5.6 Site Geology and Characteristics of Riverbed Material

5.6.1 Site Geology and Outlook

The low lying flood plain where the Meghna bridge is located has a deep alluvial deposit transported by the Ganges and Jamuna rivers, which is characterised by the absence of solid layer beneath it. From the geological point of view, it can be said that the river bank and sand bar have a relatively high content of silt and clay, but in general, the river channel is formed by uniform and fine sand.

5.6.2 On-site Borings

(1) Past survey

The borings carried out during the surveys up to the present are as follows:

- In the period of the Feasibility Study, March 1985
  - 9 holes, average 40 m deep, total 360 m
  - 4 holes (for design of foundation), average 70 m deep, total 280 m
- In the period of the Detailed Design, March 1986
  - 8 holes (for design of foundation), average 60 m deep, total 480 m
  - 22 holes (for access road and construction material), average 10 m deep, total 280 m
- In the period of Basic Design, November 1993
  - 2 holes, average 40 m deep total 80 m

(2) Survey in April 1997

A survey by drilling at 3 sites (ave. 30 m deep, 90 m in total) was conducted to study the relationship between soil mechanical characteristics and slope stability of the revetment. Location of borings is shown in Fig. 5.6.1. Ground water levels in the drilled holes were measured from May to August 1997 and the results are shown in Fig. 5.6.2. The boring logs and geological profile of the bridge axis are illustrated in Fig. 5.6.3.

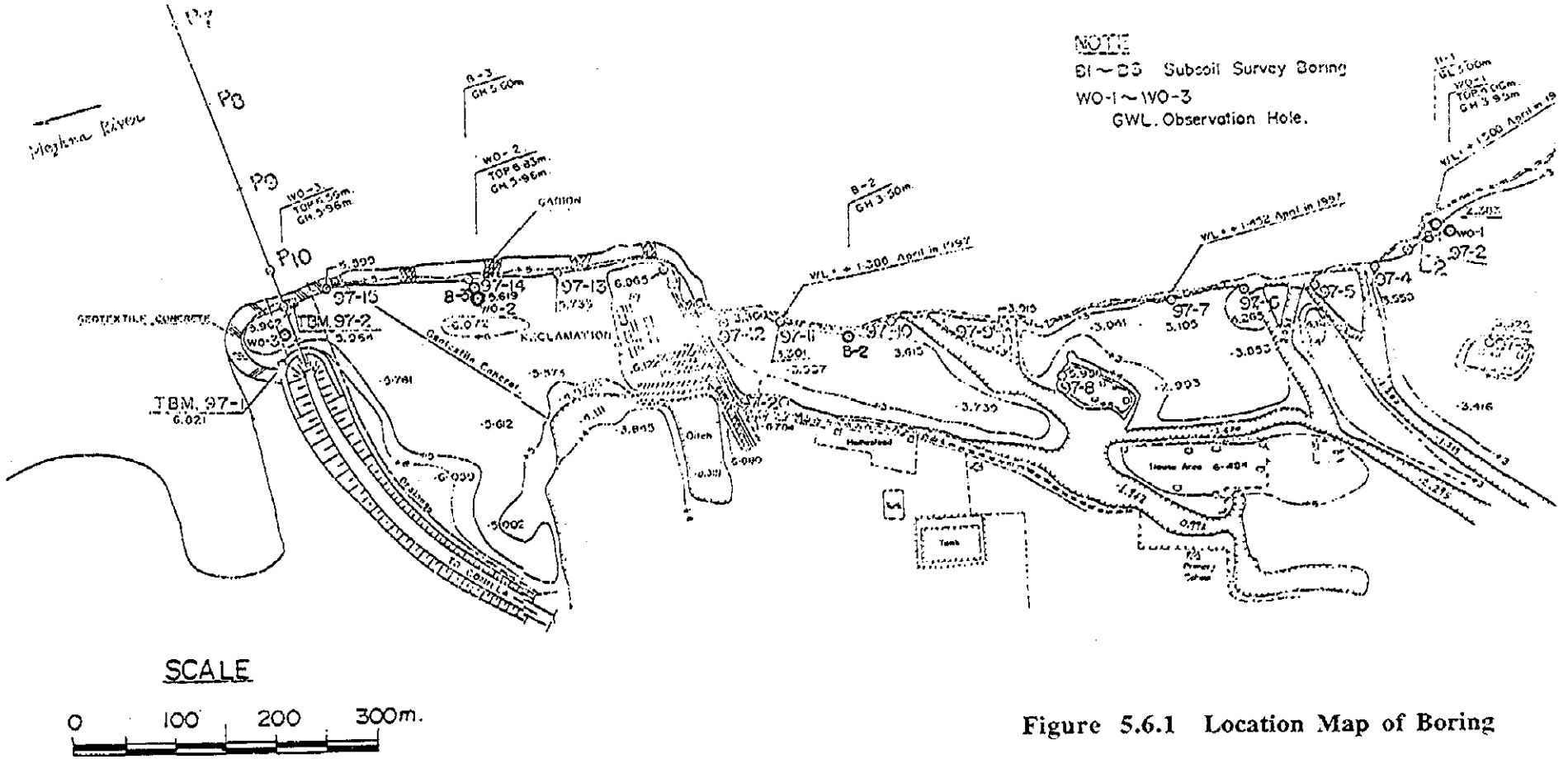


Figure 5.6.1 Location Map of Boring

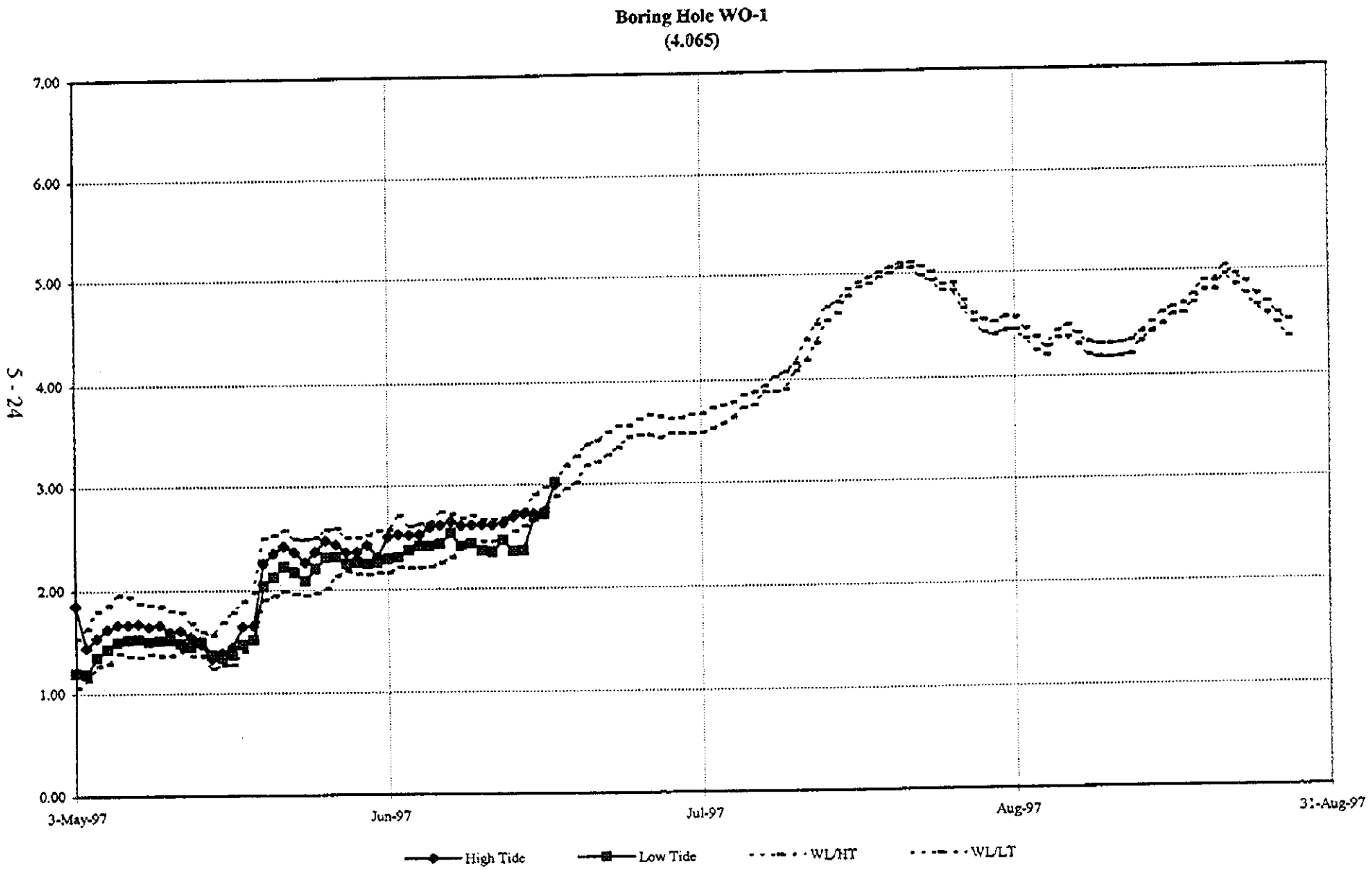


Figure 5.6.2 Record of Ground Water Levels (1/3)

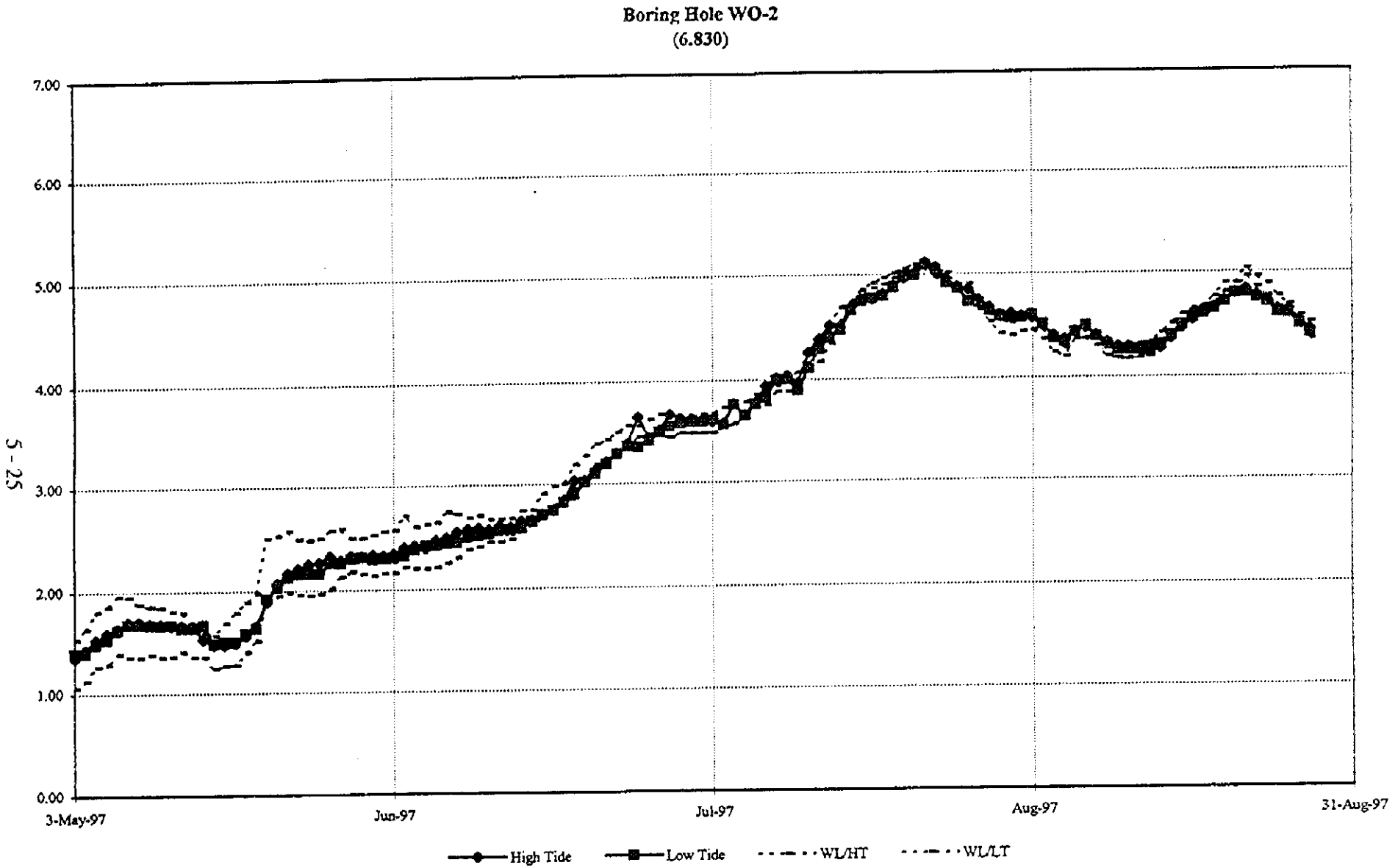


Figure 5.6.2 Record of Ground Water Levels (2/3)

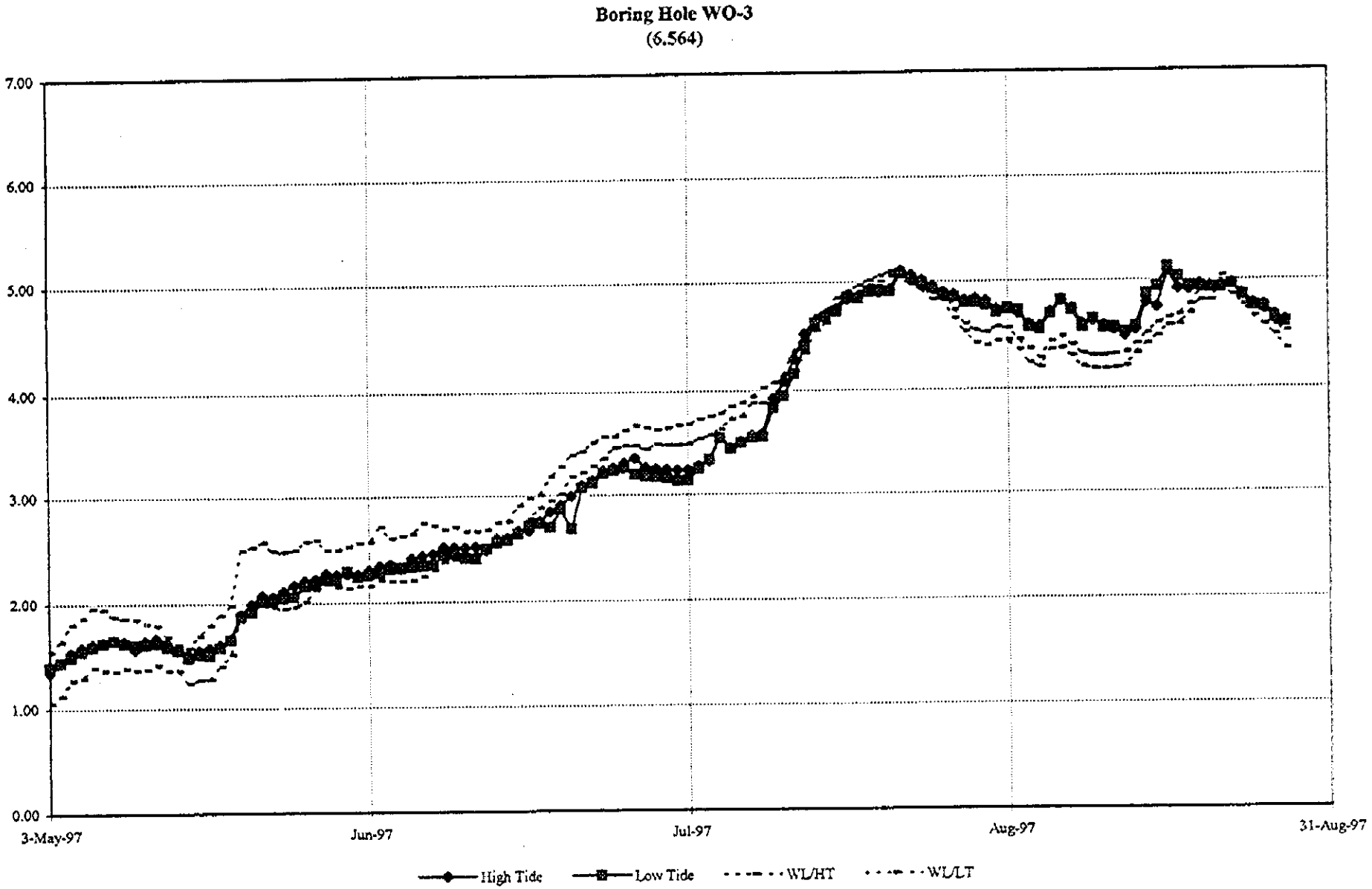
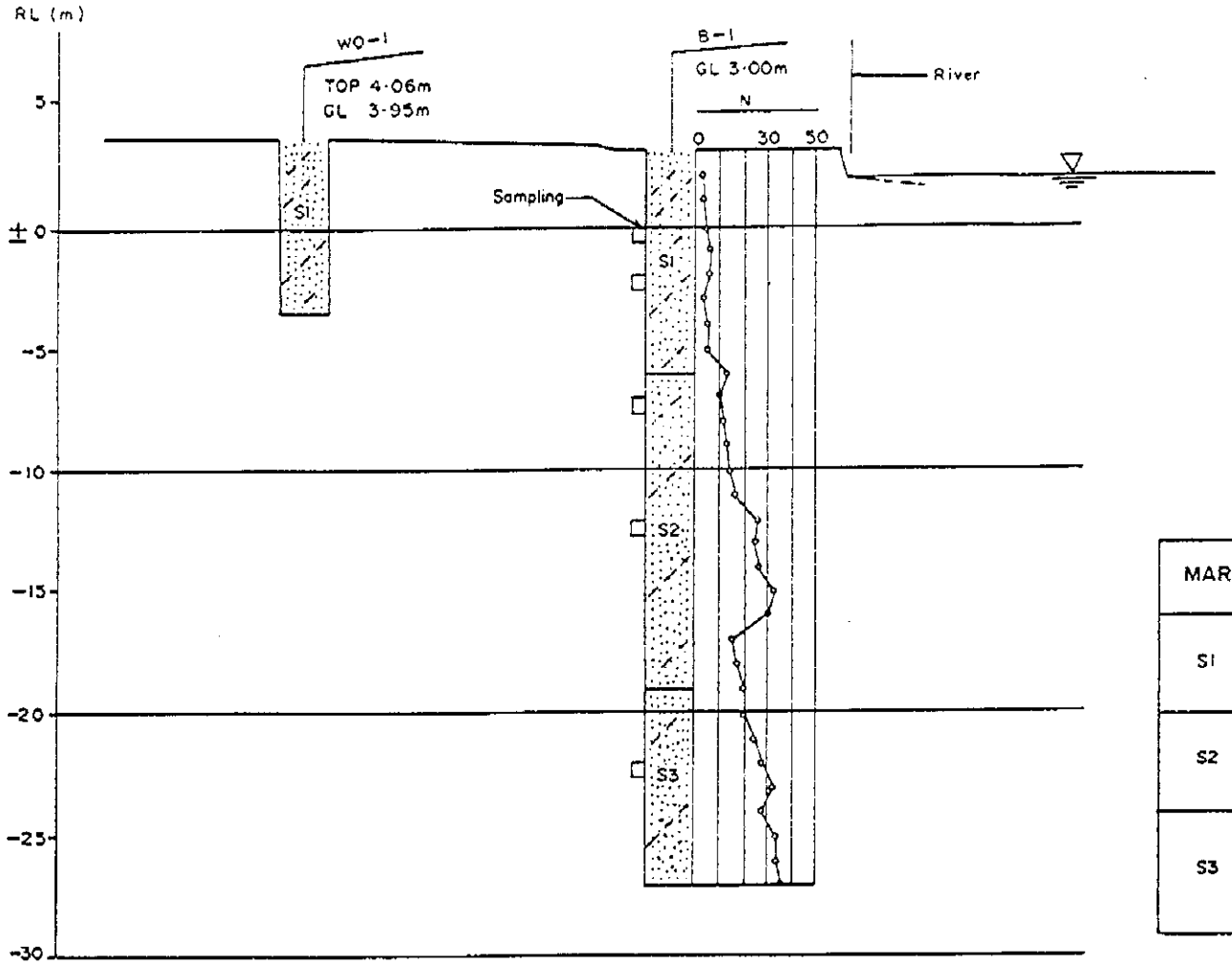


Figure 5.6.2 Record of Ground Water Levels (3/3)



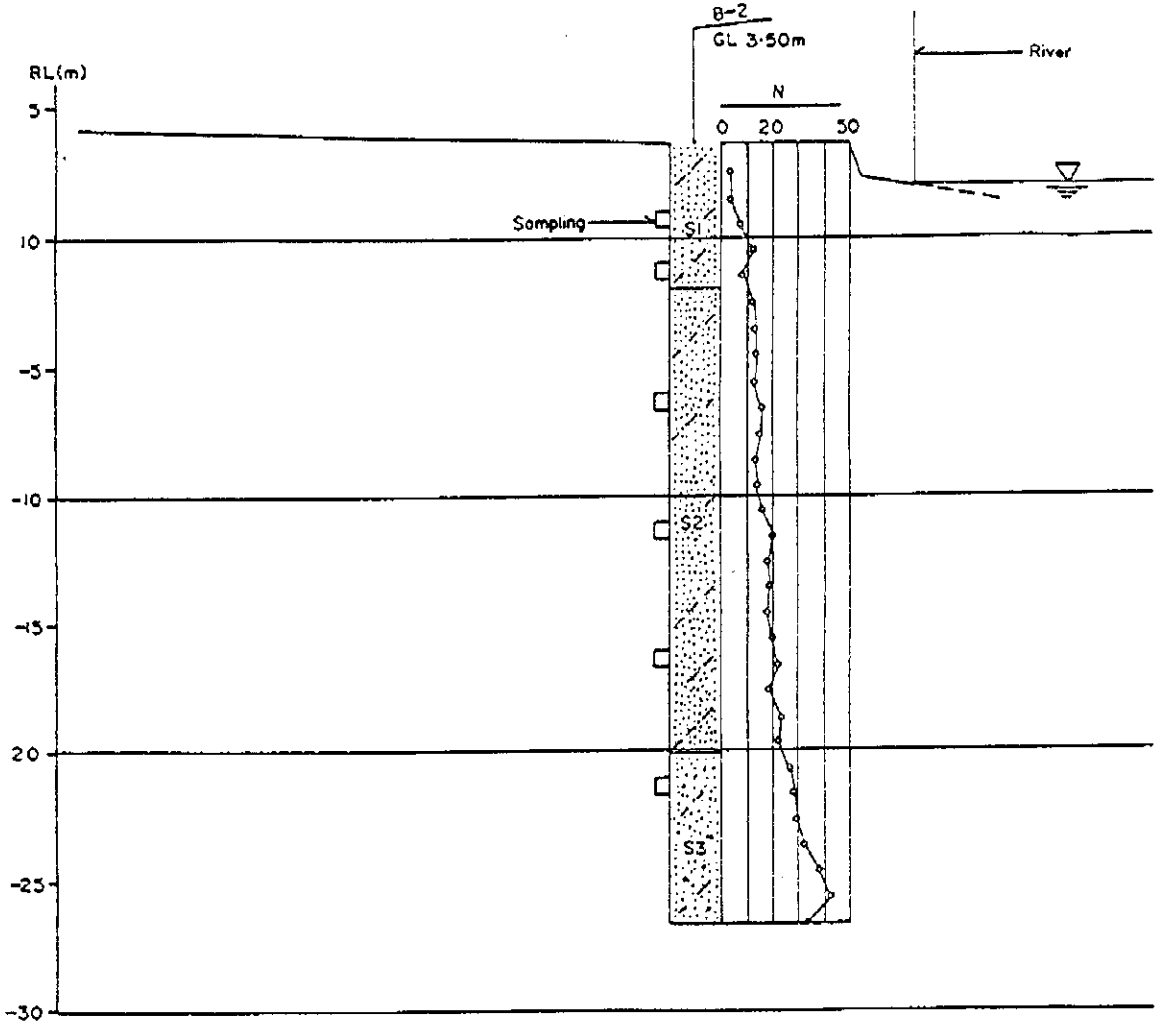
LEGEND

MARK	SOIL – TYPE	N (S.P.T.)	CHARACTER
S1	Fine SAND	2~8 Ave: 5	Very Fine Loose Silt a little
S2	Fine SAND	10~30 Ave: 20	Contains Silt medium grains Scatter
S3	Fine to Medium SAND	20~35 Ave: 27	Medium grains increase Fairly Firm

