MINISTRY OF COMMUNICATIONS
THE PEOPLE'S REPUBLIC OF BANGLADESH

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR PROTECTION WORKS FOR MEGHNA BRIDGE
IN
THE PEOPLE'S REPUBLIC OF BANGLADESH

FEBRUARY 1998

JAPAN INTERNATIONAL COOPERATION AGENCY
PACIFIC CONSULTANTS INTERNATIONAL
NIPPON KOEI CO., LTD.

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PREFACE

In response to a request from the Government of the People's Republic of Bangladesh (the Government of Bangladesh), the Government of Japan decided to conduct a basic design study on the Project for Protection Works for Meghna Bridge and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Bangladesh the Basic Study Team, two times from April 5 to May 17, 1997 and from July 31 to August 29, 1997.

The team held discussions with the officials concerned of the Government of Bangladesh, and conducted field surveys in the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Bangladesh in order to discuss the draft final report from November 9 to November 13, 1997 and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Bangladesh for their close cooperation extended to the team.

February 1998

Kimio Fujita
President
Japan International Cooperation Agency

February, 1998

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Protection Works for Meghna Bridge, in the People's Republic of Bangladesh.

This study has been made by PACIFIC CONSULTANTS INTERNATIONAL in consortium with NIPPON KOEI CO., LTD., based on a contract with JICA, from 24th March to 6th February, 1998. Throughout the study, we have taken into full consideration of the present situation in the People's Republic of Bangladesh, and have planned the most appropriate project in the scheme of Japan's grant aid.

Finally, we hope that this report will be effectively used for the promotion of the project.

Very truly yours,

Naoya Ogawa

Project Manager
The Project for Protection Works for Meghna Bridge
Pacific Consultants International in Consortium with
Nippon Koei Co., Ltd.

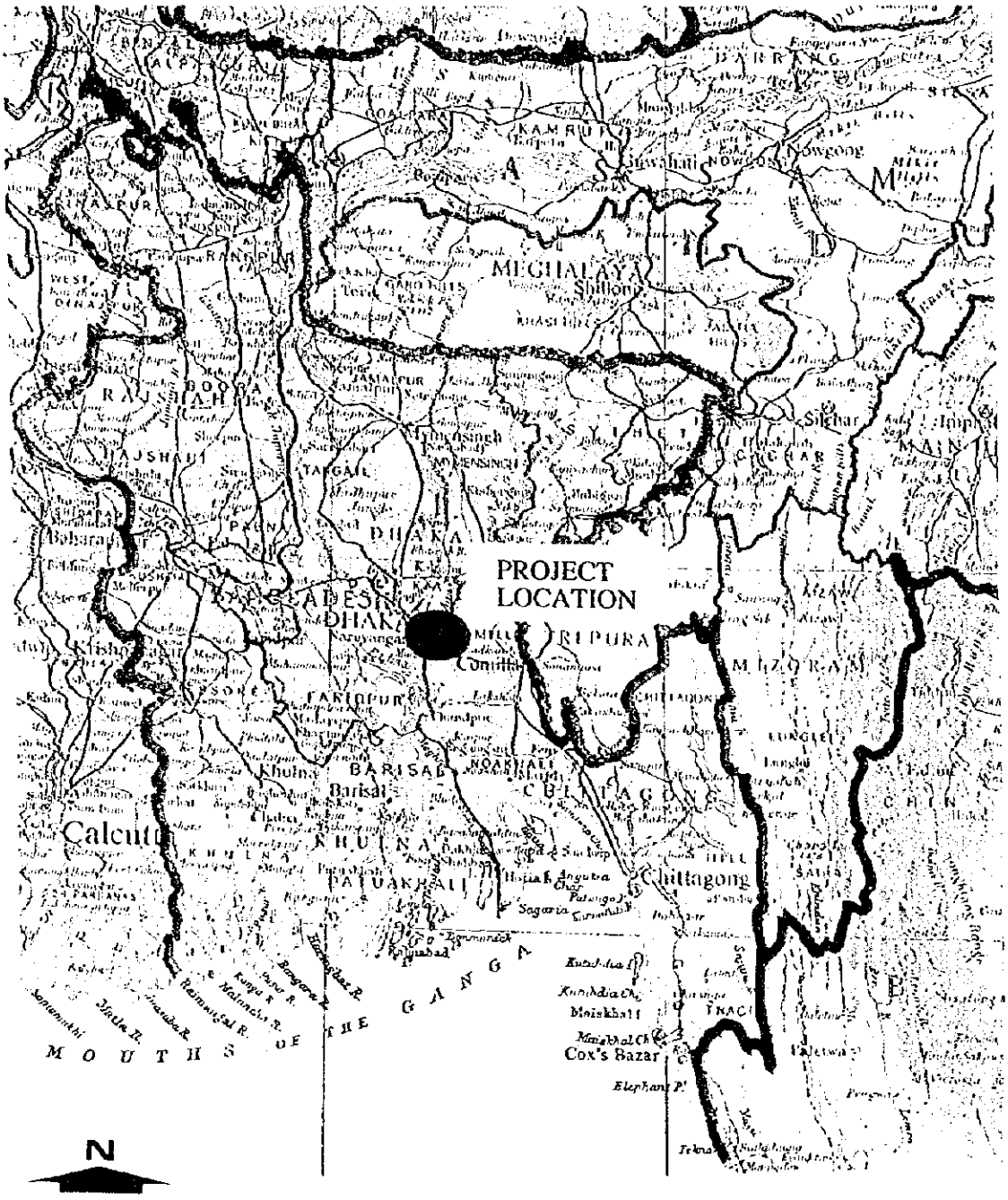
ABBREVIATIONS

A. Authorities and Agencies

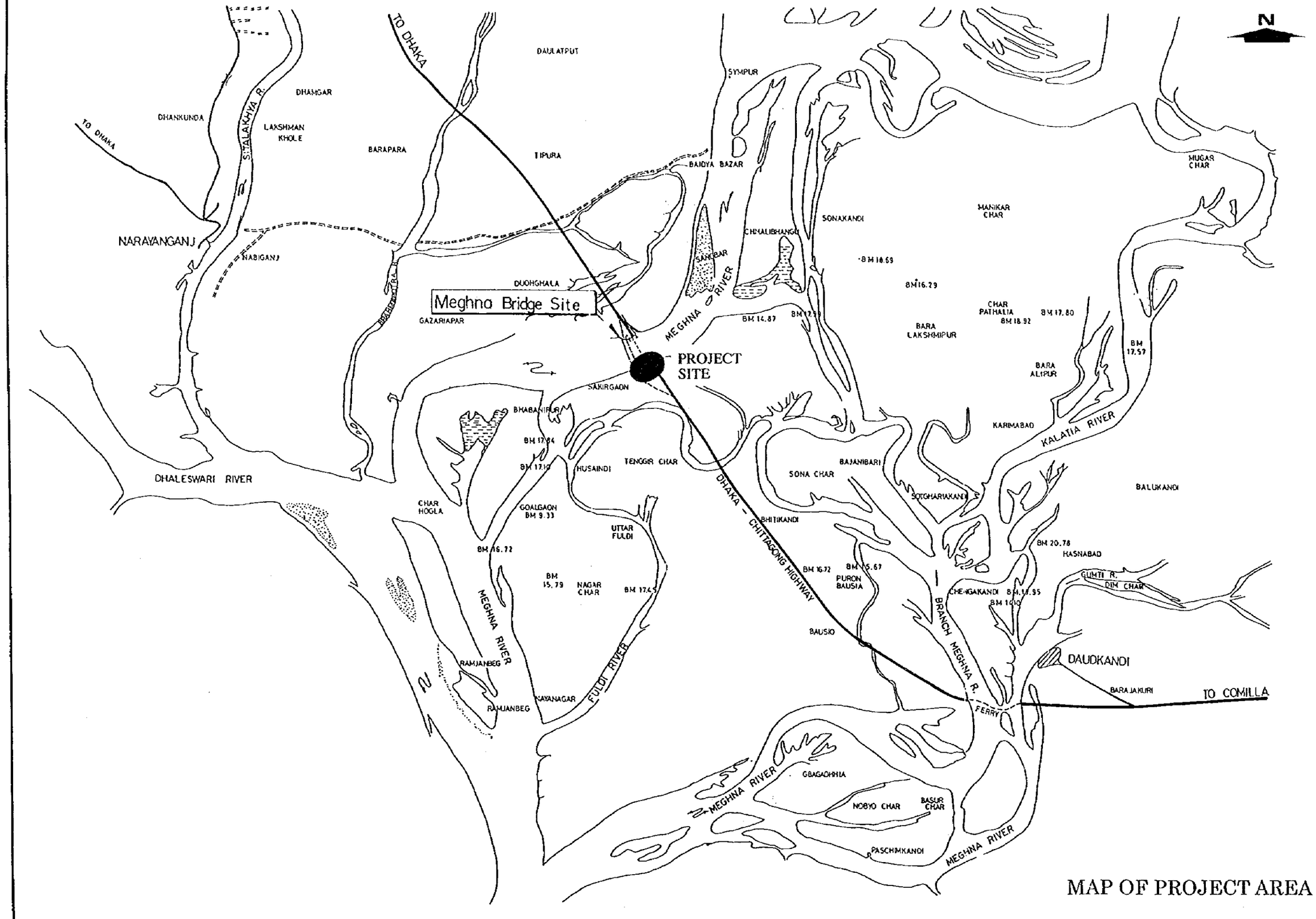
ADB	:	Asian Development Bank
BUET	:	Bangladesh University of Engineering and Technology
ERD	:	Economic Relations Division, Ministry of Finance
JICA	:	Japan International Cooperation Agency
MOC	:	Ministry of Communications
PWD	:	Public Works Department
RHD	:	Roads and Highway Department
RRD	:	Roads and Railway Division

B. Other Abbreviations

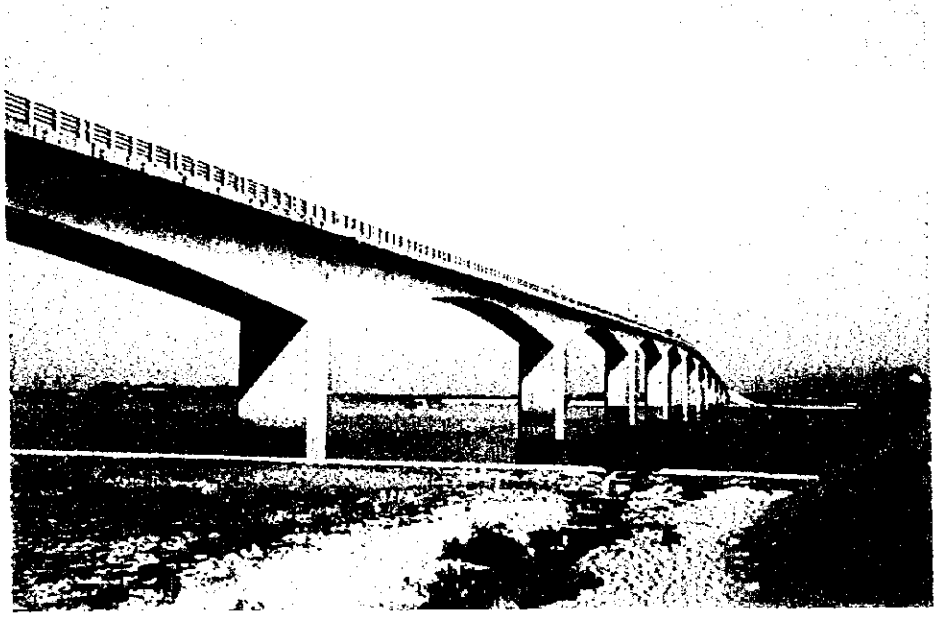
BM	:	Bench Mark
DL	:	Datum Line
EL	:	Elevation
EN	:	Exchange of Notes
GWL	:	Groundwater Level
LT	:	Low Tide
HT	:	High Tide
HWL	:	High Water Level
LWL	:	Low Water Level
m/s	:	Metre per Second
m^3/s	:	Cubic Metre per Second
N	:	Blow Number of Standard Penetration Test
NP	:	None Plastic
PPM	:	Parts per Million
PS	:	Metric Horsepower
SS	:	Suspended Solid
TBM	:	Temporary Bench Mark
WL	:	Water Level



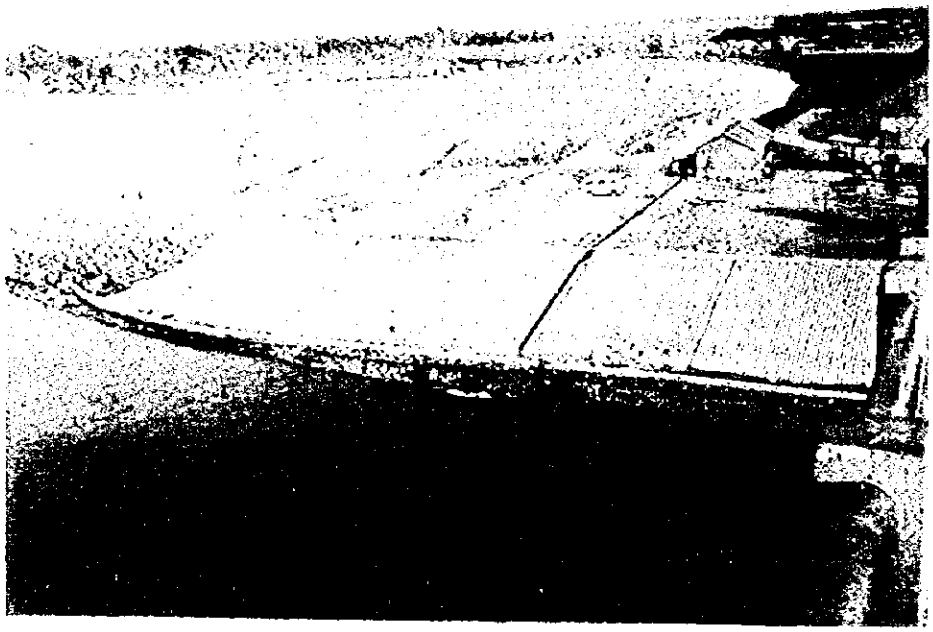
PROJECT LOCATION MAP



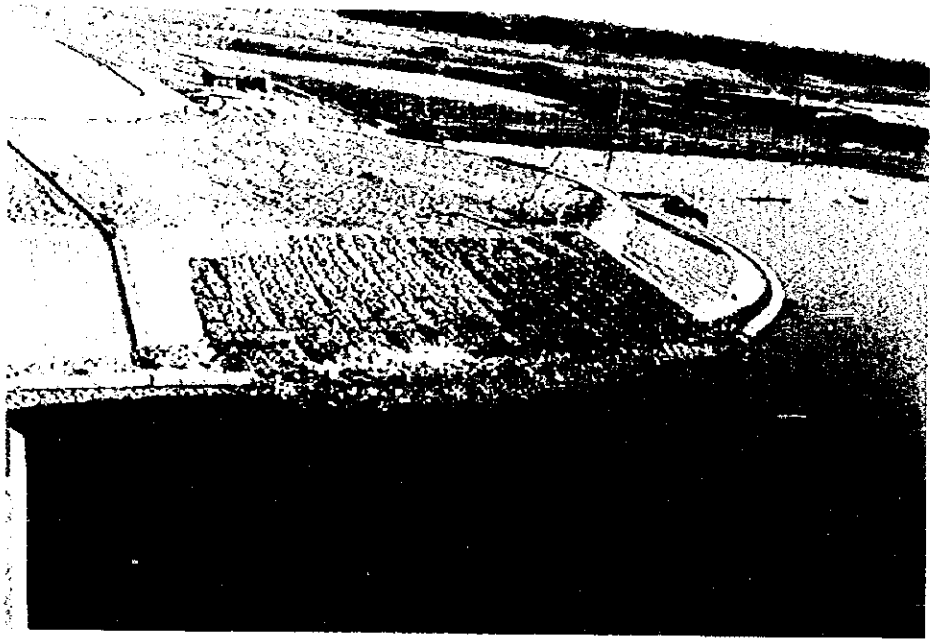
MAP OF PROJECT AREA



Meghna Bridge
(Viewed from Comilla Side)

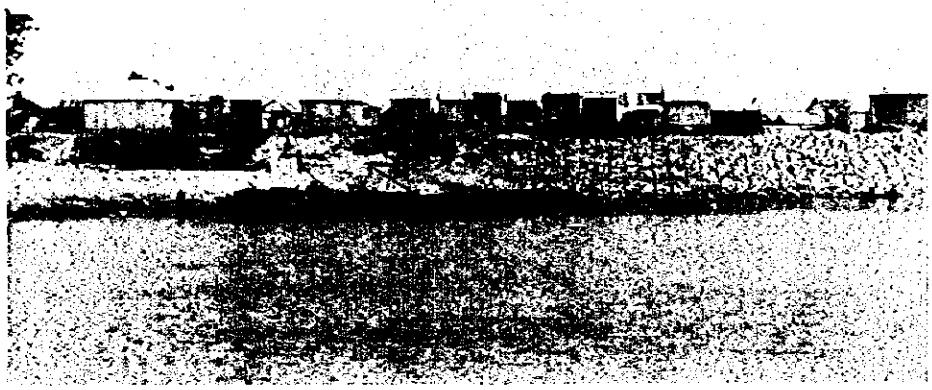


Existing Revetment
(Left Bank, Upstream)



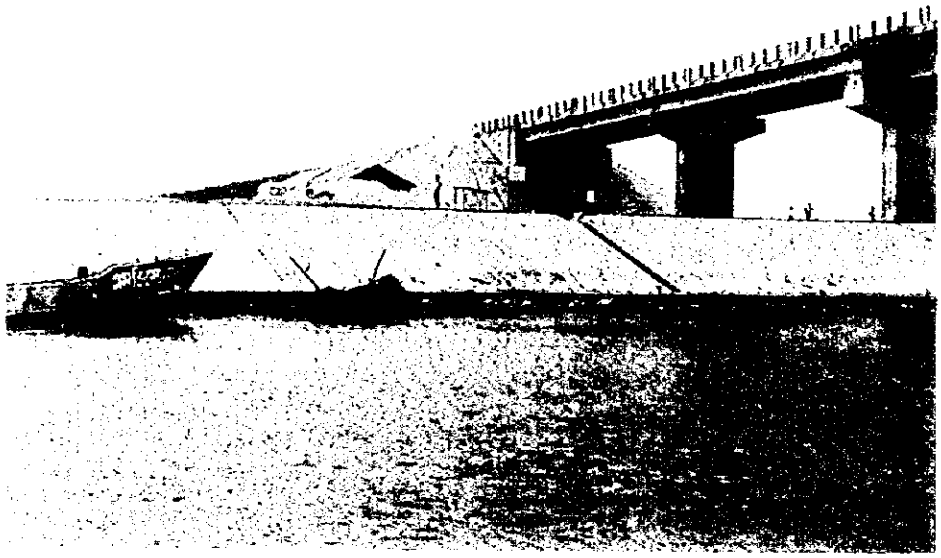
Existing Revetment
(Left bank, Downstream)

Erosion of River Bank
(Left Bank, Upstream)

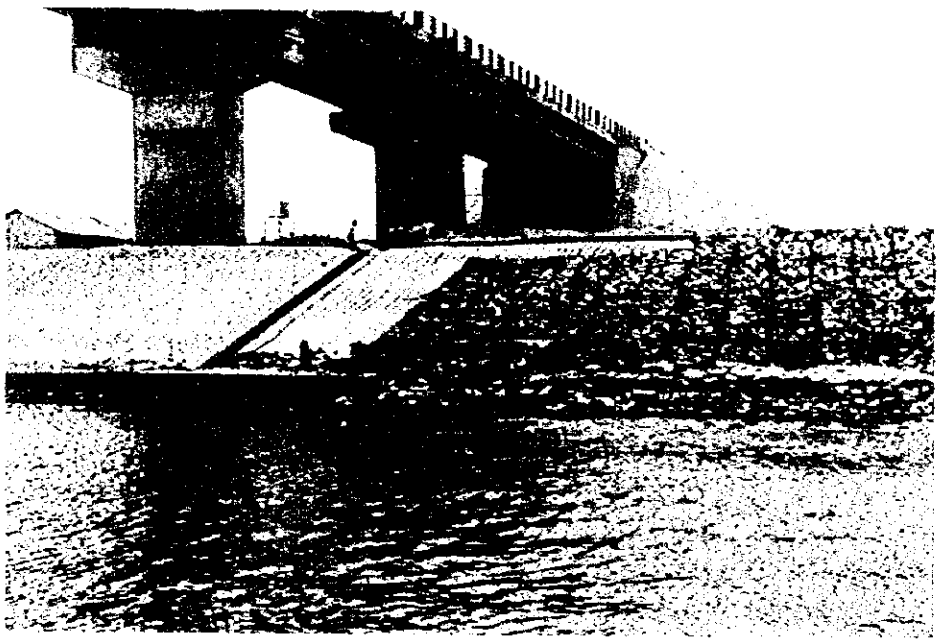


Revetment Construction
with Gabions
(Left Bank, Upstream)

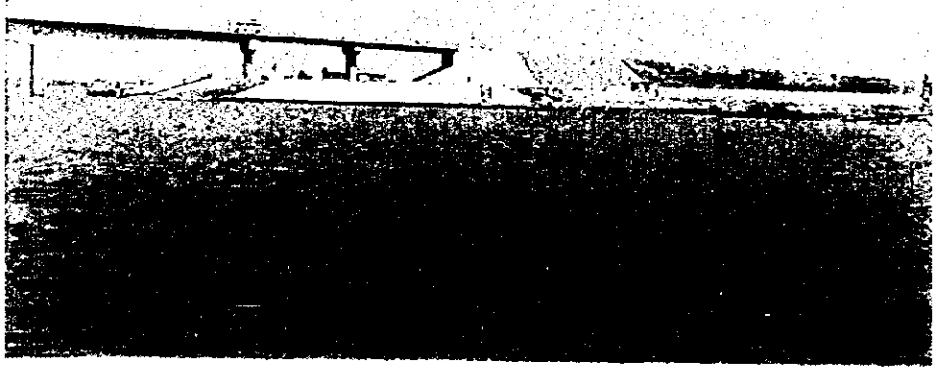
Same as above



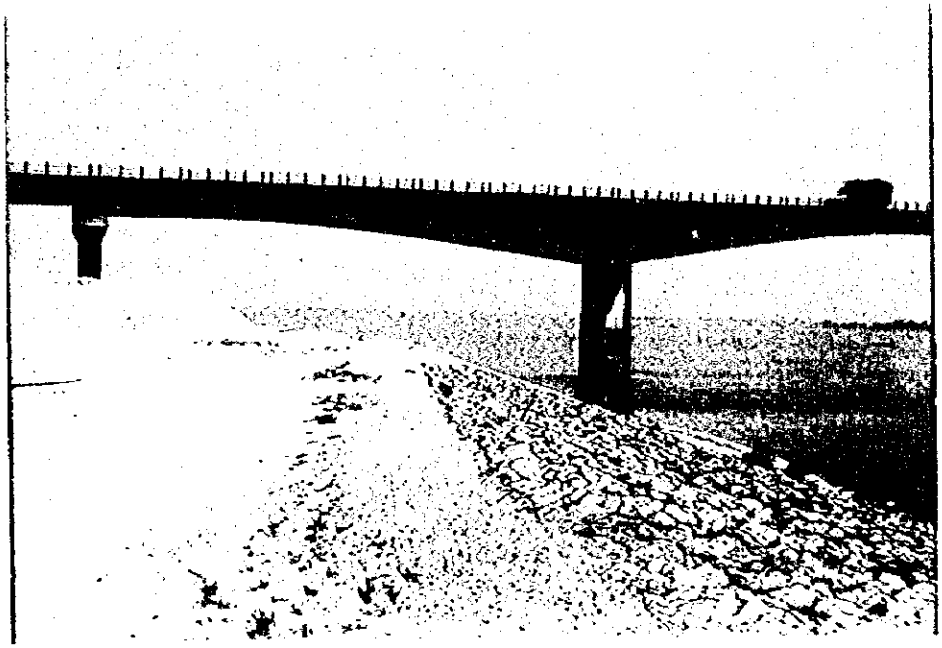
Original Revetment at Left Bank



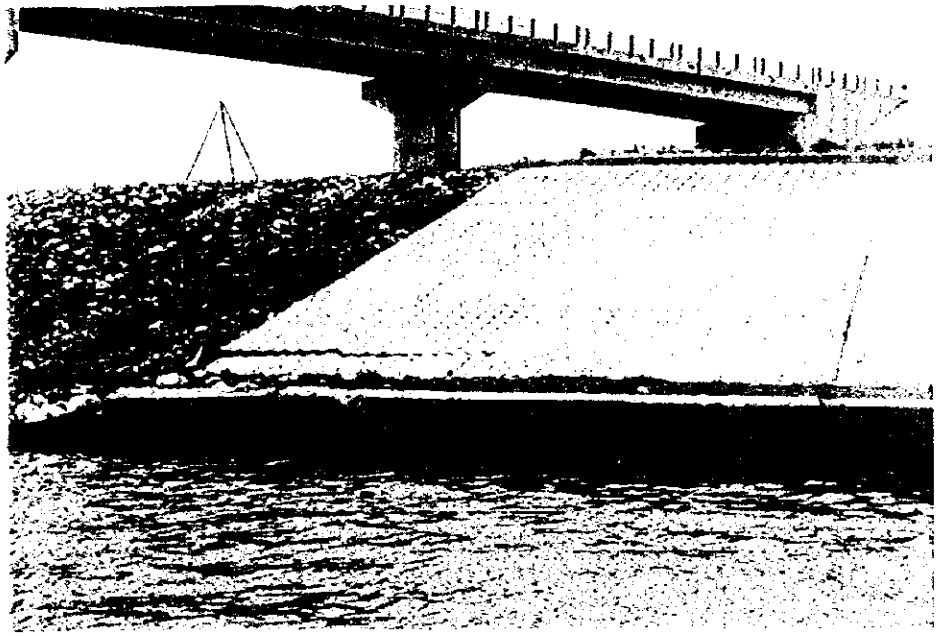
Original Revetment and Restored Revetment with Gabions at Left Bank



