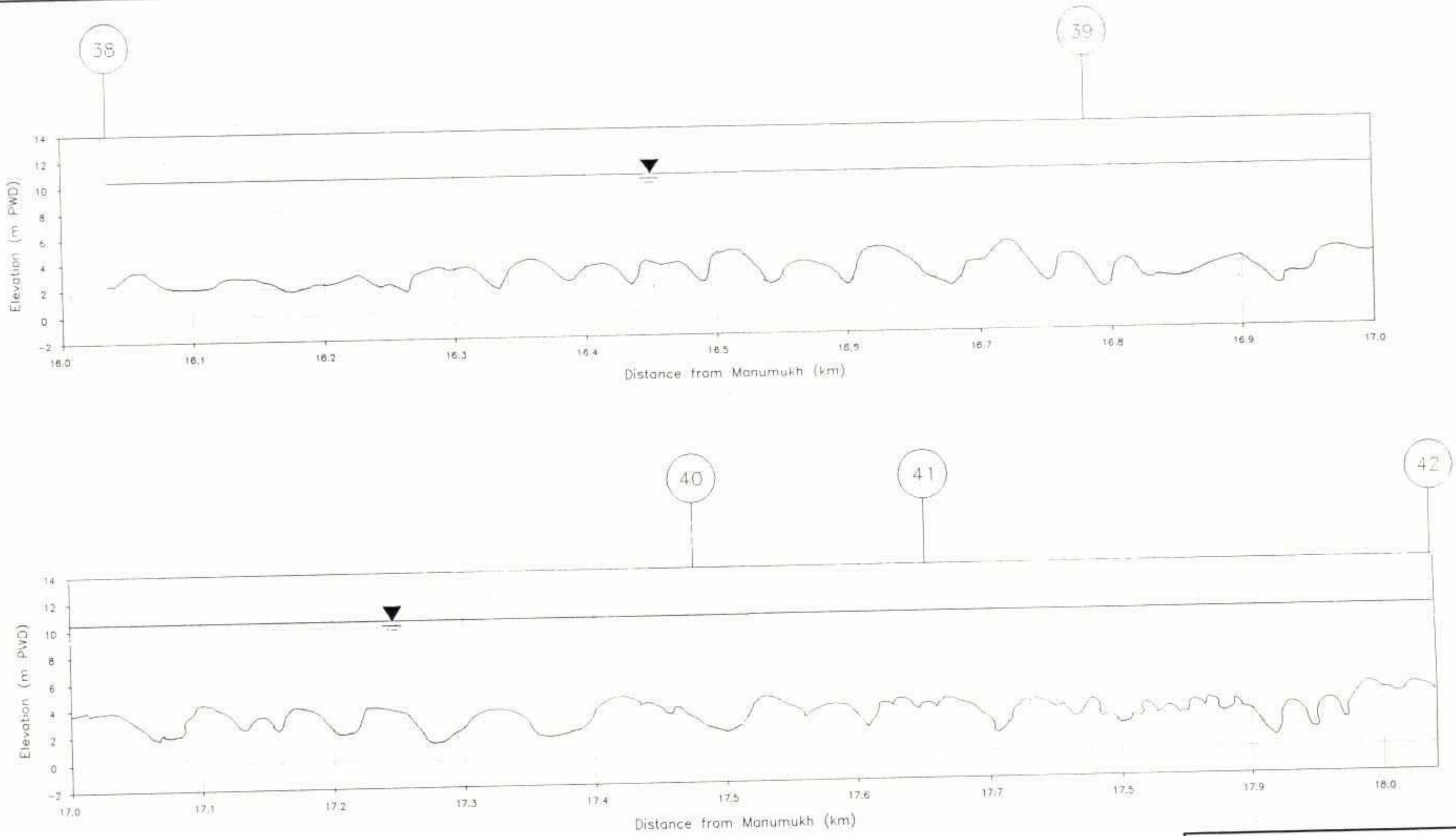
Highlight of Sediment Dunes in Manu River between km 7.9 and 10.6, on June 14, 1993.

Northeast Regional Project	
Manu River Sediment Dunes II	
Prepared by: CHW	July 1993

FILE: CHW-031DWG

286

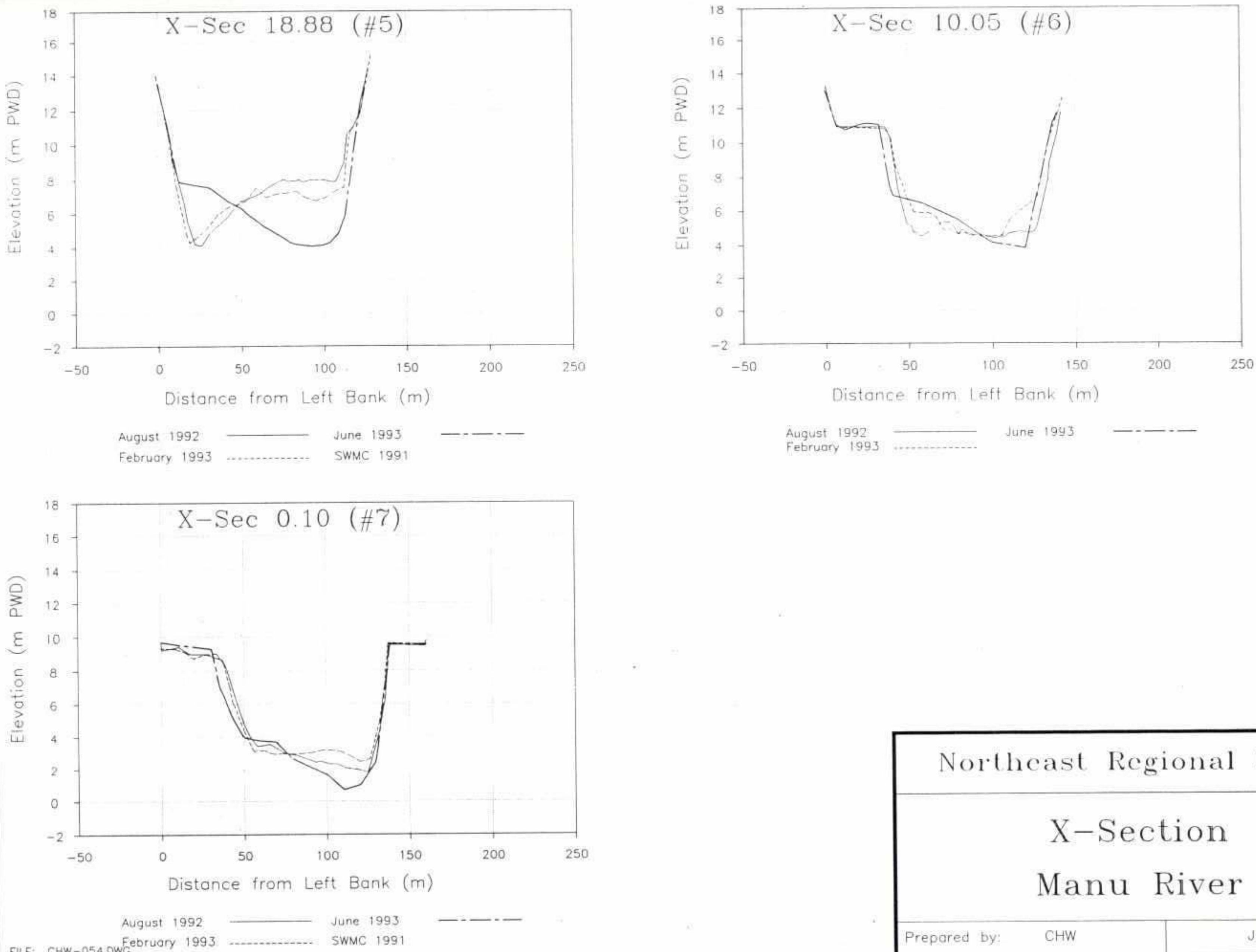
Figure 28



Highlight of Sediment Dunes in Manu River
between km 16.0 and 18.1, on June 14, 1993

Northeast Regional Project	
Manu River Sediment Dunes II	
Prepared by: CHW	July 1993

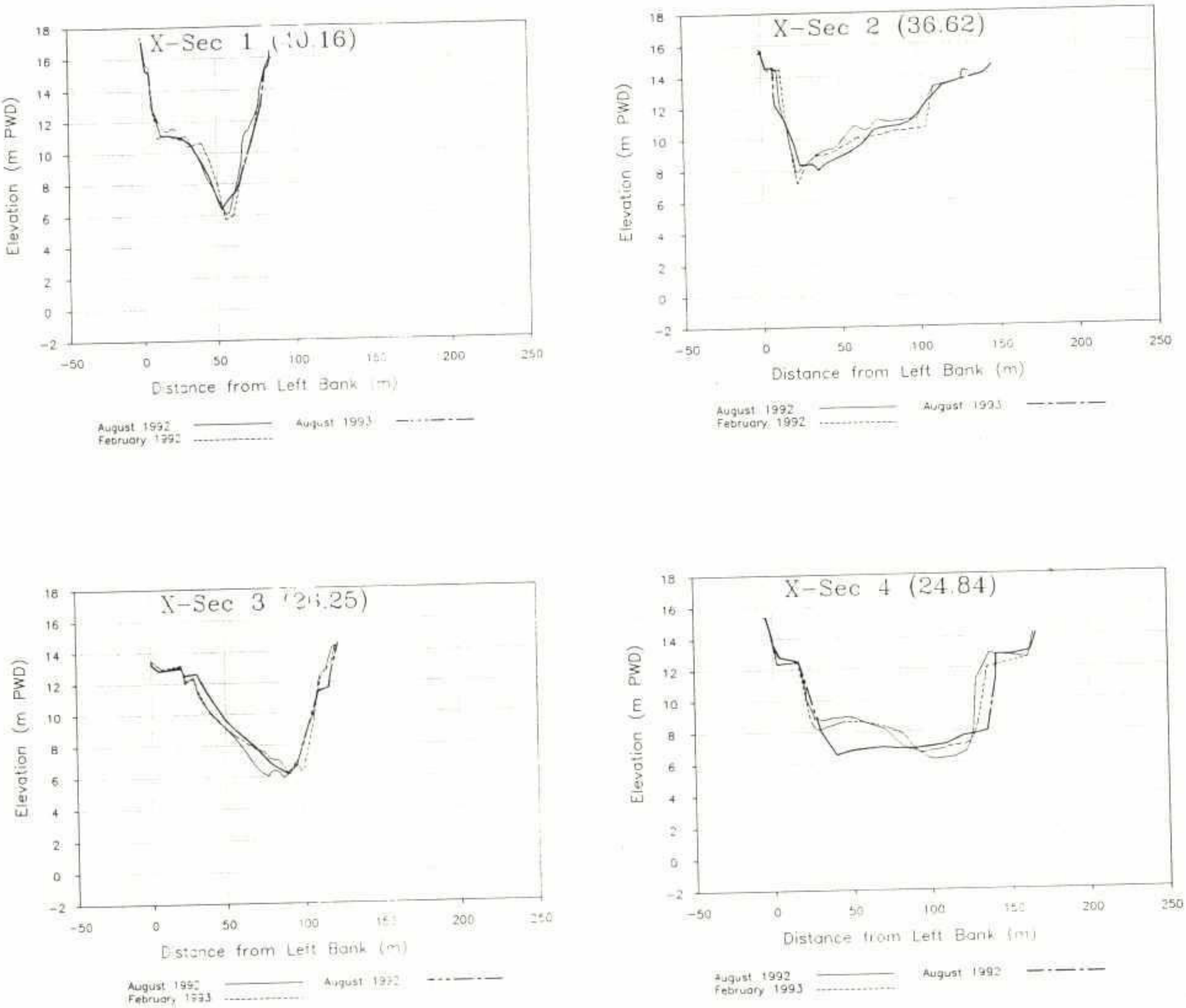
FILE: CHW-032.DWG



Northeast Regional Project	
X-Section Manu River	
Prepared by: CHW	June 1993

Figure 29

Figure 30



Northeast Regional Project

Manu River

X-Section

Prepared by: CHW	June 1993

FILE: CHW-053.DWG

D83

APPENDIX C

SOCIAL ANTHROPOLOGY DATA

APPENDIX C : SOCIAL ANTHROPOLOGY DATA

INDEX

C.1 EMPLOYMENT

Earthwork
Earthwork is a source of employment for poor people. Earth-workers generally work in groups, although there are many who work individually. The main work season starts from Falgun. They usually work in agricultural land for land levelling and ail construction, in homesteads for making and repair of homestead platforms, excavation and maintenance of canal and its dike, construction and repair of road, excavation and re-excavation or pond and so on. They are the same people who work as farm labourers when work is available in the farm, particularly at the time of plantation and harvesting of crops.

Migrant labourers who come to work as earth-workers are mainly from Brahmanbaria, Comilla, Noakhali, Kishoreganj, Mymensingh, Netrokona, Habiganj and Shaistaganj. Some of them stay in the project area during the period of work, while others stay in colonies in and around the Moulvibazar town.

People of Rokta are undertaking maintenance works of the graveyard and road through voluntary contributions. The portion of road from Rokta to Modhurbazar has been taken up for repair. Each well to do household contributed tk 100 and the poorer households contributed tk 50 each.

If a labourer is employed for three months he is paid Tk 800-900 per month plus three meals per day, one lungi and one under-shirt. If a labourer is employed for six months he is paid Tk 700-800 per month plus three meals a day, one lungi, one under-shirt and some medicines in case he is sick. Someone who is contracted for one full year is paid Tk 8,000-9,000 in total plus three meals a day, two lungis, two under-shirts, and necessary medicines.

For women labourers, the wage isTk 15-20 per day plus two meals a day. The monthly wage in Baishakh for rice drying and other household work is 2-3 maunds of rice plus three meals a day. From mid-Sravan to mid-Bhadra and in Agrahayan, one sari is paid to the female labourer in addition. The yearly wage for a woman labourer is tk 250-300 per month plus three meals a day and one or two sari.

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Child labourers (8-13 yr) get a monthly wage of Tk 100-2000. They are employed as cowboy or helper of adult labourers. All seasonal labourers get food and clothes.

In Dheupasha and Barkapon villages, most of the medium and large farmers employ seasonal labourers for a period of six months to twelve months. Agrahayan is the terminal month of contract for seasonal labourers. In Ontehori, Rokta and Sonateki villages, Baishakh or Jaistha is the terminal month.

Contractual farm wage

Plantation: For plantation, the wage is tk 100 for local varieties and tk 120 for HYVs per ker.

Aus harvesting: Tk 80-100 per ker. Two person days needed to harvest the crop of one ker. The wage would be Tk 150-200 if transportation of grain to homestead is included in addition to harvesting.

Aman harvesting: Tk 100-120 per ker and Tk 150-200 including transportation.

Boro harvesting: The labourer gets 4 muri out of 40 muri harvested (10%). Labourer's share increases to 8-10 muri if transportation is from field to the land-owner's house is also included.

Bepari: Labourers who harvest rice from the field are termed *mehnati* or *bepari*. The term *bepari* is more common.

Many of them come from outside the area to harvest rice in the low-lying areas of Kawadighi Haor in March-to-April. Migrant beparies get lower wages than the locals for the following reasons:

(a) migrant beparies need to be accompanied to the field as they do not know the area;
(b) local beparies are more loyal to the farmer and take more care of the crop.

Beparies mainly come from the districts of Noakhali, Comilla, Mymensingh and Kishoreganj. Many *kuli* from tea gardens also come to harvest rice.

Aus is harvested by local beparies. Few migrant beparies come to harvest aman crop in Charkarpar and Kashempur.

Child labour

Children are engaged in all sorts of house work. Girl children collect fuel and wild vegetables from the haor for their own use. They also work in others' house. Male children are engaged in a variety of activities like rakhal, fishing, day labourer, shop-keeping and peddling. The wage is about half of that of the adult labourer. For example:

Work	Monthly wage (Tk)
Rakhal	200-400
Fishing	300-400
Shop	300-500
Agriculture	30-40 (daily)

Employment during and after the flood

Unemployment was high after the occurrence of flood. The scope of work for harvesting of aus declined. Also the scope of employment in the work of transplantation of aman shrank. Some people are engaged in collecting and carrying sand. 75 boats from Sonateki, 75 boats from Fatehpur, Shahbazpur and Betagonj, 10 boats from Medinimahal and 6 boats from Keola are involved in this activity. On an average, 2 to 5 persons work with one boat. The capacity of a boat ranges from 60 maunds to 500 maunds. They pay a fee of Tk 30 to Tk 300 to the lease-holder depending on the size of the boat for a boat-load of sand. They carry sand to Koradair area where this is sold to sand traders and the contractors who use the sand in repairing the embankment, construction of bridge and other private constructions. Each cycle of work including loading of sand, transportation, unloading and returning to the source involves a period of three days. Many labourers also rent boat for this purpose. The daily net income per labourer is about Tk 60-70.

C.2 MARKET

Thirty to 40 retailers of vegetables are seen in a village market in January. They usually bring brinjal, bean, cabbage, potato, etc. Sometimes market is extended to the adjacent rice field. Many farmers sell shail rice for cash. Fish are brought in plenty by the nikaries. Fish price is also lower by 10-30% than before. Buying and selling of fish and vegetables in Poush and Magh is higher than that in other months.

There are 20-25 markets in the area. A variety of commodities including fish, pan, textiles, rice, medicine, vegetables, other food items and stationary products are traded. Within one mile radius of the study village Panchgaon and Rokta, there are four markets. These are:

Market	Market day
Sarkar bazar	Thursday, Sunday, Tuesday
Azader bazar	Friday, Monday
Oichhoder bazar	Saturday, Wednesday
Fielder bazar	Everyday in the afternoon

Barter trade

Mobile traders are involved in barter trade. In exchange of rice, they sell vegetables, pan-supari, biri, matchbox, biscuit, soap and cosmetics. The main seasons for such trade are Bhadra, Agrahayan and Baishakh. Sometimes in other periods, commodities are sold on credit which is realised after the harvest.

The exchange rate is fixed in line with the market price of rice and the size of the pot which is used to measure the quantity of rice. Generally the prices are high for bartered commodities. The price is almost double when rice is exchanged for other commodities after the harvest in the haor. It is argued that the exchange value of rice should be low as the farmer can sell it at the farm side and do not take the trouble to carry it to the market.

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C.3 CREDIT

Logni

Many people including women are engaged in logni karbar which is also termed as shudi. Women lend to women only. They lend both in cash and rice at the rate of interest up to 20% per month. The amount of loan is high for those who intend to go abroad. If the loan is not repaid in time the rate of interest is compounded.

Rice is usually borrowed at time of distress, particularly in the months of Ashwin, Kartik, Falgun and Choitra. Loan is repaid in Agrahayan or Baishakh. Cash or rice equivalent is repaid in line with the market price of rice at the time of borrowing. Also land or other assets are mortgaged against loan. In the case of land, the mohajan gets the benefits of the land. In the case of other assets mortgaged, the mohajan takes interest at the rate of 5-20% per month.

The money-lender does not take any immediate step to recover loan in case of default. Rather she or he allows the interest to go up at compound rate. When the amount of interest is high enough the money-lender tries to collect. Sale of agricultural land or homestead is very common to repay such loans in this area. In Panchgaon one person sold one half *ker* of homestead land to repay a loan of Tk 500.

In Jahidpur, different systems prevail in logni karbar. Some of these are as follows:

(1) According to one system, 150 taka is to be repaid for a loan of 100 taka borrowed at the time of distress. The interest thereof is tk 50 and is termed as dera shud.

(2) One maund rice is to be repaid in Baishakh if Tk 120 is borrowed in Falgun.

(3) If one maund of rice is borrowed in Ashwin, Tk 400 is to be repaid in Agrahayan.

(4) According to another system, value equivalent to market price of rice at the time of borrowing plus tk 100 is to be repaid for one maund of rice borrowed.

Sale of labour in advance is also in practice. For example, if the wage is Tk 50-60 per day in Baishakh, labour is contracted in Falgun or Choitra at the rate of Tk 30-40 and the wage is paid in advance.

Bank

Farmers find it difficult to obtain credit from the bank. They have to go to the bank several times and approach brokers. If credit is sanctioned, they receive tk 800 for 1,000 taka sanctioned.

C.4 SITUATION OF WOMEN

Employment

Women and their children in some villages are engaged in earthwork but they work only within their own homesteads. Working as a casual earth-worker is considered disgraceful. Men feel that women are not good in earthwork and that they should not work outside the house. In Islampur village women who are migrants from Mymensingh are good in earthwork and do not feel bad about their work. Women belonging to poor households and those without any adult male member work outside the house. In Jahidpur, 20-25 women of such background were found.

During April-May, women are involved in the work of threshing, winnowing and parboiling of rice and get a wage of 4 seer rice (unhusked) per day. Monthly wage for contractual labourer is 8 *fali* of rice plus food and one set of clothes

Work is seldom available from May to July. Some women work by husking rice. Many poor women live on begging during these monsoon months.

During August the demand for labour is very low. Some women are engaged in household work and storage of *aus*. The monthly wage is 1-1.5 maund of rice plus one sari.

In November and December there is work available in threshing, winnowing, parboiling, etc. after the aman harvest. The monthly wage is 1-2 maunds of rice plus one sari.

During January and February some women collect wild plants and stalks of rice from the haor. They also collect cattle-dung. They collect many wild vegetables to eat, as many of them can not afford to buy rice.

Gleaning of rice from the *haor* after the harvest is a common practice among the destitute children and women. Going to the *haor* is an act of disgrace for women and only the very poor do this gleaning. In Shahpur, 15 old women and children go to the haor for gleaning of rice. Each gets 2-3 kg of rice in one day. Many poor people feel that begging in the village is more respectful than gleaning rice in the *haor*. In Jahidpur the poor *namasudras* and the *bangals* glean rice. Members of other communities, though poor, do not glean rice which, they feel, is derogatory to their family pride.

Women are also employed on a daily basis for various work, such as searing the floor of the house, winnowing rice, making *muri*, washing cloth, processing of tree logs for use as fuel, making *ghute* out of cattle-dung, washing utensils, bringing water, and so on. The daily wage is two meals plus one or two *seer* of husked rice depending on the nature of the work. Old women, particularly widows, work in others' houses. Unmarried girls work only in the house of close relatives.

March and April are two months of distress. Women collect *singra* which the destitute people eat as a staple. They also sell *singra* by peddling inside the village. They also collect *atobhato, bhet, shaluk, kheichar*, and other plants from the haor to use in making curry.

House Maids
Migrant labourers from Sylhet, Sunamganj, Ajmiriganj, Mymensingh, and Comilla are preferred. Locals are not preferred as they frequently drop out from the work. The wage is Tk 100-150 per month for migrants and Tk 50-100 per month for locals, plus food, clothes, and other essentials.

Self-Employment
Women also earn some income through self-employment. Some *namasudra* women are involved in making *muri*. If they make *muri* they keep one-third of the rice as wage. Some *maimol* women are involved in net making.

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Tailoring by Women

Two women in Panchgaon are involved in tailoring. They work at home. Before the Durga Puja festival, they got some orders for women's and children's wear. This year, the market for tailoring is poor compared with the previous years. The income was twice as high during the previous year. They also received more orders in the previous years.

	Wages (Tk/piece):
Blouse (cotton)	15
Blouse (silk)	20
Salwar-kamiz	30
Frock (with embroidery)	15
Frock (without embroidery)	20
Trousers	80-90
Shirt (for boys)	20-25
Shirt (for men)	30-40
Short pants	12-15

Seclusion of Women (in Panchgaon)

Women, especially housewives, have to be careful about the honour of their households. Their mobility outside the house is not socially acceptable. They go out only with male members or with children, even if they go collecting wild vegetables, fuel, or water. Seclusion is more rigid among middle-class farm families. If there is no tube-well in a middle class house or if the tube-well is out of order, the women of those households will not go out to bring water from another tube-well. Instead they will drink water from the pond within the homestead. If any of them work for wage they would not confess it. Wage employment is socially disgraced. When women go out they use umbrellas to cover their faces.

Many girl students after passing the school final are not allowed to enrol in college as they would have to study along with male students or would be taught by male teachers. In many families, girls are not allowed to study even in secondary schools. The households whose members are working in Saudi Arabia or England are very careful about the *purdah* and do not allow their daughters to study in schools. They feel that the girl will become "bad" and will not obey their guardians if they receive education. The most offensive act by a girl, according to them, is to marry a boy of her own choosing which might happen if the girl gets higher education.

Distance from house to school is also a factor in low enrolment of girls in secondary schools. In Jahidpur there is no facility for girls' education at the secondary level. They would have to go to Balaganj which is far away, and they would need to go by motor launch in the monsoon months. Girls cannot go that far.

People who receive remittance money from overseas feel that if there is enough money a good bridegroom can be found for the girl and therefore education is not necessary. Also they feel that after the marriage the girl would leave the house of her parents, and all investments of the parents would be lost. If the girl gets a job after marriage her husband's family would be the beneficiary and not her parents.

Family Planning
Contraception is mostly done by women. A family planning association, Radhubala, works in the area which includes Panchgaon, Bhumiura, Khanikul, and Rokta. There are 466 eligible couples of which 281 use contraceptives. The distribution is as follows:

Table C1: Use of Contraceptives

Method of Contraception	Number of Users
Pill	177
Injection	48
Copper T	24
Condom	18
Tubectomy	11
Vasectomy	3
Total	281

Among the women who use contraceptives about half do so without the knowledge of their husbands. Some users are assisted by their mother-in-law without the knowledge of the husband.

Women are generally interested in the use of contraceptives and many are willing to have permanent sterilization. But the husband does not take the initiative and does not take the wife to the clinic for tubectomy.

C.5 FLOOD

Flood shelter/survival
People took shelter in Panchgaon hospital, schools, Durga mondir, and the UP office. Some of them took shelter in temporary camps, working as rickshaw-puller. Others lived on rations provided by the government and a few rich people. The rations included rice, pulses, milk, flour, and candles. Those who did not receive any relief borrowed cash and rice from the *mohajan*. Many people borrowed from relatives.

Flood frequency
People say that the frequency of flooding has increased. Before the project, when water level used to rise in April and May the dike in Koradair Khal and Machhuakhali were enough to protect the haor. People of Ontehori, Islampur, Kashempur, and other adjacent villages used to make dikes on their own initiative. People say that the river could previously carry more water than is now the case.

Drinking water
Those who possess boats carried water from tube-wells from other areas where tube-wells were not submerged. Others used flood water.

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Fuel
Fuel wood was in short supply. People use bamboo and other building materials to cook food. Cooking is done less frequently. Many eat *chira* with water.

Flood in Korayer Haor
Due to construction of embankments along the right bank of the Manu and left bank of the Dhalai, water has to overflow to Korayer Haor. The problem has been intensified by the siltation of Kata Gang. This happens almost every year now.

Flood in villages outside the embankment
Villages outside the embankment are subject to flooding almost every year. *Aus* and *shai*l rice are partly or completely damaged. These villages are Mohonlal, Goria, Jivanganj, Shashmohan, Govindashree, Konagaon, Togorpur, Adnabaz, Syedernagar, Bhangarhat, Akua, Goneshpur, Ekamodhu, Kandirkul, Ujirpur, Haripasha, and Ibrahimpur.

In Kashipur and Hajipur, where there is no embankment, land use for *paner bor* remained unchanged. It was reported that if the water recedes immediately after inundation it does not harm *paner bar* significantly. Many vegetables are also grown on the same land. Now there is scarcity of vegetables

Impact on the other side of the Kushiyara and Manu Rivers
The water level is higher and current is stronger because of the embankment. Flooding has been increased in the Ballavpur and Gurapur haors. It was reported that this was the first year after completion of the project that farmers have been able to harvest the boro crop.

Flood levels are also reportedly higher in upstream areas. On the left bank of the Manu is a strong dike for town protection. The town is important and the people are very powerful there, so the dike is never cut on that side. If there is a possibility of overtopping the people cut the dike on the right bank to release the pressure.

Flood in Rokta
The whole village was flooded in June. There was knee-deep or waist-deep water in almost all houses except ten. In some houses the water level rose to the roof level and the household members had to leave their premises in search of shelter, either in relatives' house, the primary school, or the few houses within the village which were above the flood level. One flood shelter was set up in the village. One or two male members per household stayed behind to guard their houses and other belongings. They made a make-shift home on boats where they cooked their food and slept at night. They stored their goods on the boat. Some people made shelter on the roof of their house. Some put one cot over another and made a temporary place to cook their food. People were almost confined and could move only with boats and rafts.

In the Dakshin settlement the level of the homestead was higher and most houses were above the flood level. People could move from one house to another. However they had to use a boat or raft to go to other villages or to the market.

Vegetable gardens have been submerged but fish are abundant. People are taking rice and fish in their meals. Some people are taking only rice and salt. As people are not able to husk rice the price of rice rose by Tk 1-1.5 per kg. The price of kerosene increased by Tk 4-8 per liter and the price of salt rose by Tk 2 per kg. The poor people were hard hit by the price hikes.

The work load of women increased. They have to be cautious so that no household belongings are damaged. They have to keep constant watch on the small children so that they are not drowned. Women also face problems because the latrines are all submerged. Male members of the household go out by boat but women cannot. They remain confined for days on end. Many of them become sick.

Children also become sick. When they come into contact with contaminated water they suffer from fever, cold, measles, diarrhoea, and skin disease.

Flood in Panchgaon
Out of 213 houses only 7 or 8 houses were above the flood level. Five flood shelters were set up. People from Panchgaon, Amirpur, Khaldawar, Koituba, Sharampur, Bageshwar, Jalalpur, Shilbhog, Khanikul, Surananda, Jaipur, and other places took shelter. People also took shelter in the schools and the temple. Most of the people who came to the shelters are poor people. The better-off people took shelter in the house of their relatives.

Flood damage
Damage to the homestead and other properties are high, taking the form of:

Damage to the vegetables garden;
Loss of crops in the field;
Damage to the trees;
Loss of poultry and cattle;
Damage to house structure, wall, roof;
Erosion of homestead platform;
Damage of household belongings;
Loss of pond fishery.

Due to strong wind wave and rain from 16-19 June, 1993, haor villages of Ontehori, Sonapur, Jagatpur, Kadirpur, and Mojaffarpur were badly affected. Houses fell and homestead platforms were eroded.

In Sonapur, 44 out of 48 *bari* were submerged under water. Even in the last week of June, 2 to 4 feet water were flowing over Ontehori bazar. Retailers sold commodities from boats.

Cattle diseases broke out as a result of the flood. Disease in the mouth of the cattle has been observed. Due to this, cows cannot eat grass. Three cows died of this disease in Ekatuna village. Leg infection was also observed. Diseased cows cannot walk. Infectious parts of the body bleed and cows become very weak. This disease was seen in almost every flood-affected village.

Crop damage
The entire *katari* crop and 90% of the *aus* has been lost. There will be no harvest in Sravan-Bhadra. Earlier the boro could not be harvested properly due to incessant rain. So, many people consume *shail* seed which they had stored for cultivation. The stock of seed in many households has been damaged due to the flood. All summer vegetables and spices such as *arum, brinjal, dherosh, jhinga, data, korolla*, papaya, and chilies have been lost.

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Drinking water
Most of the tube wells in the Unions of Panchgaon, Fatehpur, Monsurnagar, Ekatuna, and Akhailkura went under water. Some ponds which were normally used for drinking purpose were also submerged. The water became more contaminated. Few tube-wells in some villages were still functioning. Children of age 8 to 14 years, both boys and girls, were fetching water from tube-wells. Many were unable to bring water from tube-wells and were forced to drink flood water, resulting in diarrhoea.

Flood shelter
Those families who took refuge in flood shelters each received 3 to 4 kg of rice, 2 packets of biscuits, bleaching powder, water purifying tablets, and one soap during the period of 11-19 June. Those people who brought rice from their house had three meals per day initially. Now, out of 80-90 families in the shelter, few can afford two meals a day. The male members earn their livelihood by driving rickshaws, making bamboo baskets, selling eggs and fish, and begging.

People who came to the shelter brought their own bed, utensils, poultry, and cattle. They shared their food with poultry and cattle. They mostly ate rice with salt, *kochu shak*, and *bhater mar*. Many families have nets with which they catch fish for consumption.

There is severe scarcity of fuel. For this reason, people sometimes cannot cook. Those people whose houses have been damaged or destroyed brought pieces of bamboo from their homes to burn as fuel. Some collected branches of trees. The people of Rokta, Amirpur, and Khaldwar villages generally store fuel wood for the whole year prior to the monsoon; now some of them used their stock during the flood.

Flood shelters do not possess adequate latrines. There is no latrine in the union office shelter. There is only one latrine for 23 families who took shelter in Panchgaon high school. Many people have taken shelter in and around the temple where there is no latrine. In response to the need the UP Chairman made arrangements for construction of two temporary kutcha latrines in the premises of the temple and the high school.

A three-member medical team worked in the affected area. They treated the sick people in the flood shelters and in the villages.

The people have mixed feeling about the cause of floods. Some of the perceptions are:

(a) The embankment has caused flooding; floods did not occur before the construction of the embankment;

(b) The floods are the wrath of Allah because the world is now full of sins, the number of fake *moulanas* has increased, or because women do not abide by the purdah (seclusion).

Fishing in flood water
With the recession of flood water the people start catching fish from crop land. Different species of small fish, such as *shing, magur, taki, puti,* and *chanda*, and some big fish like *katla, rui,* and *carfu*, which come from overflow of ponds, are available. People catch fish from their own lands. Encroachment to other's land often leads to quarrels. Although the price of other commodities have increased in this period, fish are cheap.

Livestock care
Cattle-feed was scarce. Many people sent their cattle to relatives' house in other villages. Some of them sent their cattle to the workers of tea gardens. They charge 100-200 taka per month for taking care of a buffalo. Many peopole sold their cattle at a low price.

Lack of employment
All sorts of activities such as agriculture, earthwork, homestead-based activities declined. Bamboo and cane works in Khanikul stopped. The affected people were forced to borrow money at exorbitant rates of interest. Money-lenders are reluctant to give credit as there was crop failure in two successive years and they are worried about the recovery of loan.

Breach in the embankment
The people cut the embankment at Machhuakhali to release the rising water. In some other places the embankment was eroded by wave action. Approximately 2 to 3 km of embankment were eroded in Kashempur, Rashidpur, Abdullahpur, Charkarpar, Jahidpur, Shahpur, and other villages.

Relief
Moulvibazar Jana Milon Kendra was made a flood shelter on 8 June. On that day each family of Baliakandi and Dheupasha villages who took shelter were given 1 kg of *chira*, 50 grams of molasses, 1 box of matches, 1 candle, and 1 packet of cigarettes. Relief was organised by the government agencies, the BNP, and the Chhatra Dal who raised money from their own funds and through subscription from the people. In the villages of Baliakandi and Dheupasha, relief goods were distributed by the members of Chhatra Dal on 9 June. Each family was given 1 kg of *chira*, 250 grams of molasses, 1 box of matches and 1 candle. Relief goods were distributed in Monsurnagar union by the Union Parishad.

Many flood-affected people did not receive any relief material. Many of them could not reach the place from which relief goods were distributed. Those who distributed relief goods could not reach the houses of all flood-affected people.

Earlier in May, 10 tons of wheat was sanctioned for the flood-affected people of Kamarchar union. The allotment of wheat was brought to Rajnagar thana but it was not distributed at that time. It was stored in the warehouse of the *thana*. During the June flood the TNO milled 5 tons of the wheat and distributed it among the people; 3 tons in Kamarchar union, 1 ton in Tengra union, and 1 ton in Monsurnagar union.

The relief goods were not distributed uniformly. All unions of Rajnagar *thana* were affected by the flood. Hence relief goods which were available for the thana had to be distributed in the entire thana and so there was less for each. But in Moulvibazar sadar thana all unions were not flooded, so the people of these unions received more relief goods than the flood-affected people of Rajnagar thana.

In Panchgaon union, relief goods were allocated to UP members for distribution in respective Wards. There were many complaints about the distribution of relief materials. The people who had taken shelter in the Panchgaon high school said that they received 1.5 kg of rice each although the UP chairman said that each family was given 2 kg of rice.

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A second allotment of 5 tons of wheat reached the union office on 23 June. But this wheat could not be distributed until 17 June because of problems reaching a decision on how to distribute it. It was argued that since all Wards are not equally affected the allotment of wheat should vary according to the degree of damage, but some UP members demanded that it should be allocated equally. The conflict could not be resolved. Ultimately, wheat was allocated to all Wards in equal quantity on 28 June.

In Munshibazar union each affected family was given Tk 50 along with rice.

Return to home after recession of water
People of Rokta village started coming back home from flood shelters and relatives' houses after 20 June, and the process of self-rehabilitation began. Some people repaired earth-fill on homestead platforms which were eroded by flood water. Some had to repair and rebuild houses. Dheupasha village was still under water on 23 June.

Flood damage included:

1. Loss of pond fishery,
2. Damage of aus crop,
3. Damage of t.aman seed-bed,
4. Damage of houses due to wave action,
5. Erosion of homestead platforms,
6. Loss of fruit trees.

Baliakandi: 70-80 houses were damaged. Five percent of the cattle died. About 70% of the poultry were lost. The village was flooded all on a sudden at night when the dike breached. The people could not move many belongings. They had stored fuel for the whole monsoon period; now most of the stock of fuel have been lost.

Rice varieties saved: In Panchgaon village some rice varieties partially withstood the flood despite being submerged under water for several days. These varieties (China aus, BR-12, BR-20, and IR-50) are reported to be more flood-tolerant than others. However, the damage to seed-beds of t.aman was extensive; only 10% survived. The supply of seed for preparation of new seedbeds was not enough from the local sources. Farmers were buying rice at 10 taka per kg to use as seed.

Aus harvest: The harvesting of aus which survived the flood did not involve any cost. People volunteered to do the harvest in exchange for straw as severe scarcity of fodder is anticipated.

Communication: Villagers of Panchgaon, Bhumiura, and adjacent villages remained stranded for a couple of days. Rafts aere made of banana trees for transportation. The price of banana trees rose to tk 50.

Damage to houses: An estimated 2,500 houses were completely damaged and another 4,000 were partially damaged in 10 unions by the June flood. After the July flood, homestead platforms were eroded in many villages by strong wave action. The worst affected villages were Ontehori, Chalbon, Bagherbari, Sunampur, Kadipur, and Fatehpur.

Areas affected:
The intensity of the June flood reportedly surpassed the flood of 1929. The July flood water level was 6 inches higher. The scale of damage was reported as follows:

Table C2: Flooded Area

Union	Percent of Area Flooded	
	Completely	Partially
Panchgaon	95	5
Rajnagar	50	50
Munshibazar	40	60
Tengra	40	60
Uttarbhag	25	75
Fatehpur	100	0
Monsurnagar	95	5
Chandnighat	50	50
Ekatuna	100	0
Akhailkura	100	0

C.6 IRRIGATION

Construction of closures
Traditionally, water is stored for irrigation by making a closure in the Akali Nadi at the mouth of the Machhua Nadi. This closure used to be constructed by Khalil Member of Ghargaon who had a large amount of land. This was known as member Shaheber Bundh. This closure has not been made during the last four years as he sold most of his land. Land-owners of the area now subscribe Tk 20 per ker for the work, and have been doing it for the last two years. They said that a 1 or 2 vent sluice would be enough to irrigate a block of 200 ha of land.

Farmers of Amirpur contributed Tk 10-20 per ker to construct two closures in the Pabijuri Khal and three closures on Oghar Khal. When the canal water reaches Pabijuri it cannot irrigate high land, so the farmers make a closure to raise the water level. However this closure obstructs the supply of water to Machhua Nadi and to another closure in Dhalidhara Nadi. This problem has been created by late release of water through the canal. Farmers feel that sluices are needed where the closures have been made, and that timely release of water has to be ensured.

Irrigation is also done by constructing 2 closures on Poukkar Khal. However, the closure was washed away and this permitted canal water to flow to Kusra Beel. Farmers requested sluices to replace the sluices.

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People propose that sluice gates should be constructed to replace closures at the following locations:

Location	No. of sites
Pabijuri nadi	2
Oghar khal	3
Machhu nadi	3
Dhalidhara	2
Gulaidhara	2
Digla	1
Akali nadi	3
Poukkar khal	2

Water supply not in time
It was reported that sometimes water is not available from the project canals when it is needed. It has been observed that maintenance repairing is done in the canal when water is needed. On the other hand water is abundant when it is not needed.

The 1993 plantation was late due to late release of water. Consequently, in the first week of May 1993 the crop was still in the field and was submerged under water. The problem could have been avoided if the crops had been planted in time.

Irrigation systems: post-project
Chhara water: There are 21 *chhara* (small streams) coming from Bhatara hills. Among these, 8 have water only in the monsoon and the rest carry water throughout the year. These are:

Akali nadi
Binajuri chhara
Udna chhara
Kuchimura chhara
Khoiyajani chhara
Puranali chhara
Pagla chhara
Goali chhara
Aar chhara
Jamria chhara
Dhamai chhara
Jhalamura chhara
Marua chhara

The land in Kawadighi Haor is irrigated from these chhara. Irrigated crops are *katari*, *b.aus*, *t.aman*, and vegetables. It is reported that 60-70% of the land in Chhoto Kawadighi Haor is irrigated by chhara water.

Canals
The irrigation capacity of the project is 12,000 ha. Presently 18-20% of the area is irrigated. Low-lying areas are irrigated mainly by canal water. Among the benefitted areas are Sonateki, Medinimahal, Bagbari and Fatehpur.

Why farmers do not use canal water to grow boro in high land areas

(a) Most of the lands are sharecropped out;
(b) Land-owners do not allow tenants to grow boro in high land;
(c) Most of the land-owners live outside the country;
(d) Ploughing is difficult and the draft animals are weak;
(e) Seeds are not available in time;
(f) Water is not available in time in the canal;
(g) In some areas, there are borrow-pits between the canal and the crop land, and water cannot be taken to the cropland.

