No. 1

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF COMMUNICATION
THE PEOPLE'S REPUBLIC OF BANGLADESH

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR PROTECTING REVETMENT ON THE BANK OF MEGHNA RIVER IN THE PEOPLE'S REPUBLIC OF BANGLADESH

NOVEMBER 1992

PACIFIC CONSULTANTS INTERNATIONAL
NIPPON KOEI CO. LTD.

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR PROTECTING REVETMENT ON THE BANK OF MEGHNA RIVER IN THE PEOPLE'S REPUBLIC OF BANGLADESH
NOVEMBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF COMMUNICATION
THE PEOPLE'S REPUBLIC OF BANGLADESH

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR PROTECTING REVETMENT ON THE BANK OF MEGHNA RIVER
IN
THE PEOPLE'S REPUBLIC OF BANGLADESH

NOVEMBER 1992

PACIFIC CONSULTANTS INTERNATIONAL
NIPPON KOEI CO. LTD.

PREFACE

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

JICA sent to Bangladesh a study team headed by Mr. Masayuki Watanabe, Institute for International Cooperation, Japan International Cooperation Agency (JICA) and constituted by members of Pacific Consultants International in consortium with Nippon Koei, Co. Ltd., from 13th June to 3rd July 1992.

The team held discussions with the officials concerned of the Government of Bangladesh, and conducted a field study at 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 interim report 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 The People's Republic of Bangladesh for their close cooperation extended to the teams.

November 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

November 1992

Mr. Kensuke Yanagiya,
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are preased to submit to you the basic design study report on the Project for Protecting Revetment on the Bank of Meghna River, in the People's Republic of Bangladesh.

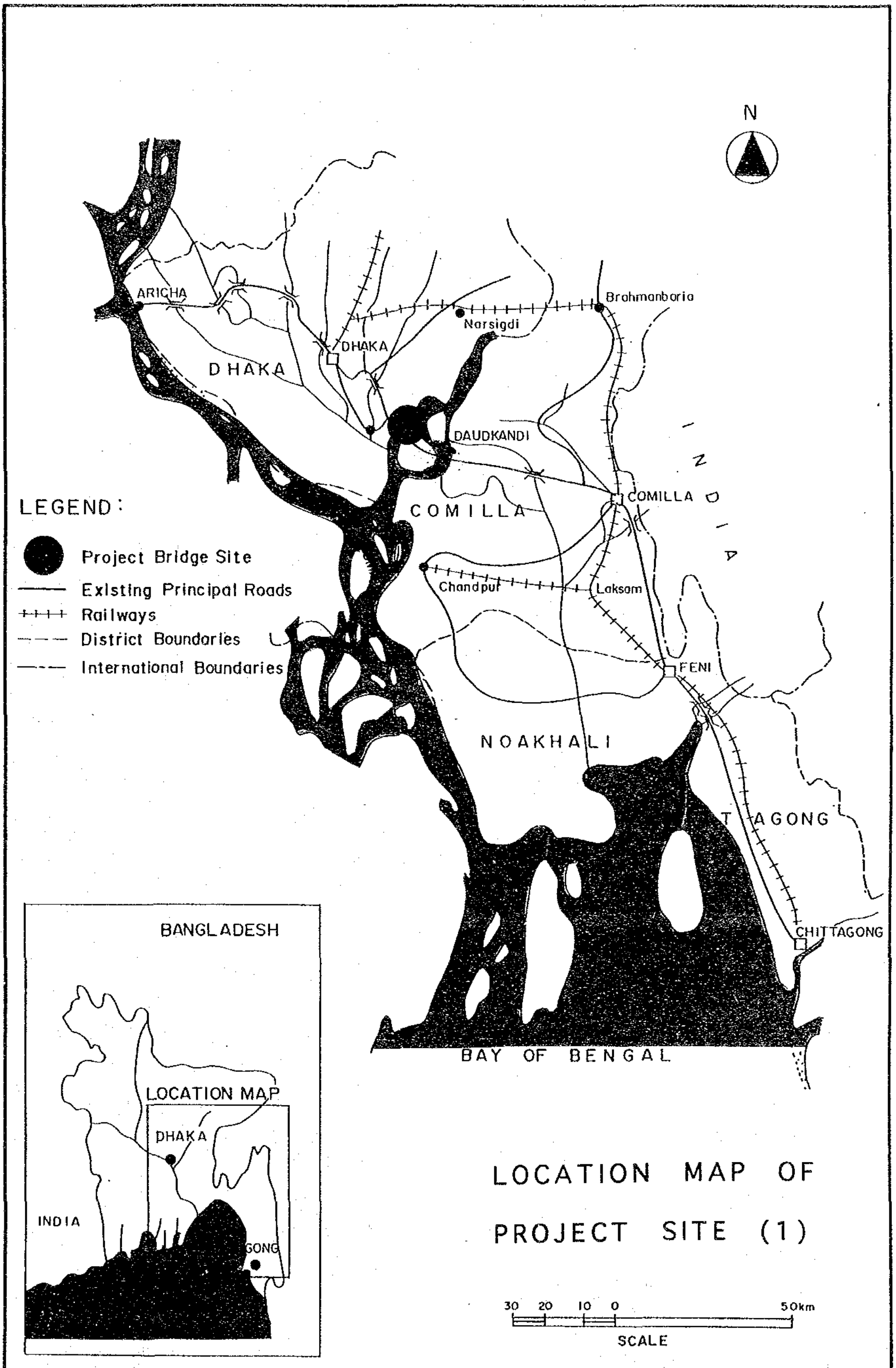
This study has been made by PACIFIC CONSULTANTS INTERNATIONAL in consortium with NIPPON KOEI CO., LTD. based on a contract with JICA, from 1st June 1992 to 30th November 1992. Throughout the study, we have taken into full consideration of the present situation in the People's Republic of Bangladesh, and have planned the most appropriate project in the scheme of Japan's grant aid.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA and the Ministry of Foreign Affairs. We also wish to express our deep gratitude to the officials concerned of Ministry of Communication, JICA Bangladesh Office, the Japanese Embassy at Bangladesh for their close cooperation and assistance during our study.

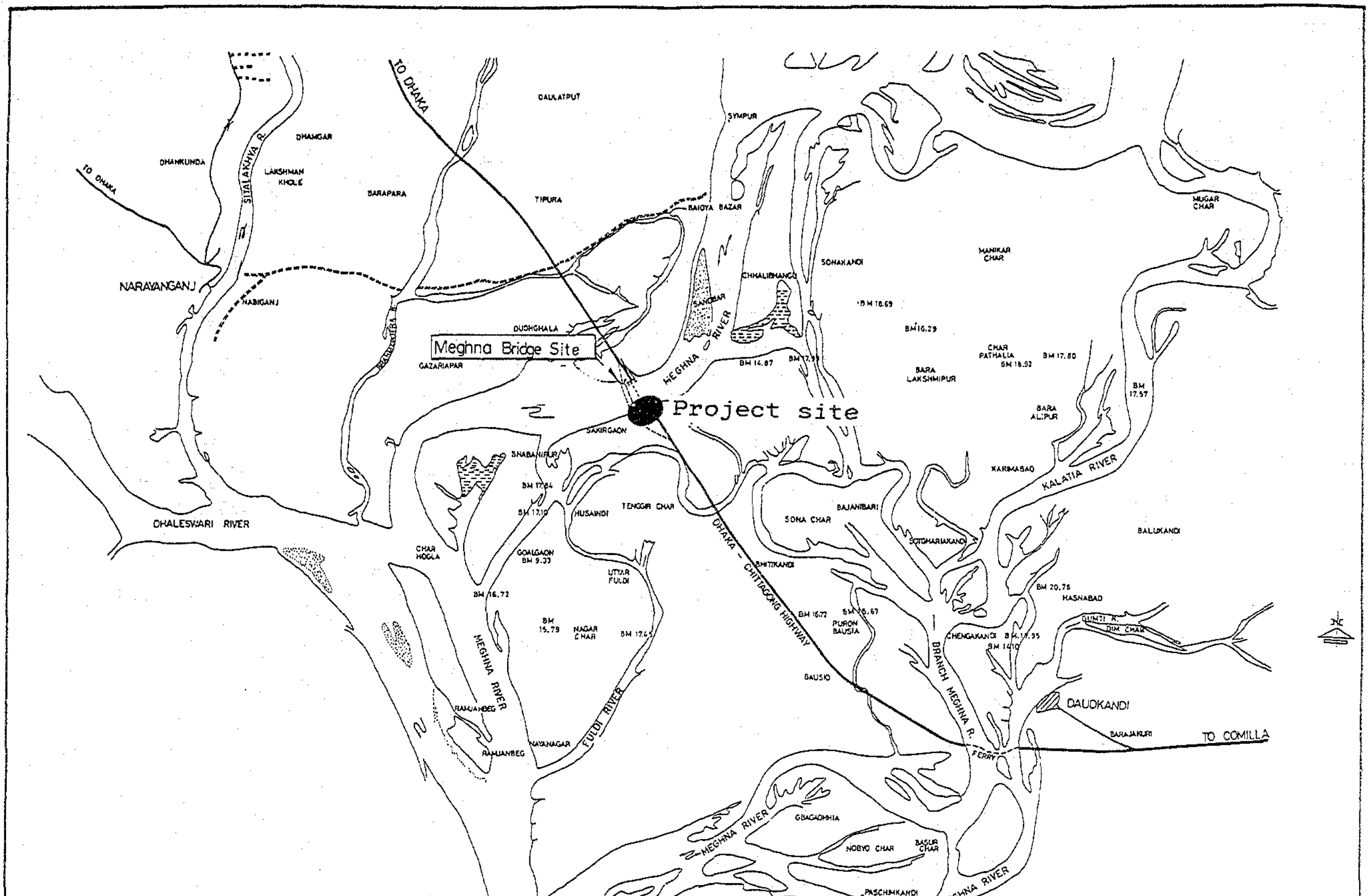
At last, we hope that this report will be effectively used for the promotion of the project.

Very truly yours,

Project Manager, Takeshi Nakayama
The Project for Protecting Revetment
on the Bank of Meghna River
Pacific Consultants International in Consortium
with Nippon Koei Co. Ltd.



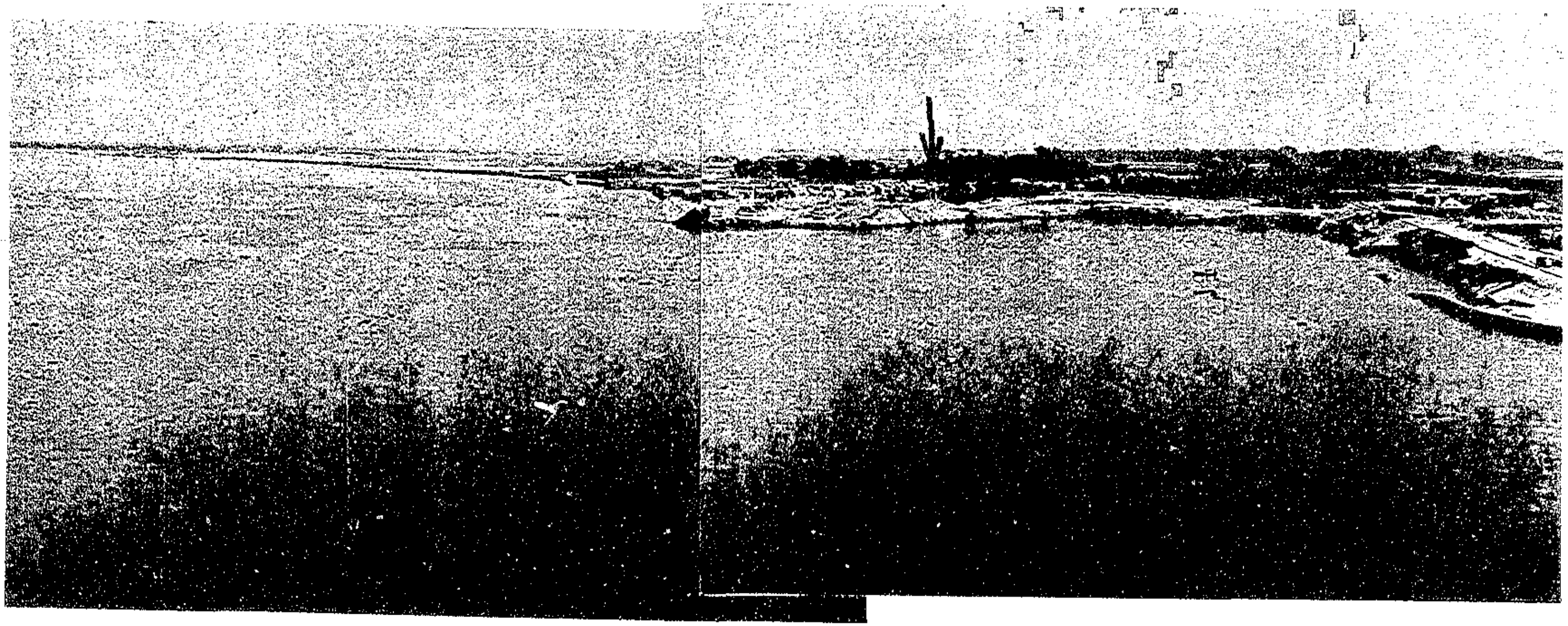
LOCATION MAP OF PROJECT SITE (1)



PROJECT SITE

Dacca side

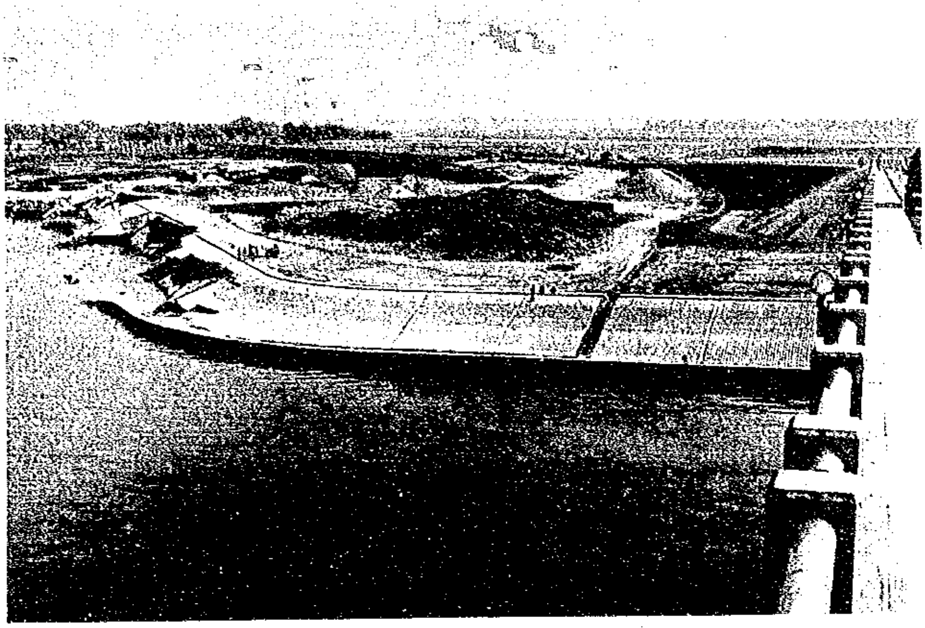
Comilla side



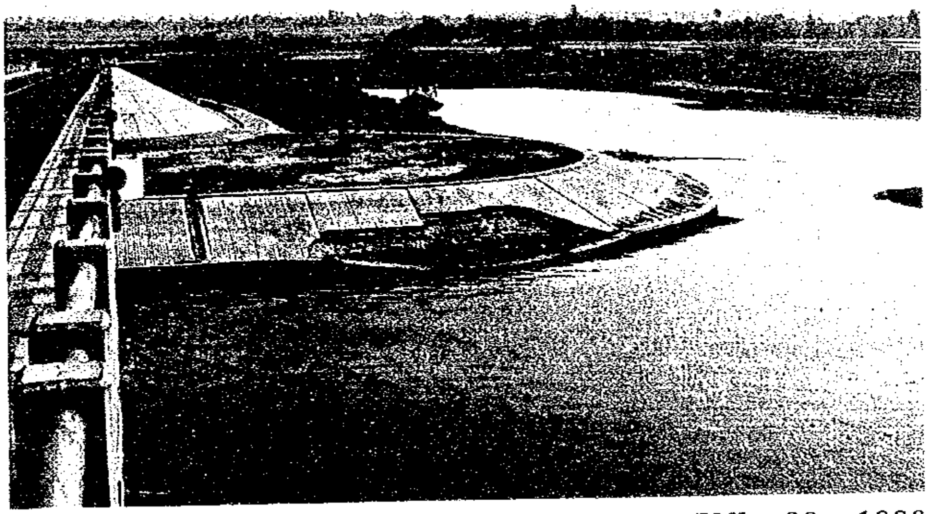
JAN. 20. 1992

UP STREAM SIDE

Photograph (1)



UP STREAM SIDE



JAN. 20. 1992

DOWN STREAM SIDE

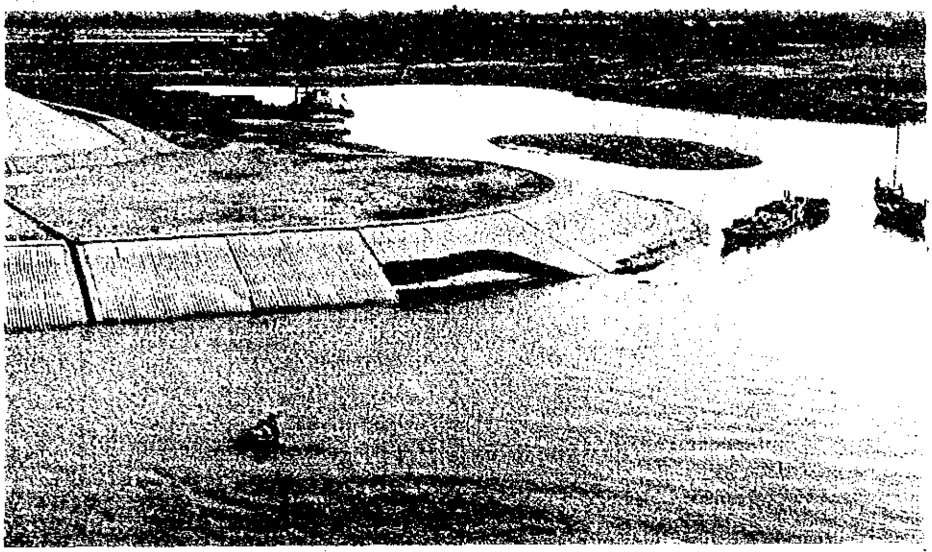
Photograph (2)

No.1

OCT.20. 1991

No.2

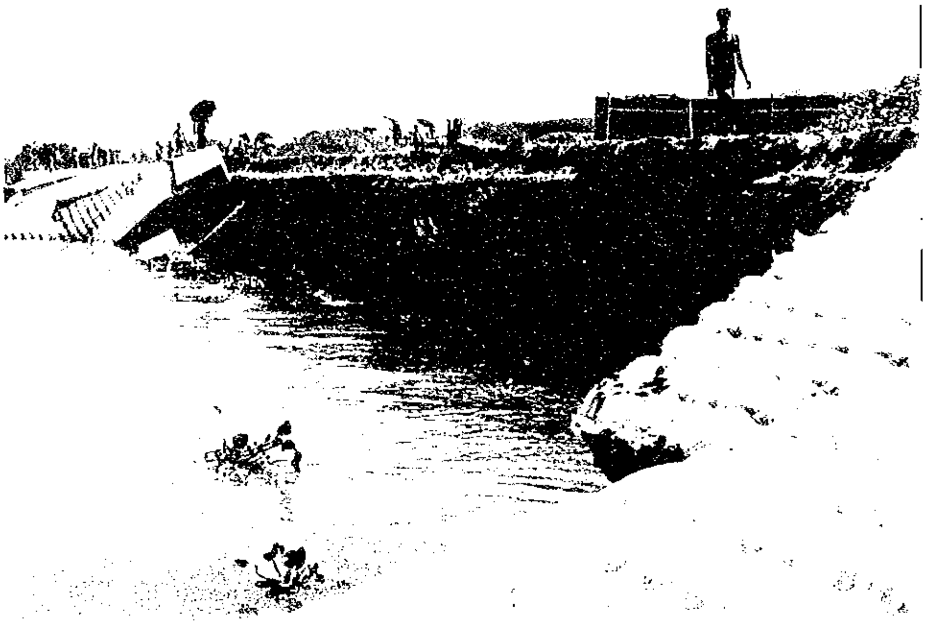
Photograph (3)



No.3

No.4

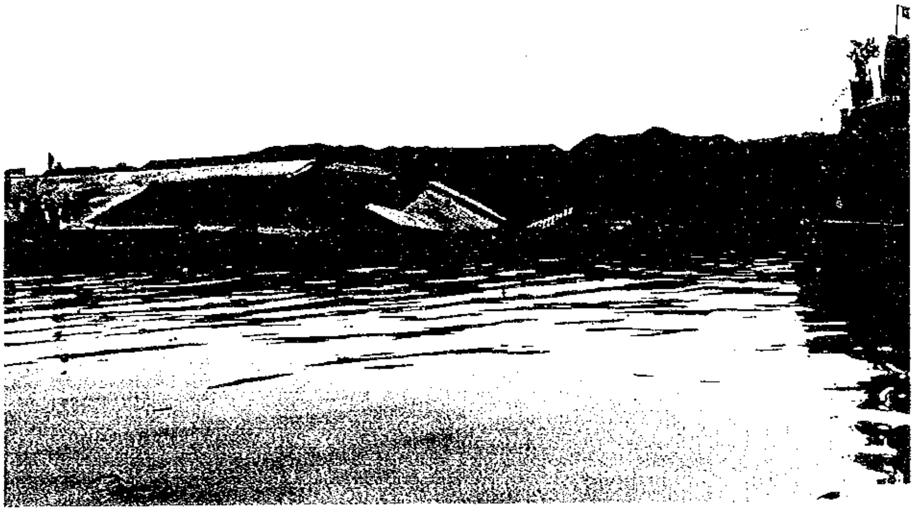
Photograph (4)



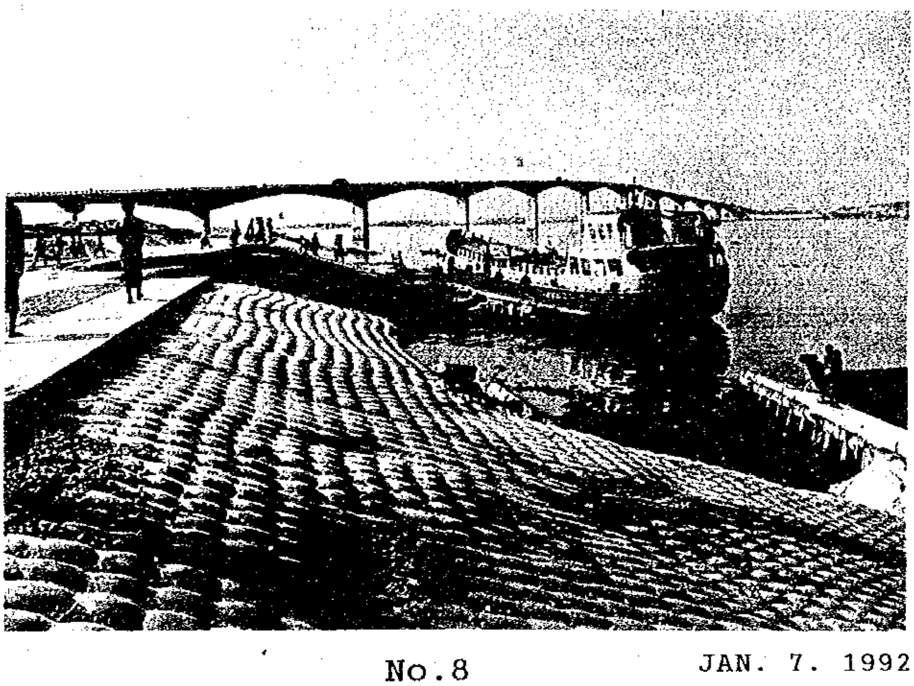
No.5

No.6

Photograph (5)