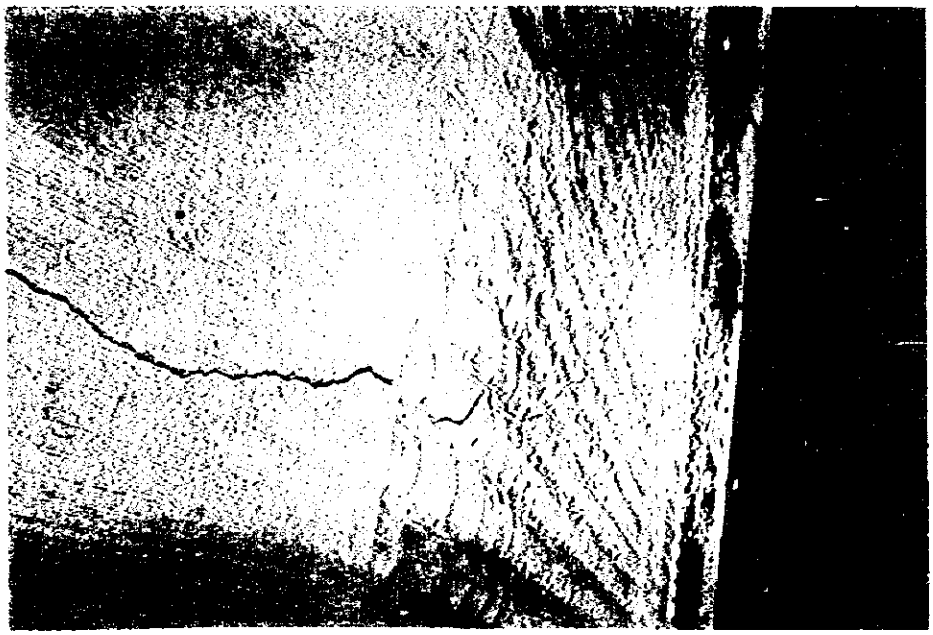
End Spans of Meghna Bridge (Comilla Side, viewed from Downstream)



Existing Condition of
Gabions Revetment
(Left Bank, Upstream side)



Existing Condition of
Geotextile Form Concrete
Revetment
(Left Bank, Downstream side)



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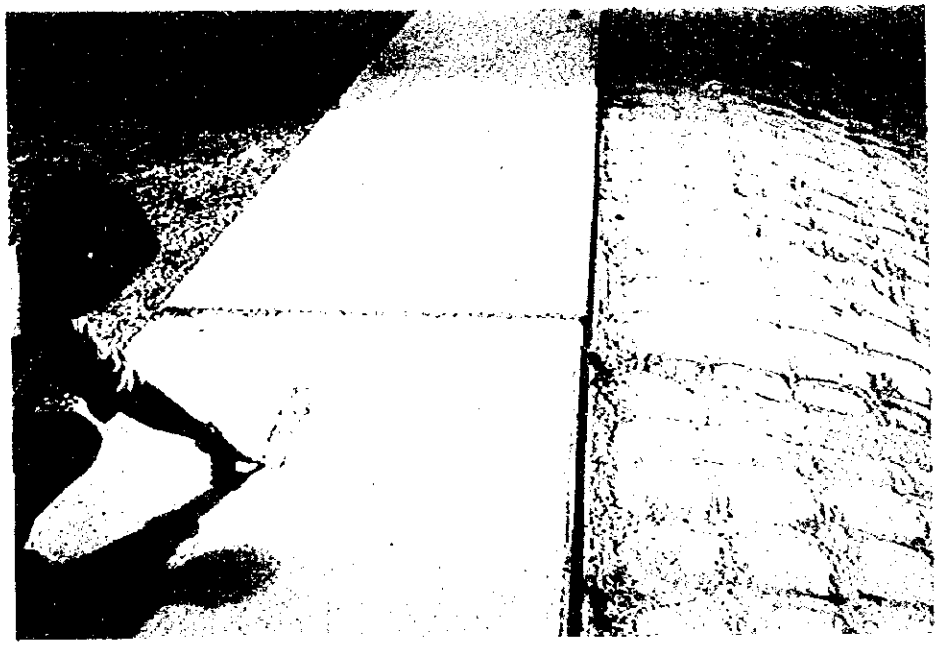
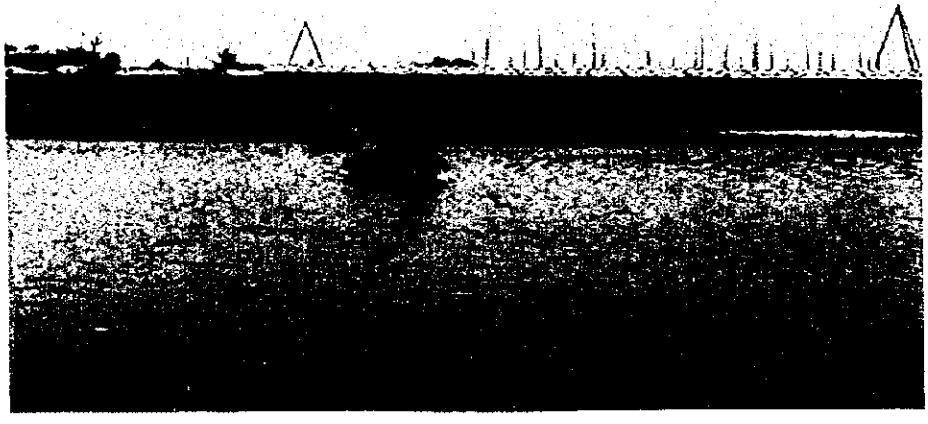
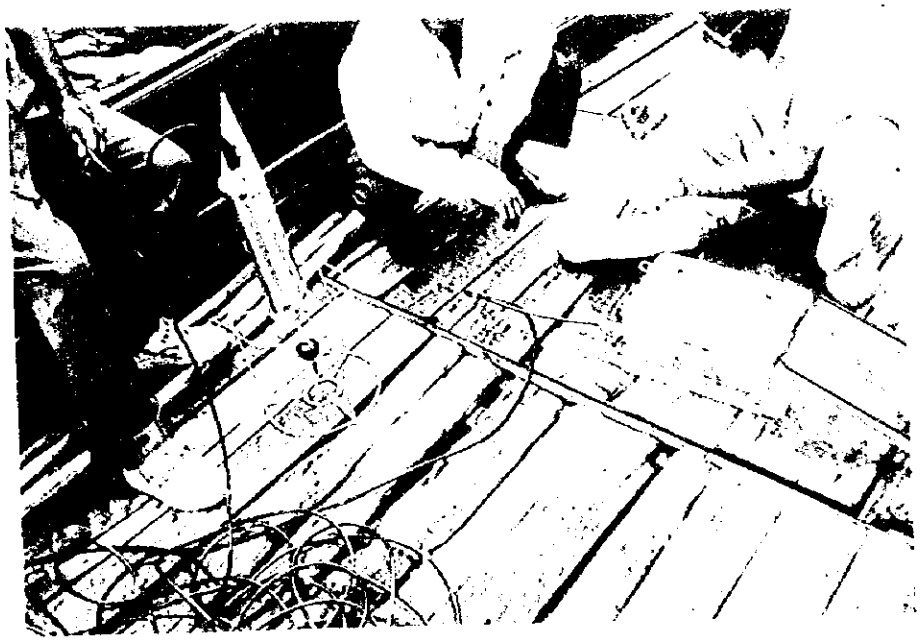


Temporary Bench Mark

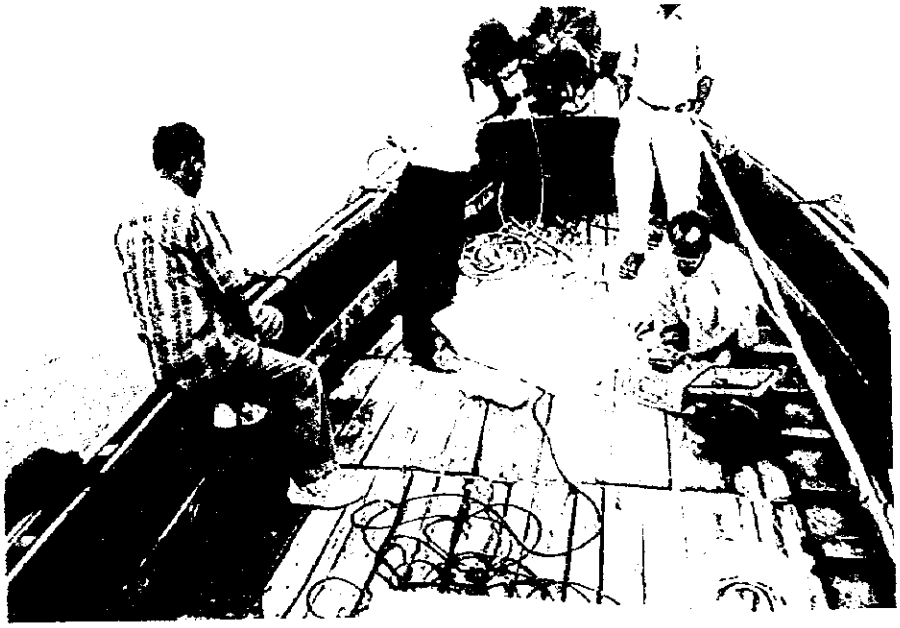
Sounding Work
(Echo Sounder)



Sounding Boat



Flow Direction and
Velocity Measurement



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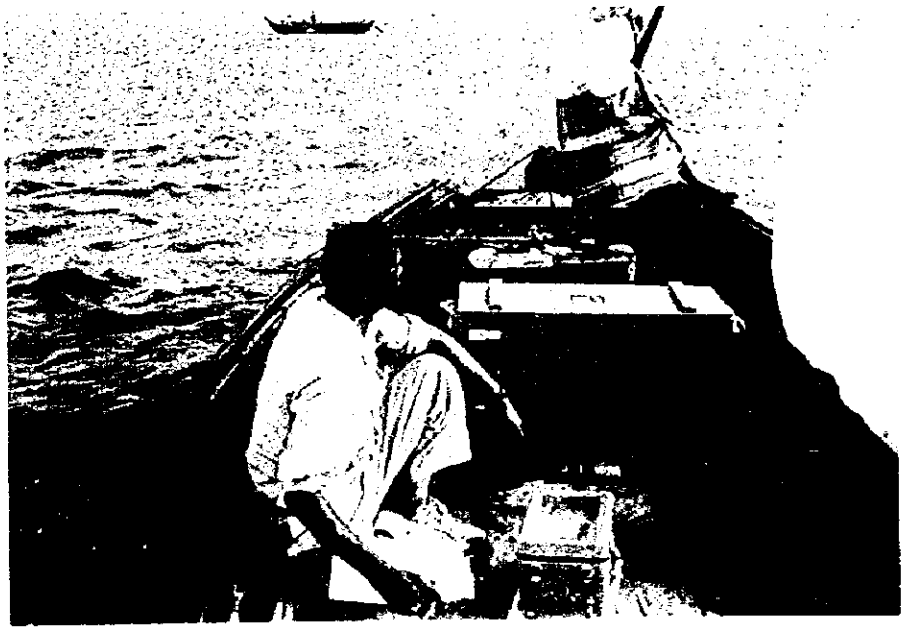

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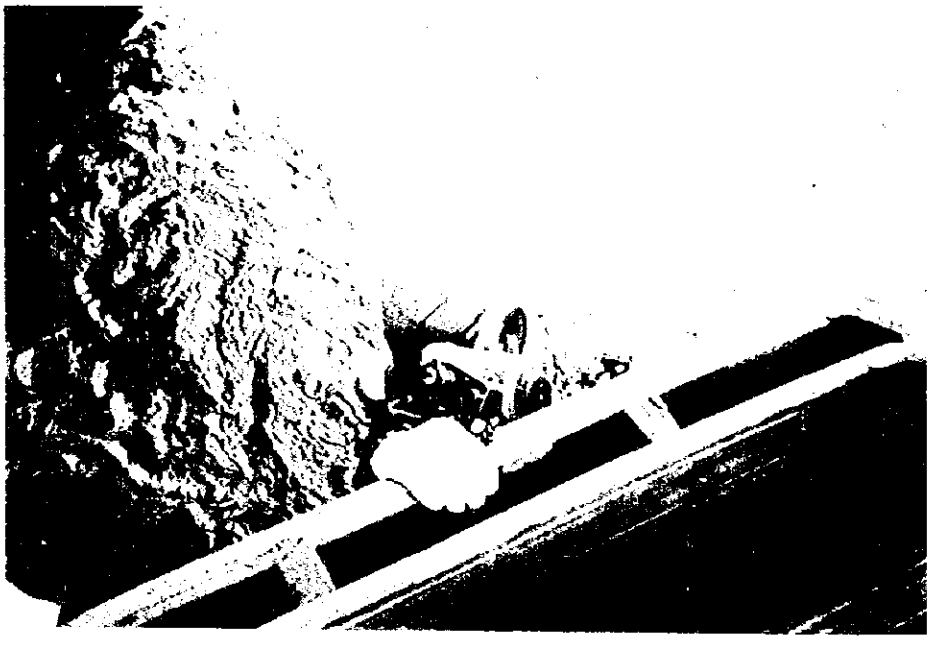
Sampling for Suspended-Load Test

Same as above

Bottom Sampling

Same as above

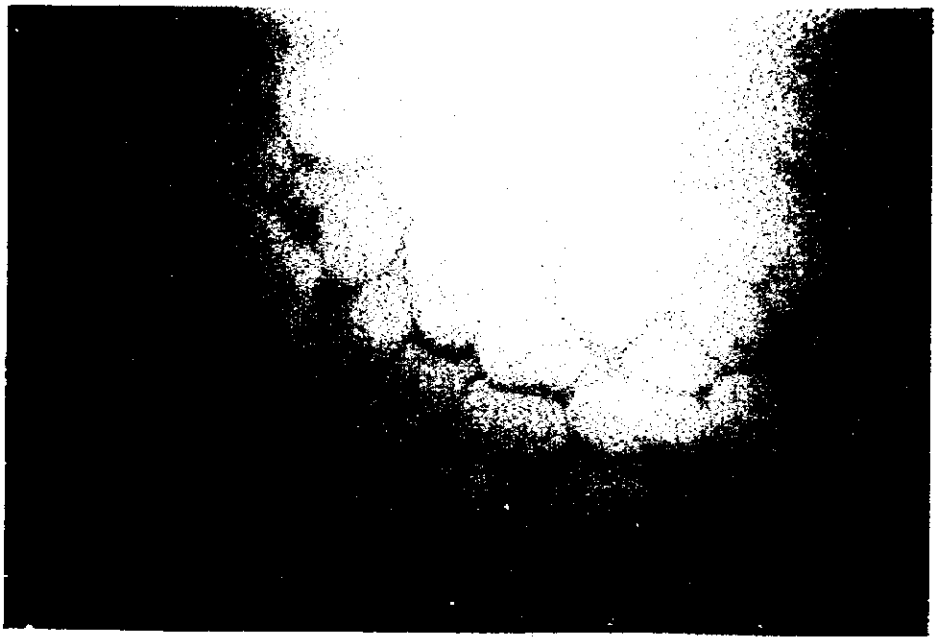
Scouring Observation by a Diver's Crew



Same as above

Existing Condition of Riprap Protection at Pier Footing

Same as above



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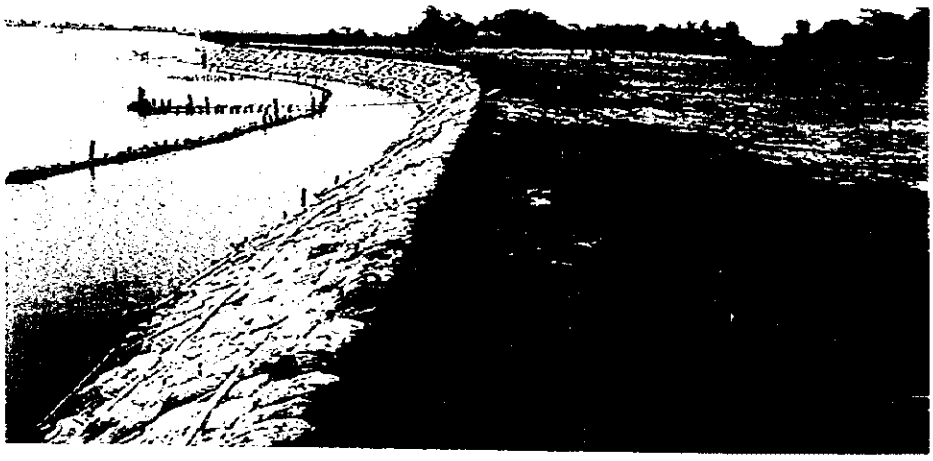
Left Bank, Upstream
(0.5 km)
Private Land
Reclamation

Same as above



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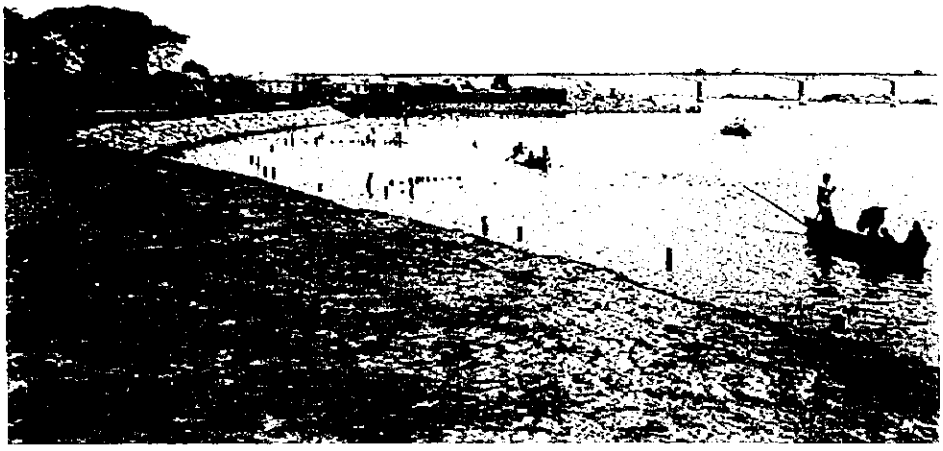
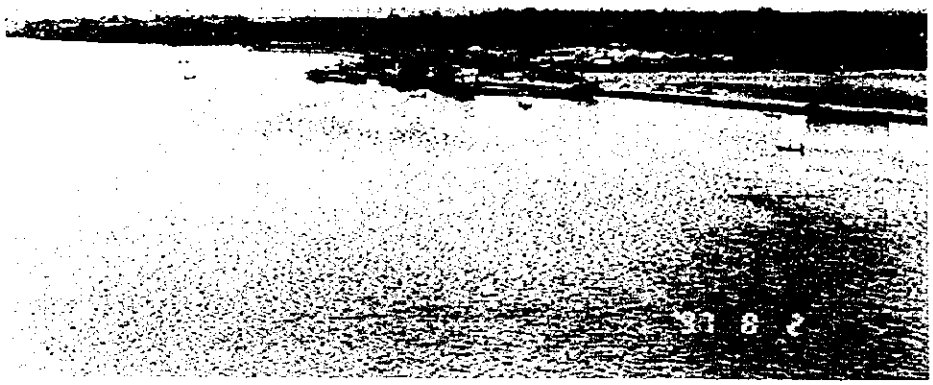


Left Bank, Upstream
(0.5 km)
Private Land
Reclamation

Same as above

Left Bank, Upstream
(0.5 km)
Signboard of Private
Land

Left Bank, Upstream Vortex



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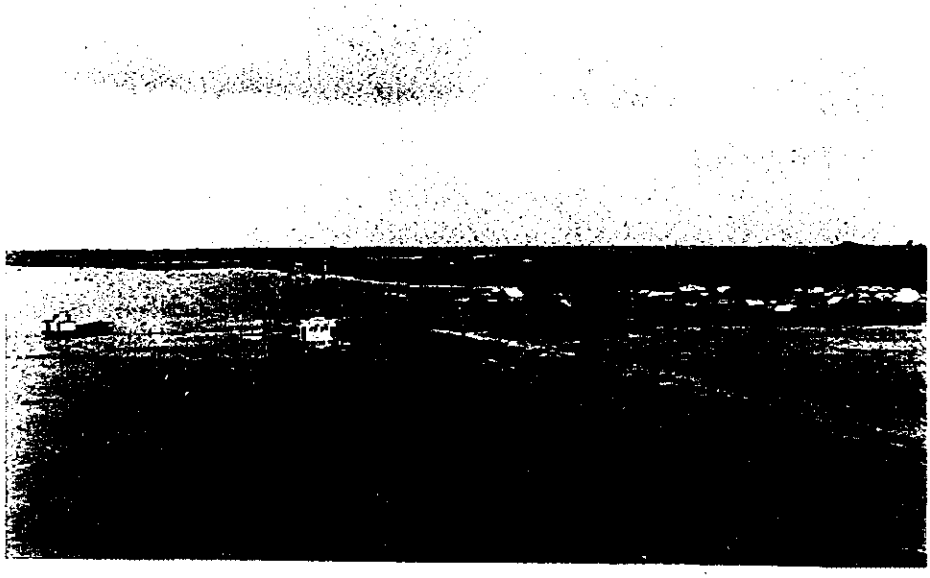

Same as above

SUMMARY

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1. Background

The Dhaka-Chittagong Highway with a total length of about 260 km is the nations "Lifeline" connecting Dhaka, the capital city and centre of social and economic activities of Bangladesh, with Chittagong, the country's second largest city which has an industrial area and the country's largest port.

The development of the Dhaka-Chittagong Highway was given the highest priority due to the large share of population and gross regional product (both about 30 % of the nation's total) within the Highway's service area, and due to its important role in the movement of passengers and cargoes in Bangladesh.

The Dhaka-Chittagong Highway crosses the Meghna river (830 m wide) and the Meghna-Gumti river (1,350 m wide) at about 25 km and 40 km southeast of Dhaka respectively, where the Roads and Highways Department (RHD) had been providing ferry services. As the waiting time of vehicles for ferry crossing had increased, RHD had to increase the number of ferry vessels and strengthen ferry facilities to accommodate the traffic demand. However, it had been anticipated that the economic loss by time consuming ferry crossings will increase drastically in the future as a result of rapid growth of road traffic.