Boro cultivation and irrigation in Tengra union
Tengra union has been made "flood free" by the embankment, but no canal for irrigation has been made. The Chairman of the union says that there is no need for a canal. The water of the chhara coming from the hills is enough to grow rice in all seasons.

The Akali gang plays an important role. In 1993 eight closures were made in this chhara to irrigate about 400-500 acres of land. These closures have been constructed by collecting *chanda* from the beneficiaries. Three closures were made on the Mitha Chhara. The cost of each closure was about Tk 3,000. These together irrigate about 200 acres of land. There are several closures on other chhara which irrigate about 400-500 acres of land. Crops are mostly HYVs. They say that there is no need for irrigation canal by which valuable land is lost.

At the site of each closure, guards have been posted to save the closure. The location of the closure is not acceptable to many people and some of them often try to cut the closure. The beneficiary farmers guard the closure by themselves or through hired persons.

Closures of Dhamai Chhara and Kalamua Chhara were late to be constructed in 1993 due to disagreement regarding the location. In 1992, there were three closures on Dhamai Chhara and five closures on Kalamua Chhara. The cost of constructing closures is high which the people sometimes cannot afford (the cost of three closures on Dhamai Chhara last year was tk 15,000).

Closures were constructed on Puranoli Chhara and Kuchimura Chhara in December to prepare land for transplanting boro.

The gates of the barrage were closed on 28 December 1993. Water reached Keola, Dhulijura, and Medinimahal on 2 January, Sonateki on 3 January, and Ontehori on 14 January. Farmers of Ontehori were late in transplantation.

Irrigation vs bamboo business
On 2 January '94, a bamboo trader requested the BWDB authority to raise the gates of the barrage so that the required draft would be maintained in the Manu river and bamboo could be transported downstream. Forty-eight labourers carried bamboo manually and put them on the river at the site of the barrage. Two hundred thousand pieces of bamboo were transported and the bamboo lessee was thus saved an amount of tk 120,000-140,000 in wages. As a result, farmers were deprived of irrigation water as the gates of the barrage were closed, and boro transplantation was delayed. The farmers of Ontehori, Mirpur, and Palpur were still waiting for water to come through the canal on 4 January.

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C.7 DRAINAGE

Problems created by canal

The canal between Rajnagar union and Munshibazar union does not have enough saiphal. This obstructs the runoff from Bhatara Hills and causes flooding in about 30 villages on the eastern side of the Asia Road and another 20-25 villages on the western side. This had never occurred before the commissioning of the canal. Now the people cut the dike of the Rajnagar main canal and its branch canals in many areas to use these cnals to drain water from their lands.

Drainage in Kawadighi haor

Almost all beels in Kawadighi Haor retain water from November to January. At the request of the fisheries lease-holders the staff do not operate the drainage pumps in order to retain water. This delays plantation of boro and causes delay in harvest; consequently the crop becomes vulnerable to pre-monsoon season rainfall. The low-lying areas were once connected by many natural creeks which used to drain out water; now most of these have been closed.

Nolu Gang and Kalibarir Khal

Most of the water coming through the *chhara* in Uttarbhag and Munshibazar unions used to flow to the Kushiyara River through Nalu Gang and Kalibarir Khal. Now these natural drainage passages have been closed.

Pukuria Khal and Munia Gang

Part of the water coming through different *chhara* from the Bhatara Hills and the water coming from Panchgaon, Rajnagar, and Munshibazar unions used to flow through Pukuria Khal and Munia Gang. These have been closed completely.

Machhuakhalir Khal and Tolas Gang

Most of the water from Ekatuna and Akhailkura unions used to pass through these two channels. These are now dead.

Water-logging in Korayer haor

Since the commencement of the project about 4,000 acres of land in Korayer haor are suffering from drainage congestion. These areas were earlier cultivated during the boro season but now it remains fallow. In the aman season, shail rice is grown on 80% of the land and the remaining 20% remains fallow.

Water-logging in Kawadighi haor

In different beels in Chhoto Kawadighi Haor and areas to the west of Asia Road, boro crop is irrigated by *chhara* water from the Bhatara hills. From 17-22 February 1993, early rain and consequent overflow in the *chhara* submerged boro crops in some parts of Kawadighi Haor. Crop was inundated in the following areas:

Table C3: Inundated Crop Areas

Name of Beel	Area Inundated (ha)
Bara beel	12
Burburi beel	20
Pukuria beel	8
Bolotta beel	2
Singua beel	20
Chatol beel	4
Burijuri beel	6
Total	72

These beels are suffering from drainage congestion in recent years due to siltation of the creeks, construction of roads, construction of canals, and earth-filling of creeks by the farmers for expanding farm area.

This year about 55 ha of land in Pukuria beel could not be cultivated for boro due to water-logging. There is a drainage channel called Noakhara Khal between Pukuria Beel and Burijuri River. It is 10 feet wide and 5 feet deep and is not wide enough or and deep enough to drain out the water from Pukuria Beel. There was also another channel between Burijuri and Munia Gang which has been almost silted up.

Effect of canal water
In the early morning of 1 January 1993, water was released in canal RL4 near Panchgaon. Water flowed for the whole day and caused flooding of six inches to one foot in some land adjacent to the canal. Farmers were concerned and some of them constructed barriers in different places along the Rajnagar-Munshibazar road to prevent the water from entering their land.

Pump house
After heavy rain fell on 2 May 1993 about 50% of the area under HYV boro in Kashempur, Islampur, Abdullahpur, Jahidpur, Shahpur, and other villages was inundated. Farmers blame non-functioning of the pump house for this damage. They say that if the project cannot protect their crop then why it is there? They say that they have made a mistake by depending on the project. Otherwise they would have transplanted their crop earlier so that it could be harvested earlier before the start of the monsoon. They also say that whenever there is a bad weather the water level rises in the haor and inundates crop. In this situation the pump house always has power failure. Even if there is power all pumps are not put in operation. Uninterrupted power supply should be ensured.

The repair work in the pump house begins at the start of the monsoon. For this reason, pumps are not operational when they are needed. They are not repaired when they are idle during the dry season.

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Sluice out of order
The 3-vent sluice to the north of the pump house has been out of order since its installation. Leakage through the sluice is equal to the capacity of one pump. Despite repeated complaints no action has been taken to repair the sluice.

Canal proposed for drainage
To solve the existing problem of water-logging in zone 1 the people have proposed to make a drainage channel by extending Kuchimura Chhara from Charua Beel to Singua Beel and then to Munia Beel. Another canal is proposed from Singua Beel to Nagri Khal via Burburi Beel, Chalbon village, Kusra Beel, and canal RL6R1. Kordair Khal is also proposed to be re-excavated.

Breaching of canal dikes
People have cut the dikes of the irrigation canals in several places to drain trheir land. Sometimes the dike erodes due to the excess monsoon flow. Some cases of the breaching are as follows:

1. Due to water congestion in boro land between Rajnagar and Konnigram one farmer of Rajnagar cut the dike at one side of the Rajnagar canal to drain water to the canal and to save the crop on five *ker* of land.

2. Water of Udna Chhara is not drained out properly through the syphon of the canal. The crop is inundated a by few days' rainfall. Homesteads are also submerged in Nandiura village, so the people cut the dike of the canal. The dike on both sides of the canal for a length of 150 to 300 meters is eroded by the increased flow, which allows water to overflow to Udna Chhara. People feel that the problem could be solved if the syphon at Udna Chhara is made bigger and the chhara is cleared of weeds.

3. Although there is a syphon in Baligaon, water level rose up to 2 feet above the homestead level during the rainfall of 2-4 May 1993. The people cut the dike of the canal to drain the water.

4. Kuchimura Chhara passes to Singua Beel through a syphon under canal RL7R1. During incessant rain of 2-4 May, 1993, the creek flow could not pass through the syphon and it spilled into the canal and eroded its dike. Despite this about 40% of land which was planted to HYV boro was flooded. About 60% of the crop was yet to be harvested.

5. Araiyar Khal passes to the south of Ontehori and drains Machhuakhali Beel and Chatal Beel. The Manumukh main canal crosses Araiyar Khal in two syphons. Farmers say that these are not large enough to drain the water of Araiyar Khal. Due to inadequate drainage about 50% of the nearby crop was submerged during the rainfall of early May 1993.

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C.8 EMBANKMENT

The people between the dike and the embankment
During planning of the Manu Irrigation Project many people living along the right bank of the Manu refused to accept the project embankment alignment which had been proposed on the basis of a standard setback distance of 120 m (400 ft) from the river. If the proposed alignment had been adopted in this densely populated area many residents would have had to be re-located and, as they were not threatened by flooding at the time, they refused to re-locate. Consequently, the alignment was altered, leaving many residences outside the project embankment.

It is estimated by BWDB sources that 28,000 people were living between the Manu River dike and the project embankment in 1991. This includes parts of Tengra, Chandnighat, Ekatuna, and Akhailkura unions. The protective dikes were built by the Union Parishad, except the part form Roysree to Balirbhag which was built by the BWDB. During the flood of 1986 the then Minister for flood control visited the area and instructed the BWDB to construct a dike along the river. After construction of one mile of dike from Gujrai to Islampur the work was abandoned.

Flood water carries sand which is deposited on the land and affects it adversely. During the flood of 1991 some ponds in Chandnighat were completely filled up with sand.

Villagers living inside the embankment guard it in anticipation that the people living outside the embankment may cut it.

The price of land is much higher inside the embankment than outside (Tk 80,000-90,000 per *ker* compared with Tk 20,000-30,000 per *ker*).

Two crops, aus and shail, are grown. The yield was 12-15 maunds per ker before the project, and now it has decreased to 8-9 maunds per ker.

In 1991 the people marched in procession in Maulvibazar town demanding protection against floods, while the people living inside the MRIP area took to the streets demanding protection of the embankment.

Embankment cuts
During the flood of 1991 the people outside the project cut the embankment at the following locations:

Bhangarhat
Kaliakandi
Dheupasha
Ujirpur
Terapasha
Bakherhat
Kamihata

People living within the project area also cut the Kushiyara embankment at Machhuakhali to drain out the accumulated water.

The water level was 0.3-0.5 m high in the homesteads.

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Public cut of the embankment on the Kushiyara side
There are four types of public cuts:

a) Cutting the dike on the right bank of the Manu River to try to lower the river levels (this dike is also breached at several locations);

b) Cutting the project embankment on the right side of the Manu when there is flood in the villages along the river;

c) After cutting the dike and the embankment the water levels rise in the haor. Then people from within the haor cut the embankment at Machhuakhali to let water drain into the Kushiyara. The water level in the Kushiyara is always lower than in the Manu.

d) People between the dike and the embankment sometimes cut the dike in Palpur area to let water drain to the Manu River. Otherwise water is trapped in the area between the dike and the embankment.

Why the people do not cut the embankment in the Kushiyara while there is flood in Kushiyara?
The people have the opinion that the Kushiyara embankment has less effect on river levels tan the Manu embankment does, because:

a) there is embankment on only one side of the Kushiyara;
b) the Kushiyara River is wider than the Manu;
c) the Manu dikes are very close to the river, and so the floodway is very narrow.

Perceived Merits of embankment
Some people expressed the following opinions:

(a) Boro and b. Aman have been saved from floods;
(b) The cropped area has increased as the people now feel safe against floods;
(c) Double-cropped area has increased (aus followed by shail);
(d) Land where only b. Aman was grown is now planted in boro in some places such as Ontehori due to supply of water from the canal;
(e) Cultivation of the HYV's has increased. HYV's which were virtually non-existent before the project now account for about 40% of the total crop. The yield is 15-25 md per ker compared with 6-10 md/ker for b. Aman and *Khoiyabor*;
(f) Transportion has increased by virtue of the embankment acting as a roadway;
(g) The borrow-pits are being used for fish culture;
(h) More grazing is now available for cattle during the monsoon;
(i) The people can take shelter on the embankment during the time of flood;
(j) The embankments save homesteads from wave action during the monsoon;
(k) The people are planting trees, although in small numbers, along the embankment and are getting fruit and fuel wood from them.

Advantages of cutting the embankment
Some people have the opinion that cutting the embankments has advantages:

(a) It allows the inflow of silt which increases fertility of land;
(b) It increases fish production;
(c) The flowing water clears water hyacinth and other grasses through the Machhuakhali cut and saves labour expenses for land preparation;
(d) Moulvibazar town is saved from flooding;
(e) Flood damage is reduced between the river and the embankment;
(f) The quality of the water in the haor is improved;
(g) Some contractors and BWDB personnel are benefitted through contracts for repair and maintenance work.

Cuting of embankment in 1993
The water level in the Manu rose rapidly on 7 June. About 0.25 km of dike upstream of Kadamhata Bazar went under water. All houses in Malikona, Shashmahal, Premnagar, Govindashree, Bakshikona, Tagarpur, Konagaon, Akua, Adnabaz, and Bhangarhat were inundated. Almost all the villages in Monsurnagar union were flooded. By evening there were breeches in the dike at 10 or 12 sites from Kadamhata to Horipasha. During the night the people cut the embankment at two sites near Malikona. These two breaches eroded rapidly to become50 meters and 100 meters wide.

At the same time the people cut the dike near Baliakandi to save Moulvibazar town from flooding. By the morning of 8 June people cut the project embankment at Dheopasha. During the day the people cut the embankment in Sompashi, Noarai, Akhailkura, and Mirpur. On the same day the dike was cut at two sites in Palpur to drain out water to the river.

At the time of cutting the embankment at Akhailkura the villagers of Uluura, inside the embankment, came out to resist. After seeing the grave situation of the villages between the embankment and the Manu dike they went back without any resistance.

Despite cuts on 8 June the water level did not fall significantly. On 9 June the people cut the embankment at another place in Dheopasha near the cut of the previous day. This cut was about 30 or 40 meters wide and helped to drain out water between the dike and the embankment. Most of the houses were above water by the afternoon.

Due to the cut in the Baliakandi dike, the following villages between the dike and the embankment were flooded:

Chandnighat union:
- Baliarbagh
- Baliakandi
- Dheupasha
- Monrujpur
- Sompashi

Akhailkura union:
- Kamargaon
- Noarai
- Shahbazpur
- Akhailkura
- Dhonpur

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Khargaon
Mobarakpur
Paguria
Mirpur
Palipur
Amua
Shewaijuri
Chandpur

At 11 A.M. on 12 June the water level in the haor had risen until it was almost the same as in the Kushiayara River. At 12:00 clock the BWDB staff opened the 6-vent and the 3-vent sluices at Kashempur, but the water level continued to rise. People assembled to cut the embankment at the location in Machhuakhali where it had been cut in 1991 but the BWDB staff requested them to cut it at a new location where the soil is hard and where there are trees so that there would be no erosion due to the cut. The people complied. The water level in the haor continued to rise and houses were going under water in the villages. So, despite the request of the BWDB staff, the villagers then cut the embankment at the older location. Then the water level in the haor stopped increasing.

At 4:00 in the morning on 13 June the people living between the dike and the embankment cut the embankment at Bhangarhat. BWDB staff and administration filled the cut with sand bags immediately.

In June the embankment was cut in 11 places. Ten of these cuts expanded in July by about 25%. Along a 10 km stretch of the embankment about 90% of the earth was eroded. Many distressed families from low-lying villages of Ontehori, Sunampur, and Islampur who had taken shelter on the embankment had to shift to safer places.

C.9 SOCIOANTHROPOLOGY STATISTICS TABLES

Table C4: Estimated Project Area Population in 1991

Thana	Union	Total population	Fraction within project area[1]	Project population (estimated)
Rajnagar	Rajnagar	20,010	1.00	20,010
	Tengra	22,430	0.50	11,215
	Monsurnagar	20,205	0.90	18,185
	Uttarbhag	27,486	0.70	19,240
	Panchgaon	18,847	1.00	18,847
	Munshibazar	24,835	0.60	14,901
	Fatehpur	21,295	0.50	10,648
	Sub-total	155,108	0.73	113,046
Moulvibazar	Ekatuna	14,895	1.00	14,895
	Akhailkura	16,182	0.10	1,618
	Chandnighat	23,774	0.15	3,566
	Sub-total	54,851	0.37	20,079
Total		209,959	0.63	133,125

Source: BBS

[1] *Fractions within the project area are estimated from empirical observation.*

Table C5: Population by age Group and Sex

Age (year)	Panchgaon						Jahidpur					
	Male	%	Female	%	Total	%	Male	%	Female	%	Total	%
0-4	23	14.02	20	13.70	43	13.87	17	12.50	15	12.29	32	12.40
5-9	17	10.36	21	14.38	38	12.25	14	10.29	13	10.66	27	10.47
10-14	16	9.76	18	12.33	34	10.97	17	12.50	25	20.49	42	16.28
15-19	16	9.76	15	10.27	31	10.00	15	11.03	11	9.02	26	10.08
20-24	19	11.59	12	8.22	31	10.00	11	8.09	08	6.56	19	7.36
25-29	17	10.36	17	11.64	34	10.97	07	5.15	09	7.38	16	6.20
30-34	11	6.71	04	2.74	15	4.84	07	5.15	03	2.46	10	3.88
3-39	13	7.93	04	2.74	17	5.48	12	8.82	15	12.29	27	10.47
40-44	05	3.05	06	4.11	11	3.55	06	4.41	07	5.73	13	5.04
45-49	07	4.27	08	5.48	15	4.84	10	7.35	03	2.46	13	5.04
50-54	02	1.22	08	5.48	10	3.23	04	2.94	05	4.10	09	3.49
55-59	01	0.61	01	0.68	02	0.65	03	2.20	02	1.64	05	1.94
60 +	17	10.36	12	8.22	29	9.35	13	9.56	06	4.92	19	7.36
Total	164	100	146	100	310	100	136	100	122	100	258	100

Source: Sample household survey, NERP

Table C6: Literacy Level

Level of schooling	Panchgaon						Jahidpur					
	Male	%	Female	%	Total	%	Male	%	Female	%	Total	%
Illiterate	49	29.88	67	45.89	116	37.42	39	28.68	47	38.52	86	33.33
Primary	72	43.90	56	38.36	128	41.29	69	50.73	63	51.64	132	51.16
Secondary	25	15.24	18	12.33	43	13.87	21	15.44	09	7.38	30	11.63
S.S.C +	18	10.98	05	3.42	23	7.42	07	5.15	03	2.46	10	3.88
Total	164	100	146	100	310	100	136	100	122	100	258	100

Source: Sample household survey, NERP
Note: children are included.

Table C7: Marital Status

Marital status	Panchgaon						Jahidpur					
	Male	%	Female	%	Total	%	Male	%	Female	%	Total	%
Never married	105	64.02	74	50.68	179	57.74	82	60.29	64	52.46	146	56.59
Married	56	34.15	55	37.67	111	35.81	50	36.77	49	40.16	99	38.37
Widowed	03	1.83	16	10.96	19	6.13	04	2.94	08	6.56	12	4.65
Divorced			01	0.69	01	0.32			01	0.82	01	0.39
Total	164	100	146	100	310	100	136	100	122	100	258	100

Source: Sample household survey, NERP
Note: children are included.

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Table C8: Occupational Distribution of Population

Occupation	Panchgaon						Jahidpur					
	Male	%	Female	%	Total	%	Male	%	Female	%	Total	%
Agriculture	59	35.98	-	-	59	19.03	66	48.53	-	-	66	25.58
Housework	-	-	77	52.74	77	24.84	-	-	69	56.56	69	26.74
Service	13	7.93	04	2.74	17	5.48	10	7.35	-	-	10	3.88
Wage labour	10	6.10	-	-	10	3.23	07	5.15	-	-	07	2.71
Student	41	25.00	35	23.97	76	24.52	28	20.59	35	28.69	63	24.42
Trading	08	4.88	-	-	08	2.58	02	1.47	-	-	02	0.77
Children	23	14.02	20	13.70	43	13.87	17	12.50	15	12.30	32	12.40
Unemployed	02	1.22	06	4.11	08	2.58	05	3.68	03	2.46	08	3.10
Inactive	03	1.83	04	2.74	07	2.26	01	0.74	-	-	01	0.39
Goldsmith	01	0.61	-	-	01	0.32	-	-	-	-	-	-
Carpenter	01	0.61	-	-	01	0.32	-	-	-	-	-	-
Ricksha-puller	03	1.83	-	-	03	0.97	-	-	-	-	-	-
Total	164	100	146	100	310	100	136	100	122	100	258	100

Source: Sample household survey, NERP
Note: children are included.

Table C9: Month-wise Wage Rate in Agriculture

Month	Work available for number of days	Type of work	Daily wage	Monthly wage
Baishakh	30	Boro harvesting, threshing, transportation of rice and straw	12.5-15 kg rice plus 3 meals	10-12 md rice plus 3 meals
Joishtha	30	Ploughing for katari rice, seed-bed preparation for aus, land preparation for aus, house repair	Tk 40-50 plus 1 meal	Tk 700-800 plus 3 meals
Ashar	20	Aus plantation, seed-bed preparation for shail crop	Tk 35-40 plus one meal	Tk 700-800 plus 3 meals
Sravan	30	Seed-bed preparation for shail crop, weeding in aus land, harvesting of aus	Tk 40-50 plus one meal	Tk 800-900 plus 3 meals
Bhadra	30	Harvesting of aus, drying of aus seed and straw, plantation of shail	Tk 50-55 plus one meal	Tk 800-900 plus 3 meals
Ashwin	12-15	Weeding and fertilizer application in shail land	Tk 30-35 plus one meal	Tk 600-700 plus 3 meals
Kartik	15-20	Preparation for winter vegetables cultivation, preparation for nurseries, house cleaning, seed-bed preparation for boro	Tk 30-35 plus one meal	Tk 600-700 plus 3 meals
Agrahayon	30	Harvesting and threshing of aman, seed-bed and land preparation for boro	Tk 50-55 plus three meals	Tk 1,000-1,500 plus 3 meals
Poush	30	Boro plantation, collection of straw from the field	Tk 30-40 plus one meal	Tk 700-800 plus 3 meals
Magh	30	Plantation of boro	Tk 30-40 plus one meal	Tk 700-800 plus 3 meals
Falgun	15	Land preparation for katari, house repair and cleaning	Tk 30-35 plus one meal	Tk 600-700 plus 3 meals
Choitra	20	Land preparation and sowing for katari rice, house repair	Tk 40-50 plus one meal	Tk 600-700 plus 3 meals

Source: Field observation

Table C10; Wage Rate for Seasonal Farm Labourers in 1993

Village	Cash wage of a male labourer for one season (tk)					
	For 6 months		For 8 months		For 12 months	
	More skilled	Less skilled	More skilled	Less skilled	More skilled	Less skilled
Ontehori	4,000	3,000	5,000	3,500	7,000	4,500
Rokta	4,000	3,000	5,000	3,500	7,000	4,500
Sonateki	4,000	3,000	5,000	3,500	7,000	4,500
Dheupasha	5,000	3,500	6,000	4,000	8,500	5,000
Barkapon	5,000	3,500	6,000	4,000	8,500	5,000

Source: Field observation

Table C11: Number of beparies involved in harvesting of Boro Rice in Selected Villages, 1993

Village	Number of bepari			
	From outside	Local	Total	% immigrant
Jahidpur	250	90	340	74
Shahpur	250	110	360	69
Charkarpar	90	55	145	62
Abdullahpur	90	45	135	67
Kashempur	200	90	290	69
Total	880	390	1,270	69

Source: Field observation

Table C12: Vegetable Cultivation in Selected Villages, October 1993

Village	Households growing vegetables (%)	
	Homestead	Bisra
Barkapon	2	70
Sonateki	10	4
Dheupasha	5	10
Rokta	12	30
Ontehori	8	2

Source: Field observation

Table C13: Farm Wage Rate, October 1993

Village	Daily cash wage for male labourers (taka)			
	More skilled		Less skilled	
	With food	Without food	With food	Without food
Ontehori	30-35	50-55	25-30	45-50
Rokta	30-35	50-55	25-30	45-50
Sonateki	30-35	50-55	25-30	45-50
Dheupasha	40-45	60	40	50-55
Barkapon	40-45	60	40	50-55

Source: Field observation

Table C14: Wage Rate in November-December 1993

Village	Monthly cash wage (tk)	Daily cash wage (tk)	
	With food	With food	Without food
Ontehori	600-800	30-35	40
Rokta	700-800	35	55
Sonateki	700-800	35-40	55
Dheupasha	1,000-1,200	40-45	55
Barkapon	1,000-1,200	40-45	55-60
Zahidpur	700-800	35	50-55
Panchgaon	700-800	35-40	55-60
Mirpur	700-800	35-40	55-60
Akhailkura	700-800	35-40	55-60

Source: Field observation

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Table C15: Distribution of Migrant Labourers, December 1993 (aman harvest)

Union	Village	No. of migrant labourers from greater districts			
		Mymensingh	Comilla	Noakhali	Sylhet
Monsurnagar	Lamua	8	6	7	2
	Bhanumol	6	3	2	2
	Aoi	3	7	2	0
	Muraura	3	6	2	0
	Purbosing	2	5	0	5
	Dhaisar	3	2	0	2
	Premnagar	150	40	25	75
	Chikka Modhupur	5	2	0	0
	Parchakro	5	2	2	6
	Chatur	2	2	3	15
Ekatuna	Barkapon	115	50	20	25
	Uluail	100	60	15	15
Chandnighat	Dheupasha	125	45	20	35
	Baliakandi	100	60	40	30
Akhailkura	Palpur	15	5	5	5
	Mirpur	35	15	10	10
	Akhailkura	30	23	7	15
Total		707	333	160	242

Source: Field observation

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Table C16: Statistics on Migrant Labourers, March 1994

Place of work	Number of workers	Origin
Machhuakhali	200	Lakhai thana (Habiganj)
Kalagram-Sonateki road	100	Nasirnagar thana (Brahmanbaria)
Modhurbazar-Balaganj road	12	Saatgaon, Srimangal thana (Moulvibazar)
Kalagram-Sonateki road	14	Chunarughat thana (Habiganj)
Dike repair in Dheupasha	80	Jalsuka, Ajmiriganj thana (Habiganj)
	70	Baniachang thana (Habiganj)
	40	Shaistaganj (Habiganj)
	100	Nikli thana (Kishoreganj)
Ontehori	60	Jalsuka, Ajmiriganj thana (Habiganj)

Source: Field observation

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Table C17: Farm Wage Rate, March '94

Union	Village	Activity	Daily wage (tk)
Fatehpur	Ontehori	Transplantation	25-30 plus 2 meals
		Weeding	25-30 plus 2 meals
		House repair	30-40 plus 2 meals
		Earthwork	25-30 plus 2 meals
		Chopping of wood for fuel	40-50 plus food
Panchgaon	Rokta	House repair	25 plus 1 meal
		Wood chopping	30 plus 2 meals
Munshibazar	Sonateki	Weeding	30
		House repair	25-30 plus 1 meal
		Earthwork	30
		Wood chopping	40-50 plus 1 meal
	Kalagram	Earthwork in the road	50
Akhailkura	Chanpur	Weeding	40
	Sumarai	Earthwork in dike	30
	Palpur	Earthwork	30
	Mirpur	Earthwork	30
Ekatuna	Barkapon	Application of manure	30-40 plus food
		House repair	40 plus 1 meal
		Wood chopping	50 plus food
Chandnighat	Dheupasha	House repair	40-50
		Earthwork	30-40 plus food
		wood chopping	40-50 plus food

Source: Field observation

Table C18: Relief goods officially distributed in Rajnagar thana during 14-27 June 1993

Union	Cash (tk)	Wheat (tonne)	Rice (tonne)	Biscuit (tin)	Shari (no.)	Lungi (no.)
Fatehpur	39,700		20.40	33	30	26
Uttarbhag	28,360		14.20	7	18	18
Munshibazar	25,736		13.00	7	17	17
Panchgaon	35,236		17.50	15	18	18
Rajnagar	22,973		11.85	7	12	12
Tengra	12,890	1	7.75	8	13	13
Kamarchak	39,330	3	20.95	16	21	21
Monsurnagar	47,329	1	19.70	13	21	21

Source: Rajnagar thana TNO's office

APPENDIX D

AGRICULTURE DATA

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APPENDIX D : AGRICULTURE DATA

INDEX

D.1 CULTIVATION PATTERNS AND PRACTICES

Land Use

The area is a part of the Kushiyara River floodplain. The net cultivated area covers 76% of the gross project area. Agriculture is supported by surface water irrigation.

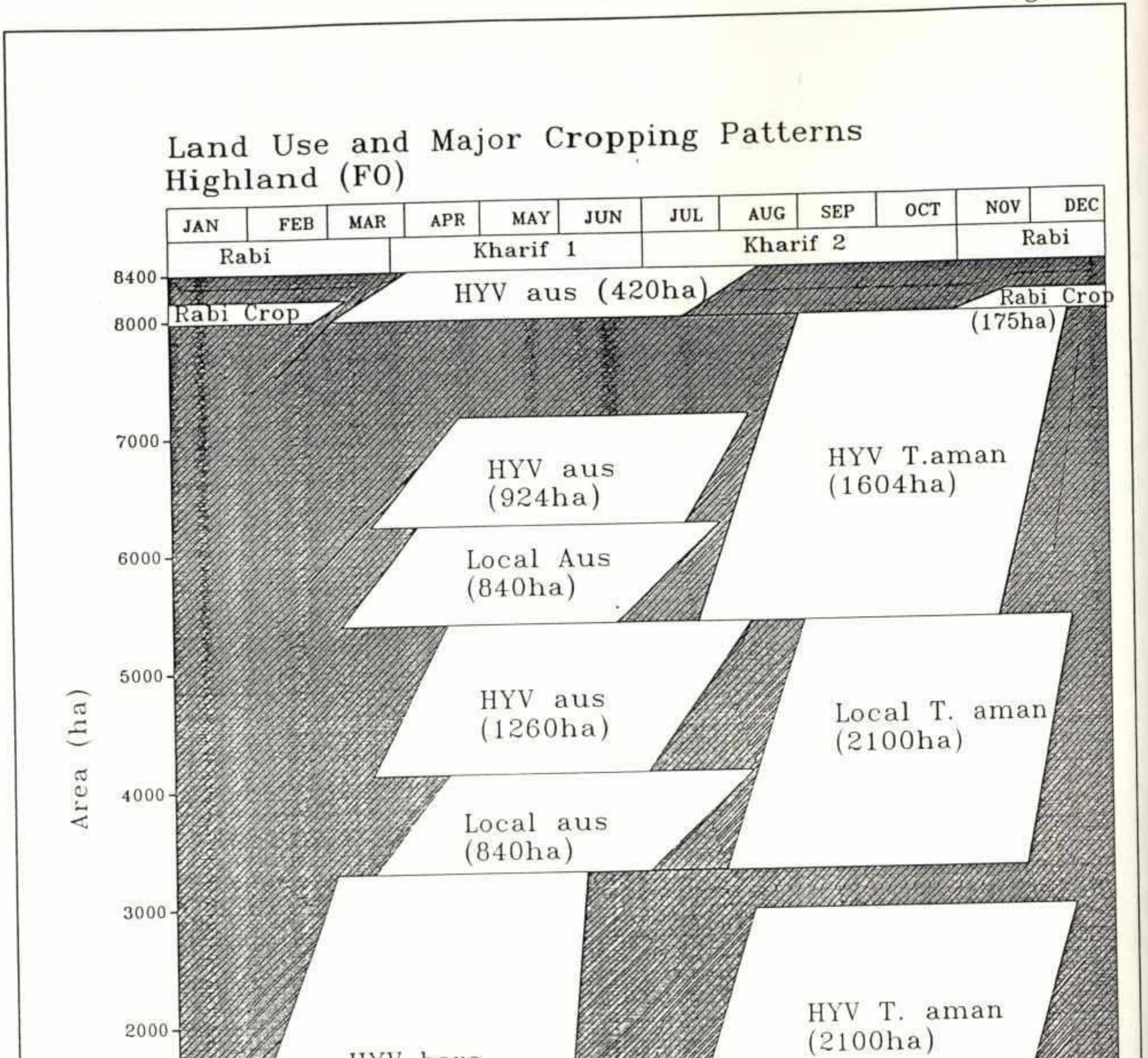
Land type varies from non-flooded to deeply flooded land including beels and haors. Under present conditions about 45% of the cultivated area can be considered to be free from flooding. In this area the cropping intensity is about 187%. About 11% of the cultivated area floods from 30 to 90 cm depth and is therefore subject to moderate cropping constraints during the monsoon season. The cropping intensity is about 175% in this area. More than two-fifths of the cultivated area, which floods to a depth of more than 90 cm, are subject to major constraints to cropping during the monsoon season; almost all of these lands are used for single cropping.

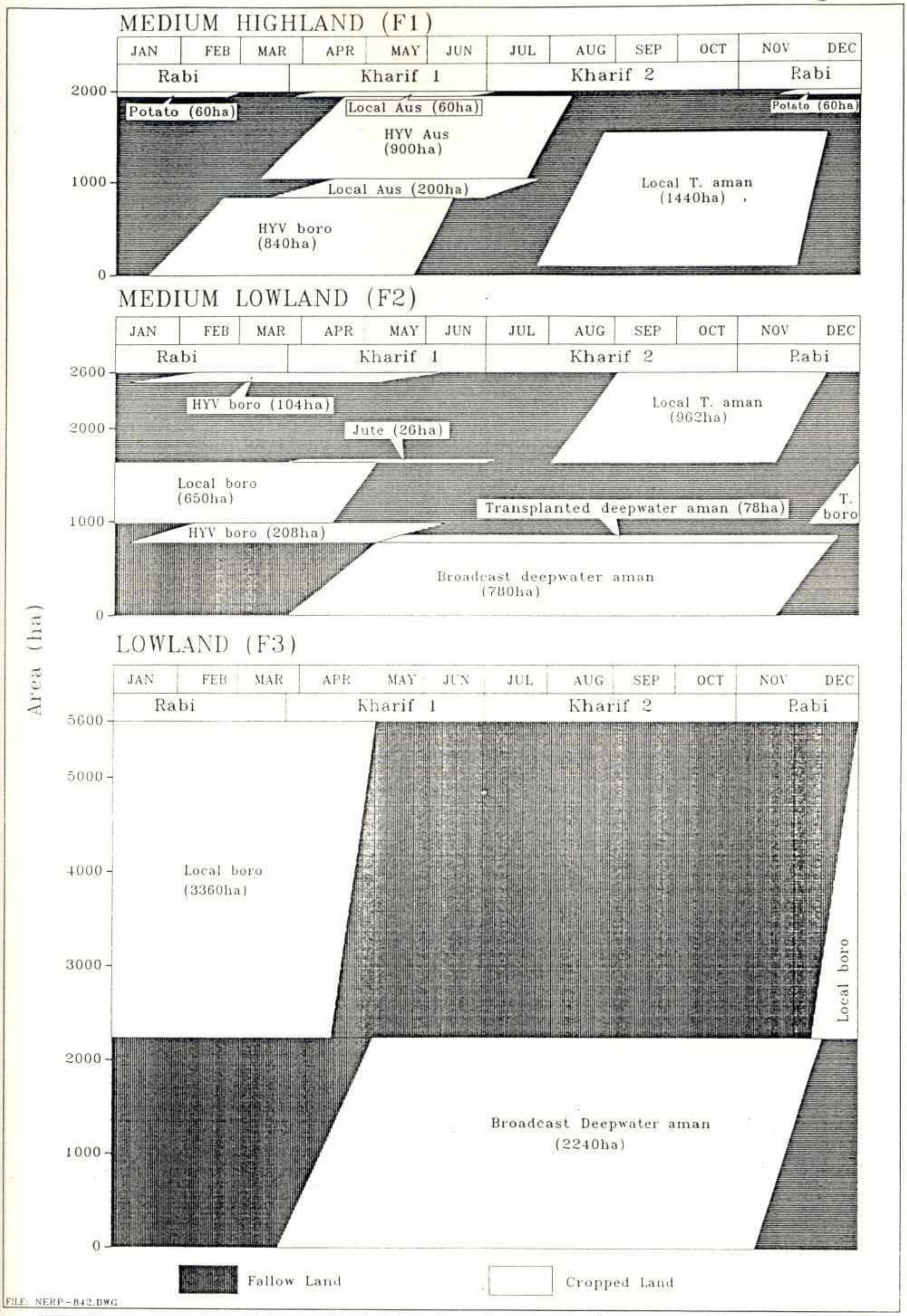
About 59% of the net cultivated area is used for double cropping and the remainder for single cropping. The average cropping intensity is 149%.

Cropping Patterns

The risk of flood and drainage problems influence the type of crop to be grown, the sowing or transplantation time, use of inputs, and the crop yields. A wide range of crops are grown but the major crop is rice which accounts for more than 98% of the total cropped area. Rice varieties include local and modern (high yielding varieties) plus an improved variety called pajam. More than half of the rice cropped area is occupied by local low-yielding rice varieties due to riskiness of farming caused by flooding in the pre-monsoon and monsoon seasons and by late drainage in the post-monsoon season.

2k2


Land Use and Major Cropping Patterns
Highland (FO)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Rabi
Kharif 1
Kharif 2
Rabi
8400
8000
7000
6000
5000
4000
3000
2000
1000
0
Area (ha)
Rabi Crop
HYV aus (420ha)
Rabi Crop
(175ha)
HYV aus
(924ha)
HYV T.aman
(1604ha)
Local Aus
(840ha)
HYV aus
(1260ha)
Local T. aman
(2100ha)
Local aus
(840ha)
HYV boro
(3276ha)
HYV T. aman
(2100ha)
Local T. aman
(840ha)
Fallow Land
Cropped Land
FILE: NERP-841.DWG


MEDIUM HIGHLAND (F1)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Rabi
Kharif 1
Kharif 2
Rabi
2000
1000
0
Potato (60ha)
Local Aus (60ha)
Potato (60ha)
HYV Aus (900ha)
Local Aus (200ha)
Local T. aman (1440ha)
HYV boro (840ha)
MEDIUM LOWLAND (F2)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Rabi
Kharif 1
Kharif 2
Rabi
2600
2000
1000
0
HYV boro (104ha)
Local T. aman (962ha)
Jute (26ha)
Local boro (650ha)
Transplanted deepwater aman (78ha)
T. boro
HYV boro (208ha)
Broadcast deepwater aman (780ha)
Area (ha)
LOWLAND (F3)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Rabi
Kharif 1
Kharif 2
Rabi
5600
5000
4000
3000
2000
1000
0
Local boro (3360ha)
Local boro
Broadcast Deepwater aman (2240ha)
Fallow Land
Cropped Land
FILE: NERP-842.DWG

Transplanted aman is the major crop covering more than 36% of the total cropped area. Boro is the second major crop occupying 31% of the total cropped area. Aus and deepwater aman occupy 20% and 11% of the total cropped area, respectively. The non-rice crops which include mainly oilseeds, vegetables and spices occupy about 2% of the total cropped area.

Details of the cropping pattern are provided in Figure D-1 and D-2. On highlands (F0) areas, there are four principal cropping patterns:

- local broadcast aus or local transplanted aus or HYV transplanted aus, followed by HYV or local transplanted aman;
- HYV or local transplanted aman, followed by HYV boro;
- HYV aus, followed by rabi crops;
- HYV transplanted aman, followed by rabi crops.

On medium highlands (F1), there are four principal cropping patterns:

- local broadcast aus or local transplanted aus or HYV transplanted aus, followed by local or HYV transplanted aman;
- HYV transplanted aus, followed by fallow;
- local transplanted aman, followed by HYV boro;
- In some cases a winter rabi crop is planted after HYV transplanted aus or aman.

On medium lowlands (F2), there are three principal cropping patterns:

- local transplanted aman, followed by HYV boro or fallow;
- HYV or local boro, followed by fallow;
- deepwater aman, followed by fallow or HYV boro.

On lowlands (F3), local boro is the major crop. Deepwater aman is also grown.

Crop Cultivation Practices

Aus rice varieties are photoperiod-insensitive varieties which are sown in the pre-monsoon season and are harvested in the monsoon season. They are grown on both flooded and non-flooded lands. The rice is grown either by broadcast or transplanted. Broadcast aus varieties are local. The transplanted aus varieties, however, are both local and high-yield varieties. Very little or no fertilizer is applied except in HYV fields where moderate doses of fertilizers are used. The aus rice is grown on land where flood depth in the monsoon is less than 90 cm.

Deepwater aman (broadcast aman) varieties are photosensitive traditional varieties. It is either broadcast or transplanted and is harvested after the monsoon season. Deepwater aman varieties have the ability to elongate with gradually rising water levels, after they are about 6 to 8 weeks old. When broadcast, seeding takes place in the pre-monsoon period (March/April). When transplanted, fields are transplanted before the flood depth exceeds the submergence tolerance limit of the seedlings. Relatively aged seedlings are used. Usually no fertilizers are applied in deepwater rice cultivation. The depth of flooding where the crop is grown can range from 90 to 300 cm. Most of the deepwater rice lands area is outside the command area of the irrigation canals.

Table D1: Rice Varieties Cultivated in Manu Project Area

Season	Type	Name of Variety
Aus	Local	Arai, Bauras, Chengri, Dumai, Jambura, Kali Arai, Khasalat, Kotoktara, Lal Aus, Lal Birui, Murali and Saita
	HYV	BR1, BR3, BR9, and BR14
Deepwater Aman	Local	Badal, Bagdar, Bazal, Birpak, Dudhlaki, Gabur, Ghotok, Godalaki, Harinsail, Jhal, Katiabagder, Kotkotia, Laki, Lakshibilash, Parichak, Phulkari and Sirmoin
Transplanted Aman	Local	Balam, Biruin (Afzal, Guti, Hati, Madhumala, Neel), Butubalam, Kalizira, Kartiksail, Latisail, Madhu Birui, Moinasail, Nagrasail, Nizersail, Nazimuddin, Nidhan and Thakurbhog
	HYV	BR3, BR4, BR10, BR11 and Pajam
Boro	Local	Chengi, Gochisail, Gorchi, Khoia, Lakhai, Pashusail, Rata, Tepa and Zagli
	HYV	BR3, BR8, BR9, BR14, Pajam and Gopalveri (exotic)

Transplanted aman (t aman) rice is transplanted during the monsoon season and is harvested during the post-monsoon season. These varieties are photoperiod-sensitive. The t aman is either single-cropped or is grown after aus or before boro. Low to moderate doses of fertilizers are applied. Both local varieties and HYVs are grown on transplanted aman lands. The local varieties also include fine and aromatic rices.