Figure 5.6.3 Boring Log (1/5)

Note: WO – Boring Hole for G.W.L. Observation
B – Boring for Sub-soil Study
N – Blow Number of Standard Penetration Test

SCALE (1/200)
0 5 10 (M)



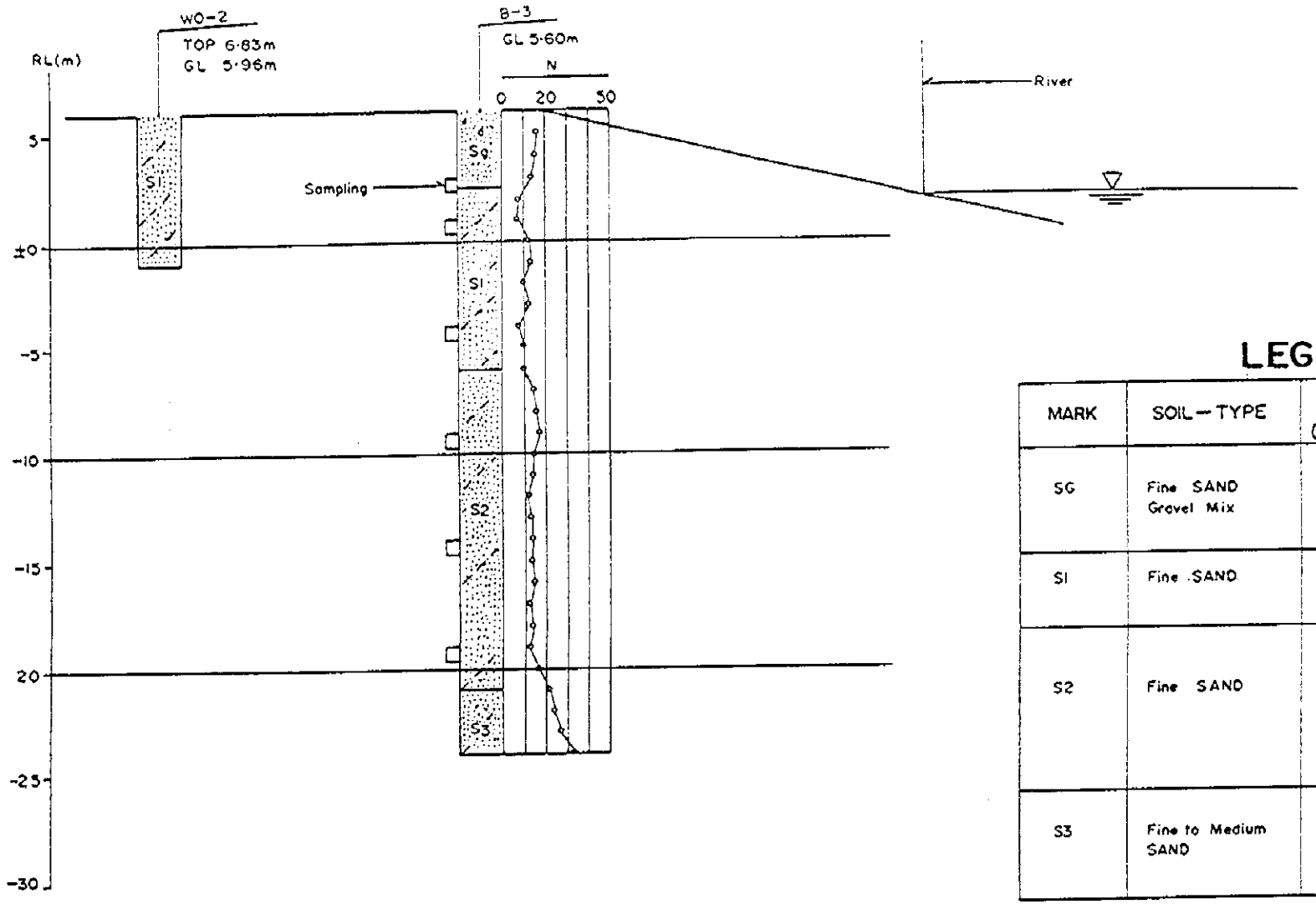
LEGEND

MARK	SOIL-TYPE	N (S.P.T.)	CHARACTER
S1	Fine SAND	2~12 Ave: 5	Very Fine Silty Loose.
S2	Fine SAND	12~24 Ave: 17	Silt a little Medium grains Containig Homogeneous.
S3	Fine to Medium SAND	20~41 Ave: 30	Medium grain increase Fairly Firm in density.

Note: Wo — Boring Hole for G.W.L. Observation
B — Boring for Sub-soil Study
N — Blow Number of Standard Penetration Test

SCALE (1/200)
0 5 10 (M)

Figure 5.6.3 Boring Log (2/5)



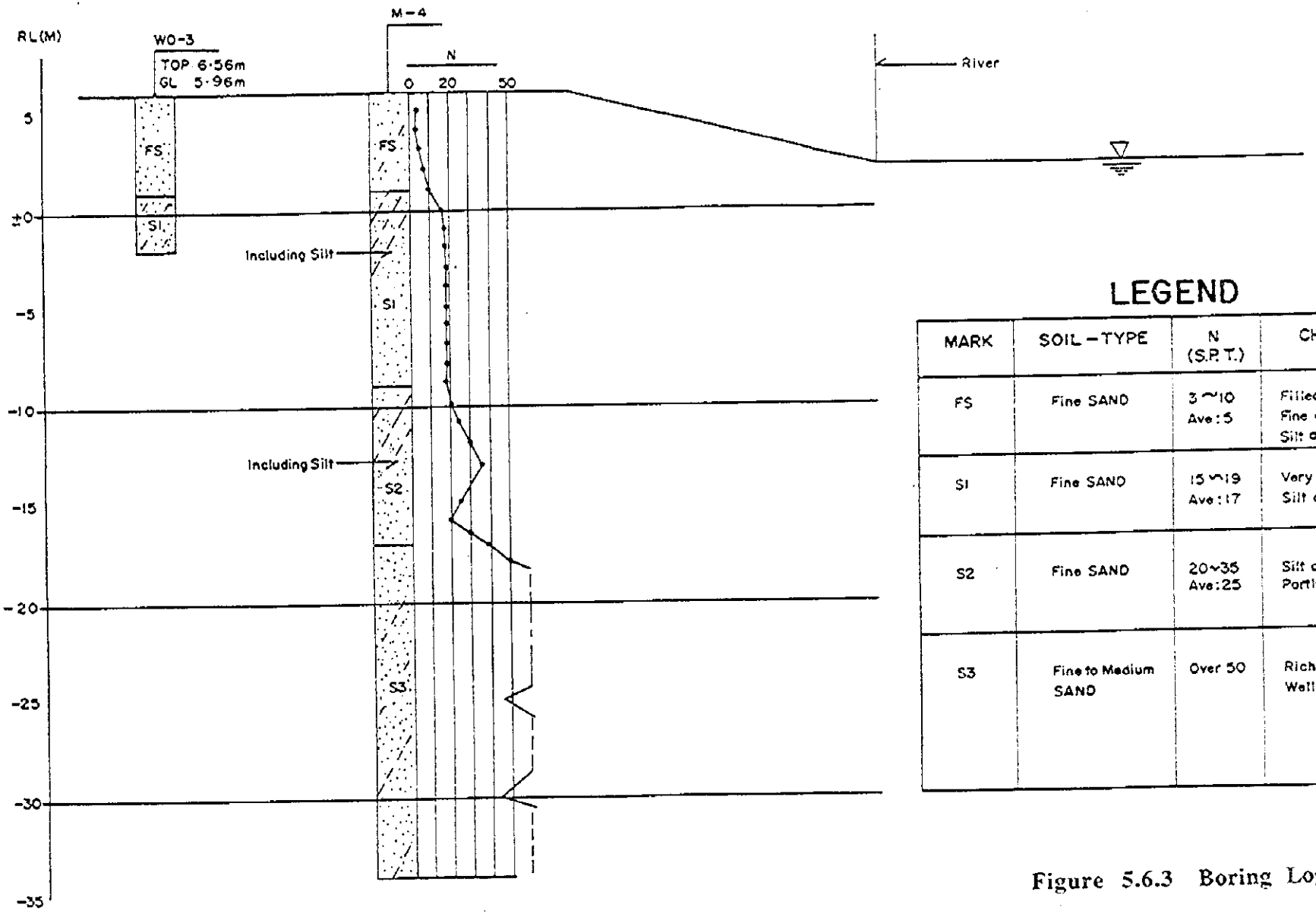
LEGEND

MARK	SOIL—TYPE	N (S.P.T)	CHARACTER
SG	Fine SAND Gravel Mix	13~17 Ave: 15	Containing Stone fragments of Dyke Embk.
SI	Fine SAND	8~12 Ave: 10	Homogeneous Loose. Silt a litte
S2	Fine SAND	11~17 Ave: 15	Silt a litte A little quantity of medium Sand Homogeneous Slightly Loose.
S3	Fine to Medium SAND	20~32 Ave: 25	Medium grains Increase Fairly Firm.

Note: WO — Boring Hole for G.W.L. Observation
B — Boring for Sub—soil Study
N — Blow Number of Standard Penetration Test.

SCALE (1/200)
0 5 10 (M)

Figure 5.6.3 Boring Log (3/5)



LEGEND

MARK	SOIL-TYPE	N (S.P.T.)	CHARACTER
FS	Fine SAND	3~10 Ave:5	Filled Sand Fine and Loose Silt a little
SI	Fine SAND	15~19 Ave:17	Very fine. Silt containing
S2	Fine SAND	20~35 Ave:25	Silt containing Partly Medium grains
S3	Fine to Medium SAND	Over 50	Rich in Medium grain Well consolidated

Note : 1) W/O-3 Hole for G.W.L. Observation
2) M-4 Boring in D/D

SCALE (1/200)
0 5 10 (M)

Figure 5.6.3 Boring Log (4/5)

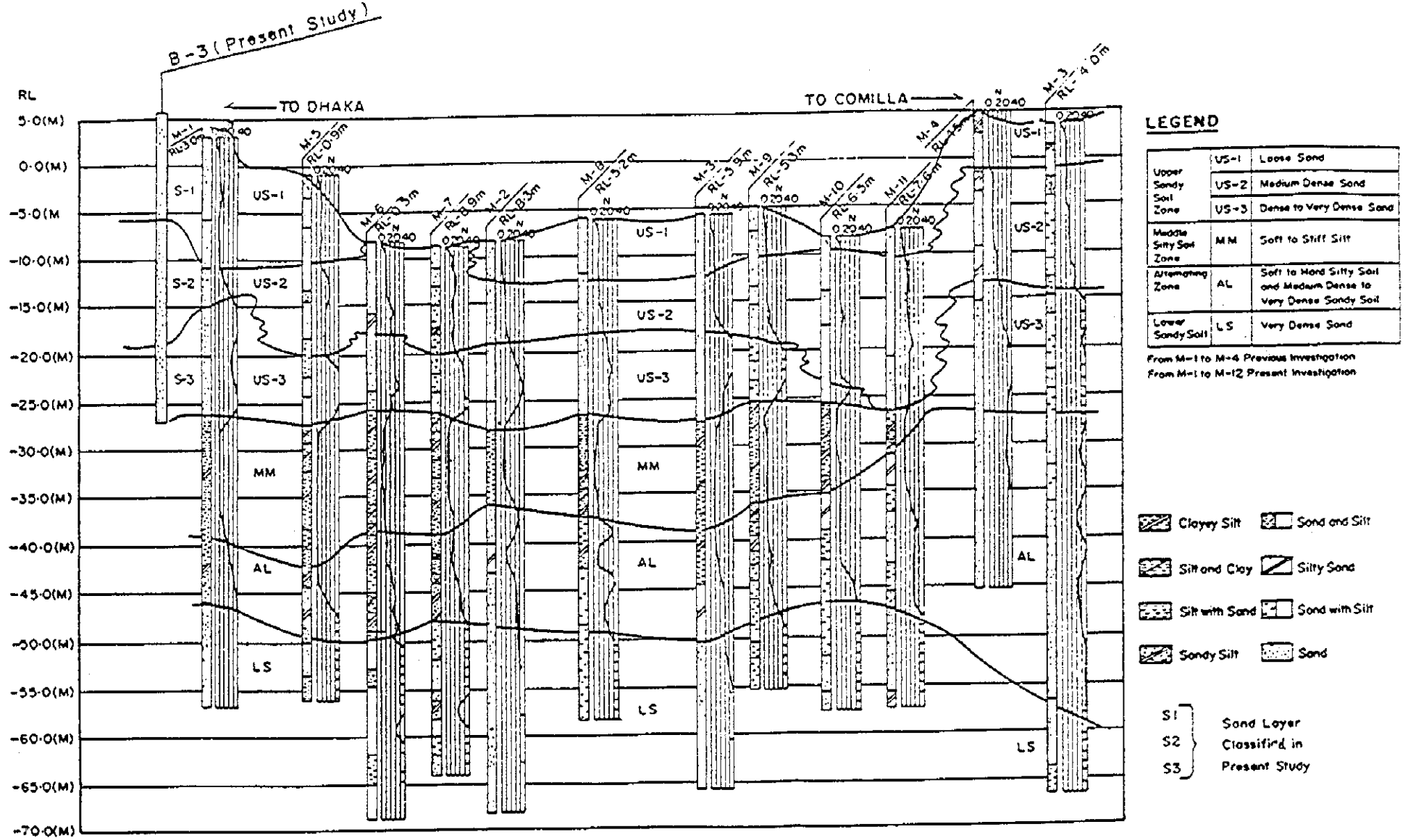


Figure 5.6.3 Boring Log (5/5)

5.6.3 Characteristics of Riverbed Material

(1) Location of Sampling and Sampling Condition

In the First Survey in April 1997, sampling of riverbed material at a total of 19 sites, mainly at bridge piers, in front of the revetment and on riverbed along the water course, was carried out and grain size distribution test was conducted. A survey of riverbed material and analysis of its results had also been carried out in the "Survey on Erosion at River Bank near Meghna Bridge (PCI)" in 1988. During the latter survey 5 sites at on the river bank and 6 sites on the sand bar in the middle or the river channel were selected for sampling. The locations of sampling in April 1997 are shown in Fig. 5.6.4 and those of the survey in 1988 is shown in Fig. 5.6.5.

During the sampling, the riverbed material waved and loosely accumulated near the deepest point of the scoured pool in front of the revetment and sampling of material by hand was possible. At other points, however, sampling by hand was not possible because the riverbed soil was compacted relatively stiffly. In particular, the riverbed near the bridge pier was solid and its surface was smooth and flat. This fact indicates that a consolidated sand layer with N-value of 20 to 40 exposes at a depth of RL. -20 m to -25 m and no bed load and suspended load material accumulate on it. On the other hand, at the deepest portion of the pool, it seems that bed load deposits again when the water level descends after floods have flushed the bed material.

Further, in order to compare the riverbed condition and transportation of soil particles between the dry and rainy seasons, sampling of bed material at the same sites (D-1 ~ D-6) was carried out in the Second Survey in August 1997. The location map of sampling sites is shown in Fig. 5.6.6.

(2) Result of Laboratory Tests

The results of laboratory test (grain size distribution) of the samples obtained through this survey are given in Table 5.6.1, and grain size distribution curves are shown in Fig.5.6.7. Further, for comparison, the result of survey in April 1989 is extracted from the report on Survey on Erosion at River Bank near Meghna Bridge and shown in Fig.5.6.8.

As shown in the grain size distribution curves, most samples consist of fine sand with a quite narrow size range (0.074 ~ 0.42 mm) and silt content (0.005 ~ 0.084 mm) was less than 10% to 20% of weight for most samples. However, the samples taken near the left bank along D-line (D1 ~ D5) have a relatively larger grain size ranging from 4.4. to 6.2 of Cu (uniformity coefficient) and

have a silt content of 20% to 50% which is comparatively larger than other samples. It is presumed that fine suspended solid has accumulated on the surface of river bed because this site is located along the main course of flow and sampling was performed during the dry season. On the other hand, the sampled material in the vicinity of piers (A1, A2), just downstream of the bridge (B3, C3, C4, C5), on the right side half along D-line (D6 ~ D10), and on the sand bar (E1, E2, E3) shows small content of fine particles and eventually the grain size distribution becomes narrow.

Moreover, the grain size distribution of core samples from 3 boreholes drilled in this survey has a narrow range in the surface layer as well as in the deep layer as shown in Fig.5.6.7 (3/3). Thus, it is judged that the matrix consisting of river bank is quite unstable and resistance against scouring is weak.

The results of laboratory tests on the samples taken during the survey in August 1997 are shown in Table 5.6.2. The grain size distribution curves obtained by the surveys in April and August 1997 are graphically shown in Fig. 5.6.9 for comparison. Generally, component of silt (0.002 mm <d<0.074 mm) in the rainy season become smaller than in the dry season.

It is considered that movement of the accumulated soil on the riverbed is activated in the rainy season. Further, there is a tendency that the range of grain size distribution is narrow between the left bank and the center of the thalweg (D1~D3). The same tendency is confirmed around the crest of the sand bar (D6). On the contrary, the range is wide between the center of the thalweg to the slope of the sand bar underwater (D4~D5). This tendency is similar to the result of the First Survey in April 1997.

According to the results of laboratory tests, the material on the river bank and riverbed near the bridge consists mainly of fine sand with d = 0.02 ~ 0.3 mm and ave. d = 0.10 mm, and cohesive clay (d < 0.002 mm) is almost not contained. Further, the largest particle size of the material is around 0.2 to 0.3 mm and size distribution range including small content of less than 0.014 mm is narrow. The specific weight of soil is 2.63 to 2.73 (2.73 on average), which is the same as common soil.

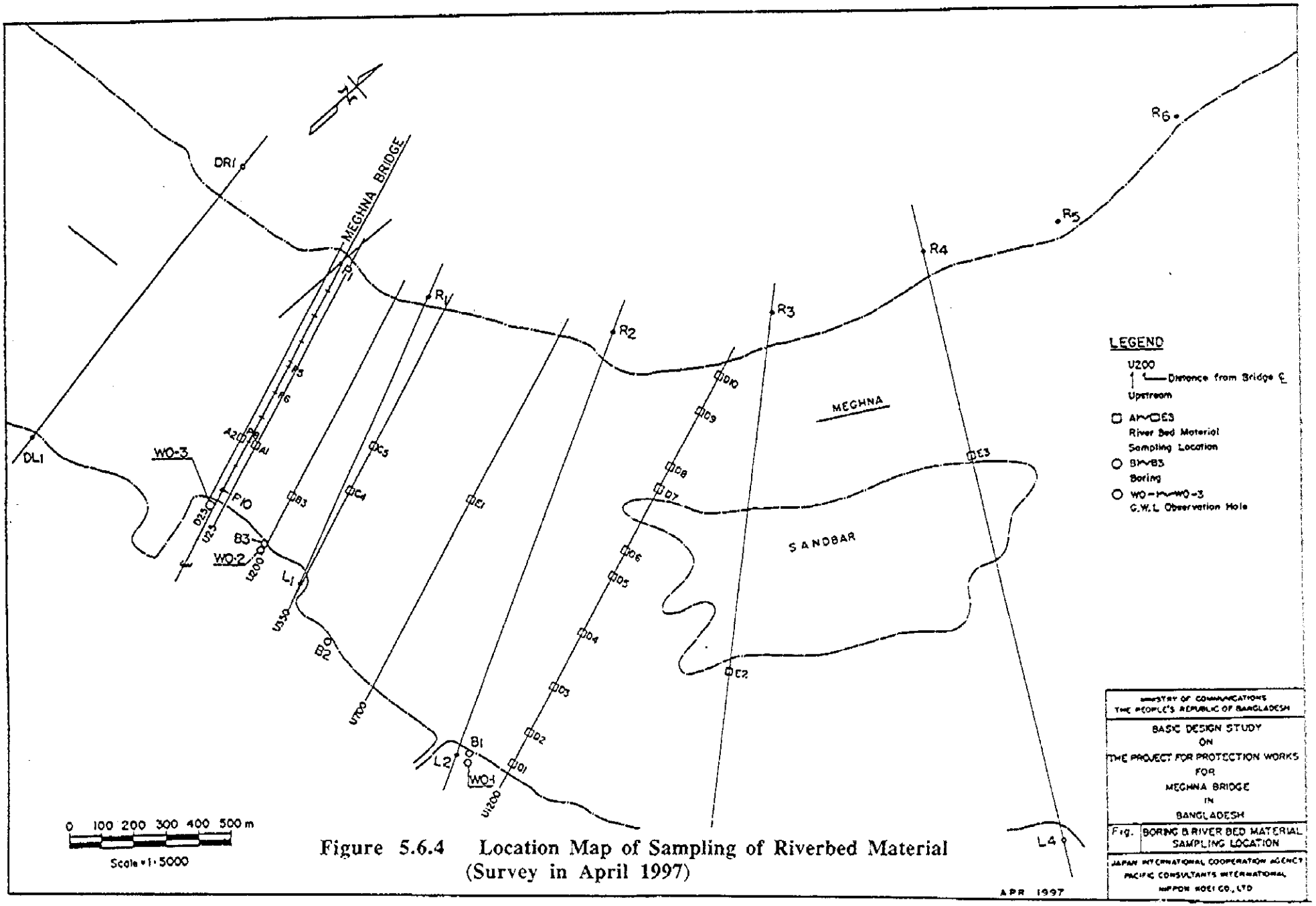


Figure 5.6.4 Location Map of Sampling of Riverbed Material (Survey in April 1997)

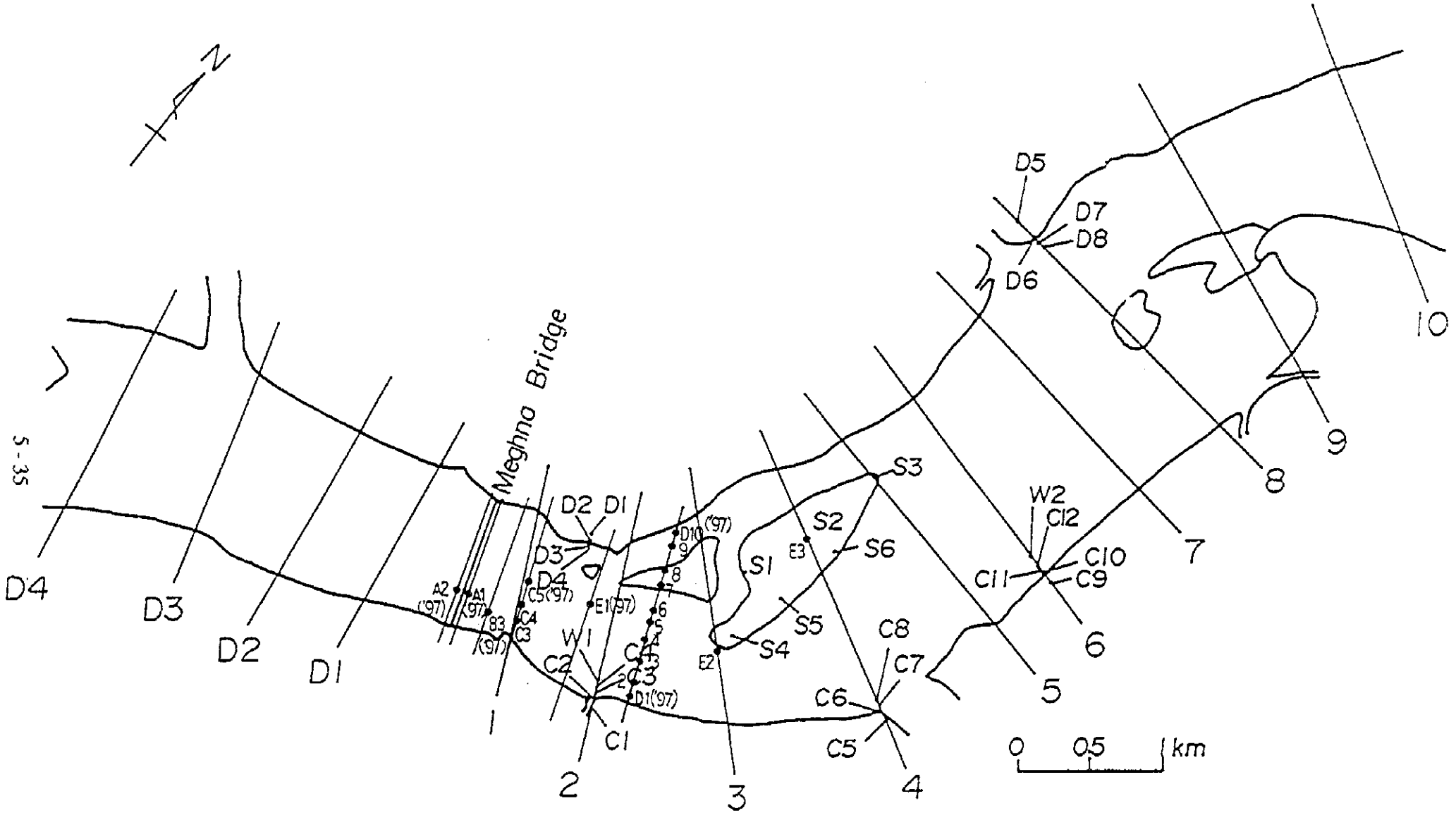


Figure 5.6.5 Location Map of Sampling of Riverbed Material (Survey in April 1989 and April 1997)