Under such circumstances there had been an urgency to construct the Meghna Bridge and Meghna-Gumti Bridge since the road transport interruption at the Meghna and Meghna-Gumti rivers could become a major problem in the very near future and the usage of the Dhaka-Chittagong Highway would be restricted unless the problem of "no ferry crossing" is completely solved.

At the request of the Government of Bangladesh (GOB), the Government of Japan (GOJ) accepted to extend a grant aid for the construction of the Meghna Bridge and Meghna-Gumti Bridge. The construction of these bridges was completed in 1991 and 1995 respectively and goods and passengers have been transported faster at lower costs, thereby contributing to the activation of the national economy.

After the flood in 1988, a large sand bar located 2 km upstream of the Meghna Bridge advanced toward the left bank, then the main river channel shifted toward the left bank.

When the water level receded after the flood in 1991, the bank protection for the Meghna Bridge had collapsed in the Comilla side. The collapse could seriously affect the safety of the Meghna Bridge and its approach road.

The GOB then has requested the GOJ for a grant aid for the construction of revetment of the Meghna river to protect the Meghna Bridge and its approach road. In response to this request, the "Basic Design Study on the Project for Protecting Revetment on the Bank of Meghna River" was carried out in 1992 and the detailed design and construction of the said revetment took place in 1992 - 1994 under a Japanese grant aid project.

After the completion of the above-mentioned revetment construction, periodical observation of the revetment structure and the cross-section survey of the Meghna river course have been carried out within the framework of Japanese technical assistance program (1994 - 1997). Result of the survey revealed that erosion and deposition were progressing in the river section upstream of the Meghna Bridge.

In order to grasp the recent situation of the Meghna river and to secure the safety of the Meghna Bridge, the Japan International Cooperation Agency (JICA) sent a Follow-Up Study Team to Bangladesh on October 3 - 7, 1996 and the team found out:

- Erosion was progressing for about 4 km on the left bank upstream of the Meghna Bridge.
- Local scouring was occurring on the riverbed in front of the revetment which was constructed in 1993 - 1994 (the Project for the Construction of Revetment on the Bank of Meghna River, Japanese grant aid project).

In the light of the result of the Follow-Up Study, the GOB further requested the GOJ for grant aid for the construction of protection works which are urgently required.

In response to the request from the GOB, the GOJ decided to conduct a basic design study on the Project for Protection Works for Meghna Bridge and entrusted the study to JICA.

JICA sent to Bangladesh the Basic Design Study (the Study Team), two times from April 5 to May 17, 1997 and July 31 to August 29, 1997 to confirm the contents of the request and to investigate the requirements to see whether it is justified for a Japanese grant aid programme.

2. Basic Policy of the Study and Aim of the Project

The basic design was performed bearing in mind the discussions held in Bangladesh with the officials concerned of the GOB and the results of the field surveys. The major points of understanding reached are:

- The objective of the Project is to provide short-term protection works against erosion hazards on the Comilla side of the Meghna Bridge; and
- The protection works consist of armoring of the riverbed around existing pier footings and armoring of the deeply scoured riverbed area in front of the existing revetment constructed in 1992 - 1994 (Project for Protecting Revetment on the Bank of Meghna River).

3. Field Surveys

In Bangladesh, the Study Team conducted the following surveys in the Study Area:

- Topographical survey and sounding;
- Soils survey;
- Riverbed materials investigation;
- Study and observation of discharge, velocity, flow direction and water level of the Meghna river;
- Measurement of suspended solid contents;
- Identification of erosion, siltation and scouring;
- Inspection of existing revetment; and
- Study of flow regime.

4. Major Findings and Recommendations

The major findings of the field surveys and the basic design study are described in the following.

- The stability of piers was analyzed and the result of analysis revealed that the bridge piers will maintain enough safety for all loading conditions in the case the riverbed elevation is higher than R. L. -22 m.
- At present, the areas around the foundations of piers P7, P8 and P9 located in the riverbed lowering area are covered with stone mats and the said stone mats are judged as in the stable condition.

- The riverbed between stone mats is composed of a hard sand layer, therefore scouring would not proceed easily. However, the thickness of the said sand layer is relatively small and the provision of riverbed protection works around the existing stone mats is recommended.

- The safety to sliding was checked for the existing revetment at about 350 m upstream of the Meghna Bridge. The result revealed that no major sliding would occur even if the face of slope becomes extremely steeper (about 1 to 1).

- The deep scouring area, the lowest riverbed elevation R. L. -29 m, in front of the above-mentioned existing revetment has been basically remaining at the same location and depth since 1994. However if the riverbed scouring proceeds further and changes the location downstream due to eventual future large floods, it will affect the Meghna Bridge piers. In order to prevent this kind of hazard and the scouring at the toe of the revetment slope, construction of riverbed armor is recommended.

5. Proposed Protection Works

The proposed protection works for the Meghna Bridge is as follows:

(1) Scope of Protection Works

Protection works will be done for the Meghna Bridge on Comilla side.

a. Riverbed armoring around the bridge pier footings (P7, P8 and P9)

One meter thick stone mat protection.

b. Riverbed armoring for the deeply scoured area in front of the existing revetment (on the left bank, about 250 meters upstream of the Meghna Bridge)

One meter thick sacked gravel mat protection.

c. Grading work around the Comilla side abutment and the repair of the existing revetment

Grading of the area on the rear side of the existing revetment and replacement of existing concrete filled fabric tubes with new gabions.

(2) Work Components

The work components are classified into the following six categories:

- Preparatory Work;
- Stone or Sacked Gravel Mat Protection;
- Grading Work;
- Removal of Damaged Slope Paving;
- Gabion Work; and
- Clean-Up.

(3) Construction Policies

The adopted construction policies are briefly summarized as follows:

- Make maximum use of construction materials available in Bangladesh, and allow for future repairs and protections to be made by the Government of Bangladesh.

- Complete all construction works before the start of the rainy season in 1999.

- Set up construction offices and lodging facilities in RHD's land on the left bank upstream of the Meghna Bridge (Comilla side) to allow round-the-clock construction operations as well as thorough monitoring and inspection of the construction works.

- The stone and gravel to be used for the construction will be procured during the high water season of the river (June - November) considering the inland water transport situation.

(4) Construction Materials and Equipment

The following construction materials and equipment will be procured from the market in Bangladesh.

- Stone and gravel;
- Jute bags; and
- Construction equipment and steel shapes for temporary works.

Bangladeshi barges, tugboats, lighters, etc., will be utilized for the construction.

6. Future Maintenance

Because of the hydraulic characteristics of flow in the river stretch where the Meghna Bride is located, a lot of unknown factors concerning river morphology still remain. Hence more extensive studies and investigations will be needed. For this reason, data collection and surveys are prerequisite for such studies and investigations in the future.

In the vicinity of the Meghna Bridge, bank erosion and siltation and shifting of the sand bar seem to become moderate after completion of the revetment on the bank on Comilla side. However, it should be noted that unknown phenomena might occur in case of excessive floods, and this requires immediate provision of countermeasures. Therefore, reinforcement of the organization for operation and maintenance of existing facilities by the Government of Bangladesh is quite important to ensure safety of the Meghna Bridge.

7. Effect of the Project

The Dhaka-Chittagong Highway is the country's most important highway and the land transport demand of Bangladesh originates mainly in Dhaka and Chittagong. The traffic volume at the Meghna Bridge had marked approximately 4,000 vehicles/day in 1990 but this demand jumped to 2.5 times volume of 10,000 vehicles/day at the same place in 1997. The Meghna Bridge together with neighbouring Meghna-Gumti Bridge are thus contributing not only to the development of surrounding regions of the bridges but also activating the economy of the whole of Bangladesh.

The implementation of the Project is expected to attain the following effects:

- Securing of safety of the bridge piers and abutment against scouring hazard;
- Prevention of scouring at the toe of existing revetment to secure the safety against sliding;
- Enhancement of embankment and revetment stability around the existing abutment; and
- Technical transfer of protection works for the Meghna Bridge to the GOB officials touching with the Project.

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INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background

In response to the request from the Government of the People's Republic of Bangladesh (GOB), the Government of Japan (GOJ) decided to conduct a Basic Design Study (the Study) on the Project for Protection Works for Meghna Bridge (the Project) in the People's Republic of Bangladesh (Bangladesh) and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Bangladesh the Basic Design Study Team (the Study Team), headed by Mr. Junji YOKOKURA, Deputy Director of Follow-up Division, Grant Aid Project Management Department, JICA, two times from April 5 to May 17, 1997 and July 31 to August 29, 1997.

In Bangladesh the Study Team held a series of discussions with the officials concerned of the GOB and conducted the following surveys in the Study Area:

- Topographical survey and sounding;
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- Study of flow regime.

After the Study Team returned to Japan, further studies were made. Then, a mission was sent to Bangladesh in order to discuss the Draft Final Report from November 9 to 13, 1997 and this report was prepared.

1.2 Objectives of the Study

The objectives of the Study are:

(1) To examine the effect of the Project and its appropriateness for the Grant Aid Program of JICA.

(2) To determine the most suitable contents and scale of the Project.

1.3 Contents of the Study

The aim of the Study is to provide a basic document necessary for the appraisal of the Project by the GOJ. The contents of the Study are as follows:

- Confirmation of the background, objectives and benefits of the Project, and also institutional capacity of agencies concerned of the recipient country necessary for the Project's implementation;
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from the technical, social and economic points of view;
- Confirmation of the items agreed upon by both parties concerning the basic concept of the Project;
- Preparation of the basic design of the Project; and
- Estimate of the Project cost.

CHAPTER 2

BACKGROUND OF THE PROJECT

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Under such circumstances there had been an urgency to construct the Meghna Bridge and Meghna-Gumti Bridge since the road transport interruption at the Meghna and Meghna-Gumti rivers could become a major problem in the very near future and the usage of the Dhaka-Chittagong Highway would be restricted unless the problem of "no ferry crossing" is completely solved.

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After the completion of the above-mentioned revetment construction, periodical observation of the revetment structure and the cross-section survey of the Meghna river course have been carried out within the framework of Japanese technical assistance program (1994 - 1997). Result of the survey revealed that erosion and deposition were progressing in the river section upstream of the Meghna Bridge.

In order to grasp the recent situation of the Meghna river and to secure the safety of the Meghna Bridge, JICA sent a Follow-Up Study Team to Bangladesh on October 3 - 7, 1996 and the team found out:

- Erosion was progressing for about 4 km on the left bank upstream of the Meghna Bridge.
- Local scouring was occurring on the riverbed in front of the revetment which was constructed in 1993 - 1994 (the Project for the Construction of Revetment on the Bank of Meghna River, Japanese grant aid project).

2.2 Major Items Requested by the Government of Bangladesh

In the light of the result of the Follow-Up Study, the GOB further requested the GOJ for grant aid for the construction of protection works which are urgently required. The requests are as follows:

- Execution of technical observation and survey for engineering study.
- Construction of short-term protection works for the Meghna Bridge on Comilla side.
- Formulation of study items for the medium and long-term protection works for the Meghna Bridge.

CHAPTER 3

OUTLINE OF THE PROJECT

CHAPTER 3 OUTLINE OF THE PROJECT

3.1 Objective of the Project

The objective of the Project is to provide short-term protection works against erosion hazards on Comilla side of the Meghna Bridge.

3.2 Description of Construction Work Components

The protection works consist of: i) Armoring of the riverbed around existing pier footings; and ii) Armoring of the deeply scoured riverbed area in front of the existing revetment constructed in 1992-1994 (Project for Protecting Revetment on the Bank of Meghna River).

The work components are classified into the following six categories:

- Preparatory Work;
- Stone or Sacked Gravel Mat Protection;
- Grading Work;
- Removal of Damaged Slope Paving;
- Gabion Work; and
- Clean-Up.

3.3 Executing Agency and Management Organization

The executing agency of the Project will be RHD, the Government Agency that has the total responsibility for principal internal roadway systems (national highways, regional highways, feeder roads type A) and is charged with the administration, planning, construction, operation, and supervision.

3.4 Maintenance Programme

The Project consists of short-term construction of riverbed protections (armoring) and will require maintenance work and maintenance administration after the completion of the construction.

The maintenance of the Meghna Bridge and Meghna-Gumti Bridge has been taken place by RHD's Narayanganj office. The total budget of the said office was approximately TK 160,000,000 (approximately Yen 470,000,000) in the fiscal year 1996-1997. Specific budget for the maintenance of the Meghna Bridge and Meghna-Gumti Bridge has not been designated but special budget allocation for these bridges is possible as required.

Table 3.1 shows the trend of RHD's allocated budget in the past seven years.

RHD's Allocated Budget

Unit: TK million

Fiscal Year	Development Project			Maintenance	Total
	Foreign Aid	Local Cost	Total		
1990-91	2,398	1,468	3,866	983	4,849
1991-92	3,891	3,082	6,973	1,401	8,374
1992-93	4,546	4,387	8,933	1,749	10,682
1993-94	4,384	6,456	10,840	1,796	12,636
1994-95	4,980	7,459	12,439	2,265	14,704
1995-96	2,659	5,226	7,885	2,256	10,141
1996-97	3,690	6,090	9,780	2,591	12,371

Source: 5-Year Highway Development Plan

CHAPTER 4

HYDROLOGY AND HYDRAULICS

CHAPTER 4 HYDROLOGY AND HYDRAULICS

4.1 Principal Features of Meghna River

The Meghna river is one of the three giant rivers which flow into the Bay of Bengal and form a huge delta in Bangladesh. The other two rivers are the Brahmaputra (Jamna) and Ganges (Padma) rivers which originate in the Himalayan Ranges.

Many tributaries join the Meghna river, namely the Jadukata and Ronga rivers running in Megaraya State, the Surma and Kaloni rivers running Assam State, and the Bimyana river running in Tripura State in India. The river's catchment area is approximately 70,000 km^2 at the Meghna bridge site. The Meghna river basin is affected by the climate over the hilly regions of Megaraya, Assam and Tripura in India because 63% of the basin belongs to the Indian territory. These hilly regions receive abundant rainfall in the monsoon season from July to September. At the Meghna bridge site, rise of water level and floods mostly occur one to two weeks later than the monsoon season in the upstream area.

The Meghna river is a primitive river like the Ganges and Burahmaputra rivers which are forming the delta and their river courses are changing extremely. Although survey and research data regarding the Meghna river are quite limited in comparison with the other two rivers, chronological changes of its river course near the Meghna bridge can be characterized based on old maps, Landsat images, and river survey results from 1989 to 1997 (this Study) as described in the following paragraphs.

Until the 1770s, the Brahmaputra river ran along the present Old Brahmaputra river. Since the Teesta river, which is a tributary of the Brahmaputra river, changed its course directly to the Ganges (it is said that was due to earthquake), in the middle of the 1770s, the Brahmaputra river shifted to the present river course from the Old Bramaputra river.

According to a map in 1919, the Meghna river almost ran along the present channel course. The sand bar on the right bank immediately upstream started to develop around 1973. It was completely separated from the bank and moved toward the left bank and downstream side. Based on the river survey results, the sand bar moved about 10 m annually on average toward the left bank and about 20 m toward downstream during the 9 years from 1989 to 1997.

4.2 Water Level and Discharge Records at Bhairab Bazar

4.2.1 Hydrological Records

In order to grasp the hydrological features around the Meghna bridge, the records at the Bhairab Bazar gauging station located nearest the bridge (60 km upstream) and at Chandpur gauging station were scrutinized. Further, hydrological monitoring was performed continuously during the bridge construction period from 1987 to 1990.

A location map of the gauging stations is shown in Fig. 4.2.1 and the period of availability of hydrological data is illustrated in Fig. 4.2.2.

4.2.2 Catchment Area

The catchment areas at the Bridge site and at Bhairab Bazar are listed below:

(Unit : km^2)

Location	Out side Bangradesh Territory	Within Bangladesh Territory	Total
Bhairab Bazar	41,300	21,570	62,900
Remaining area	2,760	4,170	6,930
Meghna bridge	44,50	25,740	69,890

Source: Feasibility Study Report on Meghna and Meghna-Gumti Bridges Construction (March 1985)

4.2.3 Water Level and Discharge Records

Water level and discharge records at Bhairab Bazar are graphically shown in Figs. 4.2.3 and 4.2.4, and those at Chandpur in Figs. 4.2.5, 4.2.6 and 4.2.7.

Annual maximum discharges at Bhairab Bazar are tabulated in Table 4.2.1 and the maximum discharge of 19,900 m^3/s was recorded on July 24, 1993.

4.3 Water Level and Velocity Records at Meghna Bridge

Hydrological data at the Meghna bridge were collected during the bridge construction and the recording periods are as follows:

- Water level records (hourly) : Jun. 1989 to Jan. 1990
- Water level records (daily) : Sep. 1987 to Jan. 1990
  May 1991 to Feb. 1992
- Velocity records (daily) : Sep. 1987 to Jan. 1990

The water level and velocity records are graphically shown in Figs. 4.3.1, 4.3.2 and 4.3.3 respectively.

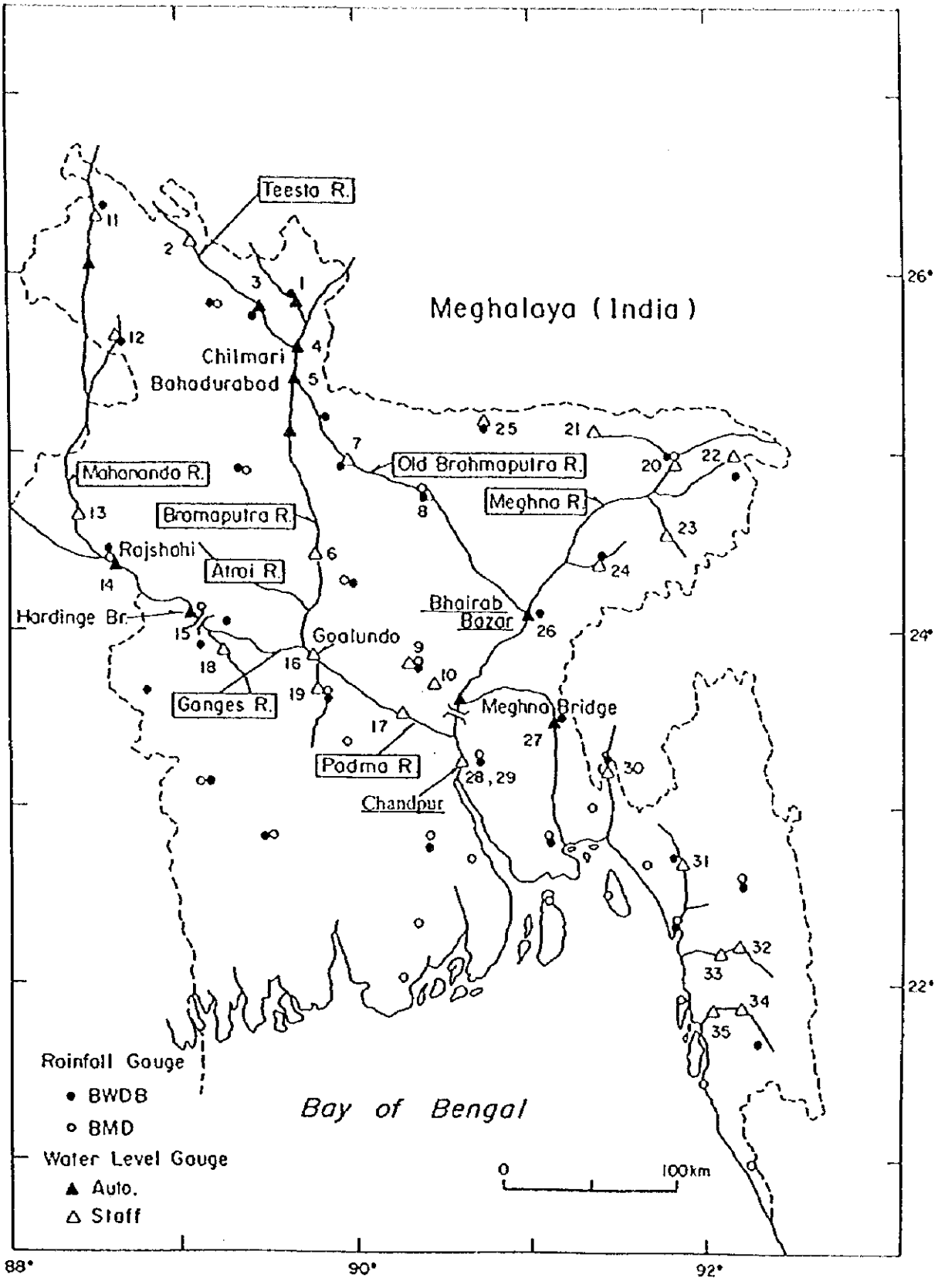


Figure 4.2.1 Location Map of Meteohydrological Observatories in Bangladesh

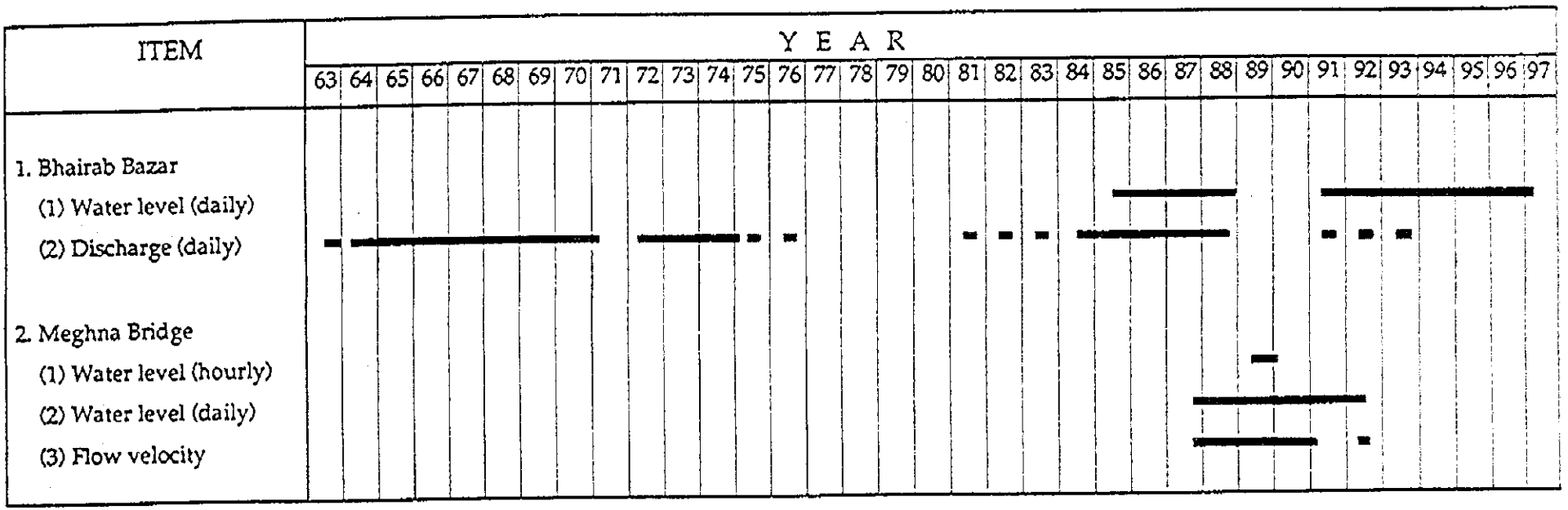


Figure 4.2.2 Available Hydrological Data near Meghna Bridge

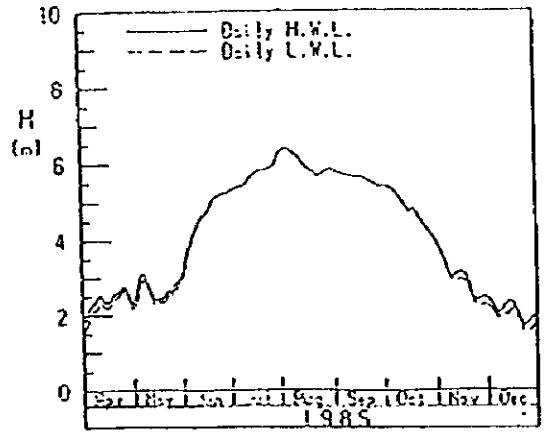


Figure 4.2.3 Daily Water Level at Bhairab Bazar (1)