Boro varieties are photoperiod-insensitive local and HYV varieties. They are transplanted during the dry season and are harvested during the pre-monsoon season. Local varieties are grown as a single crop in lowlands which are too deeply flooded during the monsoon season to permit deepwater aman to grow. HYVs are usually followed by transplanted aman on the higher land. In some cases local varieties are transplanted without tillage. Fertilizers are seldom used in the cultivation of local varieties but are very often used for HYVs.

Field visits confirm that HYV boro rice is grown only in areas that are irrigated from the project canals.

Where weed infestation is high in areas grown to local boro, farmers required a substantial number of labourers for weeding to prepare the land for planting. It appears that early drainage and late flooding increases weed problems. The weeds, however, also have a benefit because their biomass provides essential nutrients and organic matter to the soil. Damage of boro seedlings by rats can also be severe.

The transplantation period in the project area was found to be long, from late December to late February, but it is still too short to transplant all of the lands. The farmers first plant the local boro varieties in lowland areas and then they transplant the HYV boro on high lands. They often run out of time before the HYV transplantation is completed. Cultivation of local boro is more attractive to some farmers because it has a short growth period, it requires very little fertilizer, and in some cases it requires less ploughing.

Local boro varieties cannot be planted earlier because they are planted in the lowlands which are the last to be drained. HYV's are not planted earlier because these varieties are require higher temperatures during the critical flowering period. The cold sensitivity of the HYV boro varieties is a greater factor in this region of Bangladesh due to the cooler temperatures of this region in the winter.

Local boro is grown on the periphery of Katasingra Beel which is a fishing area. The land is rented to the farmers (who are also fishermen in many cases) by the lessee of the beel. The cultivators pay one-fourth to one-half of their produce to the lessee but they bear the entire cost of production.

Differences in Quality of Rice Varieties

Several dozen rice varieties are cultivated in the project area. Important considerations include cooking and eating quality.

Long, slender, translucent rice grains are usually favoured in Bangladesh. High volume of expansion during cooking is considered to be a good quality by the common people (they do not care whether the expansion is lengthwise or crosswise). Wealthy people, on the other hand, prefer varieties that expand more in length than in breadth.

The Rice Technology Division of the Bangladesh Rice Research Institute studied the rice quality of two HYVs (BR3 and BR4) and two local varieties (Balam and Nizersail) which are cultivated in the project area. Balam, Nizersail, and BR4 have long, slender grains. According to the study, these varieties expand more in length than girth on cooking. They sell at higher prices and are consumed by high- and intermediate-income people.

The local varieties yield 50% less than HYVs. BR4 is preferred for its good grain quality but its yield is lower than BR3.

BR3 is a coarse variety but is popular with farmers because of its high yield potential. It expands more in girth than in length on cooking and its volume expansion is high. This variety has poor cooking and eating qualities; it cooks fluffy and dry and is not considered very tasty. This variety sells at a lower price and is generally consumed by people on low incomes.

Varieties having high yield potential and good grain quality can contribute to the expansion of the rice area, particularly in boro season.

Fertilizers

Chemical Fertilizers: Interviews with a group of farmers and 10 individual farmers in different areas showed that fertilizer use has increased in HYV rice cultivation. It appeared, however, that the use is poorly balanced and that farmers are applying less than the recommended rates:

D2: Fertilizer Application in the Project Area (Percent of Recommended Rate)

Type of Crop	Nitrogen (N)	Phosphorous (P)	Potassium (K)
Aus	42%	56%	77%
HYV t aman	51%	65%	73%
HYV Boro	53%	62%	59%

Table D3: Fertilizer Use (kg/ha) in Rice Cultivation

Crop	Urea	TSP	MP	Gypsum	Zinc Sulphate
B Aus	0-41	0-8	0	0	0
Local T Aus	25-82	8-17	0-8	0	0
HYV T Aus	33-98	33-66	12-49	0-57	0-8
Deepwater Aman	0-24	0	0	0	0
Local T Aman	33-49	16-49	0-12	0	0
HYV Aman	33-131	33-98	0-49	0-57	0-8
Local Boro	16-49	0	0	0	0
HYV Boro	66-148	41-98	0-66	0-57	0-8

Some farmers use no Potassium (K) in HYV t aman and HYV boro cultivation, particularly in medium lowlands.

Fertilizers are available in the local markets. Prices increase during the rabi season because this is when fertilizers are applied for various crops such as boro rice, wheat, potato and mustard.

Compost Application: Green manure and farmyard manure (mixture of animal excreta and crop residues) are occasionally applied to the fields. Farmers leave about 5 to 40% of rice straw, with a length varying from 15 to 50 cm, as stubble during harvest. The stubble is usually left long. Few farmers know that rice stubble provides nutrients to the fields and increases the number of beneficial bacteria.

Use of Ecological Fertilizer: Only a minor portion of the project area is used for crops which fix the nitrogen in the soil. Farmers are not well informed about the importance of *dhaincha*, sun-hemp, cowpea, blackgram, mungbean, soybean, and other green manuring and leguminous crops in maintaining productivity and fertility of soil. There is no strategy to encourage farmers in the use of technologies that increase productivity while conserving soil.

Single Cropping and Soil Fertility: The cropping patterns in the project area are rice-based. Comparison of pre-and post-project cropping patterns shows that no diversification of crop has taken place in the project area. If one crop is grown for a number of years on the same land the soil is depleted in certain nutrients and hence the crop yield is reduced.

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D.2 HYV BORO PRODUCTION

The area under HYV boro was substantially greater area in 1993-94 than in 1992-93. The local boro area has tended to decrease with the expansion of HYV boro.

Early drainage in the 1992-93 boro season helped farmers to increase their HYV boro area in medium lowland area. There was a substantial increase in HYV boro cultivation using barrage water from MR6, MR7 and RL7 canals.

Major Constraints to HYV Boro Production
About half of the command area of the project irrigation system remains fallow during the boro season. Much of these lands are owned by absentee landowners who are reported to be less interested in growing HYV boro since these require irrigation water and improved cultivation practices. People who lease this land under a sharecrop arrangement have little incentive; they bear the entire cost of inputs while they share the output with the owner, and thus their returns are lower. Dominance of large farmers or absentee landowners, therefore, could be considered as a constraint to expanded HYV rice area in the boro season. Drainage problems, delays in supply of irrigation water, and early flooding are also constraints to HYV boro cultivation.

Different views were expressed by the large and small farmers on the constraints to HYV boro cultivation in the project area. Large farmers reported that:

- returns are not attractive,
- it is difficult to manage all the plots with irrigation water,
- more labour is required and is not available in sufficient quantity,
- more initial investment is required,
- the crop is damaged by grazing livestock,
- damage by insects and birds is high,
- many land owners want to keep their land fallow in the boro season to maintain soil fertility.

Medium and small farmers reported that:

- delays in supply of barrage water and lack of an irrigation system hamper the start of seedlings, transplantation, and the growth of plants,
- large farmers or absentee landowners, who keep their land fallow, free their livestock for grazing.

Extension workers have expressed concern that farmers are less interested in growing HYV boro than local varieties and that the cropped area is increased only when aus and/or aman rice is damaged. According to some farmers the actual HYV boro yields are generally less than they expected and consequently surplus-rice growers lose interest because of low returns. However, according to the DAE and BWDB crop data, there has been a significant increase in HYV boro area since 1991-92.

Case studies which are described below illustrate the problems and potential for increased boro production in the project area.

Sample Case Studies
In 1994, farmers in Khargao village, which is a lowland areas, were found to have cultivated HYV boro instead of local boro. After the flood water had drained, 80- to 90-day old seedlings were transplanted about one month later than usual. These lands are not in the project irrigation area. The deepwater rice growers in this area demand barrage water for their land. There is a strong desire among these farmers to cultivate HYV boro instead of deepwater aman.

In Uttar Mulaim village in Ekatona union, farmers stopped the water supply from the project canal during the 1992-93 boro season. According to the farmers their lands remained water-logged for a long period in the post-monsoon season. Consequently, the soils lost their bearing capacity for draft animals, making tillage difficult in winter. The farmers stopped the barrage water supply in their area in order to make the land ready for tillage in the aus season. In these lands, aus followed by transplanted aman is the major cropping pattern.

The available crop data for Akhailkura union suggest that the cropping intensity in this area reached as high as 212% since the project was constructed. In 1988-89 the HYV boro area was 648 ha. In the following year the area decreased to 293 ha because the irrigation water supply was delayed due to repair of the canals. In 1992-93 the HYV boro area was found to cover about 350 ha.

Yunus Ahmed of Sonateki village has 3.6 ha of lands. In 1992-93 he cultivated deepwater aman on 1.2 ha, local boro on 0.4 ha, and HYV boro on 2.0 ha. All of his boro land is irrigated with water from the project canal. The supply of irrigation water is delayed which creates problems in raising seedlings. He prefers to cultivate BR3 and *gopalveri* on boro lands. The latter (an exotic variety introduced from India in late 1980s) matures 10-15 days earlier than the former.

Farmers in Sonateki village cultivate HYV boro extensively. They were found to be organised in using irrigation water from the project canal. The farmers have constructed many tertiary and field canals for the distribution of water. During a field visit it was observed that some farmers were asking BWDB extension officer for the extension of a RL7 secondary canal to supply sufficient irrigation water to their boro lands. Many farmers were also found to have cultivated potato and winter vegetables using the irrigation water.

D.3 CROP YIELDS

The present level yields were estimated by crop cuts in 1992-93. Three plots of each type were sampled. Large variations in the yields reflects the differences in the level of input use, cultivation practices, and crop management by farmers.

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Table D4: Yield (t/ha)

Crop	Range	Average
Broadcast Aus	1.3 - 1.4	1.4
Local Transplanted Aus	1.9 - 2.6	2.2
HYV Aus	2.5 - 3.9	3.2
Broadcast Deepwater Aman	1.7 - 2.6	2.1
Transplanted Deepwater Aman	1.8 - 3.5	2.7
Local Transplanted Aman	1.2 - 3.1	2.1
HYV Aman	3.5 - 4.7	4.1
Local Boro	1.8 - 2.6	2.2
HYV Boro	3.8 - 4.9	4.9
Jute	1.3 - 1.6	1.5
Potato	9.5 -12.4	11.2
Oilseeds	0.63 - 0.82	0.75

D.4 FLOOD DAMAGE TO RICE

In 1993, the aus and deepwater aman was submerged in early vegetative growth stage by the sudden rise in pre-monsoon flood water level. Almost the entire deepwater aman area, about 80% of the local aus area, and 70% of the HYV aus area was flooded. The damaged field could not be replanted in many areas. Photosensitive deepwater rice was resown in some areas about four months later than the usual broadcast time. About 11% of the HYV boro area was submerged at ripening stage. Late drainage of flood water caused a delay in transplantation of seedlings in about 85% of the local aman area and 70% of the HYV aman area.

The area of local t aman was 20% less than in 1992/93 and the area of HYV aman was 30% less. Due to late transplantation the plants could not get sufficient time for their vegetative growth and had low yield.

The decrease in yield due to flood depends on the growth stage of the crop. In a sample survey in 1993 the following yield reductions relative to the yields in the damage free areas were observed due to flooding:

local aus	59%
HYV aus	47%
deepwater aman	63%
HYV boro	14%
HYV aman	15%
local t aman	16%

From the sample survey data it was estimated that the production of local aus decreased by 47%, HYV aus by 34%, deepwater aman by 60%, and HYV boro by 1% due to pre-monsoon floods. Late transplantation caused production decreases of 7% in local t aman and 6% in HYV aman.

In 1994 it was estimated that about 46% of local boro and 26% of HYV boro cropped area was flooded due to heavy rainfall in the pre-monsoon season. The flooding damaged local boro at ripening stage and HYV boro at reproductive stage.

D.5 IRRIGATION

Irrigated agriculture does not appear to be as popular as it is in other parts of the country and is well below project targets.

Irrigation in the project area is mainly used for starting seedlings, transplantation, and growth of boro rice. Irrigation is also used for early raising of aus seedlings and for initial establishment of aus seedlings in upland conditions. No supplemental irrigation in the transplanted aman fields has been reported. Non-rice crops use an insignificant proportion of irrigation water.

Timely, assured, and regular supply of water are the important factors in HYV boro cultivation. The start date of irrigation is fixed in consultation with farmers and is announced ahead of time. Accordingly, farmers prepare seedbeds, raise seedlings, and start transplantation. However, it has been reported that barrage water supply to boro land is delayed in the interest of the fishermen and lessees. This occurs because the water supply to boro lands increases the volume of water in the fishing areas and causes the fish to migrate, which decreases the catch. Fishing also requires more time and labour when the water volume is greater.

Boro transplantation starts in the project area during the fishing season. Thus, a delay in supply of water to suit the fishermen damages seedlings, hampers transplantation, and frustrates farmers.

D.6 DRAINAGE

During the field visits and discussions with local people, it appeared that the project area has had drainage congestion and water-logging problems since its inception. Heavy rainfall and flood water submerge large areas of land.

The project has a drainage pumping plant and two drainage sluices to drain excess runoff from the project area and to keep the water at the desired level. However, it has been reported by the farmers that the performance of the pumping station is inadequate and that this sometimes damages rice crops. According to the farmers the sluice gate usually remains open during the pre-monsoon season, at the request of fishermen and lessees of the fishing area, in order to allow migration of fish from the Kushiyara into the project area. This causes significant damage to rice in the project area when there is excess rainfall.

Recent increases in rainfall, inadequate carrying capacity of drainage channels, and inadequate drainage networks contribute to the drainage problem in the project area.

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Water Logging: On many occasions some lands remain water-logged for a long period, which makes tillage difficult and delays or eliminates the next rabi crop. According to the farmers the water-logging situation very often reduces the productivity of soil. Continuous leaching from water-logged soils causes loss of plant nutrients and reduces the fertility of soils. Many resultant harmful salts and chemicals may cause increasing salinity and alkalinity. If this situation continuous year after year the productivity of soil can be destroyed.

Crop Damage: Crops are mainly damaged by natural flooding of lower land, and by flooding resulting from public cutting of embankments. The embankment cuts mostly cause damage to aus and aman rice crops. Runoff entering the project area from the Bhatera Hills can damages all types of rice. Available data from BWDB extension unit and DAE from 1985 to 1994 indicate that 70 to 90% of the aus crop areas were submerged, 62 to 70% of the t aman, and 50 to 91% of the deepwater aman.

D.7 OTHER PROBLEMS

Draft Power Shortage

Traditional land preparation in transplanted rice cultivation involves ploughing and puddling which require substantial draft power. Many areas are suffering from a shortage of draft animals for land preparation. Small and marginal farmers and share croppers suffer most from this shortage as tillers are used by the large farmers. Peak shortages are reported in the short period of preparing t aman land. Timely tillage and proper tillage depth are not achieved due to the shortage of draft power. Thus, draft power shortage can be considered as an important constraint to crop production.

Labour Requirement

Labour requirements for the various farm activities vary according to the crop and the season. Seasonal shortages of labour have been reported in the project area. Farmers suggest that HYV boro requires substantially more labour and this discourages boro cultivation.

Agriculture Extension Service

Limited manpower in agricultural units of the project is a major obstacle to the planned increase in crop production. A large team was planned to perform agricultural extension services as part of the project implementation but only a small team has actually been provided. The lack of sufficient extension workers has resulted in poor motivation among the farmers. The planned increase in crop production will not be achieved without a more comprehensive approach.

Agricultural extension activities in the project area are also carried out by the Department of Agricultural Extension (DAE) through Maulvibazar and Rajanagar Thana Agriculture Officers under the supervision of the Deputy Director of Moulvibazar District. However there is little integration between the DAE and agricultural extension unit of the project.

Pests

The following pests infest rice fields. Significant damage, however, has not been reported in the project area during the study period.

- Aus: Stemborer, rice bug, hispa, and thrips.
- T aman: Stemborer, case worm, rice bug, and hispa.

- Boro: Stemborer, thrips, and hispa.
- B aman and T aman fields: rats.

D.8 LAND TENANCY

Farming by owner-operators is mainly limited to small farmers. Some large farmers also manage their farms by themselves while employing labourers on a seasonal or yearly basis. Sharecropping is more common among the large land-owners, particularly among the *Londonee* families.

Several systems of lease are in operation:

(a) Equal share: Land is share-cropped for one or two crops and the product is shared equally between the land-owner and the cultivator. All costs are borne by the cultivator. The crop and straw are shared.

(b) *Tebhaga*: All inputs except labour are provided by the land-owner who gets two-thirds of the harvest. The cultivator gets one-third for his labour. Under this system, the cultivator looks after draft animals. In the *Londonee* areas, particularly in Ekatuna, Akhailkura, and Chandnighat, more than half of the farm area is sharecropped under the *tebhaga* system.

(c) *Chukti bhag or Chukti chash*: This is a system of fixed rent of land in the form of rice to be paid after the harvest. The rent depends on the quality of the land and the variety of the crop to be grown. *Chukti chash* is common in boro land of *Kawadighi haor*. Land-owners prefer this system because it maximizes their returns.

(d) *Rongjoma/bhukti*: This is a system of lease in exchange for cash in advance. The rent is Tk 200-300 per ker for one crop season, depending on the quality of land. Farmers pay the rent to an agent of the land-owner plus a fee of Tk 25 per ker, plus an additional amount of Tk 50-200 per ker as *bokhshish* (tip or bribe) in order to obtain good quality land.

(e) *Ijara*/ mortgage: This takes two forms. In one form the mortgage-holder cultivates the land and takes the crop until the land-owner repays the loan. In the second, the *Ekrar* system, the loan has to be repaid within a specified period. If the land-owner fails to repay the loan within that period the land is forfeited to the mortgage-holder. The rate of *ekrar* is fixed on the basis of the quality of land.

Ijara land is mostly high land. It is usually mortgaged for one year. Many farmers mortgaged out land after the floods of 1988 and 1990.

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D.9 LIVESTOCK

Bathan

A *bathan* is a collection of about two hundred or more cows and buffaloes which are kept in a particular place for grazing for several months. These bathans are mainly in the *kanda* and other grazing lands in Kawadighi Haor. These lands are full of grass from November to April.

Many powerful people claimed ownership of kanda and other grazing lands and sold them to others when the demand for land increased after the construction of embankment. Cattle are no longer brought for grazing from distant areas. About 20 to 25 groups come from adjacent villages.

The charge is Tk 50 per month for each cow and Tk 100 per month for each buffalo. However no money is charged for milch cattle. The cattle of the ex-zaminder/mirasder is kept free of charge and some quantity of milk is to be supplied to them as *kandar khajna* every day.

The bathan's income also include sale of milk and dung.

Pala

Previously there was the system of pala grazing where all villagers of a village collectively engaged two *rakhals* to look after their cattle in the haor and all shared the expenses of the rakhals. Now people have to look after their own cattle.

Milk

2-4 maunds of milk are supplied from each bathan every day during the dry season. At one time 30-35 families in Panchgaon and many families in other villages used to buy milk from the bathan. They made chhana, ghee, and butter and sold these in the towns and the villages. With more extensive cultivation and bringing more and more fallow and kanda land under crop cultivation the milk production has dropped substantially.

Fodder in the monsoon

Fodder is scarce during floods. People move their cattle to relatives' house or sell them. Some farmers worked in the harvest in exchange for rice straw instead of the more customary share of the crop. 5-10% of the cattle died during and after the flood. Cattle were severely malnourished and most of these were sick. About 80% of the cattle were shifted to safer places, and 20-30% of the cattle were sold.

D.10 FIELD OBSERVATIONS BY SOCIO-ANTHROPOLOGY TEAM

Among the traditional t aman varieties are *lathishail, balam, moinashail, biruin, akhlishail, naijershail, kattikshail, kalijira, katichini,* and *meghraj*. *Pajam*, an improved local variety, is also grown. In most of the lands in Munshibazar and Uttarbhag unions, *balam* is grown in the aman season. HYVs were grown on 40 to 50% of the land in 1992. Among the HYVs *mukta* (BR-11) is the most common. Other varieties are *progati* (BR-10) and *biplab* (BR-3). All these are harvested from late November to mid December.

Some poor farmers used a spade for tilling the *boro* land in Dcember 1992. They are sharecroppers and do not have any plough or draft animal. They prepare the land with spade and level it by hand.

Several *bathans* were operated to take care of livestock. The charge was tk 50 per month for each cow and tk 100 per month for each buffalo. The charge for milch cattle was the milk and dung which were produced, not cash.

In some villages of Panchgaon, Rajnagar, and Munshibazar unions, plantation of boro started in February to March. Seed-beds were prepared in January and February. Many people, expecting better yields, are now switching over from *aus* to HYV *boro*. This trend is evident in the last 2 to 3 years.

Weeding of *boro* starts in February. Main weeds are *chesra, paora* and *phutki*. Weeding by hired labourer costs Tk 100 per *ker*.

In 1993, harvesting of local *boro* started at the beginning of April and was in full swing by the middle of April. In some areas such as, Ontehori, Sonampur, Sonateki, Govindapur, Shahbazpur, and Fatehpur harvesting started in late April.

In areas which were affected by hailstorms the labourers received higher proportions in contracts for harvesting, ranging from one-third to one-half instead of the usual 10%.

The wage for carrying rice to Jalalpur village from the *haor* is 8 kg per *fali*, compared with 12 kg in Panchgaon and 16 kg in Gargaon.

Those who have contracts for harvesting they take their share after threshing. The wage is one-eighth of HYVs and one-sixth of local varieties.

Rice is carried with a *holla*. 100 kg of rice can be carried with one *holla*.

One labourer can carry 1 *fali* of rice at one time and can earn 15-20 kg of rice in a day.

Some people use horses to carry rice. One horse can carry 2.5 *fali* of rice at a time and can earn 40-60 kg of rice in one day.

Bullock/buffalo carts are also used to carry rice. The rate is one *maund* of rice per trip for a distance of up to three km. Transportation by boat is rare.

Dhumaiya, murali, and *chengri* which are grown extensively during the *aus* season have a short gestation. Seeds are sown in mid-March and are harvested in June. The land is immediately ready for t aman. However, this sequence was followed in a small proportion of the land. The yield of b aus is low, 3 to 5 *maunds* per *ker*. It is mainly grown by poor farmers for their own consumption.

Many farmers grow transplanted aus in Ekatuna, Akhailkura, and Monsurnagar unions. All highland farmers prepared seed-beds. Due to heavy rainfall in May 1993, particularly in Ekatuna union, many seed-beds were submerged.

Seed was scarce following the floods of June/July 1993. The price, which is normally Tk 175-225 per *maund*, increased to tk 320-350. Time ran out for preparation of fresh seed-beds and many farmers resorted to broadcasting of *aman* seeds, hoping for some crop for subsistence and for seed for the following year.

People moved their cattle to relatives' house or sold them. Some cattle died during and after the flood. Fodder was scarce. Cattle were severely malnourished and most of them became sick. About 70-80% of the cattle were moved to safer places and 20-30% were sold.

In September about 10% of the labourers were engaged, weeding aman land. The wage for weeding was tk 40-50 per ker. Some people of Ontehori were seen collecting *durba* grass from under the water to feed their cattle. They also collect water hyacinth. Some people stock water hyacinth and sell it at tk 50 per decimal.

Due to the shortage of draft animals following the floods of June/July 1993, people transplanted boro in many areas without ploughing. About 10-15% of the area was transplanted without ploughing, where the soil was soft and where there was 6-12 inches of standing water. Some poor farmers in almost all villages tilled their lands with spade.

Some farmers cultivated *boro* in the high lands of Noyatilla village to the south-east of Munshibazar. They used *chhara* water originating from the hills.

Some farmers in Dheupasha grew wheat. Lands adjacent to the canal seemed more favourable for production of wheat. Farmers grew wheat in those lands which would have otherwise remained fallow.

Due to the shortage of draft animals many farmers were giving out land under share-cropping. In Biraimabad and Ontehori 40% of *boro* lands were cultivated under the share-cropping system. Share-cropping increased by 5-10%.

Many farmers of Biraimabad, Uttarmolaim, Barkapon, Rokta, Gargaon, and Monsurnagar gave out land under *chukti bhag* system. The rent was 2.5-3 *maunds* per *ker* for local *boro* and 3-5 *maunds* per *ker* for HYVs. About 70% of *beel* lands were under this system.

Tebhaga system is unpopular among the land-owners. Only 10% of low-lying lands were share-cropped out under this system.

The amount of mortgaged land increased by about 10%, while the rate of the mortgage declined by 20%. The rate was tk 1,500-2,000 per *ker*.

In Dheupasha village, lands adjacent to breached portions of the embankment were covered with sand. People removed sand with spade by engaging local labourers. The wage was tk 125-150 per *kua*.

In January 1994 it was observed that about half of the cattle were grazing at the *bathans* and the rest were taken care of by the farmers themselves in their homesteads. *Bathan* caretakers consider milk of the buffalo as their wage. They sell milk to the members of the *Ghosh* community at tk 15 per kg.

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Boro transplantation in low-lying areas of *Kawadighi haor* had almost been finished by the first week of March. In some areas of Ontehori and Sonateki where transplantation was late, weeding and fertilizers application were still continuing.

In some high land areas of Rajnagar, Monsurnagar, Chandnighat, and Ekatuna unions some activities of plant care were going on. Some lands were being irrigated where transplantation was late. Some farmers of this area were preparing seedbeds for *aus* using water from the canal.

D.11 AGRICULTURAL STATISTICS TABLES

Table D5: Positions in Agricultural Units in Manu River FCDI Project

Post	Proposed No.	Position							
		1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
A. Agricultural Development Unit									
1. Chief Extn. Officer	1	-	-	-	-	-	-	-	-
2. Asstt. Agronomist	1	-	-	-	-	-	-	-	-
3. Agril. Overseer	1	-	-	-	-	-	-	-	-
4. Other Office Staff	17	-	-	-	-	-	-	-	-
Subtotal	20	-	-	-	-	-	-	-	-
B. Agricultural Extension Unit									
1. Agril. Exten. Officer	2	1	1	1	1	1	-	-	-
2. Asstt. Extn. Officer	4	-	1	-	-	-	-	1	1
3. Agri. Extn. Overseer	20	8	10	9	8	7	6	6	6
4. Spray Mechanic	1	-	-	-	-	-	-	-	-
5. Mukaddam	2	1	1	1	-	-	-	-	-
6. Other Office Staff	16	4	5	5	4	2	2	2	-
Sub Total	45	14	18	16	13	10	8	9	7
Total	65	14	18	16	13	10	8	9	7

Source: Agricultural Extension Unit, BWDB, 1992.

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Table D6: Crop Areas in Selected Unions of Rajnagar Thana, 1992

Union	No. of blocks	Single crop area (ha)	% of total area	Double crop area (ha)	% of total area	Triple crop area (ha)	% of total area	Cultiv-able fallow (ha)	% of total area	Total cultivated area (ha)	Average Cropping Intensity
Fatehpur	2	1480	56.64	948	36.28	80	3.06	105	4.02	2613	1.4
Uttarbhag	2	342	15.38	1383	62.25	141	6.35	356	16.02	2221	1.7
Munshibazar	2	2480	52.68	1983	42.12	205	4.35	40	0.85	4708	1.5
Panchgaon	2	850	34.56	1377	55.95	202	8.23	31	1.26	2460	1.7
Rajnagar	3	519	27.05	1339	69.83	41	2.13	19	0.99	1918	1.7
Tengra	2	560	15.28	1990	54.30	150	4.09	965	26.33	3665	1.6
Monsurnagar	3	595	22.97	1463	56.50	482	18.60	50	1.93	2590	1.9
Total	16	6826	33.83	10483	51.96	1301	6.45	1566	7.76	20176	1.6

Source: Rajnagar thana Agriculture office

Note: The area shown includes thana areas which lie outside the project boundary.

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Table D7: Area Inundated in Kawadighi Haor due to Heavy Rain during 17-22 February 1993

Name of Beel	Area Inundated (ha)
Bara beel	12
Burburi beel	20
Pukuria beel	8
Bolotta beel	2
Singua beel	20
Chatol beel	4
Burijuri beel	6
Total	72

Source: Field observation, NERP Socioanthropology team

Table D8: Boro Crop Area Adversely Affected by February '93 Rain

Location	Boro area affected (%)
Bara beel	25
Burburi beel	25
Singua beel	25
Pukuria beel	20
Koya beel	15
Boroiuri beel	20
Piala beel	20
Melaghor beel	25
Tanakhali beel	20
Rukkua beel	20
Niamoter dhibi	20
Kopnia beel	15
Dashteki beel	20
Chatol beel	80
Machhuakhali beel	25
Poshchim kawadighi	10

Source: Field observation, NERP Socioanthropology team

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Table D9: Carrying cost of Harvested Boro Rice from the Field, 1993

From Kanda	To village	Distance (km)	Rice carried (maund)	Worker's share (maund)
Pialar kanda	Uttar Molaem	7	16	4
Mithapurer kanda	Uttar Molaem	8	16	6
Patasingra kanda	Uttar Molaem	6	16	3
Chelamelar kanda	Rokta	4	16	2
Chelamelar kanda	Panchgaon	5	16	3
Chelamelar kanda	Gargaon	6	16	3

Source: Field observation, NERP Socioanthropology team

Table D10: Price of Summer Vegetables, 1993

Item	Price per kg (Tk)	
	Pre-flood	Post-flood
Borboti	8	Not available
Jhinga	12	14
Cucumber	10	Not available
Kakrol	7-8	12
Bitter gourd	10-15	Not available
Chichinga	10-12	Not available
Dherosh	12-13	Not available
Kochumukhi	10-12	6
Data	2-4	4-5
Water gourd	3-4	5
Pumpkin	3	5

Source: Field observation, NERP Socioanthropology team

Table C11: Rice Varieties Saved in Panchgaon Despite being Submerged under Water for Several Days, 1993

Aus variety	No. of days submerged under water	Date (July)	Crop saved (%)
China aus	12	12-24	50
BR-20	5	12-17	40
BR-12	7	12-19	40
IR-50	7	12-19	35

Source: Field observation, NERP Socioanthropology team

Table D12: Rate of Cultivation of Transplanted Aman, 1993

Union	Achievement (%)
Fatehpur	5
Panchgaon	40
Uttarbhag	25
Munshibazar	40
Tengra	80-85
Monsurnagar	85-90
Ekatuna	50-60
Akhailkura	40-50
Chandnighat	70
Roynagar	85

Source: Thana agriculture extension office and field observation, NERP Socioanthropology team

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Table D13: Harvesting of T.Aman, 1993

Union	Harvest completed (% of crop area) by December		
	Second week	Third week	Fourth week
Chandnighat	65	75	100
Akhailkura	50	65	100
Fatehpur	60	70	100
Uttarbhag	65	75	100
Munshibazar	65	80	100
Tengra	75	85	100
Rajnagar	75	85	100
Panchgaon	75	85	100
Ekatuna	60	80	100
Monsurnagar	80	90	100

Source: Field observation, NERP Socioanthropology team

Table D14: Extent of crop damage in canal catchment areas, 1993

Zone	Area cultivated				Area affected by rainfall, February 17-22		Area affected by hailstorm, April 11			Area affected by rainfall, May 2-13		
	Khoiya bon boro	Shail boro	HYV	Total	Khoiya bon boro	Shail boro	Khoiya bon boro	Shail boro	HYV	Khoiya bon boro	Shail boro	HYV
1	285	310	960	1555	111	43	15	13	88	9	38	345
2	815	556	91	1462	80	13	129	94	9	66	38	31
3	159	367	518	1044	7	2	97	232	120	5	5	114
4	163	207	930	1300	33	16	3	3	7	21	26	299
Total	1422	1440	2499	5361	231	74	244	342	224	101	107	789

Source: Field observation, NERP Socioanthropology team

Table D15: The extent of boro transplantation, January 1994

Union	Village	Plantation coverage (% of crop area)
Fatehpur	Zahidpur, Abdullahpur, Ontehori	75
Panchgaon	Rokta, Kewla, Amirpur	75
Munshibazar	Medinimahal, Sonateki	80
Uttarbhag	Holdigul, Mokambazar	70

Source: Field observation, NERP Socioanthropology team

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Table D16: Crop Affected due to Rain, March 1994

Union	Village	Crop area (%) inundated due to heavy rainfall in March
Panchgaon	Rokta	90-95
	Amirpur	
	Noagaon	
	Mukasuta	
	Dheubon	
	Sarampur	
	Kewla	
	Dhulijura	
	Poshchimbag	
	Jalalpur	
	Bageshwar	
	Kaldar	
	Kuchkipur	
Fatehpur	Fatehpur	90
	Shahbazpur	
	Shahpur	
	Hamidpur	
	Rashidpur	
	Abdullahpur	
	Berkuri	
	Bedahunja	
	Sonapur	
	Ontehori	

Union	Village	Crop area (%) inundated due to heavy rainfall in March
Akhailkura	Kadirpur	85
	Jagatpur	
	Kalaipura	
	Durgapur	
Ekatuna	Biraimabad	75
	Burikona	
Munshibazar	Medinimahal	60
	Sonateki	
	Kandigaon	
	Kazirhat	
	Goyeshpur	
Uttarbhag	Chanbagh	70-75
	Bardal	
	Teghori	
	Haipur	
	Kalarbazar	

Source: Field observation, NERP Socioanthropology team

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Table D17: Crop Area Inundated in Kawadighi Haor due to Heavy Rainfall, March 1994

Haor	Beel	Local variety		HYV
		Khoiya-boro	Shail boro	Gopalberi
Bara kawadighi haor	Katasingra	100	95	95
	Melaghar	100	100	100
	Salkatua	100	100	100
	Rukhiya	100	100	
	Majherbon	100	100	
	Ulauli	100	100	
	Kusra	100	85	80
Chhoto kawadighi haor	Charua beel	25	15	10
	Bara beel	30	20	15
	Burburi	90	80	70
	Boilta	90	80	70
	Jalua	90	80	75
	Chatol	95	85	80
	Baladmara	30	15	10
	Pukri	75	70	60

Source: Field observation, NERP Socioanthropology team

Table D18: Statistics on Selected Bathans in Different Kanda, 1992-93

Bathan owner	Village	Location of bathan	No of cows	No. of buffalo
Masud Ali	Nayagaon	Mirpurer kanda		21
Mintu	Gargaon	Mirpurer kanda	5	8
Sattar Mia	Terachung	Mirpurer kanda	10	40
Feroz Ullah	Bhaduganj	Piyalar kanda	40	50
Beraisabad	Durgapur	Melagharer kanda	10	25
	Ontehori	Melagharer kanda	5	30
	Gargaon	Ulaulir par		40
Faruk	Gargaon	Gargaon	50	40
Total			120	254

Source: Field observation, NERP Socioanthropology team

Table D19: Situation of the Cattle in Selected Villages, September 1993

Village	Cattle habitat (%)		Fodder
	Own home	Relatives' home / hills	
Rokta	15	85	Straw, shapla, durba, kura
Ontehori	20	80	Water hyacinth, durba, kura, straw
Fatehpur	35	65	Kura, durba, water hyacinth, straw, shapla
Sonateki	60	40	Green grass from hills, straw, water hyacinth
Dheupasha	95	5	Green grass on dike and embankment, straw, durba

Source: Field observation, NERP Socioanthropology team

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Table D20: Statistics on Selected Herds Grazing in the Haor, December 1993

Location	No. of cows	No. of buffaloes
North and north-east of uluail	120-150	20
East of Mirpur	150	30
West of Ontehori	100	15
East of Biraimabad and Kuzargaon	75	15

Source: Field observation, NERP Socioanthropology team

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APPENDIX E

FISHERIES DATA

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APPENDIX E : FISHERIES DATA

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E.1 WATER BODIES

Fisheries data were collected at Manumukh, just above the confluence of the Kushiyara and Manu Rivers. The Kushiyara flows west along the Northeast Regional Project's northern boundary, while the Manu flows northwest along the western boundary. The Manu and Kushiyara Rivers are morphologically active and carry significant sediment during the monsoon season, although sediment has not been a factor in operating the barrage. Sediment deposition is nominal during the dry season.

The project area contains the following fisheries (beels and water bodies), of which the 85 km^2 Kawadighi Haor is the most important. Location of the beels in the project area are shown in Figure E1.

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Table E1: Fisheries in Manu River

Name of Fishery	Area (ha)	Name of Fishery	Area (ha)
Singua beel	14.37		
Hawa beel	61.54	Kalibari Khal	4.09
Majerband beel	76.72	Kanaki gang	5.26
PataSingra beel	233.79	Kati taka beel	1.62
Goali beel	13.87	Ghaagatia beel	0.41
Shakatua beel	48.87	Charupama beel	2.74
Peala beel	11.19	C.M.Karsha beel	6.00
Kaliarkuli beel	9.68	Chapra beel	3.65
Noamati khora	25.91	Chow. dighi	0.45
Hawa beel	24.62	Chota existence beel	0.51
Melaghar beel	12.19	Jibonia beel	5.06
Munia river	16.84	Jira beel	4.37
Akhali nadi	24.85	Daldalia beel	6.11
Erali pukuria	14.06	Dewan dighi	4.29
Karadhair river	13.65	D.Baraiuribeel	7.89
Chatla Burijuri	12.12	Nalua gang	7.81
Bodirbhara beel	11.63	Nagori gang	6.60
Boldabolchira B	15.33	P.Matikura beel	2.15
Niamoter doba	12.94	Baladmara beel	0.32
Bhoba naga beel	12.72	Balita beel	3.83
Nalua nadi	10.29	Bacha dubi beel	1.40
Karadhair Nadi2	8.40	Boicha beel	2.65
Machuakhali G fishery	36.44	Bagan beel	0.49
Agadubi beel	0.40	Rukua beel	5.79
Akali nadi UP		Sat bhuterdubi	1.61
Uper Goali beel	2.92	Harium beel	4.13
Karadair Nadi 1	4.21	Ulauli beel	2.66
Koia beel	2.12	Dhansara Khal	3.15
Karira nadi	5.10	Sagar dighi	1.65
TOTAL JALMOHAL AREA = 833.46 ha			

E.2 ENVIRONMENTAL MONITORING

Temperature
Noontime air and water temperatures taken during the study are presented below:

Table E2: Water and Air Temperatures

Date	Temperature (°C)	
	Air	Water
01 Oct 92	39	37
22 Dec 92	21	20
19 Apr 93	30	28
20 Apr 93	31	30
21 Apr 93	32	30
22 Apr 93	34	31
28 Jun 93	32	33
26 Sep 93	31	29
27 Sep 93	30	30
28 Sep 93	24	30
? Sep 93	29	28
15 Oct 93	31	29
16 Oct 93	30	30
17 Oct 93	30	29
01 Nov 93	30	30
03 Nov 93	25	27
04 Nov 93	29	28
05 Nov 93	31	29
30 Nov 93	28	28
29 Jun 93	31	30
30 Jun 93	30	30
02 Jul 93	32	30
03 Jul 93	32	31
01 Aug 93	31	31
02 Aug 93	32	31
03 Aug 93	31	30
01 Dec 93	27	28
02 Dec 93	30	29
25 Dec 93	27	24
26 Dec 93	29	27
28 Dec 93	28	26
26 Feb 94	28	27
27 Feb 94	29	29
28 Feb 94	31	30
28 Apr 94	33	30
29 Apr 94	34	31
30 Apr 94	35	31
11 May 94	33	30

General Observations
Rainfall data indicates that runoff from the eastern Battara Hills was Kawadighi Haor's main water source during the monitoring period. The Kashimpur Pump House hydrograph of the Manu Project indicates that the Kushiyara River usually rises above the water level inside Kawadighi Haor through early August. After that, the river rises above the haor's water level for only a few days during early September and mid October. Figure E2 shows the sources of water inflow to Kawadighi Haor which existed prior to implementation of the project.

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Due to low rainfall in 1992, water levels in the Manu Project area are one meter lower than during the previous study years. These low levels plus a late monsoon inhibited fish breeding and growth in the haor. Under such conditions, juvenile fish could be easily harvested, which could result in a sharp decline in fish production. Without flooding, the haor is not adequately flushed of pollutants, resulting in high numbers of diseased fish, environmental degradation, and a serious threat to human health.

July 1992

Monitoring in July 1992 showed that water levels in the haor were 1.5 to 2 m lower than it was during the same period one year earlier. During the monsoon, brooding fish tried to enter into the Kawadighi haor either for spawning or grazing through natural connecting canals. Due to the embankment fish cannot enter the haor and large carp and cat fish are reportedly less plentiful now. The current SDE said that many big fish gathered in front of one pump house vent during operation. He also said that Kawadighi Haor was previously a fish mine in the area. During normal water level years, *koi, shinghi, magur, punti,* and snakeheads are the dominate catch from the haor.

January 1993:

The gate of the pump house was open. Beel fishing in the area started earlier this year than previous years due to rapidly falling water levels. The area of the study that usually was covered by beels was down 50 percent from normal years and most of those were only .5 m deep. Most beels were densely covered in rooted aquatic plants. About 80 percent of the fish were affected by ulcerative syndrome disease which could reduce future fish stocks and pollute the water. All agricultural land was available for cultivation during January 1993, although most was fallow. Only land located close to water, such as in the periphery of beels or adjacent to canals, was being sown. At this time, farmers also were hampered by excessive weeds which are prohibitively expensive to eradicate.

February-April 1993:

During late February, five, 10 to 15 kg brood *rui* were caught in the Manu River a few hundred meters upstream of Manumukh where there was no water during the dry season. Fishermen reported that early flash floods caused early spawning migration in the region.