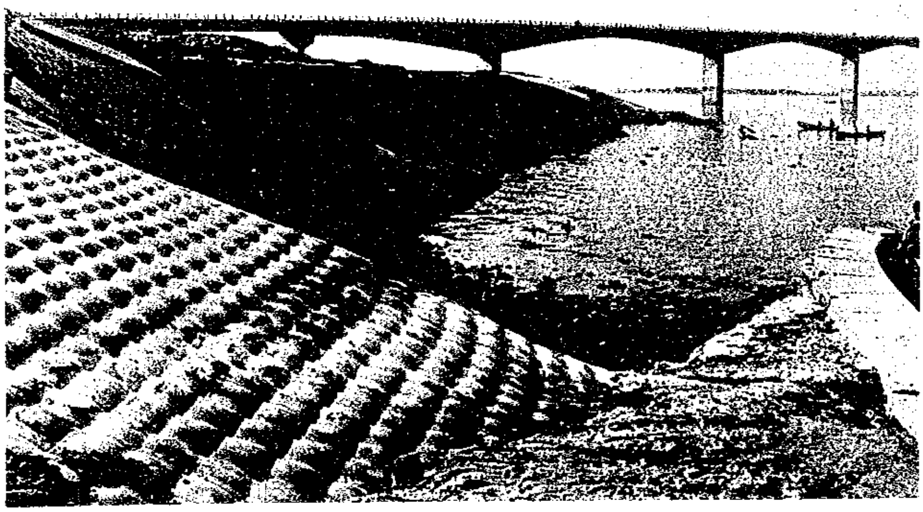
No.7



No.8 JAN. 7. 1992

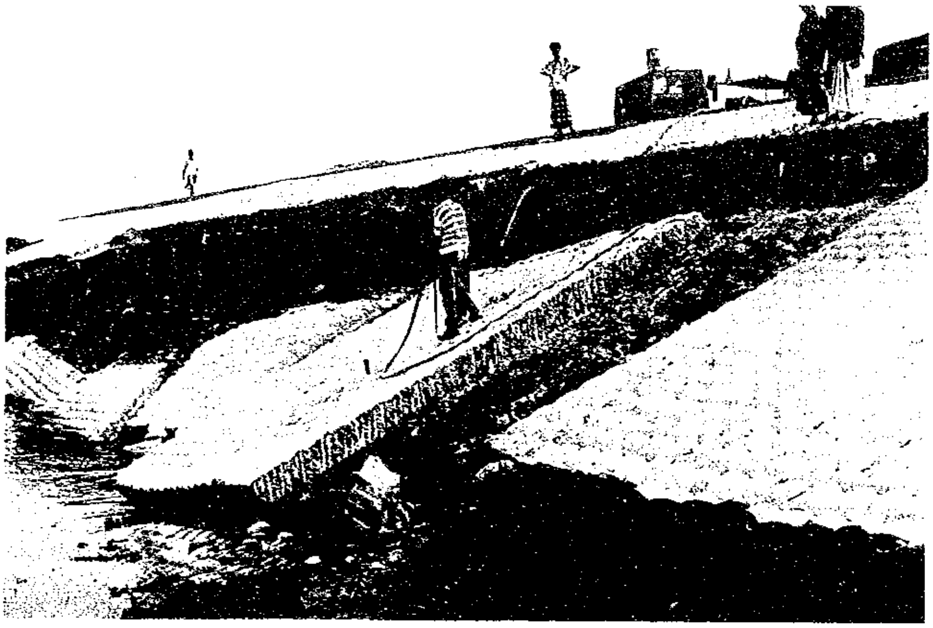
Photograph (6)

No.9



No.10 JAN. 7. 1992

Photograph (7)



No.11

No.12 JAN. 1992

Photograhp (8)

SUMMARY

SUMMARY

The capital city of Dhaka, which is the centre of politics and economy of Bangladesh, and Chittagong the second largest city and industrial centre and largest trading port, make the socio-economic sphere in the southern part of the country, with the heaviest concentration of the population, and this axis is the most important part of the whole nation. The Dhaka-Chittagong Highway (National Road 1, approximate length 246 km) traverses this area and it is considered the most important roadway.

There are two bottlenecks on this Dhaka-Chittagong Highway which requires crossing of the Meghna River and its branch by two ferry crossings. In order to overcome the bottlenecks, the Government of Bangladesh has planned to provide bridges to cross over the rivers to replace the ferry crossings with a Grant Aid Bridge Project from the Government of Japan, and the one bridge, namely Meghna Bridge has been completed and turned over to the Bangladesh Government. A second bridge to replace the remaining obstacle, the Meghna-Gumti Bridge, is presently under construction similar to the Meghna Bridge.

In 1962 the worst flood in 40 years struck Bangladesh, together with another flood of equal proportion struck again in 1963 the following year. The river banks and levees of the Meghna River were badly eroded due to the rapid rise in the river together with the meandering waterways. Also, in 1963, the upstream side of the Meghna Bridge levees collapsed by scouring, thus endangering the bridge abutments and supports.

The Dhaka-Chittagong Highway is the most important roadway and is considered the lifeline of Bangladesh. The safety and security of the Meghna Bridge is presently the most important issue for the road traffic system in Bangladesh. Under these circumstances the Government of Bangladesh has made a request for a Grant Aid project to provide river bank protection for the Meghna Bridge.

In response to this request the Government of Japan decided to conduct a Basic Design Study, and JICA sent the Study Team from June 13, 1992 to July 3, 1992 to confirm the contents of the request and to investigate the requirements to see whether it is justified for a Grant Aid program.

The details of the Basic Design were performed as follows, bearing in mind the discussions held in Bangladesh and the results of the field investigations.

(1) Design Methods:

The basic design for the project for Protecting the Revetments of the Banks of the Meghna River was decided as follows:

- The structures for protecting revetments will be based on the results of the river data and results of analysis conducted at the time of the basic design.

- The proposed bank protection in this study is a short-term countermeasure. Hence, the purpose of the project will be to provide the minimum amount of work required to protect the bridge abutment and supports and the bridge access roads on the Comilla Side of the Meghna Bridge.

- The structures to protect the revetments will consist of materials produced in Bangladesh in order to minimize the construction costs and the maintenance costs. The structures will be designed for construction by simple technical skills. It allows for mid-term and long-term repairs and protection to be made by the Government of Bangladesh.

- The implementation of the project will be planned for completion during the present dry season in order to prevent any further collapse of the preventive structures by further rise in the river water levels that may be brought on by the next flood season.

However, the Meghna River is a large-scale river, and the future changes of the meandering waterways is not predictable.

(2) Comparison of Construction Methods, Materials, Etc.

The construction methods considered to protect the river banks were as follows:

(A) Continuous Steel Pipe Piling
(B) Rock-Fill Dike
(C) Combination of methods (A) and (B) above.

After a technical and economic comparison of the above methods, method (B) was selected which is generally an accepted method used in Bangladesh.

The materials will be of locally procured and quarried stone, but the plastic filter sheets (non-corrosive geotextile) will be imported from Japan. The earth fill material for the fill behind the levee will be dredged from the river bed.

Based on the Basic Design, the project will be as follows:

(1) Location: Left river bank in the vicinity of Meghna Bridge (Comilla Side) on the Meghna-Chittagong Highway, Bangladesh.

(2) The Facilities:

Protective facilities of stone revetment are generally as follows:

Length of Levee:	Approximately 700 m (left bank abutment downstream side of Meghna Bridge, to old Ferry Ghat.
Height of Levee:	Approximately 18 m.
Crest Height:	RL + 6.0 m.
Type of Structure:	Less than RL + 2.0 m (underwater in dry season) will be pitched stone with rip-rap facing. More than RL + 2.0 m (dry portion in dry season) will be stone-filled gabion. The area behind the levee will be earth filled.

(3) Principal Materials:

This project will be a levee constructed with locally produced materials, and the principal materials will be local stones of approximately 77,000 m^3 (a loss of 20 % has been included).

The time for implementation of the project will be 2 months to contract for the design, and 8 months for the construction operations, which will consist of the time to consummate the contract with the consultant for the detailed design, preparation of Tender Documents, Tender Evaluation, Contract Negotiation and Award, all to be concluded after signing of the Exchange of Documents between the Governments of Japan and Bangladesh.

The justification, practical effects and problems are expected to be as follows:

(1) Justification and Practical Effects:

This project is for the important facility of the Meghna Bridge which is located on the Dhaka-Chittagong Highway. This roadway has the largest amount of road traffic of all the existing roads in Bangladesh, and is the most important of the roadways which will affect the socio-economic aspects of daily life, and is maintained with the highest priority. With this point in mind, and with the impending spread of the river bank erosion and the necessity to protect the river banks and bridge facilities, the project is well justified. The implementation of this project is expected to provide the following benefits:

- prevent further erosion of the river banks at the bridge site.
- the stone river protection will require preventive maintenance work which will lead on to establishment of methods to prevent erosion of similar projects.
- the use of locally produced materials will contribute to the local economy.

(2) The Problems:

This project requires that the construction works be completed prior to commencement of the next rainy season, and the time required to prepare the detailed design and perform the Tender Procedures will be severely limited. For this reason, it will be necessary for the Government of Bangladesh to recognize the peculiarities of this project, and to provide assistance to reduce the time for Government formalities to be exercised. On the other hand, the consultant will have to exercise his judgment in the selection of construction materials (procurement of large amounts of quarried stone).

Further, the Meghna River is a large-scale river changing its river course extensively, and the water colliding point in the meanders of the river channel has shifted to the Bridge site. Based on the results of river surveys and numerical situation by two-dimensional flow model, it is presented that erosion at the river bank upstream of the proposed protection works at Comilla side will gradually proceed. Thus, the effectiveness of the proposed bank protection depends upon continuous monitoring of stability and immediate provision of countermeasures as required against unforeseenable scouring after the completion. In order to perform the post-construction works, it should be stressed that to establish an institutional organization for monitoring and maintenance works of the bank protection by the Government of Bangladesh is essential.

The significance in implementing this project under the Grant Aid Program is very large, and its early implementation is expected.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

The Government of Bangladesh made a request to the Government of Japan (GOJ) for a Grant Aid Project to construct protective facilities for the Meghna River Banks. The purpose of this investigation is to comprehend fully the request from the Government of Bangladesh in its implication the request for the project for Protecting Revetment on the Bank of Meghna River, and to examine the soundness of the project to qualify as a Grant Aid Project, and to provide the optimum measures for the basic design required for the project.

This is the Basic Design Study for (Short-term) Protection of Meghna Bridge on the Comilla side. Mid-term or Long-term activities are not included in the project.

Based on the request from the Government of Bangladesh, the Government of Japan decided to perform the investigation for the basic design, and JICA dispatched a Study team headed by Mr. Masayuki Watanabe, Institute for International Cooperation of Japan International Cooperation Agency to Bangladesh from June 13, 1992 to July 3, 1992, and exchanged Minutes of Discussion.

A copy of the list of team members, the investigation schedule, the minutes of the discussions, and the names of the Bangladesh team members are appendixed to this report.

The Basic Design Study Team was briefed on the present condition of the Meghna Bridge and the river banks, and through the discussions held and data furnished by the Bangladesh Government Agencies, were able to comprehend the contents of the request, and made the following field investigations:

- made investigations of the present conditions of the project site, soil studies, studies the topography, hydraulics in order to comprehend the technical implications of the project;
- made studies of the construction techniques and practices peculiar to Bangladesh, and the building codes and regulations, in order to prepare construction costs and construction schedules;
- made investigations of construction implementation plans;
- confirmed the preventive maintenance organizations and capabilities of the Government of Bangladesh;
- made studies to confirm the work items to be performed by the Government of Bangladesh, and the work implementation;
- made the studies to confirm the soundness of the project.

CHAPTER 2 BACKGROUND OF THE PROJECT

CHAPTER 2 BACKGROUND OF THE PROJECT

2.1 Background of the Project

The capital city of Dhaka, which is the center of politics and economy of Bangladesh, and Chittagong the second largest city and industrial centre and largest trading port, make the socio-economic sphere in southeast part of the country, with the heaviest concentration of the population, and is the most important part of the whole nation.

The Dhaka - Chittagong Highway (National Road 1, approximate length 286 km) traverses this area and is the most important roadway, the population makes for about 30 % of the country (based on the 1981 census) and approximately 32 % of the GNP (actual 1987/88).

Based on the socio-economic background described above, all land transportation in Bangladesh is centered and generates from this area. Cargo movement of which 52 % is by truck generates in Dhaka, and 30 % is from Chittagong, and the freight movement between the two cities makes up 30 % of all freight movement in Bangladesh (source ADB 1985).

The largest bottleneck of the Dhaka - Chittagong Highway are the two ferry crossings over the Meghna River and its branch. In order to overcome the bottlenecks the Government of Bangladesh has planned to provide bridges to cross over the rivers to replace the ferry crossing points, and made a request to the Government of Japan in 1983 for a study to construct the Meghna Bridge and the Meghna - Gumti Bridge.

The Government of Japan upon receipt of the request from the Government of Bangladesh decided to implement an investigation for the project, and the Japan International Cooperation Agency (JICA) conducted a Feasibility Study from March 1984 to February 1985 for the construction of the two bridges. The results of the Study confirmed the need for the bridges, and the Government of Japan commenced construction of the Meghna Bridge Project under a Grant Aid Programme in 1986 and was completed in June 1990. The Meghna Gumti Bridge Project was started in 1990 also under a Grant Aid Programme and is currently under construction.

The meandering of the Meghna River could not be fully analyzed from the time of the Feasibility Study, even with the most recent knowledge of hydrology of the natural waterways of the river.

In 1987 the largest flood struck for the first time in 40 years and the worst flood in history struck Bangladesh again in 1988 the following year. The river banks and levees of the Meghna River were badly eroded due to the rising water of the flood and the meandering waterways, and in November of 1988 the Ferry Ghat collapsed disrupting ferry services for one full day. The erosion of the Meghna River dealt a heavy blow to the road traffic of Bangladesh.

It is contemplated that the erosion of the banks and levees of the Meghna River could expand further, endangering bridge abutments and foundations, and it has become necessary to plan means to protect the banks and levees by a project for Projection of the Meghna River. A request for a Grant Aid for the Project was received by the Government of Japan.

After examining the contents of request from the Government of Bangladesh JICA despatched a survey team to Bangladesh from June 13, 1992 to July 3, 1992. The survey has been completed and it has been confirmed that the project justifies a Grant Aid.

2.2 Detailed Description of the Request

The details of the request are as follows:

1) Purpose of the Project:

The purpose of this project will be to take the necessary means to address proper remedies to problems associated with erosion problems and to protect the river banks of the Meghna River on the Comilla Side from further erosion.

2) The Area of the Project:

The area of the project will be the left bank of Meghna River in the vicinity of the Meghna Bridge (Comilla Side).

CHAPTER 3 OUTLINE OF THE PROJECT

CHAPTER 3 OUTLINE OF THE PROJECT

3.1 Objectives of the Project

The project proposes to provide remedies to problems associated with erosion caused by scouring of the Comilla side of river banks in the vicinity of the Meghna Bridge. This project will allow the smooth flows of road traffic on the Dhaka - Chittagong Highway, and expect to contribute greatly to the economic development of the Country of Bangladesh.

3.2 Study and Examination of the Request for the Project

3.2.1 The Position of the Project:

The volume of passenger traffic by mode in the last ten years has increased by 7 % and 8 % for roads and water traffic, whereas the amount of rail traffic is low and has decreased by approximately 5 %. The share of passenger traffic for 1989 was 54 %, 23 %, and 23 % for roadways, inland waterways and railways in this order. On the other hand, movement of cargo by railways has been low, and the share of cargo for roads, inland waterways, and railways was 49 %, 34 % and 17 %. The share of the total investments in the 3rd 5 years programme was 42 %, 23 % and 35 %.

The highest priority has been given for the improvement of the existing trunk road systems in the 3rd 5 years programme. Traffic on the Dhaka - Chittagong Highway is the heaviest of all the existing trunk roads, and is the main artery for the socio-economy system of Bangladesh, and its repair and maintenance has been performed ahead of all the other road systems. There are many ferry crossings on the trunk roadways, and it has been planned to replace the ferries with bridges on the roads with high priorities. The Meghna Bridge has already been completed, and with the completion of the Meghna - Gumti Bridge, the Dhaka - Chittagong Highway will become a capable of travel over land.

Bangladesh has many many large size rivers, and for this reason inland water transport has contributed greatly to transportation systems. In recent years with the large scale felling of trees in the upper reaches of the rivers and construction of dams, there has been floods by rising waters and silting of the river beds.

There has been an increase of erosion of the banks and levees of the Meghna River, and the safety of the bridges have become endangered, and it has become important to provide protection for the river banks.

3.2.2 The Components of the Project:

This project consists of the following components:

Dhaka - Chittagong Highway: Protection of the left river banks (approximately 700 m, Comilla side) in the vicinity of the Meghna Bridge.

3.2.3 Description of the Facilities and Materials Requested:

In summarizing the project described above, a general description is as follows:

- Levelling of the river bed.
- Rock-Fill dike work.
- Earth fill work.
- Pitch stone work (underwater).
- Gabion work (land side).
- Grading of earthwork.
- Protection work for loss of earth and sand.

3.2.4 The Viability and Need for the Project:

The importance of the Dhaka - Chittagong Highway has been described in paragraph 3.2 Study and Examination of the Request; and subparagraph (1) The Position of This Project.

The Meghna Bridge was opened to traffic in June 1990, and the bank protection and related works were completed in March 1991. The Meghna - Gumti Bridge is presently under construction and is expected to be completed in 1996. With the completion of the Meghna - Gumti Bridge, the ferry crossings which were the bottleneck will no longer be required. The road from the Comilla Terminal of the Meghna Bridge towards Chittagong to Daudkando, approximately a distance of 76 km started construction in 1988 with funds from the ADB and is expected to be completed in the very near future. Other roads, with the exception of the sector from Daudkandi to Feni will be improved with funds from the ADB under the 2nd Roadway Improvement Project, and so the maintenance of the function of the river banks in the vicinity of the Meghna Bridge will be sound and very necessary.

3.3 Project Description

3.3.1 The Executing Agency and the Management Organization:

The executing agency for this project will be Roads and Highways Department (RHD) under the Roads and Road Transport Division (RRTD) of the Government of Bangladesh.

The RHD (Road and Highway Department) is the Government Agency that has the total responsibility of principal internal roadway systems (National Highways, Regional Highways, Feeder Roads, Type A) and is charged with the administration, planning, construction, operation, and supervision. There is a Chief Engineer (one), with Additional Chief Engineers (11). Their areas of responsibility are 3 in charge of foreign aids, 5 in charge of regional roads, and the remaining 3 are stationed in the Dhaka Headquarters and look after general affairs, planning, development, and ferry-boats. Within the organization, there are 600 civil and mechanical engineers, 624 technical experts, 21,713 technicians and general employees.

3.3.2 Implementation Plan

On October 19 and 20, 1991, there was severe collapse of the existing protective revetment. Subsequently, the temporary restoration/strengthening of 150 m of fabrimat levee. Subsequently, RHD took up emergency preventive measure for the protective works by placing stone filled gabions. Placing of these gabions in front of sheet piles have contributed to some stability of the reverent during the rainy season of 1992.

However these works are of temporary nature, and there is no assurance that in mid-term or long-term period it may protect the bridge if the erosion escalates and endangers the bridge in future.

It will be important to continue with long-term professional maintenance monitoring to be performed, using local low-cost materials available at the site, using local construction techniques. This will require cooperating with mother nature and be a long-term project for the development of Bangladesh.

3.3.3 The Position of the Project and Local Conditions:

1) Location of the Project Site:

   The Meghna River (900 m wide) crosses under the Dhaka - Chittagong Highway at a point approximately 25 km southeast of Dhaka City, and Meghna Bridge crosses the river here.

2) *The Topography at the Project Site:*

The topographical features at the project site is a perfectly flat flood plain with an elevation less than 6 m, and the main roads and villages are totally inundated during floods when there is rising waters in the area.

3) The Conditions of the River at the Project Site:

Refer to Chapter 4, Hydrology and Hydraulics; and Chapter 5, Present River Conditions Near Meghna Bridge.

4) Description of the Facilities:

Length of Bank:	Approximately 700 m.
Height of Bank:	RL + 6.0 m.
Bank Slope Protection:	Gabions (H x W x L) = 0.6 x 16 x 700 m.
Underwater Portion:	Rock-fill dike and Pitch Stone work.

Note: For details refer to enclosed drawing planes.

3.3.4 Maintenance Programme:

This project is for the construction of bank protection facilities, and it will require maintenance and maintenance administration after the facilities are constructed.

The amount of budget amounts spent by RHD for management, maintenance, and administration for the past 4 years are shown in Table 3.1. This indicates that approximately 75 % of the total budget was spent on the maintenance of roads. The administrative and ferry expenses were spent for the operation, maintenance and administra-expenses for the ferry systems. The budget allocated for FY1988 - 1989 for operation, maintenance and administration is 750 million Taka.

Table 3.1 The RHD Budget for Operation, Maintenance, and Administration

(in million Taka)

Fiscal	Road Related			Ferry Related			
Year	Maint.	Admin.	Total	Maint.	Admin.	Total	Total
1985-86	206	99	305	25	80	105	410
1986-87	235	121	356	37	97	134	490
1987-88	328	130	458	55	102	157	615
1988-89	365	180	545	92	113	205	750

CHAPTER 4 HYDROLOGY AND HYDRAULICS

CHAPTER 4 HYDROLOGY AND HYDRAULICS

4.1 General Features of the Meghna River

The Meghna River is one of the three main rivers which form the alluvial plain of Bangladesh. It flows into the Bengal Bay with the Bramaputra and the Ganges (Paduma) Rivers which originate in the Himalayan Mountains.

The Meghna River has many tributaries in India : the Jadukata and Ronga Rivers cross the Megharaya highlands; the Surma and Kalni Rivers pass through Assam; and the Bimyana River passes through Tripura. The Drainage area is approximately 70,000 km^2 at the Meghna Bridge. Since 63% of the watershed is in India, it is affected by the climate in Megharaya, Assam and Tripura. In the mountainous areas, the monsoon season lasts from June to October and brings an abundance of rainfall. At the Meghna Bridge in Bangladesh, the river water level rises and floods occur one to two weeks after the monsoon starts in the upstream area.