—•— Sampling point of survey in Apr.1997

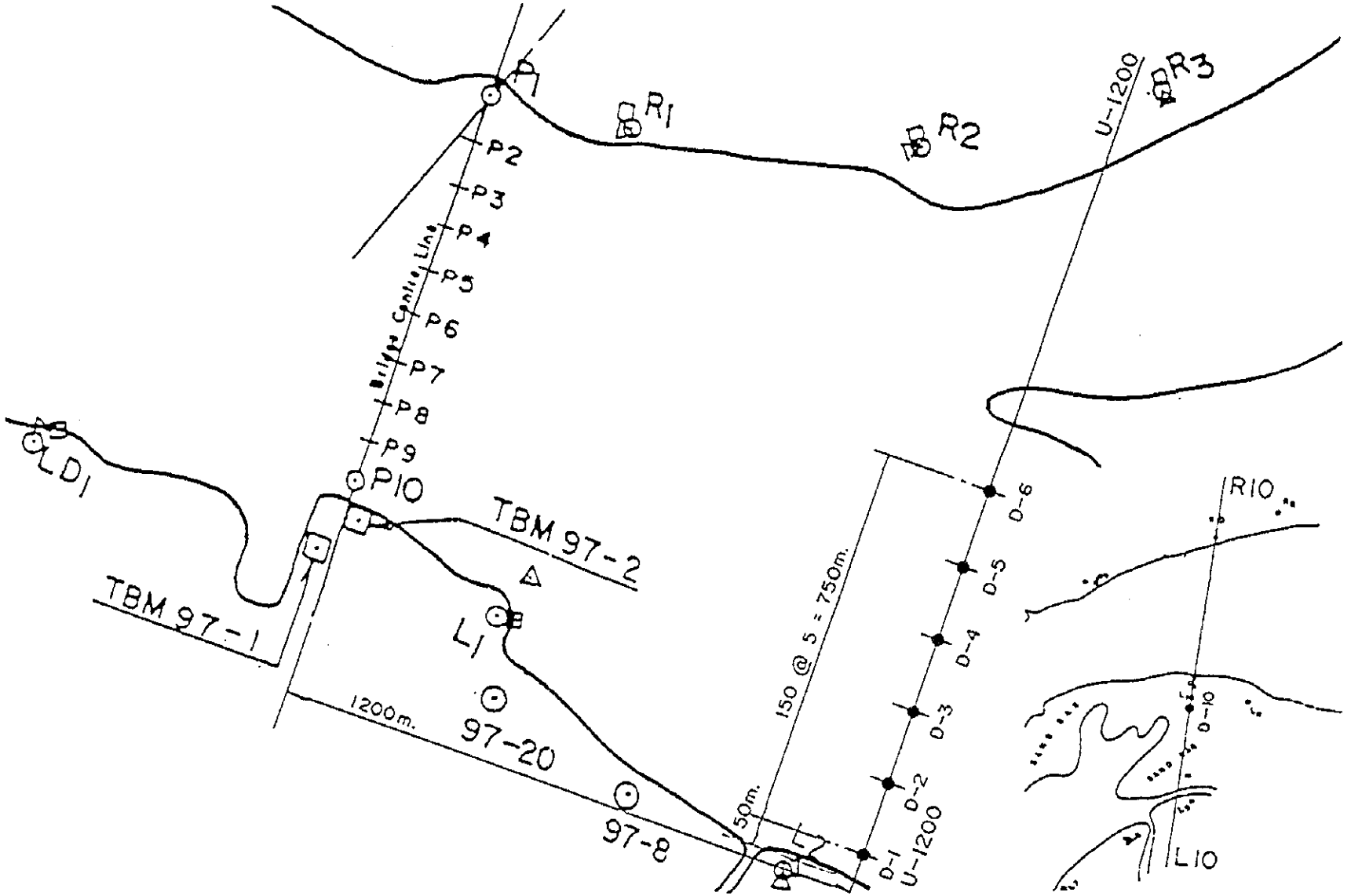


Figure 5.6.6 Location Map of Sampling of Riverbed Material (Survey in August 1997)

Table 5.6.1 Summary of Soil Test (April 1997) (1/2)

Sample No.	Depth	Grain Size Analysis						D50	Cu = D60/D10	Unified soil classification symbol (USCS)	Remarks
		Gravel 76.1-4.76 mm	Coarse sand 4.76-2.0 mm	Medium sand 2.0-0.425 mm	Fine sand 0.425-0.075 mm	Silt 0.075-0.002 mm	Clay < 0.002 mm				
	(m)	(%)	(%)	(%)	(%)	(%)	(%)	(mm)			
A-1	21	Nil	Nil	Nil	98.00	02.00	Nil	0.205	1.450	SP	Fine sand, trace silt, grey, NP
A-2	18	Nil	Nil	Nil	98.00	02.00	Nil	0.202	1.820	SP	Fine sand, trace silt, grey, NP
B-3	25	Nil	Nil	Nil	99.00	01.00	Nil	0.205	1.440	SP	Fine sand, trace silt, grey, NP
C-3		Nil	Nil	Nil	97.00	03.00	Nil	0.190	2.290	SP	Fine sand, trace silt, grey, NP
C-4	14	Nil	Nil	Nil	96.00	04.00	Nil	0.150	2.010	SP	Fine sand, trace silt, grey, NP
C-5	2	Nil	Nil	Nil	98.00	02.00	Nil	0.165	2.180	SP	Fine sand, trace silt, grey, NP
D-1	9	Nil	Nil	1.00	73.00	26.00	Nil	0.140	4.910	SM	Fine sand, some silt, grey, NP
D-2	12	Nil	Nil	3.00	49.00	48.00	Nil	0.776	5.050	SM	Fine sand and silt, grey, NP
D-3	12	Nil	Nil	1.00	75.00	24.00	Nil	0.133	4.380	SM	Fine sand, some silt, grey, NP
D-4	8	Nil	Nil	Nil	64.00	36.00	Nil	0.090	5.000	SM	Fine sand, some silt, grey, NP
D-5	2.5	Nil	Nil	Nil	45.00	55.00	Nil	0.060	6.230	ML	Silt and fine sand, grey, NP

Note : NP = Non-plastic

Table 5.6.1 Summary of Soil Test (April 1997) (2/2)

Sample No.	Depth	Grain Size Analysis						D50	Cu = D60/D10	Unified soil classification symbol (USCS)	Remarks
		Gravel 76.1-4.76 mm	Coarse sand 4.76-2.0 mm	Medium sand 2.0-0.425 mm	Fine sand 0.425-0.075 mm	Silt 0.075-0.002 mm	Clay < 0.002 mm				
	(m)	(%)	(%)	(%)	(%)	(%)	(%)	(mm)			
D-6-1	2	Nil	Nil	Nil	09.00	85.00	6	0.031	6.500	ML	Silt, trace fine sand, grey, NP
D-6-2	2	Nil	Nil	Nil	74.00	26.00	Nil	0.100	3.640	SM	Fine sand, some silt, grey, NP
D-7	4	Nil	Nil	Nil	93.00	07.00	Nil	0.115	1.560	SP-SM	Fine sand, trace silt, grey, NP
D-8	4.5	Nil	Nil	Nil	88.00	12.00	Nil	0.147	2.750	SP-SM	Fine sand, little silt, grey, NP
D-9	3	Nil	Nil	Nil	84.00	16.00	Nil	0.140	3.200	SM	Fine sand, little silt, grey, NP
D-10	3	Nil	Nil	Nil	87.00	13.00	Nil	0.100	1.920	SM	Fine sand, little silt, grey, NP
E-1	3.5	Nil	Nil	Nil	73.00	27.00	Nil	0.095	3.550	SM	Fine sand, some silt, grey, NP
E-2	1	Nil	Nil	Nl	90.00	10.00	Nil	0.125	1.870	SP-SM	Fine sand, little silt, grey, NP
E-3	0.5	Nil	Nil	Nil	98.00	02.00	Nil	0.165	2.160	SP	Fine sand, trace silt, grey, NP

Note : NP = Non-plastic

Table 5.6.2 Summary of Soil Test (August 1997)

Date of Sampling : August 10 - 20 / 1997

Date of Testing : August 10 - 20 / 1997

Sample No	Depth of Sample	Grain Size Analysis						D50	D60	D10	Cu = D60/D10	Unified soil classification symbol (USCS)	Remarks
		Gravel 76.1-4.76 mm	Coarse sand 4.76-2.0 mm	Medium sand 2.0-0.425 mm	Fine sand 0.425-0.075 mm	Silt 0.075-0.002 mm	Clay <0.002 mm						
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(mm)	(mm)	(mm)			
D - 1	River bed	Nil	Nil	0.6	94.4	5.0	Nil	0.19	0.21	0.09	2.33	SP	Fine sand, trace silt, grey, NP
D - 2	River bed	Nil	Nil	3.9	92.2	3.9	Nil	0.22	0.25	0.15	1.67	SP	Fine sand, trace silt, grey, NP
D - 3	River bed	Nil	Nil	1.3	95.4	3.3	Nil	0.12	0.15	0.08	1.88	SP	Fine sand, trace silt, grey, NP
D - 4	River bed	Nil	Nil	1.0	85.3	13.7	Nil	0.11	0.13	0.045	2.89	SM	Fine sand, little silt, grey, NP
D - 5	River bed	Nil	Nil	0.4	68.6	31.0	Nil	0.11	0.13	0.009	14.44	SM	Fine sand, some silt, grey, NP
D - 6	River bed	Nil	Nil	2.7	95.5	1.8	Nil	0.21	0.24	0.15	1.60	SP	Fine sand, trace silt, grey, NP
D - 10	River bed	Nil	Nil	Nil	54.8	45.2	Nil	0.08	0.10	0.026	3.85	SM	Fine sand and silt, grey, NP

Note : NP = Non-plastic

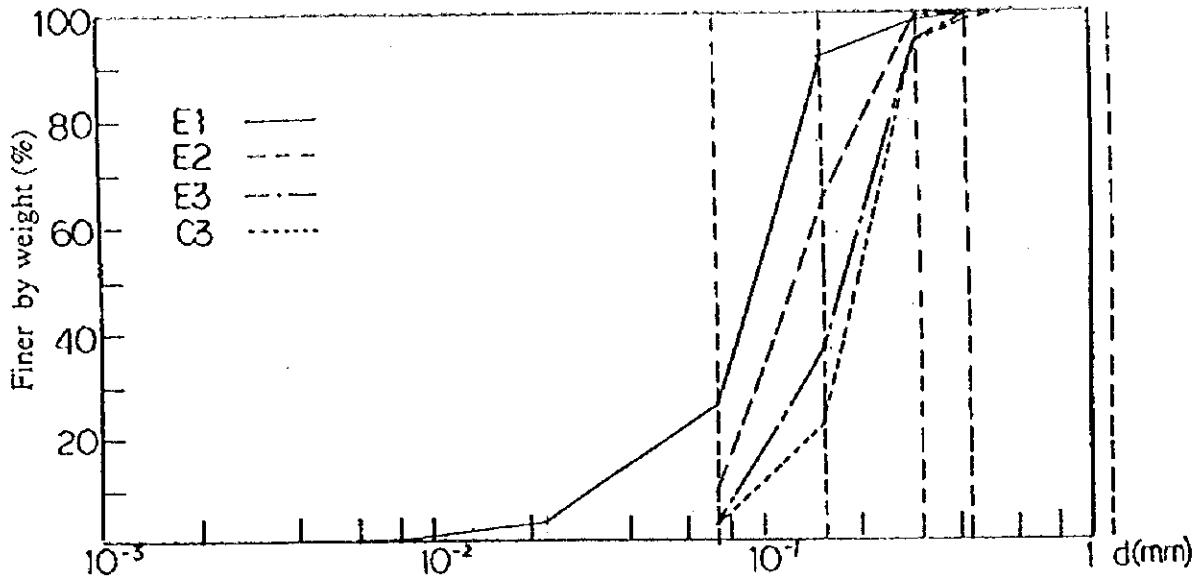
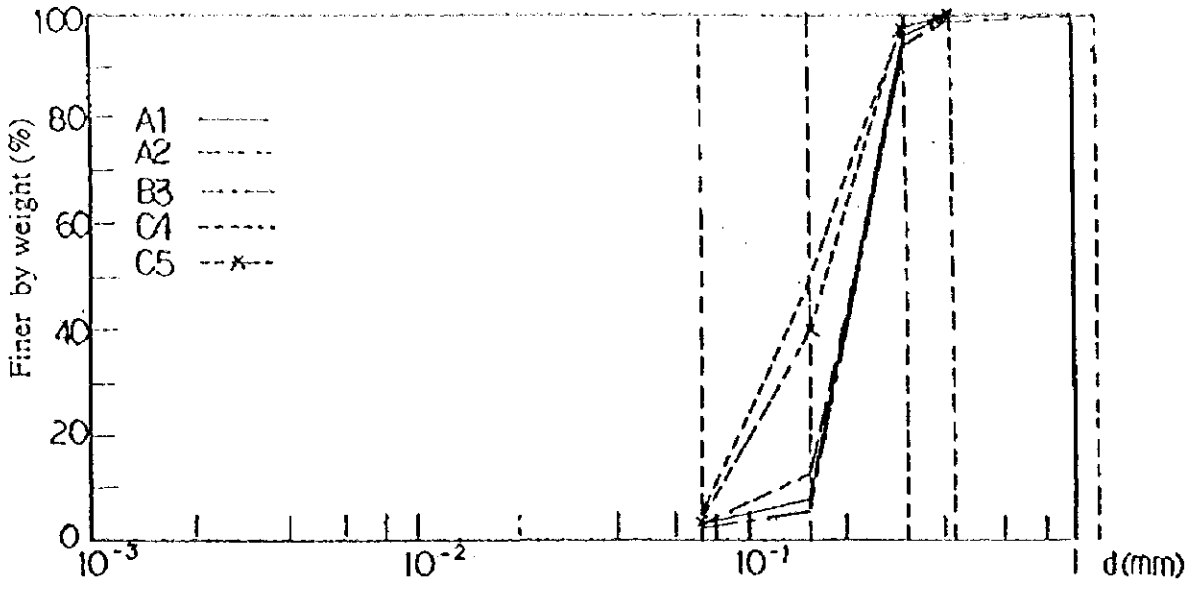
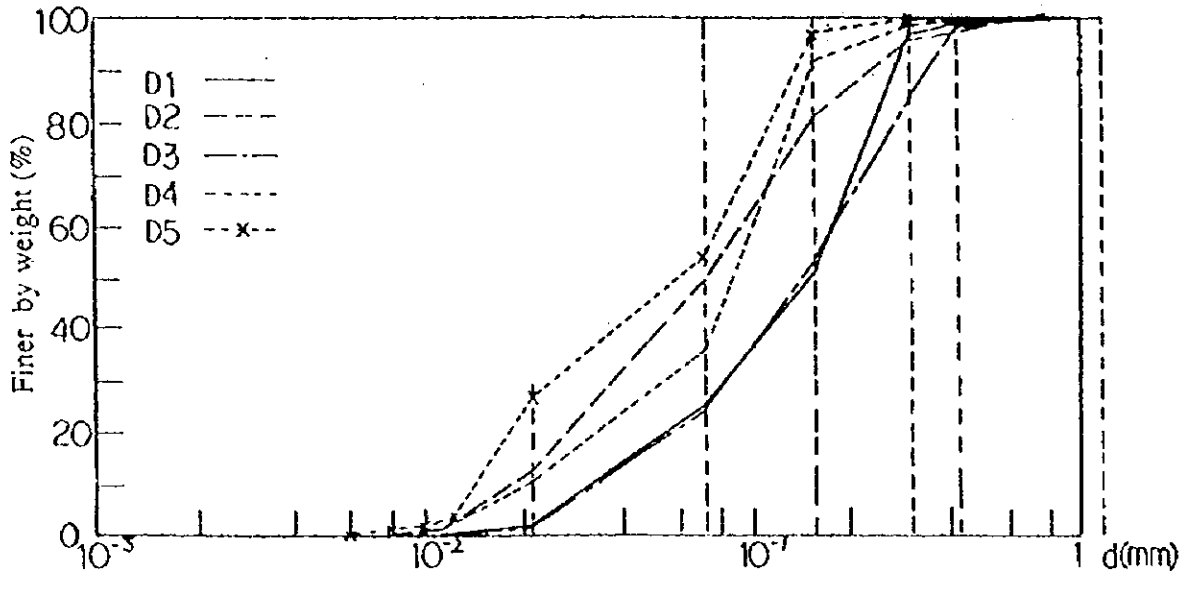


Figure 5.6.7 Grain Size Distribution Curve (1/3)





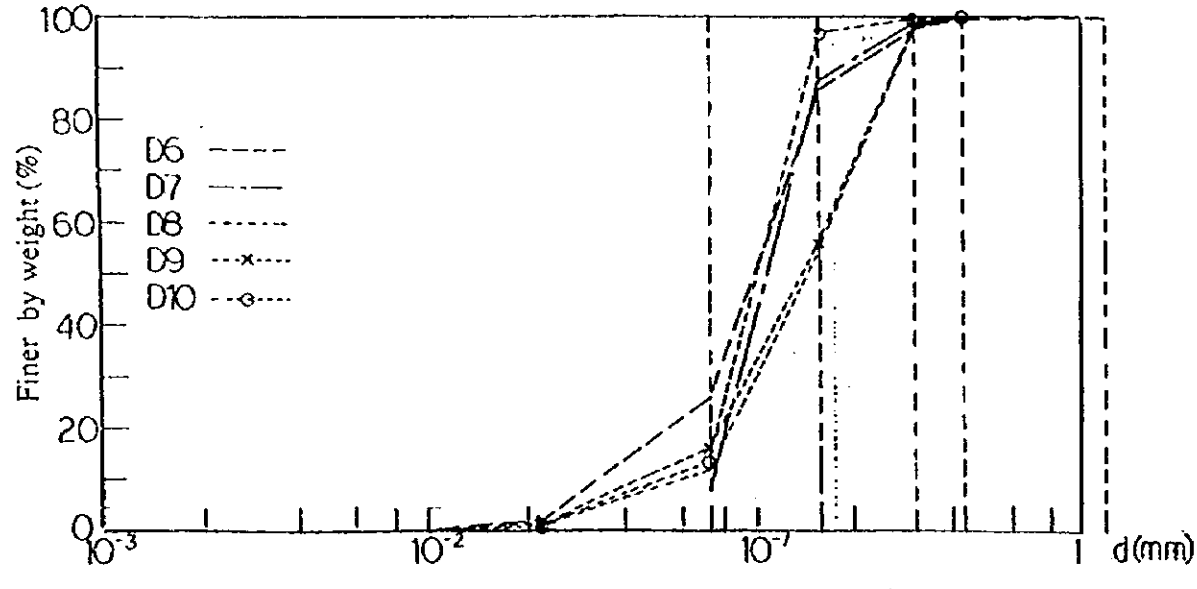
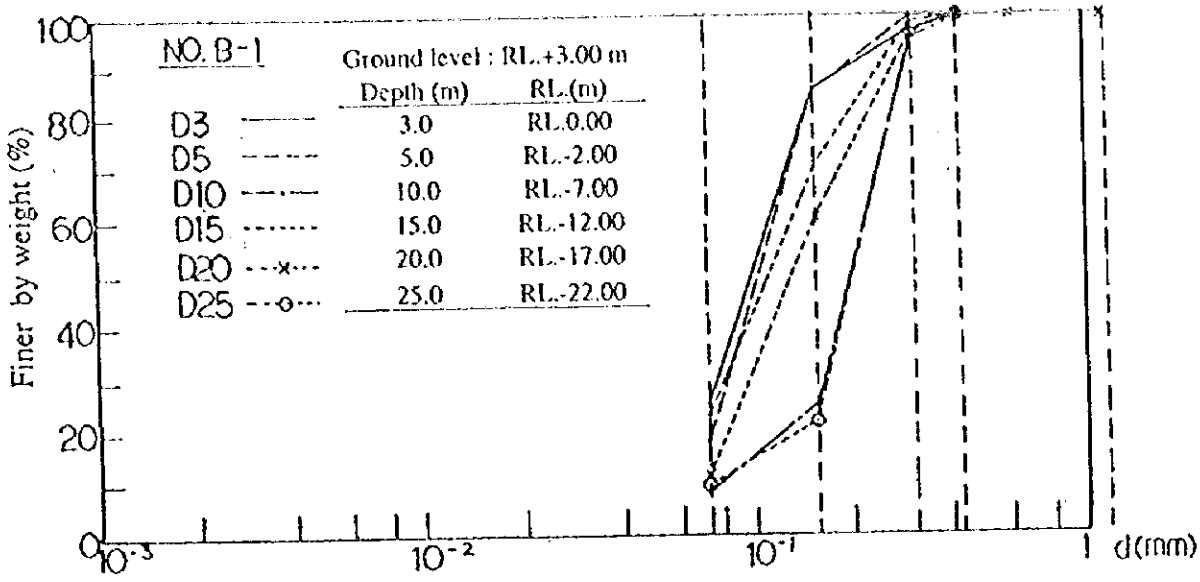
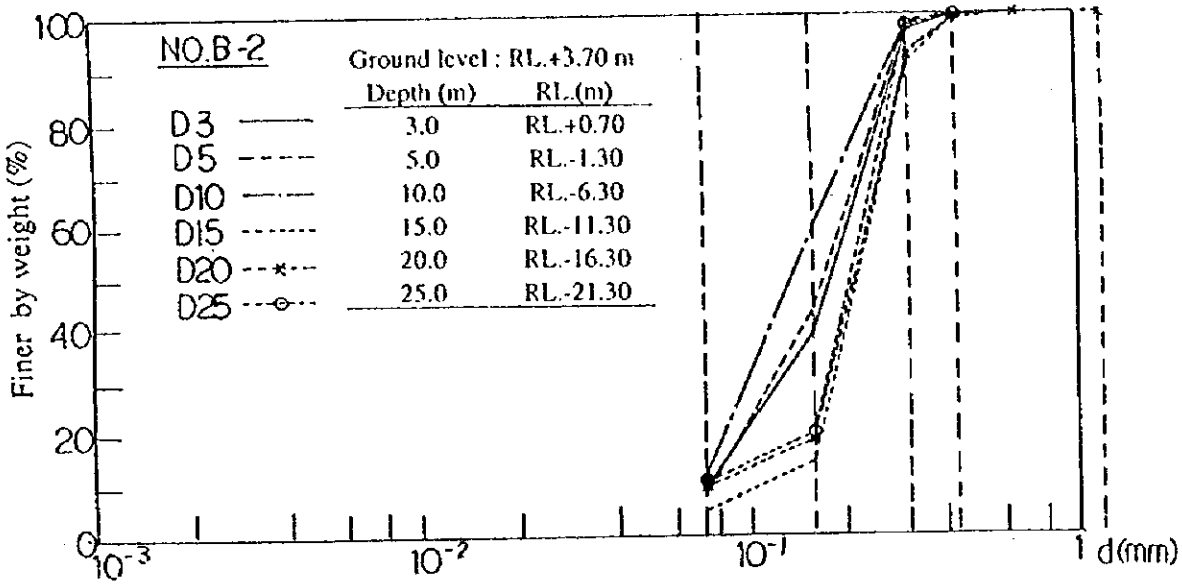


Figure 5.6.7 Grain Size Distribution Curve (2/3)