June 1993

Flash flood waters entered the Manu River Project Area on 6-7 June 1993 through a public-made breech near Ashrakona. Most homesteads and cultured fish ponds were inundated within a few hours. To relieve the flood pressure, residents of inside villages such as Antahari, cut the embankment on the Machuakhali Canal.

Due to embankment breaching that coincided with the flooding, Kawadighi Haor and other small water bodies received water via the breaches. Fishermen placed about 15 nets around the breach at Machuakhali and caught many large fish from the haor side. Juvenile river fish also were caught in the haor area. Such fishing opportunities greatly increased the number of fishermen and daily catch size over the previous year. These conditions continued until late monsoon.

July-August 1993

Embankment breaches changed the daily life of fishermen in the Manu Project Area. A number of river fish, that are not usually available, became plentiful with the breaching. Because of this availability and increased catch size, fishermen's income was higher than during the previous year. Catch size, however, decreased from the previous month.

August-September 1993
Embankment breaching on the Manu Irrigation Project continued to create a tremendous opportunity for Fisheries PMP evaluation. All fishermen in the project area increased their catch several times over the previous year's catch. With the increased availability of fish, fishermen were able to fish productively during the breaching period. Large *rui, catal, boal, ilish, rita,* and *gharua* were caught. It was assumed that the beel production will be several times greater than the previous year's production. Fish prices were less than the previous year.

October-November 1993
The flood waters receded rapidly and the project area dried quickly. Cultivation began in the relatively higher land. Negotiations began to lease fishing rights in area beels. Aquatic vegetation was much less of a problem than in the previous year.

November-December 1993
Beel fishing occurred in small and shallow beels. Farmers were actively cultivating throughout the project area. Due to the floods, agriculture land was more productive and farmers were spending less for agriculture inputs. The year's income for most fishermen made up losses they incurred in previous years. On the whole, most people of the project area seemed to enjoy a productive year.

January-February 1994
Fishing in small and shallow beels was mostly completed by early 1994, but fishing still occurred in about 15 to 20 percent of the large beels. The large fish harvest from the different beels of Kawadighi Haor proved the importance of the fish resource in the area. Regular water flows through the haor could prevent excessive aquatic vegetation as well as improve soil quality.

Water Quality
The water in Kawadighi Haor was mostly clear throughout the year due to low turbidity and huge rooted aquatic plants. However, in the shallow regions where the large aquatic plants were adjacent to the embankment, the water was mildly poisonous and irritated the skin.

Historically, the haor's water quality was clearer and fresher than the water of the Kushiyara (which receives effluents from the Fenchuganj Fertilizer Factory) and the water of the Manu (which carries excessive silt). Broodfish migrating upstream from the Upper Meghna, Kalni, and lower Kushiyara found shelter and good water quality in Kawadighi Haor. The various compositions of the waters feeding the haor, (Monia River, Karadhair/Machuakhali Rivers, Manu River canals, Battara Hills, Rokkya Beel) created a favorable environment for breeding and as a nursery.

The monthly discharge of toxic waste from the Fenchugonj Fertilizer Factory kills fish in the Kushiyara River as far downstream as Markuli during the dry season. Moreover, the flesh of Kushiyara River fish have a bad odor during the dry season when water levels are low.

Chemical analysis of project area water is as follows:

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pH

All incoming waters (Kushiyara and Manu Dhalai Rivers) are moderately basic (pH 7.1 to 7.7). Water in the Khawadighi Haor area is acidic (pH 5.8 to 6.7). The low pH probably causes metals to settle out of sediments and dissolve in the water column. Red discoloration of some beel waters suggest that iron is leached out of the sediment.

Nitrate

Nitrate values in Kawadighi Haor are moderately high (11 to 14 mg/1). High nitrate levels in stagnant water conditions probably are due to the death and decomposition of aquatic plants. This decomposition generates ammonia which turns to nitrate in the presence of dissolved oxygen. However, the ultimate source of nitrogen loading in the area is fertilizer. Apart from paddy applications, fertilizer also enters the ecosystem from the Fenchuganj fertilizer plant located on a hill at the extreme northeast end of the project area. This plant produces ammonium sulfate fertilizer and uses 20 tons of sulfuric acid and 10 tons of caustic soda per month. Sulfur dioxide, ammonia gas, and urea dust is emitted into the atmosphere. Some of the ammonia gas dissolves as aqueous effluent, averaging 100 mg/1, and is ejected in periodic pulses. A pipeline takes the effluent to a lagoon near the Kushiyara River. It is possible that the plant is responsible for a general and continuous diffusion of contaminants into the southwest part of the Manu Project Area.

September 1992

Reddish colored water was observed in the Machuakhali Beel area. People in the area reported that the water irritates human skin.

December 1992

Turbid water was observed in the Akali River and Lach Gang (near Antahari and other shallow areas), and clearer, but black-colored water was observed in the deeper area of the beel. Continuous fishing and adjacent agriculture activity resulted in turbidity. Rotting aquatic plants and runoff make the water in deep spots appear black. Pollution flourished in this area during the dry season as river and flood waters did not regularly flush the area water bodies. The pollution heightened the opportunity for fish disease.

January 1993

Many beels and canals seemed polluted due to agricultural activity and rotted fish. Silt muddied the khals fed by the gravitational flow of the Manu Barrage, while other beels were relatively clear. Rotting fish and aquatic plants fouled the smell of many beels during this period.

February-April 1993

Beel water was used only for agriculture during this period. Manu River water via irrigation channels and rainwater runoff from the Battara Hills increased the water level on the beel/haor side of the project area. The water was clear on the beel side, but slightly turbid on the eastern khal/river side.

June 1993

Turbidity was high in project area water bodies after large amounts of silt was carried by flood waters of the Manu River. The water appeared muddy and red-colored near Machuakhali. Some embankments near Machuakhali were destroyed by erosion, and about 20 cm of silt were deposited on the shallow bed of the Manu River near Kazi Bazaar. Choto Kawadighi Haor, in the northeast portion of project area, was relatively clear due to runoff from the Battera Hills.

Embankment breaching opened area water bodies to both the Manu and Kushiyara Rivers. Manu River water, carrying a large amount of sediment, caused turbidity in northwest part of Kawadighi Haor. The water flow improved water quality by flushing pollutants out of the haor. The situation continued until late monsoon, creating higher water quality and fish production than the previous year.

July-August 1993
Muddy water from the Manu River entered the area through breaches and caused turbidity in the southwest and northwest part of the project. Runoff from the Battara Hills resulted in clear haor water in the northeast area.

August-September 1993
Turbidity continued as observed in the previous few months. But local people said that the water quality was better; it no longer irritated the skin as it did in the previous year. Silt-laden water flowed from the Manu River through breaches in the southeastern part of the project to the Kushiyara River and through the breach in Machuakhali closure in the northwest.

October-November 1993
Water level rapidly lowered. Water in the beel and deeper areas looked clear, while agricultural activity in the higher lands created turbidity in the shallow area.

November-December 1993
During November, water in the large beel area was clear but turbid in the shallow canals. Turbidity was due to intensive agricultural practice throughout the haor area. Fishing activity increased the turbidity of the beels during December.

January-February 1994
Gravitational flows from Manu Barrage cleared the water in the Manu Project Area although beel fishing continued. Water levels increased about 40 cm during this period. Water in some narrow canals seemed turbid, probably due to agricultural activity and fishing.

March-May 1994
Heavy rain resulted in high turbidity and water logging during late March. A large area of boro crops were inundated. A few fishermen were observed fishing during this period.

Aquatic Plants
Beels in the western part (Machuakhali) of the project were full of aquatic weeds. Deeper areas of the haor were relatively clear but there was strong indication that aquatic weeds would take over in the near future.

September 1992
Shallow beels and stagnant water prove the best habitat for aquatic plants. In some places, it is not possible to navigate a boat around or through the plants. The excessive plant growth also takes over some agricultural land, preventing or slowing cultivation.

December 1992-January 1993
Most land adjacent to beels was covered by a thick layer of rotted aquatic plants. This rotted mat can be as deep as 15 cm and creates extra work for farmers who wish to cultivate such areas. Farmers reported that it cost between Tk. 75 and 500 per hectare to clear the rotted mat, which

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is usually more than it costs to prepare and plant the same area. Uprooted weeds also cover up between five and eight percent of the area's agricultural land. Poor farmers usually cannot afford to clear such weed and plant cover. In the shallow beels, aquatic plants such as *singra, najas,* and *ghora ghash* create cluster structures which make boat travel difficult if not impossible. The overgrowth of aquatic plants reduced the year's income from agriculture and fishing.

<u>February-April 1993</u>
Areas that were freshly inundated by flood waters were free of aquatic plants, while permanent water bodies that were not inundated were covered in *singra.*

<u>June 1993</u>
Most aquatic plants that flourished in previous years were carried out by heavy flash floods. The floods were caused by sudden embankment breaching in the southeast corner of the project area and in the northwest near Machuakhali. People residing near Machuakhali reported that a large quantity of weeds were carried out a breach cut by early flood waters. Few aquatic plants were observed in the project area. By late monsoon, only a few farmers had the problem of removing aquatic plants from their land. It appeared that there would be less rooted vegetation than in previous years.

<u>July-August 1993</u>
There was much less aquatic vegetation than in the previous year. A few plants of *paura, erali,* and *shapla* were observed in shallow areas. No plants were observed in the main beel during the reporting period.

<u>August-September 1993</u>
Continuous turbid water flow through the haor kept about 80 percent of the area free from aquatic vegetation. On the village side of the haor some vegetation was observed. Livestock owners complained that the lack of vegetation reduced their cattle food supply during the dry season.

<u>October-November 1993</u>
No aquatic plants were observed in the beel area, although shallow areas in the northeast part of the project had some plants of *erali, putki, shapla,* and *jao.* Compared to the previous year, however, it was accurate to report that there was no aquatic plant growth in the project area.

<u>November-December 1993</u>
Aquatic plants were removed from the highlands by the owners of the respective land. Mainly *singra* and *chailla* grew in the shallow regions of the beel.

<u>January-February 1994</u>
It was observed that most shallow area were covered in *singra,* although *chachra* and *paura* bells were also present. No significant aquatic plant deposition was observed in the haor area during this period.

<u>March-May 1994</u>
Some *khai, shapla,* and *jao* were observed in shallow areas, while *erali* and *paura* were observed in the deeper areas of the beel.

E.3 MONITORING FISH STOCK

Fish Abundance

Prior to construction of the Manu River Project, Kawadighi Haor was a mother fishery and one of the fish mines of the greater Sylhet area. The project's embankments have obstructed fish migration into the Kawadighi Haor. During the monsoon, fish can move into the Kawadighi Haor through only one sluice gate.

Prior to the completion of the project, the Kushiyara river was the only source of fish. During early monsoon flash floods, large numbers of broodstock *rui, catal, boal, pungus, nanid, chital, kalibaush, gonia,* and *ghagot* entered Kawadighi Haor via the Karadhair, Machuakhali, and Munia Rivers that are fed from the Kushiyara. Some individual fish weighed more than 40 kg. After completion of the project, fish numbers reportedly dropped suddenly. However, if fish are given an entrance into the haor by natural embankment damage, public cuts, or overtopping, fish numbers rise markedly.

In May 1991, when the embankment near Machuakhali was damaged giving fish an entrance into the haor, the lessee of the Machuakhali group fishery harvested more than 650 individual *rui* and *catal*. The largest fish weighed 18 kg, while most weighed between 2.5 and 4 kg. Large female carp with eggs were also caught in April and May 1991. More were caught during November and December of that year. In sharp contrast, basically no carp were caught between 1985 and 1990.

One fisherman reported catching one 10 kg *rui* in Sangla Jal at the confluence of the Manu River on 17 May, 1992, the day after the first flash flood. Another 20 large *rui* and *catla* were caught on the same day in the same area.

Embankments were also breached in 1984, resulting in the catch of one 35 kg *rui*. The number of fish caught also increased several fold in 1993 when a major embankment was breached along the Kushiyara.

Before implementation of the Manu Project the first flash flood of the season was reportedly a festive occasion for the people of the haor. Several thousand fishermen and others gathered for the fishing. Many fish were full of eggs during this period and fishermen reported that they harvested more than 30 kg of egg-laden *rui, catal, boal,* and *chital* averaging 5 to 10 kg each (fish during early monsoon from outside the haor).

November through January was the peak fishing season, and during this time most fish were migrating back to the Kushiyara. At that time, it was normal to harvest four to five *maunds* (a local unit of measurement; one maund equals 37.5 kg) of fish per day per net, and a few fishermen reported that they harvested more than 12 *maunds* of fish per day. During the peak fishing period individual fish weighed around one kg. These are fish from within the haor caught in late monsoon after grazing.

Currently juvenile *hilsa* are the main species harvested from the Kushiyara River by the Kona jal. *Punti, koi,* and *lati* dominate the catch inside the project area. Local people reported that there were 50 percent less *cpue* caught in 1992 than in 1991.

The Markuli-Karadhair stretch of the Kushiyara is the best source of large brood fish but most

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of its tributaries along the stretch are closed, preventing lateral movement of migrating broodfish. Prior to the construction of the project, the first major flooded area encountered upstream used to be Kawadighi Haor.

Species diversity has decreased since the project was built, but previously the entire area was famous for large carp during the early monsoon. Monumuhk, Machuakhali, and Karadhair, just outside the embankments, are still famous for large carp broodfish.

Fishermen and other villagers in the Manu Project area agree that Kawadighi Haor was the most important breeding ground of the area before the project was built. Large schools of several different species entered the haor during early flash floods. Because of the large numbers of fish, people were able to fish with only plunge baskets or spears. Fishermen from other areas frequently came to fish the plentiful waters.

All of the fishermen interviewed said that they used to observe fish forming pairs after flash floods. During late May to early June numerous eggs and one-cm fry were caught by Thela Jal. From mid to late monsoon fingerlings were stocked in ponds near the project. Most fishermen agreed that Kawadighi Haor was the primary fish nursery of the area.

Late in the monsoon, fish used to move from the haor toward the river. The fishing season ran from October through March. One Rakta Village fishermen said that in November 1974, he estimated that about 1,000 maunds of *rui* moved continuously through the Karadhair River over a six to eight day period. This same fisherman, who held the lease on the Karadhair River, harvested less than five percent of the fish he saw, but was happy with the size of his catch.

One man of Chanpur Village said that numerous large fish were caught during the monsoon in front of the embankment opposite the Karadhair and Machuakhali Rivers up to three years after the embankments were built. Migration and homing instincts probably brought the fish back to that area, but currently the fish do not gather at that location. Local people and officials at the pump house said that many large carp do gather in front of the pump and try to cross over to their old spawning grounds during the monsoon.

Effects on Livelihood

Before the Manu Project was built, many fishermen earned a respectable living in the area. In February and March of 1959 and 1960, one experienced fisherman reported that he had earned Tk 35,000 at Kata singra fishery, one fishery in Kawadighi haor. The market price of different fish species at that time were: *rui*, Tk. 20 for 46 kg; *catla*, Tk. 18 for 46 kg; *ghagot/air*, Tk. 12 for 46 kg; and other species, Tk. 10 to 12 for 46 kg. The average size of individual fish was about five kg and the average yield was 132 kg/ha/year.

Between 1975 and 1977 Abu Bakar and his associates earned Tk. 14,00,000 from the same Kata singra fishery when the average price of fish was Tk. 500 per maund and the average yield was 179 kg/ha/year. *Catla* and *rui* were the most commonly caught fish. During this period, Roikkya Beel, which is connected with the Karadhair River, was called the "navi," or nucleus, of the haor. Water circulated well through Roikkya Beel and many large fish were caught near this beel during the early monsoon. Kalia Beel, located on the eastern side of the Karadhair River near Rasulpur, was famous for its large *catla* and *rui* during the monsoon. Mr. Chaia Hazi of Ghargaon leased the beel and earned more than Tk. one lak every year before the project was built.

Kapini Beel was another quality fishery. The lessee earned more than Tk. 10 lak every year before the project was completed. Before the project, the beel leased for Tk. 1.25 lak; now the lease costs only Tk 20,000, although fish prices have increased five fold during the same period (from around 1980 to 1992). The lessee said that the number of fish caught dropped suddenly when the Karadhair River was closed permanently after pumps were installed at Kashempur.

Ten to 15 years ago, fishermen could reportedly catch between 900 and 1,200 kg of fish/day. Currently, fishermen are not sure they will be able to support themselves fishing in the area even though they enjoyed a good year in 1991 due to flooding and embankment damage. Some experienced nikery claim the overall decline in fish production is as much as 95 percent, although the available data indicates that the decline has been much less.

The cost of a fishery lease within the Manu Project area has and is declining, which is the reverse of what is happening in other area fisheries. Currently, there are 27 fisheries (above eight ha) on approximately 800 ha of government land within the project area. Because of the historical importance of the fish resource, a large number of fishing villages are located in the project area.

Rakta fishing village is located in the center of the project near Kawadighi Haor. All the beels of this area dry up during the winter season. Farmers depend on rainwater as barrage water does not irrigate the area. Fish production has reportedly declined by about 90 percent since the project was constructed. Existing production depends on flood water. Since construction of the embankment *rui, catal, boal,* and other large fish are no longer caught. Due to the decline in fish number, many fishermen have or are changing their profession. Currently, 20 percent of the total catch by Rakta fishermen is consumed locally and the rest is marketed elsewhere.

The water volume delivered by the Manu Barrage during the dry season is insufficient to prevent most of the beels from drying up.

When discharge increases abruptly in the Manu River, large *rui* and *catal* are caught downstream from the Kushiyara confluence.

The turbidity of the Manu River can persist for six to eight days. Large *boal* and *air* are more abundant there than carp, and large *bagmas* and stingrays are occasionally caught.

Pre-Project Production Estimates

Fisheries production data were not collected prior to implementation of the project and, therefore, were estimated from recall information collected from local fishermen. Estimates of the beel production (catch), floodplain production, and fish spawning are documented in the following tables. These data indicate that the average pre-project production from the Kawadighi Haor was 640 T/year, of which 480 T/year (75 percent) originated from the floodplain fishery and 160 T/yr (25 percent) were captured in the beels. The value of the pre-project catch is estimate to be in the order of 37 million taka per year based on today's prices.

The value of Kawadighi Haor as a spawning area for the region far exceeded the value of fish actually captured in Kawadighi Haor. It is estimated below that only 10% of the spawned fish were captured in the haor, the vast majority presumably returning to the Kushiyara River where they contributed to the fish abundance and productivity of the region. The fish that could be produced from spawning activity in Kawadighi Haor are estimated to have a market value of Tk 422 million, based on current market prices. This spawning activity has been largely eliminated

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by the project embankments. Even if the rate of spawning was grossly overestimated, the economic value of fish which were spawned in Kawadighi haor was substantial.

It should be noted that these data are based on sketchy recall information and should be considered order-of-magnitude estimates.

Table E3: Estimation of Pre-project Conditions

Estimation of Pre-Project Production in Kawadighi Haor (in 1975)

1. Beels:

Approximate area of beels = 1,000 ha
Assumed beel production per ha = average of 1975 and 1976 production
= (135+185) / 2 = 160 kg/ha/year
(based on recall data of local fishermen)
Total annual beel production = 1,000 ha x 160 kg/ha/year = 160 T/yr
Current value of pre-project beel production @Tk 80/kg = Tk 13 million

2. Floodplain:

Total area of productive floodplain = 8,000 ha
Assumed floodplain production per ha = 60 kg/ha/year
(typical maximum production in the NE region)
Total annual floodplain production = 8,000 ha x 60 kg/ha/year = 480 T/yr
Current value of pre-project floodplain production @Tk 50/kg = Tk 24 million

3. Total:

Total Kawadighi Haor (pre-project) production = 160 + 480 = 640 T/yr
Total value of pre-project production = Tk 37 million

Estimation of Pre-Project Fish Spawning in Kawadighi Haor (in 1975)

It is estimated from interviews with local fishermen that 5,000 pairs of different large fish species, having an average body weight of 5 kg per fish, spawned in the haor before the project. It is known that a spawning female will produce eggs equal to 15% of her body weight on average, and that there are 250,000 eggs per kg of spawn. It is also known that, on average, 1% of fish eggs eventually develop into table-sized fish (0.75 kg or larger). Therefore, the weight of fish which were produced from spawning in Kawadighi Haor, and their market value, are estimated as follow:

Total body weight of spawning females = 5,000 females x 5 kg = 25,000 kg
Total weight of spawn = 15% of body weight = 3,750 kg
Total number of spawn = 250,000 eggs/kg x 3,750 kg = 938 million eggs
Total number of table-sized fish produced (1% of eggs) = 9.4 million fish
Total weight of fish produced = 0.75 kg/fish x 9.4 million fish = 7,030 T
Current value @Tk 60/kg = Tk 422 million

There are two drainage sluices in the project area to handle the flash floods that flow from 15 streams originating in the Battera Hills. The two drainage sluices operate only when the water level of the project is higher than the Kushiyara River. Local people want the implementation of one bypass canal on the eastern side of the project to connect the Manu River with the Kushiyara River. This connection would allow runoff from the hills and excess water from the Manu River to drain without flooding the project area. However, this runoff from Bhatera Hills is of good quality and is an important factor in maintaining good quality water in the haor.

Fish Abundance Journal

YEAR 1: May 1992 - April 1993

January 1993

Most of the beel was drying up and no one was subsistence fishing. Harvest of the beel's fish was started one month earlier. Fish found in high abundance included: *punti, tengra, chingri, bheda, lati, shoal, baila, shinghi, kaikkya*, and *chanda*. Fish found in medium abundance included: *chapila, pholi, gonia, boal, koi*, and *chela*. Fish found in low abundance included: *carpio, catla, rui, golda, pabda, air, baim, lachu*, and *kalibaush*.

At Majerband Beel on 18 January 1993, about 50 nikeries from Gargaon, Amirpur Banarai, Rakta, and Berkuri competed for rights to buy fish. Most of the winners bought only two to three kg of fish; none got more than four kg. Old nikeries reported that they never bought less than 80 kg fish per day in the days before the project was built. In those days, fishermen would sometimes push the nikeries to buy more fish as they had more than they could sell.

February-April 1993

Only a few fish were observed migrating toward shallow regions. A large number of people from adjacent villages were found fishing, but few had any fish. The following species were caught during migration: *shoal, gajar, koi* (with eggs), *shinghi* (with eggs), *gutum* (with eggs, some juveniles), *magur* (with eggs), *punti* (with eggs, some juveniles), *mola, tengra* (with eggs), *taki* (juveniles), *chanda* (juveniles), *gonia*, and *baila* (juveniles). The capture of fish with eggs during spawning is illegal in Bangladesh.

YEAR 2: May 1993 - May 1994

June 1993

There were more fish than last June because fish migrated into the project area and escaped from inundated cultured ponds. Their numbers were included in the current haor fish population. In the shallow regions *rui, catal,* and *carpio* fingerlings were caught by current nets.

About 15 nets were in use near the breached embankment at Machuakhali. *Chanda, mola, tengra, icha, punti, baila*, and *foli* were the main species caught at Machuakhali, while *shinghi, koi, lati, foli, magur, punti*, and *tengra* were the main species caught inside the project.

Machuakhali fishermen said that just after the Machuakhali embankment was cut, the catch income per fishing boat was Tk. 500 to 600 a day; normally it is Tk. 100 to 150 per day.

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Fishing near the Machuakhali cut was very productive and fishermen were catching about 10 times as much as they normally would.

July-August 1993

A decrease in the number of fish caught during this period was probably due to over-fishing in the previous month. Only 14 *khora jal* and five *uther* nets were observed in and around the Machuakhali breach. *Catla, rui,* and *carpio* fingerlings were caught in current nets as they left the haor. *Chanda, mola, chela, punti, baghair* fry, *gharua, bacha, rita,* and *golda chingri* were the primary species caught near Machuakhali during this period.

August-September 1993

Research and observation indicated little change in the number of fish caught from the previous month. *Chapila, chela, chanda, punti, mola, baim, taki, tengra, shoal, gojar, icha, baila,* and *kaikkya* were the most common fish caught. *Rui, ghagot, foli, kalibaush, carpio, boal, air, shinghi, magur, catla, lacho,* and *golda chingri* were the next most common species caught. *Rita, bagair, ilish, mirgel, bacga, garua,* and silver carp were the least common fish caught during this period.

One nine to 10 kg *catal* was caught within the project area near the Machuakhali breach and sold for Tk. 1,100.

The Second Aquaculture Development Project (ADB) under DOF released 1,283 kgs of several species of fingerlings into Hawa Gulya Beel on 13 September 1993. The following tables shows the species and kilograms released:

Table E4: Fish Released

Species	Target (kg)	Delivered (kg)
CATLA	330 (27.5%)	274.41
SILVER CARP	180 (15%)	91.52
RUI	330 (27.5%)	320.50
KALIBAUSH		2.30
COMMON CARP	180 (15%)	214.45
MRIGAL	180 (15%)	380.01

October-November 1993

Common fishing activities fell sharply during this period due to the rapid drop in water level. The number of river fish species caught decreased within the project area. Small fish dominated the catch, but the average size was still larger than that of the previous year. During this period there was an increase in the catch of *punti, chapila, taki, bata, baim, shoal, boal, gazar, icha, chanda, kaikkya,* and *baila*. There was no change in the numbers of *carpio, foli, air, shinghi, magur*, and *kalibaush* caught. There was a decrease in the catch of *rui, mrigal, catla, bacha,* silver carp, and *gharua*.

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November 1993
Although fishing was restricted in the main beel area, some fishermen secretly made their way in through contact with the guard and caught primarily *ilish* and *pabda*. Shallow beels and channels were still open to fishing. *Rui, punti, chapila, taki, foli, tengra, gutum, bata, icha, chanda,* and *kechki* were the main species caught. *Rui, chapila, carpio, punti* and snakeheads were more common than the previous year, while *shinghi, magur*, and *koi* were less abundant.

January-February 1994
The beel fishing harvest during this season clearly indicated the importance of the Kawadighi Haor for fisheries. *Rui, carpio, air, boal, chapila, foli*, and *tengra* were found in large numbers during this period, but numbers of *koi, shinghi,* and *magur* declined by 60 percent since last year. The ratio of big to small fish was 4:6. Some *ilish* were harvested from Kawadighi Haor during beel fishing.

Species that were most common in various beels are noted in the following tables:

Table E5: Common Species in Beels

Beel	Species
Ulauli Beel	RUI, BOAL, AIR, CARPIO, CHAPILA, PUnTI, TENGRA, FOLI, ICHA
Mazerband	CARPIO, RUI, CATLA, AIR, GAZAR, BOAL, CHAPILA, TENGRA, ICHA, PUnTI, BAILA, TAKI, PABDA
Salkatua Beel	CARPIO, RUI, AIR, BOAL, GAZAR, PUnTI, BHEDA, BAILA
Patasingra Beel	CARPIO, RUI, AIR, BOAL, SHIOAL, GAZAR, CATLA. CHAPILLA, TENGRA. PUNTI, BHEDA, BAIM, BAILA
Karadhair River	RUI, AIR, CATLA, MRIGEL, BOAL, CARPIO, ILISH
Rukhua Beel	RUI, AIR, CARPIO, BOAL and some other small fish

Kari Shamsul Haque, a prominent fishermen from Gargaon and one of the longest lease holders of beels in Kawadighi Haor, classified the current year's production as:

- Local Production 15%
- Pond Culture Fish 35%
- Migrated Fish 50%

The difference in the fish catch from last year to this year is outstanding when considering the numbers, types, and sizes of fish caught in the project area. The following table shows the difference in the largest fish for a particular species caught in the area:

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Table E6: Largest Record Fish for the Species

Species	Weight (kg)	
	1993	1994
AIR	5	10
RUI	5	9
CATLA	3	3
BOAL	7	12
SILVER CARP	absent	3
GRASS CARP	"	3.5
CARPIO	3	8

February-April 1993
Fish were observed following normal spawning migration patterns within the project area. Fish inside the haor traveled against the current from the deeper areas to shallow regions. More fish were caught outside the Karadhair Pump House than in any other area. The following species were caught in the Karadhair River during migration from the river toward the pump house: *air, boal, gulsha, kajali, pholi, bacha, gharua,* and *batashi.*

June 1993
Rui, rita, hilsa, bacha, ghaura, and juvenile *air* found their way inside the haor areas through the breach at Machuakhali. One five kg *rui* was caught from Machuakhali beel and a 5.5 kg *catal* was caught near Mirpur Village. Many *hilsa* and *rita* were caught near Antahari and Amirpur.

July-August 1993
Rui, rita, ilish, air, baghair, bacha, and *gharua* were found within the project area. *Juvenile kalibaush, baghair,* and *catla* were also caught. The number of small fish such as *chanda, punti, chela,* and *kaikkya* was much higher than during the last year.

August-September 1993
Several breaches on the Manu Project embankments allows fish to move from the Kushiyara River into Kawadighi Haor. As a result, *ilish, rita, baghair, bacha, ghagot, lachu, pabda,* large *rui,* large *catal,* and *gharua* were harvested from Kawadighi Haor area. Local people said the fish grow to large sizes when allowed to migrate into the haor area to feed.

Table E7: Fish Recorded in River and Haor

Species	Recorded in River		Recorded in Haor	
	1992-93	1993-94	1992-93	1993-94
AIR	Yes	Yes	No	Yes
BAIM	Yes	Yes	Yes	Yes
BATA	Yes	Yes	No	Yes
BAILA(>2 species)	Yes	Yes	No	Yes
BACHA	Yes	Yes	No	Yes
BOAL	Yes	Yes	No	Yes
CHANDA	Yes	Yes	Yes	Yes
CHAPILA	Yes	Yes	Yes	Yes
CATAL	Yes	Yes	No	Yes
CHITAL	Yes	Yes	No	Yes
CHELA	Yes	Yes	Yes	Yes
FARING	Yes	Yes	No	Yes
GHARUA	Yes	Yes	No	Yes
GUTUM	Yes	Yes	No	Yes
GILON CHAKI	Yes	Yes	No	Yes
ICHA(>2 species)	Yes	Yes	Yes	Yes
KECHKI	Yes	Yes	No	Yes
KAJALI	Yes	Yes	No	Yes
LACHU	Yes	Yes	No	Yes
JATKA, ILISH	Yes	Yes	No	Yes
JAINJA	Yes	Yes	No	No
MOLA	Yes	Yes	Yes	Yes
PHOLI	Yes	Yes	No	Yes
RITA	Yes	Yes	No	Yes
RUI	Yes	Yes	No	Yes
SHAKUSH	Yes	No	No	No
TENGRA	Yes	Yes	Yes	Yes
PUNTI	Yes	Yes	Yes	Yes
SHINGHI	No	No	Yes	Yes

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Species	Recorded in River		Recorded in Haor	
	1992-93	1993-94	1992-93	1993-94
MAGUR	No	No	Yes	Yes
LATI	No	No	Yes	Yes
KAIKKYA	No	No	Yes	Yes
SHOAL	No	No	Yes	Yes
GAJAR	No	no	Yes	Yes
KOI	No	No	Yes	Yes
BHEDA	No	No	Yes	Yes
COMMON CARP	No	No	Yes	Yes
ILISH	Yes	Yes	No	Yes
BAGHAIR	Yes	Yes	No	Yes

January-February 1994
Many *ilish, bacha, lachu*, and large *rui, boal*, and *catal* were observed migrating from outside the project into the haor during the beel fishing season. Some pregnant *shinghi, magur,* and *pabda* were in February. No *ilish, bacha,* or *lachu* were caught during this period last year, however breaches had been repaired during early February.

March-May 1994
Only a few fishermen were observed fishing, as most of the small beels were fished out.

Fish Abundance Based on NERP Sampling

The study attempted to determine the numbers of different species both inside and outside the embankments by sampling of strategic locations. Figure E3 shown the location of fish sampling sites. During the sampling, it was observed that:

- Few fish are found in areas with high velocity currents.
- The most fish were found on the river side of the cross embankment.
- Many important species were not found in the haor.
- Some juvenile species *(chanda, punti, icha, lati, chela,* and *kaikkya)* were always found in the haor.
- In general, fish grow less inside the haor than outside it.

Specifications of the nets used to obtain the samples is shown in the following table:

Table E8: Net Specifications Used in Sampling

Net Used	Length	Depth	Twine	Type	Mesh
Ber jal	35.0m	8.0m	Synth.	Mult.Fil.	1.5cm
Kona jal	35.0m	8.0m	Synth	Mosquito net	2.0mm

The *kona* and *ber jal* nets were set in an arc and then towed a short distance before lifting. Each net was 50 m long and would cover a circled area of 199 sq m. The estimated area swept by one haul was about 300 sq m. This figure was used to calculate the apparent nominal standing crops from *kona* and *ber jal* sampling (The term "standing crop" defines the production level at the time of observation in a particular fish habitat).

This sampling was intended to directly assess the numbers and seasonal varieties of fish. The study found that the average number of fish caught in *kona jal* nets doubled from 10.25 kg/ha during the 1992 monsoon to 21.1 kg/ha during the 1993 monsoon. That doubled figure compares evenly with the average 1992 river side catch of 20.4 kg/ha. Due to logistic constraints, only a few samples were taken. Fish catch estimates by type of equipment used for each sampling period follows:

Table E9: Fish Catch Estimates for Kona Jal

K O N A J A L					
Year	**Month**	**Location**	**No. of Hauls**	**Mean Standing Crop (kg/ha)**	**Range**
1992	July	Haor	5	7.20	1.1-10.0
		River	2	9.15	8.3-10.0
	Oct	Haor	8	10.25	6.7-18.5
		River	10	20.4	7.5-46.6
1993	Sept	Haor	11	21.1	9.3-63.3

Table E10: Fish Catch Estimates for Ber Jal

B E R J A L					
Year	**Month**	**Location**	**No. of Hauls**	**Mean Standing Crop (kg/ha)**	**Range**
1992	July	Haor	8	4.3	0.8-8.3
		River	5	2.68	1.16-5.0
	Oct	River	1	34.9	
1993	Sept	Haor	10	13.7	1.0-34.7

Fish Disease
Observations for the two different years (1992-93 and 1993-94) in Kawadighi Haor indicated that water logging and excessive amounts of rooted aquatic vegetation may increase fish disease. Improved hydrological conditions in 1993-94 reduced fish disease by more than 80 percent over the previous year.

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WINTER OF 1992-93

In 1992, fish disease (ulcerative syndrome) spread rapidly throughout the project area. The incidence of infection was two to three times higher than in the previous year. Incidence of infection by species is shown in the following table:

Table E11: Incidence of Infections

Species	Incidence of Infection
PUNTI	80%
TAKI	60-70%
BAIM	60%
BHEDA	60%
SOAL/ GAJAR	50%
B. TENGRA	40%
KAIKKYA	25%
SHINGHI	20%
CHANDA	10%

On average, about 75 percent of all fish were effected by diseases during the winter of 1992-1993. Local people suggested that when the haor is not flushed or the water mixed sufficiently, more fish become infected. In fact, more fish in the stagnant waters of Salkatua and Majerband Beels were infected than in Patasingra Beel which experiences more flushing and better natural water circulation.

Fishermen were interviewed and observations were made to determine the degree of disease in two beels in Rajnagar Thana. Majherband Beel is a shallow beel located in the middle of Kawadighi Haor, southwest of the Akali River. Patasigra Beel is located to the midwest of Kawadighi Haor, is deeper than Majherband Beel, and is connected with a canal. The following are disease observations in the two beels:

Majerband Beel:

- All fish species were affected.
- Some live fish were experiencing rotted flesh.
- Infected dead fish floated throughout the beel.
- About 75 percent of each *ber jal* haul were rotted dead fish.
- Fishing intensity declined in January 1993 and the numbers of newly infected fish seemed to be less, possibly due to increased water volume from Manu Barrage.
- Beel water was not clear and produced a bad odor.
- At the present time there is little flushing of the Majerband system or draining of water from the beel. However the Akali River is on one side of the beel and it may be possible in future to construct channels to and from the beel and introduce a flow of water through the beel.

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Patasingra Beel:

- All fish species were affected
- Some live fish were already experiencing symptoms.
- Infected dead fish floated in all but the deepest areas of the beel.
- About 25 percent of *rek jal* nets were rotted dead fish.
- Fishing intensity increased in January 1993 while numbers of newly infected fish was decreasing.
- Patasingra beel receives water from Digala Khal which is located in the southern part of the beel. Water drains out of the beel to the north to Mogra River and generally there is good circulation in the beel.
- Southern part of the beel was full of dense aquatic weeds which prevented fish movement.

The study found that during the last few years fish disease has helped reduce fish production inside the project area. Fish in the river, however, are basically free of disease. In the Manu Project area, the following observations on fish disease were made:

- Disease struck during the late monsoon when the area's water level was receding.
- Low temperatures may trigger disease.
- Disease started in the low elevation and in shallow regions.
- Fish in blocked water bodies were more prone to disease.
- The disease may be related to agricultural practice.

Disease incidences were monitored according to the depth of the beel, the extent of flushing or water exchange, density of aquatic weeds, agricultural land use, and fish species. Majher Band, Patasingra, Salkatua, and Chatal Beels were all monitored for fish disease. In general, it was found that:

- Fish in shallow beels with dense rooted aquatic weeds were more susceptible to disease than fish in other areas.
- Fish in beels that were not connected to other water bodies were more susceptible.
- More diseased fish were found in beels surrounded by intensive agricultural activity than in other areas.
- Smaller, shallow water herbivorous and slow swimming fish were contaminated earlier than others species.
- Flash floods and rain reduced both contamination and infection.

Habitat quality had a direct relationship with fish disease. The following is the probable scenario of the annual outbreak of fish disease:

1. Macrophytes grow rapidly during late monsoon due to less turbidity, less water movement, and increased sunlight.
2. Receding water levels cause fish deaths and spoil aquatic weeds.
3. Water bodies become polluted and lose their primary food producing capacity.
4. Fertilizer, insecticides, and herbicides runoff from adjacent agricultural land and increases pollution.
5. Fish metabolism decreases as temperatures lower.

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6. Herbivorous fish become more susceptible and infected first.
7. Carnivorous fish become infected later, but carry the disease long-term.
8. Reduced water velocity produces stagnation and anaerobic oxidation.

It was observed that heavy rain and flash floods reduce disease by 90 percent in all areas.

These observations are only preliminary and should be considered further through a detailed study before any fisheries development project is undertaken in the floodplain.

The observations and interpretation of fish disease outbreak in the Manu River Project suggests that habitat improvement is the best, and perhaps the only, practical measure to control fish disease.

<u>January 1993</u>
More than 75 percent of fish were effected by disease. Local people suggested that the haor needed outside water flowing in to flush a haor of pollutants and disease. People also said that infection was worse in Salkatua and Majerband Beels than in Patasingra Beel.

On 20 January 1993, less than five percent of the fish observed in the Sherpur wholesale market were diseased.

<u>February-September 1993</u>
No diseased fish were observed or reported during the four monitoring periods that took place between February and September.

WINTER OF 1993-94

<u>October-November 1993</u>
Some diseased fish were observed in the last week of October, but the numbers were much less than were reported during the same period of the previous year. Affected fishes include *punti, chanda, baim,* and *taki*.

<u>November 1993</u>
In the second week of November disease spread into the shallow beels, but still not as seriously as during the previous year. In the closed and isolated water bodies of Choto Kawadighi Haor, *punti, chanda, tengra,* and snakeheads were mainly affected. In December, more fish were infected.

<u>January-February 1994</u>
Some diseased fish were observed, with *tengra* being the most affected. *Punti, baim,* and *taki/lati* were also affected. The situation, however, was improving rapidly.

E.4 MONITORING FISHERIES

Fishing Communities
There are 21 fishing villages around Kawadighi Haor. In 1992, these villages had a population of 2,464 active fishermen; by 1993, the number increased to 4,340 active fishermen.

No other haor area of the northeast region has such a large fishing population, indicating the importance of Kawadighi Haor as a fishery. Historically, many political leaders and other influential people came from fishing communities. But, after the Manu Project was built and the fishery declined, many wealthy fishermen pursued more economically sound businesses. Currently, only the poor who have no other source of income, consider fishing as their primary occupation. A few people in the area participate in subsistence fishing. In the Manu Project area there are three fisherman groups: the Muslim Maimol group, and two Hindu groups, the Koibatya and Jele. There were 16 Fisheries Cooperative Societies (FCS) serving the Kawadighi Haor area in 1992-1993.

The Maimol group has some influence on the government administration of Rajnagar where many fishing villages are located. Historically, there were two Maimol families who owned the total Kawadighi Haor area, about 15,000 acres. Most of the land was acquired by the government in 1975.

A substantial number of fishermen were able to supplement their incomes by participating in beel fishing. These fishermen would negotiate with beel lease owners, usually agreeing to retain 20 to 25 percent of their catch. It was observed that no beel lease owners hire fishermen from outside the haor area. Other fishermen supplement their incomes by working in nikeries.

Fishing Survey

It was difficult to survey fishing activities within the Manu Project area because of communication and transportation problems, because there was no easy access to fishing villages, and there were no regular field workers.

It was not possible to visit every fishing villages within the Manu Project area. However, data were collected on 24 villages. It is interesting to note that fishermen avoided discussing the current fishing situation, but were keen to speak about past fishing in Kawadighi Haor. Figure E4 shows the locations of villages which were surveyed.

Fishing Equipment

YEAR 1: May 1992 - April 1993

July 1992
Current and *footpain* (locally made gill nets) were the primary fishing equipment used in the project area. Hooks and line were the second most used equipment. Few beshal nets were observed during the visit.

August 1992
Most fishermen used hooks and line, gill nets, and *kona jal* in the project area. *Lati* was the main species caught using hooks and line, while *koi, shinghi,* and *punti* were the main species caught in gill nets. *Mola, chela, chanda,* and *punti* also were caught in *kona jal*. Some *thela jal* were used by families for consumption fishing.