Since the river bed gradient is extremely gentle, about 1 to 20,000, and the ground elevation is low, the river flow surges back upstream to the Bridge site by because of tide fluctuations in the Bengal Bay when the water level is low (in the dry season).

The river system of the Meghna is complex and meanders intensely. Its tributaries join with other river systems. The Bramaputra is connected with the Meghna by a tributary (Old Bramaputra River) which was the mainstream of the Bramaputra River around 200 years ago.

Further, since the river bed of the Meghna River is composed of very fine sand and silt, the bank protection is susceptible to erosion in the flood season. Location map of the Meghna River basin is presented in Fig. 4.1.

4.2 Water Level and Discharge Records at Bhairab Bazar

In order to assess seasonal fluctuation of water level and discharge at the Bridge Site, information at Bhairab Bazar, which is the nearest water level gauging station to the Bridge located around 60 km upstream, is essential. Locations of meteohydrological observatories in Bangladesh are shown in Fig. 4.2.

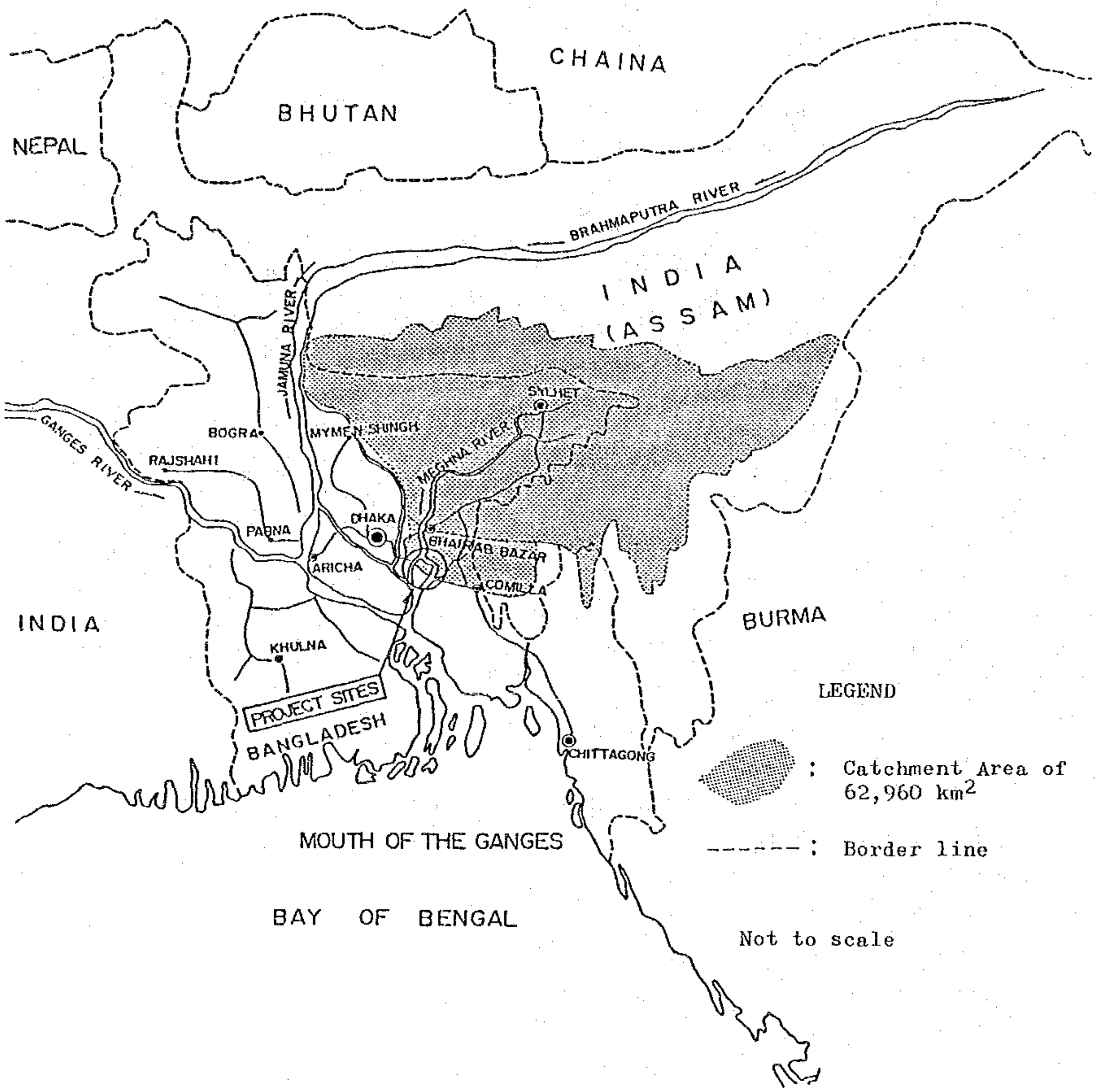


Fig. 4.1 DRAINAGE AREA OF MEGHNA RIVER AT MEGHNA BRIDGE

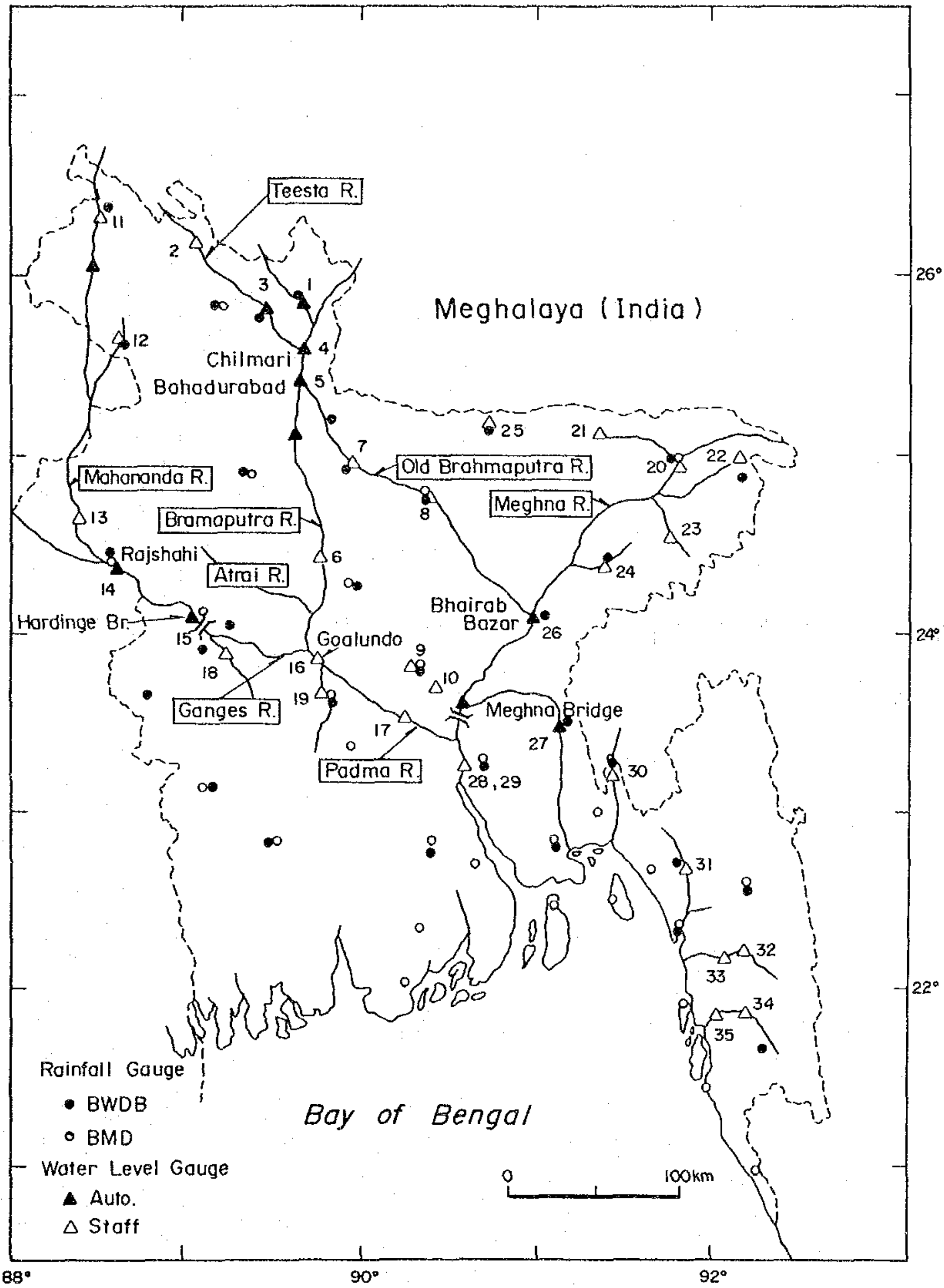


Fig. 4.2 LOCATION MAP OF METEOHYDROLOGICAL OBSERVATORIES IN BANGLADESH

The drainage areas at the bridge site and Bhairab Bazar are as follows:

Unit: km^2

Location	Outside of Bangladesh	Inside of Bangladesh	Total
- At Bhairab Bazar G/S	41,390	21,570	62,960
- Others	2,760	4,170	6,930
- Meghna Bridge site	44,150	25,740	69,890

Source: Feasibility Study on Meghna, Meghna-Gumti Bridges Construction Project, March 1985

In the recording sheets, the highest and lowest water levels with range are noted daily. The periods of the records at Bhairab Bazar are illustrated in a bar chart in Fig. 4.3.

Fluctuations of daily water level and discharge at Bhairab Bazar are graphically shown in Fig. 4.4 and 4.5.

From comparing flood magnitude year by year, it is found that the 1988 flood was exceptional, specially in terms of discharge volume. The duration of discharges over 15,000 m^3/sec is listed with the highest water level and peak discharge as follows:

Year	Duration (days)	Water level (R.L. m)	Peak discharge (m^3/sec)
1970	1	N.A.	16,400
1974	23	N.A.	19,500
1976	20	N.A.	16,700
1983	28	N.A.	16,000
1987	7	6.88	15,200
1988	57	7.24	19,800

The highest water level of R.L. 7.66 m was recorded on 10th and 11th September in 1988, the corresponding discharges are 17,600 m^2/sec and 17,800 m^3/sec. On the other hand, when the largest discharge of 19,800 m^3/sec was recorded, the water level was R.L. 7.24 m. Thus, it is noticed that the relation between water level and discharge is not consistent within the high water range. Therefore, to correlate definitely between water level and discharge and/or water surface profile at Bhairab Bazar is difficult. The cause of the phenomenon will be further examined through field measurements and correlation analysis in the future.

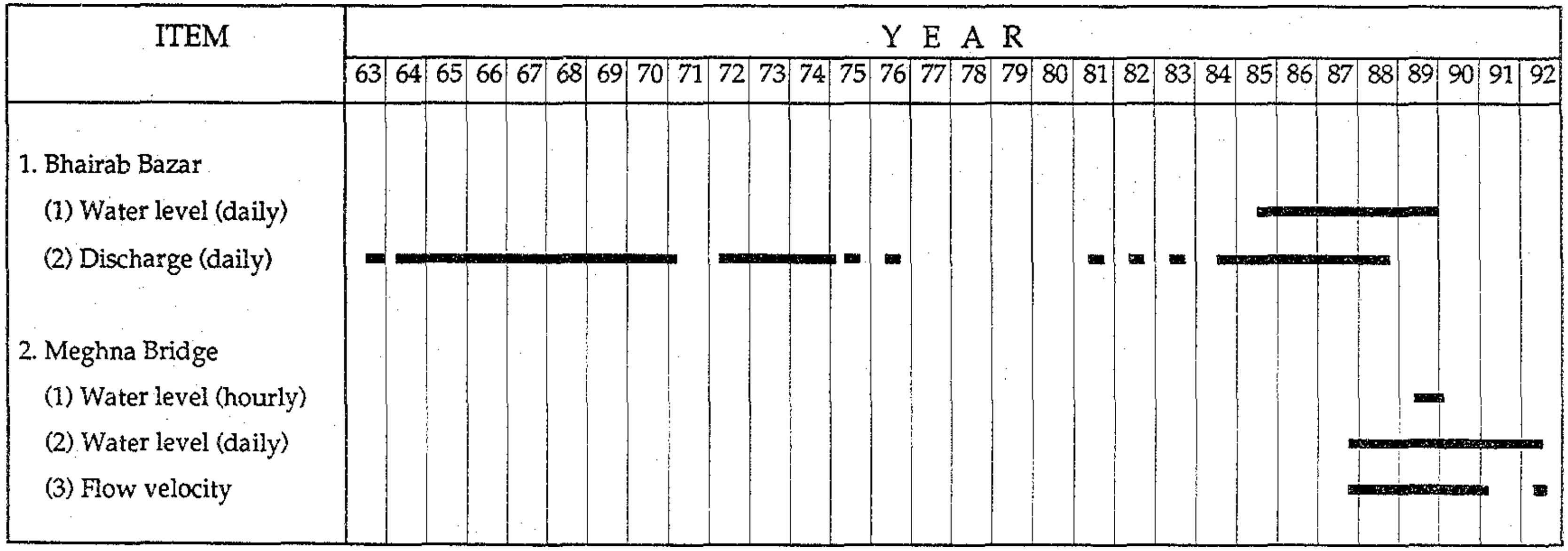


Fig. 4.3 AVAILABLE HYDROLOGICAL DATA NEAR MEGHNA BRIDGE

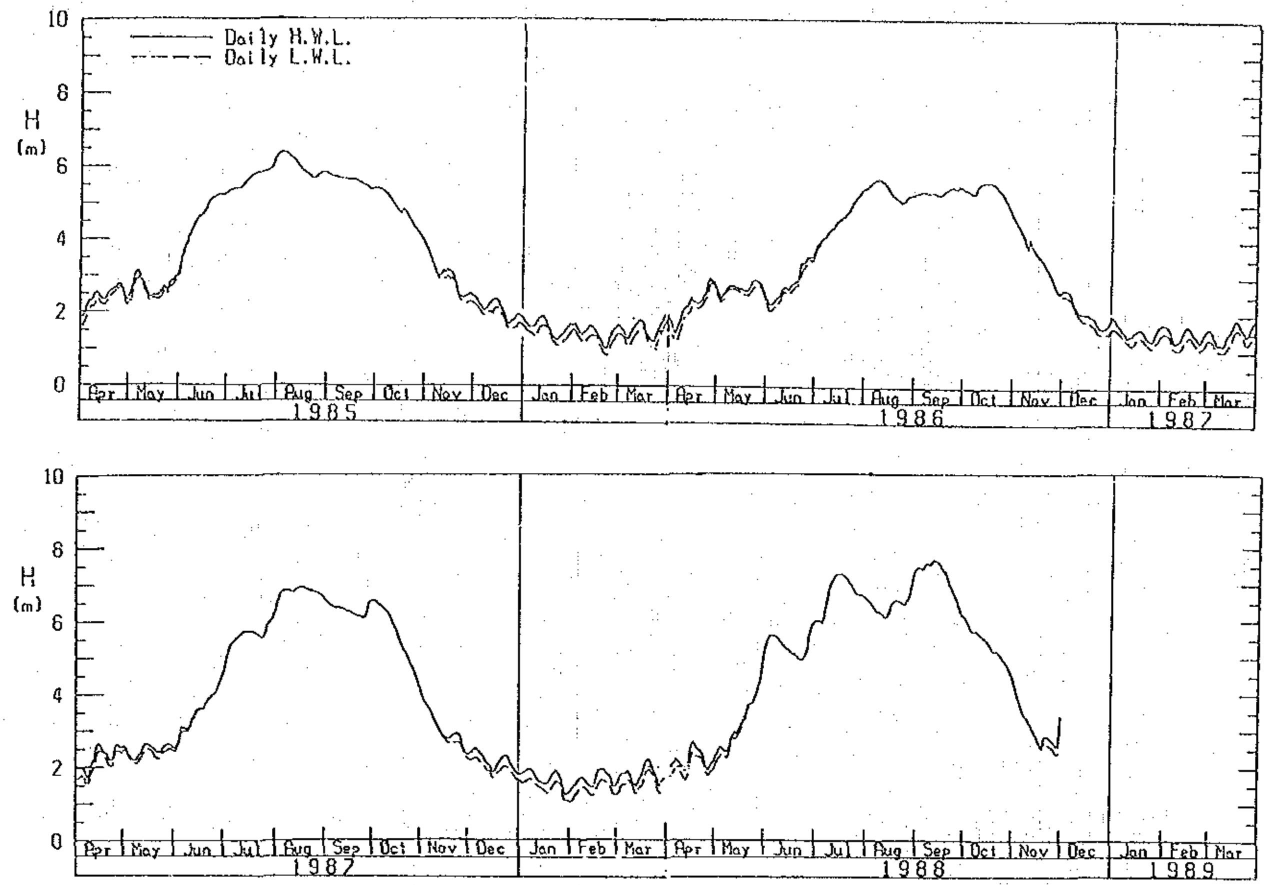


Fig. 4.4 DAILY WATER LEVEL AT BHAILAB BAZAR

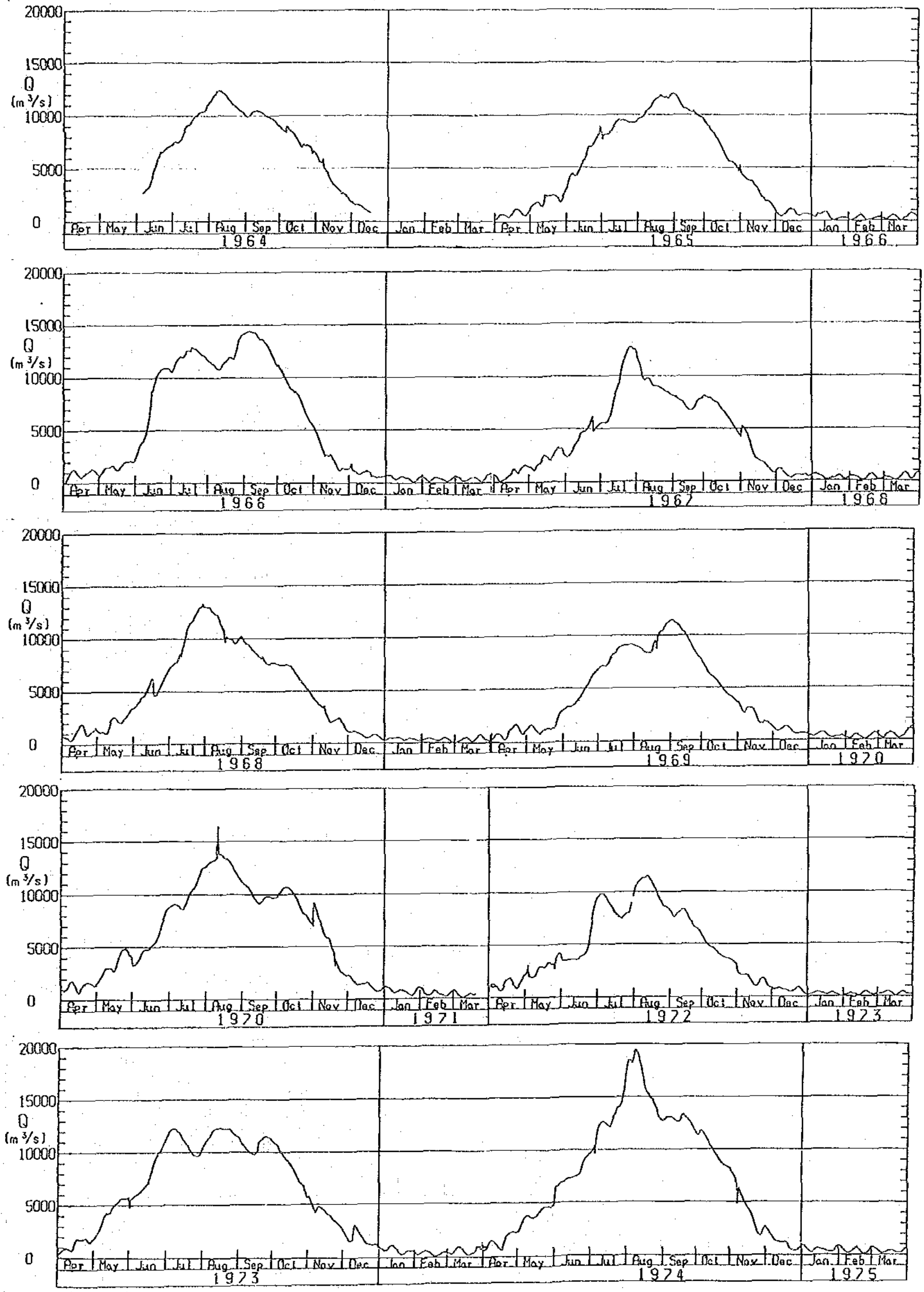


Fig. 4.5 DAILY DISCHARGE AT BHAILAB BAZAR (1/2)

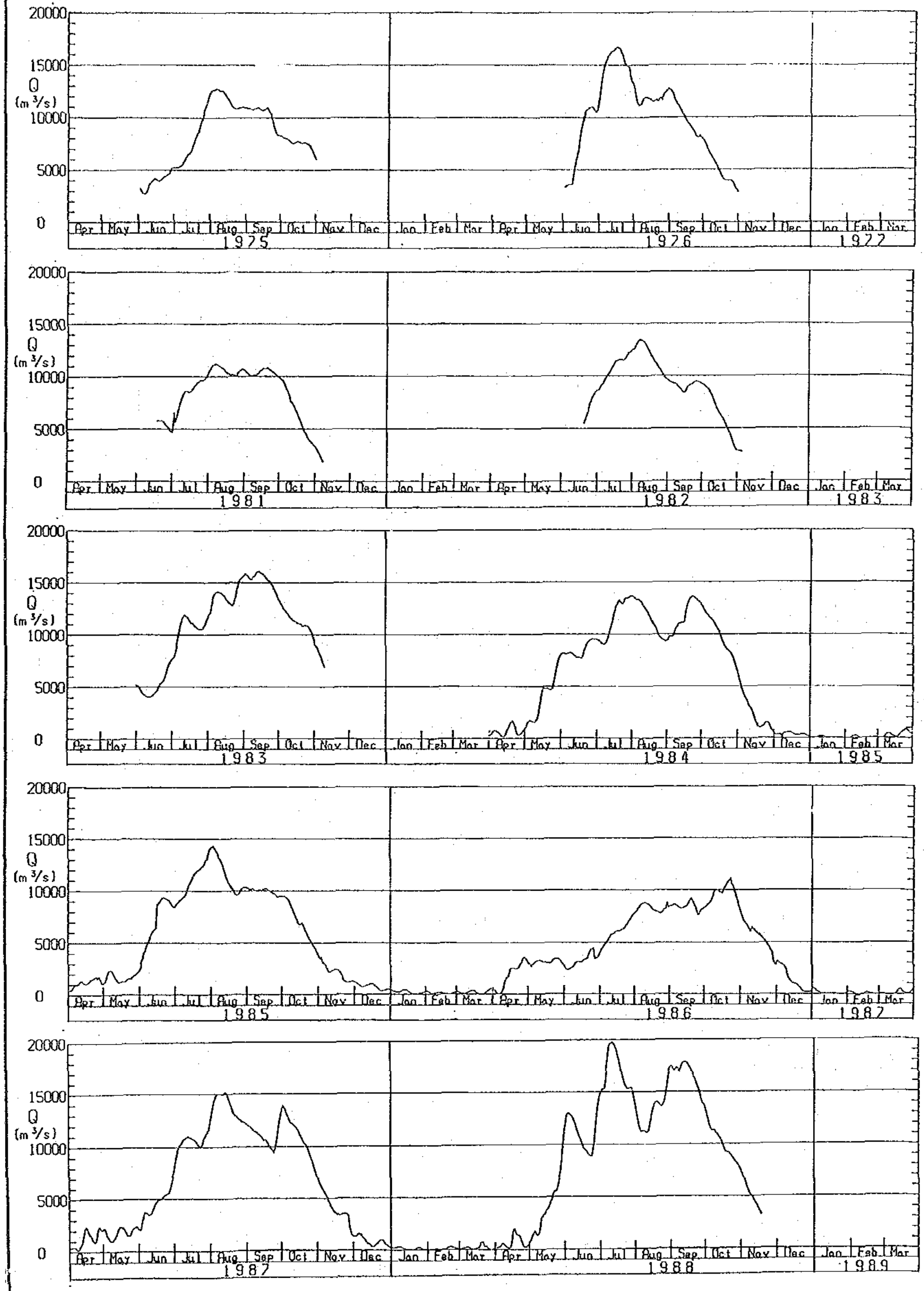


Fig. 4.5 DAILY DISCHARGE AT BAHIRAB BAZAR (2/2)

The total 23 annual maximum discharge records are available as listed in Table 4.1. The maximum discharge of 19,800 m^3/sec was recorded on July 11, 1988 and the second maximum discharge of 19,500 m^3/sec occurred on August 7 to 8, 1974. Its arithmetic mean is estimated at 14,000 m^3/sec. Based on the records, frequency analysis was carried out and the probable discharges were obtained by Gumbel's distribution as follows:

Recurrence period (year)	Probable discharge (m^3/sec)
1.01	9,410
2	13,620
5	16,130
10	17,790
20	19,390
30	20,300
50	21,450
100	23,000
200	24,540

The above results indicate that the peak discharge of the 1988 flood is equivalent to around a 25-year probable flood. In the Feasibility Study on the Meghna, Meghna-Gumti Bridges Construction Project, the 100-year flood peak discharge was estimated at 23,700 m^3/sec from analizing 12 records as compared to 23,000 m^3/sec as found in this Study shown above.