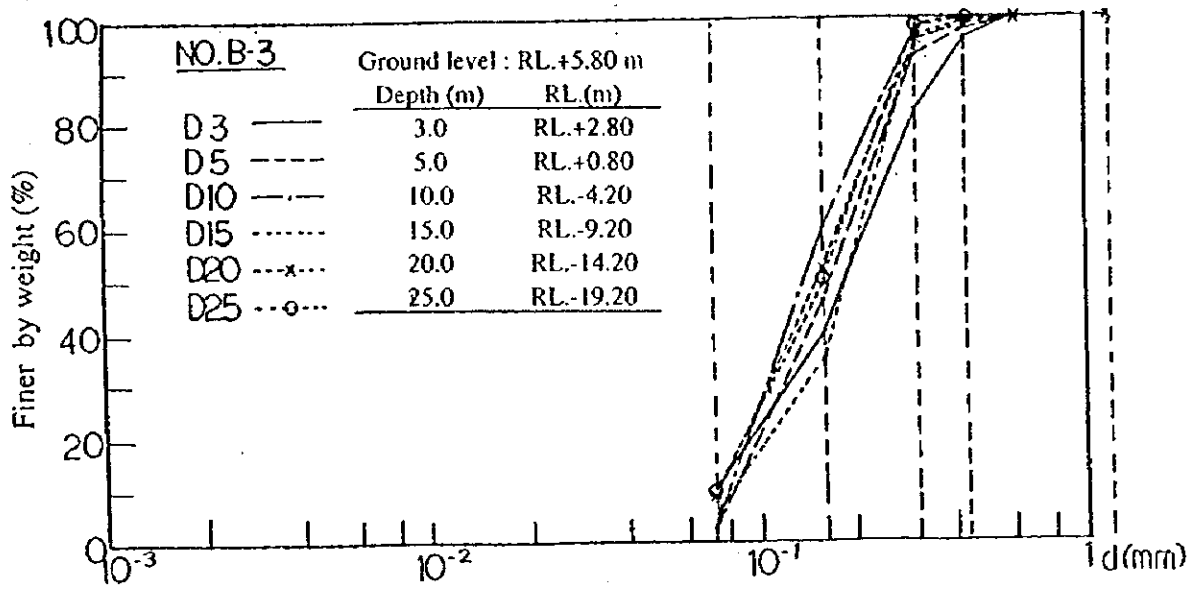
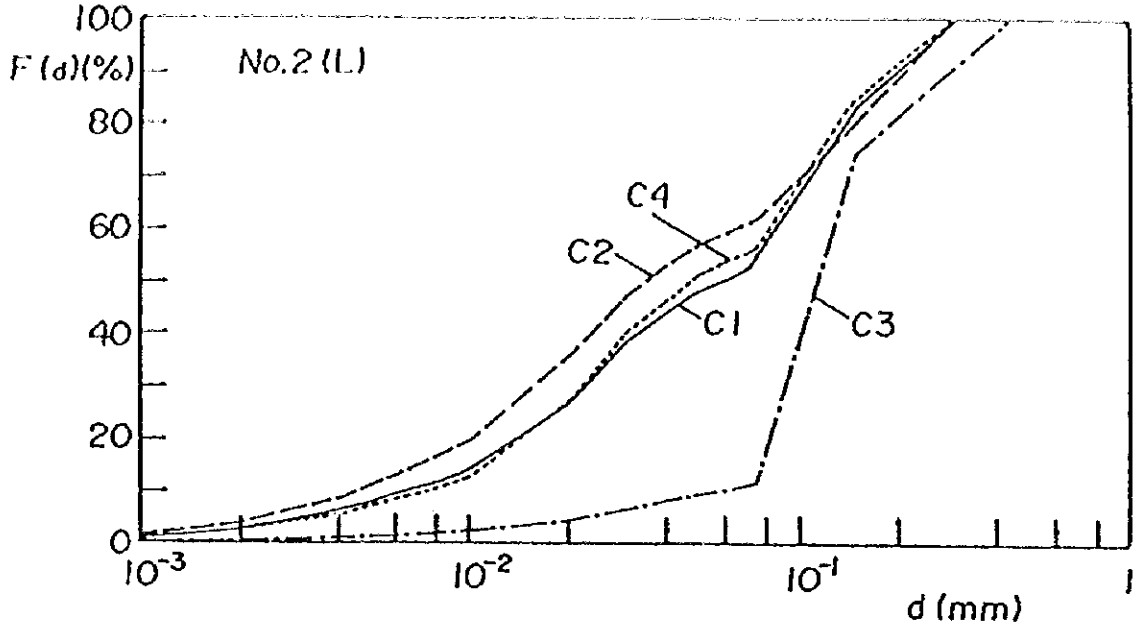
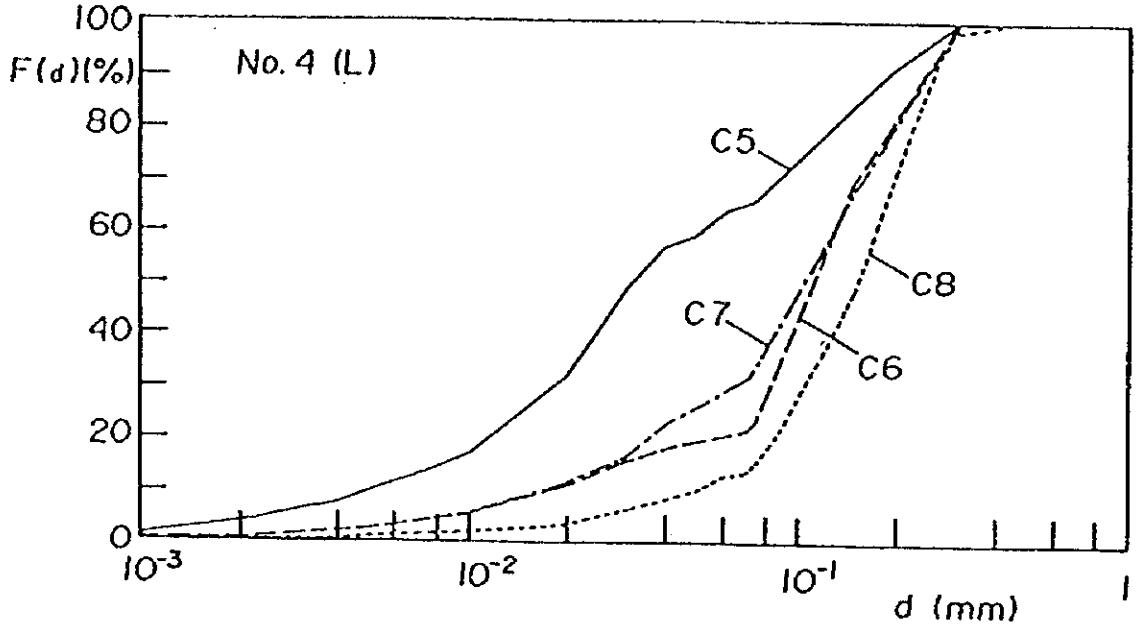


Figure 5.6.7 Grain Size Distribution Curve (3/3)





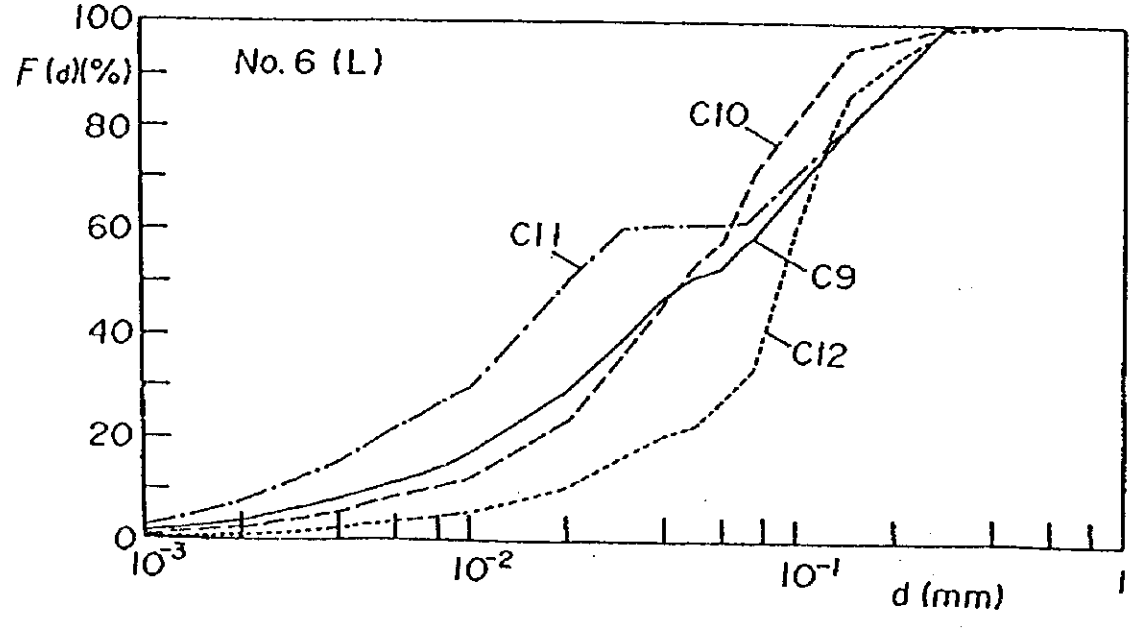
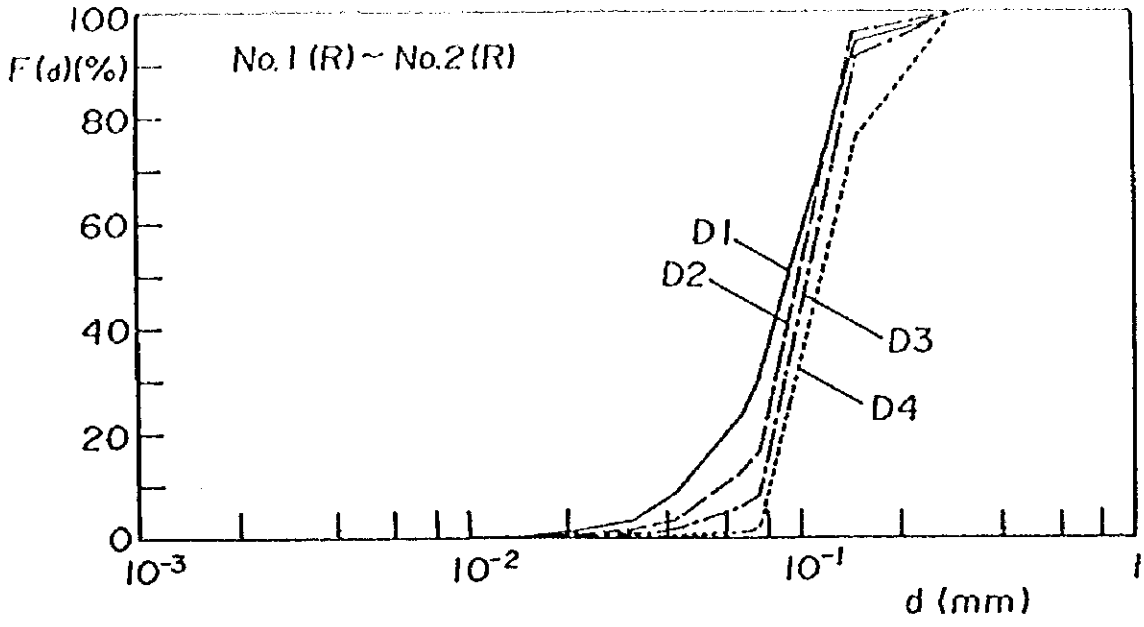
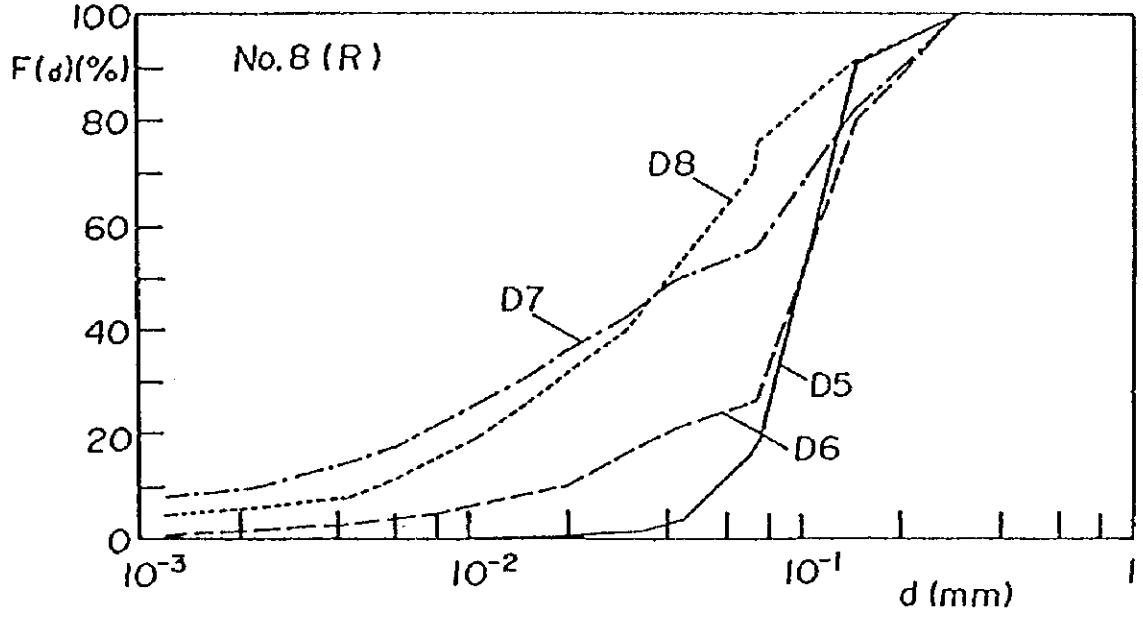


Figure 5.6.8 Grain Size Distribution Curve (Survey in 1988) (1/3)





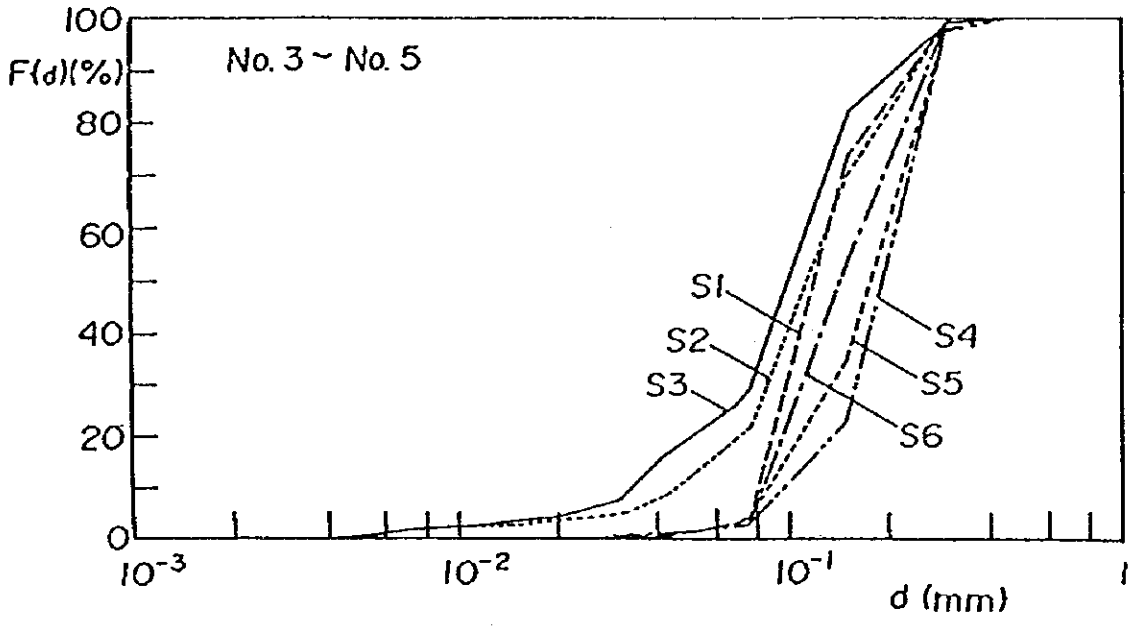


Figure 5.6.8 Grain Size Distribution Curve (Survey in 1988) (2/3)

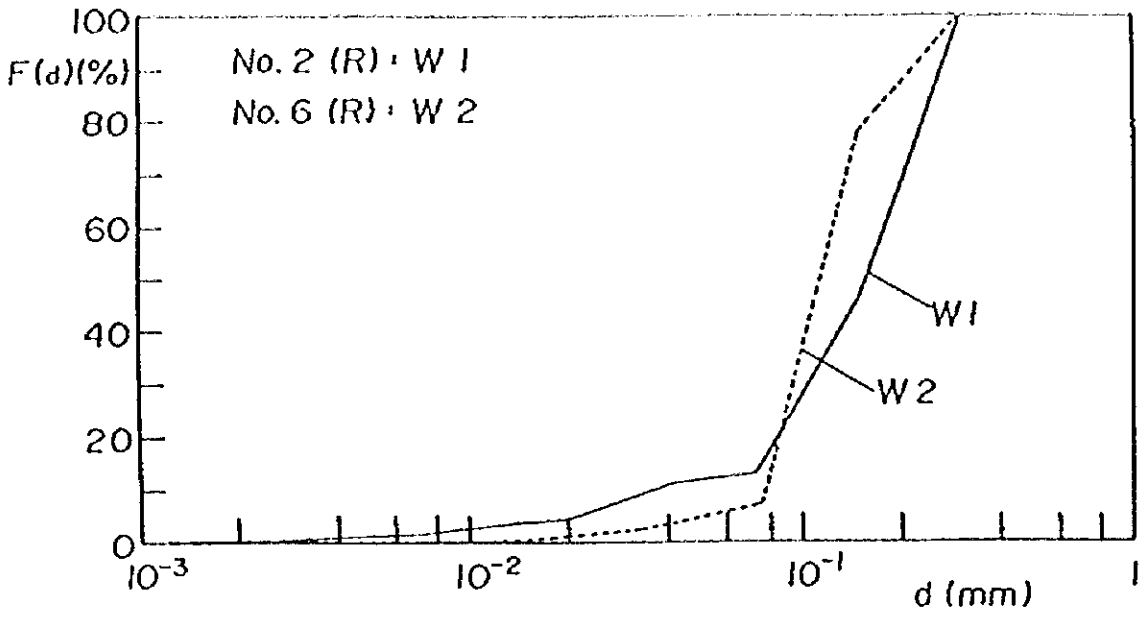
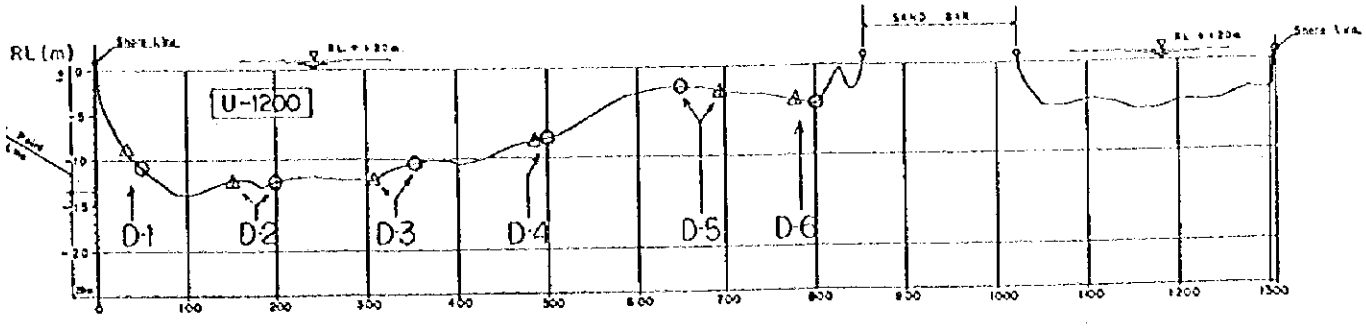
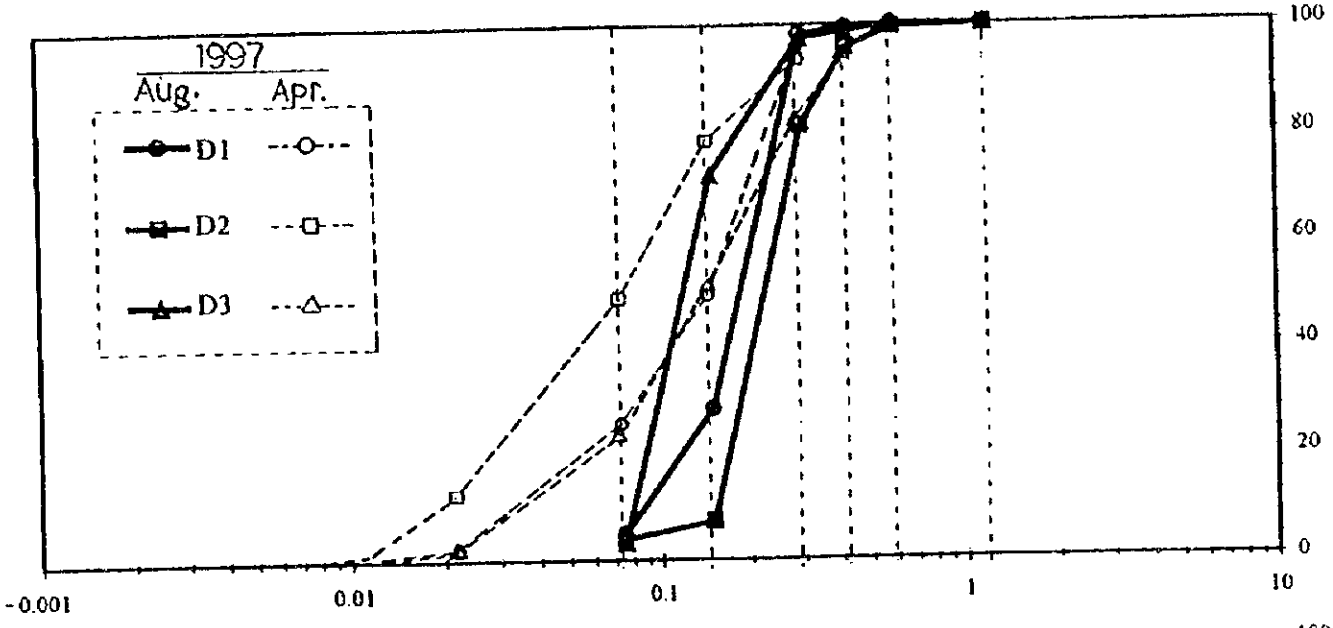


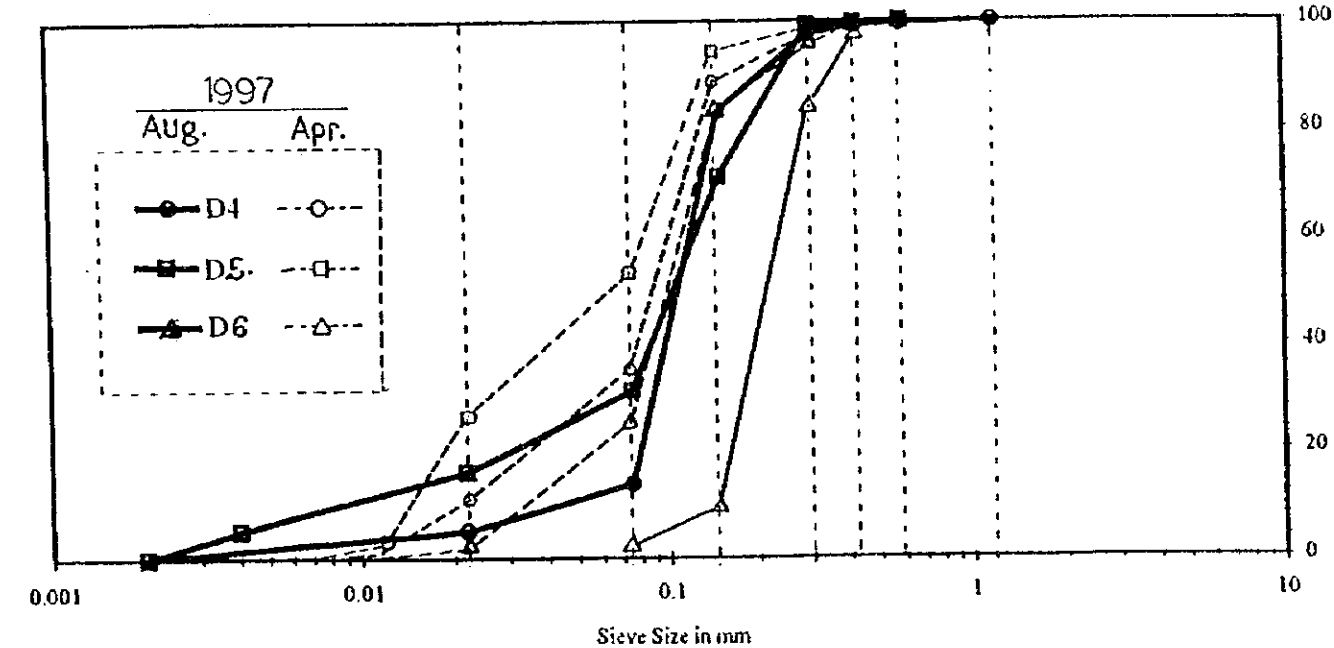
Figure 5.6.8 Grain Size Distribution Curve (Survey in 1988) (3/3)



Legend : △、Apr.1997 ○、Aug.1997

RIVER CROSS SECTION ALONG SAMPLING POINTS
(measured in Apr.1997)





Sieve Size in mm

Grain size	D1		D2		D3		D4		D5		D6	
	Apr	Aug	Apr	Aug	Apr	Aug	Apr	Aug	Apr	Aug	Apr	Aug
D50(mm)	0.14	0.19	0.776	0.22	0.133	0.12	0.09	0.11	0.06	0.11	0.031	0.21
Cu (D60/D10)	4.91	2.33	5.05	1.67	4.38	1.88	5.00	2.89	6.23	14.44	6.50	1.60

Figure 5.6.9 Grain Size Distribution Curve (comparison between survey in April and August 1997)

CHAPTER 6

CONDITION OF EROSION IN THE VICINITY OF MEGHNA BRIDGE

CHAPTER 6 CONDITION OF EROSION IN THE VICINITY OF THE MEGHNA BRIDGE

6.1 Result of Interview Survey on Bank Erosion

6.1.1 Objective and Method of Survey

In order to clarify the condition of erosion, deposition and shift of sand bar in the river stretch where the Meghna Bridge is located, an interview survey of villagers was conducted. Old people who have lived for a relatively long time in the selected sites were interviewed and their verbal answers were recorded on survey sheets for the following analysis.