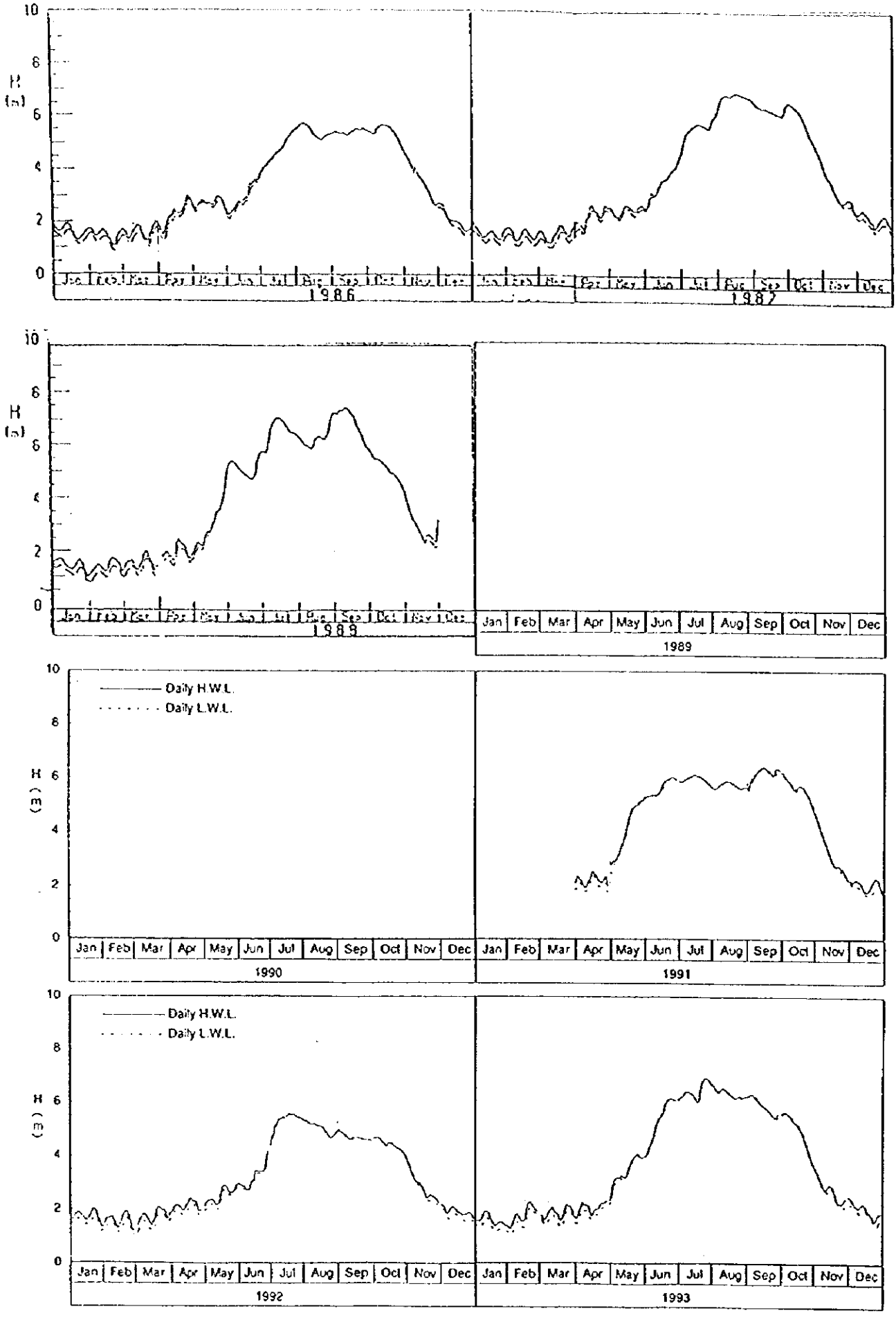


Figure 4.2.3 Daily Water Level at Bhairab Bazar (2)

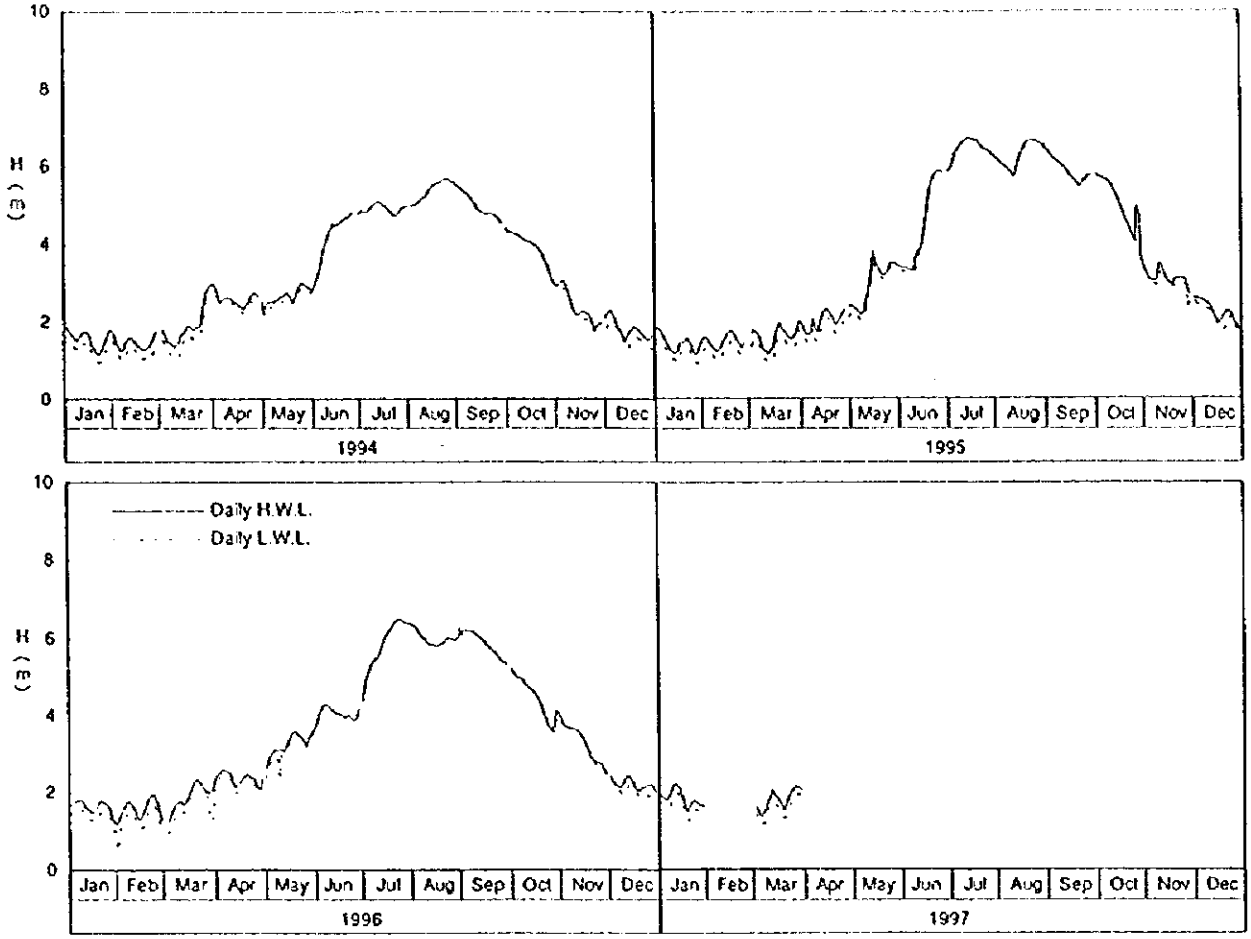


Figure 4.2.3 Daily Water Level at Bhairab Bazar (3)

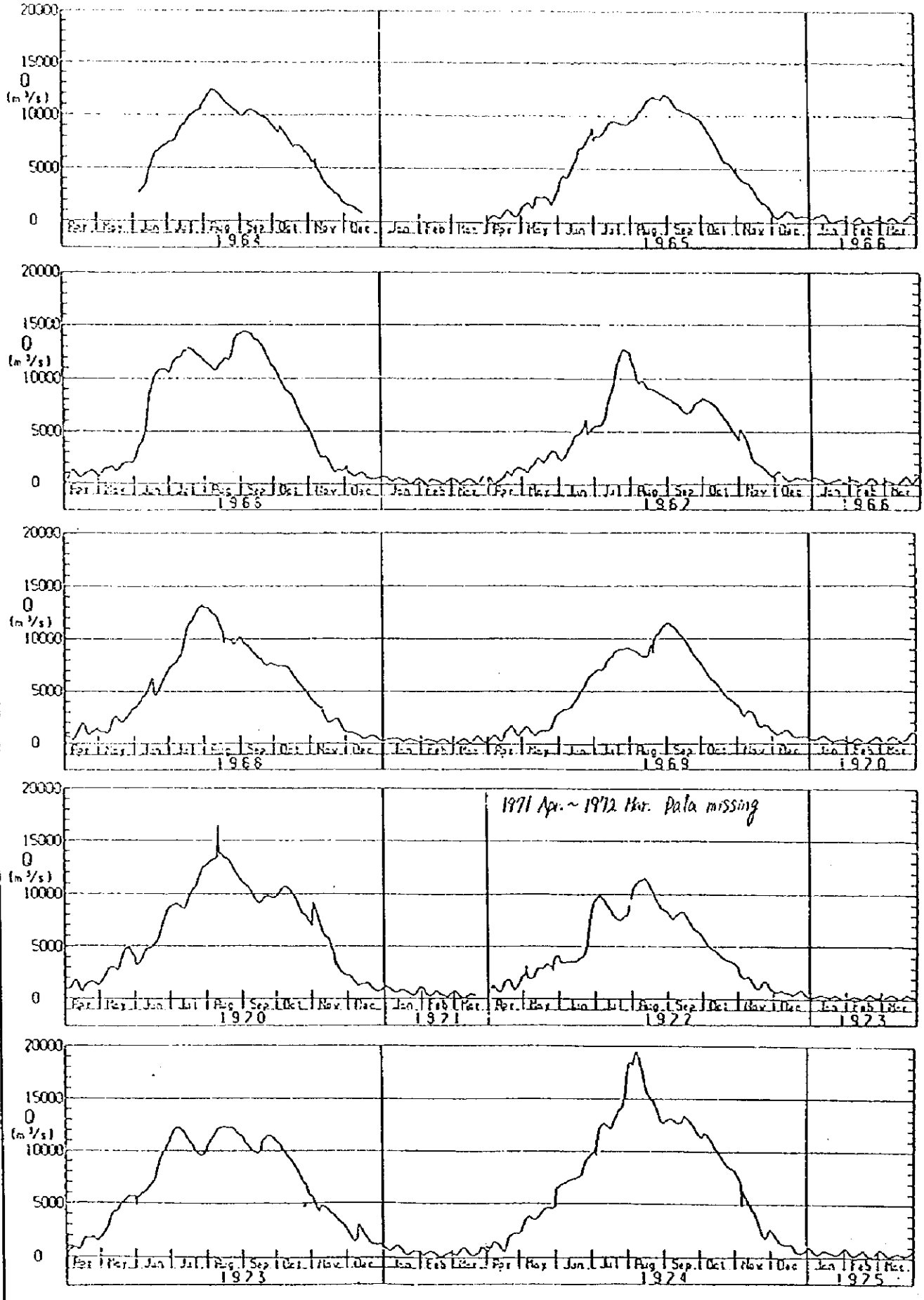


Figure 4.2.4 Daily Discharge at Bhairab Bazar (1)

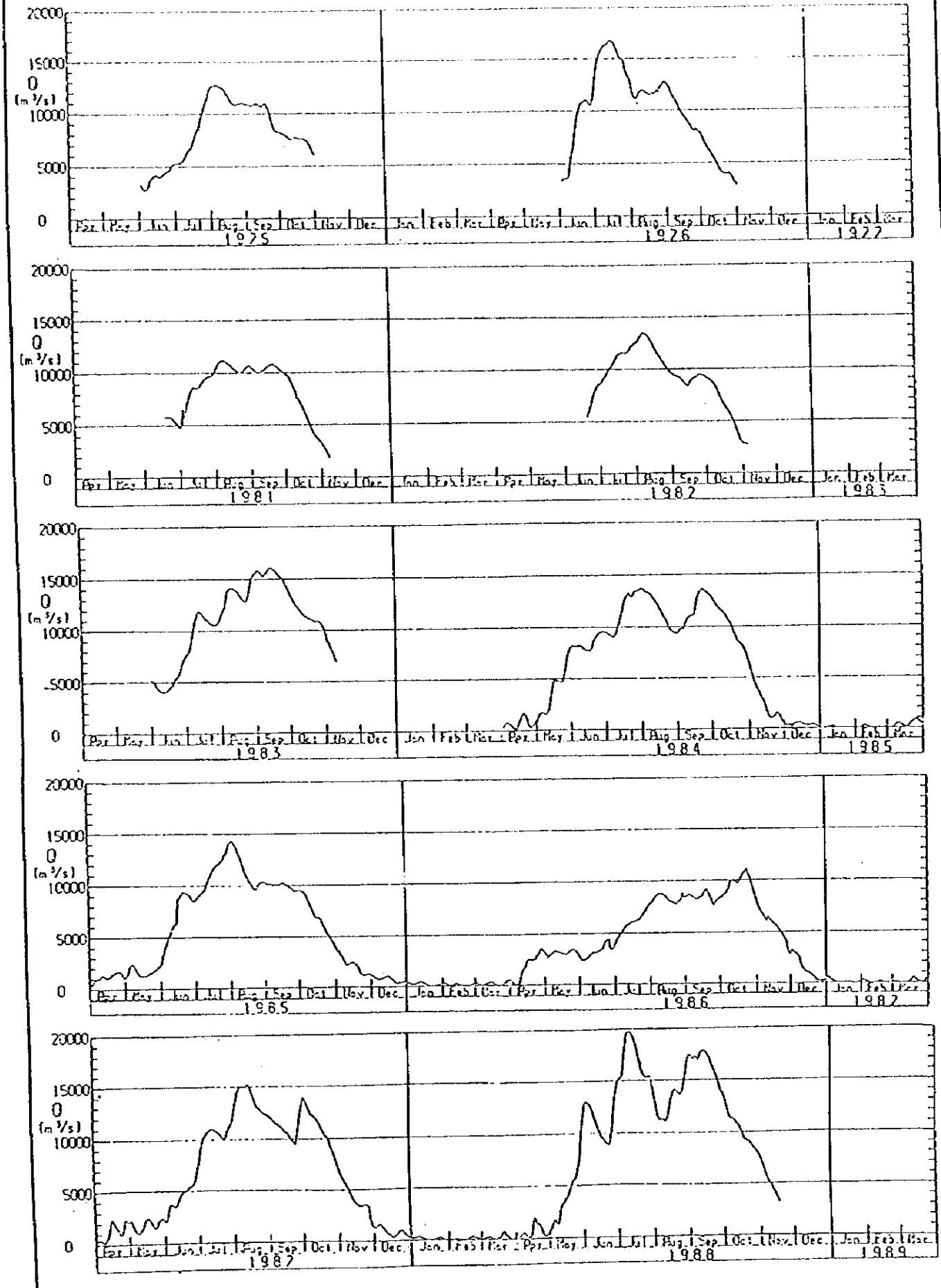


Figure 4.2.4 Daily Discharge at Bhairab Bazar (2)

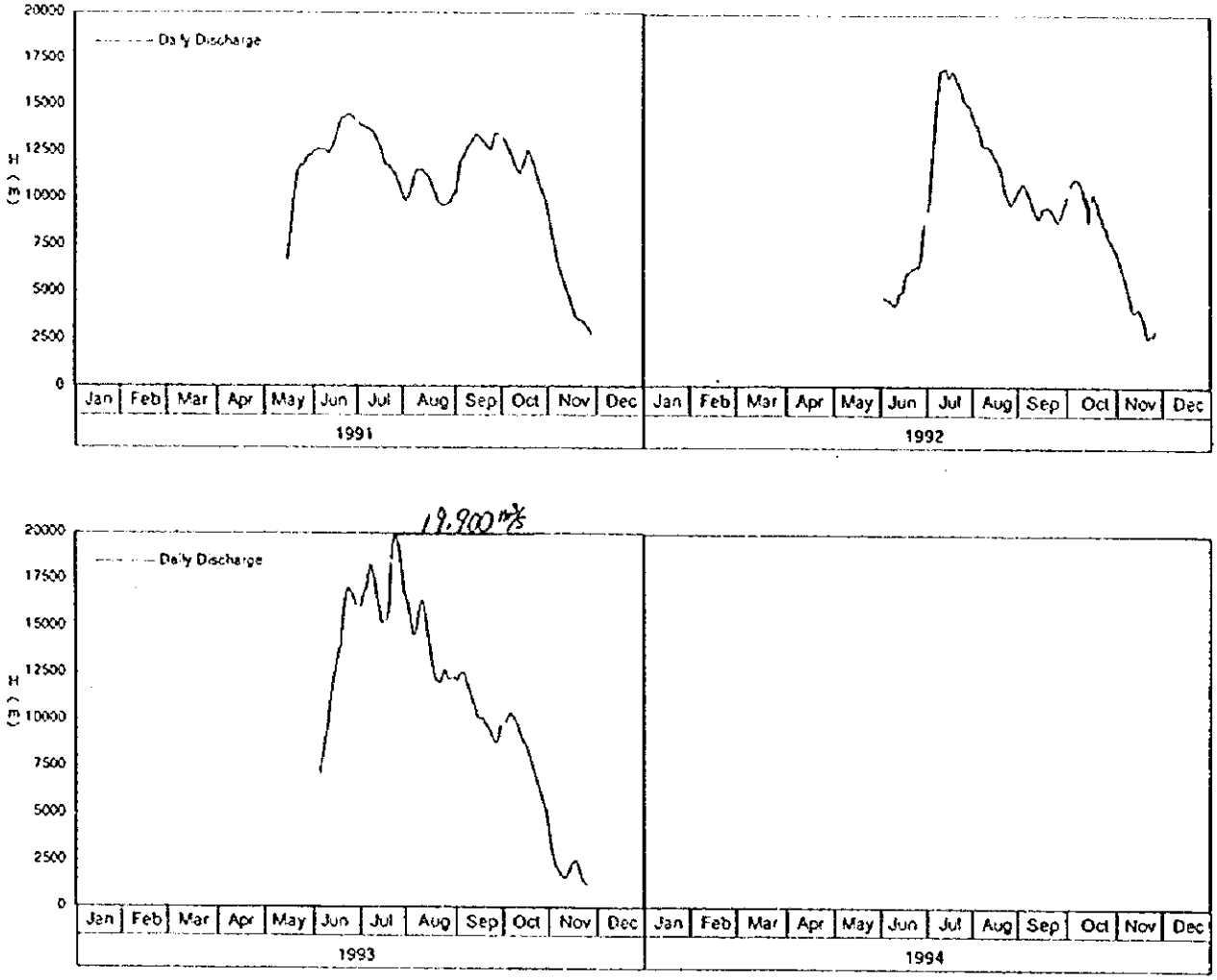


Figure 4.2.4 Daily Discharge at Bhairab Bazar (3)

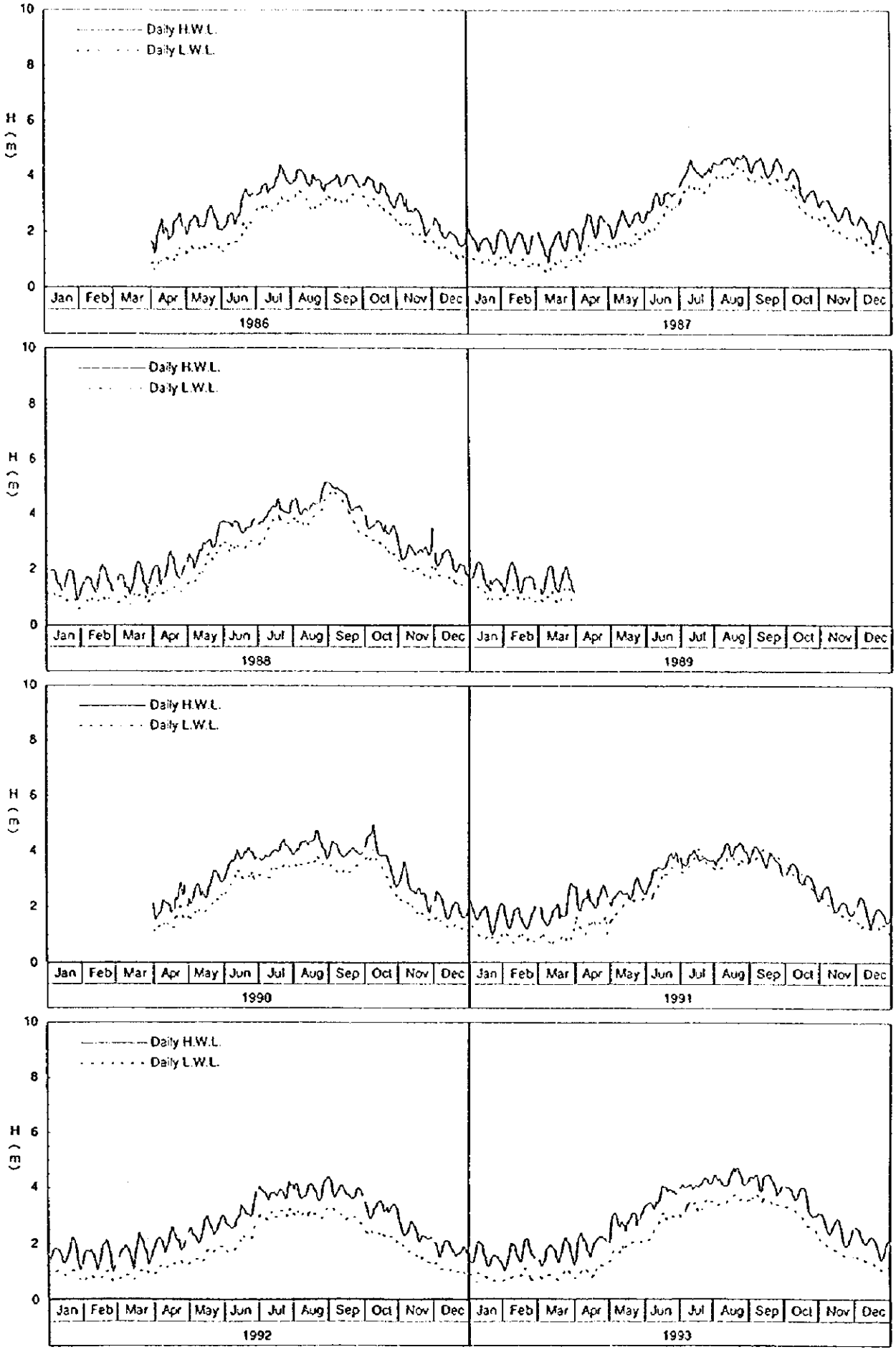


Figure 4.2.5 Daily Water Level at Chandpur (1)