4.3 Water Level and Flow Velocity Records at Meghna Bridge

In the course of construction works of the Meghna Bridge, observation of water level and flow velocity at the Bridge site has been recorded since September 1987. The measurement has been carried out at arbitrary selected points (mentioned pier No. for some records) just upstream side of the Bridge section regularly at around 8 a.m.

Periods of the respective records at the Meghna Bridge are presented in Fig. 4.3.

Daily fluctuation of water level and flow velocity are illustrated in Figs. 4.6 and 4.7 respectively. All the observed records are plotted in Fig. 4.8 to examine the relationship between the two parameters.

As far as reviewing the records, the following hydraulic features at the Meghna Bridge was clarified

Table 4.1 ANNUAL MAXIMUM DISCHARGE AT BHAILAB BAZAR

Year	Discharge (m3/sec)
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
Average	13,974

Source : Surface Water Hydrology
Bangladesh Water Development Board, Dahka

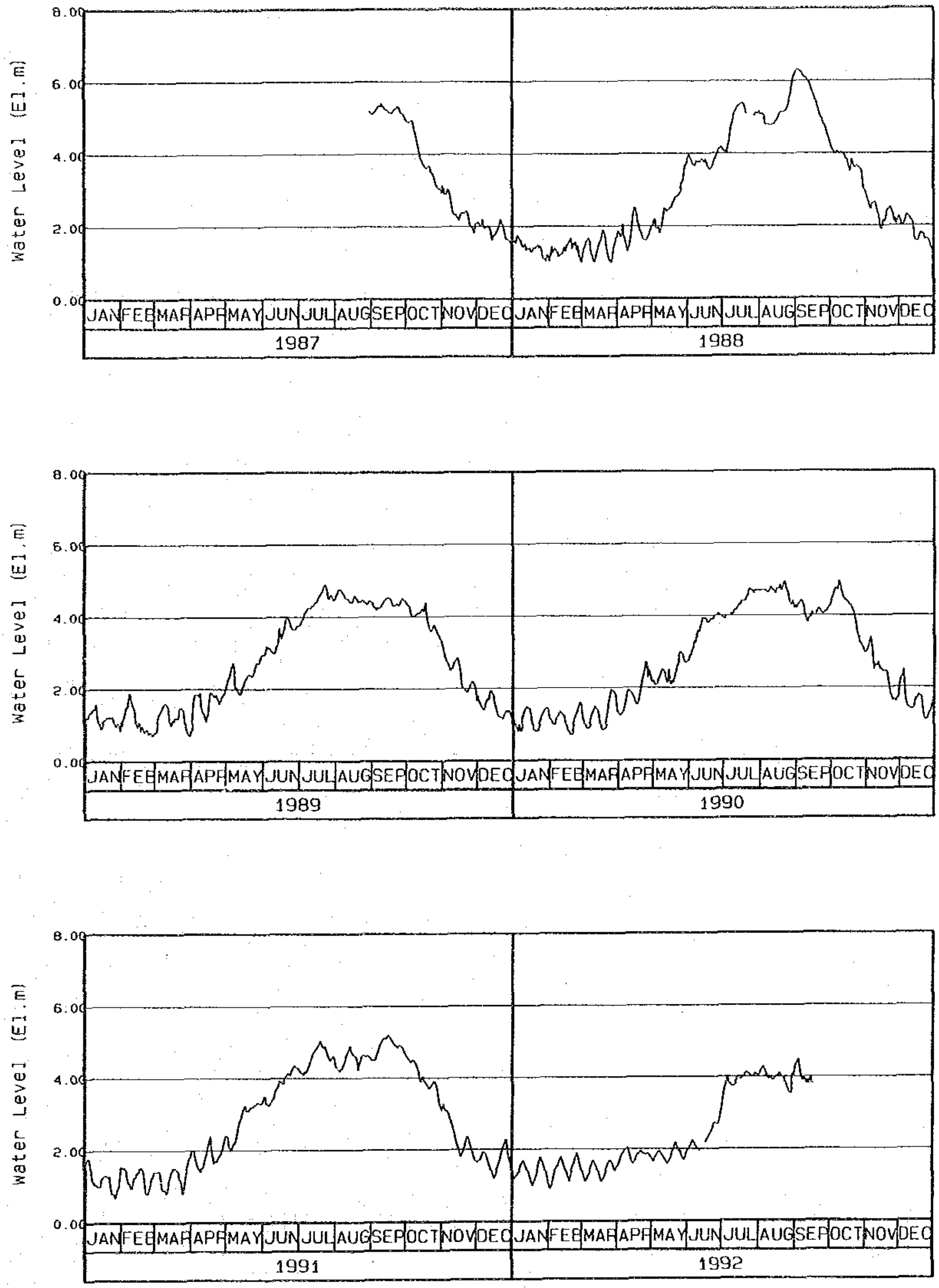


Fig. 4.6 DAILY WATER LEVEL AT MEGHNA BRIDGE

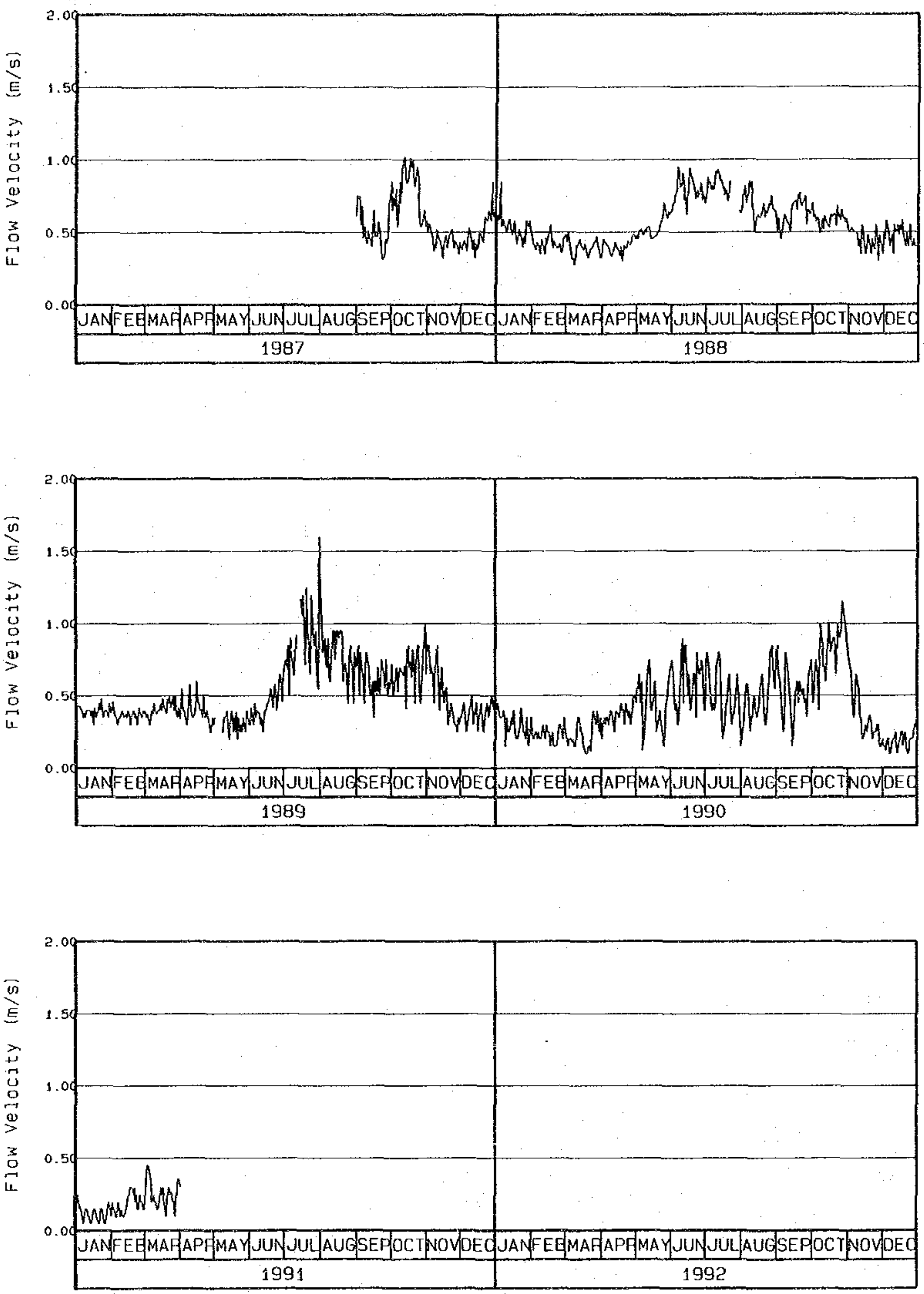


Fig. 4.7 DAILY FLOW VELOCITY AT MEGHNA BGIDGE

(1) The maximum flow velocity reaching 1.6 m/sec occurred in August 1st. 1989.

(2) Although relatively high velocities occur when large-scale floods took place, high velocities do not always appear during the high stage of water level during floods. It is deemed that tidal surging may govern the phenomenon .

(3) The flow velocity varies widely in the range from low to high of its magnitude at certain water levels. Referring to an average of daily values within a week, it shows small peaks with intervals of a half month.

(4) As a whole, the high velocity occurs when the water level is in the range of R.L 3.0 m to 5.0 m as shown in Fig. 4.8. It is considered that this phenomenon might be hydraulic characteristics in the river stretch adjacent to the Meghna Bridge.

4.4 Estimation of Discharge at Meghna Bridge

Although available hydrological data is limited, it is necessary to assess the hydraulic condition near Meghna Bridge and to provide reasonable boundary conditions for mathematical simulation which follows in Chapter 6.

According to the report, "Feasibility Study on Meghna, Meghna-Gumti Bridges Construction Project, March 1985", the results of discharge measurements, conducted at the Meghna and Meghna-Gumti Bridge sites in July 1984, are presented as follows:

- 9,020 m^3/sec at Meghna Bridge site
- 4,840 m^3/sec at Meghna-Gumti Bridge site

On the other hand, the discharge increased from around 9,000 to 14,000 m^3/sec within the same month at Bhairab Bazar. Thus, about two-thirds of the discharge at Bhairab Bazar passed through Meghna Bridge site. Considering the proportion of the respective discharge, the maximum discharge of 19,800 m^3/sec recorded on July 11, 1988 at Bhairab Bazar is converted at around 13,000 to 14,000 m^3/sec at the Bridge site.

In addition, the Feasibility Study Report presents the results of the discharge measurement in July 1984 that the mean velocity was calculated 1.10 m^3/sec at water level with the maximum velocity of 1.54 m/sec at the Bridge site as plotted in Fig. 4.8.

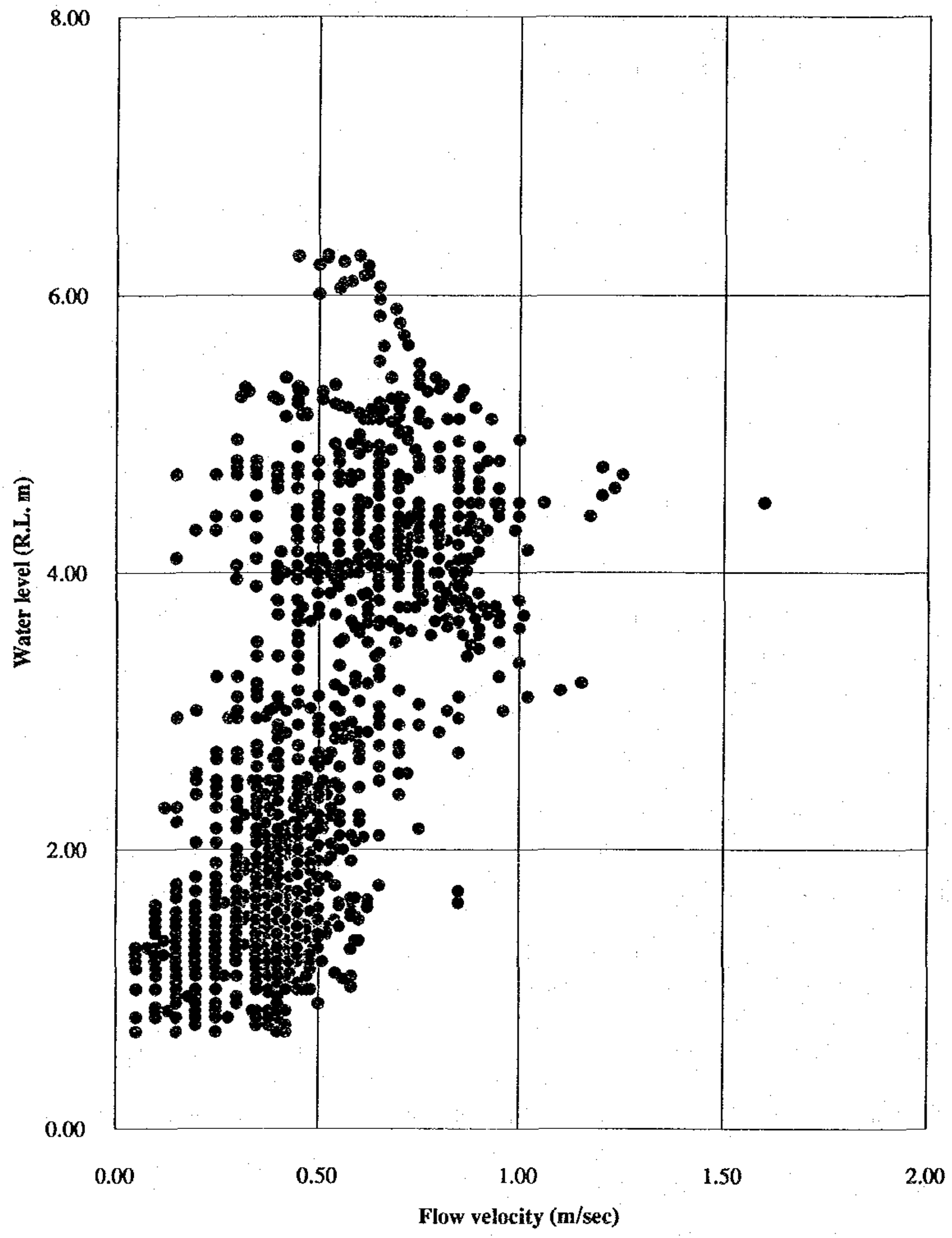


Fig. 4.8 RELATIONSHIP BETWEEN WATER LEVEL AND FLOW VELOCITY AT MEGHNA BRIDGE

Further, water level of H = 5.10 m was observed on July 11, 1988 when the maximum discharge occurred at the Bridge site. The flow area was estimated at about 11,000 m^2 based on the survey result in June 1992. If the flow velocity value of 1.1 m/sec as a representative one, the discharge can be estimated at 12,000 m^3/sec at the Bridge site.

As for the simulation by the two-dimensional flow model, representative discharge value of 12,000 m^3/sec is given at the water level of H = 4.00 on and 6.29 m in Chapter 6.

CHAPTER 5 PRESENT RIVER CONDITION NEAR MEGHNA BRIDGE

CHAPTER 5 PRESENT RIVER CONDITION NEAR MEGHNA BRIDGE

5.1 River Survey in 1992

5.1.1 Result of Survey in June 1992

During the Basic Design Study for Protecting Revetment on the Bank of the Meghna River in June 1992, a river survey was carried out to clarify the latest river condition near the Meghna Bridge. The work quantity of survey works are summarized as follows:

(1) Topographic Survey and River Cross-Section Survey

- Number of control points	:	28 points
- Traverse survey	:	8 km^2
- Plane table survey	:	95,000 m^2 x 2 sides
- Topographic survey and mapping	:	950 ha
- River cross-section survey	:	15 sections (interval approx. 500 m)

(2) Bathymetric Survey

The area was selected on the Comilla side of the Meghna Bridge. The work quantity is as follows:

- Width of survey lines	:	700 m
- Number of survey lines	:	46 sections

Prior to the above survey works, a river cross-section survey was carried out in April 1989, January 1990 and January 1992. Some of the control points were reestablished because they had been relocated or washed away due to scouring of the river banks. Basically, the same control points were utilized. A location map of the control points and cross sections are shown in Fig. 5.1. Coordinates of control points are listed in Table 5.1 as well as the results of the past two surveys for comparison. The coordinates of control points utilized in January 1992 are not available.

(3) Output of Survey

There are 28 sheets of drawings in total listed in Table 5.2.

5.1.2 Result of Survey in September 1992

Subsequent to the river survey conducted in June 1992 during the first field reconnaissance described in Section 5.1.1, additional river survey was carried out while the second field reconnaissance in September 1992. Survey items and results obtained are explained as follows:

(1) Flow Velocity and Flow Direction Survey

Surface flow velocity and flow direction were measured along the cross-section survey lines which had been set through first survey. The interval between the measuring points are about 100 m along the respective survey lines. Three survey lines (A1, A2, and A3) were added upstream side of the section between No. P and No. U1. The flow direction was measured using of a transit and floats, and velocity was measured by a current meter.

(2) River Cross-section Survey

Additional river cross-section survey was carried out along seven survey lines (No. D3, D1, U2, U4, U6, U8, and U10) among total 15 lines in the same manner which was applied in the first survey in June 1992.

(3) Distribution of Flow Velocity in Vertical Direction

In addition to the measurement of the surface flow velocity, distribution of flow velocity in vertical direction was measured along the five (5) survey lines, i.e. No. P, A1, A2, A3, and U1. The interval for measurement of the point velocity is 1.5 m in vertical direction at respective measuring points.