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Table E12: Equipment and Catch in 1992-93

Fishing Equipment	Species caught
Current jal	Punti, sing, koi, chapila, meni, rui/catal fry
Fanda jal	Boal, ghagot, rui, katla, kangla, mrigel
Hook	Taki, sing, shol, magur, gojar
Hato jal	Chapila, chela, mola,
Phelun	Icha, chanda
Bara jal	Boal, rui, katla, ghagot, carp, kangla
Kun	Tengra, golsha
Chai	Tengra, golsha

Source: Field observation

September-October 1992
The same fishing equipment was used as was used in the previous month.

December 1992
Current *jal* and *kona jal (tana jal, ber jal, hatu jal)* were the main fishing equipment used during beel fishing, although a current *jal* between 2.5 and 8 cm mesh was the most popular. Two persons are required to operate a current *jal*, but it takes 20 people to operate a *tana jal* and eight to operate a *hatu jal*. The equipment used in two different beels is given below:

Table E13: Fishing Equipment Used

Equipment	Size	No of Units in Katasingra Beel	No of Units in Ulauli Beel
Current jal	250-300 m	55-60	30-35
Kona jal (tana)	200-250m/5-6m	2	1
Kona jal (Hatu)	50-75m/4-5m	6	3

January 1993
Ber jal, gill nets, *rek jal* (smaller than *uther), chouhanda, ural jal, thela jal, beshal jal,* and *pollo* were used for beel fishing. *Chouhanda jal* and *ural jal* were specialized for *katha* fishing, while gill nets, *thela jal, beshal jal,* and *pollo* were used in normal fishing. *Ber jal* and *rek jal* were commonly used for both.

February-April 1993
Harpoons, *chai*, and *thela jal* were used primarily during this period. A few current *jal* and *beshal jal* were also used.

YEAR 2: May 1993 - May 1994

June 1993
Kona jal, beshal jal, current nets, and hooks and line were the main equipment used during this monitoring period. Some traps such as *ukha, chai, dori,* and *ucha* were used to catch *tangra* around Racta Village.

July-August 1993
The same equipment observed in June was used in this period.

August-September 1993
Tana jal, hator jal, uther jal, current nets, *thela jal,* and hook and line were used during this period. *Gui, ucha,* and *dori* also were used.

October-November 1993
Hook and line, current nets, *tana jal, thela jal, bel jal, bar jal,* and *afa jal* are were used primarily during this period.

January-February 1994
Most fishing continued in the beel areas using *tana jal, hator jal,* current nets, gill nets, and *uther* nets. *Thela jal* was used in shallow areas and some *bhesal* nets were fixed in the canals.

Beel Fishing
There are 79 beels in Kawadighi Haor with a total area of 1,223 ha. Among the government-owned beels, 21 are eight ha or larger and 32 are smaller than eight ha. Another nine are privately owned with total area of 127 ha. Seventeen beels with a total area of 185 ha have mostly silted up and are no longer leased. A substantial proportion of the private beels are cultivated for boro crops. Most of the silted beels, both private and government owned, are fallow due to poor drainage.

Beels larger than 8.1 ha were leased out by the district administration, while those between 1.2 and eight ha were leased out by the Thana Nirbahi Officer. There was no bidding process for small beels less than 1.2 ha, which bring Tk. 5,000 a year. Instead these were leased out without competion among the FCS.

Beside each large beel, a temporary *khola* was set up for harvesting fish. Each *khola* contained 20 to 25 thatched bamboo rooms and is set up in *agrahayan*. Fresh fish were sold everyday in the *khola*.

Between 10 and 15 groups of local fishermen, and two or three groups from outside areas, fish in the main beels. Each group of 10 to 15 persons possessed at least one *tana jal* and made their own house in the *khola*. At the beginning of the fishing season when the most fish were caught, the lessee of the *khola* received 70 to 80 percent of the sale, while the fishermen received only 20 to 30 percent. As the volume of the catch decreases over time, the fishermens' share increased up to 50 percent.

Each fishermen group was allowed to keep some big fish for consumption. In many cases, the fisherman opted to sell the big fish, earning between Tk. 10 and 15 per fish.

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Conflicts also arose between beel lease owners and farmers. For example, farmers who cultivated boro rice around Singua Beel dug ditches beside their respective plots for fish. As the water receded, the farmers caught the fish in the ditches. The beel lease owner complained that sometimes the farmers' ditches encroached into the beel. About 250 to 300 ditches were found around the beels of the area and the lease owners claimed the harvested fish. Confrontations were frequent between farmers and lease owners, and a few times the disputes were brought to court.

Beel fishing equipment used in the dry season includes: *tana jal, gur jal, rek jal, pai jal, ural/jhaki jal,* and *dhundi jal*. In the monsoon season it includes: *phelun jal, tana jal, bara jal, fanda jal, bel jal, pai jal, chai, guin,* and *borshi*.

Poor fishermen used to fish free of charge in the shallow waters of the haor during the monsoon. Currently, they must pay. Fishing with hook and line cost Tk. 5 per day, with *pai jal* cost Tk. 10 per day, and with *tana jal* with boat cost Tk. 40 to 50 per day. Some people were allowed to fish without paying. Most fish with hook and line.

Table E14: Fishing in Katasingra beel, January 1994

Date (January)	Equipment used	Catch (%)			Total catch (kg)	Estimated price (taka)
		Big fish	Medium fish	Small fish		
1-5	tana/hator jal: 17-19	30	10	60	9,000	375,000
6-10	tana/hator jal: 17-19	48	13	39	7,750	250,000
11-15	tana/hator jal: 17-19, uthar jal: 1, jhaki jal: 20, polo: 20	21	42	37	11,499	350,000
16-20	tana/hator jal: 6-15, jhaki jal: 20, polo: 20	25	35	40	4,200	150,000

Source: Interview

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Table E15: Fish resources in Katasingra beel

Abundance of fish stocks	Species	Change in abundance (%) between 1992-93 and 1993-94	
		Increase	Decrease
High	Karpu	95	
	Katla	60	
	Ghagot	10	
	Rui	80	
	Boal	10	
	Taki		10
Medium	Mrigel	50	
	Icha		25
	Punti		40
	Tengra		25
	Gulsha		30
	Meni		5
	Shol/gojar		10
Rare	Kaliara		25
	Puta		85
	Lasso		90
	Goinna		90
	Koi		70
	Sing		65
	Magur		70
	Chitol	15	
	Pabda	5	
	Baim	5	

Source: Interview / field observation

Winter of 1992-93

December 1992
Fishing in Ulauli, Majerband, Patasingra, and Karadhair Beels started early due to fish disease and the possibility of rising of water levels. However, fishing in some small, shallow beels, such as Kua Beel, was finished, while fishing in some larger beels had not begun. Fishing will

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continue until March.

Fish disease was widespread throughout the project area. The Manu Barrage was scheduled to close on 25 December 1992, which might cause rising water levels within the project area.

Annual beel fishing in large beels consists of two phases: normal fishing during this period and *katha* fishing which starts in late January.

Each September, the lease owner installs a *katha* (branches of jarul, karach, or bamboo in late September for fish shelter. The number of *katha* depends on area and fishing intensity. The fishermen set a net-wall surrounding the *katha* to capture the fish. In other areas fish were caught with gill nets, and kona jal. On 22 Dec. 1992, the harvest from Ulauli and Katasingra Beels was Tk. 5,000 and Tk. 12,000, respectively.

On 19 January, the first *katha* catch in Patasingra Beel was made. At that time the lease owner discussed the history of the beel fishery. He said he had been involved in fishing Patasingra Beel since 1963. He said he earned about Tk. 2,00,000 in 1963 when the price of *rui* was Tk. 100 per maund. He estimated that the current value of the beel should be ten million taka, but the resource is degrading, he said, because of the Manu Project. During this period, the amount paid for the lease has increased from Tk 2,000 per year in 1963 to Tk. 226,500 in 1992 and Tk. 460,000 in 1993.

That day's catch included three kg *carpio, catla,* and *rui*.

Fishermen consider water depth (deepest area is preferable) and the bottom of the beel (smooth bottom is preferable) when selecting a site for a *katha*. The best locations are adjacent to fish migration routes and free of disturbances. People usually try to set a *katha* when water levels have started to drop during the late monsoon. This encourages fish shelter in the *katha*.

Katha were set in the main beel fishing areas. Fishermen try to maximize the number of fish in the *katha* by closing off their access to connecting canals. After a reasonable fishing water level was reached, fishing began, but the *kathas* were left undisturbed so that more fish would find their way into the shelters. Sometimes fish were fed supplementary foods while in the *katha*. Suitable times were set for *katha* harvest, which takes place several times within a season depending on fish numbers and water volume.

The following is an example of one particular harvest: The *katha* was surrounded by a *chouhanda* net or *ber jal* to prevent the fish from escaping. A *ural jal* was set above the *chouhanda* net to make a pocket to trap fish that jumped out. Then, all the branches were removed for fishing. *Ber jal* was the equipment used to fish and nine fishing groups were hired to do the work. One was set and dug slowly so not to disturb the fish, while a second net was set a few meters behind the first to harvest any escaping fish. Sometimes four or five nets are set for this purpose. Other nets and equipment were used after the *ber jal*. After the harvest, the *katha* was set for next one.

This harvest took three to five days to complete. In the first haul of the season, the fishermen harvested approximately 250 kgs of fish. These were sold by auction, on the spot, for Tk. 16,000. The following species were caught during beel harvesting:

Table E16: Species Caught during Beel Harvesting

Main Species	Secondary Species	Rare Species
PUNTI	CHAPILA	CARPIO*
TENGRA	PHOLI	CATLA*
CHINGRI	GONIA	RUI*
BHEDA	BOAL	GALDA*
LATI	KOI	PABDA*
SHOAL	CHELA	AIR
BAILA		BAIM
SINGH		LACHU
KAIKKYA		KALIBAUSH
CHANDA		

February-April 1993

There was no beel fishing during this period, but the *kholas* were not removed. They were used for agricultural purpose. It was reported that the current lease holder renewed his leases on Majerband and Shalkatua Beels for nine and 10 years, respectively. The lease was fixed at Tk. 60,000 for Majerband Beel, and Tk. 126,720 for Shalkatua Beel for the first year. The lease will increase by 10 percent for each following year.

Winter of 1993-94

October-November 1993

Lease holders were preparing for beel fishing. In some areas, bamboo mats were installed to separate one beel from another. In some beels, fishermen were placing *katha* and areas were prepared for *kholas*. All connecting channel were closed.

November 1993

Beel fishing started in the shallow, small beels during the mid-November. The haor water was not draining sufficiently. *Kholas* were prepared at Patasingra, and Majerband Beels. Fishermen were recruited. Lease owners seemed confident of a large harvest due to the breaches in the embankment.

January-February 1994

Beel fishing in most of the shallow beels and in 80 percent of the larger beels was already completed. *Katha* fishing started during late January in Patasingra Beel. Lease owners predicted that fishing may continue through late March. The lease owner of Majerband and Salkatua Beels decided to reserve some *katha* as piles to increase the next year's production.

The lease owner of Patasingra Beel recruited 24 fishing groups with 174 fishermen. Twelve *tana/hator* nets were used to fish in Patasingra Beel. Fifty percent of the fishing was completed during the first 20 days. Fishing continued through February. Patasingra Beel yielded approximately 65 tons this period, in comparison with the 6.4 tons yielded during the same period last year. The value of harvested fish was Tk. 2.25 million, but only Tk. .35 million at the same time last year. The average price of fish declined by 15 to 20 percent over last year.

Yields from the different beels within the project area were significantly higher than during the last two years. Information about different beel yields are cited in the following table:

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Table E17: Beel Fish Yields

Beel	Area (ha)	Production (kg)	Value (Tk)	Composition (LARGE:SMALL)
Ulauli beel *	2.6	7,900	315,000	60:40
Salkatua and Majerband beel *	110	38,500	1300,000	35:65
Rukya beel *	5.7	8,500	350,000	65:35
Karadhair River	4.2	7,200	325,000	80:20
Patasingra beel	234	64,300	2250,000	40:60

** Actual area is greater than the recorded area.*

Fish Production Estimates

To estimate the current fish production, 2,501 fishermen households were identified. Fishing intensity was negligible compared with the numbers of fishermen residing within the haor. The *cpue* was lower and the fishing season was shorter in Kawadighi Haor than in Shanir Haor.

A survey found 676 *sangla* nets, 488 gill nets, 352 hook and line sets, and 247 *jhaki jal* within the project area. Fish production was calculated on the basis of fishing intensity and the amount of equipment used during different months. The average number of fish in the Manu River floodplain was estimated on the basis of NERP sampling records in different months.

YEAR 1: May 1992-April 1993

Floodplain Production during Monsoon:

Table E18: Catch by Kona (Ber/Hatu) Jal (1992 monsoon season)

Month	No of Units	Catch per haul (kg)	Hauls per day	Fishing Days	Total Catch (kg)
July	20	3.00	8	20	9,600
August	35	4.00	8	28	31,360
Sept	42	5.50	8	28	51,744
Oct	25	5.00	8	15	15,000
GRAND TOTAL =					107,704

E19: Catch by Gill net (1992 monsoon season)

Month	No of Units	Catch per unit (kg)	Fishing Days	Total Catch (kg)
July	150	2.00	20	6,000
Aug	225	4.00	25	22,500
Sept	400	5.00	25	50,000
Oct	400	5.00	15	30,000
GRAND TOTAL =				108,500

Table E20: Catch by Hook & Line (1992 monsoon season)

Month	No of Units	Hooksper Unit	Catch per 100 hooks	Fishing Days	Total Catch (kg)
July	100	750	0.20	25	3,750
Aug	250	750	0.25	25	11,718
Sept	300	750	0.30	28	18,900
Oct	300	750	0.35	28	22,050
GRAND TOTAL =					56,418

Assuming that the catch using *jhaki jal* was about .5 kg/net/day, with 25 fishing days, and 247 units in use, the catch was estimated to be 12,348 kg for the monsoon season. The catch using *tela jal* was estimated to be 10 percent of total catch obtained using four other types of equipment (= 28,497 kg). The *thela jal* catch was not included in the first PMP year but was included in the second year. *Uthar jal* was not used in 1992 and only three or four *khora jal* were used. Total catch using the five main types of equipment was estimated to be 313,400 kg in 1992: Kona jal, Gill net, Hooks and line, Jhaki jal, and thela jal:107,700 + 108,500 + 56,400 + 12,300 + 28,500 = 313,400kg.

Total Annual Production

Total production during Year 1 (May 1992 - April 1993) is summarized in the following table:

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Table E21: Total Annual Production Year 1

Season/Habitat	Gear	Production (tons)	
		tons	%
Monsoon/Floodplain	Kona Jal	107.7	32.0%
	Gill nets	108.5	32.2%
	Hook & Line	56.4	16.8%
	Jhaki Jal	12.3	3.7%
	Thela Jal	28.5	8.5%
Dry Season / Beels		23.3	6.9%
ANNUAL TOTAL		336.7	100%

Yields per area

The average floodplain yield from 10,200 ha during the monsoon was 30.7 kg/ha. The average *kona jal* catch during the monsoon was 8.7 kg/ha, while the average *ber jal* catch was 4.3 kg/ha. Dry season beel yields from 833 ha was 28.0 kg/ha.

YEAR 2: May 1993-May 1994

Floodplain Production during Monsoon:

Table E22: Catch by Kona Jal (1993 monsoon season)

Month	No of Units	Catch per haul (kg)	Hauls per day	Fishing Days	Total Catch (kg)
July	30	3.0	8	25	18,000
Aug	40	5.0	8	27	43,200
Sept	45	5.0	8	27	48,600
Oct	35	4.0	8	20	22,400
GRAND TOTAL =					132,200

Table E23: Catch by Gill net (1993 monsoon season)

Month	No of Units	Catch (kg) per unit per day	Fishing Days	Total Catch (kg)
July	400	2	20	16,000
Aug	550	3	25	41,250
Sept	700	4	25	70,000
Oct	750	4	25	75,000
GRAND TOTAL =				202,250

Table E24: Catch by Hooks and Line (1993 monsoon season)

Month	No of Units	Hooks per Unit	Catch (kg) per 100 hooks	Fishing Days	Total Catch (kg)
July	200	750	0.50	25	18,750
Aug	250	750	0.60	28	31,500
Sept	300	750	0.75	25	32,187
Oct	300	750	0.6	20	27,000
GRAND TOTAL =					119,437

Table E25: Catch by Uther jal (1993 monsoon season)

Month	No of Unit	Catch (kg) per unit	Fishing Days	Total Catch (kg)
July	15	2	20	600
Aug	20	3	25	1,500
Sept	30	4	25	3,000
Oct	40	4	20	3,200
GRAND TOTAL =				8,300

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Table E26: Catch by Bhesal/ Khora Jal (1993 monsoon season)

Month	No of Unit	Catch (kg) per Unit	Fishing Days	Total Catch (kg)
June	30	10	25	7,500
July	30	7	20	4,200
Aug	20	5	20	2,000
Sept	20	5	20	2,000
Oct	20	4	15	1,200
GRAND TOTAL =				16,900

Table E27: Catch by Thela Jal (1993 monsoon season)

Month	No of Unit	Catch (kg) per day	Fishing Days	Total Catch (kg)
June	600	0.50	25	7,500
July	750	0.75	25	14,062
Aug	750	1.50	25	28,125
Sept	800	1.50	25	30,000
Oct	700	0.75	25	13,125
GRAND TOTAL =				92,812

Total catch by the six types of equipment was 571,899 kg.

Beel Production during Dry season

The total production of all beels (total area of 833 ha) inside the project during the dry season was estimated at 230,000 kg. This calculation was based on a 275 kg/ha catch from Patasingra Beel which was estimated from interviews with local fishermen.

Total Annual Production

Total production during Year 2 (May 1993 - May 1994) is summarized in the following table:

Table E28: Total Annual Production, 1993-94

Season/ Habitat	Gear	Production (tons)	
		tons	%
Monsoon/ Floodplain	Kona Jal	132.2	16.5%
	Gill net	202.3	25.3%
	Hooks & Line	119.4	14.9%
	Uther net	8.3	1.0%
	Bheshal/Khora jal	16.9	2.1%
	Thela jal	92.8	11.6%
Dry season / Beels		229.1	28.6%
ANNUAL TOTAL =		801.0	100%

Yields per area

The average floodplain yield on 10,200 ha during the monsoon was 56.1 kg/ha. The average *kona jal* catch during the monsoon was 28.2 kg/ha, while the average *ber jal* catch was 13.7 kg/ha.

It is noted that the beel fishing represented less than 10% of the total catch in 1992 and about 30% of the total catch in 1993. The fish catch in 1992 was lower in part due to the effect of disease. It is also noted that beel fishing is highly profitable for a small number of individuals, compared with the floodplain fishery in which a large number of people are engaged.

The total fisheries production estimated to be 336 T in 1992 and 800 T in 1993. The production was 2.5 times higher in 1993 than 1992 due to the wetter hydrologic conditions and the effects of embankment cutting in 1993, plus the effects of fish disease in 1992.

Comparing these production estimates with those for pre-project conditions (640 T/year) which were presented earlier, it appears that fisheries production may have decreased by as much as 50%. However, these yield estimates, especially pre-project, are very approximate.

INTERYEAR COMPARISON

Production, yields, and flood intensity in years 1 and 2 is compared in the following table:

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Table E29: Inter Year Comparisons

	Season & Habitat	Year 1 (May 92-Apr 93)	Year 2 (May 93-May 94)	% Change
PRODUC-TION	Monsoon Floodplain	313.5 t	571.9 t	+ 82.4%
	Dry season beels	23.3 t	229.1 t	+ 883.3%
	TOTAL =	336.7 t	801.0 t	+ 137.9%
YIELD	Monsoon Floodplain	30.7 kg/ha	56.1kg/ha	+ 82.7 %
	Dry season beels	28.0 kg/ha	275 kg/ha	+ 882.1%
FLOOD INTENS-ITY *	Entire floodplain	1,237 mcm-months	2,066 mcm-months	+ 67.0%

** A flood intensity index was calculated as the area under the flood volumes curves presented in Section 4.1 and Appendix A.*

Figure E5 shows the relative contribution of the different types of fishing area. Figure E6 compares the floodplain and beel production in the two years. Figure E7 shows a preliminary correlation between flood intensity and fish production based on the data for the two years.

Pond Fishery

There were ponds in every village in Kawadighi Haor. The ponds were submerged during floods, allowing all fish to escape. Pisciculture was not practiced in all ponds because the profit margin is low. Also, people fear losing their cultured fish during floods. *Rui, katla,* and *mrigel* fingerlings were the primary cultured species.

There were seven fingerling traders from Gargaon Village doing business in Panchgaon Village. They grew fingerlings in several ponds in Panchgaon under two systems: an annual lease with a pond owner, or an income-sharing arrangement in which the pond owner receives half of the sale proceeds from fingerlings.

Traders bought eggs from Chittagong for Tk. 8,000 per kg and first placed them in shallow ditches adjacent to the ponds. After hatching, the fries were released in the ponds. When the fingerlings reached two inches in length, they were caught and put back in the adjacent ditches for sale. Fingerlings were traded from choitra to baishakh. Fingerlings were sold between Tk. 200 and Tk. 500 per thousand depending on the species. Traders can make up to Tk. 600,000 on the sale of their fingerlings.

Pond owners involved in pisciculture often spent between Tk. 500 and Tk. 1,000 for fingerlings. Fish are ready for harvest after one or two years. If fish were harvested by hired fishermen, the fisherman received one-third of the big fish and one-third or half of the small fish. Some pond owners preferred to pay fishermen in cash, usually at a rate of Tk. 200 to Tk. 300 per pond. Some pond owner also sold all their fish, except a few for personal consumption, to the fisherman. Pond owner could earn between Tk. 5,000 and Tk. 10,000 in one year.

Ponds are leased, in advance, for one or three years. As there was for fingerling traders, there also is a share system in which the lease owner pays for all costs, including fingerlings, fish feed, guard's wage, and fishermen's salaries. The lease holder receives one-fourth of the harvest.

Fish Processing

Kawadighi Haor is surrounded by Moulvibazar, Sherpur, Rajnagar, Balagonj, and Fenchuganj that provide markets for fresh fish. There are many consumers for the fish, as the production is not enough to meet the demand of the people living in the area. As a result, fish processing in the area is uncommon. During the dry season, large numbers of diseased fish show up at the markets, but only the poor buy these cheap fish. To avoid losses, or to make some profit, fishermen often dry diseased fish for marketing during the lean periods.

Fish Markets and Prices

There were many weekly village markets and regular town markets around the Kawadighi Haor. But after construction of the Manu Project, fish production dropped and the local people needed all the area's fish for their own consumption. As the fish production dropped, fish prices increased.

Because of the reduced fish production in the haor, fish traders often waited to buy fish from only one net, while in other haors, traders bought from several fishermen. As a result, fish was often in short supply in the markets. For example, on 28 August 1992, no haor fish were available in the Kashempur market near the pump house, and only one trader was selling hilsha for Tk. 80 to Tk. 90 per kg.

After beel fishing started in November 1992, most of the harvested fish were directly sold to nikeries from the *khola*. The selling, buying, and transporting to market was all accomplished before markets opened as their was no icing facility to prevent spoilage. Selling procedures and prices of different fish from different beel varied. The following are common characteristics of the *khola* fish market:

- Most small fish were sold on a mixed lot basis.
- No fish were sold by weight.
- Price depended on size, species, and quality.
- Big fish were sold by size and species.
- Fish sold by open auction only.
- Total catch was divided into smaller volumes to allow the poorer nikeries to participate.

It was not possible to collect the price of particular species because field visits did not coincide with market days, and all the fish species were not found in the markets visited.

January 1993

No permanent village market was visited during except Sheerpur Ghat. Selling procedures and prices in Majerband and Patasingra Beels follows:

Majerband beel (18 January 1993):

- No large fish were observed.
- Most fish were sold on an average basis not by species.
- Most fish were diseased.

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- Prices were: Tk. 15/kg for *punti* (for drying), Tk. 35/kg for mixed fish *(singhi, koi, punti, kangla)*, Tk. 25/kg for *kaikkya*.

No fish was sold on the basis of weight. Fish price depended on size, species, and quality.

<u>Patasingra beel</u> (19 January 1993):

- Big fish were sold by size and species.
- One to four kg sized *boal* sold for Tk. 60-90/kg, two to three kg *carpio* sold for Tk. 90-100/kg, .6 to .9 kg *gonia* sold for Tk. 40-50/kg, and .75 kg *air* sold for Tk. 30-40/kg.
- Mixed fish *(punti, chingri, tengra, chanda, baim, lati, baila, gutum, pholi,* and *chela)* sold for Tk. 12-15/kg, and mixed fish *(pholi, lachu, pabda, kalibaush,* and *air)* sold for Tk. 40-45/kg.
- Most fish sold in open auctions in various sized volumes.

<u>February-April 1993</u>
Traders were supplied with fish from outside the project area and sold them to local markets. *Ilish* and pond fish dominated the market.

<u>June 1993</u>
Bhumiura fish market was visited.

<u>July-August 1993</u>
Fish prices were observed. Average fish prices at the pump house market and at the Machuakhali temporary fish market were noted.

<u>August-September 1993</u>
Manumukh market, the floating market at the Machuakhali breach, the Rajnagar fish market, and the Maulvibazar fish market were observed.

<u>October-November 1993</u>
The price of some fish increased over the last month, while for others, the price decreased. The average fish size was larger than during the same period of the previous year.

<u>January-February 1994</u>
The following table shows the prices of different species in market observation in Rajnagar, Tengra Baazar, and Munshi Baazar. The prices in the beel area were 15 to 20 percent less than the market price.

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Table E30: Manu River Fish Prices (June 1992-May 1993)

Species	J	J	A	S	O	N	D	J	F	M	A	M
RUI												
CATLA												
CARPIO												
KALIBAUSH												
AIR								35				
ILISH			80						70	70	70	
GONIA								40				
MAGUR		50							65	70	70	
SINGHI		50							65	70	70	
LATI	25											30
PUNTI		30						12	25	30	30	
KOI		50						40				
BAILA												
PHOLI												
BAIM												
CHAPILA												
SHOAL/GAJAR												
CHANDA												
PABDA												
KAIKKYA								25				
ICHA									20	25	25	
Small fishes									25			
BOAL								60				
RITA												
GOLDA												
TENGRA												
CHANDA												

Table E31: Manu River Fish Prices (June 1993-May 1994)

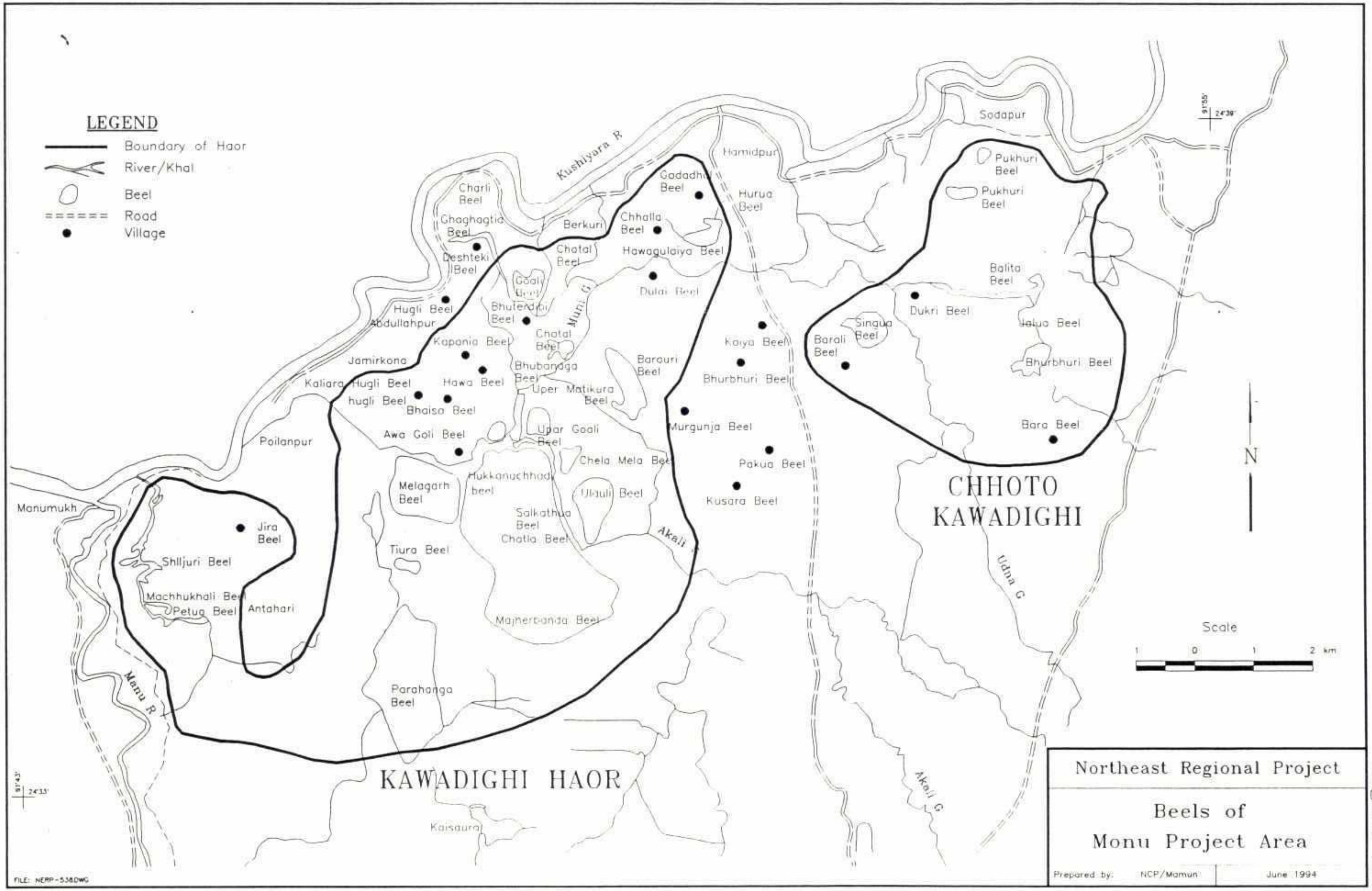
Species	J	J	A	S	O	N	D	J	F	M	A	M
RUI			75	75	70		70	90				
CATLA			70	70				65				
CARPIO		45	50	55	55	45	60	90				
KALIBAUSH					45	50						
AIR			45	45					65			
ILISH	60	60	65									
GONIA												
MAGUR		50	50									
SINGHI		50	50									
LATI	30	25	25	25		30	25	30	30			
PUNTI			25		25	25			25		45	
KOI												
BAILA					25							
PHOLI				35	30			40	45			
BAIM				45	45			40	45			
CHAPILA			30	20	20	30	20	20				
SHOAL/GAJAR				45				45	45			
CHANDA				20							25	25
PABDA								85				
KAIKKYA					25							
ICHA						10	10	5			35	35
Small fishes	20	20	20	20		20		15	20			
BOAL				45	55			60				
RITA		95										
GOLDA		150	150									
TENGRA	45		40	40	25	30	30	30	30		50	50
CHANDA				20							25	25

Table E32: Fish Prices at Selected Markets

Species	Price/kg (tk) in 1993-94						
	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Icha	12-15	10-12	8-10	8-12	8-10	25-30	40-45
Chanda	12-15	10			12	10	15-20
Puti	20	20	20	20-25	25	40-50	70-80
Taki	20-25	20	15-20	15-20	30	45-50	65-70
Baim	45-60		45	45	45	55-60	80100
Sing	55	50	50-60	55-60	55-60	60	120
Magur	55	55	50-60	55-60	60	100	125-130
Koi	55-60	55	50-60	55-60	60	100	120
Meni	35	35	30-35	30-35	40	40-45	60-70
Tengra	40-45	45	50	40	45	50-55	70-75
Boal	45-50	45-50	50	50	50-55	60	80-90
Ghagot	40-50	50	50	50	50	60	80-90
Kangla	50-55	50	50	50		80-100	90-110
Rui	50	55	55-60	55-60	55-65	120	
Katla	50	55	55-60	55	55	120	
Mrigel	50	50	50	50	50	40-50	70-80
Chapila	20-30	20	15-20	20-25			
Kali baush	50-55	50	50	55	45-50	100	125
Shol	35-40	35	30-35	30-35	40	75-80	100
Gojar	35-40	35	30-35	30-35	35	75-80	100
Karpu	50	50	50-55	50-55	55	80	100
Golsha					45-50	60-70	
Pabda					65		
Chitol					65		
Gura machh	20-25	20	15-20	15-20		25-30	60-70

Source: Field observation at Modhurbazar, Oisoderbazar, Azaderbazar and

Figure E.1


LEGEND
Boundary of Haor
River/Khal
Beel
Road
Village
Kushiyara R
Sodapur
Hamidpur
Pukhuri Beel
Pukhuri Beel
Balita Beel
Dukri Beel
Jalua Beel
Bhurbhuri Beel
Singua Beel
Barali Beel
Bara Beel
CHHOTO KAWADIGHI
Udna G
Akali G
Huruo Beel
Koiya Beel
Bhurbhuri Beel
Murgunja Beel
Pakua Beel
Kusara Beel
Gadadhu Beel
Chhalla Beel
Hawagulaiya Beel
Dulai Beel
Barouri Beel
Berkuri
Chatal Beel
Muni G
Charli Beel
Ghaghagtia Beel
Deshteki Beel
Goali Beel
Bhuterdai Beel
Chatal Beel
Hugli Beel
Abdullahpur
Kapania Beel
Bhubandga Beel
Uper Matikura Beel
Jamirkona
Hawa Beel
Kaliara
Hugli Beel
hugli Beel
Bhaisa Beel
Awa Goli Beel
Upar Goali Beel
Chela Mela Beel
Poilanpur
Melagarh Beel
Hukkanuchhadi beel
Ulauli Beel
Salkathua Beel
Chatla Beel
Akali
Manumukh
Jira Beel
Shiljuri Beel
Tiura Beel
Machhukhali Beel
Petua Beel
Antahari
Majherbanda Beel
Manu R
Parahanga Beel
KAWADIGHI HAOR
Kaisaura
N
Scale
1 0 1 2 km
Northeast Regional Project
Beels of Monu Project Area
Prepared by: NCP/Mamun
June 1994
FILE: NERP-538DWG

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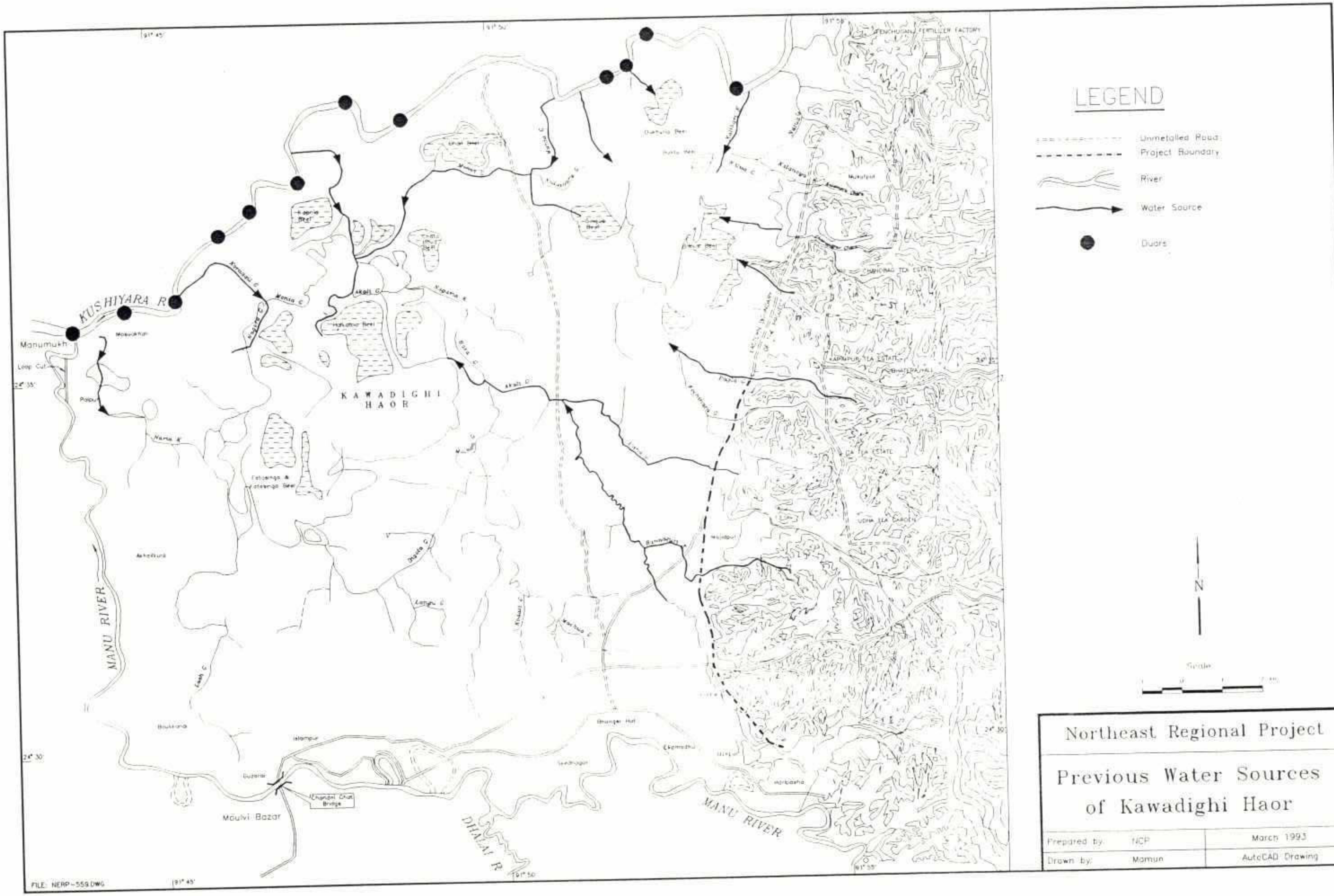
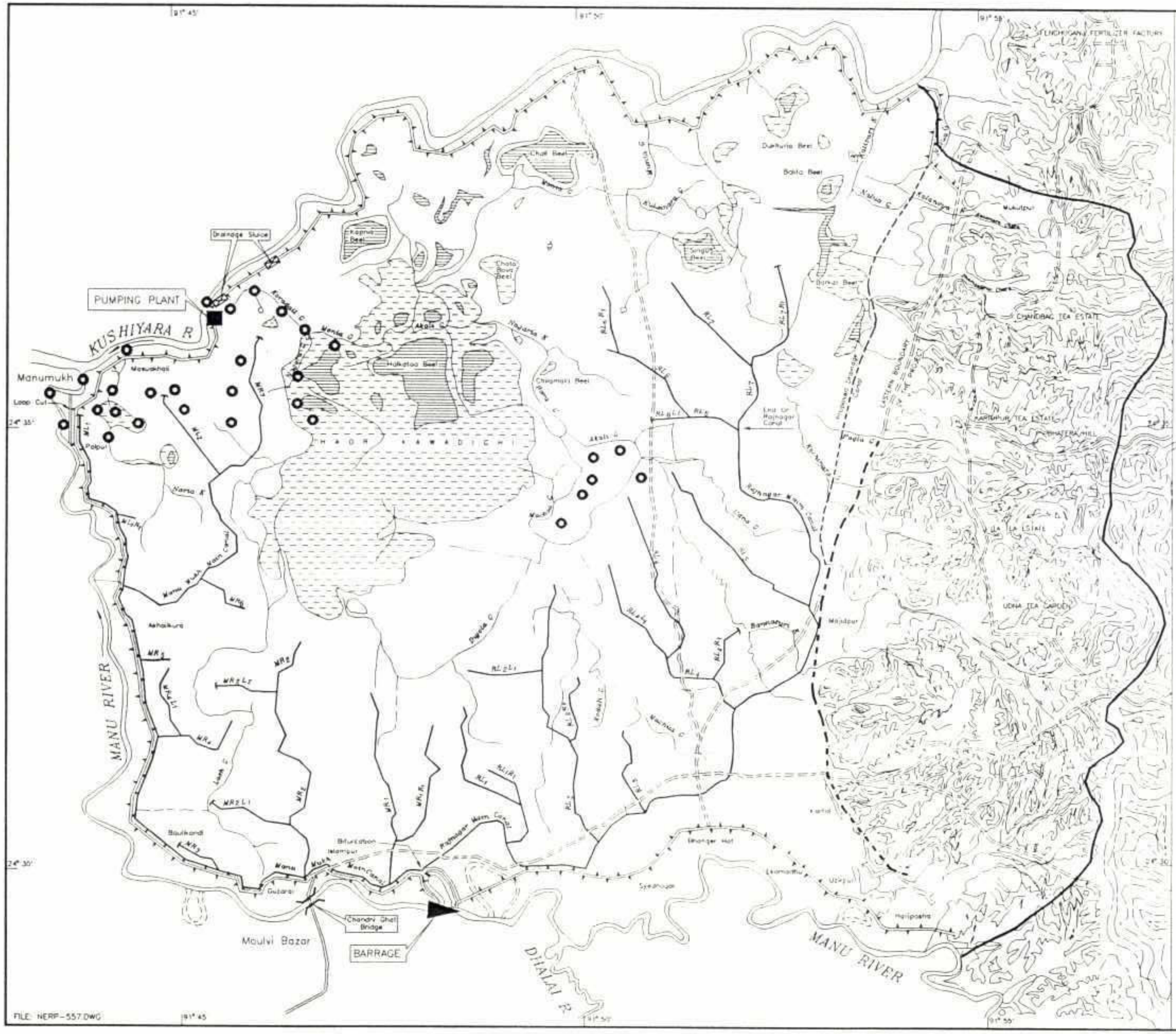