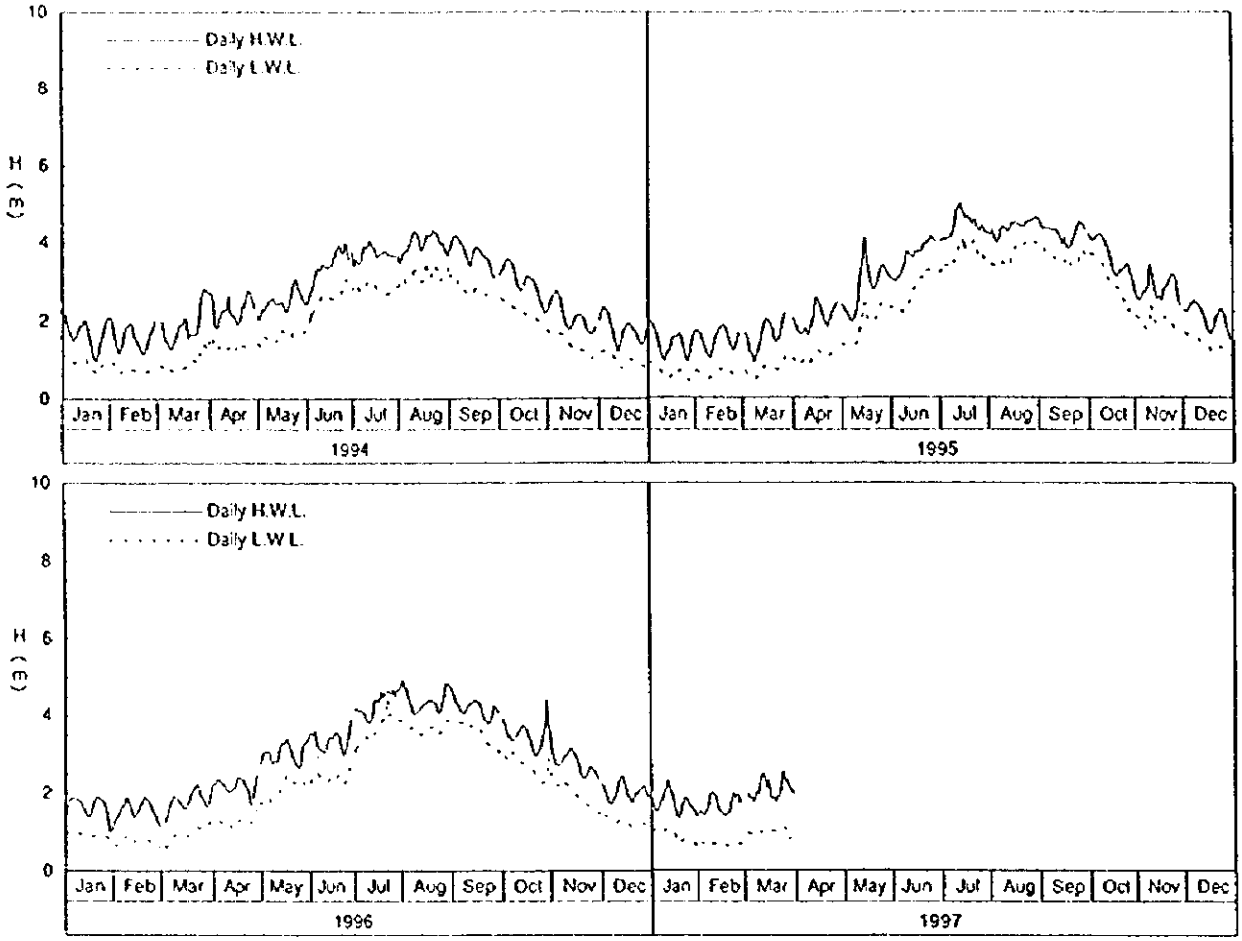


Figure 4.2.5 Daily Water Level at Chandpur (2)

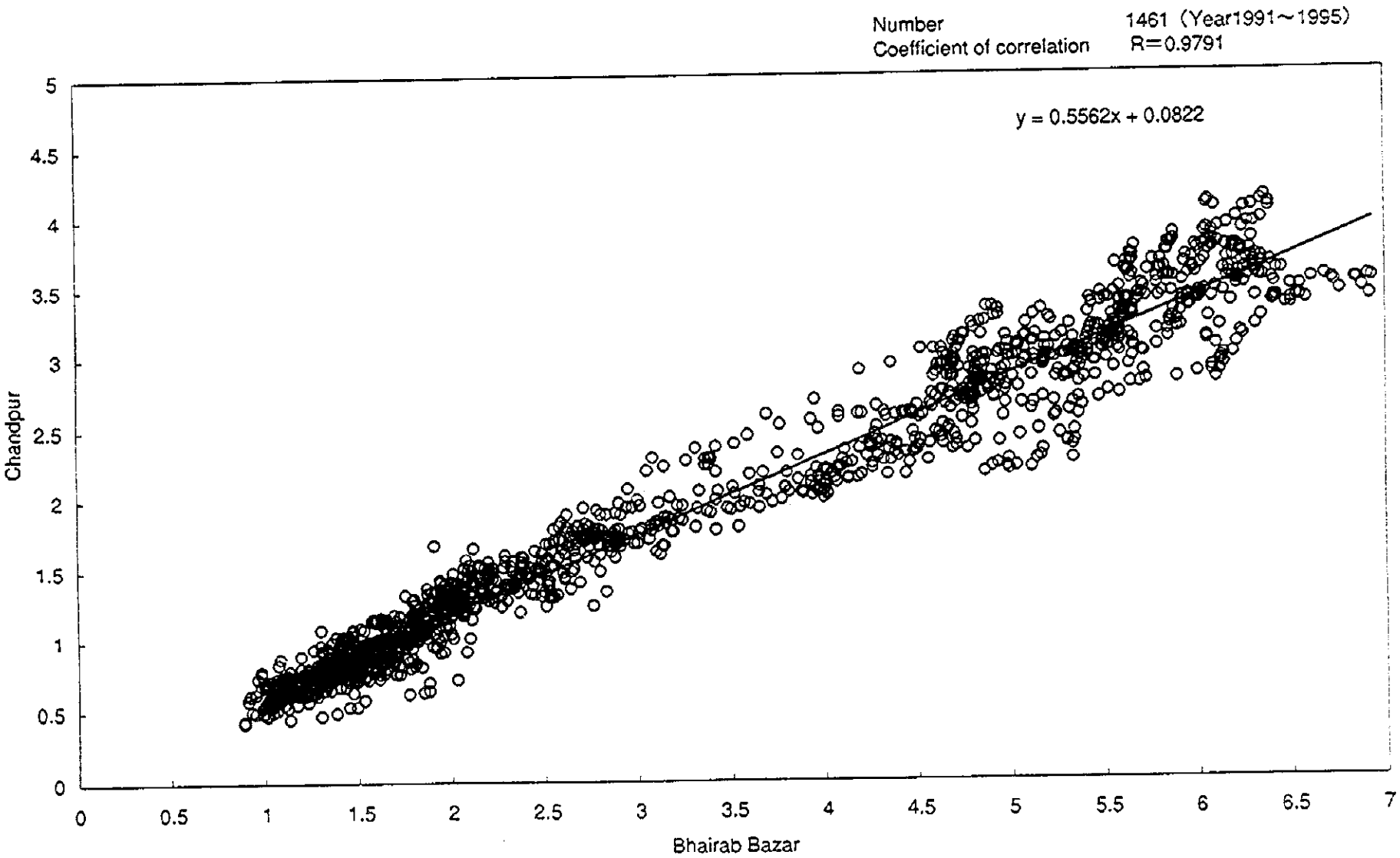


Figure 4.2.6 Correlation of Water Levels (Daily HWL)

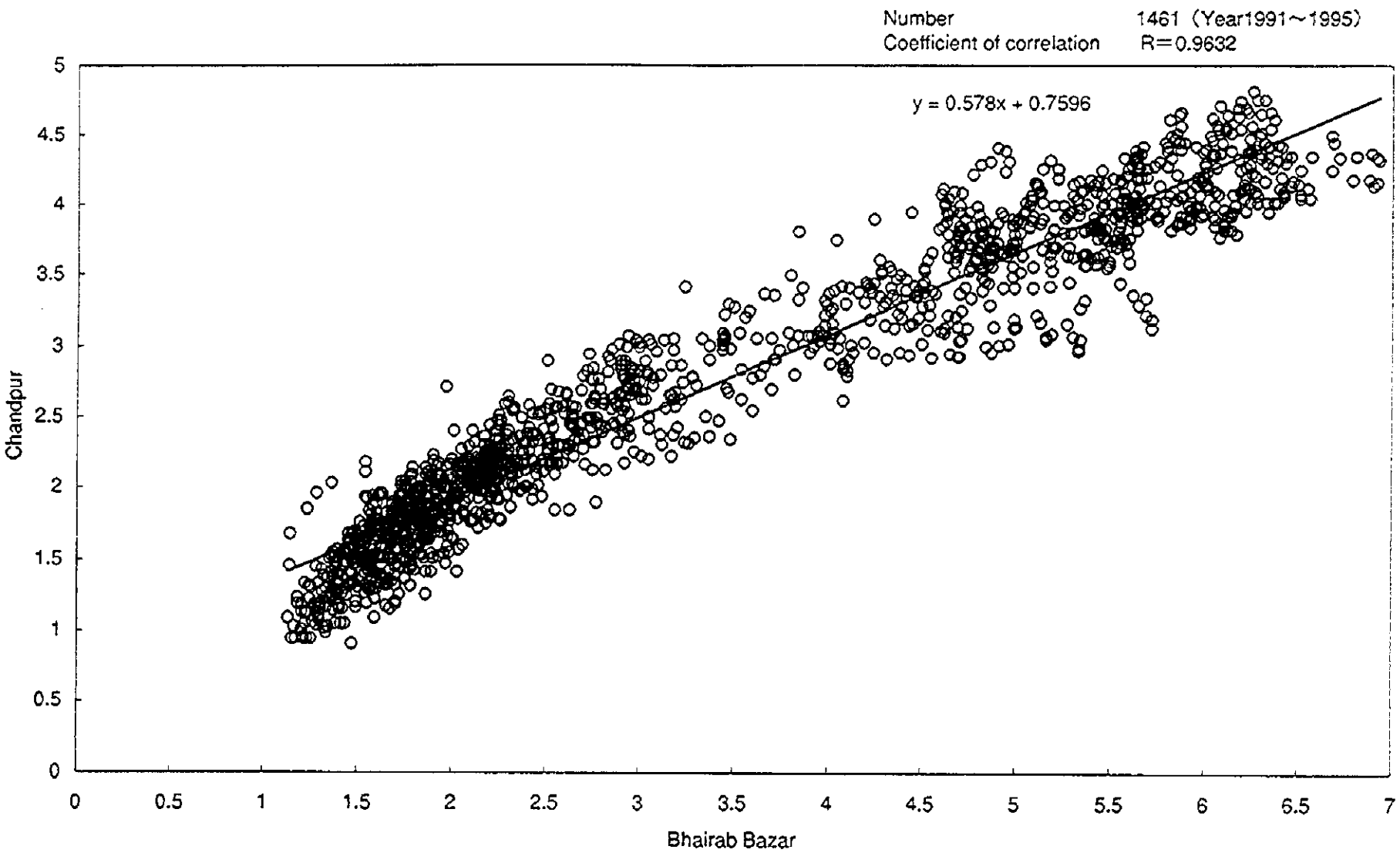


Figure 4.2.7 Correlation of Water Levels (Daily LWL)

Table 4.2.1 Annual Maximum Discharge at Bhairab Bazar

Year	Bhailab Bazar (m3/s)
1964	12,300
1965	12,100
1966	14,400
1967	12,700
1968	13,300
1969	11,500
1970	16,400
1971	N.A.
1972	11,500
1973	12,400
1974	19,500
1975	12,700
1976	16,700
1977	N.A.
1978	N.A.
1979	N.A.
1980	N.A.
1981	11,200
1982	13,500
1983	16,000
1984	13,600
1985	14,300
1986	11,100
1987	15,100
1988	19,800
1989	15,500
1990	11,700
1991	14,100
1992	12,800
1993	19,900 (Max)
Average	13,368

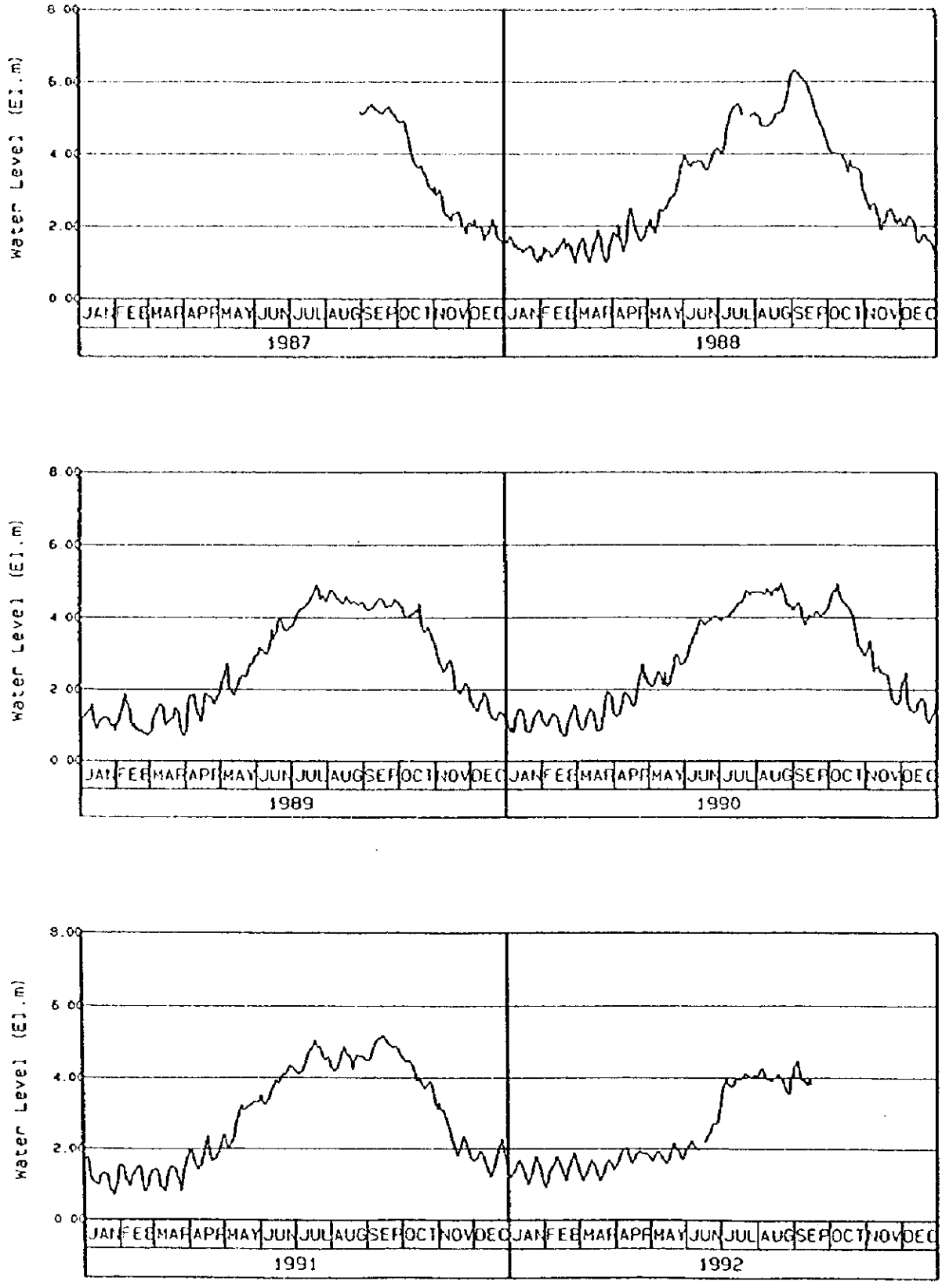


Figure 4.3.1 Daily Water Level at Meghna Bridge (1987 - 1992)

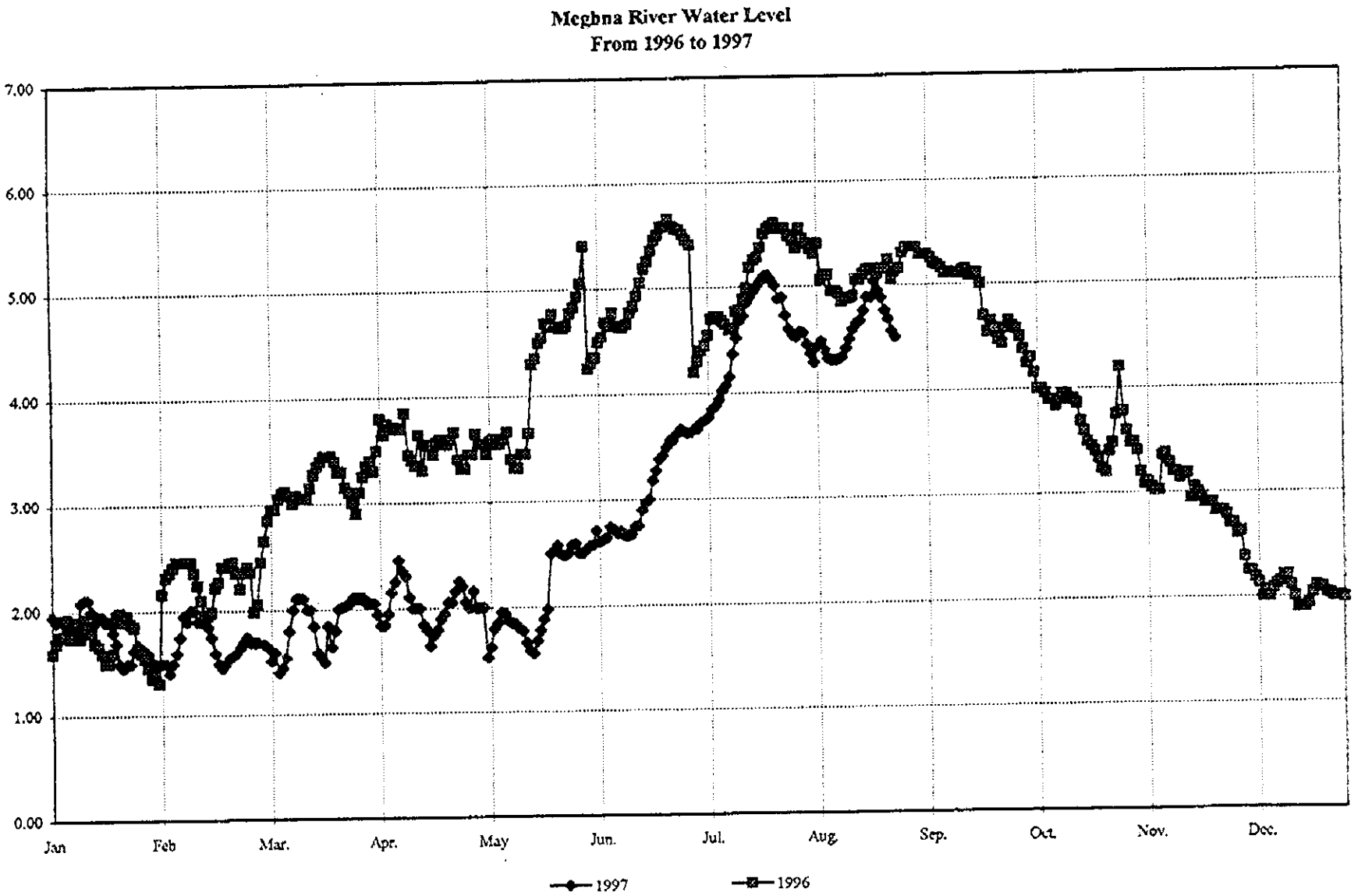


Figure 4.3.2 Daily Water Level at Meghna Bridge (1996 ~ 1997)

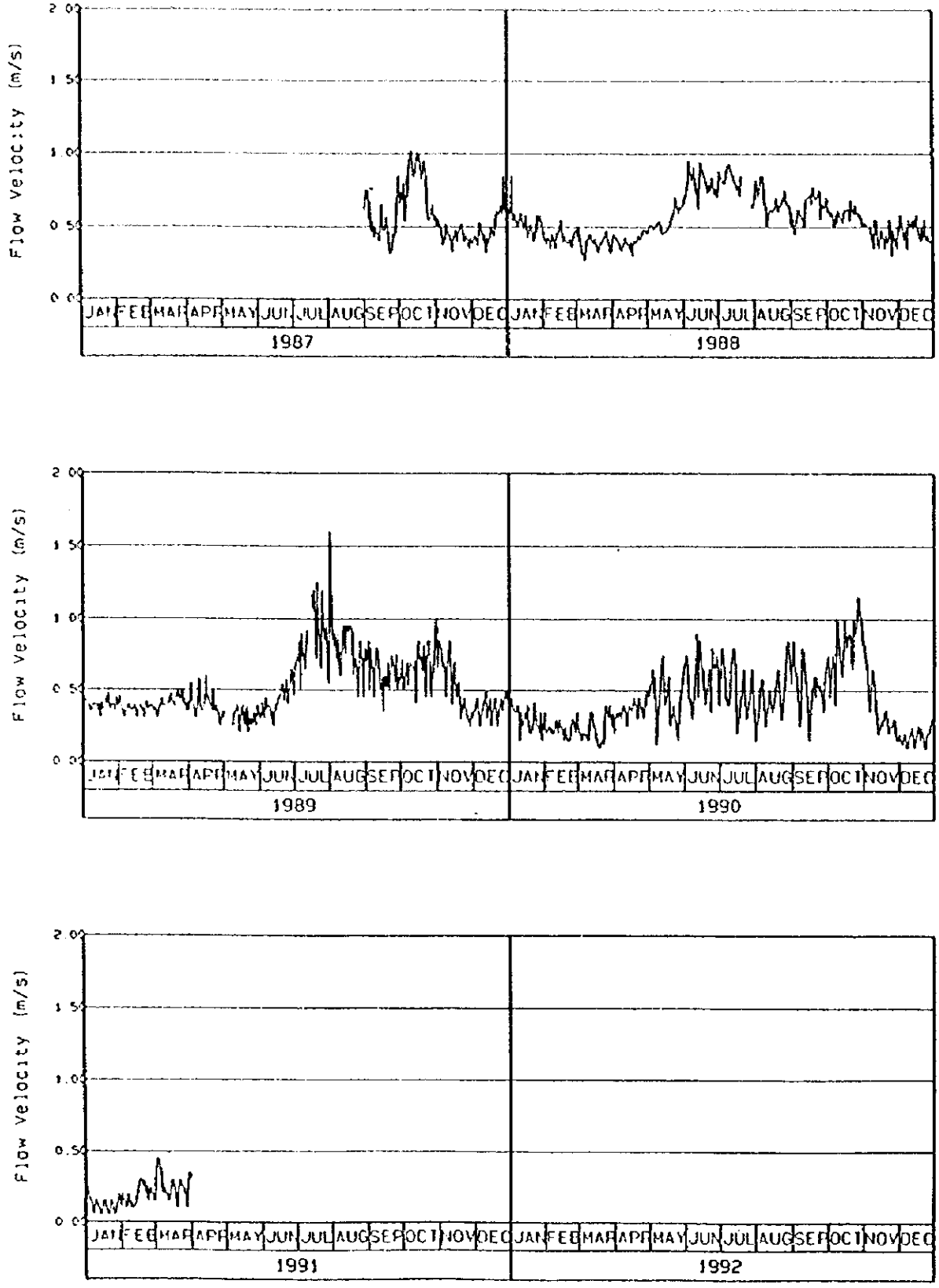


Figure 4.3.3 Daily Flow Velocity at Meghna Bridge

4.4 Magnitude of Discharge at Meghna Bridge

Discharge records at the Meghna bridge are available only a measurement result in July 1984 during the construction of the Meghna and Meghna-Gumti bridges. According to the "Feasibility Study Report on Meghna and Meghna-Gumti Bridge Construction" (March 1985), the measured discharges are as follows:

- 9,020 m^3/s at Meghna bridge
- 4,840 m^3/s at Meghna-Gumti bridge

The magnitude of discharge at Meghna bridge is estimated at around two thirds of that at Bhairab Bazar in the same month based on the records at Bhairab Bazar (9,000 to 14,000 m^3/s). Based on this rate, the maximum discharge at Bhairab Bazar recorded on July 19, 1993 is converted to approximately 13,000 to 14,000 m^3/s at the bridge site.

CHAPTER 5

RIVER MORPHOLOGY AND PRESENT RIVER CONDITION IN THE VICINITY OF THE MEGHNA BRIDGE

CHAPTER 5 RIVER MORPHOLOGY AND PRESENT RIVER CONDITION IN THE VICINITY OF THE MEGHNA BRIDGE

5.1 Items of Survey and Investigation in April and August 1997

The items and quantities of the First and the Second Survey which were conducted in April and August 1997 are summarized in Table 5.1.1.