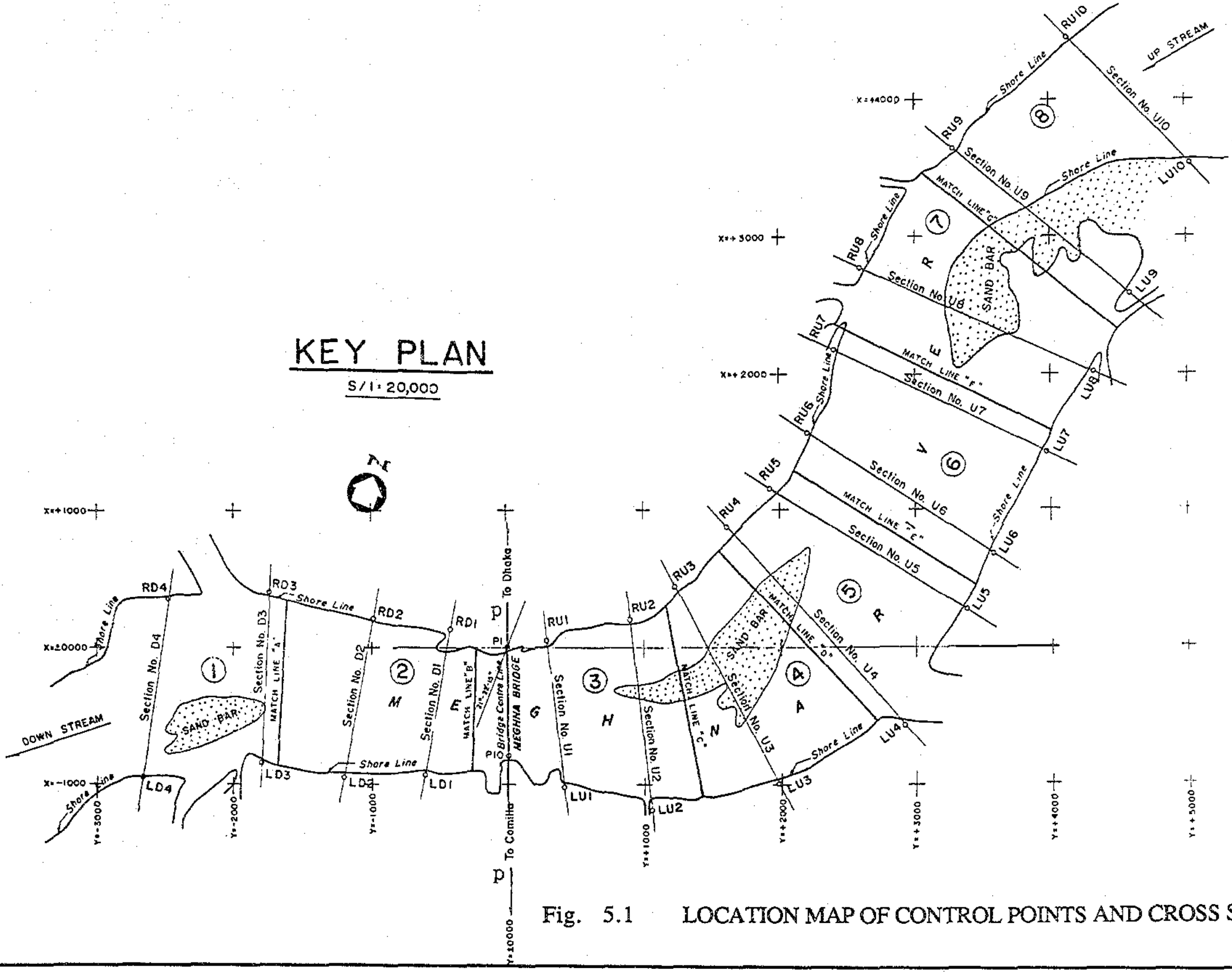


Fig. 5.1 LOCATION MAP OF CONTROL POINTS AND CROSS SECTIONS

TABLE 5.1 COORDINATE AND ELEVATION OF CONTROL POINTS

Point	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(I)-(C)
	Apr.1989			Jan.1990			Jun.1992			Horizontal	Horizontal	Vertical
No.	Xi (m)	Yi(m)	Elev. (m)	Xi (m)	Yi(m)	Elev. (m)	Xi (m)	Yi(m)	Elev. (m)	length (m)	difference(m)	difference(m)
P1	0.000	0.000	18.300				0.000	0.000	18.300	783	0.0	0.000
R1	291.501	49.189	6.568				296.053	38.056	6.568	951	12.0	0.000
R2	911.582	24.377	2.242	897.859	137.163		865.433	207.659	8.600	1,402	189.0	6.358
R3	1,245.210	366.761	5.338				1,279.936	476.054	4.220	1,604	114.7	-1.118
R4	1,585.001	885.577	4.684				1,609.045	900.046	4.684	1,869	28.1	0.000
R5	1,904.734	1,181.618	4.851				1,955.948	1,171.002	4.560	1,645	52.3	-0.291
R6	2,328.469	1,537.385	5.028	2,282.203	1,568.533		2,269.322	1,626.837	4.520	1,569	107.2	-0.508
R7	2,509.012	2,175.720	4.485	2,484.902	2,203.831		2,419.579	2,283.292	3.050	1,735	139.9	-1.435
R8	2,674.469	2,789.905	3.750	2,673.366	2,789.706		2,656.184	2,912.675	3.950	1,875	124.1	0.200
R9	3,331.269	3,672.304	5.547	3,320.725	3,682.816		3,354.778	3,772.100	5.397	1,657	102.5	-0.150
R10	4,170.892	4,498.555	4.878				4,377.711	4,631.146	4.878	1,221	245.7	0.000
RD1	-421.276	128.491	5.492			5.548	-421.729	128.328	5.992	1,041	0.5	0.500
RD2	-996.655	170.023	4.084			3.072	-991.718	202.154	4.057	1,175	32.5	-0.027
RD3	-1,749.020	320.417	3.765			3.364	-1,739.850	389.555	3.480	1,278	69.7	-0.285
RD4	-2,494.827	348.000	3.732			3.054	-2,486.502	394.699	4.035	1,393	47.4	0.303
P10	0.000	-783.000	18.333				0.000	-783.000	18.333		0.0	0.000
L1	392.075	-819.068	5.837	391.742	-821.102	5.774	369.979	-909.985	5.837		93.6	0.000
L2	1,036.405	-1,057.237	3.497	1,039.268	-1,071.649		1,057.785	-1,181.142	3.497		125.7	0.000
L3	1,932.334	-897.063	5.037	1,918.364	-918.705		1,866.048	-1,017.137	3.800		137.2	-1.237
L4	2,846.362	-459.304	3.291	2,838.093	-461.202		2,859.376	-489.515	3.290		32.9	-0.001
L5	3,367.169	315.735	2.344	3,359.622	313.855		3,360.083	313.481	3.344		7.4	1.000
L6	3,559.714	737.433	2.218	3,552.569	735.546		3,558.158	732.586	3.052		5.1	0.834
L7	3,960.175	1,476.485	3.993	3,953.634	1,475.298	4.300	3,954.252	1,474.922	3.993		6.1	0.000
L8	4,320.140	2,058.610	2.853	4,314.057	2,057.542		4,300.399	2,010.551	3.300		52.0	0.447
L9	4,572.445	2,647.174	3.262	4,566.721	2,646.168		4,573.116	2,649.113	3.262		2.1	0.000
L10	4,979.390	3,645.682	4.470				4,969.313	3,563.518	4.470		82.8	0.000
LD1	-607.771	-888.494	5.701			4.165	-601.609	-897.008	4.305		10.5	-1.396
LD2	-1,195.726	-901.720	4.322			4.322	-1,232.468	-948.346	4.115		59.4	-0.207
LD3	-1,806.671	-839.105	5.494			5.550	-1,837.263	-885.226	5.494		55.3	0.000
LD4	-2,686.262	-951.666	4.006			4.006	-2,688.796	-983.154	4.370		31.6	0.364
S1	1,872.677	-36.326	3.390									
S2	2,163.344	329.747	3.886									
S3	2,285.533	941.318	4.667				3,514.782	2,595.335				
S4	3,540.105	2,406.281	3.400		2,405.615		3,586.078	2,974.166				
S5	3,855.404	3,155.971	5.279		3,155.265							
S6	4,324.559	3,257.668	4.332		3,256.100		4,235.166	3,399.231				
S7	7,021.709	4,224.535	2.026									

Table 5.2 OUTPUT OF RIVER SURVEY IN JUNE 1992

No.	Title	Scale	Remarks
1	KEY PLAN	1:20,000	
2	PLAN AND CONTOUR	1:1,500	Result of echo sounding
3	PLAN OF MEGHNA RIVER	1:10,000	Comparison with result of Jan.1992
4	CONTOUR MAP SHEET NO.1	1:3,000	
5	CONTOUR MAP SHEET NO.2	1:3,000	
6	CONTOUR MAP SHEET NO.3	1:3,000	
7	CONTOUR MAP SHEET NO.4	1:3,000	
8	CONTOUR MAP SHEET NO.5	1:3,000	
9	CONTOUR MAP SHEET NO.6	1:3,000	
10	CONTOUR MAP SHEET NO.7	1:3,000	
11	CONTOUR MAP SHEET NO.8	1:3,000	
12	RIVER CROSS SECTION NO.1	V=1:300,H=1:3,000	
13	RIVER CROSS SECTION NO.2	V=1:300,H=1:3,000	
14	RIVER CROSS SECTION NO.3	V=1:300,H=1:3,000	
15	RIVER CROSS SECTION NO.4	V=1:300,H=1:3,000	
16	RIVER CROSS SECTION NO.5	V=1:300,H=1:3,000	
17	PROFILE OF MEGHNA BRIDGE	1:1,000	
18	CROSS SECTION NO.1	V=1:200,H=1:2,500	Cross sections near old ferry ghat
19	CROSS SECTION NO.2	V=1:200,H=1:2,500	- do -
20	CROSS SECTION NO.3	V=1:200,H=1:2,500	- do -
21	CROSS SECTION NO.4	V=1:200,H=1:2,500	- do -
22	CROSS SECTION NO.5	V=1:200,H=1:2,500	- do -
23	CROSS SECTION NO.6	V=1:200,H=1:2,500	- do -
24	CROSS SECTION NO.7	V=1:200,H=1:2,500	- do -
25	CROSS SECTION NO.8	V=1:200,H=1:2,500	- do -
26	CROSS SECTION NO.9	V=1:200,H=1:2,500	- do -
27	CROSS SECTION NO.10	V=1:200,H=1:2,500	- do -
28	PROFILE OF APPROACH ROAD	1:1,000	

5.2 River Course Shifting and Scouring of River Banks near Meghna Bridge

5.2.1 Landsat Images

Satellite photographs in 8 different years (scale 1:100,000) by Landsat were collected from Bangladesh Space Research and Remote Sensing Organization (SPARRSO). The date 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

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

5.2.2 River Course Shifting of Meghna River

Based on the Landsat images, the shoreline from about 15 km upstream to 8 km downstream of the Meghna Bridge was delineated as shown in Fig. 5.2 to check the change of the river course. As the result of the comparison of the two images, the area of erosion and siltation were clarified as illustrated in Fig. 5.3. The last figure in Fig. 5.3 (2/2) shows the shorelines in 1973 and 1991. The characteristic feature of bank erosion can be described chronologically as follows:

- The sand bar just upstream of the Bridge on the right bank was 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.

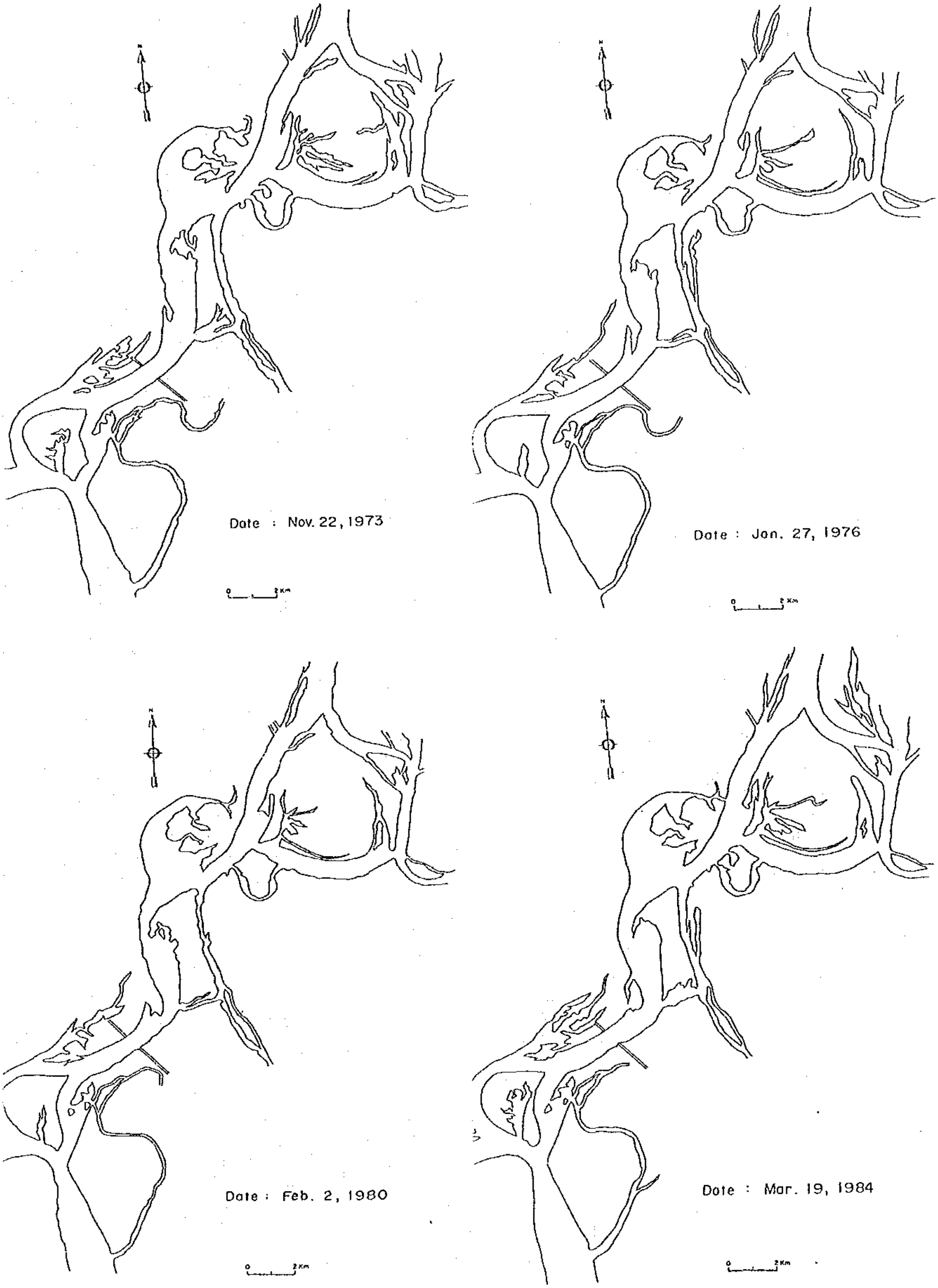


Fig. 5.2 RIVER COURSE OF MEGHNA RIVER (1/2)

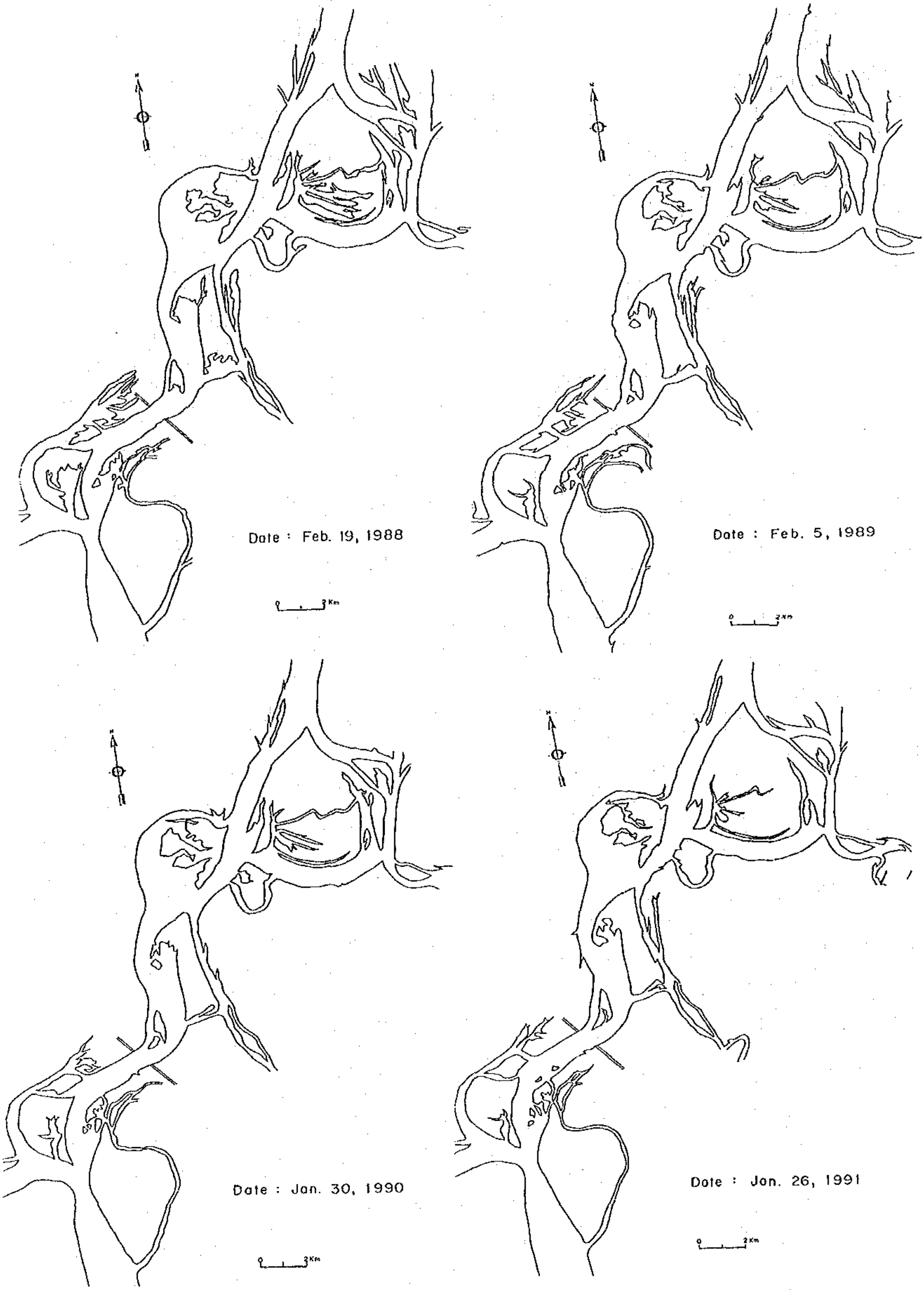


Fig. 5.2 RIVER COURSE OF MEGHNA RIVER (2/2)

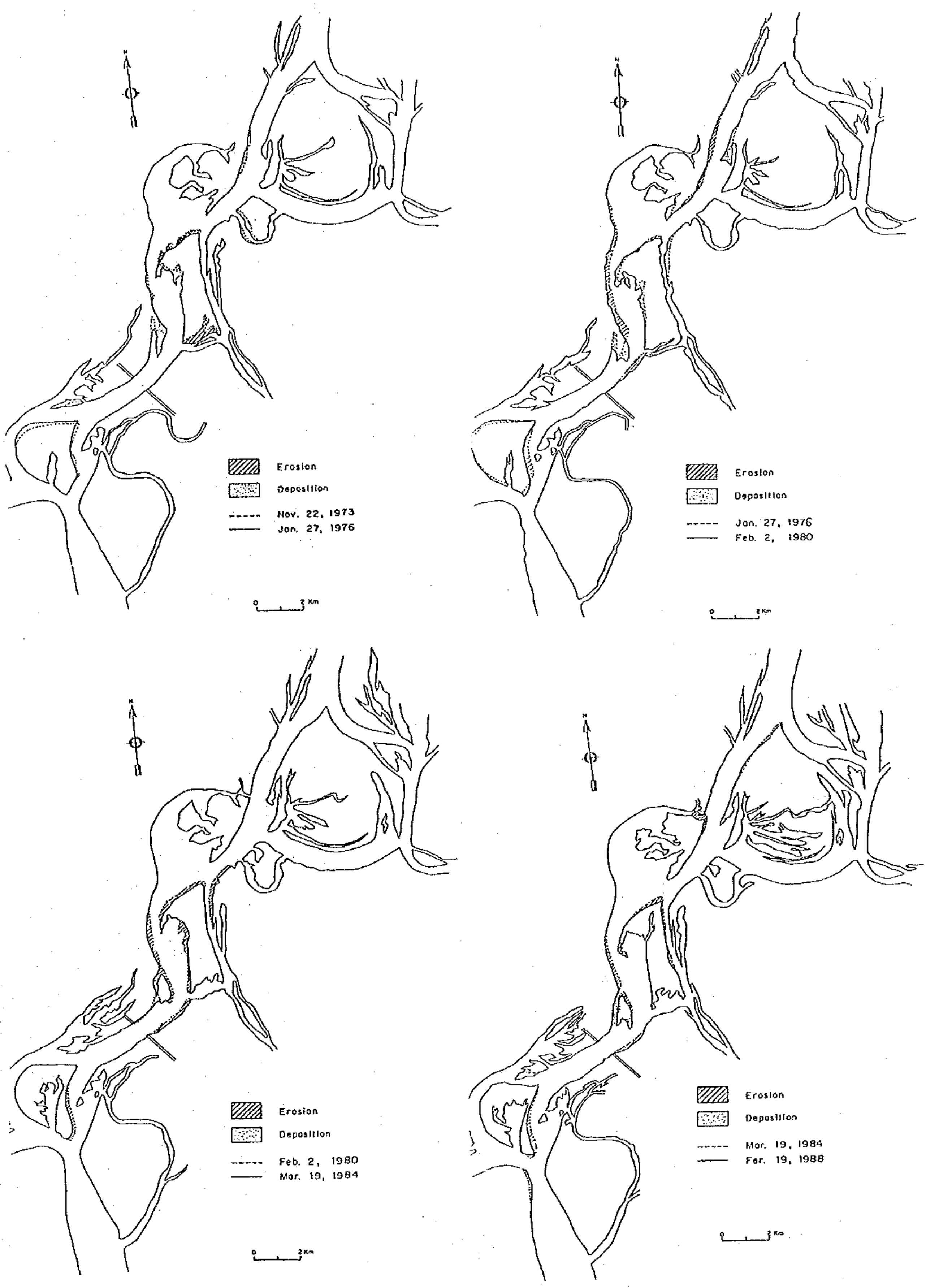


Fig. 5.3 COMPARISON OF SHORE LINES NEAR MEGHNA BRIDGE (1/2)

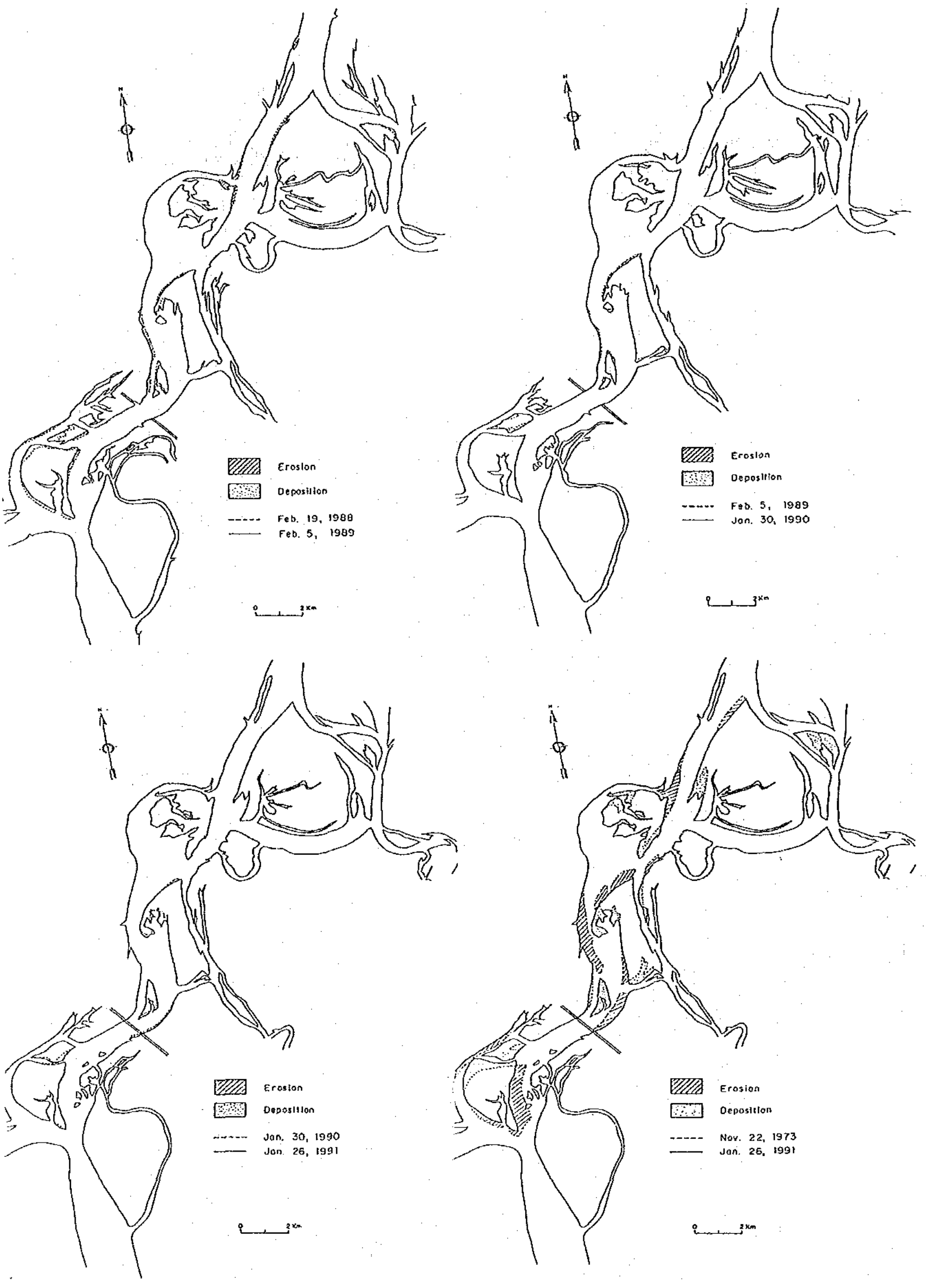


Fig. 5.3 COMPARISON OF SHORE LINES NEAR MEGHNA BRIDGE (2/2)

- The side channel (near the right bank) beside the sand bar at just 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.