Figure E.2



LEGEND

- Irrigation Canal
- Flood Embankment
- Metalled Road
- Unmetalled Road
- Drainage Canal
- Project Boundary
- Proposed Drainage Canal
- River
- Drainage Sluice
- Pumping Plant
- Barrage
- NERP Fisheres Samploing Places

N

Scale
1 0 1 2 km

Northeast Regional Project

NERP Fishing Sampling Places with in Manu Project

Prepared by:	NCP	March 1993
Drawn by:	Mamun	AutoCAD Drawing

Figure E.3

Figure E.4

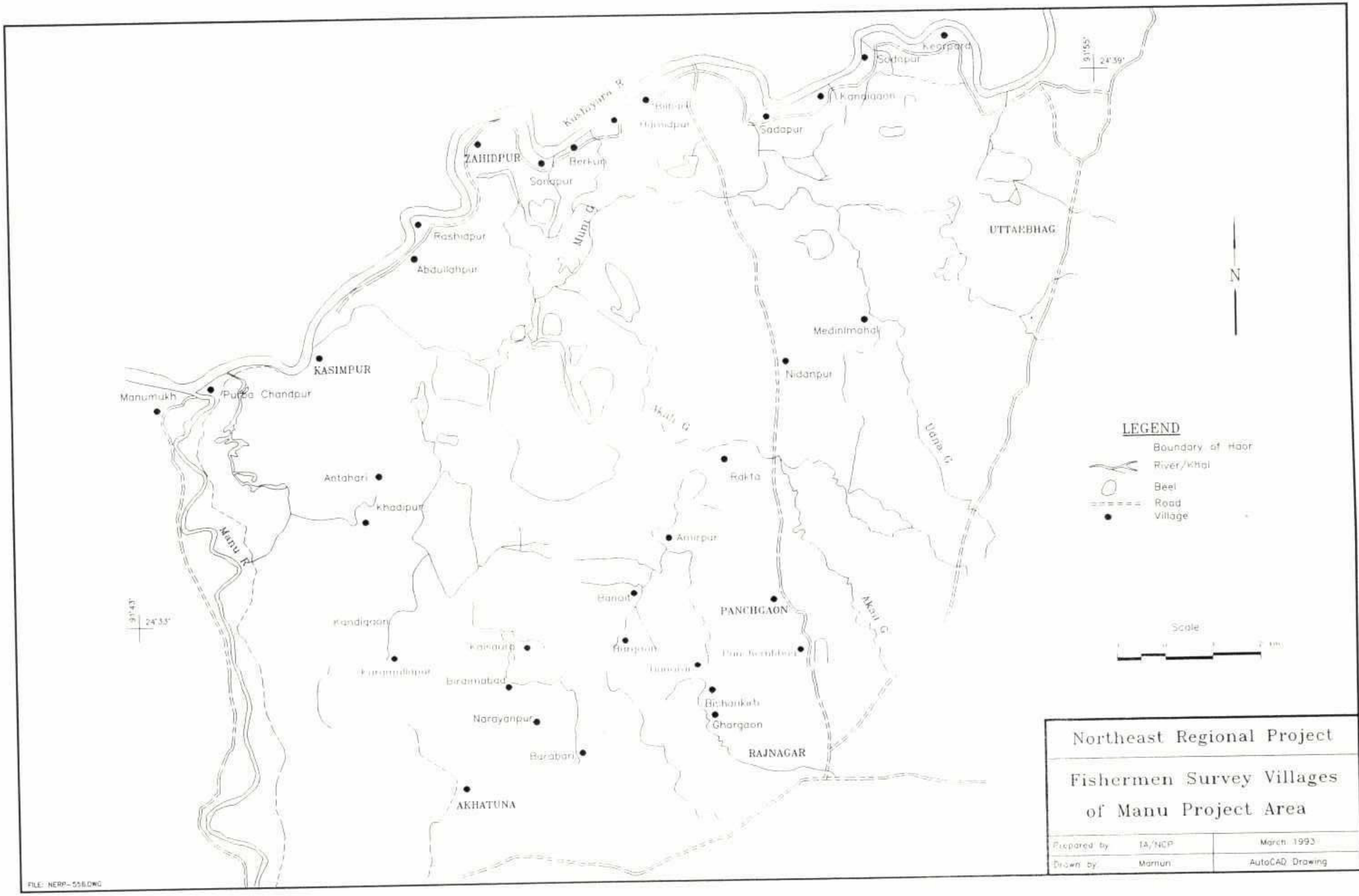
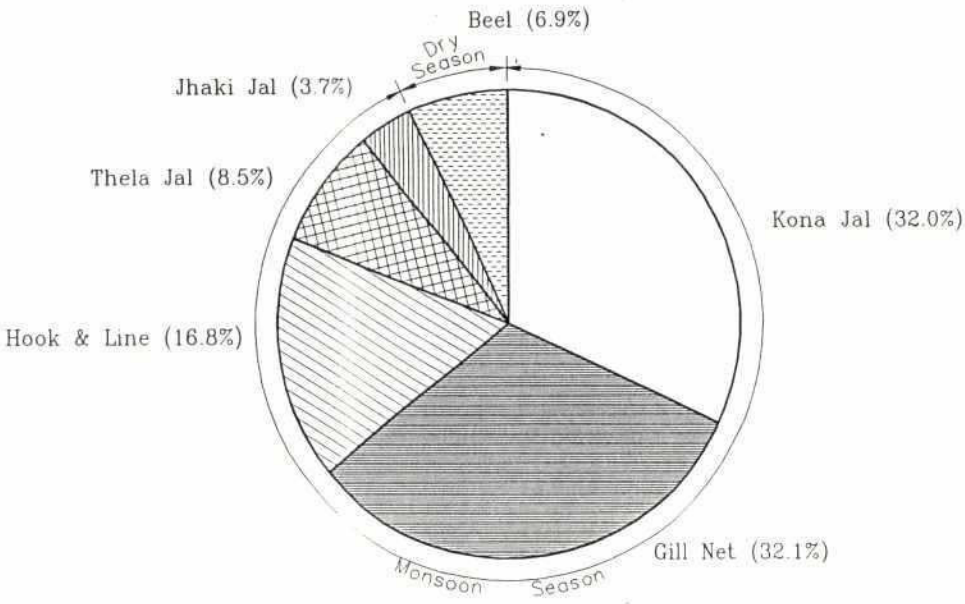
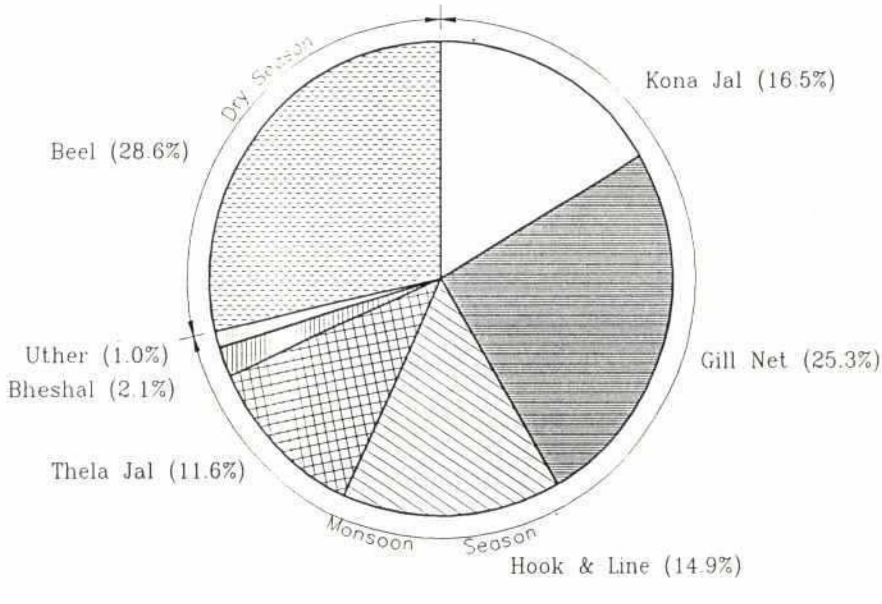

Northeast Regional Project
Fishermen Survey Villages
of Manu Project Area
Prepared by TA/NCP
March 1993
Drawn by Mamun
AutoCAD Drawing
LEGEND
Boundary of Haor
River/Khal
Beel
Road
Village
Scale
N
UTTARBHAG
Kearpara
Sadapur
Kandigaon
Sadapur
Kusiyara R.
Hajindpur
ZAHIDPUR
Berkuri
Sonapur
Manu G.
Rashidpur
Abdullahpur
Medinimahal
Nidanpur
KASIMPUR
Manumukh
Purba Chandpur
Antahari
Khadipur
Manu R.
Rakta
Amirpur
Uana G.
Akau G.
Hanoit
PANCHGAON
Kandigaon
Biraimabad
Narayanpur
Burabari
AKHATUNA
Bichankeb
Ghargaon
RAJNAGAR
91°55'
24°39'
91°43'
24°33'
FILE: NERP-556.DWG

Figure E.5



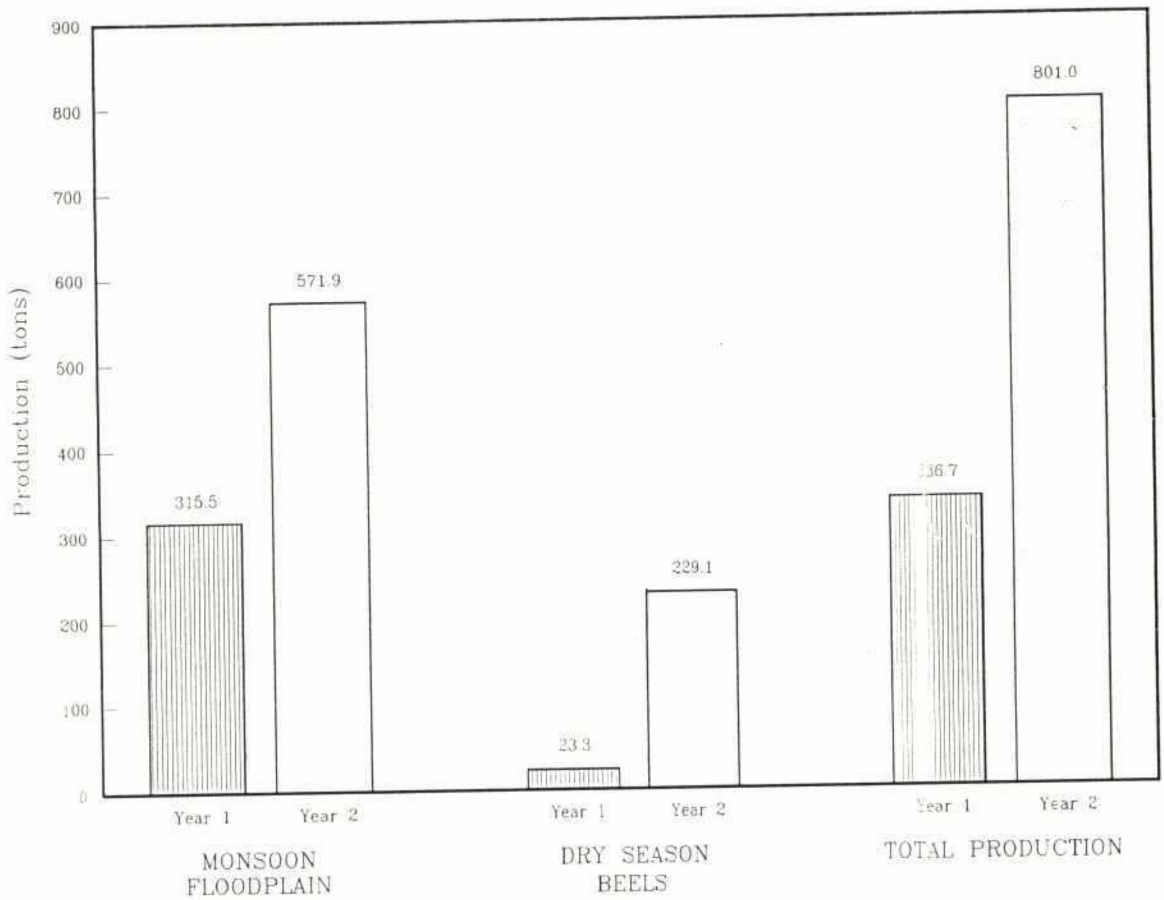
YEAR 1



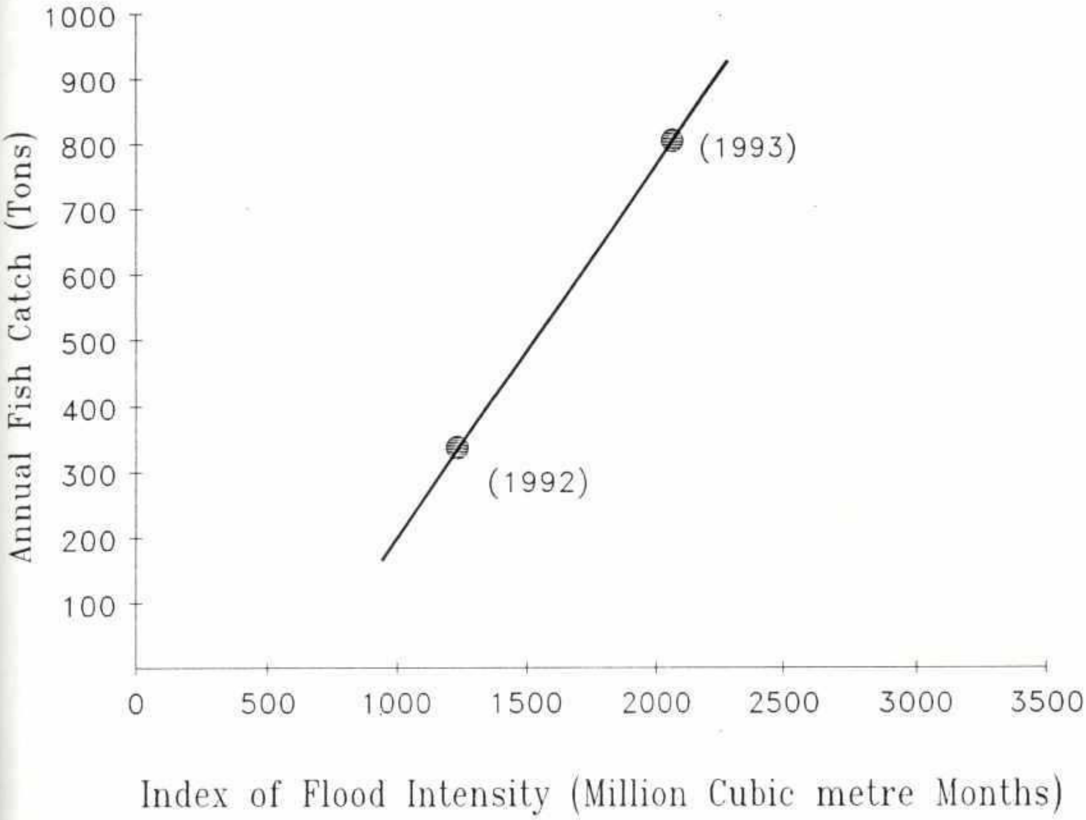
YEAR 2

Comparision of relative contribution of various Fishing Gears and Beel production to total production in year−1 & year−2 at Manu River FCDI Project

2ay



COMPARISON OF FISH PRODUCTION BETWEEN YEAR 1 & YEAR 2
IN MANU RIVER FCDI PROJECT



Relationship between flood intensity and fish production at Kawadighi Haor (Manu River FCDI Project)

APPENDIX F

FORESTRY DATA

APPENDIX F : FORESTRY DATA

INDEX

F.1 FRESHWATER SWAMP FOREST PATCHES WITHIN MRP

Table F1: Freshwater Swamp Forest Patches within MRP

Locality	Area (ha)	Dominant Species	Management System
Antahari	3.2	Koroch/Hizal	Private
Khadipur	2.0	Koroch	Private
Zahidpur	0.2	Hizal	Leased

Antahari Swamp Forest Grove: This forest patch is privately owned among the villagers. These trees, mostly koroch, are on the periphery of the village and works as the first line of defence against wave action during monsoon floods. Some hizals ($\pm$ 15 trees) on the north of the village are struggling to survive and have become isolated since most of them have been cut down during the last ten years or so. These trees are under tremendous threat from fisheries lease holders who use them for fish traps. The scarcity of branches of these trees have driven the lease holders to collect branches from far flung places and even using branches of other tree species like mango, jackfruit, bandarholla/sonai (*Cassia fistula*), etc.

Khadipur Swamp Forest Grove: This grove is adjacent to the Antahari patch. It is mostly homestead in nature with the periphery of the village being planted with koroch trees. It is owned by villagers and is managed well. Koroch grows faster than hizal which is why it is preferred by the local people. Branches of an adult koroch tree brings Tk 1,200 on average and a large tree can fetch more than Tk 3,000. Similarly sized hizal trees bring Tk 5,000 because they attract more fish, in the fishermen's view, and last longer than koroch branches. Scarcity of hizal branches in the vicinity have escalated the price.

Zahidpur Forest Grove: This grove consists of rather isolated hizal trees, 10-15 in number. The trees are in very bad shape and hence are less attractive to the leasee. Nevertheless they provide protection to the nearby embankment and also provide some fuel wood to the villagers. It is presumed that they won't live longer since their roots are exposed and lack proper care.

Apart from these forest patches most of the homesteads maintain good cover of mixed tree species ranging from fruit-bearing to water-tolerant tree species to bamboo groves.

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Table F2: Loss of Trees Due to Monsoon Flood in Selected Villages, 1993

Species	Extent of loss (%)				
	Dheupasha	Rokta	Ontehori	Fatehpur	Sonateki
Papaya	100	100	100	100	100
Banana	10	0	0	0	0
Betel-nut	40	NA	5	4	5
Betel-nut seedling	60	NA	15	10	3
Jack-fruit	35	2	5	5	5
Jack-fruit seedling	20	5	15	15	15
Coconut	35	2	3	3	5
Coconut seedling	55	NA	10	10	20
Bamboo	20	NA	0	0	5
Bamboo kuirol	80	0	5	3	10
Guava	20	5	10	10	10
Mango	10	0	0	0	2
Mango seedling	20	2	5	4	5

Source: Field observation

Table F3: Checklist of Trees with Local Names

Scientific Name	Family	Local Name
Swamp Forest		
Barringtonia acutangula	Lecythidaceae	Hijal
Crataeva nurvala	Capparidaceae	Barun
Pongamia pinnata	Papilionoideae	Karanch
Trewia nudiflora	Euphorbiaceae	Gotagamar,Panidumur
Homestead		
Aegle marmelos	Rutaceae	Bel
Alstonia scholaris	Apocunaceae	Chatim
Albizia sp.	Leguminosae	Koroi
Albizia procera	Leguminosae	Sadakorai,Silkorai
Anthocephalus chinensis	Rubiaceae	Kadom
Areca catechu	Palmae	Supari
Artocarpus heterophyllus	Moraceae	Khatal
Azadirachta indica	Meliaceae	Nim
Bombax ceiba	Bombacaceae	Shimul
Bambusa sp.	Gramineae	Bans
Borassus flabellifer	Palmae	Tal
Cassia siamea	Leguminosae	Minjuri,Eskikoroi
Cocos nucifera	Palmae	Natrikal
Diospyros perigrina	Ebenaceae	Gab,Deshigab
Erythrina variegata	Leguminosae	Mander,Piltamander
Erythrina ovalifolia	Leguminosae	Talimander
Ficus benghalensis	Moraceae	Bot

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Scientific Name	Family	Local Name
Ficus rumphii	Moraceae	Hijulia
Ficus religiosa	Moraceae	Assawath
Ficus hispida	Moraceae	Dumur
Ficus sp.	Moraceae	Chini bot
Lagerstromia speciosa	Lythraceae	Jarul
Mangifera indica	Anacardiaceae	Am
Musa paradisiaca var. *sapientum*	Musaceae	Kala
Samanea saman	Leguminosae	Rendi,Raintree
Syzygium fruticosa	Myrtaceae	Khudijam
Syzygium cumini	Myrtaceae	Kalojam
Terminalia catappa	Combretaceae	Katbadam,Deshibadam
Temarindus indica	Leguminosae	Tentul
Zizyphus mauritiana	Rhamnaceae	Boroi,Kul

F4: Uses of Different Tree Species

Species	Uses
Swamp Forest	
Barringtonia acutangula	TS,FU,FT,M
Crataeva nurvala	TS,FU
Pongamia pinnata	TS,FU,OT,M
Trewia nudiflora	TS,FU,M
Homestead	
Aegel marmelos	C,M,FF,TS
Alstonia scholaris	TS,FU,M
Albizia sp.	TS
Albizia procera	TS
Anthocephalus chinensis	TS,FU
Areca catechu	FF,TS,M
Artocarpus heterophyllus	FF,TS
Bombax ceiba	TS,FB,FU,M,EX
Bambusa sp.	TS,FB,FU,FV,OT
Cassia siamea	FU,TS
Cocos nucifera	FF,TS,FB,VO
Diospyros perigrina	FF,EX,M,DT
Erythrina variegata	FU,OR,M
Erythrina ovalifolia	FU,OR,M
Ficus bengalensis	FU,C,OT,M
Ficus rumphii	FU,TS
Ficus religiosa	C,FU,TS,OT,M

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Species	Uses
Ficus hispida	FV,TS
Ficus sp.	FU,M
Lagerstromia speciosa	TS,OR,FU
Mangifera indica	FF,TS,FU,M
Musa paradisiaca var. *sapientum*	FF,FV
Samanea saman	TS,FU
Syzygium fruticosa	FF,TS,FU
Syzygium cumini	FF,TS,EX,M
Tamarindus indica	FF,FU,M
Terminalia catappa	TS,FF,M
Zizyphus mauritiana	FF,FU

Uses: M- medicinal/narcotic/poison; C- ceremonial; FF- food: fruit & nuts; FS- food:starch /sugar/cereals; FV- food: vegetable; B- beverages; VO- vegetable oils; SF- spices/flavours; EO- essential oils; FU- fuel; SM- smoking/chewing; FP- feed plants/forage; DT- dyes; OR- ornament/hedge; TS- timber/structures; EX- exudates/resins; FB- fiber/thatching/wickerwork;
FT- fish entrenchment; BF- bio-fertilizer; BG-bio-gas; OT- other uses.

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APPENDIX G

BIODIVERSITY INVENTORY

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APPENDIX G : BIODIVERSITY INVENTORY

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Table G1: Checklist of Plants with Local Names, Family and Habit

Scientific Name	Family	Local Name	Habit
Submerged			
Aponogeton natans	Aponogetonaceae	Ghechu	H,Pe
Aponogeton undulatus	Aponogotonaceae	Ghechu	H,Pe
Aponogeton appendiculatus	Aponogetonaceae	Ghechu	H,Pe
Blyxa sp.	Hydrocharitaceae	Shayala	H,A
Ceratophyllum desmersum	Ceratophyllaceae	Jhangi,Katajhangi	H,Pe
Ceratophyllum submersum	Ceratophyllaceae	Jhangi	H,Pe
Hydrilla verticillata	Hydro	charitaceaeKureli,Jhangi	H,Pe
Lagarosiphon roxburghii	Hydrocharitaceae	Kaisa	H,A/Pe
Myriophyllum tuberculatum	Haloraceae	--	H,A
Myriophyllum tetrandrum	Haloraceae	--	H,A
Najas sp.	Najadaceae	Goisa	H,A
Ottelia alismoides	Hydrocharitaceae	Panikola,Kaorali	H,A/Pe
Potamogeton crispus	Potamogetonaceae	Keorali	H,Pe
Rotala rutundifolia	Lythraceae	--	H,A
Sagittaria guayanensis spp *lappula*	Alismataceae	Muamia,Kaowathukri	H,Pe

Scientific Name	Family	Local Name	Habit
Sagittaria sagittifolia	Alismataceae	Chhotokul	H,Pe
Vallisnaria spiralis	Hydrocharitaceae	Pataseola,Bicha	H,A/Pe
Free Floating			
Azolla pinnata	Salviniaceae	Kutipana	H,Pe
Eichhornia crassipes	Pontederiaceae	Kochuripana	H,Pe
Lemna perpusilla	Lemnaceae	Khudipana	H,Pe
Pistia stratiotes	Araceae	Topapana	H,Pe
Salvinia cucullata	Salviniaceae	Kuripana,Indurkan	H,Pe
Salvinia natans	Salviniaceae	Tetulapana	H,Pe
Spirodela polyrhiza	Lemnaceae	Khudipana	H,Pe
Utricularia exoleata	Lentibulariaceae	Chhotojhangi	H,A
Wolffia arrhiza	Lemnaceae	Guripana	H,Pe
Rooted Floating			
Echinochloa colonum	Gramineae	Parua	H,A/Pe
Hygroryza aristata	Gramineae	Phutki	H,Pe
Limnophila sessiliflora	Scrophulariaceae	Bijatighash	H,A
Limnophila heterophylla	Scrophulariaceae	Karpur	H,A
Mersilea quadrifoliata	Mersileaceae	Sushnisak	H,A/Pe
Nymphaea nouchali	Nymphaeaceae	Sada,raktoshapla	H,Pe
Nymphoides cristatum	Menyanthaceae	Chandmala	H,Pe
Nymphoides indicum	Menyanthaceae	Panchuli	H,Pe
Panicum paludosum	Gramineae	--	H,A
Pseudoraphis spinescens	Gramineae	Erali	H,Pe
Trapa maximowiczii	Trapaceae	Singra,Paniphal	H,Pe

Scientific Name	Family	Local Name	Habit
Sedges & Meadows			
Aeschynomene indica	Leguminosae	Katshola,Bhatshola	S,A
Alternanthera philoxeroides	Amaranthaceae	Helencha	H,A
Cleome hasslerana	Capparidaceae	Nunirleta,Hurhuri	H,A
Clinogyne dichotoma	Marantaceae	Sital-pati	S,Pe
Colocasia esculenta	Araceae	Kachu	H,Pe
Cyperus sp.	Cyperaceae	Mutha	H,A
Eclipta alba	Compositae	Kalokeshi,Kalohuza	H,A/Pe
Eleocharis dulcis	Cyperaceae	Panichaise	H,A
Enhydra fluctuans	Compositae	Helencha,Harhach	H,Pe
Fimbristylis dichotoma	Cyperaceae	Joina chaise	H,Pe
Fimbristylis miliacea	Cyperaceae	Joina,Chatkighash	H,A
Fimbristylis squarrosa	Cyperaceae	Jumka chaich	H,A
Ipomoea aquatica	Convolvulaceae	Kalmi shak	H,Pe
Ipomoea fistulosa	Convolvulaceae	Dhol kalmi	S,Pe
Ludwigia abscendens	Onagraceae	Kesardam,Mulcha	H,A
Ludwigia repens	Onagraceae	Panidoga	H,A
Monochoria hastata	Pontaderiaceae	Baranukha,Kechur	H,Pe
Oryza rufipogon	Gramineae	Jhara dhan	H,A
Polygonum glabrum	Polygonaceae	Bishkatali,Kukra	H,A
Polygonum stagninum	Polygonaceae	BIshkatali,Kukra	H,A
Polygonum lanatum	Polygonaceae	Kukra	H,A
Polygonum barbatum	Polygonaceae	Bishkatali	H,A
Rumex maritimus	Polygonaceae	Bonpalong	H,A

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Scientific Name	Family	Local Name	Habit
Setaria glauca	Gramineae	Kulkulle,Kauni	H,A
Schoenoplectus articulatus	Cyperaceae	--	H,A
Scirpus juncoides	Cyperaceae	Chisra	H,Pe
Sclerostachya fusca	Gramineae	Khuri	H,A
Sesbania roxburghii	Leguminosae	Huli,Phuli	S,A
Xanthium indicum	Compositae	Ghagra,Khagra	H,A
Crop Field			
Alternanthera sessilis	Amaranthaceae	Haicha,Sachishak	H,A
Amaranthus spinosus	Amaranthaceae	Kata note	H,A
Ceratopteris thalictroides	Parkeriaceae	--	H,A
Chenopodium ambrosoides	Chenopodiaceae	Chapali ghash	H,A
Cotula hemispherica	Compositae	Kancha ghash	H,A
Croton bonplandianum	Euphorbiaceae	Morchaagra,Banjhal	H,A
Cynodon dactylon	Gramineae	Durba	H,A
Cyperus cephalotes	Cyperaceae	Niratraba	H,A/Pe
Centipeda orbicularis	Compositae	Machiti,Hachuti	H,A
Dentella repens	Rubiaceae	Sadaphuli,Sadajabri	H,Pe
Digitaria longiflora	Gramineae	Chota fulka	H,A/Pe
Eleocharis atropurpurea	Cyperaceae	Panichaise	H,A
Eleusina indica	Gramineae	Gaicha,Chapre	H,A
Heliotropium indicum	Boraginaceae	Hatisur	H,A
Leucas lavendulifolia	Labiatae	Dron	H,A
Lindernia crustacea	Scrophulariaceae	Bhui	H,A
Paspalum conjugatum	Gramineae	Dadkuri	H,Pe

Scientific Name	Family	Local Name	Habit
Rottboellia protensa	Gramineae	Barajati	H,Pe
Rorippa indica	Cruciferae	Bansarisha	H,Pe
Solanum filicifolium	Solanaceae	Titbegun	S,Pe
Solanum nigrum	Solanaceae	Kakmachi	H,A
Spilanthes acmella	Compositae	Marhatitiga	H,A

H: Herb; S: Shrub; Cl: Climber; A: Annual; Pe: Perennial.

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Table G2: Uses of Different Wetland Plant Species

Species	Uses
Submerged	
Aponogeton natans	FS,FV
Aponogeton undulatus	FS,M,FV
Aponogeton appendiculatus	FS,M,FV
Blyxa sp.	--
Ceratophyllum desmersum	FP,FU
Hydrilla verticillata	M,FP,BF
Lagarosiphon roxburghii	BF
Myriophyllum tuberculatum	M,FP
Myriophyllum tetrandrum	M,FP
Najas sp.	--
Ottelia alismoides	FS,FV,FP
Potamogeton crispus	M,FP
Rotala rutundifolia	--
Sagittaria guayanensis spp.*lappula*	M
Sagittaria sagittifolia	M
Vallisnaria spiralis	OR,BF
Free Floating	
Azolla pinnata	BF
Eichhornia crassipes	FP,BF,OR,BG
Lemna perpusilla	BF
Pistia stratiotes	BF,BG
Salvinia cucullata	BF

Species	Uses
Salvinia natans	BF
Spirodela polyrhiza	--
Utricularia exoleata	M
Wolffia arrhiza	BF
Rooted Floating	
Echinochloa colonum	FS,FP,FU
Hygroryza aristata	FS,FP
Limnophila sessiliflora	M,FP
Limnophila heterophylla	M,FP
Mersilea quadrifoliata	M,FV
Nymphaea nouchali	FS,M,FV,FP,OR,BG
Nymphoides cristatum	M,FP,OR
Nymphoides indicum	M,FP,OR
Panicum paludosum	FP,FU
Pseudoraphis spinescens	FP
Trapa maximowiczii	FS,FF,FP
Sedges & Meadows	
Aeschynomene indica	OR,FU
Alternanthera philoxeroides	FV,FP
Cleome hasslerana	OR,M
Clinogyne dichotoma	FB
Colocasia esculenta	FV,M
Cyperus sp.	FP,FB
Eclipta alba	M

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Species	Uses
Eleocharis dulcis	FP
Enhydra fluctuans	FV,M
Fimbristylis dichotoma	--
Fimbristylis miliacea	--
Fimbristylis squarrosa	--
Ipomoea aquatica	FV,FP
Ipomoea fistulosa	FU,OR,OT
Ludwigia abscendens	FP,OR
Ludwigia repens	--
Monochoria hastata	M,OT
Oryza rufipogon	FS,FP
Polygonum glabrum	M
Polygonum stagninum	M
Polygonum lanatum	M
Polygonum barbatum	M
Rumex maritimus	M
Setaria glauca	FP
Schoenoplectus articulatus	FP,FB
Scirpus juncoides	FP
Sclerostachya fusca	FB,FP
Sesbania roxburghii	FU,BF
Xanthium indicum	FV,M
Crop Field	
Alternanthera sessilis	FV,FP

Species	Uses
Amaranthus spinosus	FV,M
Chenopodium ambrosoides	FV,FP
Cotula hemispherica	--
Croton bonplandianum	M
Cynodon dactylon	FP,OR
Cyperus cephalotes	FB
Centipeda orbicularis	M
Dentella repens	--
Digitaria longiflora	FP
Eleocharis atropurpurea	FP
Eleusina indica	FP
Heliotropium indicum	M
Leucas lavendulifolia	M
Lindernia crustacea	--
Paspalum conjugatum	FP
Rottboellia protensa	--
Rorippa indica	--
Solanum filicifolium	M
Solanum nigrum	M
Spilanthes acmella	M

Uses :
M- medicinal/narcotic/poison; C- ceremonial; FF- food: fruit & nuts;
FS- food:starch/sugar/cereals; FV- food: vegetable; B- beverages;
VO- vegetable oils; SF- spices/flavours; EO- essential oils; FU- fuel;
SM- smoking/chewing; FP- feed plants/forage; DT- dyes; OR- ornament/hedge;
TS- timber/structures; EX- exudates/resins; FB- fiber/thatching/wickerwork;
FT- fish entrenchment; BF- bio-fertilizer; BG-bio-gas; OT- other uses.

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LIST OF FISH SPECIES
RECORDED INSIDE MANU RIVER FCDI PROJECT

Total of 79 species (76 indigenous, 3 exotic introductions)

ANGUILLIDAE, Freshwater eels
- Anguilla bengalensis BAMOSH

SYNBRANCHIDAE, Mud eels
- Monopterus cuchia KUCHIA

TETRAODONTIDAE, Puffers
- Tetraodon cutcutia POTKA

BELONIDAE, Needlefishes
- Xenentodon cancila KAIKKA

HEMIRHAMPHIDAE, Halfbeaks
- Hyporhamphus gaimardi EK THUITA

CYPRINODONTIDAE, Killifishes
- Aplocheilus panchax KAMPONA

CHANNIDAE, Snakeheads
- Channa striatus SHOL
- Channa marulius GAJAR
- Channa punctatus TAKI, LATI
- Channa orientalis GACHUA, CHENG

CYPRINIDAE, Carps, minnows, rasboras, barbs, suckers

LEUSCISCINAE, Minnows
- Oxygaster gora GHORA CHELA
- Salmostoma argentea CHELA
- Salmostoma phulo FULCHELA

RASBORINAE, Rasboras
- Esomus danricus DARKINA
- Rasbora rasbora LEUZZA DARKINA
- Rasbora daniconius DARKINA
- Danio devario BANSPATA, CHEBLI

CYPRININAE, Carps and barbs
- Amblypharyngodon mola MOLA
- Amblypharyngodon microlepis MOLA
- Rohtee cotio CHELA
- Labeo gonius GHONIA
- Labeo calbasu KALIBAUS, KALBASU
- Labeo rohita RUI
- Cirrhinus mrigala MRIGEL
- Cirrhinus reba LASU, LACHO
- Puntius sarana SARPUNTI
- Puntius chola CHALA PUNTI
- Puntius ticto TIT PUNTI
- Puntius gelius GILI PUNTI
- Puntius sophore JAT PUNTI
- Catla catla CATLA, KATAL

COBITIDAE, Loaches

- Somileptes gongota PAHARI GUTUM
- Botia dario RANI
- Lepidocephalus guntea GUTUM

CLARIIDAE, Walking catfishes

- Clarias batrachus MAGUR

SILURIDAE, Butter catfishes, Freshwater shark

- Wallago attu BOAL
- Ompok bimaculatus KANI PABDA
- Ompok pabda MADHU PABDA

HETEROPNEUSTIDAE, Stinging catfishes

- Heteropneustes fossilis SINGI

CHACIDAE, Catfishes

- Chaca chaca CHEKA

SCHILBEIDAE, Catfishes

- Ailiichthys punctata BASPATA, ANULI
- Pseudeutropius atherinoides BATASI
- Eutropiichthys vacha BACHA
- Clupisoma garua GHAURA, LAURA

BAGRIDAE, Catfishes

- Rita rita RITA
- Batasio tengana TENGRA
- Aorichthys aor AIR, GHAGOT
- Aorichthys seenghala GUIZZA
- Mystus cavasius GULSHA
- Mystus bleekeri TENGRA
- Mystus tengara BAJARI TENGRA
- Mystus vittatus TENGRA
- Mystus armatus

SISORIDAE, Catfishes

- Gagata youssoufi GANG TENGRA
- Bagarius bagarius BAGHAIR

NOTOPTERIDAE, Knifefishes

- Notopterus chitala CHITAL
- Notopterus notopterus FOLI, KANGLA

CLUPEIDAE, Shads, herrings, sradines

- Gudusia chapra CHAPILA
- Hilsa ilisha HILSA, ILISH
- Corica soborna KACHKI

MASTACEMBELIDAE, Spiny eels

- Macrognathus aculeatus TARA BAIM
- Mastacembelus armatus BAIM
- Mastacembelus pancalus CHIRKA BAIM

MUGILIDAE, Mullets

- Rhinomugil corsula KHORSULA
- Mugil cascasia BATA

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ANABANTIDAE, Climbing perches, gouramies

Colisa sota BOICHA

Colisa fasciatus KHAILSHA

Anabas testudineus KOI

GOBIIDAE, Gobies

Brachygobius nunus NUNA BAILLA

Glossogobius giuris BAILLA, BELE

NANDIDAE, Mud perches, leaffishes

Nandus nandus MENI, BHEDA

Badis badis NAPIT

AMBASSIDAE, Glassfishes

Chanda nama CHANDA

Chanda ranga LAL CHANDA

PRAWNS

Macrobrachium rosenbergi, GOLDA CHINGRI, BORO ITCHA

Small prawns ITCHA, CHINGRI

<u>EXOTIC INTRODUCTIONS</u>

Hypophthalmichthys molitrix SILVER CARP

Cyprinus carpio COMMON CARP, CARPIO

Ctenopharyngodon idellus GRASS CARP

Table G3: List of Amphibians, Reptiles and Mammals

Scientific Name	English Name	Status	Habitat	Distribution
AMPHIBIA				
Bufo melanostictus	Common Toad	VC	WL,FS	W
Microhyla ornata	Ornate Frog	UC	WL	W
Uperodon globolosum	Balloon Frog	UC	FS	WL,FS
Rana cyanophlyctis	Skipper Frog	VC	WL	W
Rana tigrina	Bull Frog	C	WL	W
Rana limnocharis	Cricket Frog	C	WL	W
Rana tytleri	Tytler's Frog	UC	WL	W
REPTILIA				
CHELONIA				
Hardella thurjii	Brahminy Turtle	UC	WL	W
Kachuga tecta	Common Roof Turtle	C	WL	W
Morenia petersi	Bengal Eyed Turtle	UC	WL,RR	W
Lissemys punctata	Spotted Flapshell	C	WL	W
Aspideretes hurum	Peacock Softshell	C	WL,RR	W
LACERTILIA				
Hemidactylus brooki	House Lizard	C	HS	W
Hemidactylus frenatus	Common Lizard	VC	HS	W
Gekko gecko	Wall Lizard	UC	HS,FS	W
Calotes versicolor	Garden Lizard	S	HS	W
Mabuya carinata	Common Skink	UC	HS,FS	W
Varanus bengalensis	Bengal Lizard	UC	HS,FS,WL	W
Varanus flavescens	Yellow Lizard	UC	HS,FS	W

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Scientific Name	English Name	Status	Habitat	Distribution
OPHIDIA				
Lycodon jara	Yellow Wolf Snake	UC	HS,WL	W
Amphiesma stolata	Striped Keelback	C	HS,WL	W
Xenochrophis piscator	Checkered Keelback	VC	HS,WL	W
Xenochrophis cerasogaster	Dark-bellied Marsh Snake	UC	WL,FS	W
Atretium schistosum	Olive Keelback	C	WL	W
Ptyas mucosus	Rat Snake	UC	HS	W
Enhydris enhydris	Smooth Water Snake	C	WL	W
Bungarus fasciatus	Banded Krait	S	HS	W
Naja naja kaouthia	Monocellate Cobra	UC	HS,WL	W
MAMMALIA				
Suncus murinus	Grey Musk Shrew	C	WL,HS	W
Pteropus giganteus	Flying Fox	VC	HS	W
Cynopterus spinx	Short-nosed Fruit Bat	C	HS	W
Megaderma lyra	False Vampire	UC	HS,FS	W
Pipistrellus coromandra	Indian Pipistrelle	VC	HS,FS	W
Hesperoptenus tickelli	Tickell's Bat	VC	HS,FS	W
Manis crassicaudata	Indian Pangolin	R,T	HS	RS
Canis aureus	Jackal	UC	HS	W
Lutra lutra	Common Otter	UC	WL,FS,RR	W
Viverra zibetha	Large Indian Civet	UC	HS	W
Viverricula indica	Small Indian Civet	S	HS	RS
Herpestes auropunctatus	Small Indian Mongoose	VC	HS	W
Felis viverrina	Fishing Cat	UC	HS,FS,WL	W

Scientific Name	English Name	Status	Habitat	Distribution
Sus scrofa	Wild Boar Formerly common, no longer found in wetland habitats			
Bandicota bengalensis	Mole Rat	C	HS,FS	W
Bandicota indica	Bandicot Rat	C	HS,FS	W
Mus booduga	Field Mouse	C	HS	W
Mus musculus	House Mouse	C	HS	W
Rattus rattus	Common House Rat	C	HS	W
Platanista gangetica	Ganges Freshwater Dolphin	C	RR	W

LEGEND: VC - Very Common; C - Common; UC - Uncommon; S - Scarce; R - Rare; T - Threatened; E - Endangered; K - Indeterminate/unknown; WL - Wetland; FS - Freshwater Swamp; RR - Large Rivers; HS - Homestead forests and land adjacent to wetlands; W - Widely distributed; RS - Restricted distribution; ? - Unknown; Extinct - Extinct from the whole country.