5.2 Chronological Features of River Bank Erosion, Damage of Revetment and Its Restoration Works on Comilla Side

5.2.1 Notable Events of River Bank Erosion

The construction of the Meghna Bridge commenced in March 1987 and was completed in February 1991. The notable major events regarding movement of the river channel and erosion of the left bank near the revetment are summarized as below:

(1) Flood in September 1988

The river bank on Comilla side (left bank) was eroded and the tip of the old ferry ghat immediately upstream of the Bridge was slid down. The sand bar on Dhaka side (right side) has developed widely (confirmed by survey in November 1988).

(2) Erosion and landslide in the latter half of 1989

A large-scale land slide occurred immediately upstream of the left abutment on December 30, 1989. Due to this accident, the old ferry ghat was damaged and eventually a small bay was created.

Therefore, the right-of-way of the revetment near the abutment had to change.

(3) Destruction of revetment on Comilla side in 1991

The revetment made of geotextile concrete structure around the left abutment was completed in the beginning of 1991. However, on October 19 and 20, the revetment was intermittently damaged due to scouring of the foot portion of sheet piles (total 200 m in length).

With regard to this damage of the revetment, surveys and countermeasures were performed under grant-aid programs as listed below:

Table 5.1.1 Items and Quantities of Survey and Investigation

Item	First Survey (Apr. 1997 - Dry season)	Second Survey (Aug. 1997 - Rainy season)
1. Bridge pier		
(1) Condition of erosion	· 5 sites, P10, P9, P8, P7, and P6, by divers and echo sounding · The area of echo sounding is 100m each in upstream and downstream direction crossing the bridge axis. The interval is 25m.	
(2) Scattering of riprap on river bed.	· Survey of underwater riprap by divers at 5 sites.	· As same as the First Survey
(3) Flow mechanism	· Eye measurement of location, magnitude and shape of vortex.	· Total 6 sites on up and downstream sides of P7, P8 and P9. Sampling point is at 1m from the river bed at each site.
(4) SS contents	· At the center between P10 and P9, up and downstream side of P8 and the center between P7 and P6. In the vertical direction, 1m from the water surface and 1m from the river bed.	
(5) Flow velocity and direction	· From P1 to P10 at 20m interval. 5m pitch in vertical direction.	· At the center between piers P1and P10. Interval is 2m in vertical direction.
(6) Water level	· Twice a day (ebb and flood tides) by means of the gauge installed at P10.	· As same as the First Survey
2. Revetment		
(1) Cross-section survey	· 19 cross-sections	· 19 sections
(2) Condition of erosion	· Survey of revetment by divers and echo sounding · Interval of 25m by echo sounding. The area is approx. 1,500m long in the flow direction and approx. 300m wide in the right-angled flow direction.	· By echo sounding. The area is same as the First Survey.
(3) Displacement of gabion and movement of riprap	· Measurement by divers using rods and ropes underwater and by tapes above water	
(4) Flow mechanism	· Eye measurement of boil and vortex	
(5) SS contents	· 6 sites in total. 1m from the water surface and 1m from the river bed at each site.	· Total 15 sites in front of the revetment and at 1m from the river bed at each site.
(6) Crack at revetment downstream of the Bridge	· Survey of length, width, depth and hollow, etc.	
(7) Scouring in front of revetment	· Survey by divers using rods and ropes	
(8) Soil mechanical investigation	· 3 sites of core drilling x 30m depth, measurement of N-value (1m interval), physical indices and grain size distribution.	
(9) Groundwater level	· Measurement at 3 boring holes.	· As same as the First Survey
(10) Flow direction and discharge		· Total 12 sites along 4 sections near the revetment. Interval is 2m in vertical direction.
3. River Channel		
(1) Cross-section survey	· 15 sections in the river stretch of approx. 10km crossing the Bridge by echo sounding (same location as the past survey)	· As same as the First Survey
(2) Survey of river bed material	· Sampling at 18 sites	· 6 sites along the section upstream of the Bridge (U-1200) and 1 site along the section of No.10.
(3) Interview survey	· 14 sites in the river stretch of approx. 10km	
(4) Flow direction and discharge	· Total 5 sections: Three on upstream side, one on downstream side and one at the bridge axis, 100m interval in the horizontal direction and 2m interval in the vertical direction (during ebb tide)	· As same as the First Survey

• Apr. 1992	:	Preliminary survey for Basic Design Study on the Project for Protecting Revetment on the Bank of Meghna River (JICA)
• Jun. 1992 ~ Nov. 1992	:	Basic Design Study on the Project for Protecting Revetment on the Bank of Meghna River (JICA)
• Mar. 1993 ~ Jan. 1994	:	Construction of countermeasures with grant-aid
• Oct. 1996	:	Follow-up Study for the Project for Protection Works for Meghna Bridge (JICA)
• Apr. to Nov. 1997	:	Basic Design Study on the Project for Protection Works for Meghna Bridge (JICA)

5.2.2 Condition of Damage of Revetment on Comilla Side (upto 1991)

The revetment has been damaged due to serious erosion at its foot portion. Specially, in the stretch where sheet piles are driven to a depth of 9 m to 18m, the revetment has leaned toward the water side because of reduction of the passive soil pressure. Around 38% (195 m in length) of the completed stretch, has been affected.

The status of sheet piles is shown in Fig. 5.2.1.

Judging from this figure, the gabion foot protection in front of the sheet piles has subsided, but its movement toward the center of the river was not so remarkable. Thus the reason for the destruction of the revetment is considered to be scouring at the foot protection. The most serious scouring was identified at approx. 30 m downstream of the bridge axis (a 9.0 m long stretch).

5.2.3 Design Principle and Features of Construction of Revetment (1992)

As for the right-of-way of the revetment, the connected line from the tip of the old ferry ghat and the front end of the left abutment was selected to make the current stable by preventing turbulence and vortex. A comparative study of the type of revetment, i.e. steel sheet pipe piling and stone pitching was conducted. After examining flexibility to the river bed change and convenience of maintenance, the latter type was selected. The plan of countermeasures is shown in Fig. 5.2.2. The restoration works were carried out from March 1993 to April 1994. Basically, gabion mattress was provided for a stretch of approx. 350 m and stone-pitching was provided for the stretch of approx. 600 m at the foot protection.

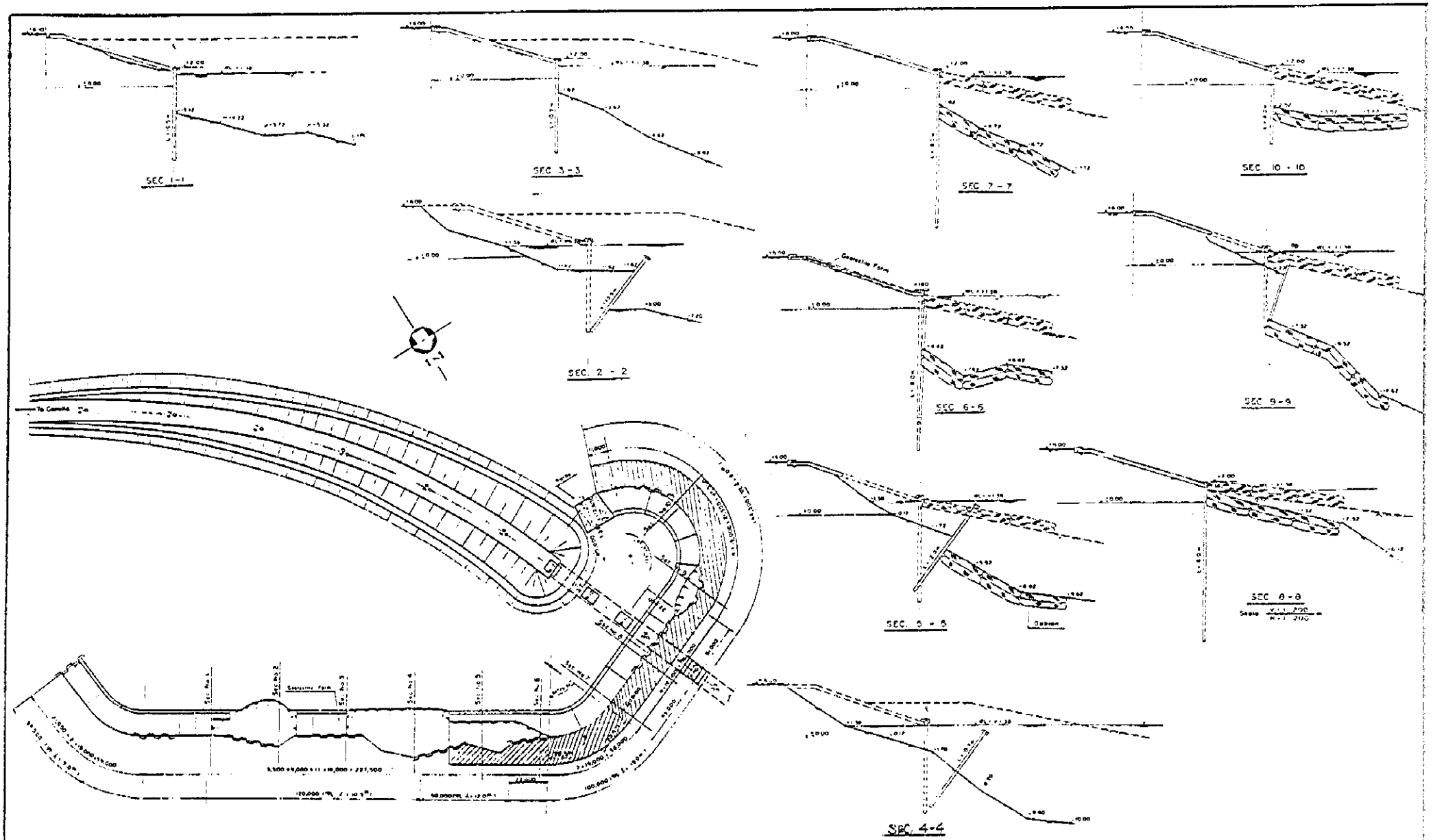


Figure 5.2.1 Condition of Destruction of Revetment at Left Bank near Bridge Abutment

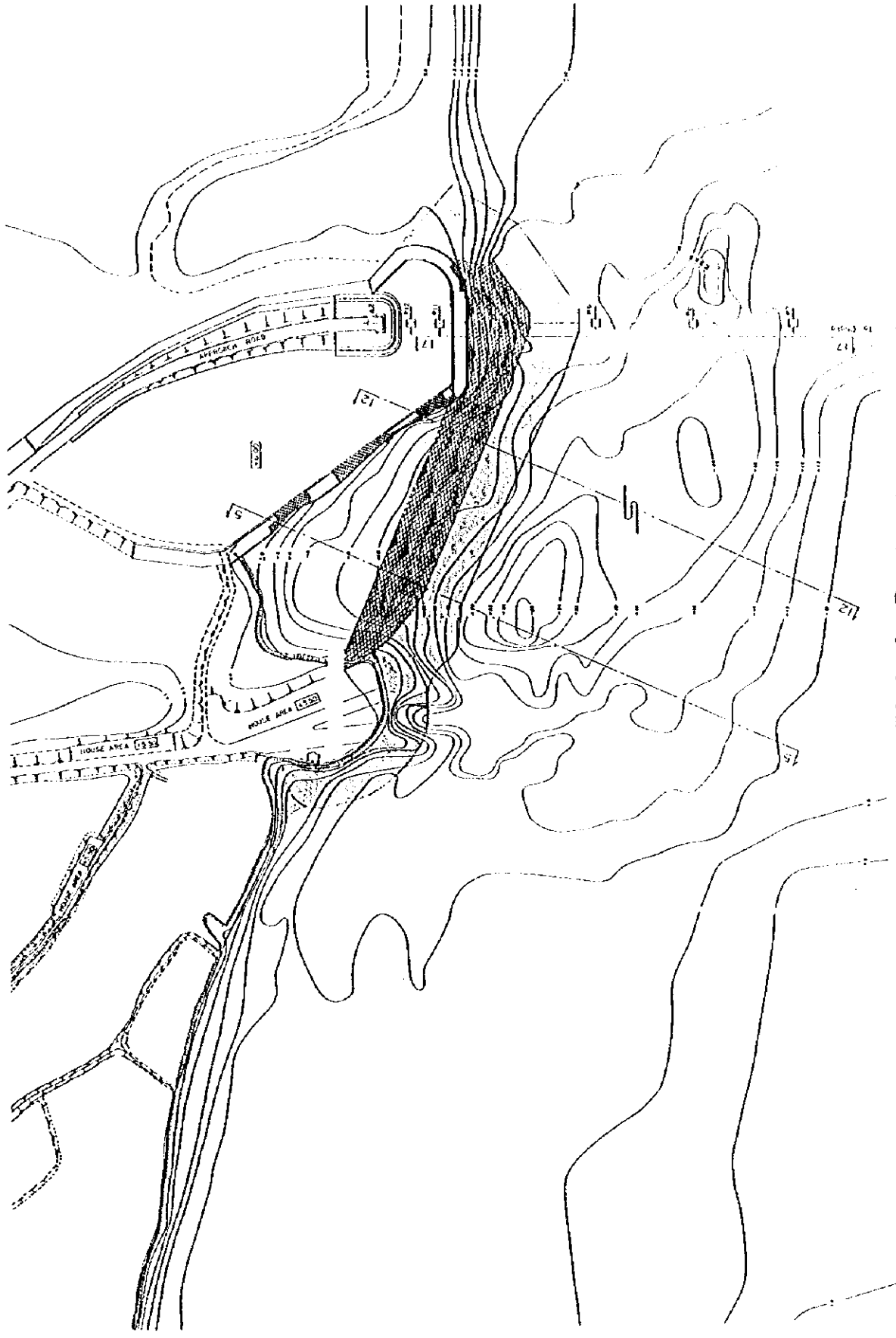


Figure 5.2.2 Plan of Rehabilitation Works for Revetment

5.3 Present Condition of Existing Revetment

The past major events and present condition of the existing revetment clarified through the First Survey on the left bank are illustrated in Fig. 5.3.1. Further, the details of erosion of the bank and displacement of the revetment are explained as follows:

(1) Natural river bank on upstream side (0.5 ~ 1.5 km, left bank) of the Bridge

Due to wave action and current, fine materials consisting of silt and clayey soil are eroded from the foot portion and are still running.

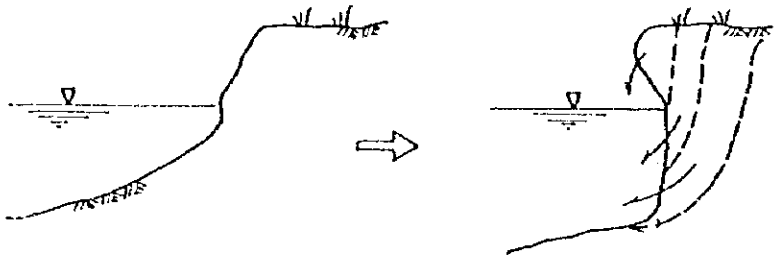


Fig. 5.3.2 Process of Erosion of Natural River Bank

(2) Revetment near left abutment (from 0.5 km upstream to 0.1 km downstream of the Bridge)

a) Crest of revetment ~ water front

Although the repaired gabion protection has subsided at some portions, a stable slope is formed. In the stretch where the geotextile concrete remains, a crack of 0.5 to 1.0 cm wide has developed on the surface, traversing from upstream to downstream beneath the Bridge. Further, the head coping portion of sheet piles has inclined toward the center of the river and cracks are also confirmed.

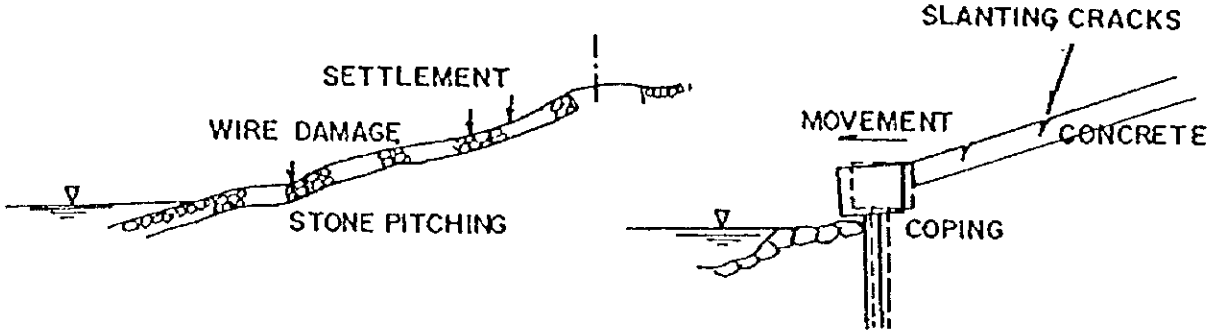


Fig. 5.3.3 Features of Distortion of Existing Revetment

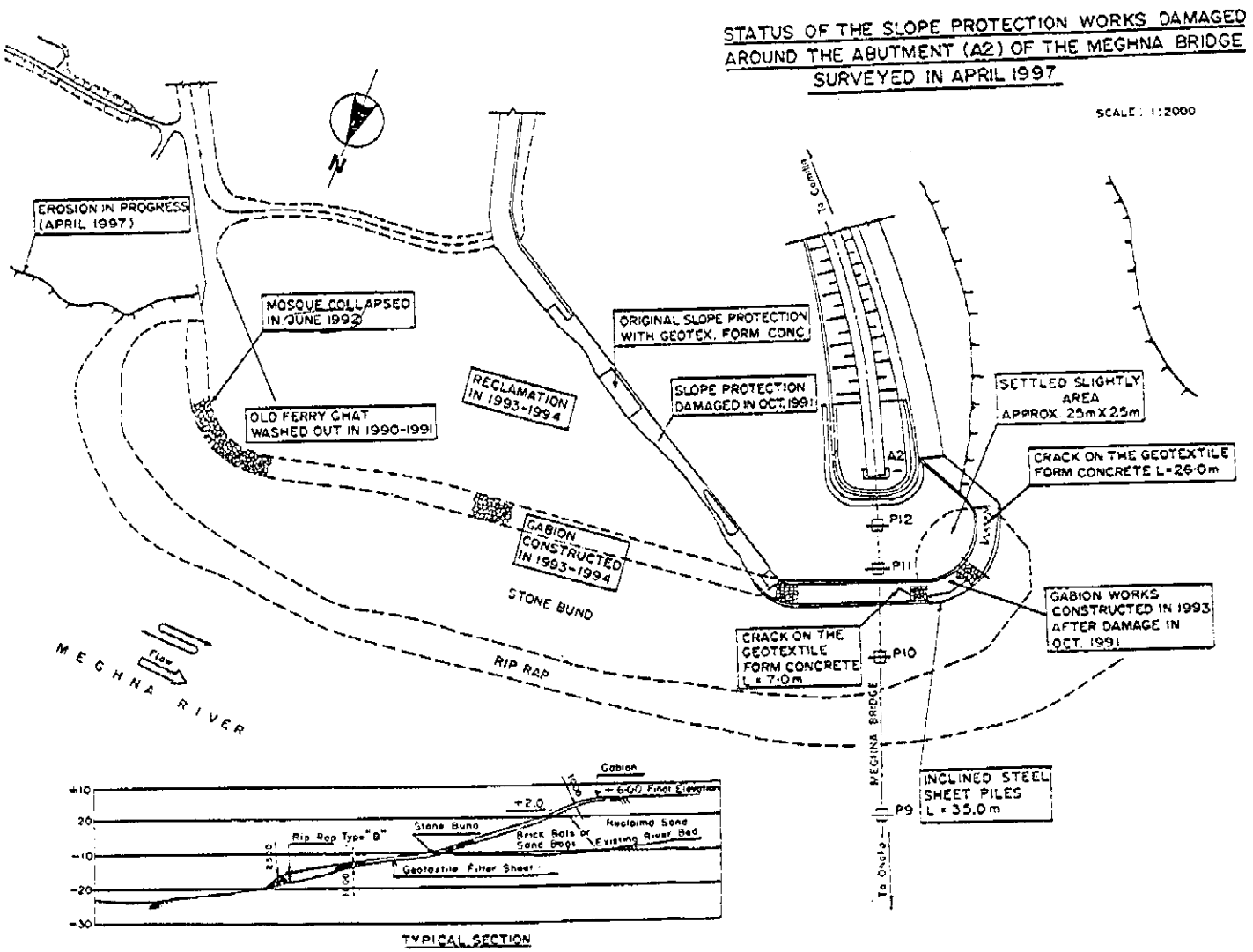


Figure 5.3.1 Present Status of Existing Revetment

b) Water front ~ river bed

The width of the riverbed covered by pitched stone varies from 30 to 70 m along the revetment. Through the investigation by divers, the surface condition from the water front to the end of underwater pitched stone section was clarified. Generally, a large amount of pitched stone provided during the construction in 1993 is still remaining. Divers could not examine the river bed and pitched stone condition, because suspended load accumulates at the upper portion of the slope and a stiff sand layer covers the surface of the pitched stone provided as foot protection. A soft sand layer forms a gentle slope toward the center of the river. Any sign of scouring around the riverbed was not identified. The riverbed elevation where the tip of the pitched stone is confirmed is approx. RL. 11.0 ~ -14.0 m. At each cross-section, the angle of slope is 15° to 30°. On the surface of the pitched stone, soft soil covers most sections.

The scoured deep pool (RL. -28 ~ -30 m) which is located at approx. 250 m upstream of the Bridge and approx. 50 m from the shoulder of the revetment was investigated by divers in the First Survey. The riverbed material couldnot be taken by hand by divers due to the stiff surface like at the site near P8. Fig. 5.3.4 shows a standard cross-section of the revetment.

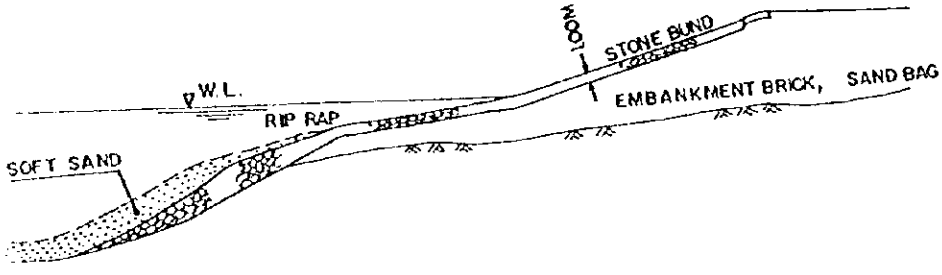


Fig.5.3.4 Standard Cross-Section of Revetment

5.4 Change of River Course in the Vicinity of the Bridge

5.4.1 Satellite Images by Landsat and Jers

In addition to the Landsat satellite photographs in 8 different years (scale 1:100,000) collected from the Bangladesh Space Research and Remote Sensing Organization (SPARRSO), 4 photographs taken by Jers (NASDA of Japan) in different years were collected. Among them, 2 relatively clear photographs were selected for comparison. The dates of photographs are identified as follows:

(1) Nov. 22, 1973
(2) Jan. 27, 1976
(3) Feb. 2, 1980
(4) Mar. 19, 1984
(5) Feb. 19, 1988
(6) Feb. 5, 1989
(7) Jan. 30, 1990
(8) Jan. 26, 1991
(9) Dec. 3, 1992
(10) Jan. 21, 1996

It is considered that the shorelines of sand bar and river banks, specially those with gentle slope, shown on the two images might contain some errors because of difference in water levels. However, since the photographs were taken during the dry season between November and March, the difference in water levels reflected in the photo images is judged to be negligible. Thus, photo interpretation to obtain geographical outlines and to observe the change in river course is valuable for further detailed discussions. The results are presented in the following sub-sections.

5.4.2 Meghna River Channel

Based on the Landsat and Jers images, the shoreline from about 15 km upstream to 8 km downstream of the Meghna bridge was delineated as shown in Fig. 5.4.1 to check the change in the river course. As a result of comparison of the two images, the area of erosion and deposition was clarified as illustrated in Fig. 5.4.1. The last figure in Fig. 5.4.2 (3/3) shows the shorelines in 1973 and 1996. The characteristics of bank erosion can be described chronologically as follows:

- The sand bar immediately upstream of the Bridge on the right bank extended downstream between 1973 and 1976.