6.1.2 Survey Period and Area

- Survey period : April 1997
- Survey area : From approx. 10 km upstream (11 sites) to approx. 5 km downstream of the Meghna Bridge (5 sites)

6.1.3 Results of Survey

The location map of the survey sites and the results of interviews are shown in Fig. 6.1.1. The main features of the respective sites are as follows:

(1) 0 km to 5 km Upstream, on the Left Bank (Meghna Ghat to Bara Raypara)

The river left bank near the old ferry ghat is seriously eroded. From 1991 to 1997, erosion advanced approx. 500 m. The erosion area extends about 3 km toward the upstream side. The degree of erosion along the bank diminishs in the area upstream of Taitala. Near the Chhoto Raypara (2) survey point, erosion gradually changes to deposition. From 0 km to 3 km upstream, the 1988 floods caused an erosion of 100 m to 250 m of the river bank. In the last 27 years, i.e., 1971 to 1997, the rate of erosion estimated based on the interview survey is 10 m to 25 m a year.

About 27 years ago, that is in Bangladesh's Independence Year of 1971, the left bank was at the edge of the sand bar, but at present it is in front of the Taitala and Chhoto Raypara survey points. A village which had been located at the old bank edge shifted to Chhoto Raypara and Bara Raypara where the surveys were carried out this time. In the past 20 to 30 years, the bank erosion in this area was approx. 700 m and the rate was 15 m to 35 m a year. Due to the presence of finer sand particles, this area is highly prone to erosions during the presence flood season and falling river stage (August to November). By wave

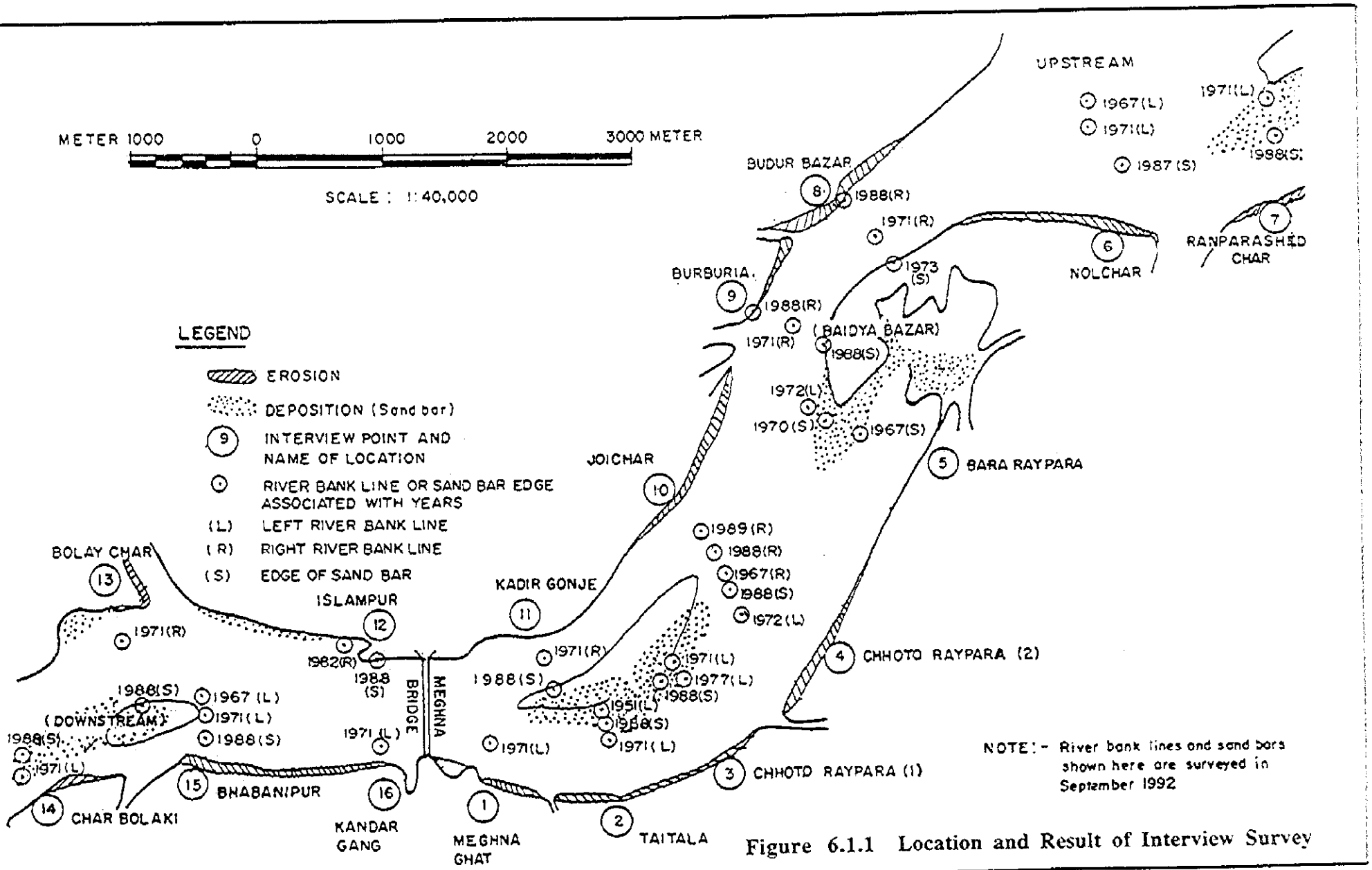


Figure 6.1.1 Location and Result of Interview Survey

actions of river flow, the bank erosion continues even in the dry season (December to May).

In the Baidya Bazar area, located in front of the Bara Raypara survey point, a point bar has developed toward the downstream in the years 1935 to 1970. The size of this point bar, which had been approx. 2,000 m long and 1,000 m wide in maximum in the past, has been reduced to approx. 1,500 m long and 700 wide at present and is still diminishing. The change in size of this point bar would directly affect the condition of the bank line at Budur Bazar and Burburia.

(2) 9 km to 10 km Upstream, on the Left Bank (Nolchar, Ranparashed Char)

The left bank has been seriously eroded since 1967. In the last 30 years, erosion advanced approx. 800 m to 1,000 m, i.e.at a rate of 30 m a year. The river portion at this place appears to be comparatively shallow because many ships equipped with grab bucket are collecting sand from the riverbed. In the flood season of 1988, the sand bar was formed on the opposite side of this left bank. The size of the sand bar is approx. 2,000 m long and 500 m wide. The main stream had been near this sand bar location about 26 years ago.

(3) 4 km to 5 km Upstream, on the Right Bank (Budur Bazar, Burburia)

The bank was eroded approx. 500 m from 1971 to 1997, at a rate of 19 m a year. At the Budur Bazar, the river shifts to the right and becomes narrow and deep (-22m). The bank was further seriously eroded approx. 200 m by floods in August 1988. Flood water rose to the level of 0.5 m above the ground and nearly 300 houses were washed out in the Budur Bazar area.

(4) 1 km to 3 km Upstream, on the Right Bank (Kadir Gonge, Joichar)

Roughly 30 years ago, the right bank near the Joichar interview point had been located approx. 700 m from the present bank line. Bank erosion has continued up to now at a rate of 23 m a year. In August 1988, the bank was further eroded approx. 150 m. The flood water level was 0.5 m above the ground level where houses are existing now. The flood water lowered gradually during the following two weeks. Near the Kadir Gonge interview point no bank erosion was noticed, but deposition has occurred in the last 5 to 6 years. The sand bar was formed in front of this point, during the flood period in 1988. The sand bar has a size of approx. 2,000 m long and 500 m wide at present and is split into the upstream and downstream parts by a small and shallow water channel. The river portion further upstream of this sand bar is relatively shallow because there are small boats collecting river sand.

(5) 1 km to 2 km Downstream, on the Right Bank (Islanpur, Bolay Char)

At the Islanpur interview point, bank erosion advanced approx. 50 m in the last 15 years. There was deposition at this site during the floods in 1988. A point bar is developing downstream of this point. At the Bolay Char interview point, the bank was eroded approx. 300 m, however, no bank erosion has been noticed in the past two to three years, but deposition has occurred in the last 5 to 6 years.

(6) 0 km to 5 km Downstream, on the Left Bank (Char Bolaki Kandar)

Near the Char Bolaki interview point, bank erosion advanced approx. 200 m since 1971, at a rate of approx. 8 m a year. At present, however, no noticeable erosion is observed. There is a sand bar under the water in front of this survey point. The size of the sand bar appears to be roughly 2,000 m long and 500 m wide. This portion used to be cultivated land. To avoid misnavigation of ships, bamboo poles are installed around the underwater sand bar where water depth is shallow.

At the Bhabanipur interview point, bank erosion advanced approx. 400 m since 1971, i.e. approx. 15 m a year. During the floods in 1988, the bank was further eroded approx. 50 m. At Kandar Gaong, the bank was eroded approx. 200 m since 1971, i.e. approx. 8 m a year.

6.1.4 Patterns of Erosion

The following typical patterns of river bank erosion were noticed during the site investigation along the river bank.

a) The erosion prone soils such as fine sand silt are broken off under the effects of waves and fluctuations of water level. Erosion of clay soil is comparatively slower than sandy and silty soils (near Taitala and Nolchar).

b) Bank erosion occurs with a steps-pattern associated with the conditions of flood scale and flood water levels (near Nolchar, Ranparashed Char).

c) Following a pattern similar to that mentioned in b), the clay portion, below the surface soil of which erosion occurs easily, is eroded relatively slowly and remains under the water (near Joichar).

d) The layer of erosion prone soil and the layer of clay soil are simultaneously eroded. This erosional condition of different soil types differs from the other patterns (near Bhabanipur).

6.1.5 Change of the River Course (According to the Result of Interview Survey)

Since 1967, erosion of the left bank upstream of the Meghna Bridge has been continuing further downstream. From 5 km to 6 km upstream on the left bank, a point bar was formed at Baidya Bazar. Before 1935, main river stream (thalweg) had been at the location where this point bar exists now. The river course, thus, shifted toward the downstream side.

The old right river bank at 3 km upstream started to be eroded since 1971. It is set back approx. 700 m to the right side from the axis of the river. Due to the formation of the sand bar the floods in 1988 near the above point, the river stream split into two currents. The left current caused serious erosion of the left bank due to the sharp bend of the river course, and erosion is still continuing now. The main river channel had been at the location where the sand bar appeared, according to the interview survey.

As for the downstream side of the Meghna bridge, the river has been widened to the left side due to the sand bar which is under the water at present. The area of this sand bar used to be cultivated land. Considering the bank erosion on the opposite side, the river channel might be narrower in the old times, and due to the deposition of the river materials, the river was widened.

6.2 Present Condition of Scoured Pool in the Vicinity of the Bridge

As described in Section 5.5, the right bank from R8 to R5 and the opposite left bank from L4 to L3 are hit by water currents due to the meanders of the river stretch near the Bridge. Along this shoreline, bank erosion is serious and deep scouring of the riverbed due to the meanders can be seen as shown in Figs. 5.5.1 and 5.5.2.

Therefore, the movement of the hitting points on the banks, the sand bars and the small channel on the right side, is an important factor to forecast fluctuations of the riverbed and channel course. From this point of view, chronological change in fluctuations of the riverbed was analyzed based on the contour maps, for the following periods:

- April 1989
- January 1994
- April 1997
- August 1997

The analysis results are as follows:

The significant phenomena are described in Table 6.2.1. Through this analysis, the following facts were clarified:

(1) Scoured pool along the right bank (R10 ~ R8)

The deepest portion is fluctuating around RL. -20 m and its location between R9 and R10 has not changed remarkably. There is no significant change at the contour line RL. -10 m which is considered as the average riverbed.

(2) Sand bar in the middle of the river channel

It is shifting to the left bank relative to the development of small channel on the right side.

(3) Right side small channel (R4 ~ R3)

Since April 1994 up to the present, the flow area of this channel has developed about three times.

(4) Scoured pool along the left bank (L4 ~ L3)

The shoreline has been eroded around 200 m at L3 from April 1989 to the present. The deepest bed of the scoured pool is almost constant at approx. RL -16 ~ -18 m. Regarding its location, no remarkable change has been seen along the line R4 - L4.

The cross-sections of R3 - L3 and R4 - L4 are shown in Fig. 6.2.1. Based on this figure, a quantitative analysis of the change of the right side channel, the sand bar and the left side channel was carried out. The results are summarized in Table 6.2.1, which shows the tendency of expansion of the right side channel and reduction of the left side channel.

6.3 Condition of Local Scour Around the Bridge Piers

6.3.1 Outline of Survey Result

During the First Survey in April 1997, the measurement of the riverbed along the Bridge axis was conducted by divers and using tapes. During the Second Survey in August, the measurement was conducted by means of tapes and echo sounding due to the flow velocity and depth of the river. The results are shown in Fig. 6.3.1.

Stone pitching was provided in a radius of 30 m to 40 m around the bridge piers to protect them against scouring. A cone-shaped surface of the protection, formed by erosion of the riverbed between the piers, was confirmed through the survey by divers in April.

Table 6.2.1 Chronological Features of Riverbed and Sand Bar

Location	Apr. 1989 (Dry season)	Jan. 1994 (Dry season)	Apr. 1997 (Dry season)	Aug. 1997 (Rainy season)
Scoured pool near the right bank (R10 ~ R8)	The lowest river bed elevation is approx. RL.-20m which is located along the survey line R9 - L9. The contour line RL.-10m extends to the line R7 - L7.	The contour line RL.-10m is almost the same as the one in Apr. 1989. But the end of RL.-18m extends up to around 400m downstream.	Scouring at deep pool has proceeded. The lowest portion is approx. RL.-22m. The location is between the line No.9 and No.10. The downstream end of RL.-10m extends around 100m upstream crossing the line R7 - L7.	The contour line RL.-20m has moved downstream around 200m to 300m. On the contrary, the downstream end of the contour line RL.-10m has shifted upstream up to the line R7 - L7.
Sand bar (No.5 ~ No.2)	On the line R4 - L4, a sand bar of which ground level is RL.+4.0m and width is approx. 400m, is confirmed.	The shape of the sand bar is not clear along the line R4 - L4. The downstream end of the sand bar, with a ground elevation of RL.+4.5m, is confirmed along R3 - L3. According to this, the sand bar is shifting toward downstream and expanding toward the left bank.	Along R4-L4, the shape of the sand bar is not clear. Relative to the widening of the right side channel, the sand bar has developed toward the left bank.	Almost no change after Aug. 1997
Right side channel (L4 ~ R3)	River width is approx. 270m at R3 and approx. 500m at R4.	River width is approx. 580m at R3 and approx. 640m at R4. Flow area has developed around three times the one in Apr. 1989.	River width is approx. 570m at R3 and approx. 640m at R4.	River width is approx. 570m at R3 and approx. 640m at R4. The width is gradually developing at R3.
Scoured pool near the left bank (L4 ~ L3)	The lowest riverbed elevation is approx. RL.-16m. Its location is between L4 and L3.	The lowest riverbed elevation is approx. RL.-17m. The depth of RL.-16m has shifted upstream a little, but the width has not changed.	The lowest riverbed elevation is around RL.-16m. The location is between the line L3 and L4.	The lowest river bed elevation is approx. RL.-18m. The range of contour line RL.-16m has become narrower.

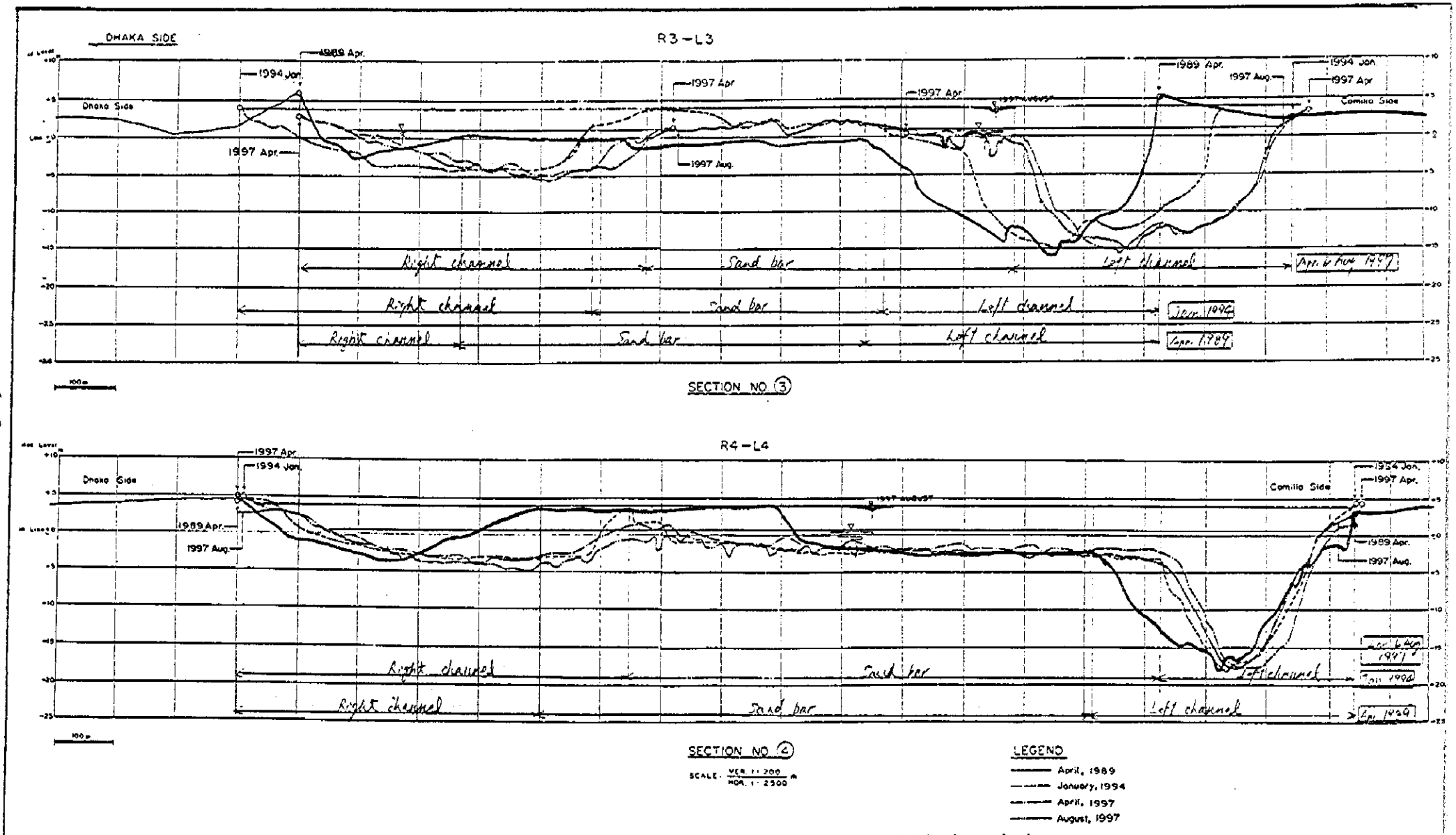
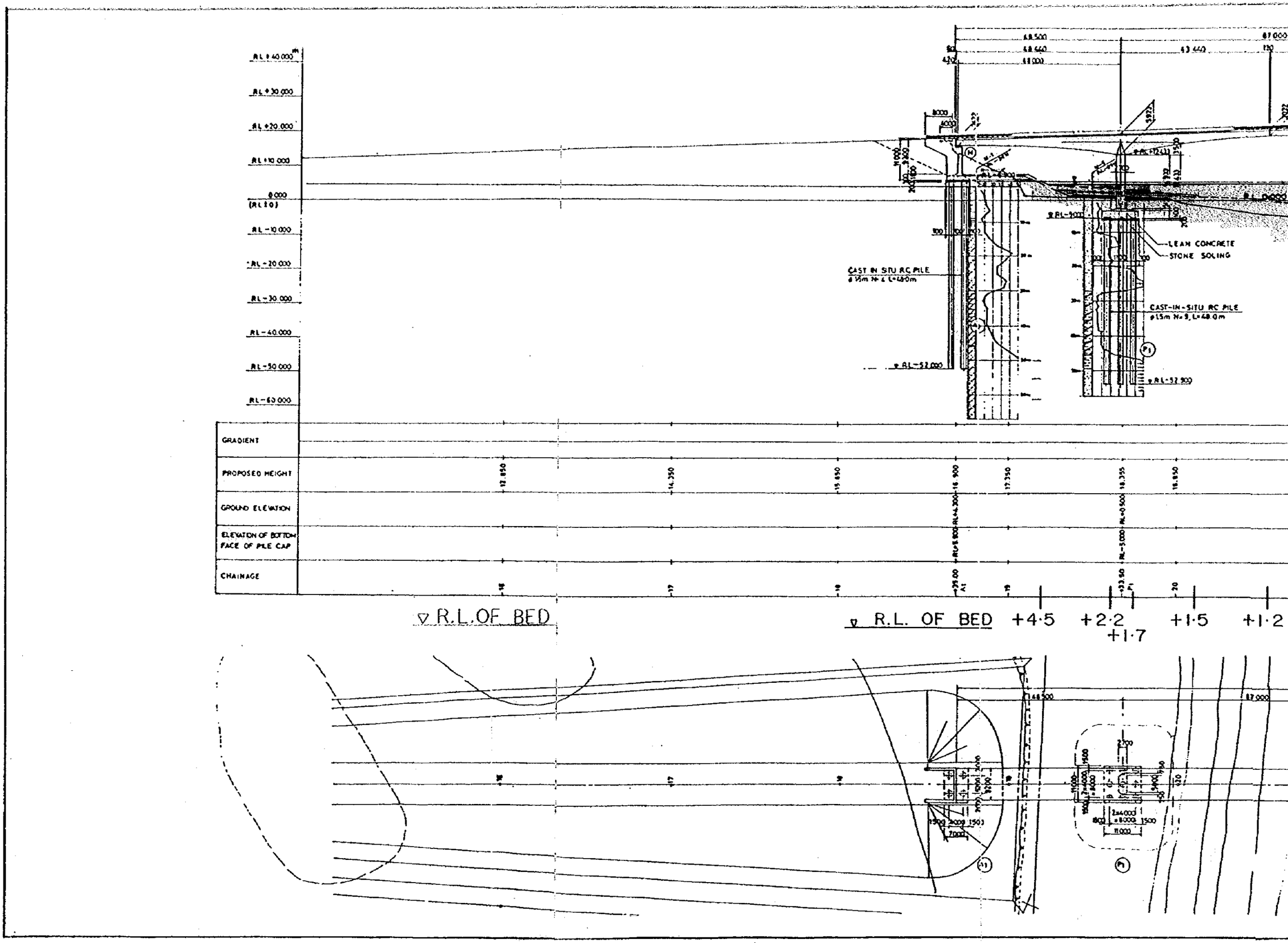
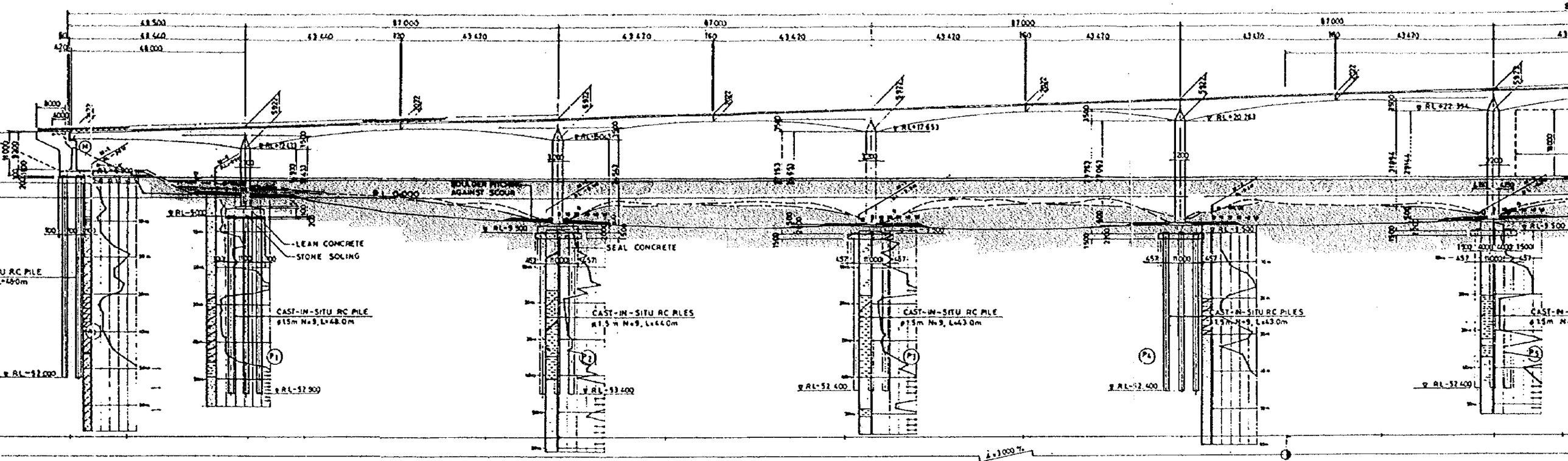