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CHECKLIST OF BIRDS RECORDED IN MRP

The sequence and nomenclature follow Harvey, W.G. (1990) Birds in Bangladesh, University Press, Dhaka.

PODICIPEDIDAE
- Little Grebe *Tachybaptus ruficollis*

PHALACROCORACIDAE
- Little Cormorant *Phalacrocorax niger*
- Oriental Darter *Anhinga melanogaster*

ARDEIDAE
- Yellow Bittern *Ixobrychus sinensis*
- Cinnamon Bittern *I. cinnamomeus*
- Black Bittern *Dupetor flavicollis*
- Black-crowned Night-Heron *Nycticorax nycticorax*
- Little Heron *Butorides striatus*
- Indian Pond Heron *Ardeola grayii*
- Cattle Egret *Bubulcus ibis*
- Little Egret *Egretta garzetta*
- Intermediate Egret *E. intermedia*
- Great Egret *E. alba*
- Grey Heron *Ardea cinerea*
- Purple Heron *A. purpurea*

CICONIIDAE
- Asian Openbill *Anastomus oscitans*

ANATIDAE
- Fulvous Whistling Duck *Dendrocygna bicolor*
- Lesser Whistling Duck *D. javanica*
- Ruddy Shelduck *Tadorna ferruginea*
- Cotton Pygmy Goose *Nettapus coromandelianus*
- Eurasian Wigeon *Anas penelope*
- Gadwall *A. strepera*
- Common Teal *A. crecca*
- Northern Pintail *A. acuta*
- Garganey *A. querquedula*
- Northern Shoveler *A. clypeata*
- Baer's Pochard *A. baeri*
- Ferruginous Duck *A. nyroca*
- Tufted Duck *A. fuligula*

ACCIPITRIDAE
- Black-shouldered Kite *Elanus caeruleus*
- Black/Pariah Kite *Milvus migrans*
- Brahminy Kite *Haliastur indus*
- Pallas's Fish-Eagle *Halieetus leucoryphus*
- Grey-headed Fish-Eagle *Ichthyophaga ichthyaetus*
- White-rumped Vulture *G. bengalensis*

Crested Serpent-Eagle *Spilornis cheela*
Western Marsh Harrier *Circus aeruginosus*
Eastern Marsh Harrier *C. spilonotus*
Pied Harrier *C. melanoleucos*
Shikra *A. badius*
Steppe Eagle *A. nipalensis*
Osprey *Pandion haliaetus*

FALCONIDAE

Eurasian Kestrel *Falco tinnunculus*
Northern Hobby *F. subbuteo*

RALLIDAE

Common Moorhen *Gallinula chloropus*
Purple Swamphen *Porphyrio porphyrio*
Watercock *Gallicrex cinerea*
Eurasian Coot *Fulica atra*

JACANIDAE

Pheasant-tailed Jacana *Hydrophasianus chirurgus*
Bronze-winged Jacana *Metopidius indicus*

ROSTRATULIDAE

Greater Paintedsnipe *Rostratula benghalensis*

RECURVIROSTRIDAE

Black-winged Stilt *Himantopus himantopus*

GLAREOLIDAE

Oriental Pratincole *Glareola maldivarum*
Small Pratincole *G. lactea*

CHARADRIIDAE

Little Ringed Plover *Charadrius dubius*
Kentish Plover *C. alexandrinus*
Mongolian Plover *C. mongolus*
Asiatic Golden Plover *Pluvialis fulva*
Grey Plover *P. squatarola*
Grey-headed Lapwing *Vanellus cinereus*
Red-wattled Lapwing *V. indicus*
Little Stint *Calidris minuta*
Temminck's Stint *C. temminckii*
Long-toed Stint *C. subminuta*
Curlew Sandpiper *C. ferruginea*
Broad-billed Sandpiper *Limicola falcinellus*
Ruff *Philomachus pugnax*
Common Snipe *Gallinago gallinago*
Pintail Snipe *G. stenura*
Black-tailed Godwit *Limosa limosa*
Common Redshank *Tringa totanus*
Marsh Sandpiper *T. stagnatilis*
Common Greenshank *T. nebularia*
Green Sandpiper *T. ochropus*
Wood Sandpiper *T. glareola*
Common Sandpiper *Actitis hypoleucos*

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LARIDAE

Common Black-headed Gull *Larus ridibundus*
Brown-headed Gull *L. brunnicephalus*
River Tern *Sterna aurantia*
Whiskered Tern *Childonias hybrida*

COLUMBIDAE

Rock Dove *Columba livia*
Collared Dove *Streptopelia decaocto*
Red Turtle Dove *S. tranquebarica*
Oriental Turtle Dove *S. orientalis*
Spotted Dove *S. chinensis*

PSITTACIDAE

Rose-ringed Parakeet *Psittacula krameri*
Red-breasted Parakeet *P. alexandri*

CUCULIDAE

Common Hawk-Cuckoo *Cuculus varius*
Indian Cuckoo *C. micropterus*
Plaintive Cuckoo *C. merulinus*
Common Koel *Eudynamys scolopacea*
Lesser Coucal *C. bengalensis*

STRIGIDAE

Barn Owl *Tyto alba*
Spotted Owlet *Athene brama*
Brown Hawk-Owl *Ninox scutulata*

APODIDAE

House Swift *Apus affinis*
Asian Palm-Swift *Cypsiurus balasiensis*

ALCEDINIDAE

White-throated Kingfisher *Halcyon smyrnensis*
Common Kingfisher *Alcedo atthis*
Pied Kingfisher *Ceryle rudis*

MEROPIDAE

Green Bee-eater *Merops orientalis*
Chestnut-headed Bee-eater *M. leschenaulti*

CORACIIDAE

Indian Roller *Coracias benghalensis*

UPUPIDAE

Hoopoe *Upupa epops*

CAPITONIDAE

Lineated Barbet *Megalaima lineata*
Coppersmith Barbet *M. haemacephala*

PICIDAE

Speckled Piculet *Picumnus innominatus*
Grey-headed Woodpecker *P. canus*
Black-rumped Flameback *Dinopium benghalense*

ALAUDIDAE

Rufous-winged Bushlark *Mirafra assamica*
Short-toed Lark sp *Calandrella sp*
Oriental Skylark *Alauda gulgula*

HIRUNDINIDAE

Barn Swallow *Hirundo rustica*
Red-rumped Swallow *H. daurica*

MOTACILLIDAE

Paddyfield/Richard's Pipit *Anthus rufulus/richardi*
Olive Tree Pipit *A. hodgsoni*
Red-throated Pipit *A. cervinus*
Rosy Pipit *A. roseatus*
Yellow Wagtail *Motacilla flava*
Yellow-hooded Wagtail *M. citreola*
Grey Wagtail *M. cinerea*
White Wagtail *M. alba*

CAMPEPHAGIDAE

Bar-winged Flycatcher-Shrike *Hemipus picatus*
Large Wood-shrike *Tephrodornis virgatus*
Black-faced Cuckoo-shrike *Coracina novaehollandiae*

PYCNONOTIDAE

Red-whiskered Bulbul *P. jocosus*
Red-vented Bulbul *P. cafer*

IRENIDAE

Common Iora *Aegithina tiphia*
Gold-fronted Leafbird *Chloropsis aurifrons*

MUSCICAPIDAE

Magpie Robin *Copsychus saularis*
Black Redstart *Phoenicurus ochruros*
Stonechat *Saxicola torquata*
Zitting Cisticola *Cisticola juncidis*
Common Tailorbird *Orthotomus sutorius*
Blyth's Reed Warbler *A. dumetorum*
Blyth's Leaf Warbler *Phylloscopus reguloides*
Red-throated Flycatcher *Ficedula parva*
White-throated Fantail *Rhipidura albicollis*
Black-naped Monarch *Hypothymis azurea*
Grey-headed Flycatcher *Culicicapa ceylonensis*
Abbott's Babbler *Trichastoma abbotti*

PARIDAE

Great Tit *Parus major*

NACTARINIIDAE

Purple Sunbird *N. asiatica*
Little Spiderhunter *Arachnothera longirostris*

ORIOLIDAE

Black-hooded Oriole *Oriolus xanthomus*

LANIIDAE

Brown Shrike *Lanius cristatus*
Long-tailed Shrike *L. schach*

DICRURIDAE

Black Drongo *Dicrurus macrocercus*
Bronzed Drongo *D. aeneus*

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ARTAMIDAE

Ashy Wood-Swallow *Artamus fuscus*

CORVIDAE

Rufous Treepie *Dendrocitta vagabunda*

House Crow *Corvus splendens*

Large-billed Crow *C. macrorynchos*

STURNIDAE

Chestnut-tailed Starling *Sturnus malabaricus*

Rosy Starling *S. roseus*

Asian Pied Starling *S. contra*

Common Myna *Acridotheres tristis*

Jungle Myna *A. fuscus*

PLOCEIDAE

House Sparrow *Passer domesticus*

Black-breasted Weaver *Ploceus benghalensis*

Baya Weaver *P. philippinus*

Scaly-breasted Munia *L. punctulata*

Chestnut Munia *L. malacca*

FRINGILIDAE

Black-faced Bunting *Emberiza spodocephala*

Chestnut-eared Bunting *E. fucata*

APPENDIX H

ECONOMIC EVALUATION DATA

APPENDIX H : ECONOMIC EVALUATION DATA

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H.1 METHODOLOGY

The economic value of production in the various sectors within the Manu Project area was estimated for the two years of the Project Monitoring Program. The following tables provide a summary of the data input and the calculations.

Economic production was estimated in the following manner:

1. Crop areas were estimated for each type of crop from BWDB data. The percentage of damaged area was estimated from NERP socio-anthropology team field informaton and observations and was applied to the various crop areas to estimate the area of flood-free and flood-damaged crops.

2. Crop yields per ha were estimated from NERP socio-anthropology field information for both flood-free and flood-damaged areas.

3. Crop production was then estimated for each type of crop as the product of crop area times yield, for both flood-free and flood-damaged areas, and the individual crop productions were summed to estimate the total volume of crop production.

4. Input requirements (labour, fertilizer, seed, and irrigation) were estimated from NERP socio-anthropology field information. Pesticide inputs were adopted from MPO guidelines.

5. Market prices for products and inputs were estimated according to FPCO guidelines.

6. The total value of crop production (gross margins) were calculated as the product of production times price. The net value of crop production (net margins) were calculated as net margins=gross margins minus cost of inputs.

7. The economic value of fisheries production was estimated as the product of area, yield, and price minus the costs of inputs. Floodplain/beel areas, yields, prices, and input costs are documented in Appendix E.

8. The economic value of wetlands products was estimated from yields and market prices based on field observations by the NERP socio-anthropological team.

9. The cost of electricity for operating the pump station was estimated from BWDB pumphouse records.

10. The net economic production of the project was computed as the sum of the economic production in the three sectors (agriculture, fisheries, and wetlands) minus the cost of operating the drainage pumps. The result is provided in the report text.

Table H.1.1
1992-93 CROP AREAS

CROP AREAS – ha:

Crops	Damage Free Area: 1992–93	Damaged Area: 1992–93
B Aus	422.31	1588
HYV Aus	887.88	2283
B Aman	1883	
LT Aman	3418	
HYV Aman	4745	
L Boro	1061	
HYV Boro	4371	540
Wheat	3	
Potato	34	
Jute	5	
Pulse	6	
Oilseeds	6	
Spices	85	
Veg	40	
Total Crop Area	16967	4411

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Table H.1.2
CROP YIELDS IN DAMAGE-FREE AND DAMAGED AREAS

Tons per ha

Crops	Damage Free Area: 1992–93	Damaged Area: 1992–93
B Aus	1.40	0.57
HYV Aus	3.20	1.70
B Aman	2.10	
LT Aman	2.10	
HYV Aman	4.10	
L Boro	2.20	
HYV Boro	4.90	4.21
Wheat	2.00	
Potato	11.20	
Jute	1.50	
Pulse	0.85	
Oilseeds	0.75	
Spices	2.25	
Veg	7.00	

Table H.1.3
1992-93 TOTAL PRODUCTION

Tons

Crops	Main Product	By-product
B Aus	1503	3005
HYV Aus	6713	6713
B Aman	3954	3954
LT Aman	7178	14356
HYV Aman	19455	19455
L Boro	2334	4668
HYV Boro	23693	23693
Wheat	6	6
Potato	381	
Jute	8	15
Pulse	5	
Oilseeds	5	
Spices	191	
Veg	280	
Total Prod'n	65705	75866

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Table H.1.4
1992-93 INPUT REQUIREMENTS PER HECTARE

Crops	Seed	Urea	TSP	MP	Gypsum	Z. Sulphate	Hired labour	D.Animal	Irri–trad	Irri–LLP	Pesticide
	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Md/ha	Pair/ha	ha	ha	Kg/ha
B Aus	98.7	41	8				26	43.7			
HYV Aus	38.3	65.5	49.5	30.5	57.0	8.0	70.0	52.7			0.5
B Aman	100.5	24.0						35.5			
LT Aman	41.0	41.0	32.5	12.0				58.0			0.25
HYV Aman	45.3	82.0	65.5	49.0	57.0	8.0	45.0	60.5			0.5
L Boro	30.0	32.5					43.0	41.0	0.4		0.12
HYV Boro	30.0	107.0	69.5	66.0	57.0	8.0	73.0	52.0		0.1	0.5
Wheat	130.0	88.0	28.0	7.0			105.0	40			0.25
Potato	1000.0	59.0	33.0	23.0			108.0	49	0.5		0.5
Jute	9.0	31.0	9.0	5.0			168.0	48			0.5
Pulse	30.0							30			
Oilseeds	10.0	26.0	62.0	15.0				36			0.1
Spices	0.1	22.0	18.0	10.0				38			
Veg	0.1	64.0	35.0	16.0			50.0	52	0.5		0.25

Table H.1.5
1992-93 CROP MARKET PRICES

OUTPUTS

Crops		Main Produc	By-Product	ByProd
		Market	Market	Fctr
B Aus	Tk/T	6074	950	2.0
HYV Aus	Tk/T	6074	700	1.0
B Aman	Tk/T	6438	950	1.0
LT Aman	Tk/T	6438	950	2.0
HYV Aman	Tk/T	6438	700	1.0
L Boro	Tk/T	6212	950	2.0
HYV Boro	Tk/T	6212	700	1.0
Wheat	Tk/T	6312	600	1.0
Potato	Tk/T	4580		
Jute	Tk/T	8012	2550	2.0
Pulse	Tk/T	14919		
Oilseeds	Tk/T	13466		
Spices	Tk/T	9047		
Veg	Tk/T	1389		

INPUTS

FERTILIZER		Market
Urea	Tk/kg	7.50
TSP	Tk/kg	8.50
MP	Tk/kg	6.50
Gypsum	Tk/kg	
Z.Sulphate	Tk/kg	
SEEDS		
B Aus	Tk/kg	10.50
HYV Aus	Tk/kg	10.00
B Aman	Tk/kg	10.00
LT Aman	Tk/kg	10.00
HYV Aman	Tk/kg	9.00
L Boro	Tk/kg	10.00
HYV Boro	Tk/kg	10.00
Wheat	Tk/kg	12.00
Potato	Tk/kg	8.50
Jute	Tk/kg	24.00
Pulse	Tk/kg	25.00
Oilseeds	Tk/kg	19.00
Spices	Tk/kg	600
Veg	Tk/kg	400
OTHERS		
Pesticide	Tk/kg	504.00
Labour	Tk/md	50.00
D.Animal	Tk/bd	45.00
Irri-trad	Tk/ha	1000
Irri-LLP	Tk/ha	2000

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Table H.1.6
1992-93 AGRICULTURAL PRODUCTION

GROSS MARGINS – Tk/ha

Crop	Gross Value	Input Costs	Net Value
B Aus	5961	4678	1282
HYV Aus	14341	7617	6725
B Aman	15515	2783	12732
LT Aman	17510	3808	13702
HYV Aman	29266	7122	22143
L Boro	17846	4975	12871
HYV Boro	33347	8566	24782
Wheat	13824	9680	4145
Potato	51296	17730	33567
Jute	19668	11370	8299
Pulse	12681	2100	10581
Oilseeds	10100	2680	7420
Spices	20356	2279	18077
Veg	9723	6262	3462

TOTAL GROSS MARGINS BY CROP

Crops	Area (ha)	Gross (Tk 000)	Net (Tk 000)
B Aus	2010	11983	2578
HYV Aus	3171	45475	21323
B Aman	1883	29214	23975
LT Aman	3418	59848	46834
HYV Aman	4745	138866	105070
L Boro	1061	18935	13656
HYV Boro	4911	163769	121703
Wheat	3	41	12
Potato	34	1744	1141
Jute	5	98	41
Pulse	6	76	63
Oilseeds	6	61	45
Spices	85	1730	1537
Veg	40	389	138
Totals	19368	460248	335539

Table H.1.7
1992-93 FISHERIES PRODUCTION

GROSS VALUE :

	Yield	Price	Gross Margin	COP	Net value
	Kg/ha	Tk/kg	Tk/ha	Tk/ha	Tk/ha
Flood Plain Area	30.7	22.88	702	70	632
Beel Area	28	45	1260	675	585

NET VALUE :

	Area		Total cost	Net Value
	ha		Tk (000)	Tk (000)
Flood Plain Area	10200		714	6451
Beel Area	833		562	487
TOTAL				6938

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Table H.1.8
1992-93 WETLAND PRODUCTION

FINANCIAL VALUE OF WETLAND PRODUCTS:

WETLAND PRODUCTS:		Tot Prod Kg	Price (Tk/Kg)	Gross Margin Tk
Food Products:				
	Khai/Ghechu	500	12	6000
	Paura	111000	0.41	45000
	Shaluk	1000	12	12000
	Dheb	200	25	5000
	Shingra	1000	10	10000
	Murta			750000
Plant Products:				
	Hijal	200	100	20000
	Koroch	500	100	50000
	Fuel			250000
	Fodder			320000
	Green manure			300000
Animals:				
	Frog			1000
	Turtles	100	50	5000
	Duck	5000	60	300000
	Pink Pearl			2000
	Lime			1000
	Duck feed			25000
Gross Value:				2102000

Cost of collection (Hired labour requirements):

		md/yr	Wage	Total Cost:
	Hijal	80	50	4000
	Koroch	50	50	2500
Total Cost:				6500

Net Value:	2095500
Net Margin/ ha	205.44

Table H.1.9
1992-93 PUMP HOUSE COSTS

Volume of Water Pumped – '000 m3		105920
Cumulative Pumping Hours:		6922
Total Electricity Consumption – kw :	@ 330 kw/hr	2284260
Total Electricity Cost – 000 Tk :	@ 2.25 Tk/kw	5140

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Table H.1.10
1992-93 NET ECONOMIC PRODUCTION

AGRICULTURAL PRODUCTION			
Net financial value - Tk 000	335539		
Average Gross Margins - Tk/ha		15695	
Cost of Pump Station - Tk 000	5140		
Net Value of Agriculture - Tk 000	330400		

FISHERIES PRODUCTION		Flood plain	Beels
Net financial value - Tk 000	6983	6451	2180
Total Production - 000 (kg)		313	23
Average Gross Margins - Tk/ha		632	585

WETLAND PRODUCTION			
Net financial value - Tk 000	2096		-
Average Gross Margins - Tk/ha		205	-

NET ANNUAL INCOME - Tk 000	339433	

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Table H.2.1
1993-94 CROP AREAS

CROP AREAS – ha:

	Damage Free Area: 1993–94	Damaged Area: 1993–94
B Aus	1672.5	
HYV Aus	3426	
B Aman	943	943
LT Aman	2756	
HYV Aman	3292	
L Boro	498.42	424.58
HYV Boro	3786.58	1330.42
Wheat		
Potato	18	
Jute		
Pulse		
Oilseeds		
Spices	28	
Veg	28	
Total Crop Area	16449	2698

1000

Table H.2.2
1993-94 CROP YIELDS IN DAMAGE-FREE AND DAMAGED AREAS

Tons per ha

	Damage Free Area: 1993-94	Damaged Area: 1993-94
B Aus	1.40	0.57
HYV Aus	3.20	1.70
B Aman	2.10	
LT Aman	2.10	
HYV Aman	4.10	
L Boro	2.20	
HYV Boro	4.90	4.21
Wheat	2.00	
Potato	11.20	
Jute	1.50	
Pulse	0.85	
Oilseeds	0.75	
Spices	2.25	
Veg	7.00	

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Table H.2.3
1993-94 TOTAL PRODUCTION

Tons

	Main Product	BY Product
B Aus	2342	4683
HYV Aus	10963	10963
B Aman	1980	1980
LT Aman	5788	11575
HYV Aman	13497	13497
L Boro	1097	2193
HYV Boro	24161	24161
Wheat		
Potato	202	
Jute		
Pulse		
Oilseeds		
Spices	63	
Veg	196	
Total Prod'n	60288	69053

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Table H.2.4
1993-94 INPUT REQUIREMENTS PER HECTARE

	Seed	Urea	TSP	MP	Gypsum	Z. Sulphate	Hired labour	D.Animal	Irri−trad	Irri−LLP	Pesticide
Crops	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Md/ha	Pair/ha	% of area	% of area	Kg/ha
B Aus	98.7	41	8				26	43.7			
HYV Aus	38.3	65.5	49.5	30.5	57.0	8.0	70.0	52.7			0.5
B Aman	100.5	24.0						35.5			
LT Aman	41.0	41.0	32.5	12.0				58.0			0.25
HYV Aman	45.3	82.0	65.5	49.0	57.0	8.0	45.0	60.5			0.5
L Boro	30.0	32.5					43.0	41.0	0.38		0.12
HYV Boro	30.0	107.0	69.5	66.0	57.0	8.0	73.0	52.0		0.10	0.5
Wheat											
Potato	1000.0	59.0	33.0	23.0			108.0	49	0.5		0.5
Jute											
Pulse											
Oilseeds											
Spices	0.1	22.0	18.0	10.0				38			
Veg	0.1	64.0	35.0	16.0			50.0	52	0.5		0.25

Table H.2.5
1993-94 CROP MARKET PRICES

OUTPUTS

Crops		Main Produc Market	By-Product Market	ByProd Fctr
B Aus	Tk/T	6074	950	2.0
HYV Aus	Tk/T	6074	700	1.0
B Aman	Tk/T	6438	950	1.0
LT Aman	Tk/T	6438	950	2.0
HYV Aman	Tk/T	6438	700	1.0
L Boro	Tk/T	6212	950	2.0
HYV Boro	Tk/T	6212	700	1.0
Wheat	Tk/T	6312	600	1.0
Potato	Tk/T	4580		
Jute	Tk/T	8012	2550	2.0
Pulse	Tk/T	14919		
Oilseeds	Tk/T	13466		
Spices	Tk/T	9047		
Veg	Tk/T	1389		

INPUTS

FERTILIZER		Market
Urea	Tk/kg	7.50
TSP	Tk/kg	8.50
MP	Tk/kg	6.50
Gypsum	Tk/kg	
Z.Sulphate	Tk/kg	
SEEDS		
B Aus	Tk/kg	10.50
HYV Aus	Tk/kg	10.00
B Aman	Tk/kg	10.00
LT Aman	Tk/kg	10.00
HYV Aman	Tk/kg	9.00
L Boro	Tk/kg	10.00
HYV Boro	Tk/kg	10.00
Wheat	Tk/kg	12.00
Potato	Tk/kg	8.50
Jute	Tk/kg	24.00
Pulse	Tk/kg	25.00
Oilseeds	Tk/kg	19.00
Spices	Tk/kg	600
Veg	Tk/kg	400
OTHERS		
Pesticide	Tk/kg	504.00
Labour	Tk/md	50.00
D.Animal	Tk/bd	45.00
Irri-trad	Tk/ha	1000
Irri-LLP	Tk/ha	2000

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Table H.2.6
1993-94 AGRICULTURAL PRODUCTION

GROSS MARGINS – Tk/ha

Crop	Gross Value	Input Costs	Net Value
B Aus	11164	4678	6485
HYV Aus	21677	7617	14060
B Aman	7757	2783	4975
LT Aman	17510	3808	13702
HYV Aman	29266	7122	22143
L Boro	9637	4975	4662
HYV Boro	32636	8566	24070
Wheat			
Potato	51296	17730	33567
Jute			
Pulse			
Oilseeds			
Spices	20356	2279	18077
Veg	9723	6262	3462

TOTAL GROSS MARGINS BY CROP

Crop	Area (ha)	Gross (Tk 000)	Net (Tk 000)
B Aus	1673	18671	10847
HYV Aus	3426	74265	48170
B Aman	1886	14630	9383
LT Aman	2756	48257	37763
HYV Aman	3292	96343	72896
L Boro	923	8895	4303
HYV Boro	5117	166998	123167
Wheat			
Potato	18	923	604
Jute			
Pulse			
Oilseeds			
Spices	28	570	506
Veg	28	272	97
Totals	17474	411154	296888

C09

Table H.2.7
1993-94 FISHERIES PRODUCTION

GROSS VALUE :

	Yield	Price	Gross Margin	COP	Net value
	Kg/ha	Tk/kg	Tk/ha	Tk/ha	Tk/ha
Flood Plain Area	56.1	24	1346	70	1276
Beel Area	275	36	9900	2000	7900

NET VALUE :

	Area		Total cost		Net Value
	ha		Tk (000)		Tk (000)
Flood Plain Area	10200		714		13019
Beel Area	833		1666		6581
TOTAL					19600

C004

Table H.2.8
1993-94 WETLAND PRODUCTION

FINANCIAL VALUE OF WETLAND PRODUCTS:

WETLAND PRODUCTS:		Tot Prod Kg	Price (Tk/Kg)	Gross Margin Tk
Food Products:				
	Khai/Ghechu	400	12	4800
	Paura	33300	0.41	13500
	Shaluk	700	12	8400
	Dheb	140	25	3500
	Shingra	700	10	7000
	Murta			750000
Plant Products:				
	Hijal	200	100	20000
	Koroch	500	100	50000
	Fuel			150000
	Fodder			128000
	Green manure			180000
Animals:				
	Frog			600
	Turtles	100	50	5000
	Duck	3000	60	180000
	Pink Pearl			2000
	Lime			1000
	Duck feed			25000
Gross Value:				1528800

Cost of collection (Hired labour requirements):

		md/yr	Wage	Total Cost:
	Hijal	80	50	4000
	Koroch	50	50	2500
Total Cost:				6500

Net Value:	1522300
Net Margin/ ha	149.25

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Table H.2.9
1993-94 PUMP HOUSE COSTS

Volume of Water Pumped – '000 m3		119000
Cumulative Pumping Hours:		7777
Total Electricity Consumption – kw :	@ 330 kw/hr	2566410
Total Electricity Cost – 000 Tk :	@ 2.25 Tk/kw	5774

Table H.2.10
1992-93 NET ECONOMIC PRODUCTION

AGRICULTURAL PRODUCTION			
Net financial value - Tk 000	296888		
Average Gross Margins - Tk/ha		15506	
Cost of operating Pump Station - Tk 000		5774	
Net Value of Agriculture - Tk 000	291114		

FISHERIES PRODUCTION		Flood plain	Beels
Net financial value - Tk 000	19600	13019	6581
Total Production - 000 (kg)		572	229
Average Gross Margins (Tk/ha)		1276	7900

WETLAND PRODUCTION			
Net financial value - Tk 000	1522		-
Average Gross Margins - Tk/ha		149	-

NET ANNUAL INCOME - Tk 000	312236	

APPENDIX I

ENGINEERING EVALUATION

APPENDIX I : ENGINEERING EVALUATION

INDEX

Much of the following information regarding the design, operation, and performance of the project infrastructure have been abstracted from the original project design report[1] and from a more recent feasibility study report on system rehabilitation[2].

I.1 HISTORY

In the early 1960's local people with their own initiative constucted a dwarf embankment along the right bank of the Manu River to protect boro crops. Subsequently a low embankment of about 37 km ranging from 0.6 to 1.5 m in height was constructed by the Union Council. This embankment was frequently overtopped and breeched and was no longer effective.

The present scheme was originally proposed in an engineering report prepared by Consulting Engineers (Pakistan) Ltd in 1960. The matter came under active consideration of the then WAPDA in 1961. An initial feasibility study for the project was presented by International Engineering Company Inc. (IECO) in June 1962.

In 1968 WAPDA commissioned Associated Consulting Engineers Ltd., a Bangladeshi consulting firm, to undertake the feasibility, planning, and design of the project. Their studies and designs were made between 1970 and 1975 and their "Definite Project Report" was submitted in 1971.

The project was constructed between 1976 and 1983 using funds provided by the Government of Kuwait. The engineering contractor was Messrs Wahidun Nabi; the pumping station was built by the Korean contractor KDC, and the electrical and mechanical contractor was KSB of Germany. The works were supervised by Associated Consulting Engineers Ltd.

More recently a feasibility study of project rehabilitation has been conducted by Halcrow and others in 1993 and has proposed several measures to rehabilitate the existing project. NERP has reviewed these project proposals during preparation of its Regional Development Plan and pre-feasibility study for Manu Project rehabilitation, and have recommended that a diversion be

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[1] "Manu River Project Definite Project Report", Associated Consulting Engineers Ltd, October 1971.

[2] "Feasibility Report Manu River Rehabilitation Project", BWDB Systems Rehabilitation Project, Sir William Hlcrow and Partners Ltd, BCEOM, and DHV Consultants in associaton with Development Design Consultants Ltd and Approtech Consultants Ltd, February 1993.

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constructed upstream of Manu Railway bridge to carry the flood peaks away from the Manu River. The final outcome of this recommendation remains to be seen.

I.2 FLOOD EMBANKMENTS

Project Embankment
A 59.9 km long flood embankment exists along the north, west, and south sides of the project area to protect it from flooding when high levels occur in the Manu and Kushiyara rivers. The 28.3 km long Kushiyara section of the embankment extends along the left bank of the Kushiyara upstream from Manumukh to Mukutpur at the northern end of the Bhatera Hills, and this forms the northern project boundary. The 31.6 km long Manu section of the embankment extends along the right bank of the Manu upstream from Manumukh to Haripasha at the southern end of the Bhatera Hills, and this forms the project's western and southern boundaries. The foot of the Bhatera Hills forms the eastern boundary of the project.

The embankments were intended to provide protection against the 100-year flood plus 0.9 m freeboard. However, the project design was based on historic water levels in the Manu River and did not allow for increasing discharges due to the cutting off of overbank spills.

A large flood and unauthorised public cutting of the embankment in 1984 caused severe damage to the flood embankment and to the irrigation and drainage systems. The resulting damage was repaired between 1984 and 1986 under an IDA loan for flood damage repair. Further flood damage has occurred since 1990 as the result of other large floods in the Manu River and public cuts in the Manu section of the embankment. Flow through these cuts causes considerable damage to crops within the project area. In order to relieve flooding within the project area, farmers have started to cut the Kushiyara section of the project embankment. The cutting of the embankments has resulted in much crop damage and frequent social conflicts.

The crest of the Manu section of the embankment slopes from 16.66 m PWD at Haripasha to 14.59 m PWD at Moulvibazar, and to 11.75 m PWD at Manumukh. The crest of the Kushiyara section slopes from 12.06 m PWD at Mukutpur to 10.96 m PWD at Manumukh. Both sections of the embankment have 1:2.5 riverside slopes, 1:2 or 1:2.5 countryside slopes, and a 4.3 m crest width.

Secondary Embankment
During planning of the Manu Irrigation Project many people living along the right bank of the Manu refused to accept the project embankment alignment which had been proposed on the basis of a standard setback distance of 120 m (400 ft) from the river. If the proposed alignment had been adopted in this densely populated area many residents would have had to be re-located and, as they were not threatened by flooding at the time, they refused to re-locate. Consequently, the alignment was altered, leaving many residences outside the project embankment.

These areas have subsequently flooded. People residing outside the project embankment, along a 12.5 km length between Baliarbagh and Palpur, have been cutting the project embankment to enable the flood water to spill away and to try to reduce their flood damages. About 23.7 km of secondary embankment have been built along the Manu right bank to further protect these areas, and this embankment is constantly being strengthened and raised to protect vulnerable residences. Nevertheless, flooding has persistently recurred in these areas.

Surveys by Halcrow in 1991 show that the embankment is in poor condition upstream of the barrage and is too low near Manumukh.

Moulvibazar Town Protection Embankment
Increased flooding in Moulvibazar town led to construction of the Moulvibazar town protection embankment on the left bank of the Manu. Increased confinement of the river upstream of the town has further exacerbated the flooding situation in the town. This situation has been studied and the town protection is to be improved under the Secondary Town Flood Protection Project (FAP 9A). Detailed design for this protection works is in progress, and construction is scheduled to take place between January 1993 and June 1995. The town and its embankment are outside the Manu Project area.

I.3 DRAINAGE

Drainage Channels
Natural drainage channels (or khals) form the main drainage network within the project. The main channels include:

- the 4.3 km Kalanova Khal which drains the northeast;
- the 9 km Udna Khal and the 4.0 km Binnajuri Khal which drain the southeast;
- the 2 km Nandiura Khal which drains the southwest;
- the 10 km Lash Gang which drains the west;
- the 3.5 km Baliardar Khal which drains the mid-west.

Drainage water from most of the area is conveyed by these channels to Kawadighi Haor, and from there it is discharged to the Kushiyara river, via the Koradair Gang, either through the two drainage sluices at Kashimpur or, during high river stages, by pumping at Kashimpur pumping station.

The natural drainage channels which convey flood water to Kawadighi Haor, and link the beels to it, are badly silted, choked by aquatic vegetation (water hyacinth). In some cases, bunds have been constructed across the channels by farmers and fishermen. Drainage congestion is causing severe problems at many places. BWDB have proposed to construct drainage regulators at the head of, and to re-excavate, the Machua Gang and Munia Gang channels to help relieve this congestion.

BWDB have proposed that a collector drain be excavated along the east side of the project area to intercept and discharge runoff from the Bhatera Hills into the Kushiyara river near Kamalpur. A regulator would be necessary at the northern end of this drain to prevent flooding due to back flow from the Kushiyara River.

Kashimpur Pumping Station
The Kashimpur pumping station is located on the left bank of the Kushiyara River about 3.5 km east of Manumukh. It provides the outlet from Koradair Khal which drains Kawadighi Haor. The pumps are operated when high river stages prevent gravity drainage through the two drainage sluices at Kashimpur.

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The pump station has eight 4.25 m^3/s electrically driven pumps (total capacity is 34 m^3/s). The pump capacity was originally designed to provide drainage of monsoon season rainfall within the project area and tributary hills, excluding any inflows from the Manu and Kushiyara Rivers. The design assumed that the pumps would be operated at capacity whenever the project water levels rose above 4.1 m PWD (12.0 ft SOB) and that there would be no gravity outflow throughout this period. It was intended that the project water levels would be maintained above 3.5 m PWD (10.0 feet SOB) and below below 6.9 m PWD (21 feet SOB). The 1965 monsoon season, having a return period of 10 years, was used as the basis for design.

According to the pump operator all pumps are supposed to be turned on when the water level is higher than 5.6 m.

According to Halcrow (1992), pumping records show that the pumps were actually operated as follows:

- during March and April to protect the Boro crop from flooding. The target is maintain the water level in Kawadighi Haor below 4.1 m PWD. Normally pumping starts when the haor water level reaches 4.0 m PWD, and additional pumps are started as inundation increases with all pumps in operation after 4.5 m PWD is reached. Pumping is usually undertaken over about 15 days.

- during July through September to protect Aman crops from submergence. The target is to maintain the Kawadighi Haor water level below 7.15 m PWD. Normally pumping starts when the haor water level reaches 7.0 m PWD, and additional pumps are started as inundation increases with all pumps in operation after 8.0 m PWD is reached. Pumping is usually undertaken over about 45 days.

According to records at the pump station the design water levels have been exceeded in all years since the project went into operation (see Figure I-1), even in years when the embankments are not breeched. The reason appears to be that the pump operation is much less than had been planned. Monsoon levels have reached 8.2 to 9 m in normal years, which is 1 to 2 m higher than intended. Monsoon levels rise to about 10 m when the embankments are breeched. Winter levels were lower than planned in the first three years, to as low as 2.5 m, but the operation has been revised since 1990 to maintain the winter levels above 3.5 to 4 m.

The pump station was not designed to cope with flooding through embankment cuts and leakage through the regulator gates. The pumping efficiency has been reduced by leakage through the sluice gates at Kashimpur and by inadequate maintenance caused by a lack of spare parts. In 1988 flood water entered the pumping station, damaging electrical components and silting up the intake channel. Precautions have been taken to prevent further flooding by constructing a sandbag cofferdam around the pumping station and electrical sub-station.

Main Drainage Sluices

There are two main drainage sluices in the Kushiyara section of the project embankment to allow gravity drainage of water from within the project area when water levels in the Kushiyara river permit. They are located on Koradair Khal immediately east of the pumping station. The larger sluice has 6 vents and an invert level of 4.1 m PWD. The smaller sluice has 3 vents sluice and an invert level of 1.4 m PWD.

The 3-vent sluice was not mentioned in the project design report and appears to have been added later to permit the haor to be drained to a lower level. Considerable leakage through the 3-vent sluice into the project area has been observed whenever the haor levels are lower than the river levels.

Other Drainage Structures
There are six surface drainage sluices in the Manu section of the project embankment between Haripasha and the Manu barrage. They are used to drain the area which is located between the river and the project embankment into the project area. These are single or two-vent RCC box structures with riverside metal flap gates. Rehabilitation works are required at all these structures. These works include repair of the RCC basin slabs and slope protection, repair and painting of flap gates, and repair of earthwork.

Syphons are provided to drain rain-water which accumulates in pockets either through the project embankment or under an adjacent canal. There are seven syphons through the embankment and 67 under the irrigation canals; 25 of the latter are in the Manu canal system and 42 in the Rajnagar canal system.

Heavy silting of the syphons occurs and requires regular maintenance which is not always available. As a result, the syphons are often blocked or their capacity is significantly reduced. BWDB have proposed that seven additional syphons be provided to relieve drainage congestion locally.

I.4 IRRIGATION

Manu Barrage
The Manu barrage, located about 3.8 km upstream from Chandnighat bridge in Moulvibazar, was constructed in a loop in the Manu river. This loop became the de-silting basin for the whole irrigation system. The depth of silt which has accumulated in the de-silting basin since the start of the project is 0.6 m.

The eight 7.31 m x 3.81 m flood gates of the barrage have a total safe discharge capacity of 1,274 m^3/s (45,000 ft^3/s). The normal pool level of the barrage is at 12.03 m PWD (38.00 ft GTS). Irrigation water is diverted at the barrage through a 5-vent intake sluice discharging into the de-silting basin. Each vent is 1.52 m x 1.83 m in size.

Irrigation Canals
Irrigation water from the Manu Barrage is conveyed to the fields via a canal system consisting of two main, 14 secondary, and 14 tertiary canals. The 18.6 km Manumukh main canal conveys water to the west side of the project area, and the 18.1 km Rajnagar main canal conveys it to the east. There are 48.9 km of secondary canals and 19.7 km of tertiary canals.

The irigation system was designed to irrigate the higher lands in the project area, located between elevation 6.6 m and 11.1 m PWD (20 and 35 feet SOB).

There has been a general deterioration of the canal system primarily due to inadequate maintenance and over-topping by flood water coming from cuts in the project embankment. Many canals are choked by aquatic vegetation, and many canal banks have been cut to facilitate drainage. Some canal lengths are badly silted as a result of inundation, and bunds have been constructed in some canals for fishing.

The Manumukh main canal is regularly damaged by public cuts, particularly in Moulvibazar Thana, and flood water often overtops its banks. Repairs by BWDB prior to the 1991 irrigation season enabled about 69% of the command area to be irrigated. The Rajnagar main canal is less prone to flood damage as it is situated in a comparatively flood free area. However, the 1991 records show that only 67% of its command area was irrigated. This under-performance appears to be the result of high conveyance losses, poor management, and a lack of field turnouts.

Further problems are being caused by borrow pits which have been excavated adjacent to the secondary and tertiary canals. In some cases irrigation water is escaping into these pits and in other cases the presence of the pits is preventing construction of needed additional turnouts. The average borrow pit is 1 m deep and 9.1 m wide.

Irrigation Structures
There are a large number of structures in the irrigation system to regulate the flow and delivery of water. These include regulators, check structures, turnouts, and LLP inlets.