- The right bank from No. U10 to No. U6 and the left bank from No. U4 to No. U1 were eroded extensively between 1976 and 1984.

- The side channel (near the right bank) beside the sand bar immediately upstream of the Bridge was formed between 1984 and 1988.
- As erosion between No. U10 and No. U6 on the right bank proceeded, the side channel beside the sand bar was widened after 1988.
- The sand bar expanded downstream and toward the left bank.

Further, the balance of erosion and deposition in the stretch between the cross sections No. D4 and No. 10 was examined as tabulated in Table 5.4.1. The results are summarized as follows:

(1) Average annual rates of erosion and deposition are around 5 million m^3/year and 3 million m^3/year respectively from 1989 to 1997.

(2) As a whole, this stretch has a stable erosion tendency during this period.

In this connection a longitudinal profile based on the series of cross-section survey results was drawn as illustrated in Fig. 5.4.3.

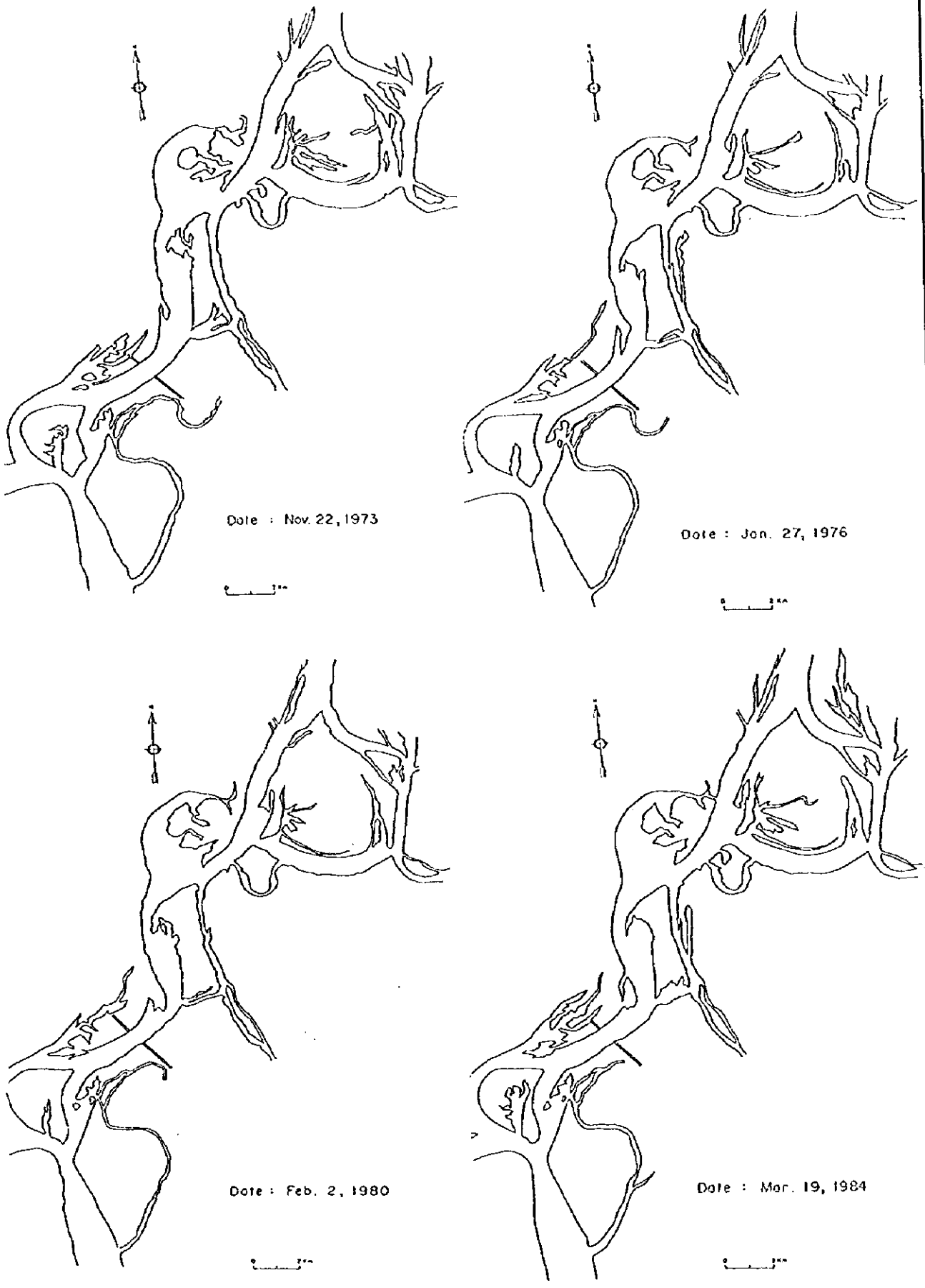


Figure 5.4.1 Shorelines of Meghna River (1/3)

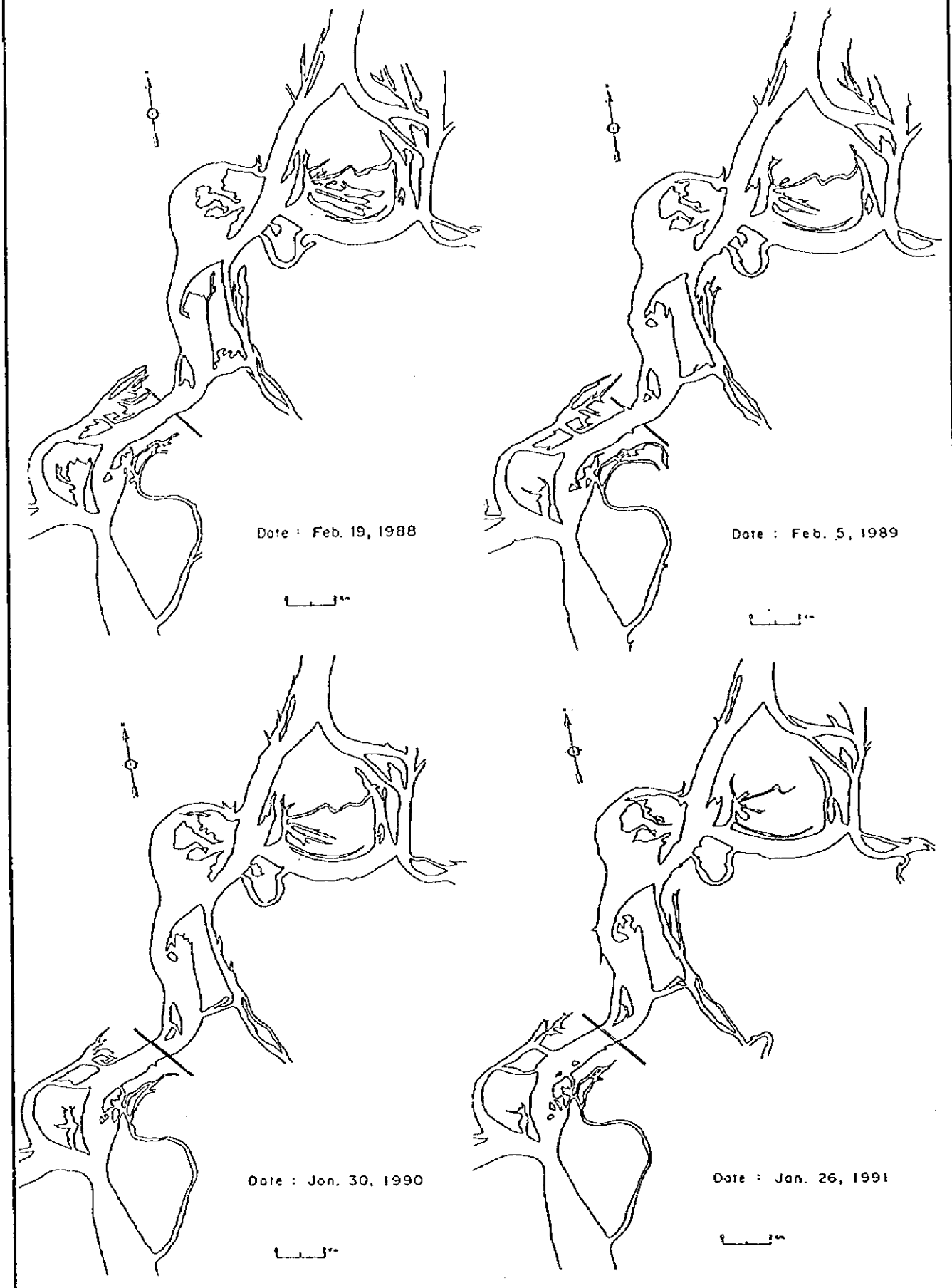


Figure 5.4.1 Shorelines of Meghna River (2/3)

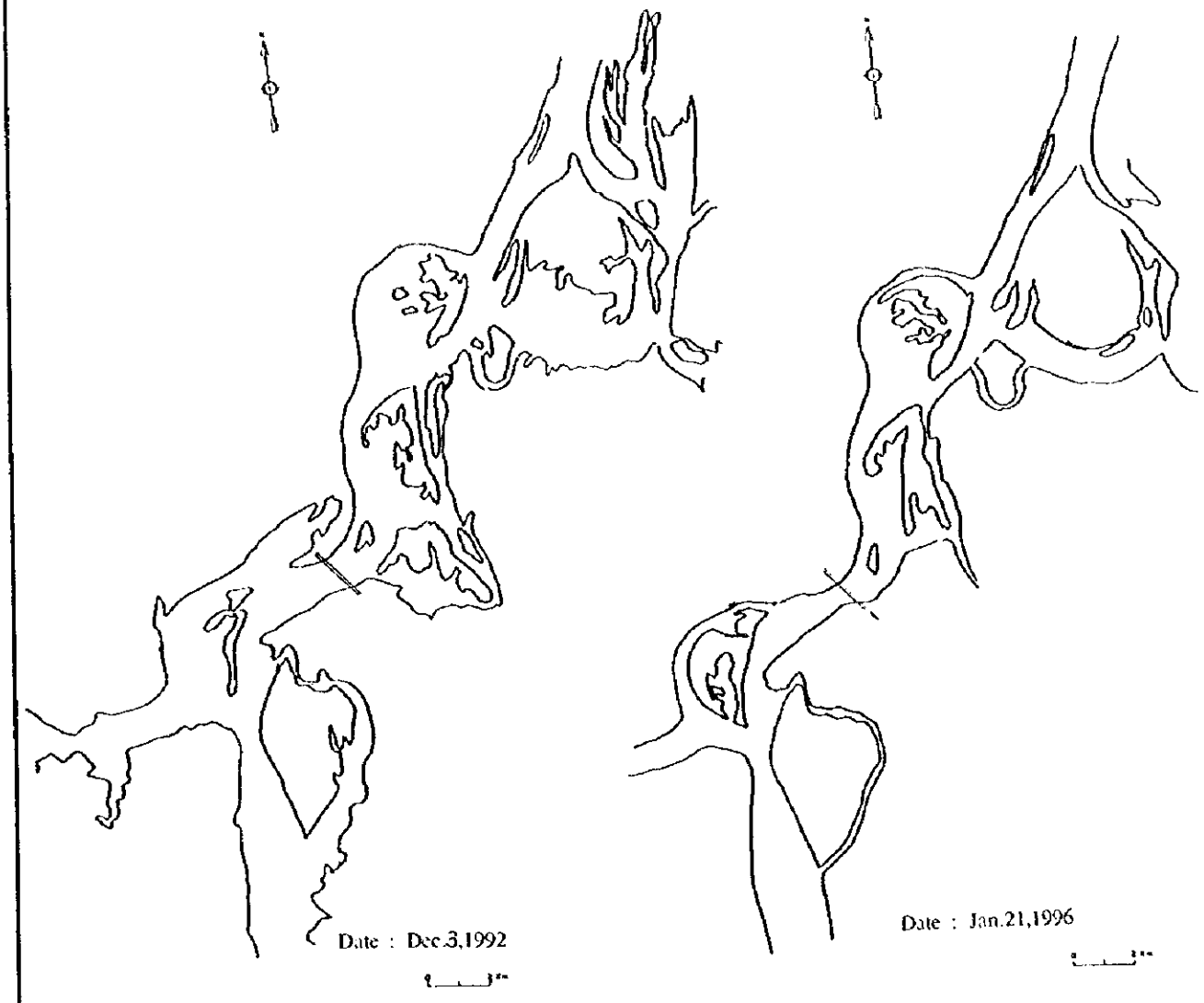


Figure 5.4.1 Shorelines of Meghna River (3/3)

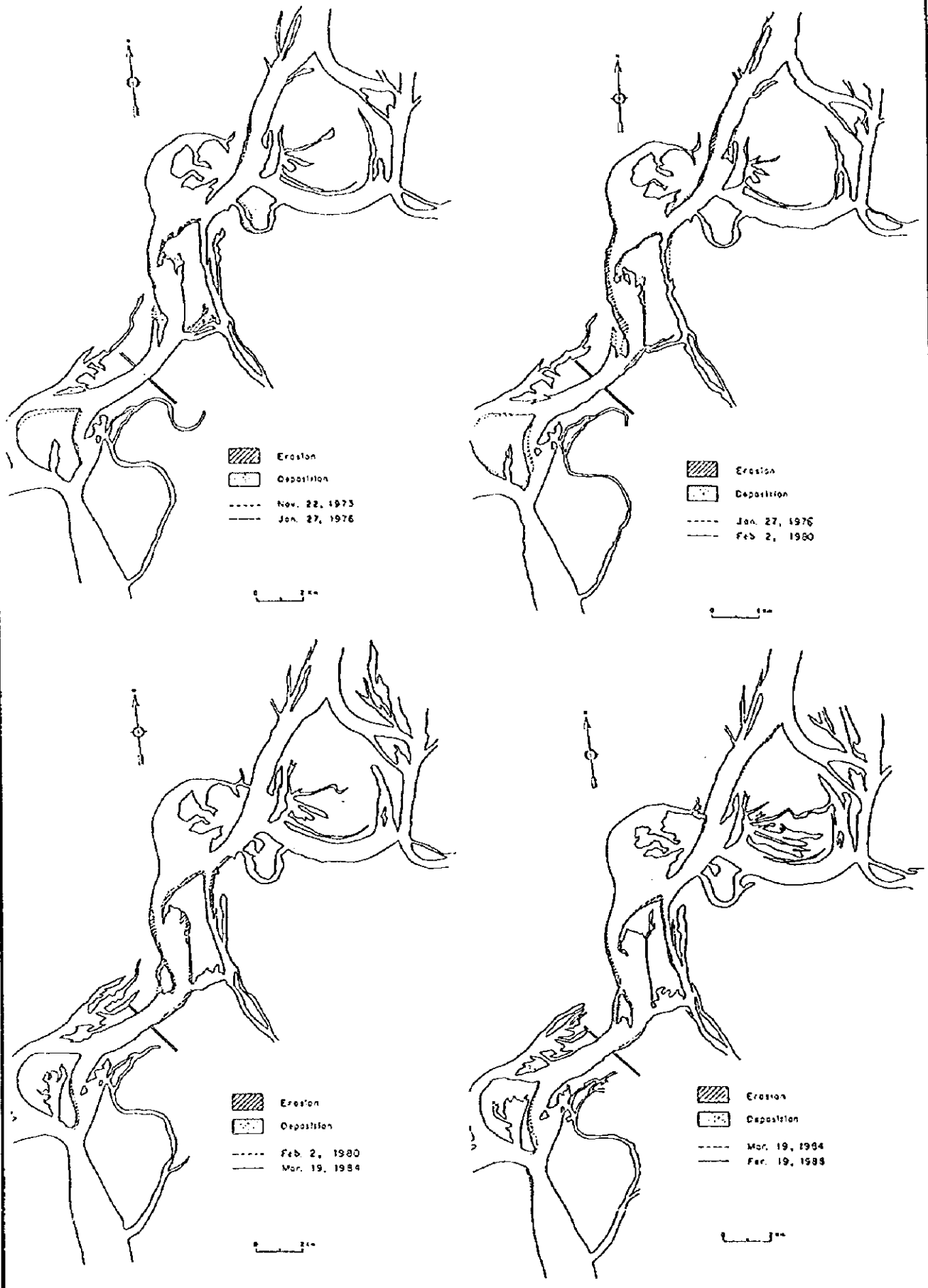


Figure 5.4.2 Comparison of Shorelines near Meghna Bridge (1/3)

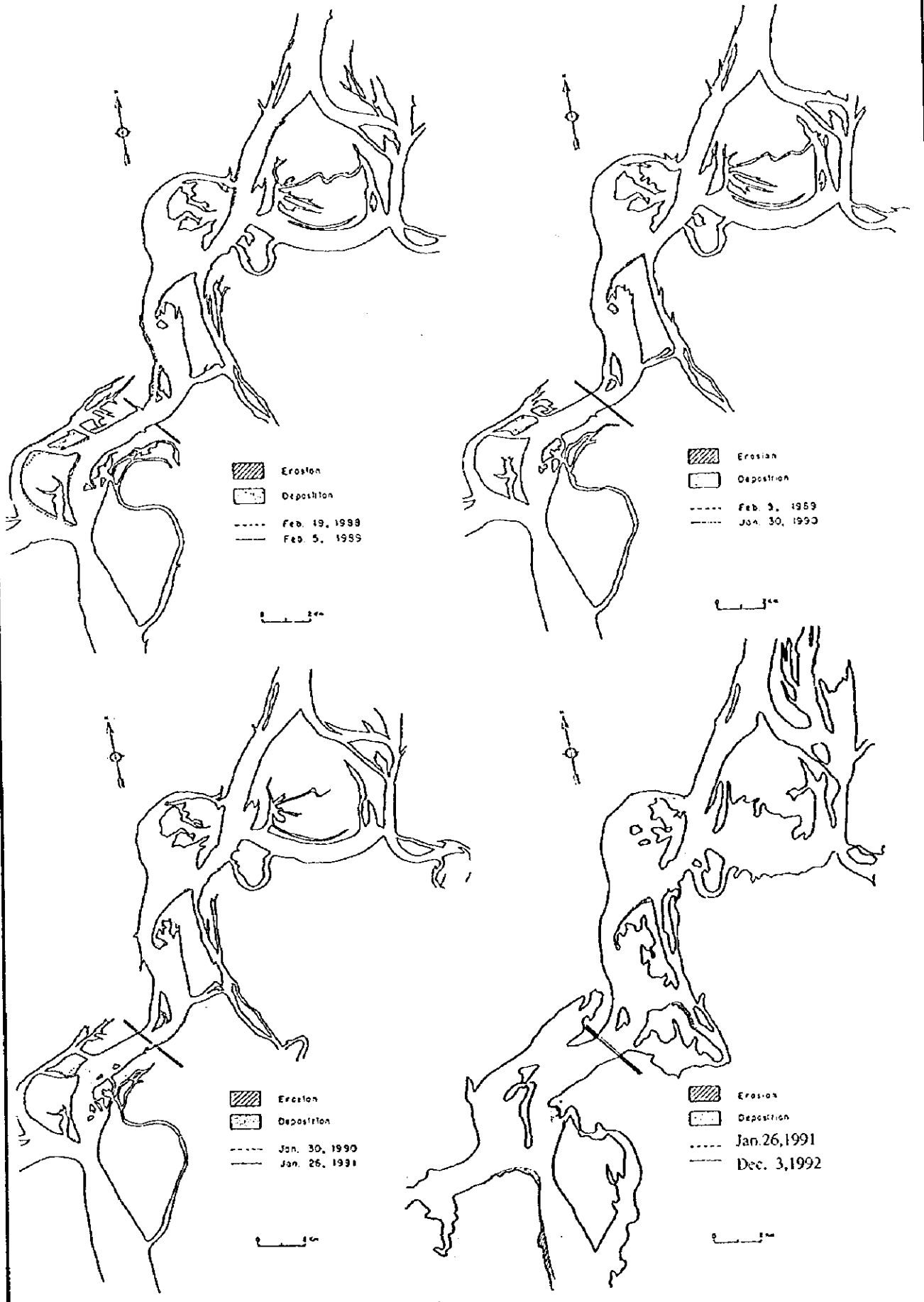


Figure 5.4.2 Comparison of Shorelines near Meghna Bridge (2/3)

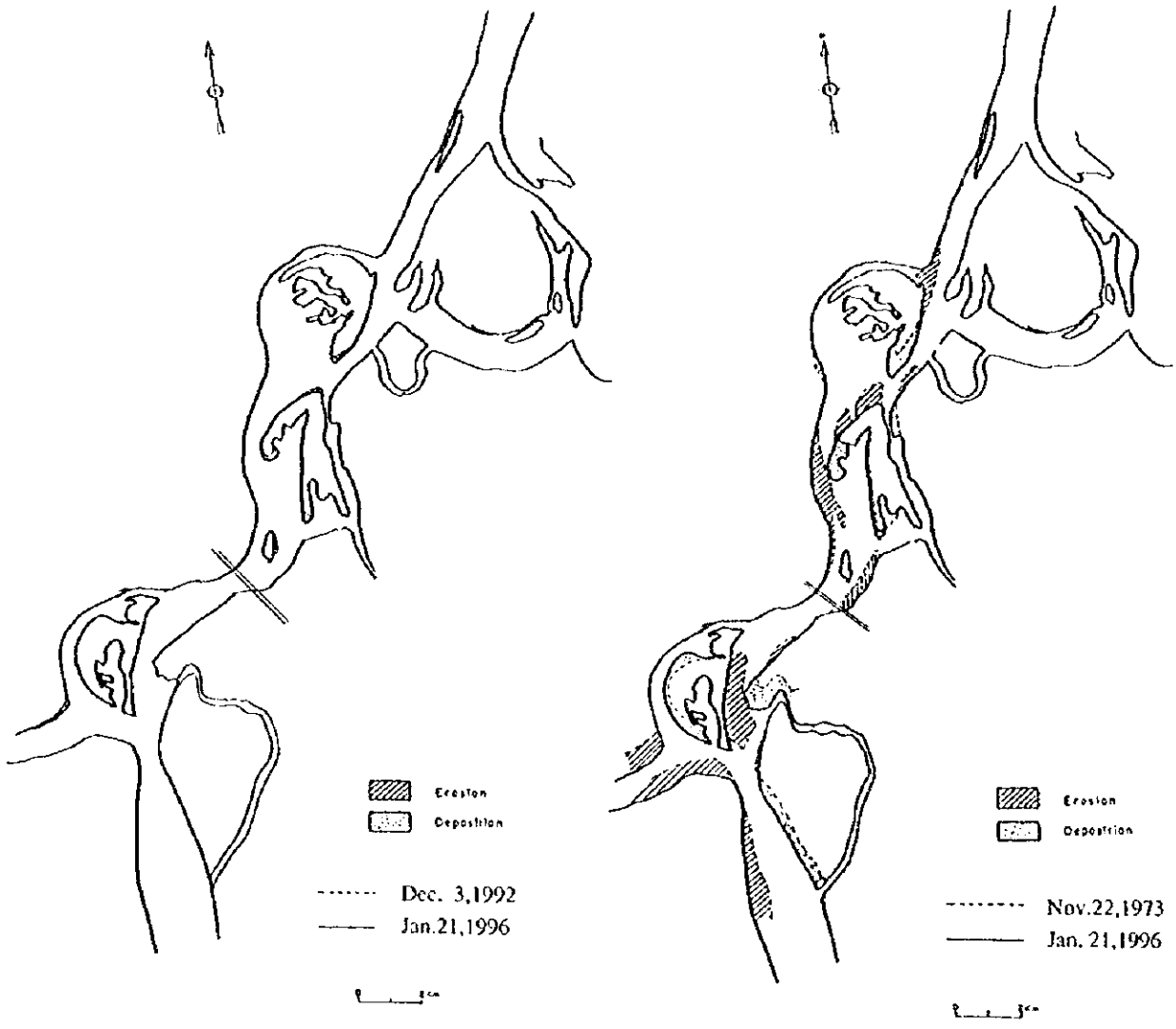


Figure 5.4.2 Comparison of Shorelines near Meghna Bridge (3/3)