Figure 6.2.1 River Cross-Sections of No.3 and 4


RL +40.000
RL +30.000
RL +20.000
RL +10.000
0.000 (RL 30)
RL -10.000
RL -20.000
RL -30.000
RL -40.000
RL -50.000
RL -60.000
GRADIENT
PROPOSED HEIGHT
GROUND ELEVATION
ELEVATION OF BOTTOM FACE OF PILE CAP
CHAINAGE
12.850
14.250
15.850
16.900
12.350
18.355
18.850
RL+5.800
RL+4.300
RL+0.500
RL-5.000
39.00
33.50
38
37
36
35
34
33
32
CAST IN SITU RC PILE
ø 1.5m N= 6 L=48.0m
CAST-IN-SITU RC PILE
ø1.5m N= 9, L=48.0m
LEAN CONCRETE
STONE SOLING
▽R.L.OF BED
▽ R.L. OF BED +4·5 +2·2 +1·7 +1·5 +1·2


BOULDER PITCHING AGAINST SCOUR
LEAN CONCRETE
STONE SOLING
SEAL CONCRETE
CAST-IN-SITU RC PILE
CAST-IN-SITU RC PILES
CAST-IN-SITU RC PILE
CAST-IN-SITU RC PILES
L. OF BED +4·5 +2·2 +1·7 +1·5 +1·2 -1·9 -6·4 -5·9 -1·9 -1·4 -1·8 -6·5 -6·5 -1·6 -1·2 -1·4 -5·8 -6·3 -1·6 -1·7 -1·9 -6·5 -6·5

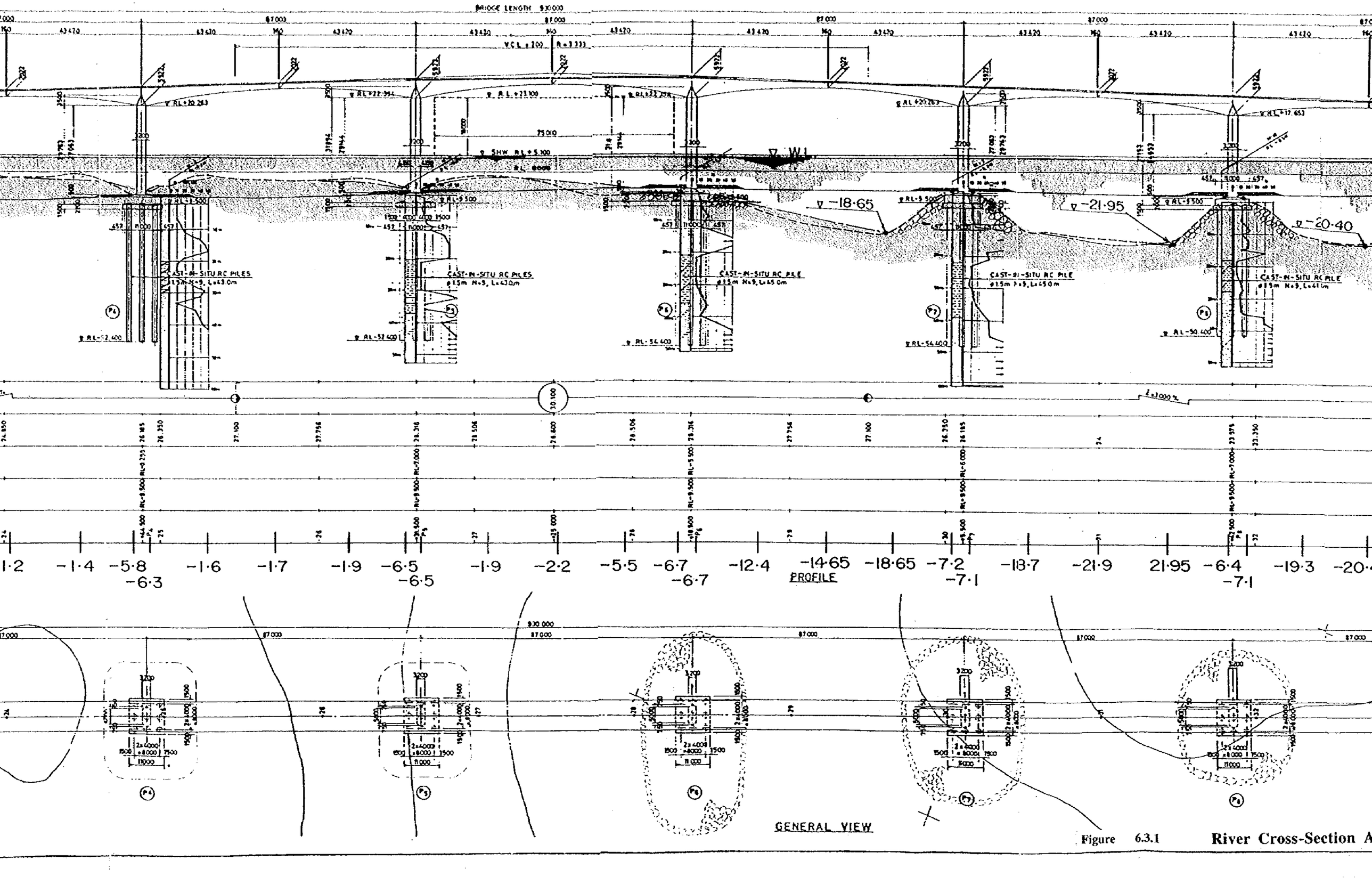


Figure 6.3.1 River Cross-Section A

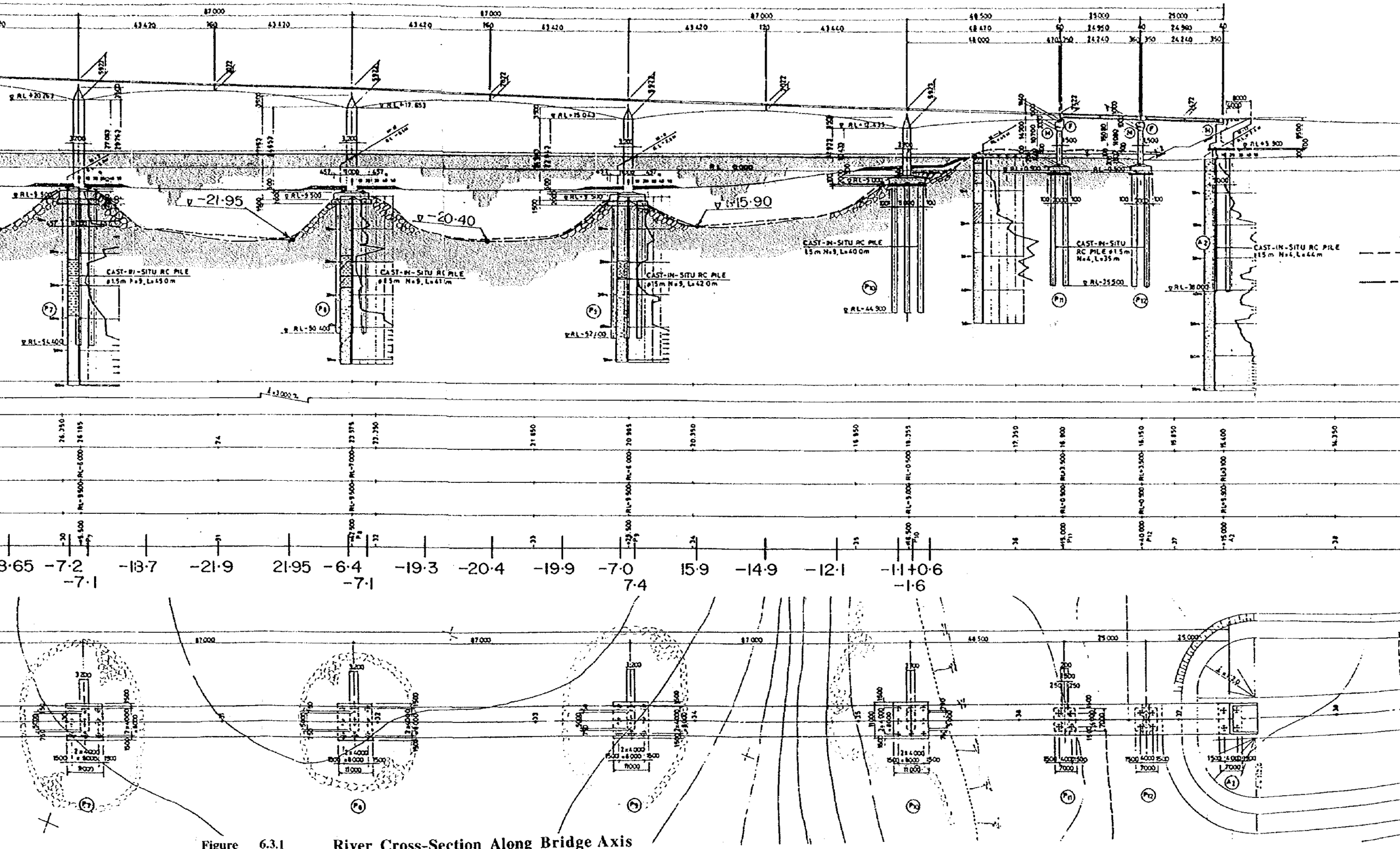
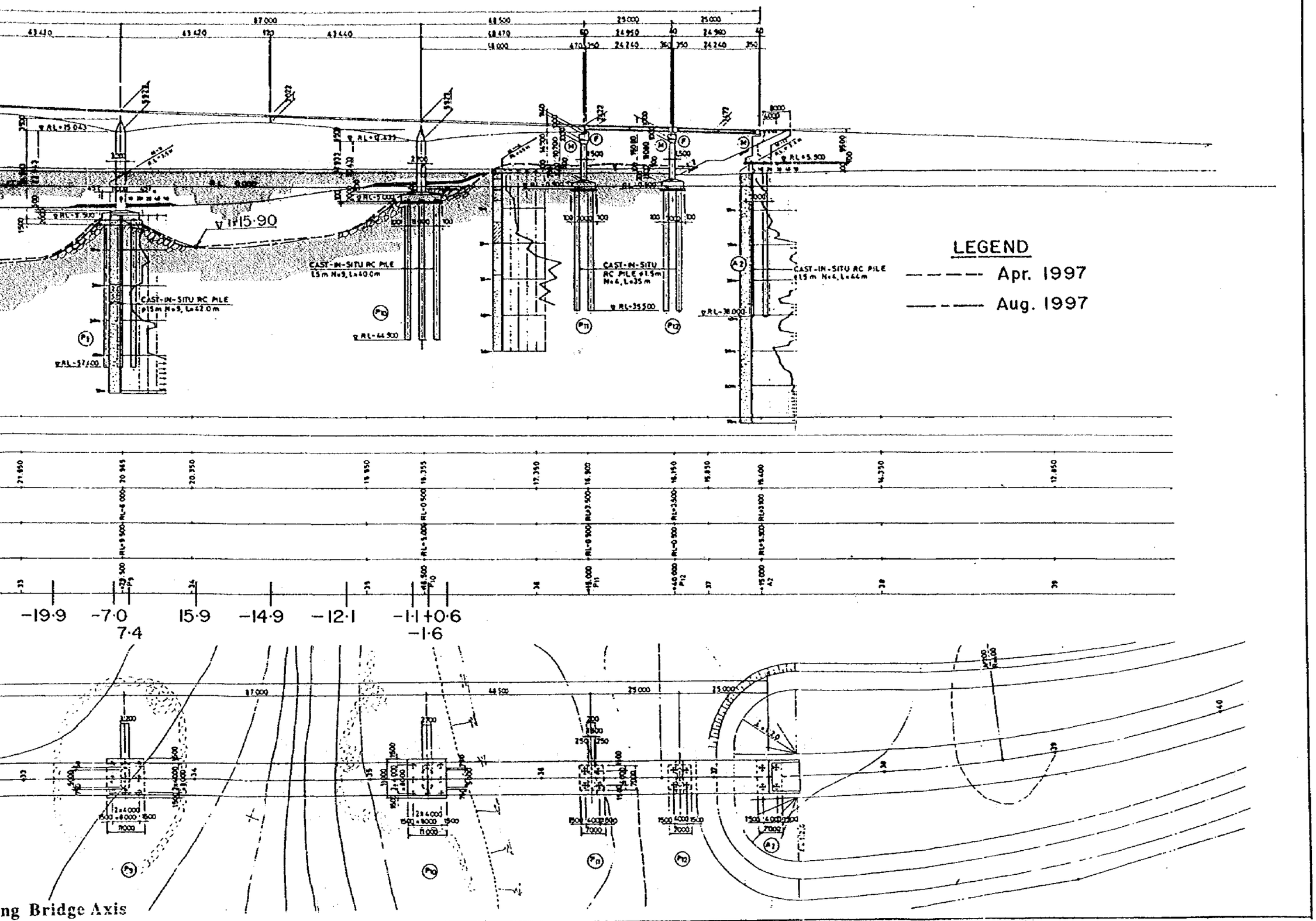


Figure 6.3.1 River Cross-Section Along Bridge Axis



ng Bridge Axis

Furthermore, it was confirmed that the lower plane of the concrete footing was severely scoured but no piles were exposed. This shows that the riprap played a function of protection against scouring. At the P8, base concrete (1.5 m thickness) was separated beneath the footing at some portions.

The stone pitching consists of rubble stone with a diameter of 15 cm to 30 cm. A stable cone-shaped surface is formed around the piers from the footing to the riverbed with an angle of 20 to 45 degrees in a radius of 20 m to 30 m. Further, random scattering of pitched stones can be seen on the riverbed at some portions. But the cone shape as a whole remains.

With regard to the riverbed elevation between the piers, no significant change is identified between the First and the Second Surveys. The lowest elevation is RL. -21.95 m between P7 and P8. In the Feasibility Study in 1985, the designed maximum scoured level of RL. -22.0 m was applied and friction at circumference of the piles was neglected up to the scoured level.

In the section from P1 to P4, the riverbed has been lowered to 0.5 m to 1.0 m from April to August 1997 due to erosion of the sand layer on the surface. On the contrary, in the section from P5 to P7 the riverbed has risen to 0.5 m to 1.5 m and tendency of siltation was confirmed.

The detailed condition around the piers from P6 to P10 is described in the next sub section, based on the results of surveys by divers using video and photocameras.

6.3.2 Condition of Erosion near the Bridge Piers

(1) Pier P6 (P1 ~ P5)

The tractive force is relatively small at the riverbed from piers P1 to P6 due to the fact that the water depth is shallow and the bed is covered with suspended soil transported from upstream stretches. At the riverbed between piers P1 and P5, a sand layer of 5 to 7 m has accumulated after the construction of the Bridge and the riverbed elevation is RL. -0.8 to -2.0 m. However, the elevation at the upper plane of the footing at P2 to P5 is RL. -5.0 to -6.5 m and the sand layer is thin.

On the other hand, the pitched stone mat forms a gentle slope from the footing to the riverbed at P6 and its cone shape remains. The sand settled on the surface of the stones can be easily removed. Observation of scouring and displacement under the footing has not been made. On the surface of the riverbed, a loose sand layer has accumulated and the elevation at the tip of the pitched stone mat is RL. -10.4 m.

(2) Pier P7

The pitched stone mat forms a gentle slope and stiff and stable riverbed composed of a sand layer around P7 as well as P8. The riverbed elevation at the tip of the pitched stone mat is RL. -12.3 m and no suspended load is seen. The lower plane of the footing is covered by the pitched stone and no serious scouring and displacement are identified.

(3) Pier P8

Because the tractive force is relatively large around P8 due to its depth of approx. 20 to 22 m, the bed material was hardly taken by hand and eventually a solid sand layer forming the present riverbed was confirmed. Therefore, the pitched stone mat cannot be seen on the surface of the present riverbed. The present riverbed is formed by a solid sand layer with N-value of over 20 according to the drilling logs.

The riverbed elevation at the tip of the pitched stone mat was measured to be RL. -20.55 m. The supplemental survey by rods and ropes showed that the lowest elevation near P8 was RL. -21.3 m.

The scouring depth adopted in the detailed design of the Meghna Bridge was at RL.-22.0 m. Although, there was no serious problem of stability, the stability of the piers is verified in Section 6.4 by changing the scoured bed elevation.

(4) Pier P9

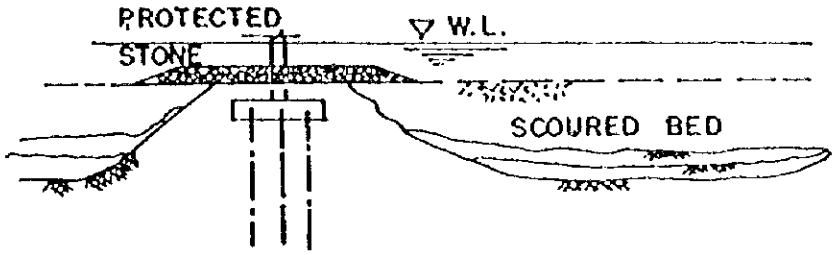
As same as P7, the pitched stone mat forms a gentle slope and the riverbed on the upstream side consists of a slightly stiff sand layer. The riverbed on the downstream side is composed of a relatively stiff sand layer. The lower plane of the footing is covered by pitched stones.

(5) Pier P10

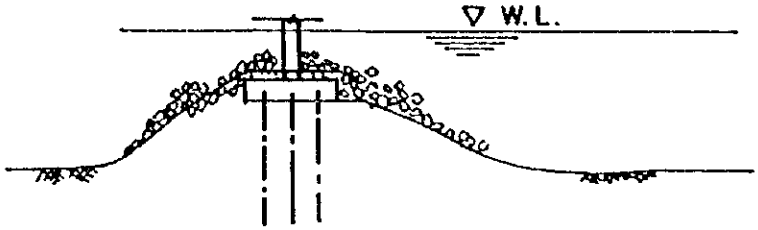
P10 is located near the existing revetment and the upper plane of the footing and its surroundings are wholly covered by stones. No scouring near the pier is observed.

On the Dahka side of the pier, the pitched stone mat forms a slope of the slope approx. 25 m long and the riverbed consists of a loose sand layer. The present riverbed including the pier section is considered to be experiencing the process as shown in Fig. 6.3.2.

(i) The river bed has been gradually scoured by large scale floods



(ii) The pitched stones fell down as the scouring of the riverbed proceeded.



(iii) The pitched stones formed a cone shape and became stable on the present riverbed,

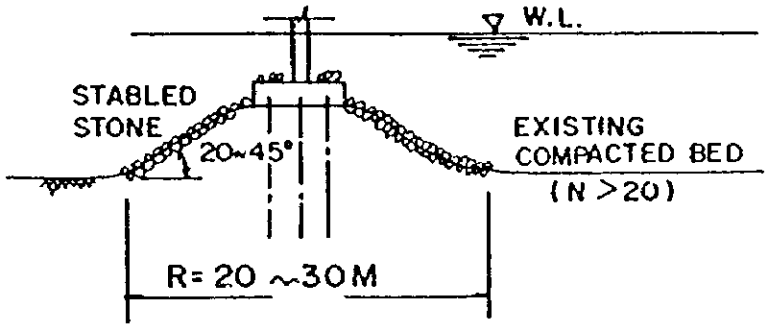


Fig. 6.3.2 Process of Scouring near the Bridge Piers

6.4 Stability Analysis of Piers

The lowest bed elevation between the piers of the Meghna Bridge was measured to be R.L.-21.95 between P7 and P8 as shown in Figure 6.4.1.

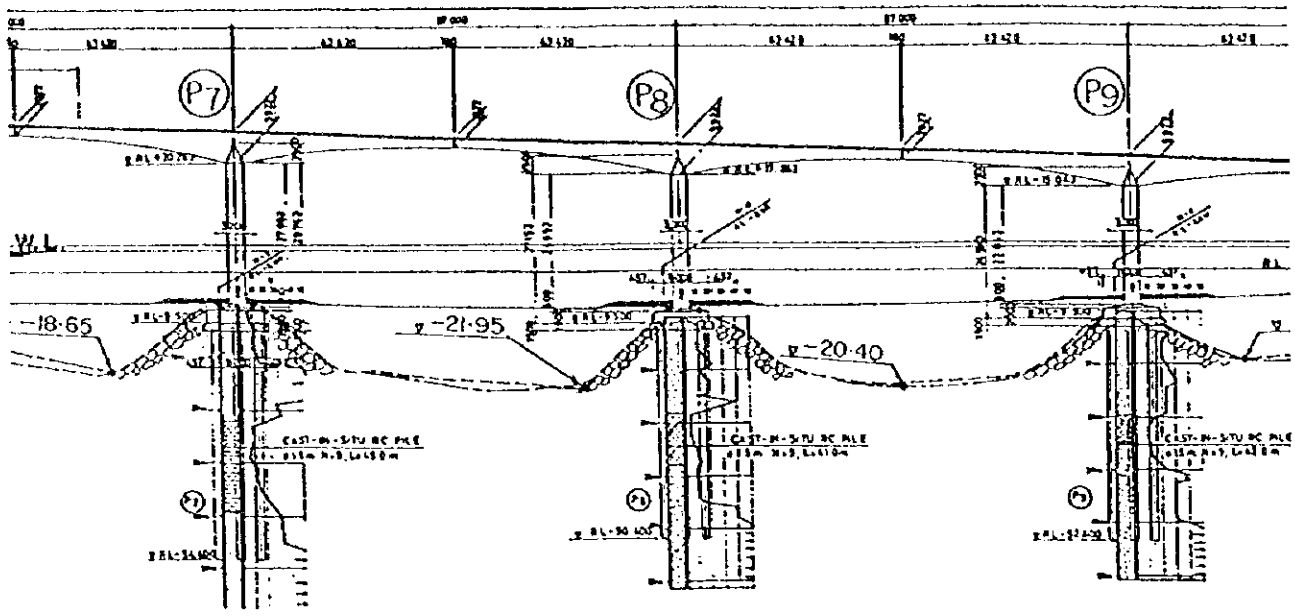


Figure 6.4.1 Existing Riverbed at the Meghna Bridge

In the "Final Report of the Feasibility Study on the Meghna, Meghna-Gumti Bridges Construction Project, March 1985", the following items were studied (see Figure 6.4.2).