5.2.3 Conditions on Scouring and Siltation of Meghna River

In addition to interpretation of the Landsat images, the extent of bank erosion and siltation was reviewed based on the river cross sections obtained through past surveys. Fig. 5.4 presents the sectional area of scouring and siltation for the two survey results in April 1989 and June 1992 for comparison. Referring to the series of cross sections, a river course of deepest portion (thalweg) was drawn with contour lines shown in Fig. 5.5. The shift of thalweg is closely related to the water colliding front at river banks and the development of sand bar. Its characteristic features between No. U10 and No. D4 are as follows:

- From No. U10 to No. U9
  The river channel and bed conditions have not changed.
- From No. U9 to No. U8
  At No. U8, erosion on the submerged slope in front of the right bank has been developed. The shoulder of the right bank has receded around 90 m.
- From No. U8 to No. U7
  The upstream tip of the sand bar has moved downstream. As same as the stretch between No. U9 and No. U8. The right bank has eroded at 10 m in places since April 1989. The thalweg has shifted around 100 m toward the right bank. The shoulder of the right bank has receded around 160 m at No. U7.
- From No. U7 to No. U6
  The deepest part of the river bed has shifted to the vicinity of the left bank downstream of the sand bar. Extensive scouring and receding of the right bank, about 130 m, has occurred.
- From No. U6 to No. U5
  Within this stretch, the direction of main current moves toward the right bank. The sand bar, 60 m wide (above R.L. 2.0 m) at No. U5 as surveyed in April 1989 has, disappeared.
- From No. U5 to No. U4
  The upstream apex of the triangular-shaped sand bar has been scoured and has moved about 400 to 500 m downstream in this stretch. Just upstream of No. U4, the Branch Meghna joins the main river on the left bank.

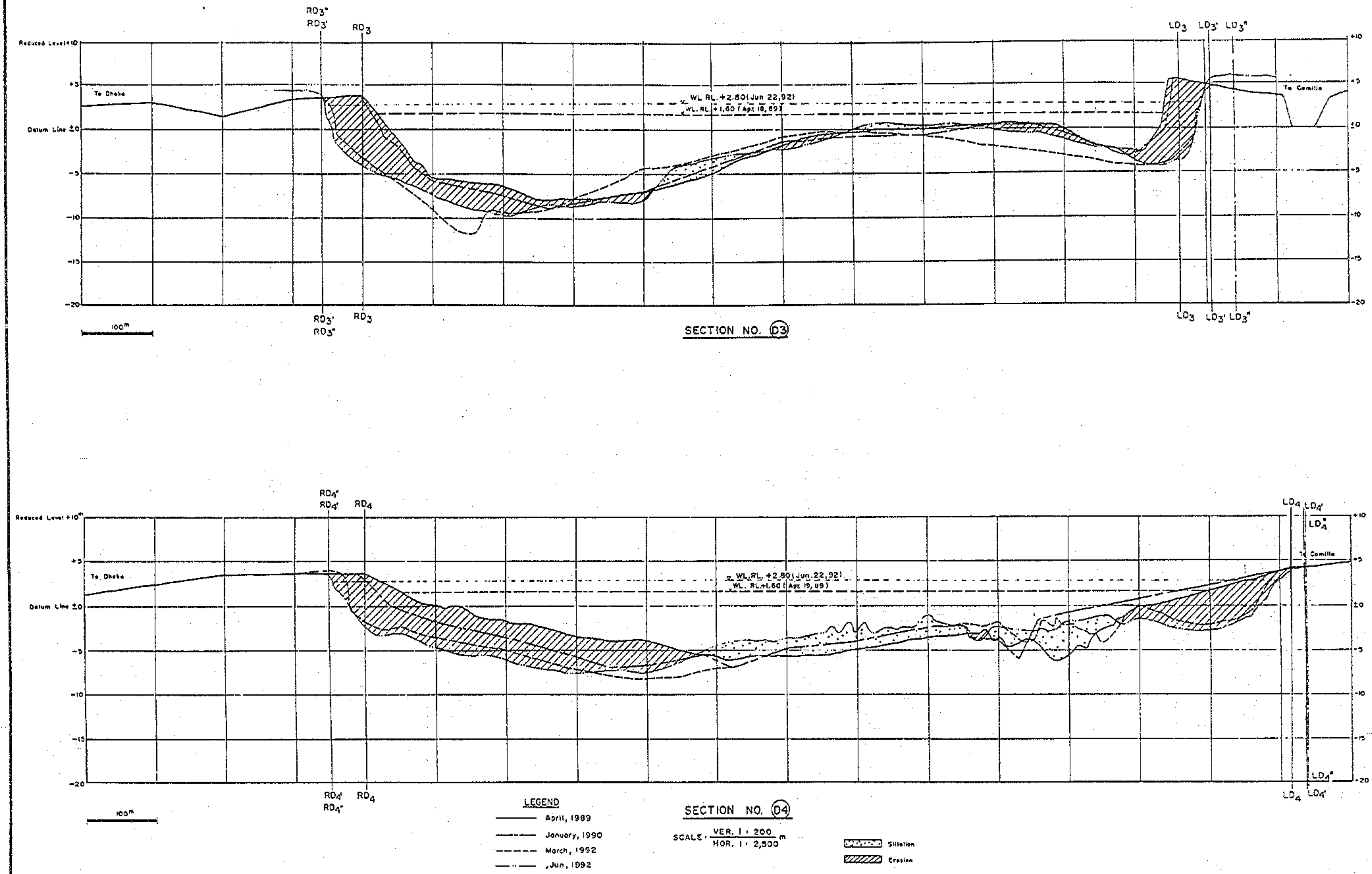


Fig. 5.4 RIVER CROSS SECTIONS (1/7)

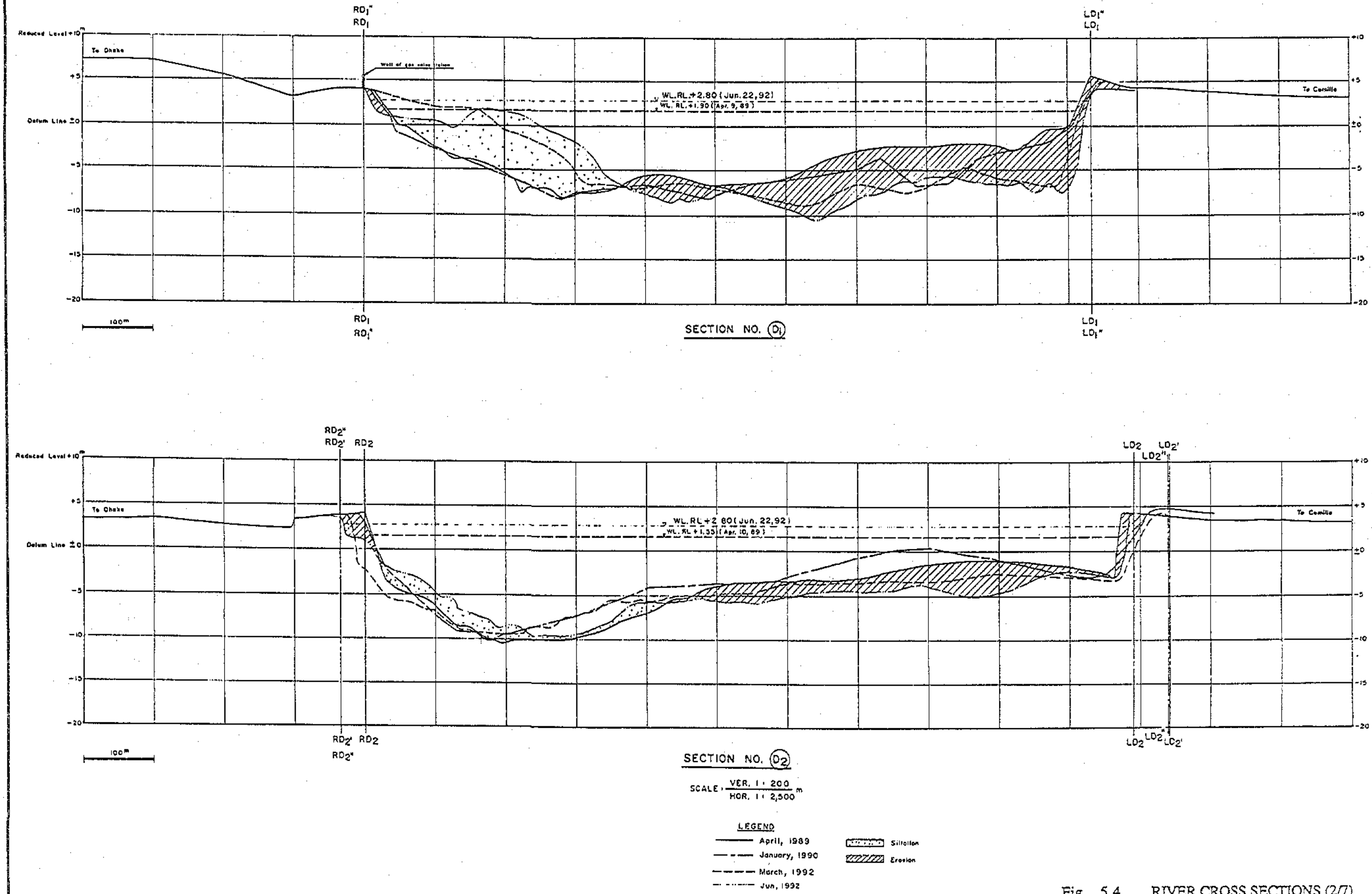


Fig. 5.4 RIVER CROSS SECTIONS (2/7)

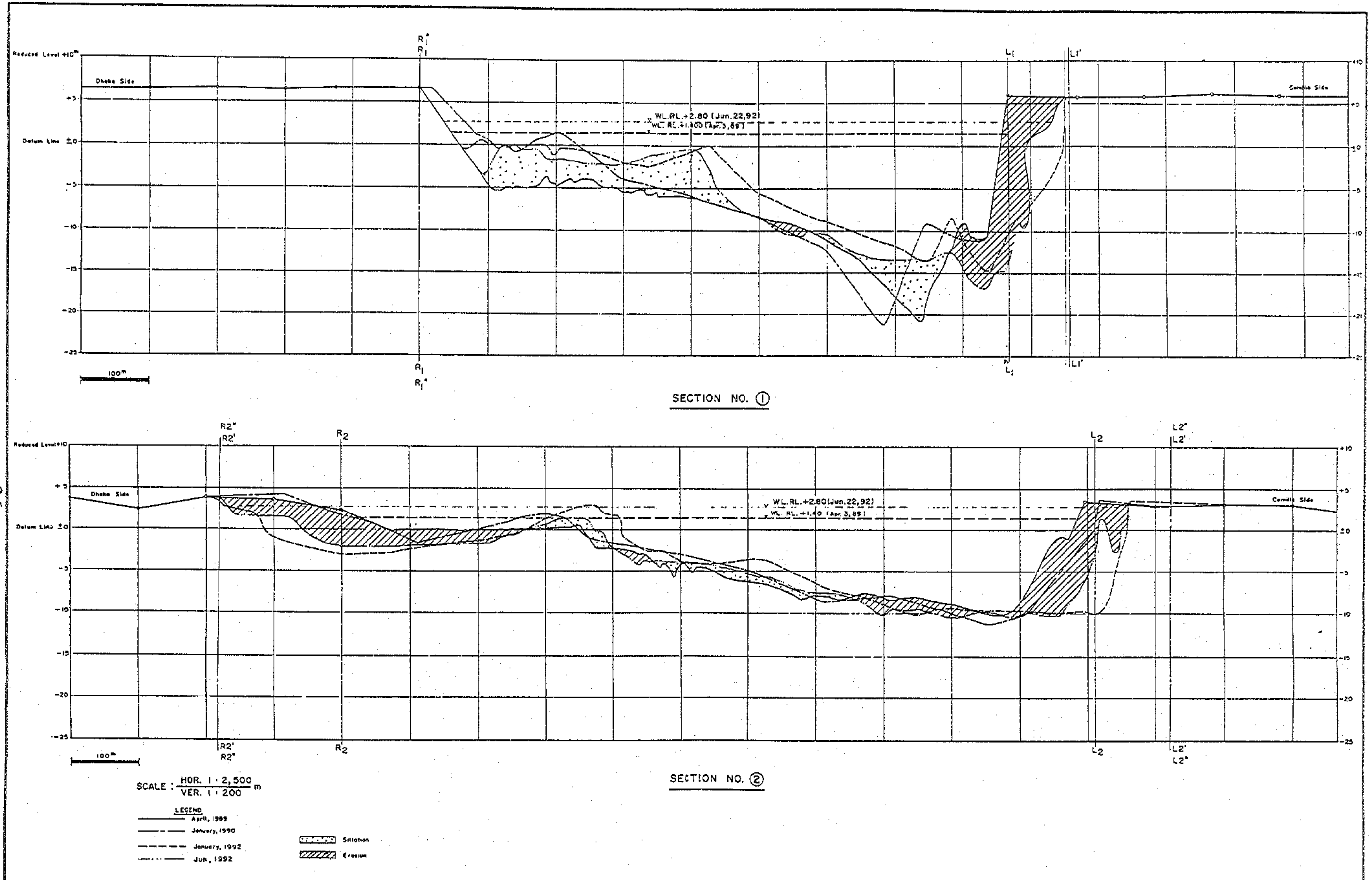


Fig. 5.4 RIVER CROSS SECTIONS (3/7)

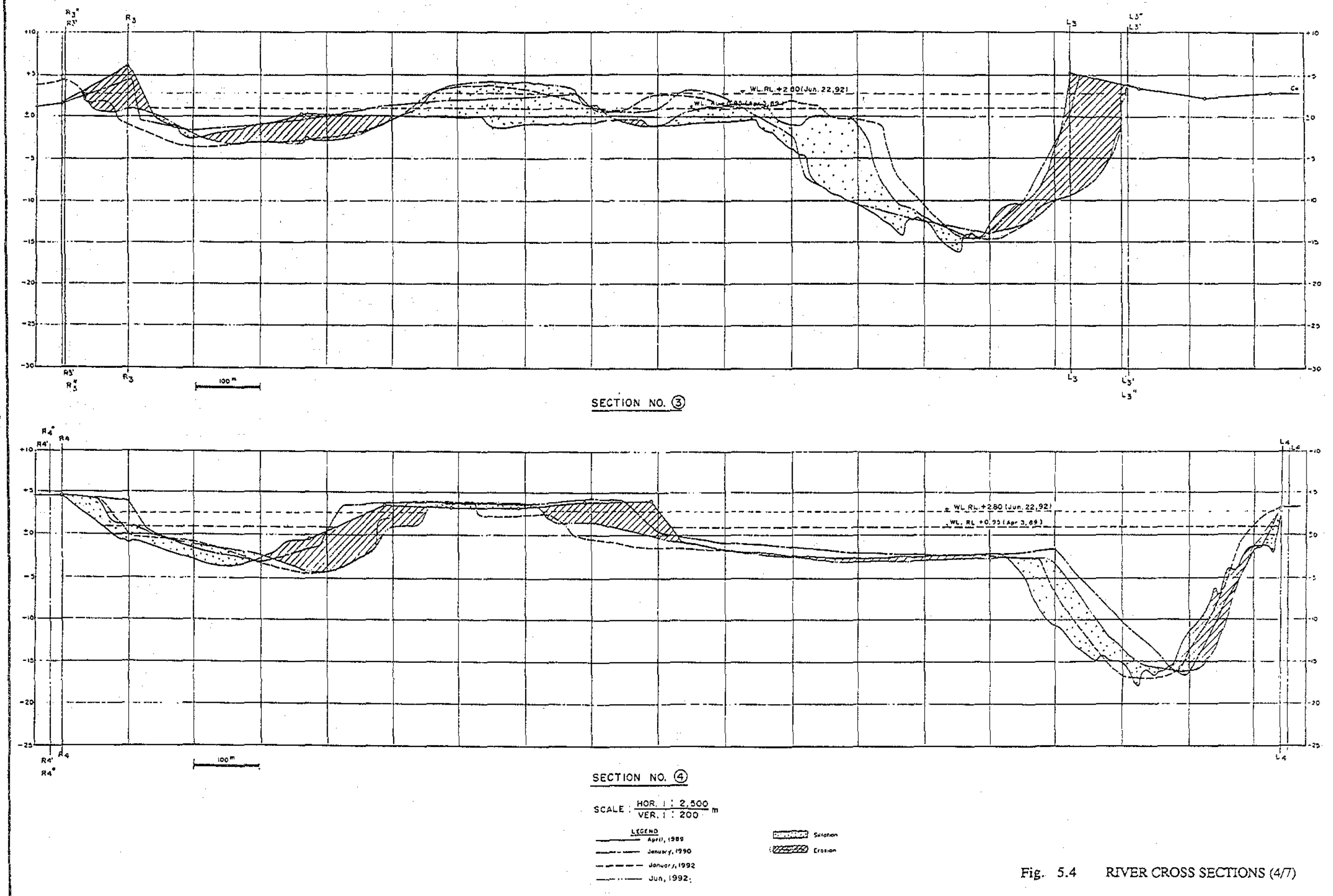


Fig. 5.4 RIVER CROSS SECTIONS (4/7)

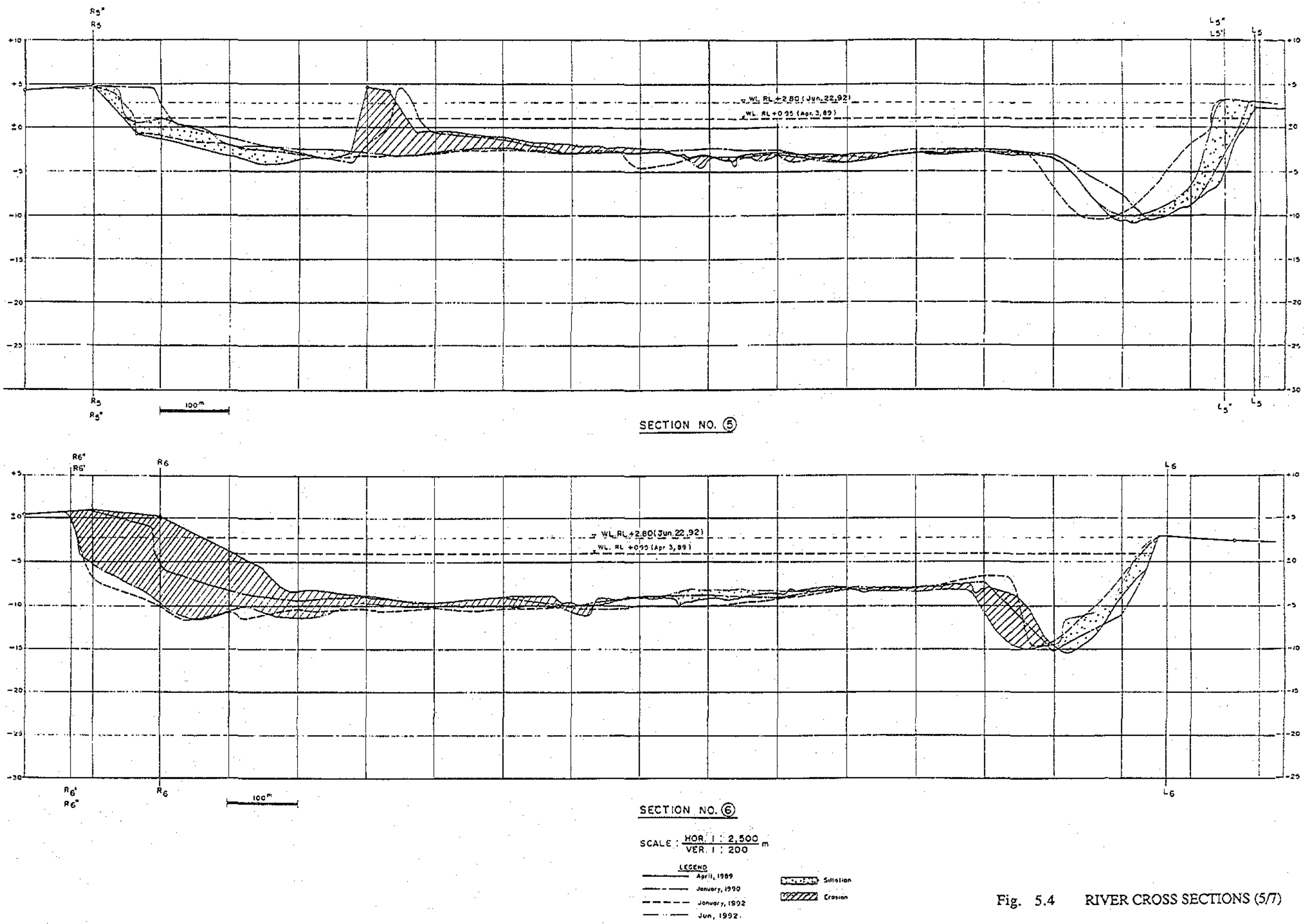


Fig. 5.4 RIVER CROSS SECTIONS (5/7)