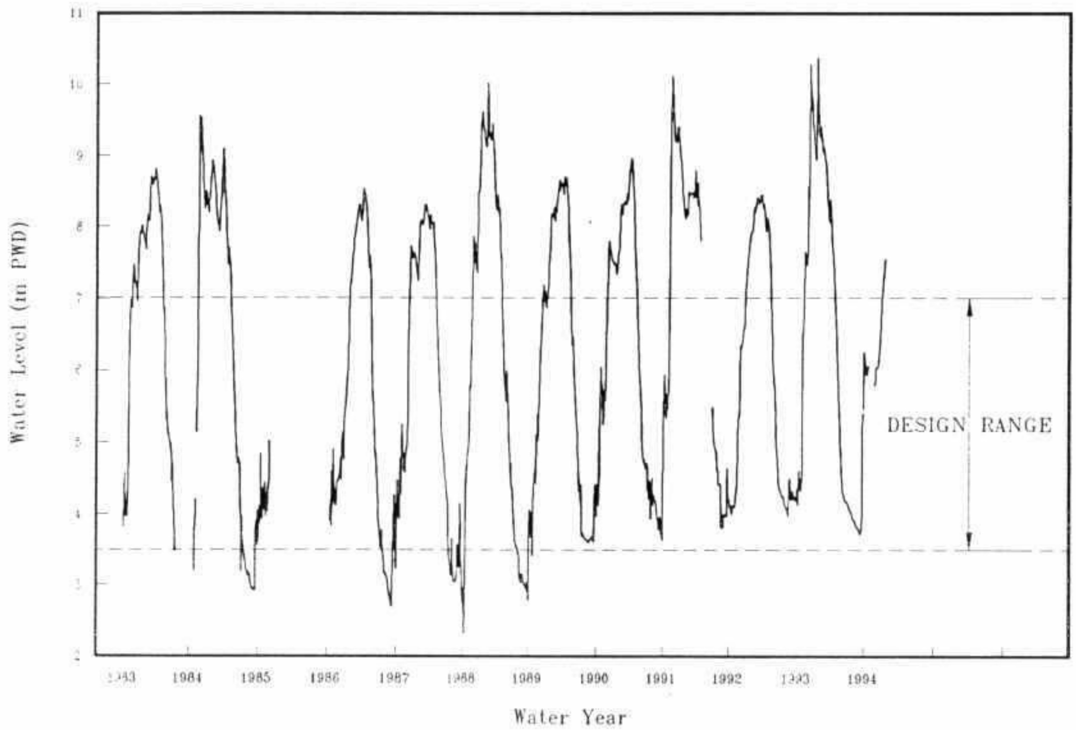
There are 262 turnouts delivering irrigation water to the fields from the tertiary and secondary canals and, in some cases, from the main canals. These structures consist of a single reinforced concrete pipe, 20 to 25 m in length and 254 mm in diameter, laid at field level between the canal and the fields. It has been estimated that an additional 250 turnouts are required to improve water distribution. Construction of the additional structures is inhibited, however, by the need to fill adjacent borrow pits to provide a foundation for the turnouts and to prevent water from discharging into the borrow pits.

There are 19 LLP inlets through the Kushiyara section of the project embankment. Each inlet consists of a single 250 mm diameter RCC pipe, an RCC intake fitted with a flap gate on the riverside, and an RCC outlet fitted with a vertical lift gate on the countryside. In most cases the inlet gates are damaged or missing. In some cases, the pipes have broken. At present farmers are not using the inlets for irrigation but they are using them for limited drainage. Ring bunds are constructed by the farmers to prevent river water entering the project area during high stages but these are not always effective.

I.5 BRIDGES AND CULVERTS

There are 39 bridges and culverts on the project canals which are the responsibility of BWDB and are in good condition. Other bridges and culverts within the project area are generally in reasonable condition, but a number of the structures which belong to the Thana require urgent repair and, in some cases, replacement.

Figure I-1



Northeast Regional Project

WATER LEVELS IN THE MANU PROJECT

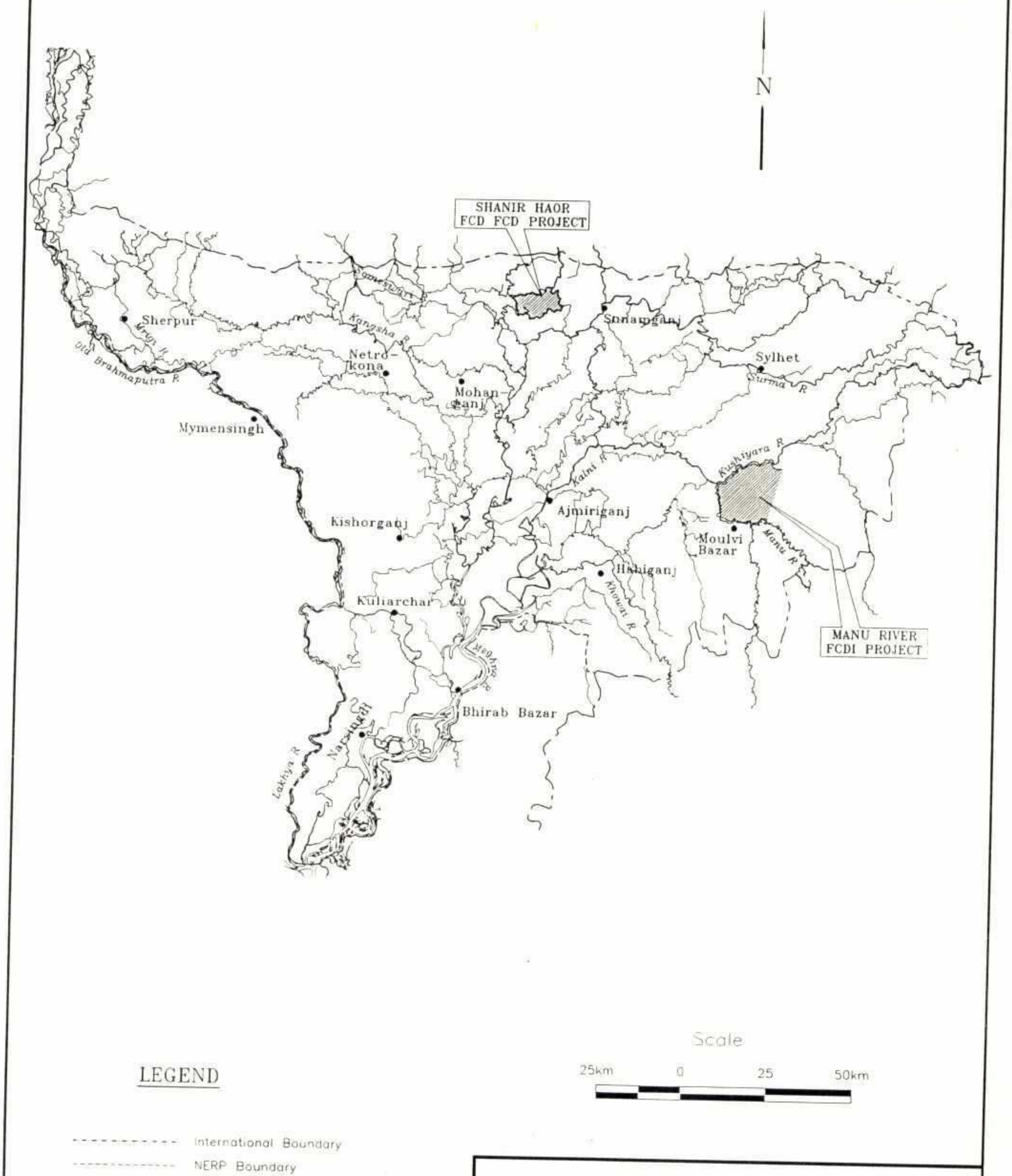
Prepared by: nahid | November 1994

FILE: manu-ns.DWG

APPENDIX J

FIGURES

Figure 1



Northeast Regional Project

Project Monitoring Program
General Location

Prepared by: BNP/Jalal	October 1994

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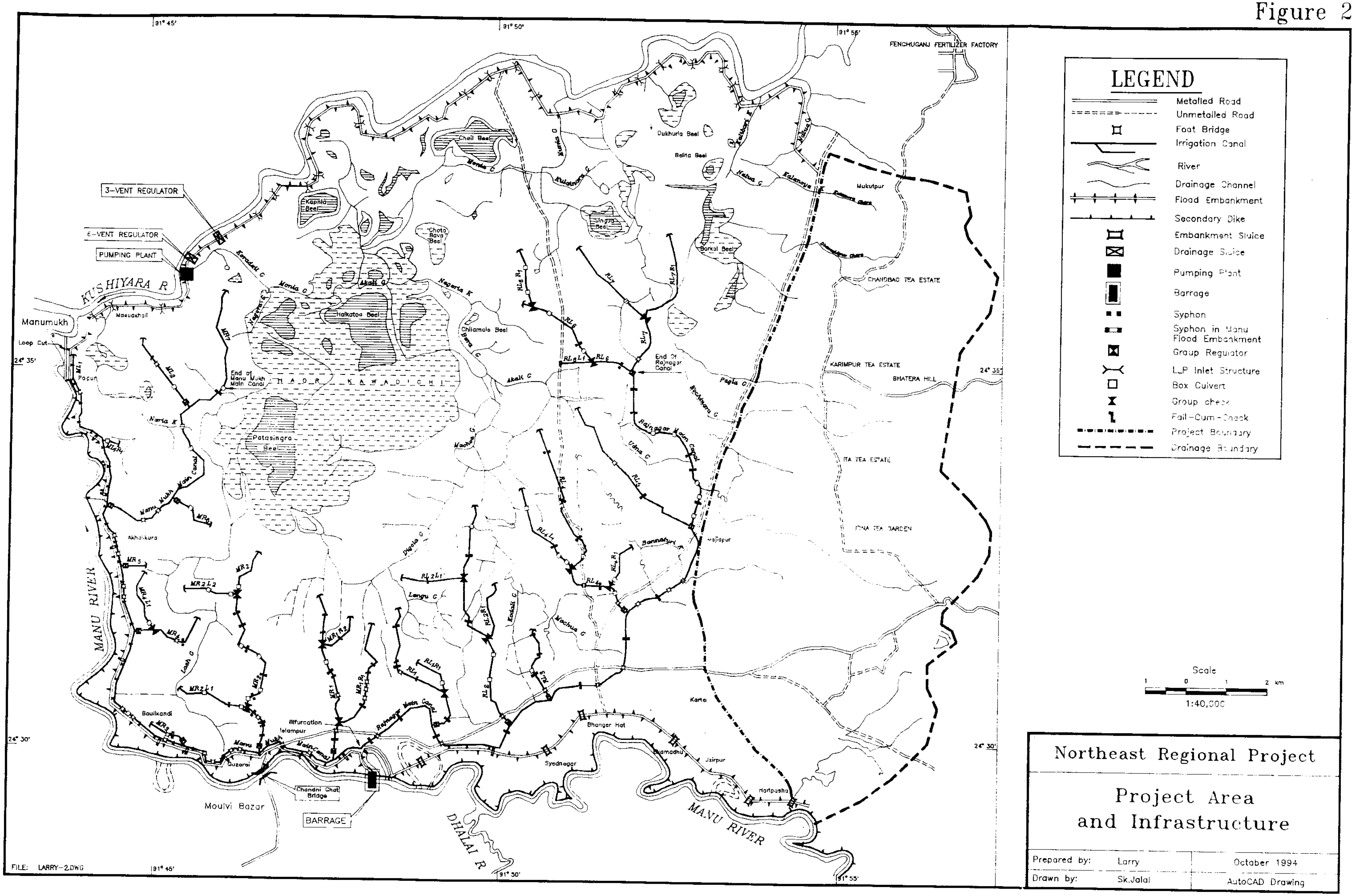
Figure 2



LEGEND
Metalled Road
Unmetalled Road
Foot Bridge
Irrigation Canal
River
Drainage Channel
Flood Embankment
Secondary Dike
Embankment Sluice
Drainage Sluice
Pumping Plant
Barrage
Syphon
Syphon in Manu Flood Embankment
Group Regulator
LLP Inlet Structure
Box Culvert
Group check
Fall-Cum-Check
Project Boundary
Drainage Boundary
Scale
1:40,000
3-VENT REGULATOR
6-VENT REGULATOR
PUMPING PLANT
KUSHIYARA R
Manumukh
Loop Cut
MANU RIVER
DHALAI R
BARRAGE
Chandni Ghat Bridge
Moulvi Bazar
Bifurcation
Islampur
Bhanger Hat
Syednagar
Hartpasha
Kartai
Majlapur
HAOR KAWADIGHI
Halkatoa Beel
Patasingra Beel
Chilamolo Beel
Dukhurla Beel
Balita Beel
Barkal Beel
Kapnia Beel
Cheil Beel
Chota Bava Beel
FENCHUGANJ FERTILIZER FACTORY
CHANDBAG TEA ESTATE
KARIMPUR TEA ESTATE
BHATERA HILL
ITA TEA ESTATE
IDNA TEA GARDEN
Mukutpur
Akhailkura
Bauilkandi
Guzarai
End of Manu Mukh Main Canal
End of Rajnagar Canal
Manu Mukh Main Canal
Rajnagar Main Canal
24° 35'
24° 30'
91° 45'
91° 50'
91° 55'
Northeast Regional Project
Project Area and Infrastructure
Prepared by: Larry
October 1994
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: LARRY-2.DWG

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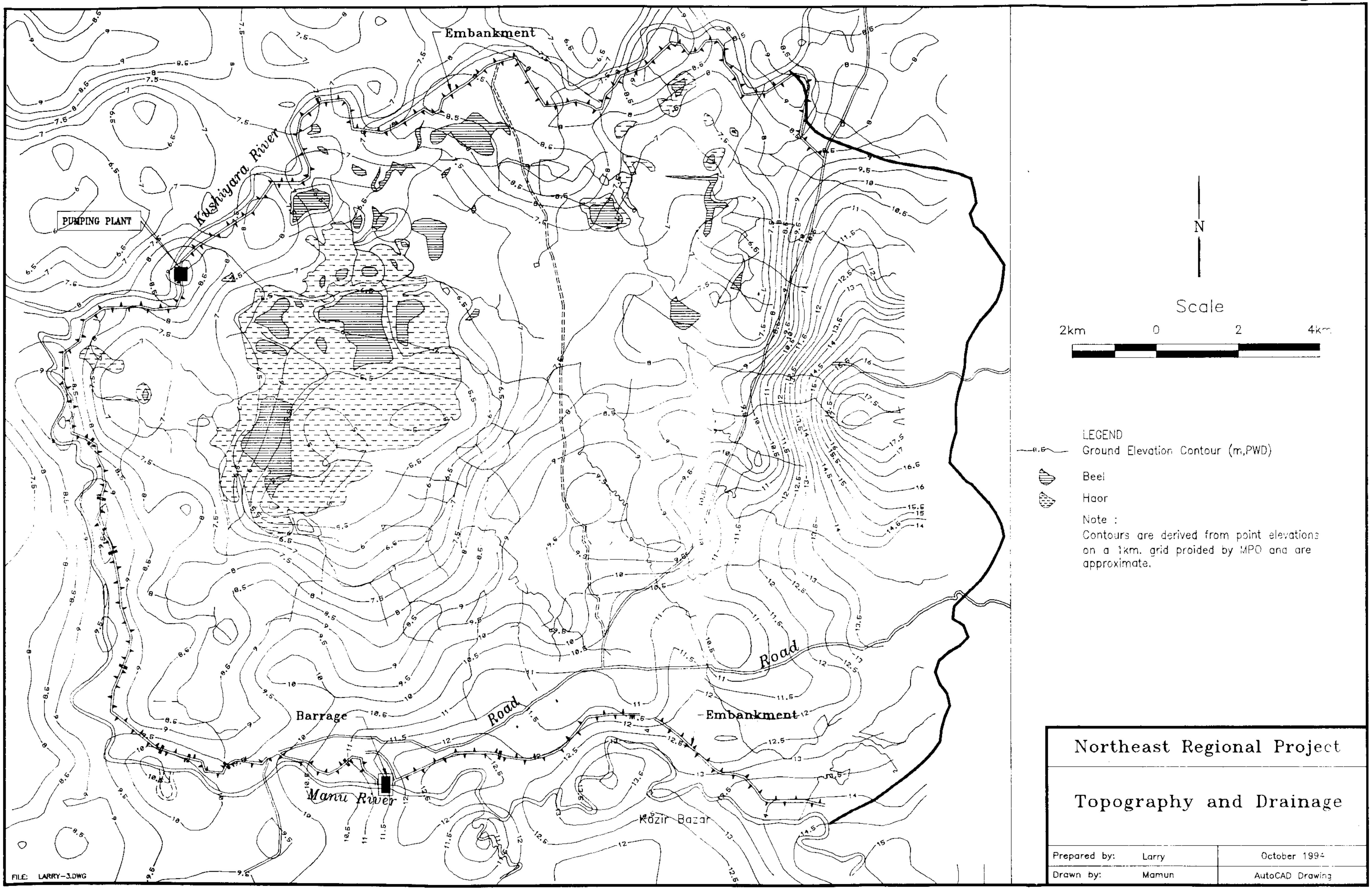
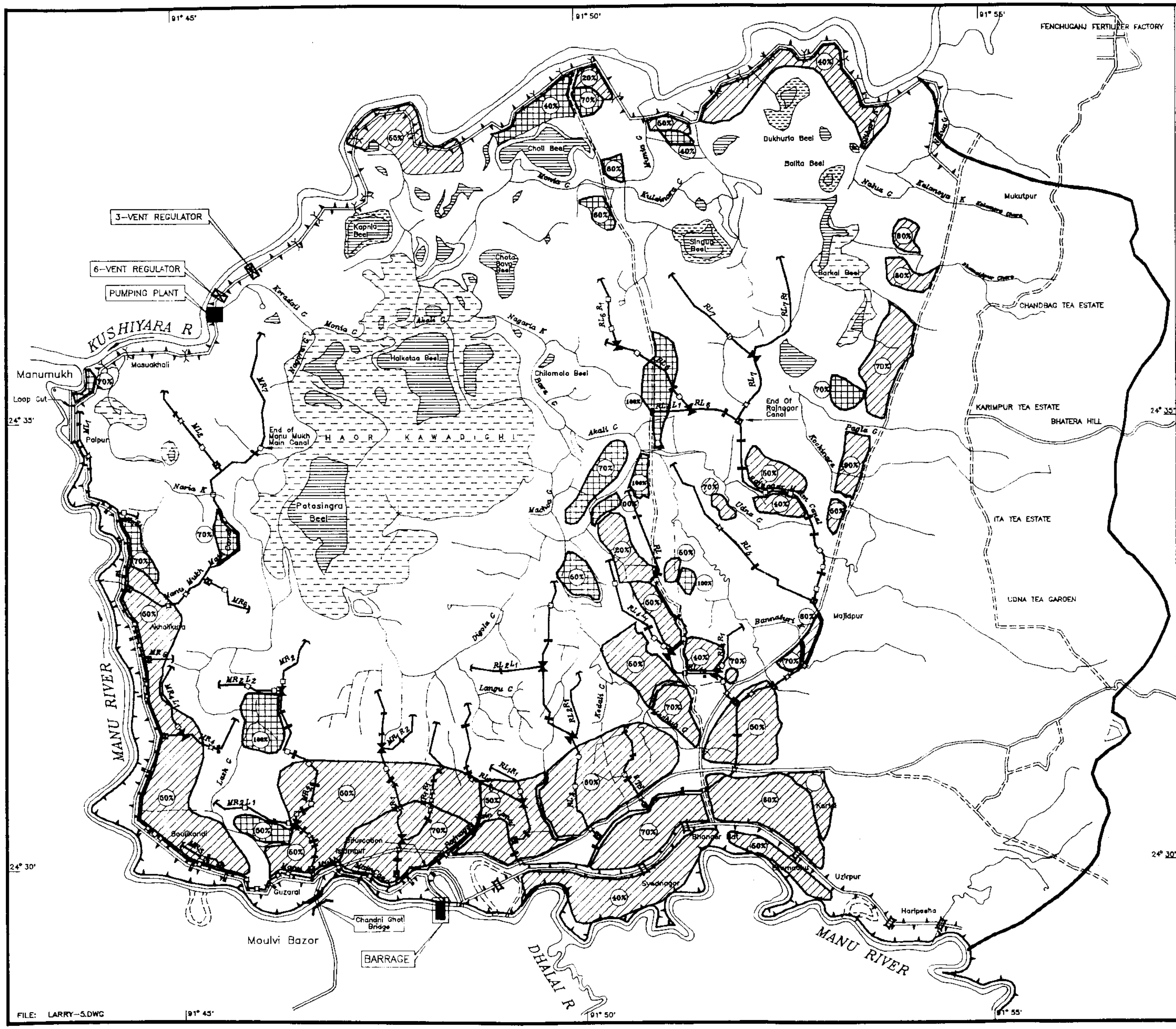
Figure 3


Embankment
Kushiyara River
PUMPING PLANT
Road
Barrage
Embankment
Manu River
Kazir Bazar
FILE: LARRY-3.DWG
N
Scale
2km 0 2 4km
LEGEND
Ground Elevation Contour (m,PWD)
Beel
Haor
Note :
Contours are derived from point elevations on a 1km. grid proided by MPO and are approximate.
Northeast Regional Project
Topography and Drainage
Prepared by: Larry
October 1994
Drawn by: Mamun
AutoCAD Drawing



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LEGEND

T-aus

B-aman

Percentage of area planted as at June 1993

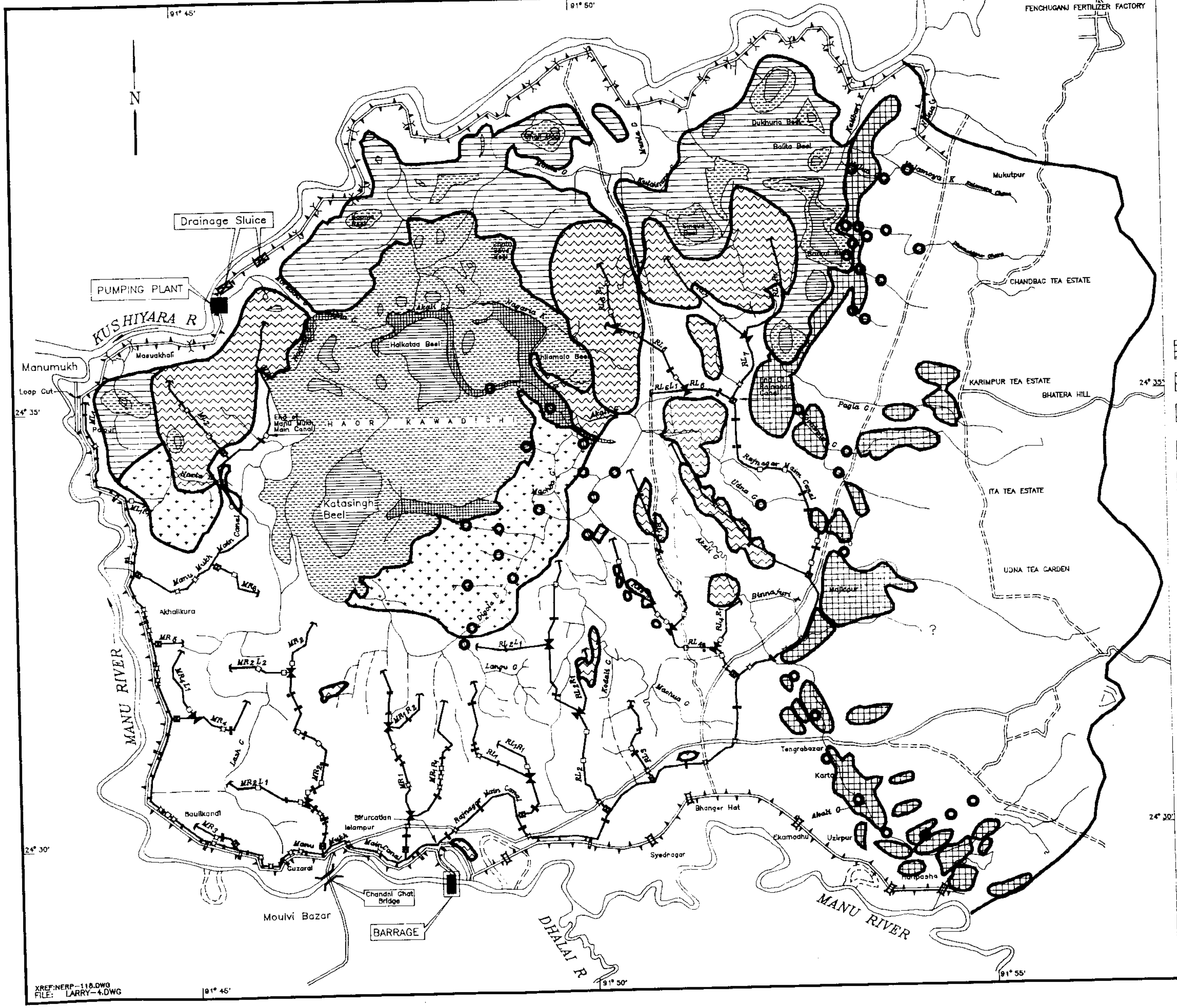
Scale
1 0 1 2 km
1:40,000

Northeast Regional Project

Cropped Areas in Early June 1993

Prepared by:	Larry	October 1994
Drawn by:	Sk.Jalal	AutoCAD Drawing

Figure 5



LEGEND

LLP and Traditional Lift Methods: (75% HYV Boro)	2,368 ha.
Project Irrigation Canals: (100% HYV Boro)	2,553 ha.
Extension of Project Irrigation Network Through People's Initiative: (75% HYV Boro)	1250 ha.
Creeks from the Bhattara Hills: (90% HYV Boro)	1,259 ha.
Traditional Methods or no irrigation (Local Boro)	2,797 ha.
Kanda (fallow land):	310 ha.
Beel:	630 ha.
Cross dams for water retention and Irrigation	

Scale

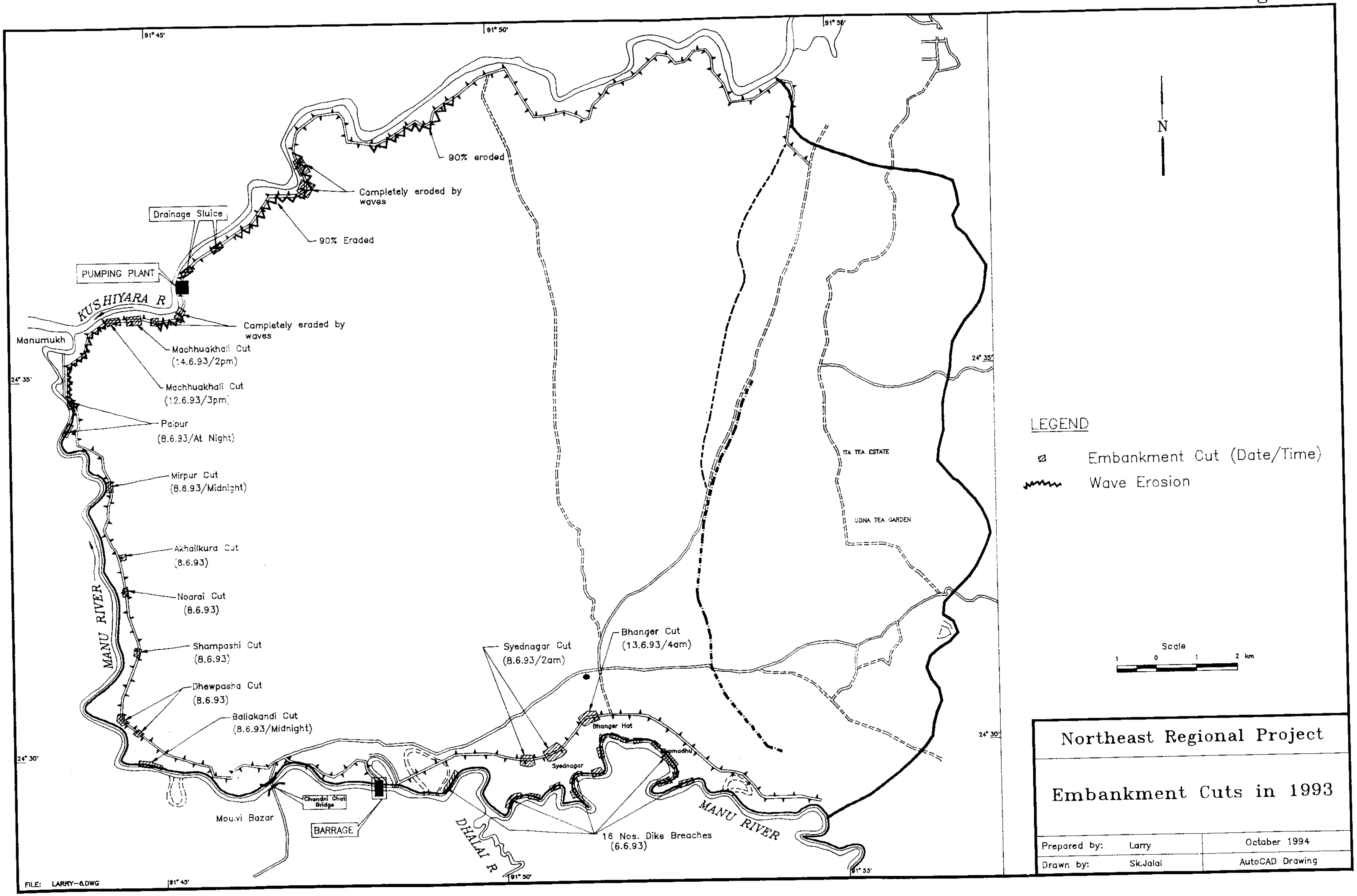
0 1 2 km

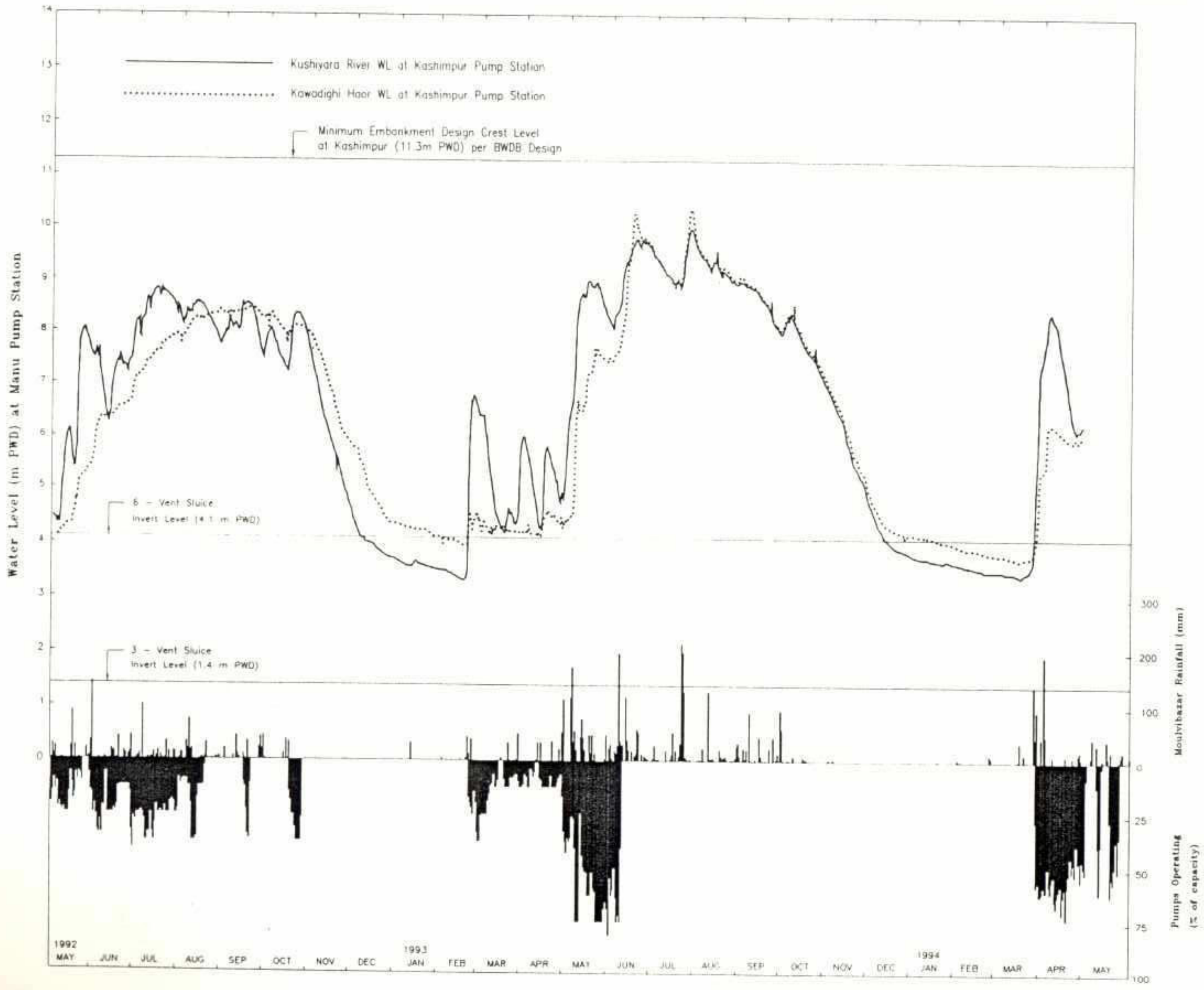
Northeast Regional Project

Irrigation and Winter Crop Areas (1992-93)

Prepared by:	Larry	October 1994
Drawn by:	Sk.Jalal	AutoCAD Drawing

Figure 8

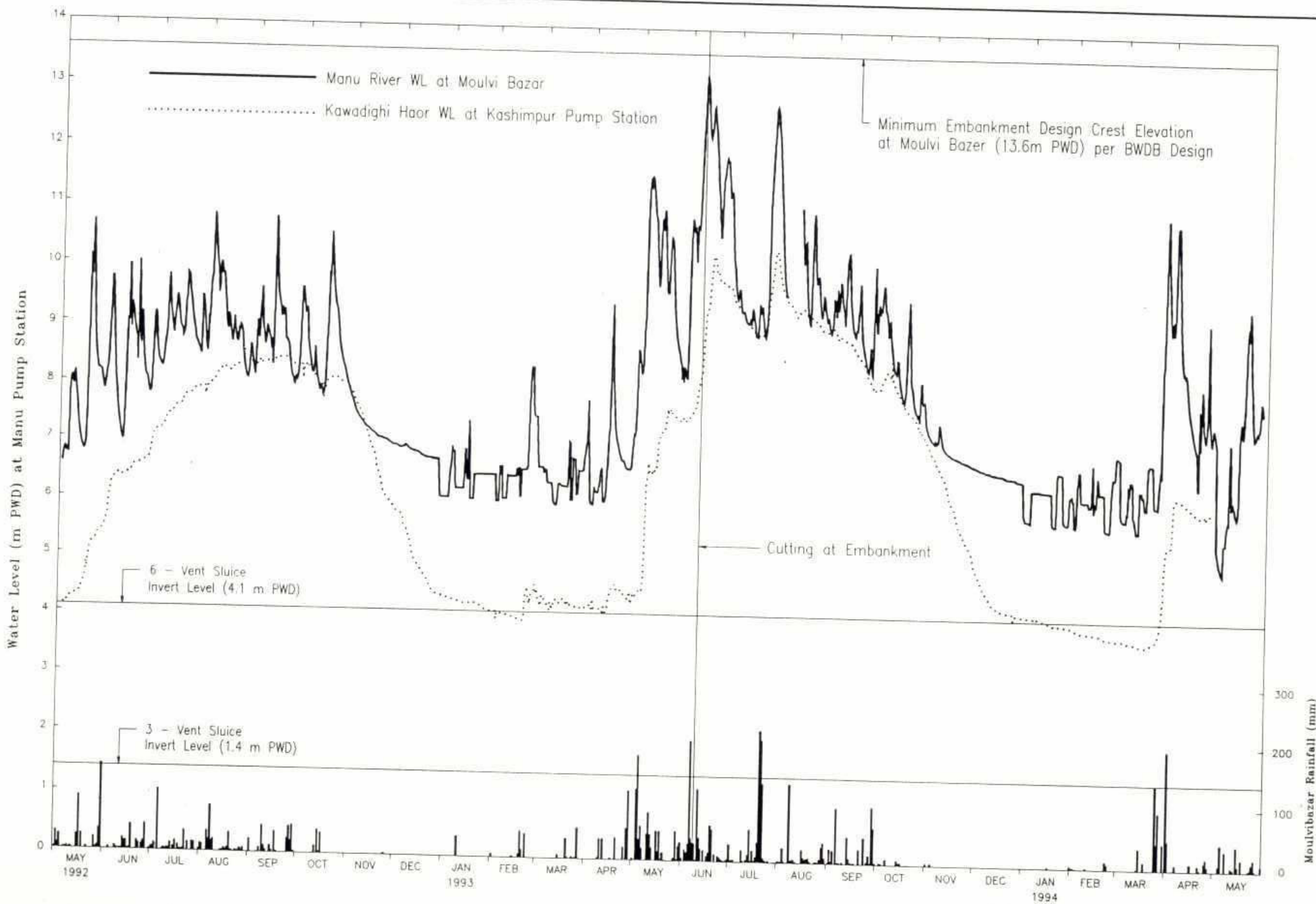

91° 45'
91° 50'
91° 55'
24° 35'
24° 30'
N
90% eroded
Completely eroded by waves
Drainage Sluice
90% Eroded
PUMPING PLANT
KUSHIYARA R
Completely eroded by waves
Manumukh
Machhuakhali Cut (14.6.93/2pm)
Machhuakhali Cut (12.6.93/3pm)
Paipur (8.6.93/At Night)
Mirpur Cut (8.6.93/Midnight)
Akhailkura Cut (8.6.93)
Noarai Cut (8.6.93)
MANU RIVER
Shampashi Cut (8.6.93)
Dhewpasha Cut (8.6.93)
Baliakandi Cut (8.6.93/Midnight)
Syednagar Cut (8.6.93/2am)
Bhanger Cut (13.6.93/4am)
Bhanger Hat
Syednagar
Chandni Ghat Bridge
BARRAGE
Moulvi Bazar
DHALAI R
16 Nos. Dike Breaches (6.6.93)
MANU RIVER
ITA TEA ESTATE
UDNA TEA GARDEN
LEGEND
Embankment Cut (Date/Time)
Wave Erosion
Scale
1 0 1 2 km
Northeast Regional Project
Embankment Cuts in 1993
Prepared by: Larry
October 1994
Drawn by: Sk.Jalal
AutoCAD Drawing
FILE: LARRY-6.DWG



FILE: LARRY-7.DWG

Northeast Regional Project	
Hydraulic Operation of Manu Project 1992-1994	
Prepared by: Larry	November 1994
Computer Drafting by: Mamun	AutoCAD Drawing

Figure 6



FILE : LARRY-8.DWG

Figure 7

Moulvi Bazar Water Levels 1992–94

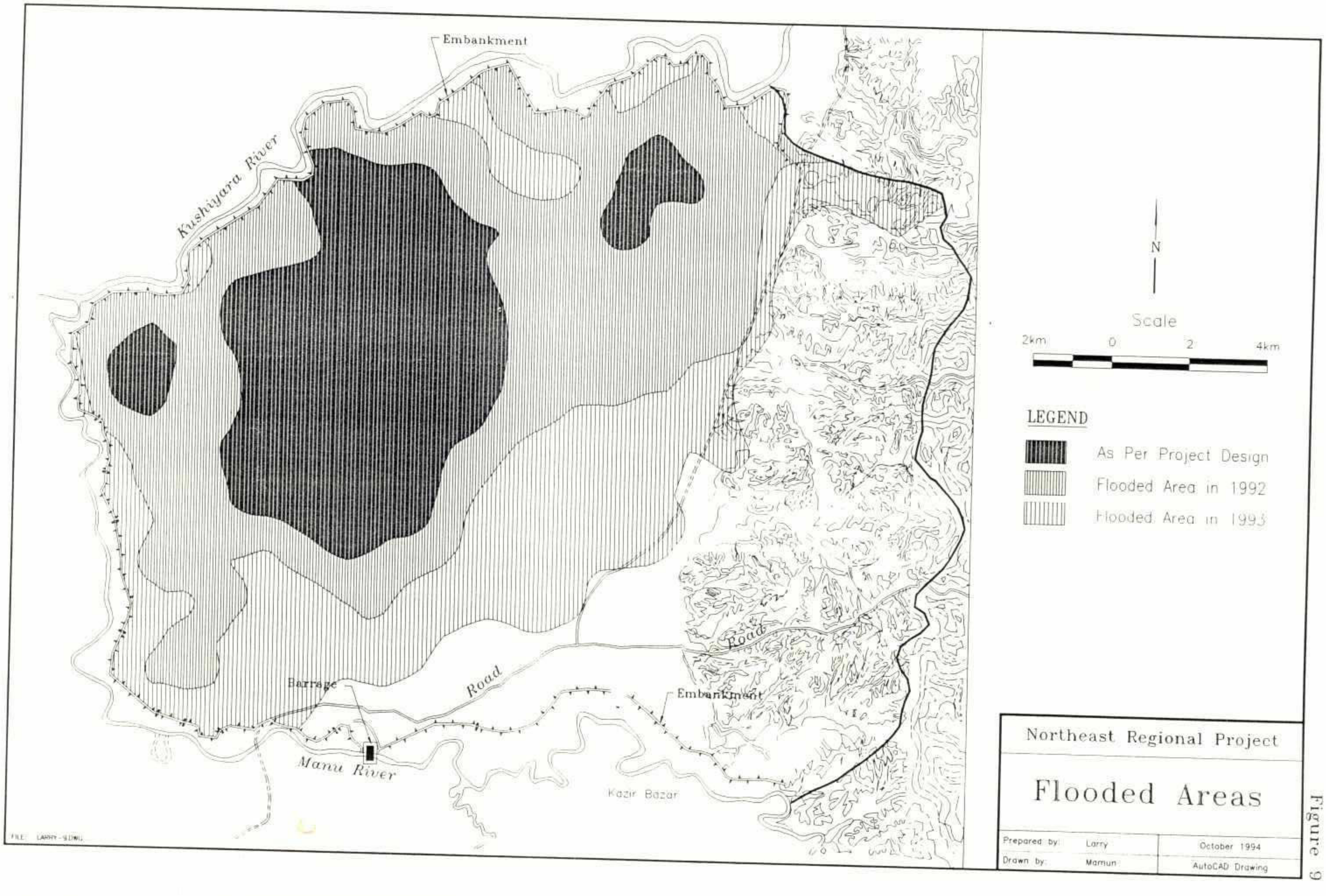

Embankment
Kushiyara River
Barrage
Road
Embankment
Road
Manu River
Kazir Bazar
N
Scale
2km 0 2 4km
LEGEND
As Per Project Design
Flooded Area in 1992
Flooded Area in 1993
Northeast Regional Project
Flooded Areas
Prepared by: Larry
Drawn by: Mamun
October 1994
AutoCAD Drawing
FILE: LARRY-9.DWG

Figure 9