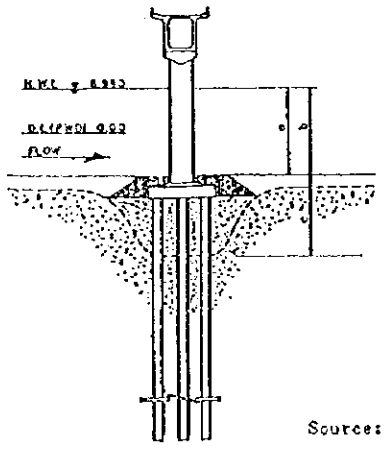


Figure 6.4.2 Scour Depths

Therefore, it can be concluded that the existing bed elevation R.L.=-22.0 is safe from the structural viewpoint. In particular the riverbed between P7 and P9 is composed of a hard sand layer and the scouring has not occurred.

In order to prevent further scouring in the future, however, the provision of protection works around the piers and the riverbed between the piers is recommended. Besides, river cross-section survey along the centerline of the bridge should be conducted periodically in the future.

6.5 Flow Condition and Local Scouring near the Meghna Bridge

6.5.1 Flow Condition near the Meghna Bridge

(1) Measurement of Flow Direction and Discharge in August 1997

a) Method of measurement

Measurement of flow direction and discharge by means of an electro-magnetic type current meter (Type ACM-210 D/H, made by Hydrotech) along 5 cross-sections (Fig. 6.5.1): one on the Bridge axis, three on the upstream river stretch (No. 10, 3, 1) and one on the downstream river stretch (No. D1). The horizontal distance was measured by two boats using measuring ropes at intervals of approx. 100 to 150 m and the vertical distance was measured at intervals of 2 m. Along the bridge axis, measurement was made at the center of the piers. Each measurement was carried out when the current becomes biggest at ebb tide.

Further, in order to grasp the mechanism of vortex in front of the existing revetment, measurement of flow direction and velocity was carried out at 12 sites along 3 sections between P10 and P8 located in the dead flow area and the deep scoured pool and 4 sections in the right-angle flow direction (Fig. 6.5.2).

b) Survey result

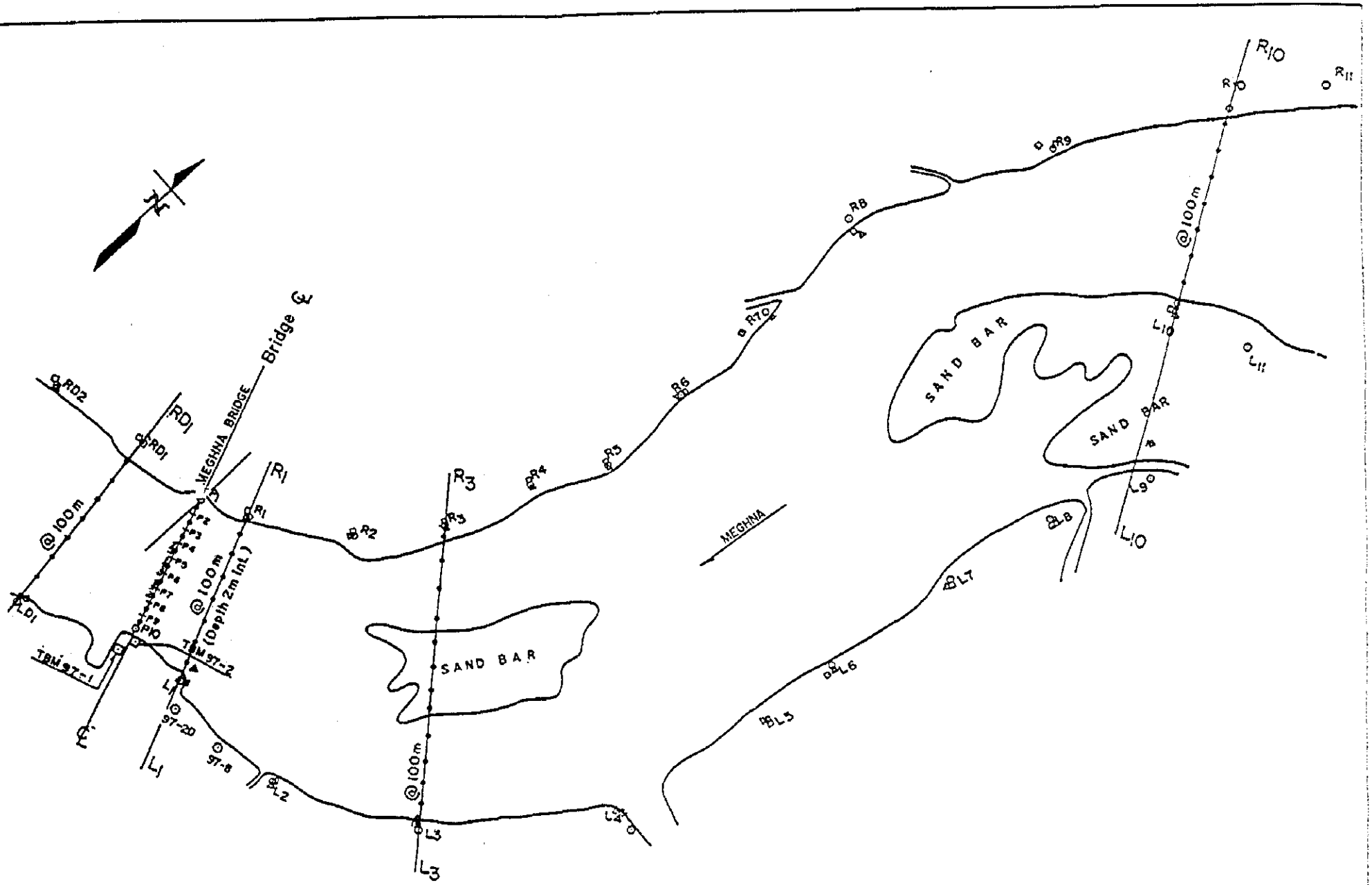
The water level during the measurements was RL. +4.30 to +4.80 m. The flow velocity measured along the 5 cross-sections was 50 to 60 cm/s at the water surface and 30 to 50 cm/s at the riverbed. In comparison with the velocity measured in the First Survey, these figures represent an increase of around 20 to 50%. The vertical distribution of velocity at each cross-section is shown in Figs. 6.5.3 and 6.5.4. The characteristics of each section are as follows:

R10 - L10: Flow velocity is relatively large along the left bank on the opposite side of the thalweg.

R3 - L3: At the section near the left bank and in the separated channel on the right side, flow velocity is relatively large.

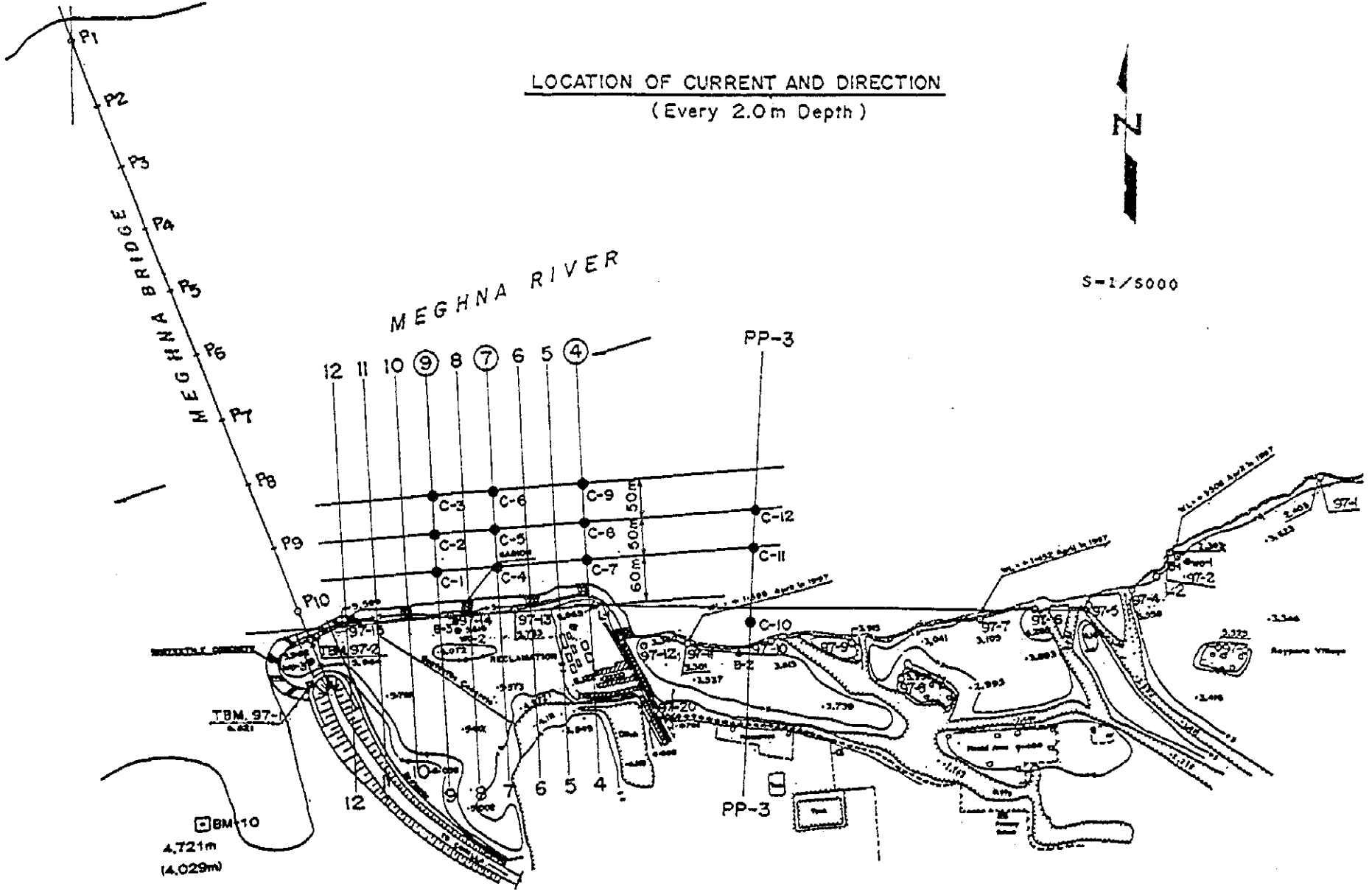
R1 - L1: At the section near the left bank, flow direction is reverse at the bottom.

Bridge axis: Flow velocity is almost uniform.



PROTECTION WORKS FOR MEGHNA BRIDGE

Figure 6.5.1 Location Map of Flow Velocity and Direction Survey (1/2)



PROTECTION WORKS FOR MEGHNA BRIDGE

Figure 6.5.2 Location Map of Flow Velocity and Direction Survey (2/2)

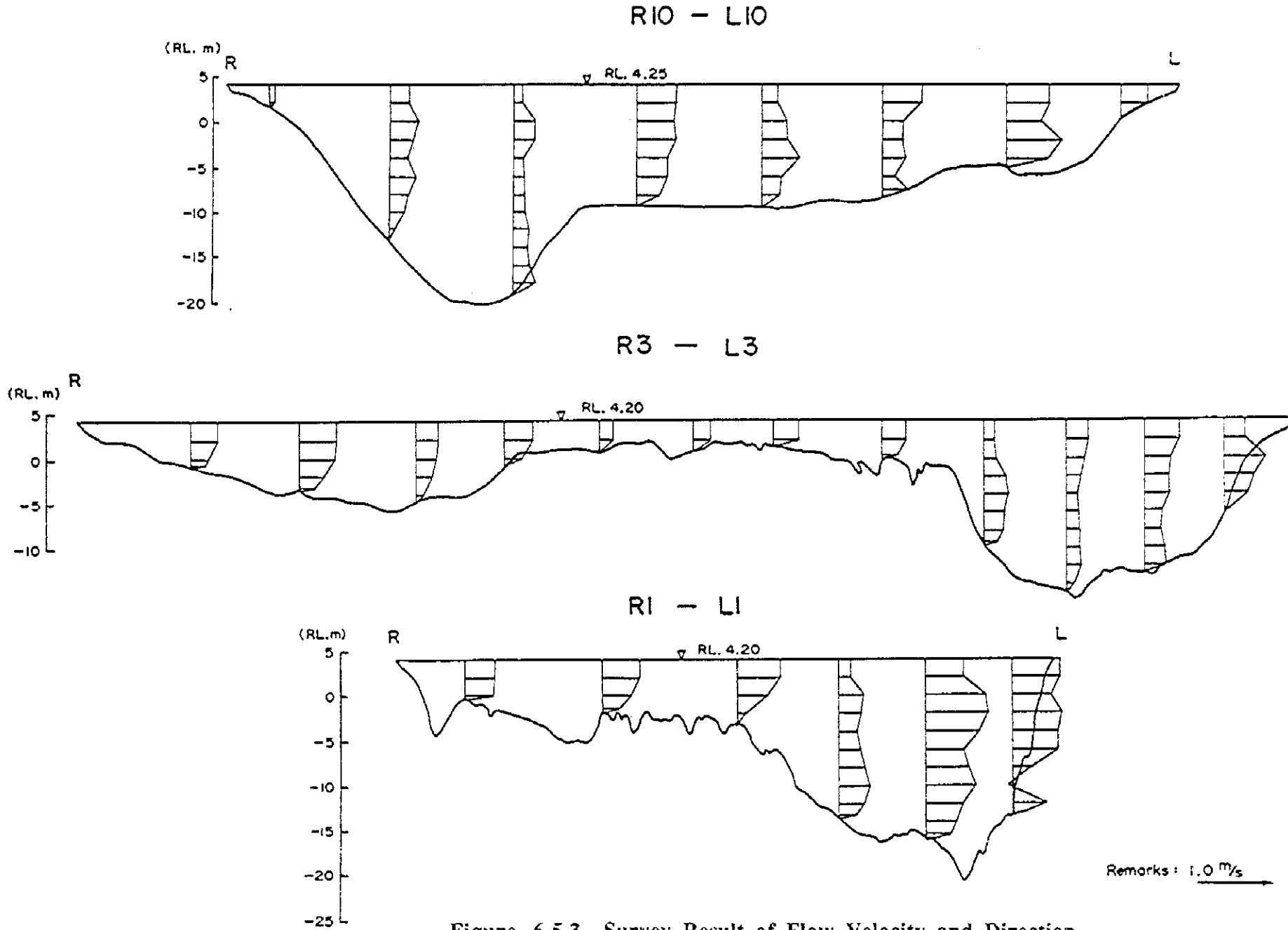


Figure 6.5.3 Survey Result of Flow Velocity and Direction (along river cross-section) (1/2)

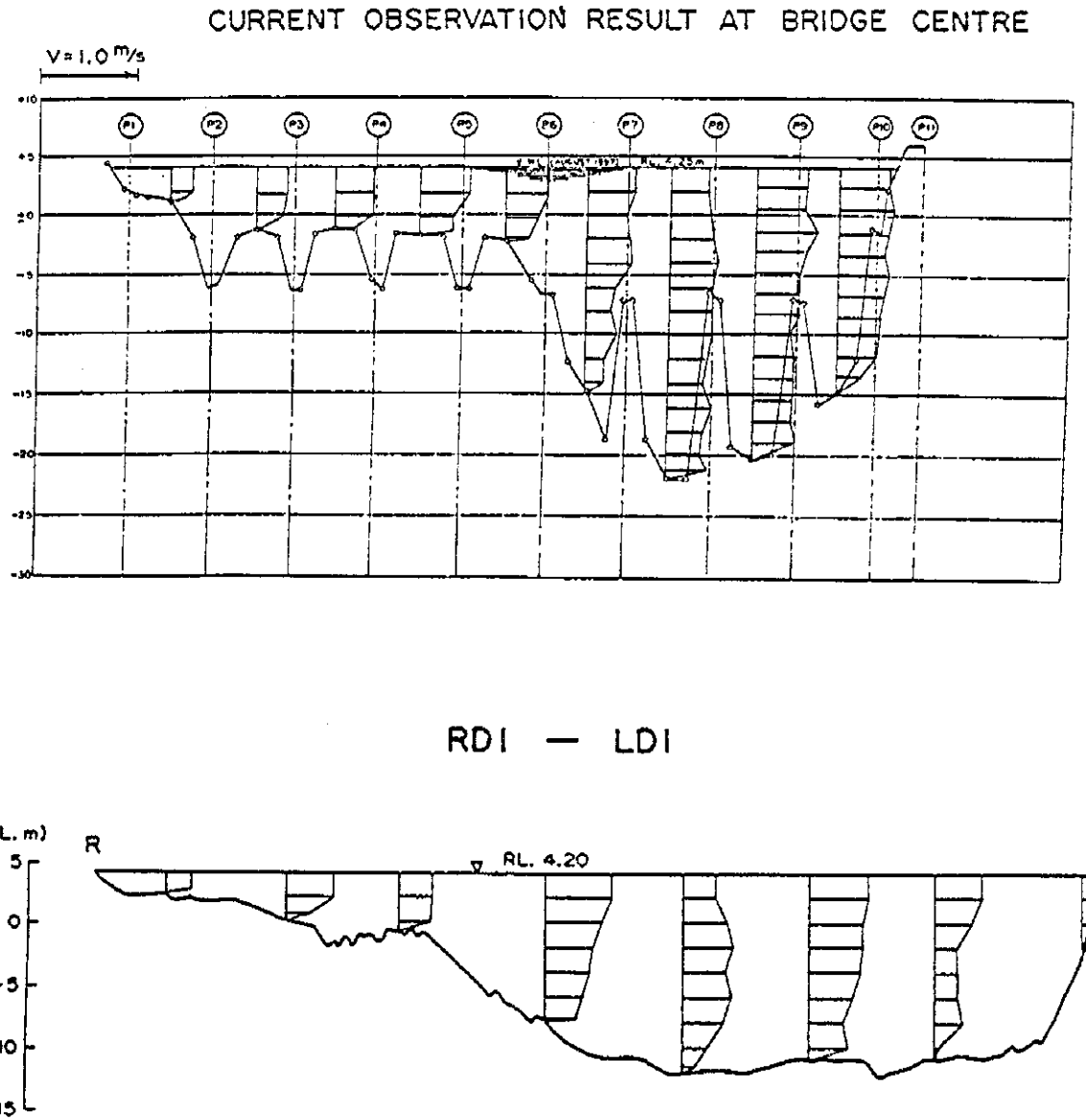


Figure 6.5.3 Survey Result of Flow Velocity and Direction (along river cross-section) (2/2)

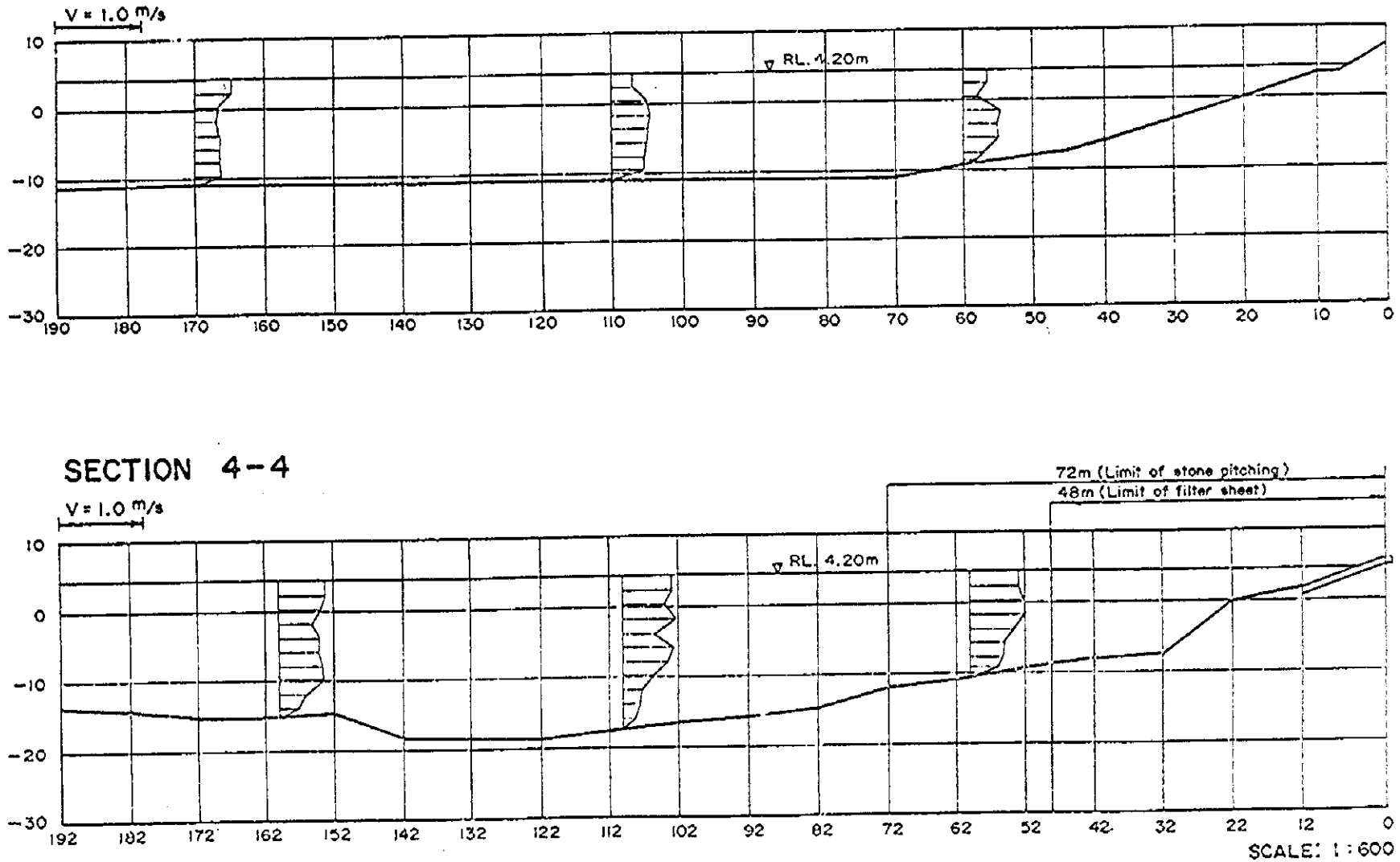
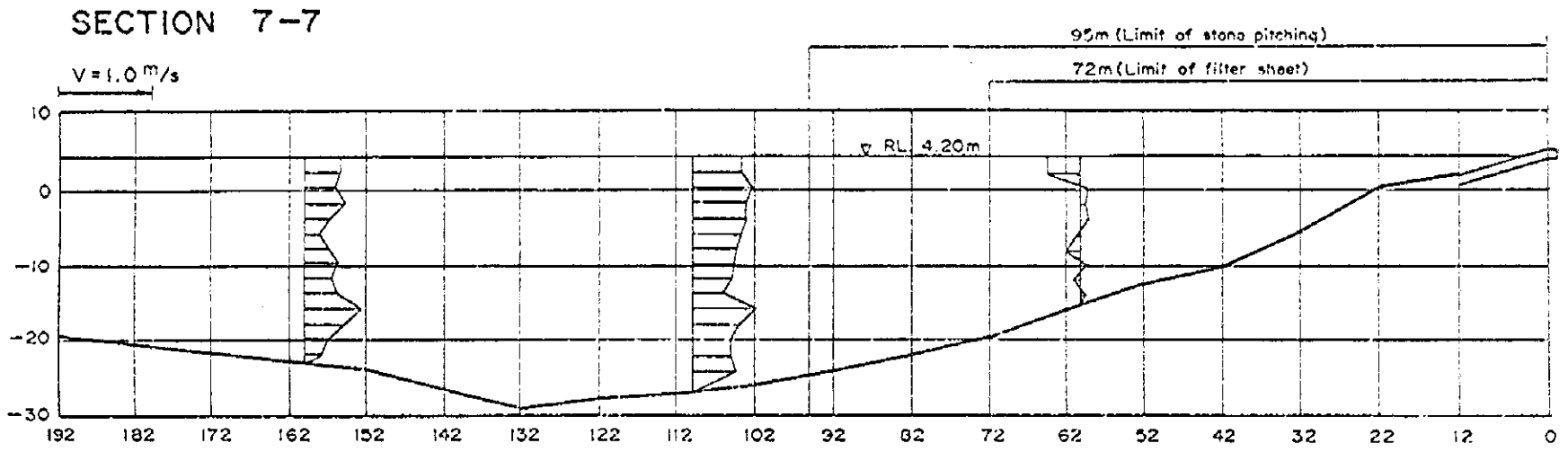


Figure 6.5.4 Survey Result of Flow Velocity and Direction (in front of existing revetment) (1/2)



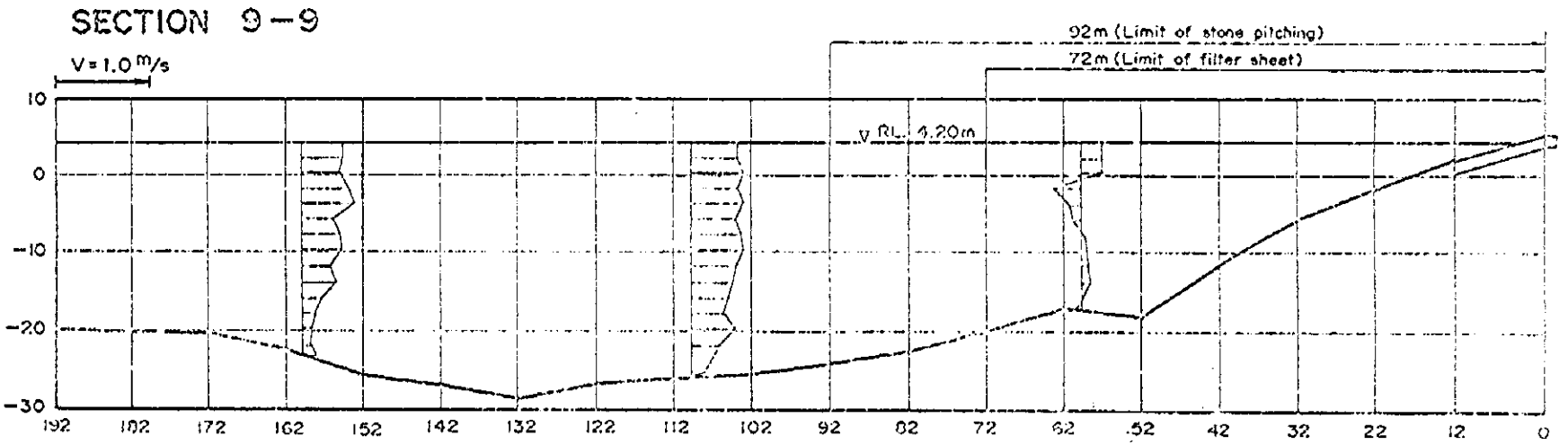


Figure 6.5.4 Survey Result of Flow Velocity and Direction (in front of existing revetment) (2/2)

RD1 - LD1: Near the center of the thalweg, flow velocity is relatively large.