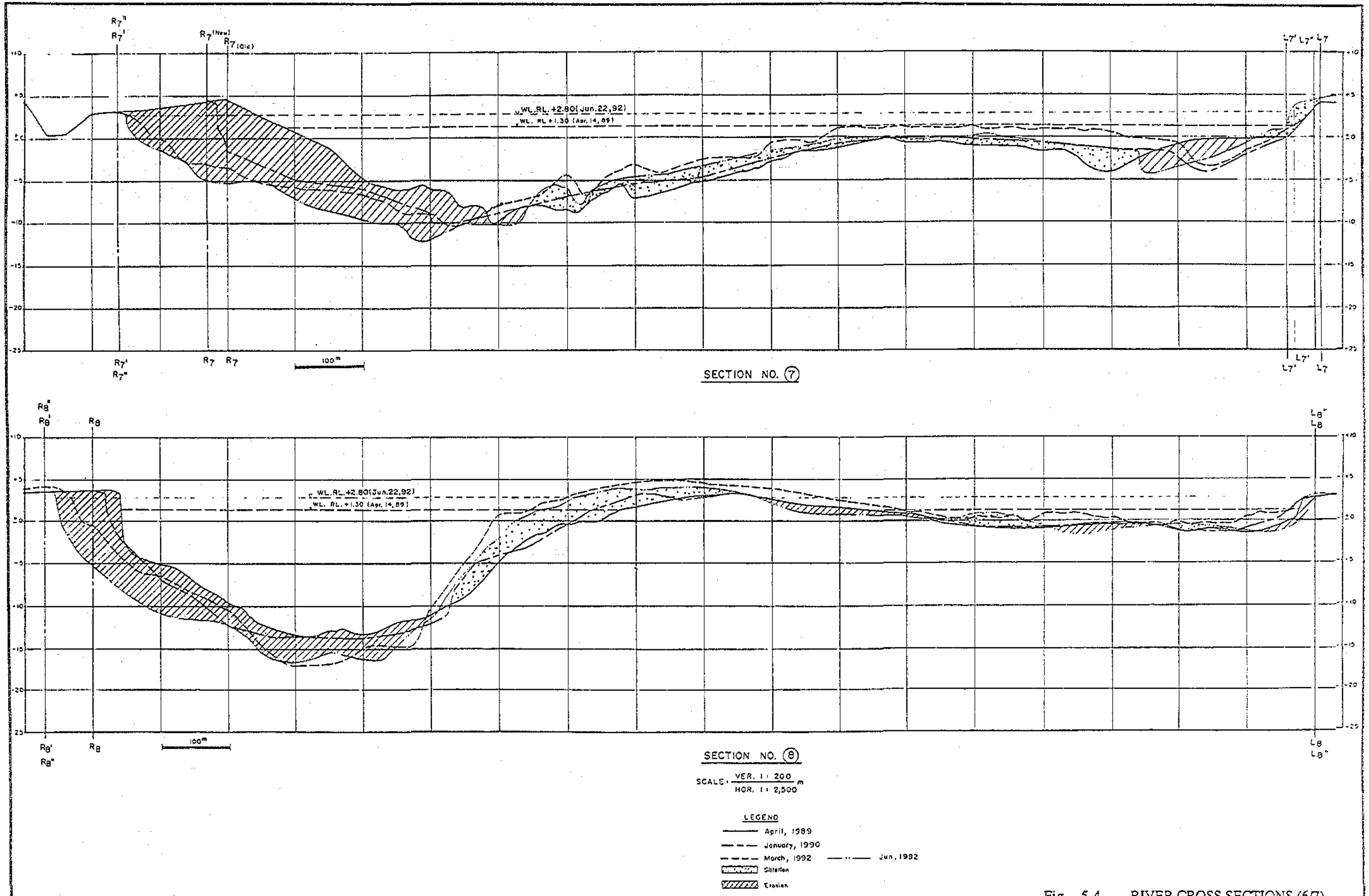


Fig. 5.4 RIVER CROSS SECTIONS (6/7)

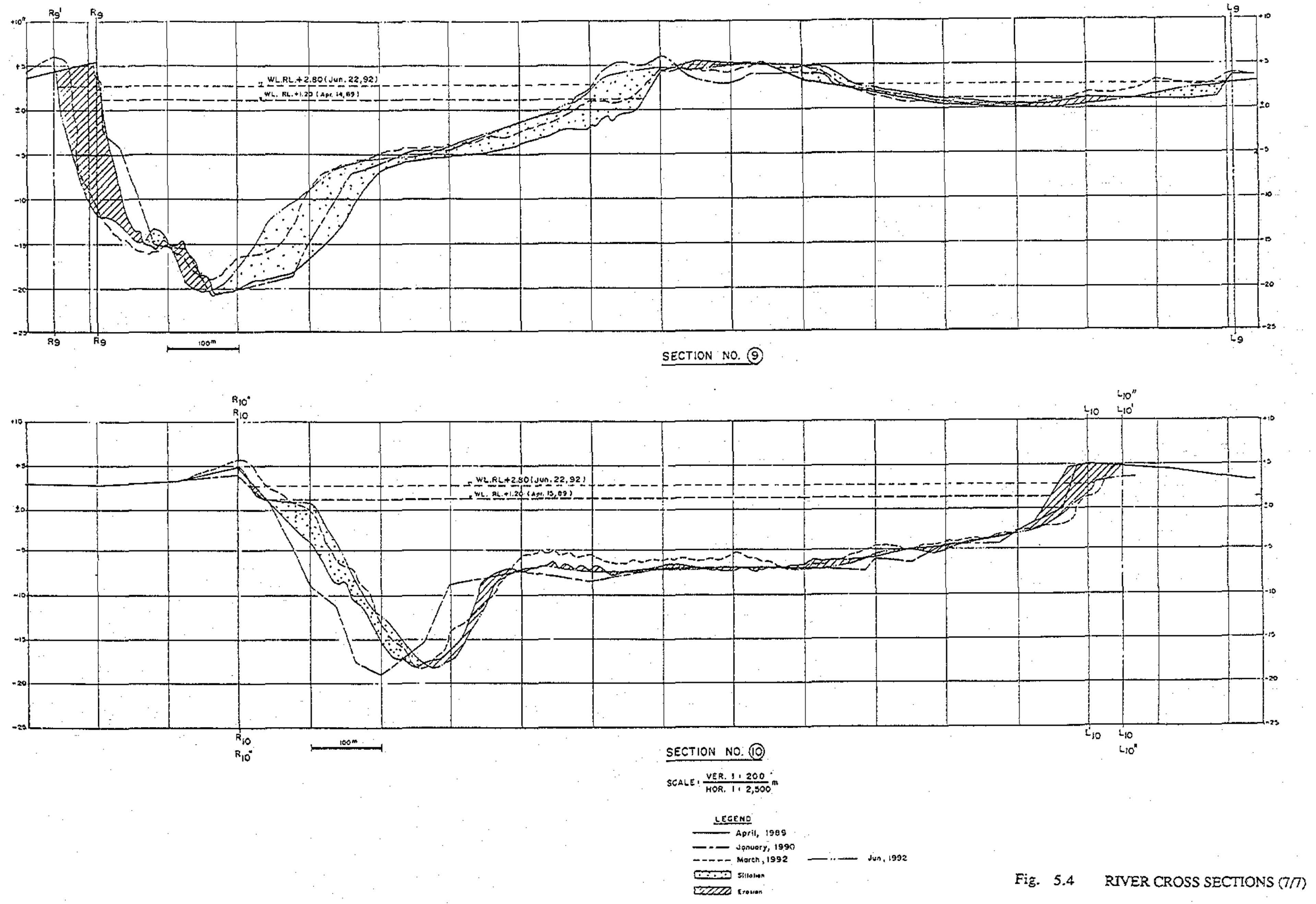


Fig. 5.4 RIVER CROSS SECTIONS (7/7)

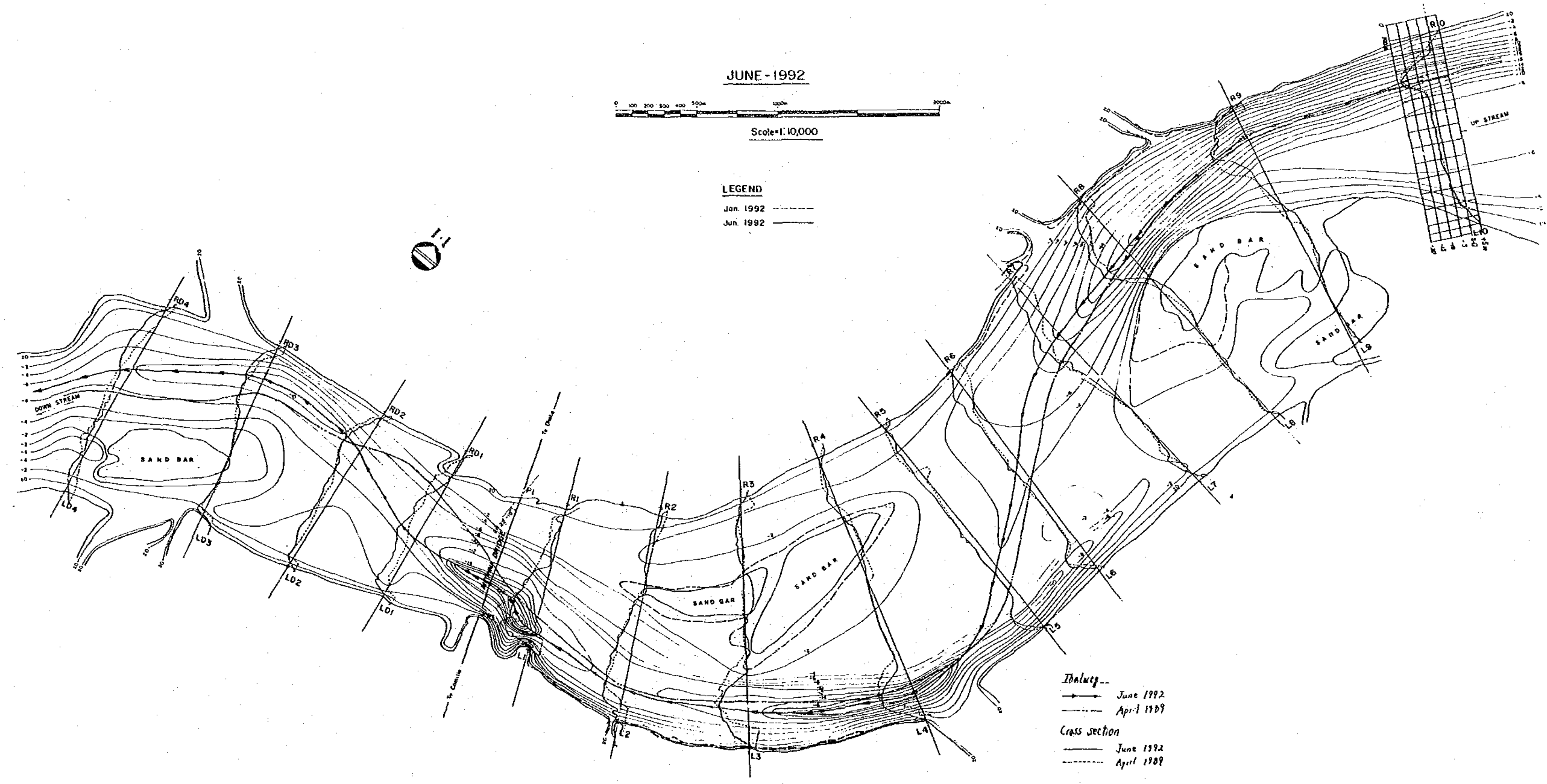


Fig. 5.5 CONTOUR MAP OF RIVER BED NEAR MEGHNA BRIDGE (JUNE 1992)

It is judged that the water colliding front at left bank is shifting downstream. At present, the main current from upstream meets the flow from the Branch Meghna at the confluence. It is deemed that turbulence of flow takes place and is causing local scouring of river bed which has developed along the shoreline.

- From No. U4 to No. U3

  Local scouring, with the maximum depth of R.L. -18 m, has occurred around 200 m from the left bank. The left bank has receded around 80 m since April 1989. As seen in section No. U3, siltation on the left side slope at the deepest point might cause the development of a sand bar near the left bank.

- From No. U3 to No. U2

  Due to the movement of the sand bar, the right bank has seriously receded 60 to 80 m.

- From No. U2 to No. U1

  Almost the same amount of erosion on the right bank is noticed at No. U2 and No. U1. The old ferry ghat near section No. U1 has slid away and the shoulder of the bank has moved around 80 m to June 1992.

- From No. U1 to Meghna Bridge

  Because of the existence of the old ferry ghat and the left abutment, the thalweg has moved toward the center of the Bridge section between Pier No. 7 and Pier No. 8. The deepest point of the river bed R.L. -26 m, between No. U10 and No. D4, was recorded in front of the old ferry ghat.

- From Meghna Bridge to No. D1

  The river bed at the Bridge tends to rise between Pier No. 1 and Pier No. 5. The section between Pier No. 5 and Pier No. 10 has not changed significantly. A significant change of cross section was noticed at No. D1. Heavy scouring with 6 m to 8 m in depth took place on the left side of the channel bed and siltation occurred with around the same magnitude near the right bank.

- From No. D1 to No. D2

  Same tendency as No. D1 is confirmed at No. D2 though at the extent of erosion and deposition is more moderate than that at No. D1.

- From No. D2 to No. D3

  Both banks have receded around 50 to 60 m at No. D3. Siltation on the river bed is minor.

- From No. D3 to No. D4

  Distribution of scouring and siltation along the section No. D4 is similar to that of No. D3. The deepest point of the river bed lowered about 2 m in this stretch.

5.3 Notable Events on Scouring of Bank Protection at Comilla Side of Meghna Bridge

During the construction of the Meghna Bridge, serious scouring occurred on the left bank due to extreme floods in the Meghna River. It is necessary to clarify the specific features of the recession of river bank on the Comilla side adjacent to the old ferry ghat and the movement of the upstream sand bar so that practical countermeasures can be duly planned. In this regard, notable events are chronologically described as follows:

5.3.1 Effect of 1988 Flood

The two successive unprecedented floods in 1987 and 1988 caused severe damages to life and properties throughout the country. Many infrastructure facilities were partially or fully damaged. Following the devastating floods, a preliminary survey was conducted on November 14, 1988 upstream of the Meghna Bridge in order to study the post-flood phenomenon of the Meghna river.

The survey revealed that a new sand bar with an area of about 496,000 m^2 had been formed towards the Dhaka side about 535 m from the Comilla side river bank. Another submerged sand bar was also formed adjacent to the new sand bar covering an approximate area of 1,000,000 m^2. The total volume of silt from these newly created sand bars would be estimated at several million cubic metres. It was confirmed that the river bank of the sand bar shifted about 50 m towards the Comilla side due to scouring in the Meghna river.

Besides, an inundated sand bar appeared adjacent the ferry ghat upstream of Dhaka and downstream of Pier No. 10 of the Meghna Bridge.

5.3.2 Scouring and Landslide in Late 1989

After two successive devastating floods, the year 1989 passed without any significant flooding. But there were other problems which are concerned to the safety of the Meghna Bridge in particular. Due to the expansion of the sand bars near the Bridge site, the course of the river was deflected and the flow directly hit the river bank on the Comilla side near the Bridge site.

On December 30, 1989 there were severe landslides along the left bank of the Meghna River which caused extensive damage to the upstream side of the Meghna Bridge. The erosion demolished all the ferry ghats and pontoons, which was causing a serious disruption to vehicular traffic. A big scour pool, about 200 m away from the front of the ferry ghat, was also formed. This incident formed a small bay between the ferry ghat and the Bridge. Hence, the original alignment of bank protection surrounding the abutment at the Comilla side was obliged to be modified to protect the shoreline.

5.3.3. Scouring in 1991

Construction of the Meghna Bridge and approach road was completed in June 1990 and the revetment at the Comilla side was inaugurated in February 1991.

To obtain an idea of the erosion and scouring that are likely to occur on the Comilla side of the Bridge, river surveys were carried out in December 23, 1990, August 10, 1991 and in October 24, 1991. It is observed from a comparison of the survey data of December 1990 with that of August & October 1991 that significant erosion of the river bank and scouring of the bed is occurring towards the Comilla side of the Meghna Bridge. The extent of erosion is more severe near the old ferry ghat and adjacent downstream areas.

It has become apparent that the flow pattern of the Meghna River is changing due to the presence of a sand bar upstream which has been expanded since its creation. This tendency is confirmed in Section 5.2.3. The flow appears to first hit the old ferry ghat and subsequently the adjacent downstream areas causing the formation of vortex. This phenomenon is causing a serious scouring problem on the Comilla side of the Meghna River upstream of the Bridge.

5.3.4 Collapse of Revetment at Comilla Side in 1991

The revetment, constructed of geotextile form concrete, adjacent to abutment at the Comilla side partly collapsed due to erosion at the toe on October 19th and 20th, 1991. The incident occurred 8 months after its completion.

Around 195 m which is 38% of the total horizontal length of the revetment collapsed and slid down. Steel sheet piles driven up to 9 m to 18 m deep for toe protection have leaned over due to absence of earth pressure. The feature of collapse of the revetment is shown in Fig. 5.6 and its photographs are attached in this Report.

As seen in Fig. 5.6, the gabion mattress has crumbled down in front of the steel sheet piles. But sliding of the gabion toward the channel center is not significant. It is judged that its deformation was caused by erosion. Most serious erosion along the revetment took place near Section 9-9 in Fig. 5.6.

At present, the gabion mattress and cylinder are being placed on the surface of the collapsed portion by RHD to prevent further erosion of the bank material.

5.4 Local Scouring near Old Ferry Ghat

Contour lines of the scour pool prepared by past surveys in front of the ferry ghat are comparatively shown in Fig. 5.7. A profile of the deepest portion of the pool is presented in Fig. 5.8. Further, a contour map surveyed during the field investigation stage of the Meghna Bridge Construction Project in 1984 is presented in Fig. 5.9.

Based on the figures, the findings are described as follows:

(1) The deepest points in the scour pool measured in November 1988 and June 1989 are R.L. -22 m and R.L. -30 m, respectively. After the survey in November 1988, the bed has been eroded around 8 m by scouring within one year.

(2) According to the water level records at the Meghna River (Fig. 4.6), the magnitude of flood in 1989 is less than that observed in 1987 and 1988. Therefore, it is deemed that much scouring of the river bed may take place because of the frequent floods which are likely to recur yearly if the present status remains.

(3) As recession of the shoreline at the old ferry ghat proceeds, the deepest point in the scour pool moved nearer to the left bank. In this sense, it can be presumed that occurrence of the deep scouring is closely connected with existence of the ferry ghat.

(4) The deep scour, R.L. -30 m, was confirmed in November 1989. One month after the survey, a large scale landslide occurred and a small bay was created. It can be judged that the sliding is primarily caused by deep scouring which has produced the steep slopes of 13 degree, at the deepest portions. On the same day when the incident happened, the water level and flow velocity recorded were R.L. 1.20 m and 0.40 m/sec at the Meghna Bridge. Drawdown speed of the water level was around 5 cm/day between Dec. 13 and Dec. 30, 1989.

5.5 River Bed Condition at Meghna Bridge

When the topographic survey works were conducted in June and in September 1992, a cross section at the axis of the Bridge was obtained for the purpose of checking the stability of the bridge piers. Three measured lines in July 1990, June 1992 and September 1992 are shown in Fig. 5.10. Aside from the three lines, a dotted line indicates the section crossing the footing of piers. It can be judged that the shape of the mound surrounding the piers may be the remains of the stone protection which was placed after the construction of the Bridge.

As far as the profile is concerned, any unfavorable phenomenon such as abnormal bed erosion, that might deteriorate safety of the piers, is not predicted at present. However, to ensure further safety against erosion at the Pier No. P6, P7, P8 and P9, additional stone dumping is recommended.