Table 5.4.1 Erosion and Deposition Volume near Meghna Bridge

1989 Apr. - 1994 Jan.

Sec.No.	Erosion				Deposition			
	Length (m)	Area (m2)	Average area (m2)	Volume (m3)	Length (m)	Area (m2)	Average area (m2)	Volume (m3)
D4	-	3,020	-	-	-	2,950	-	-
D3	865	2,860	2,940	2,543,100	865	440	1,695	1,466,175
D2	705	1,770	2,315	1,632,075	705	990	715	504,075
D1	610	2,640	2,205	1,345,050	610	1,480	1,235	753,350
1	855	1,720	2,180	1,863,900	855	1,710	1,595	1,363,725
2	625	3,450	2,585	1,615,625	625	1,250	1,480	925,000
3	665	1,565	2,508	1,667,488	665	2,650	1,950	1,296,750
4	825	2,750	2,158	1,779,938	825	1,615	2,133	1,759,313
5	725	1,870	2,310	1,674,750	725	420	1,018	737,688
6	470	3,630	2,750	1,292,500	470	900	660	310,200
7	740	3,490	3,560	2,634,400	740	1,850	1,375	1,017,500
8	765	3,240	3,365	2,574,225	765	2,160	2,005	1,533,825
9	815	1,850	2,545	2,074,175	815	2,510	2,335	1,903,025
10	805	950	1,400	1,127,000	805	170	1,340	1,078,700
Total	9,470			23,824,225	9,470			14,649,325
			Annual rate =	4,764,845			Annual rate =	2,929,865

1994 Jan. - 1997 Apr.

Sec.No.	Erosion				Deposition			
	Length (m)	Area (m2)	Average area (m2)	Volume (m3)	Length (m)	Area (m2)	Average area (m2)	Volume (m3)
D4	-	2,480	-	-	-	80	-	-
D3	865	1,960	2,220	1,920,300	865	290	185	160,025
D2	705	1,150	1,555	1,096,275	705	505	398	280,238
D1	610	1,945	1,548	943,975	610	105	305	186,050
1	855	695	1,320	1,128,600	855	1,050	578	493,763
2	625	2,020	1,358	848,438	625	775	913	570,313
3	665	2,630	2,325	1,546,125	665	2,580	1,678	1,115,538
4	825	610	1,620	1,336,500	825	1,370	1,975	1,629,375
5	725	670	640	464,000	725	1,880	1,625	1,178,125
6	470	560	615	289,050	470	3,460	2,670	1,254,900
7	740	1,270	915	677,100	740	690	2,075	1,535,500
8	765	1,970	1,620	1,239,300	765	230	460	351,900
9	815	800	1,385	1,128,775	815	760	495	403,425
10	805	4,050	2,425	1,952,125	805	120	440	354,200
Total	9,470			14,570,563	9,470			9,513,350
			Annual rate =	4,856,854			Annual rate =	3,171,117

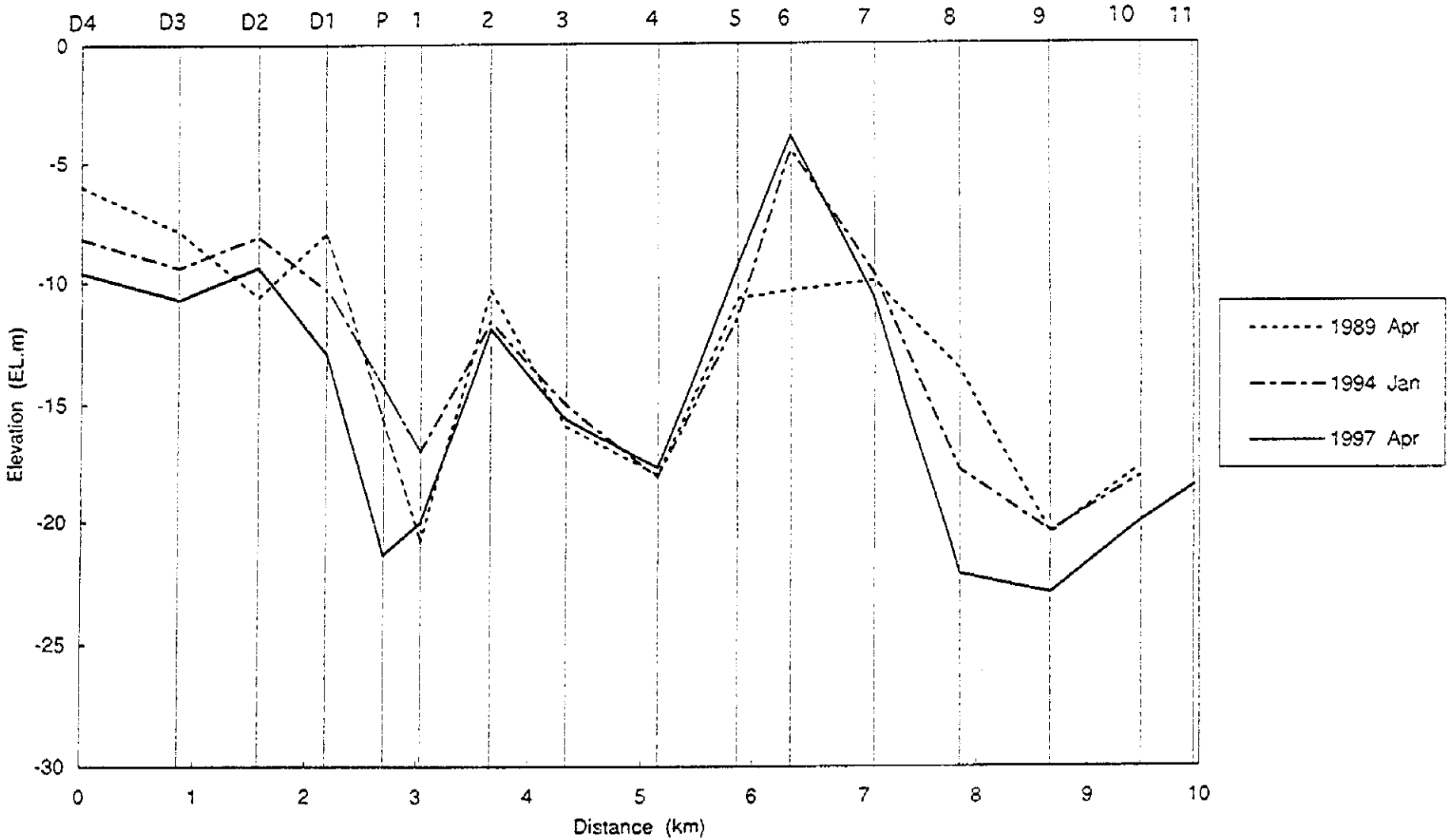


Figure 5.4.3 Longitudinal Profile (Lowest Riverbed)

5.5 Condition of Erosion and Siltation of Meghna River

After the worst flood event of 1988 which caused damage all over Bangladesh, a cross-section survey by echo sounder was consecutively performed at a total of 15 sections (at around 500 m intervals) form 3 km downstream to 6 km upstream of the bridge axis. In the survey in April and August 1997, measurement in the same manner as in the previous survey was carried out along the cross-sections which were set up in 1989. Particularly, to grasp the present condition of the scoured pool, a detailed survey was conducted following denser measuring lines (at 25 m to 50 m intervals) near the bridge axis. In order to examine the chronological change of the water edge and riverbed, the three contour lines in April 1989, January 1994 and April 1997 were drawn on the plan for comparison as shown in Figs. 5.5.1 and 5.5.2.

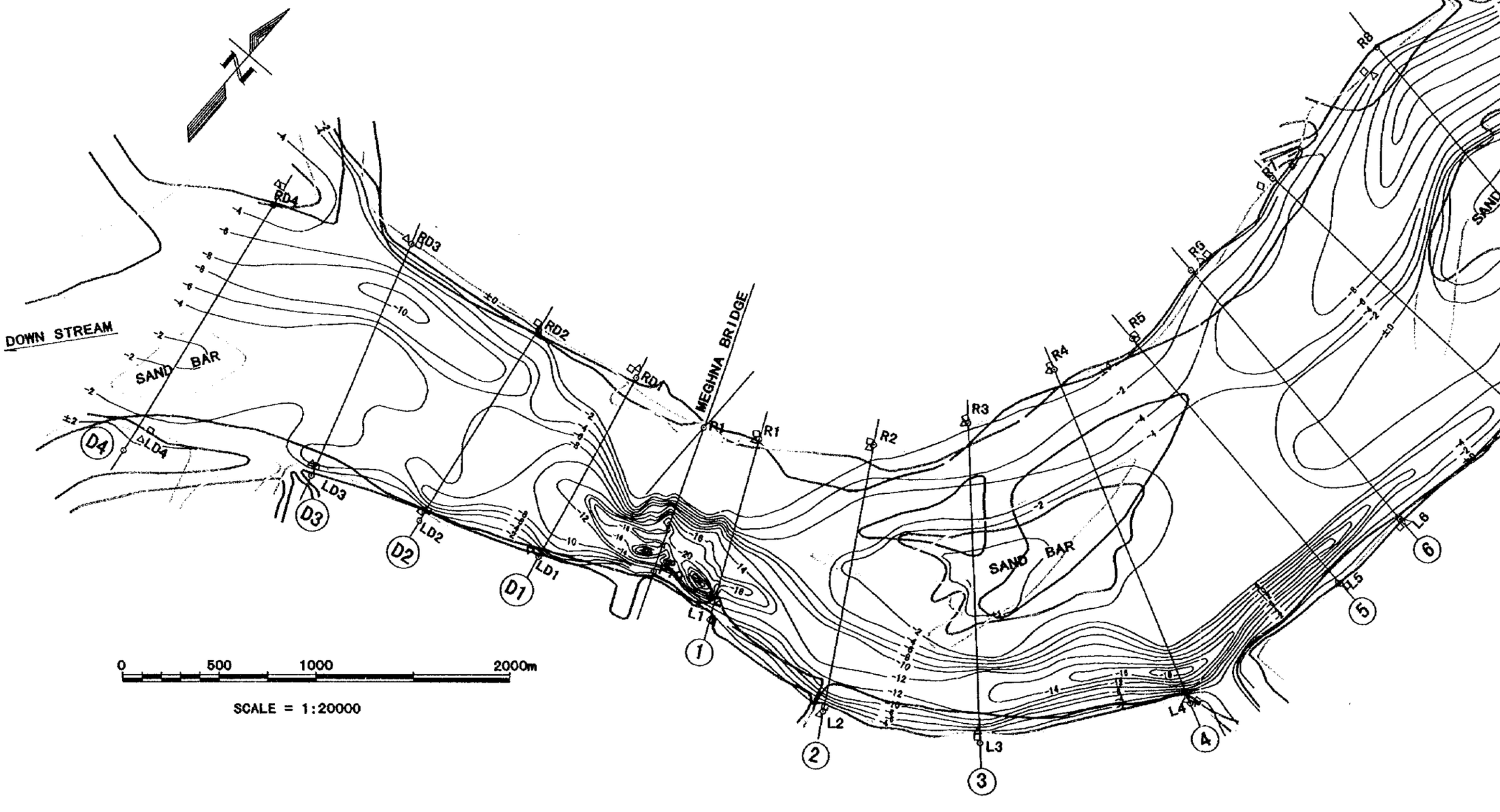
RIVER BED CONTOUR MAP & SHORE LINE

LEGEND (Shore Line)

APR. 1989

JAN. 1994

APR. 1997



ONTOUR MAP & SHORE LINE

ne)

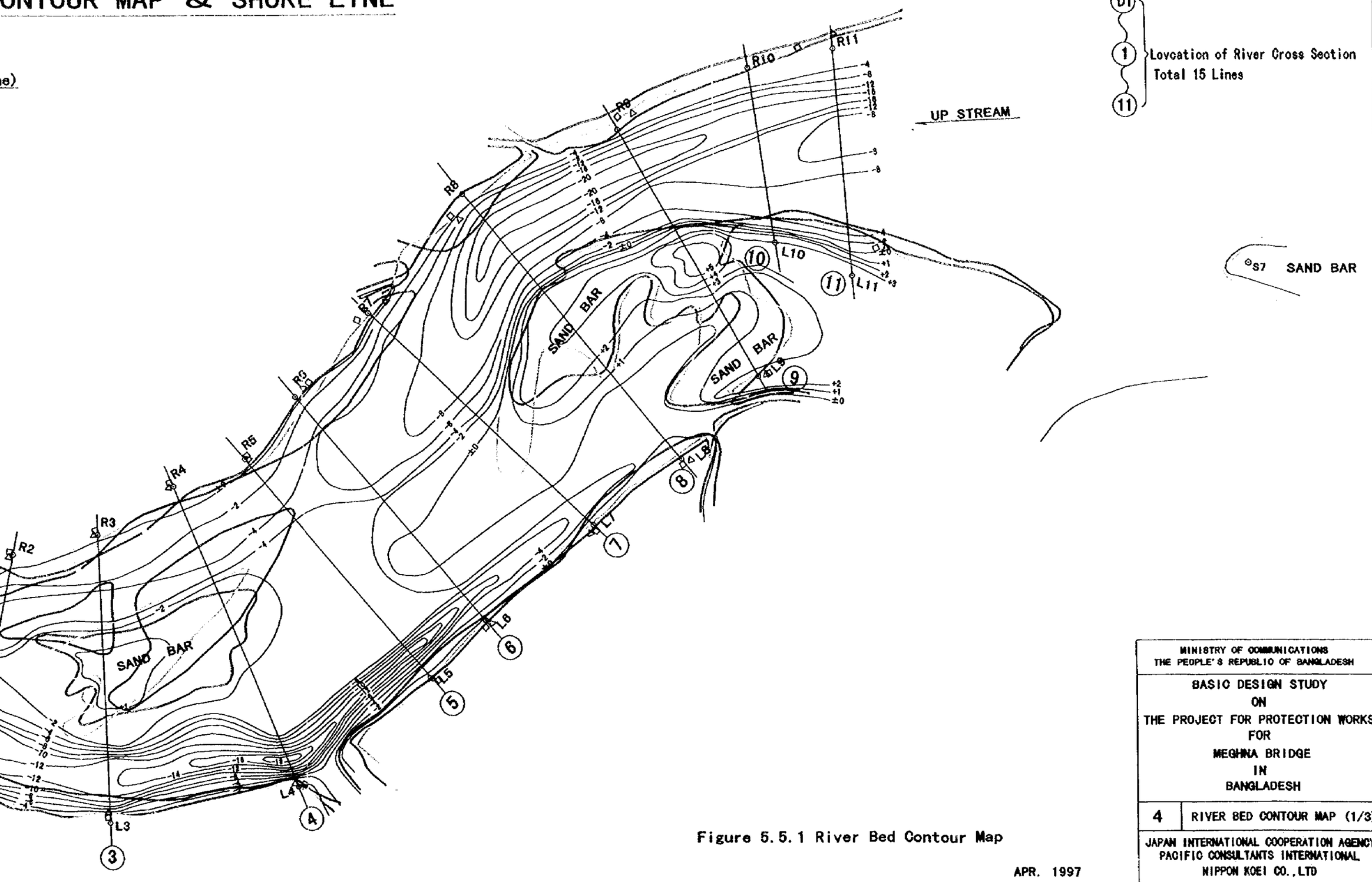


Figure 5.5.1 River Bed Contour Map

APR. 1997

MINISTRY OF COMMUNICATIONS THE PEOPLE'S REPUBLIC OF BANGLADESH	
BASIC DESIGN STUDY ON THE PROJECT FOR PROTECTION WORKS FOR MEGHNA BRIDGE IN BANGLADESH	
4	RIVER BED CONTOUR MAP (1/3)
JAPAN INTERNATIONAL COOPERATION AGENCY PACIFIC CONSULTANTS INTERNATIONAL NIPPON KOEI CO.,LTD	

SHORE LINE MAP OF MEGHNA RIVER

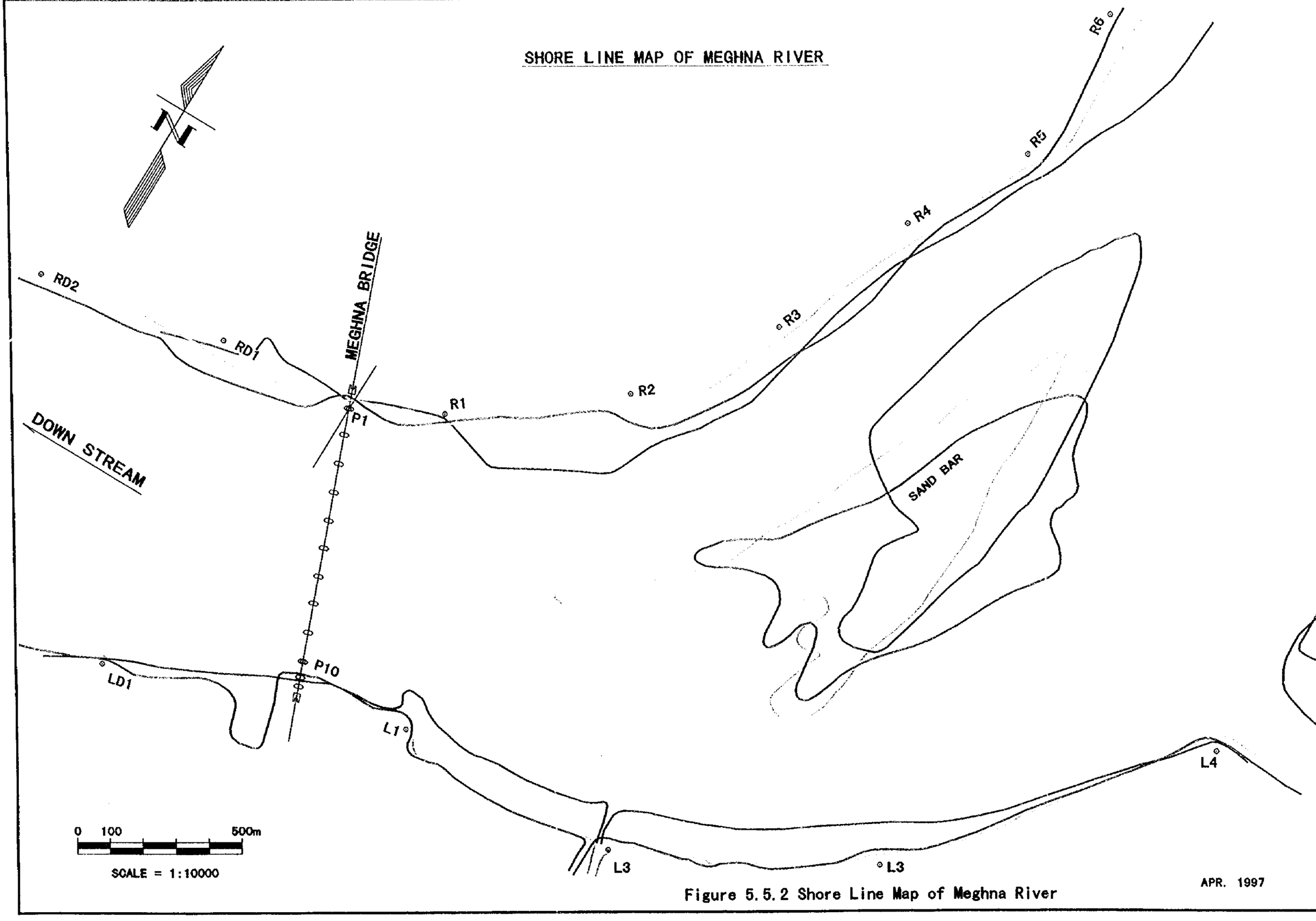
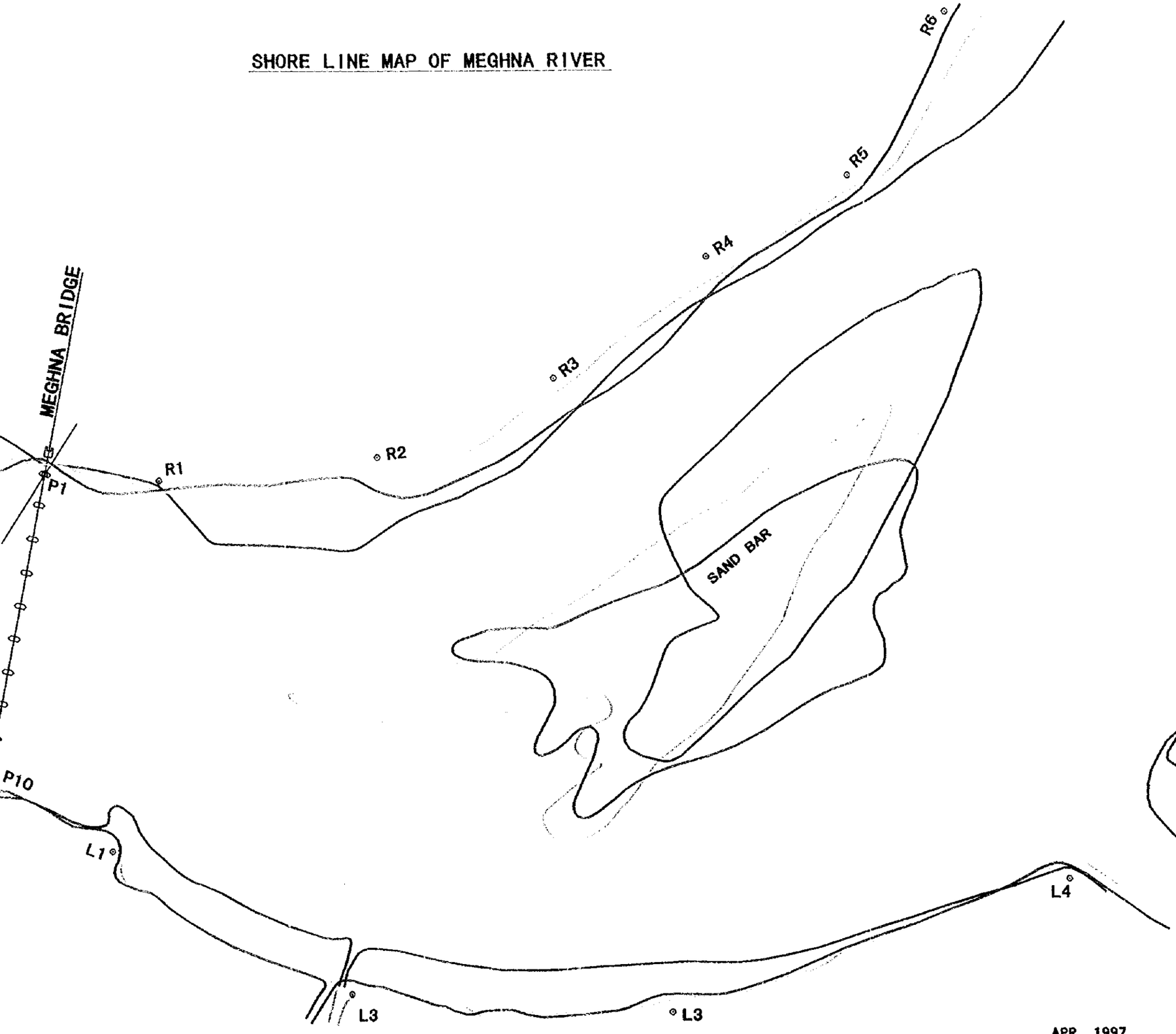


Figure 5.5.2 Shore Line Map of Meghna River

APR. 1997

SHORE LINE MAP OF MEGHNA RIVER



LEGEND

APR. 1989

JAN. 1994

APR. 1997

APR. 1997

MINISTRY OF COMMUNICATIONS THE PEOPLE'S REPUBLIC OF BANGLADESH	
BASIC DESIGN STUDY ON THE PROJECT FOR PROTECTION WORKS FOR MEGHNA BRIDGE IN BANGLADESH	
3	SHORE LINE MAP OF MEGHNA RIVER
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Figure 5.5.2 Shore Line Map of Meghna River