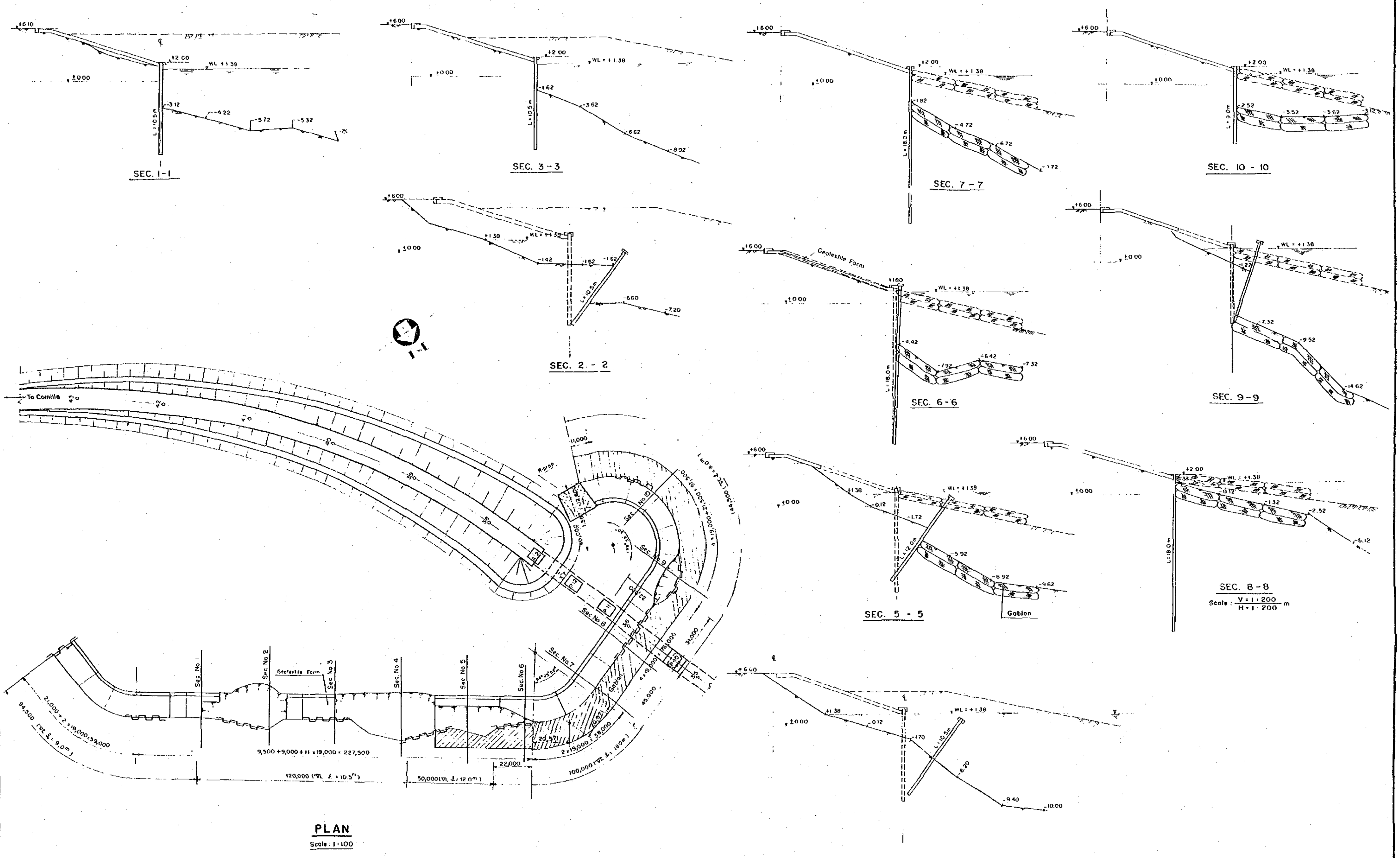


Fig. 5.6 FEATURE OF SCOURING OF BANK PROTECTION AT COMILLA SIDE

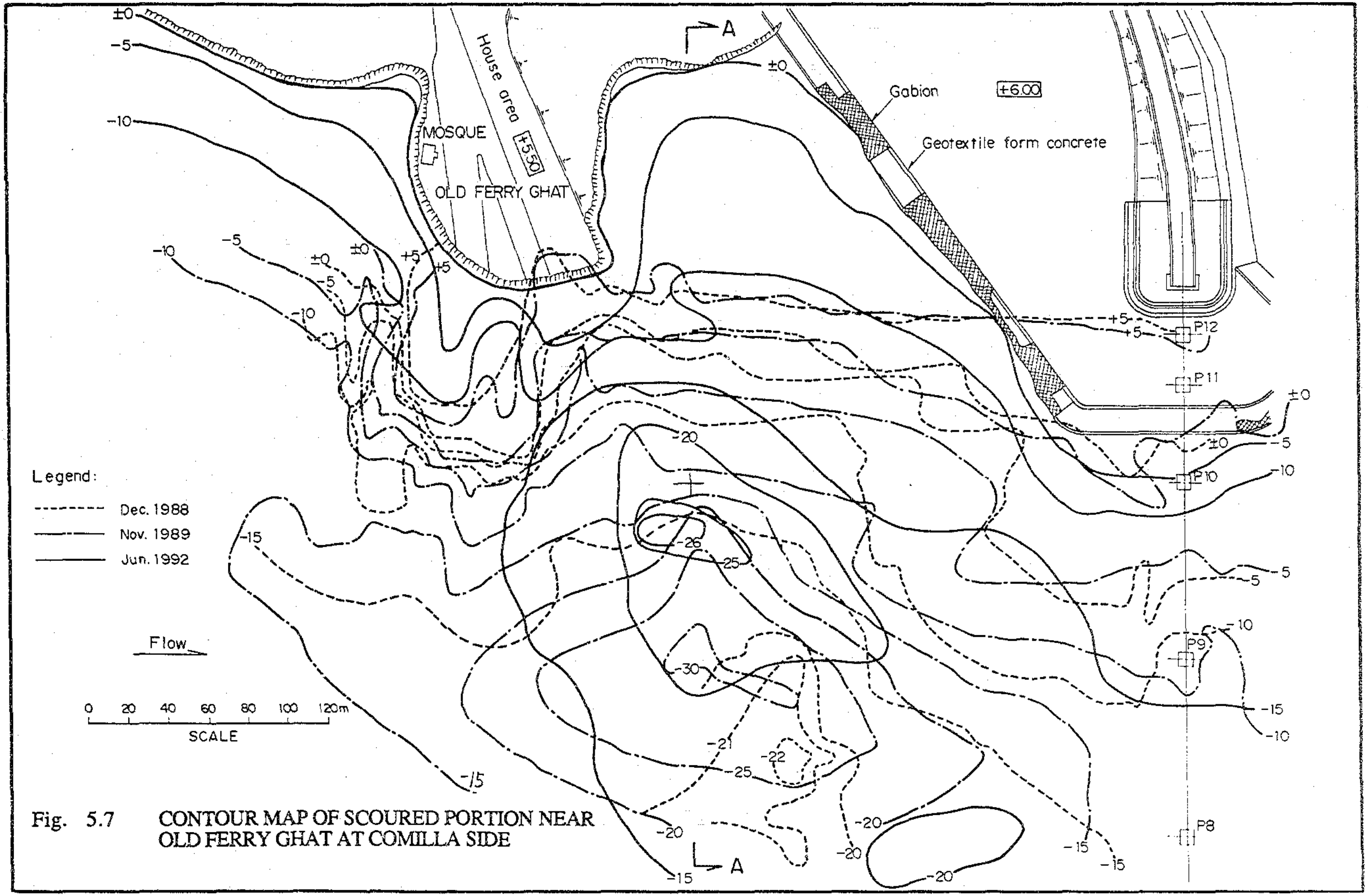


Fig. 5.7 CONTOUR MAP OF SCOURED PORTION NEAR OLD FERRY GHAT AT COMILLA SIDE

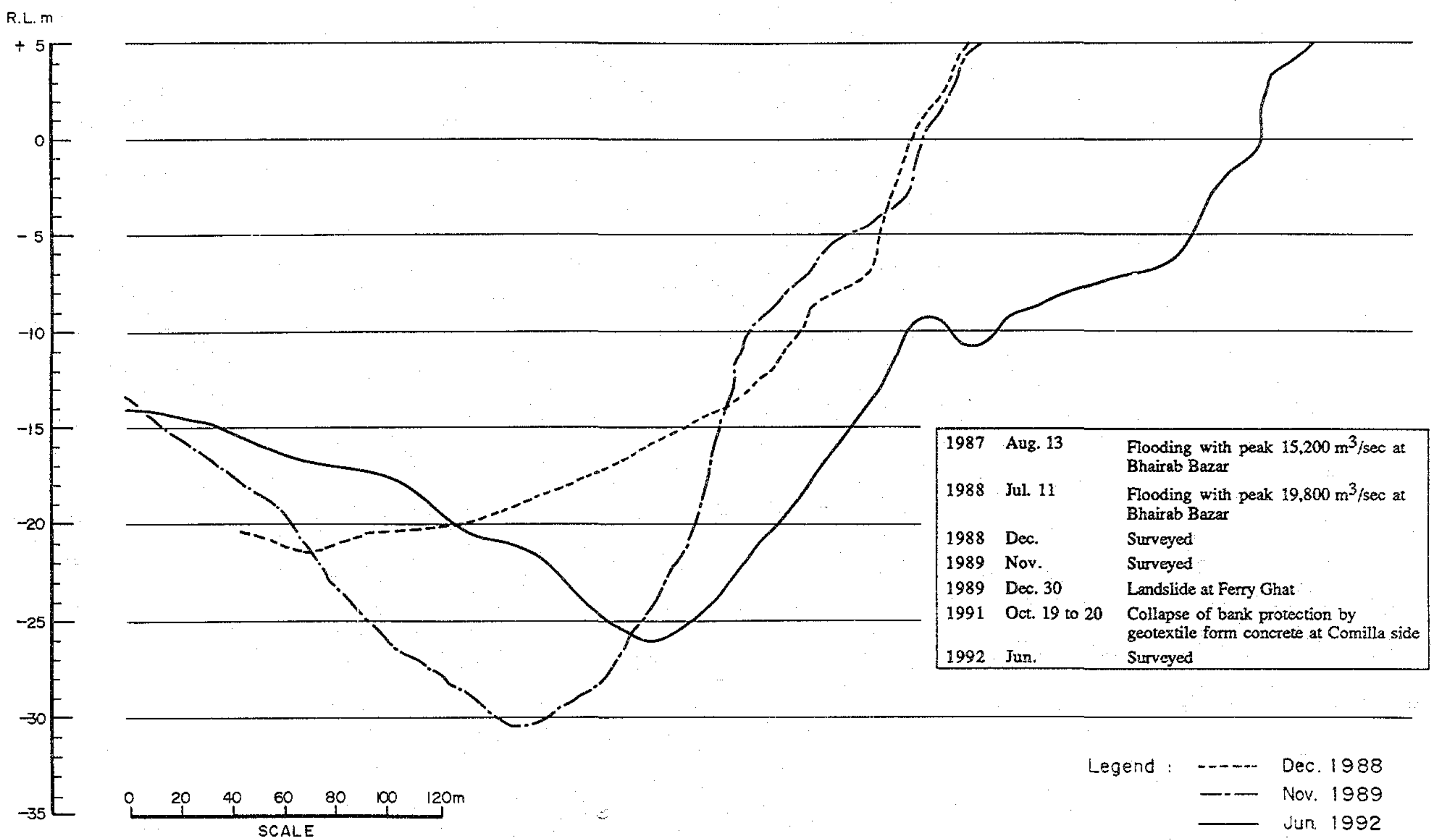


Fig. 5.8 PROFILE OF DEEPEST SCOURED PORTION NEAR MEGHNA BRIDGE (SECTION A-A)

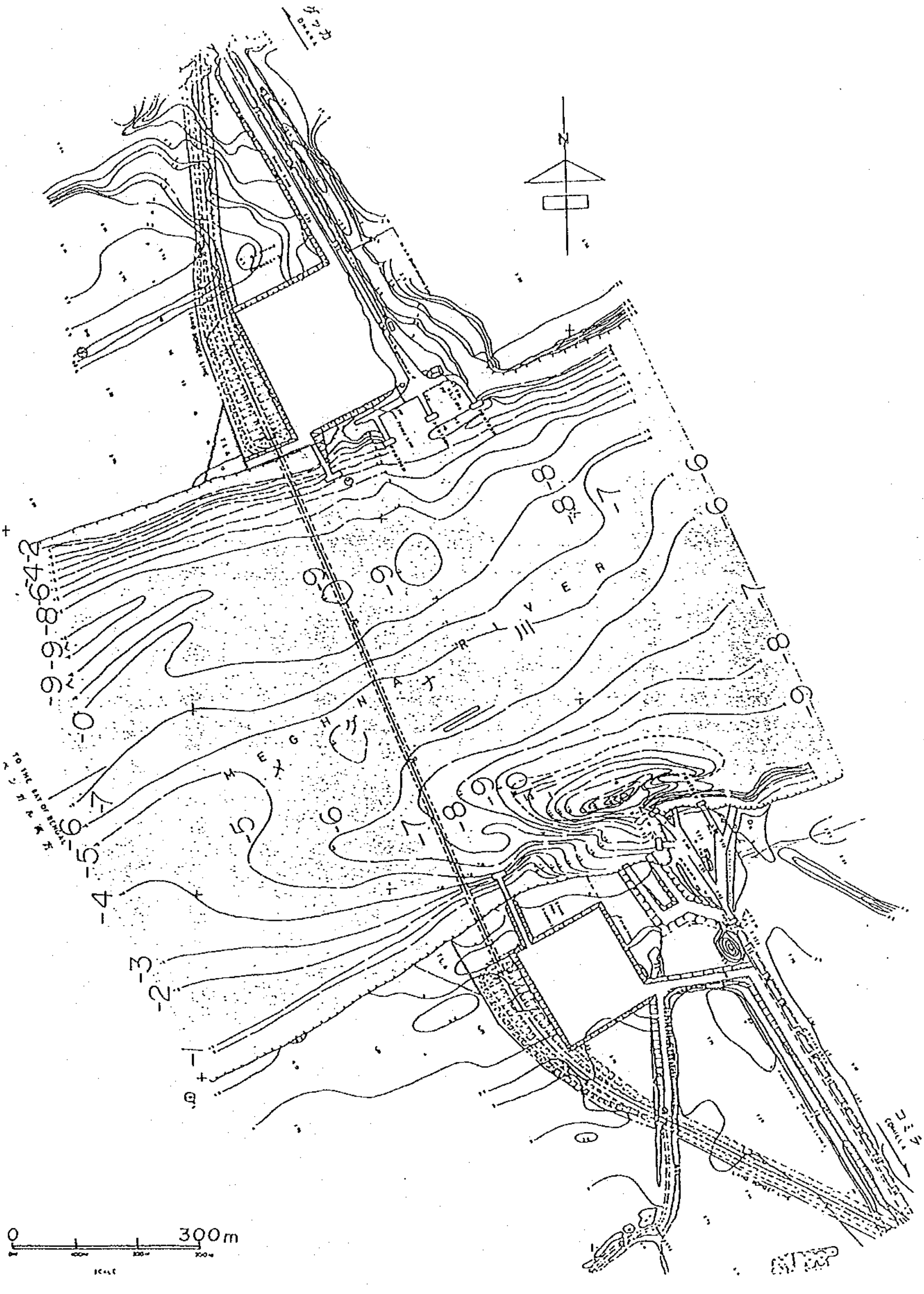


Fig. 5.9 CONTOUR MAP NEAR OLD FERRY GHAT (YEAR 1984)

5.6 Grain Size Distribution of Material at River Bank, River Bed and Sand Bar

Sampling and analysis of soil material at the river bank, river bed and sand bar upstream of the Meghna Bridge were conducted as well as the river survey in April 1989. The results of analysis are presented in "Study Report on Scouring of River Bank near Meghna Bridge, August 1989 (written in Japanese)".

Sampling at the river bank was made at five locations, and four samples (on bank, at brink, on slope under water and at bed) were taken at each location. Six samples were taken on the sand bar; samples No. S4 to S6 are material silted by the flood in 1988. Location of sampling is shown in Fig. 5.11 and grain size distribution curves are presented in Fig. 5.12. Further, relationship between d50 and $\sqrt{d84/d16}$ is shown in Fig. 5.13.

The study has pointed out the following characteristic features of grain size distribution of the obtained samples.

(1) Overall grain size distribution of all samples at river bed and bank is as below:

Maximum size	:	dm = 0.2 ~ 0.3 mm
Medium size	:	d50 = 0.021 ~ 0.192 mm (average 0.096 mm)
Index of variance	:	$\sqrt{d84/d16}$ = 1.33 ~ 6.07 (average 2.56)
Specific gravity	:	Gs = 2.65 ~ 2.78 (average 2.73)

(2) As for the samples taken on the river bank, 60% are smaller than d = 0.075 mm as seen in the distribution curves of No. C1, No. C5, and No. C9. It is assumed that the wash load is considerably contaminated. However, this is not the case for the samples taken on the right side of the river bank (D1 and D5).

(3) The percentage of grains, on the river bed, smaller than d = 0.075 mm is under 30% except No. C4 and No. C8, and the range of distribution is narrow with d50 = 0.1 ~ 0.2 mm and $\sqrt{d84/d16} < 2$.

(4) The distribution curves for the samples at the brink and on the slope show intermediate features between the ones for the river bank and bed.

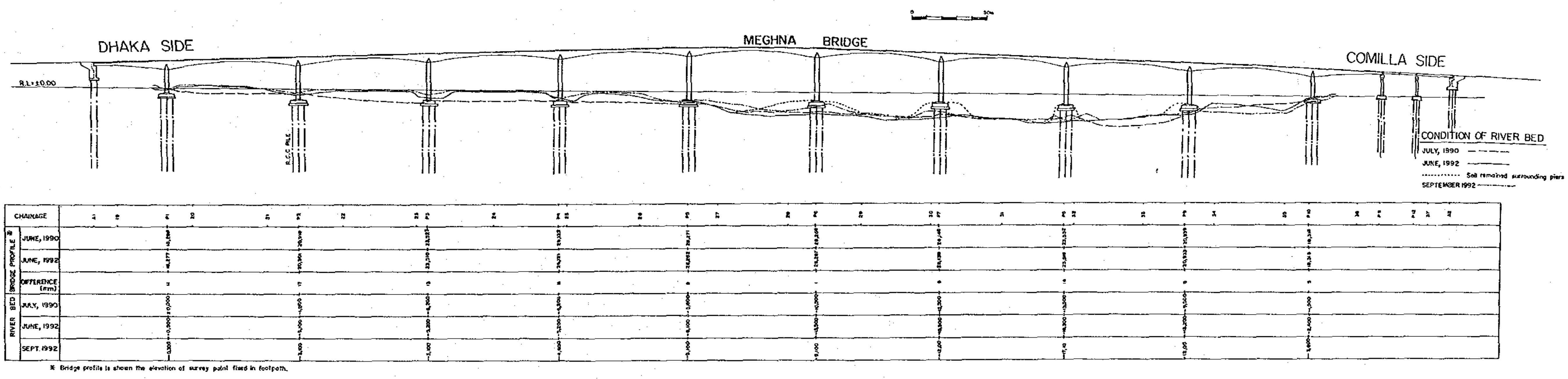


Fig. 5.10 PROFILE OF MEGHNA BRIDGE (JUNE 1992)

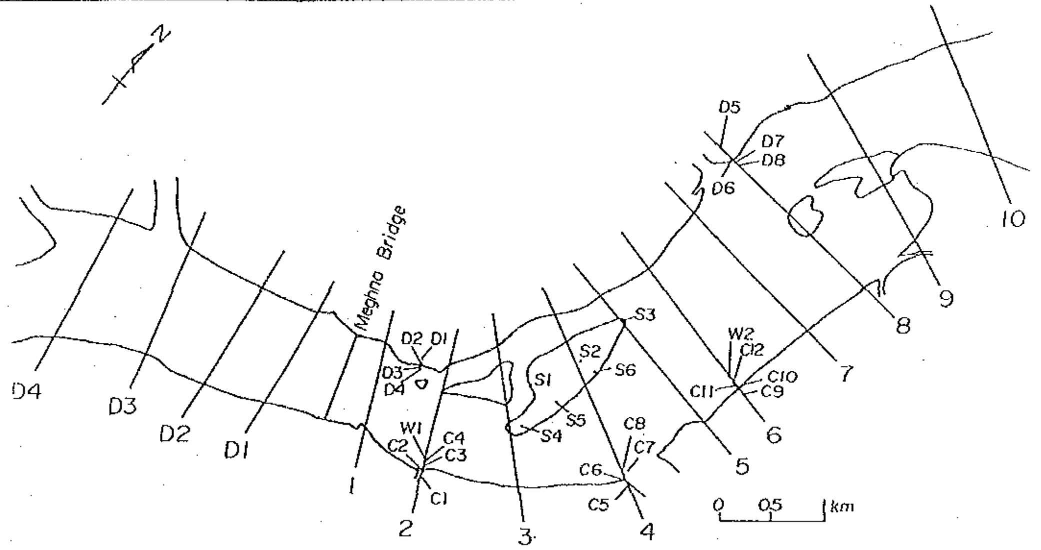
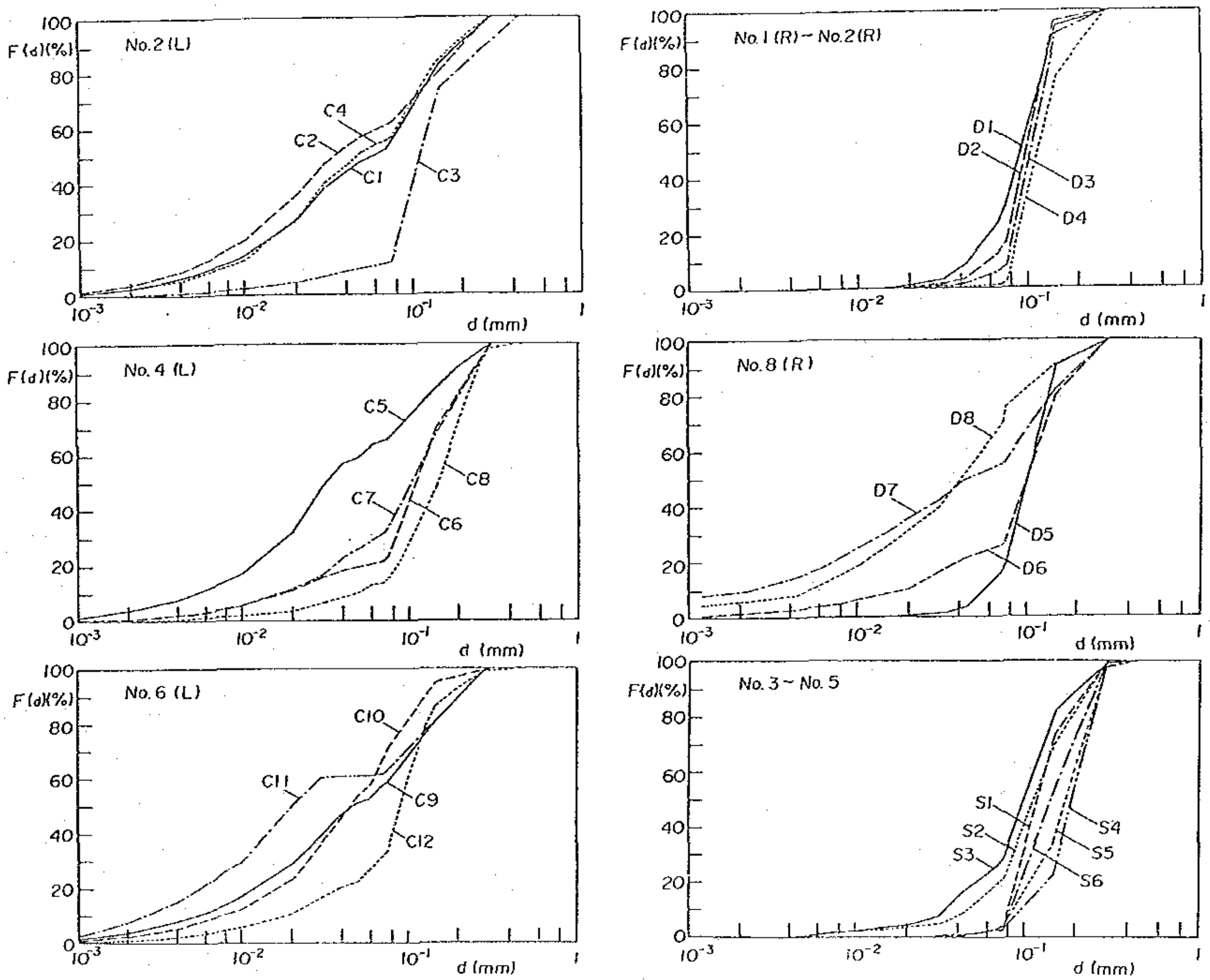


Fig. 5.11 LOCATION MAP OF SAMPLING



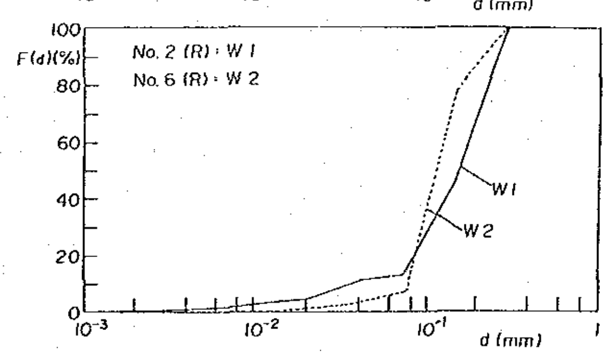


Fig. 5.12 GRAIN SIZE DISTRIBUTION OF SAMPLES

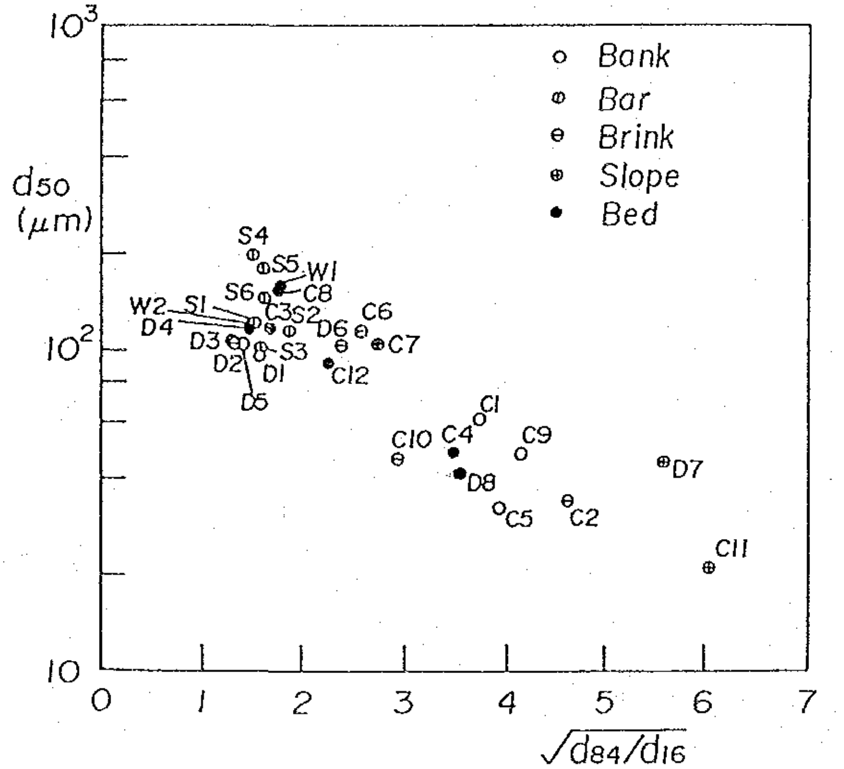


Fig. 5.13 RELATIONSHIP BETWEEN d50 and $\sqrt{d84/d16}$