Fig. 6.5.4 shows the results of measurement at the river cross-sections near the existing revetment immediately upstream of the Bridge. It is clarified that the flow velocity in front of the shoreline along Sections No. 7-7 and No. 9-9 is small and the flow direction is rather complex. The flow direction and velocity at each site at the same depth are illustrated in Fig. 6.5.5. The field records of measurements are tabulated in Table 6.5.1.

The discharges along the 5 sections were estimated based on the flow velocity and cross-sections as shown in Table 6.5.2. The result shows that the discharge during the measurements was approx. 3,400 to 4,800 m^3/s.

(2) Vortex and Suspended Solid Contents

a) Survey method

Although observation of vortex and measurement of Suspended Solid (SS) contents of water were carried out in the First Survey, the magnitude of discharge was rather small and SS content was nearly zero because significant turbulence of current was not observed. The dead flow area and vortex in front of the existing revetment were clearly identified during the Second Survey in August 1997. Sampling of water for SS contents test was made in 21 sites in total 6 sites immediately upsteam and downstream of P7, P8 and P9, and 15 sites in front of the existing revetment on the left bank. The Kitahara B type measuring apparatus was used (Fig. 6.5.6).

b) Result of survey

The result of laboratory test for SS contents is shown in Table 6.5.3 and illustrated in Fig. 6.5.7 with the contour line of the riverbed which was drawn based on the echo sounding in the Second Survey. According to this record, more than twice concentration of SS was observed on the downstream side of P8 and P9 compared with that on the upstream side of the piers. At pier P7, the upstream SS concentration was a little higher than the downstream one.

On the other hand, in front of the existing revetment a relatively high SS concentration was observed along the survey line between P8 and P9. This survey line approximately coincides with the boundary of the dead

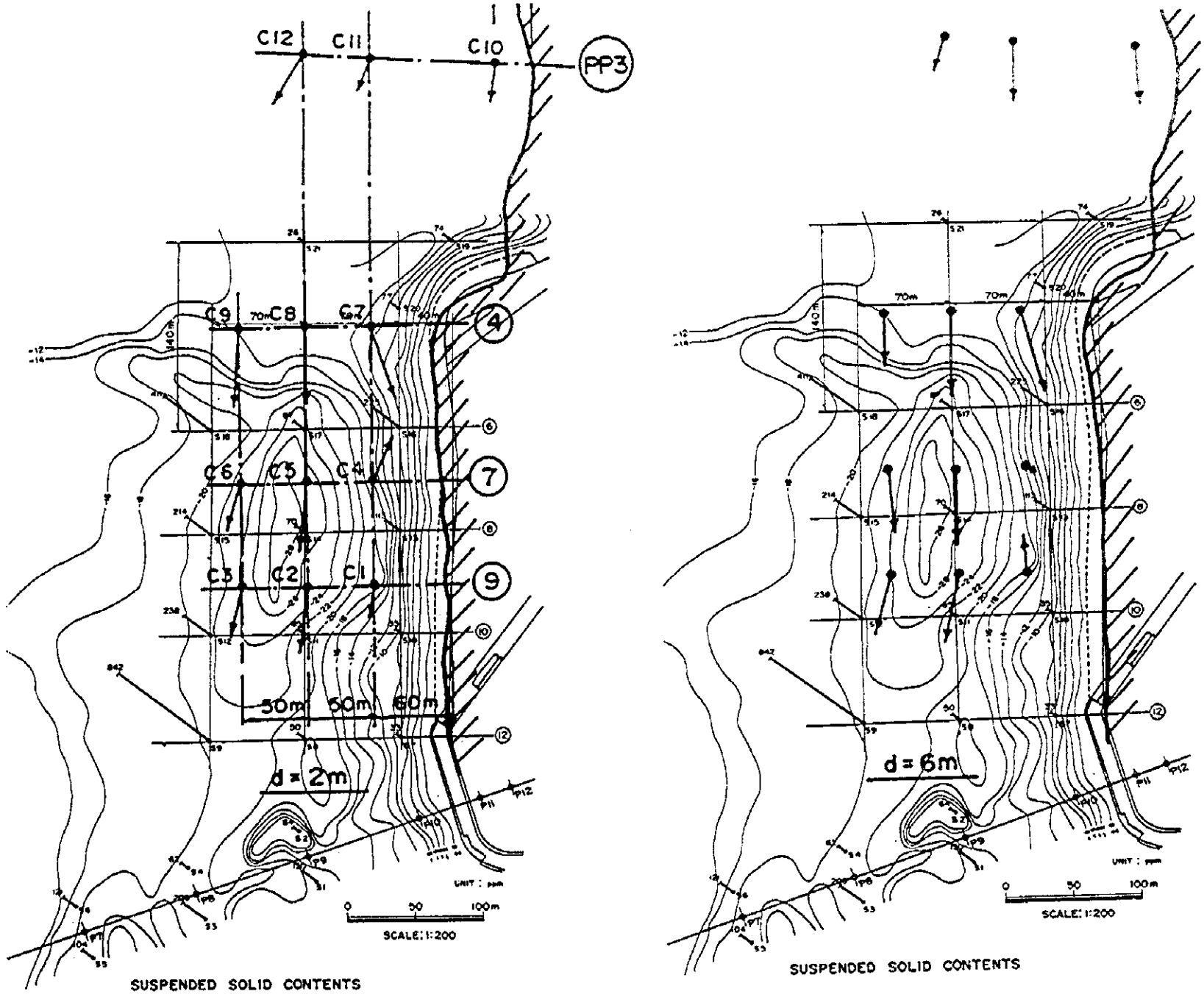


Figure 6.5.5 Plan of Flow Velocity and Direction (1/3)

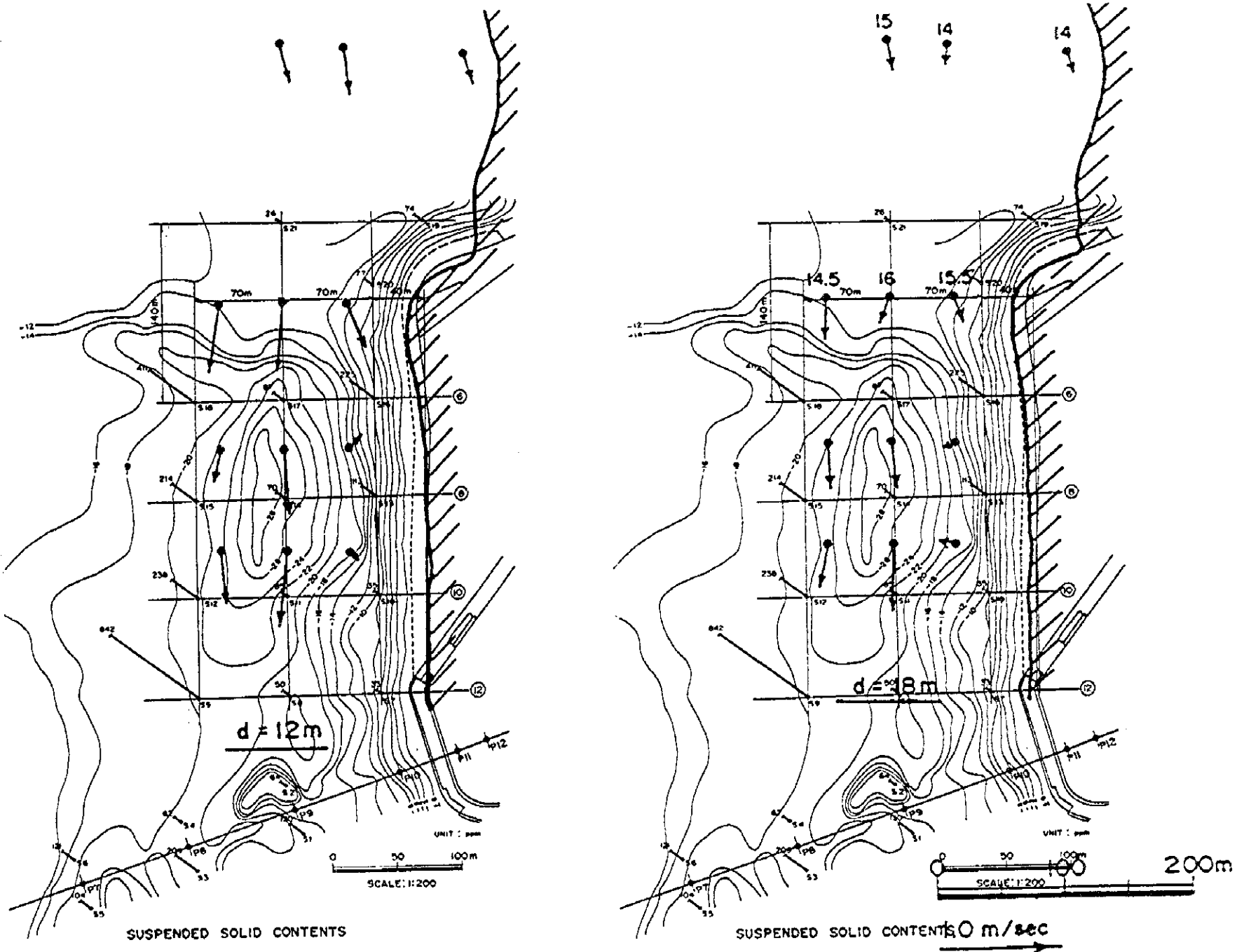


Figure 6.5.5 Plan of Flow Velocity and Direction (2/3)

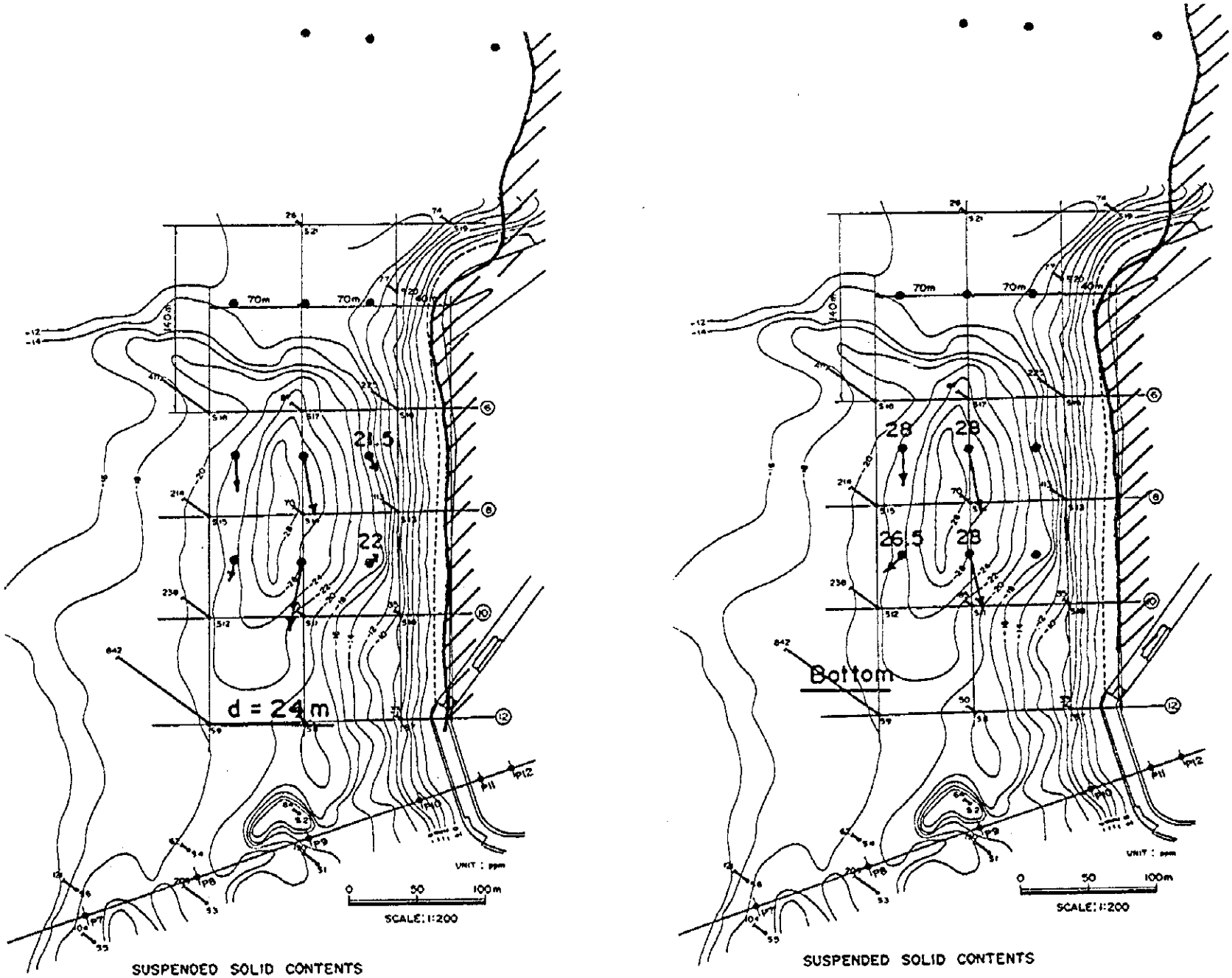


Figure 6.5.5 Plan of Flow Velocity and Direction (3/3)

Section : L10 - R10 Date : August 7, 1997
Water Level : RL. 14.30 m

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Left to Right					
50 m	2	-22.6	-15.0	37.0	234
	3	-18.0	-9.7	14.0	256
	(bottom)			Ave. 25.5	Ave. 240.0
150 m	2	-41.0	-44.0	59.0	229
	4	-48.0	-52.9	48.6	227
	6	-48.3	-58.1	76.7	229
	8	-36.1	-45.2	58.6	236
	9	-33.0	-41.1	55.1	201
	(bottom)			Ave. 59.6	Ave. 224.9
250 m	2	-38.6	-45.9	54.4	236
	4	-31.0	-38.0	29.8	250
	6	-26.2	-29.5	28.9	242
	8	-29.6	-27.2	31.4	235
	10	-18.6	-14.5	18.5	255
	12	-24.4	-26.1	36.0	223
	13	-4.6	-21.3	21.9	203
	(bottom)			Ave. 31.6	Ave. 234.7
350 m	2	-42.2	-41.3	21.1	234
	4	-29.1	-32.2	35.5	247
	6	-27.2	-29.2	35.8	229
	8	-41.4	-42.4	51.2	229
	10	-23.3	-21.1	27.7	212
	12	-26.4	-24.2	26.1	212
	13	-8.4	-15.5	18.2	297
	(bottom)			Ave. 30.8	Ave. 234.0
450 m	2	-36.8	-42.2	53.3	318
	4	-36.8	-42.2	50.0	230
	6	-35.4	-37.8	52.6	227
	8	-32.6	-37.6	40.7	234
	10	-34.4	-33.6	42.8	227
	12	-29.1	-28.6	31.3	216
	13	-7.9	-21.6	13.1	259
	(bottom)			Ave. 40.5	Ave. 245.9
550 m	2	-10.5	-12.8	9.1	326
	4	-16.3	-26.8	29.4	234
	6	-15.7	-19.4	28.1	221
	8	-15.7	-16.4	12.6	217
	10	-17.3	-16.6	15.7	216
	12	-14.6	-10.1	15.5	222
	14	-14.0	-15.5	15.5	236
	16	-18.8	-23.0	21.4	199
	18	-19.2	-27.2	19.0	199
	20	-23.9	-21.0	23.0	217
	22	-22.6	-19.6	32.0	198
	24	-22.3	-8.7	21.4	215
	25	-18.6	-5.5	12.5	181
	(bottom)			Ave. 19.6	Ave. 217.5
650 m	2	-25.9	-24.3	24.2	253
	4	-28.1	-34.2	38.7	207
	6	-27.2	-29.9	32.1	221
	8	-24.2	-28.2	24.1	211
	10	-30.2	-28.7	36.6	212
	12	-23.9	-27.7	26.8	210
	14	-20.7	-20.2	21.2	202
	15	-7.6	-7.9	7.8	234
	(bottom)			Ave. 26.4	Ave. 216.6
750 m	2	-7.0	+5.5	7.8	224
(20 m from R10)	2.6	-7.8	-0.9	8.2	254
(Say)	(bottom)			Ave. 8.0	Ave. 239.4

PROTECTION WORKS FOR MEGHNA BRIDGE	Table 6.5.1 Survey Result of Flow Velocity and Direction (1/6)

Section : L3 ~ R3
Water Level : RL. +4.20 m

Date : August 9, 1997

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Left to Right					
50 m	2	+27.8	+42.7	29.4	230
	4	+25.1	+51.4	57.9	235
	6	+20.0	+50.6	41.8	224
	8	+15.6	+40.5	33.3	234
	10	+11.3	+21.1	25.3	251
	(bottom)			Ave. 37.5	Ave. 233.7
150 m	2	+14.3	+44.9	49.1	222
	4	+15.4	+46.4	38.8	228
	6	+8.6	+40.3	35.3	224
	8	+16.9	+43.9	35.5	238
	10	+9.6	+32.4	25.6	240
	12	+7.1	+35.0	23.3	231
	14	+8.8	+35.8	28.6	232
	16	+9.0	+31.8	30.1	234
	(bottom)			Ave. 33.3	Ave. 230.7
250 m	2	+13.9	+32.9	31.1	198
	4	+10.4	+25.4	26.3	215
	6	+9.0	+25.0	21.0	212
	8	+5.1	+18.9	15.3	230
	10	+8.8	+27.0	18.8	250
	12	+9.7	+19.7	19.7	249
	14	+10.6	+22.0	19.4	262
	16	+11.0	+18.3	19.9	261
	18	-11.5	+5.9	11.4	246
	(bottom)			Ave. 20.3	Ave. 232.2
350 m	2	+10.9	+16.6	15.9	290
	4	+6.4	+16.1	17.2	265
	6	+17.4	+34.4	32.0	222
	8	+22.9	+35.1	35.4	231
	10	+17.8	+31.7	29.7	235
	12	+12.9	+29.9	27.8	237
	14	+10.0	+17.6	18.4	232
	(bottom)			Ave. 25.2	Ave. 239.7
450 m	2	+30.6	+39.5	40.0	226
	4	+19.8	+20.8	29.5	208
	(bottom)			Ave. 34.8	Ave. 218.4
550 m	2	+22.1	+38.7	37.9	203
	3	+15.4	+27.1	23.5	232
	(bottom)			Ave. 30.7	Ave. 214.1
650 m	2	+8.5	+21.7	25.7	252
	2.5	+6.5	+13.9	17.2	261
	(bottom)			Ave. 21.5	Ave. 255.6
750 m	2	-2.3	+19.8	20.2	220
	3	-2.9	+1.5	3.2	186
	(bottom)			Ave. 11.7	Ave. 215.4
850 m	2	+15.6	+40.0	38.6	206
	4	+14.1	+26.3	25.4	220
	(bottom)			Ave. 32.0	Ave. 211.6
950 m	2	+20.7	+34.7	31.3	214
	4	+11.3	+36.3	29.6	239
	6	+13.5	+23.9	23.8	255
	8	+6.7	+9.9	10.7	252
	9	+5.2	+4.9	9.5	292
	(bottom)			Ave. 21.0	Ave. 241.3

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
1050 m	2	+32.9	+59.0	51.2	207
	4	+36.5	+53.7	49.1	221
	6	+23.6	+46.6	34.4	224
	7	+14.7	+29.7	22.4	228
	(bottom)			Ave. 39.3	Ave. 218.1
1150 m	2	+28.6	+44.6	38.2	204
	4	+15.5	+28.0	26.4	228
	4.5	+4.5	+16.6	19.1	227
	(bottom)			Ave. 27.9	Ave. 216.8
1240 m	1.5	5.5	25.2	25.1	206
	(bottom)				
(on R3)	0.5	9.8	33.2	32.2	212
				Ave. 28.7	Ave. 209.4

PROTECTION WORKS FOR MEGHNA BRIDGE

Table 6.5.1 Survey Result of Flow Velocity and Direction (2/6)

Section : L1 ~ R1 Date : August 9, 1997
Water Level : RL. +4.20 m

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Left to Right					
50 m	2	+51.6	+69.2	66.1	298
	4	+37.7	+68.2	53.9	288
	6	+46.4	+46.6	69.2	286
	8	+41.6	+72.0	63.8	286
	10	+12.1	+68.7	63.0	254
	12	+31.2	+29.0	28.7	252
	14	-0.6	+2.9	3.8	41
	16	+42.7	+34.0	49.1	316
	16.5	+7.9	-11.8	13.9	219
	(bottom)			Ave. 45.7	Ave. 280.0
170 m	2	+26.1	+65.2	52.2	255
	4	+37.4	+76.2	84.6	264
	6	+17.0	+70.6	84.6	268
	8	+27.0	+63.0	74.5	264
	10	+28.4	+62.2	52.2	270
	12	+33.0	+59.3	59.0	266
	14	+27.5	+62.0	68.9	271
	16	+19.2	+53.0	50.3	264
	18	+16.3	+47.3	41.5	264
	20	+15.4	+41.3	35.5	267
	21	-8.9	+37.3	38.7	249
	(bottom)			Ave. 58.4	Ave. 264.5
290 m	2	-9.8	+19.2	17.1	329
	4	-12.9	+47.8	35.4	292
	6	-13.5	+41.6	32.7	269
	8	-8.0	+31.9	25.5	274
	10	-10.6	+38.7	30.9	289
	12	-11.7	+55.4	37.0	292
	14	-10.6	+57.6	43.2	291
	16	-21.4	+44.9	36.6	275
	18	-5.1	+27.7	22.3	268
	19	-3.8	+14.6	14.9	251
	(bottom)			Ave. 29.6	Ave. 283.6
410 m	2	-15.3	+73.1	59.9	236
	4	-9.5	+53.1	42.7	245
	5.5	-6.1	+13.7	10.6	186
	(bottom)			Ave. 37.7	Ave. 234.7
530 m	2	+24.9	+68.7	52.3	239
	4	+18.1	+53.8	40.8	244
	5.5	+11.2	+27.0	23.9	259
	(bottom)			Ave. 39.0	Ave. 244.8
650 m	2	+18.2	+48.4	42.5	236
(100 m from R1)	4	+18.5	+43.5	41.5	244
(Say)	4.5	+8.7	+15.5	15.6	259
	(bottom)			Ave. 33.2	Ave. 242.9

Section : L01 ~ R01 Date : August 9, 1997
Water Level : RL. +4.20 m

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Left to Right					
50 m	2	+15.3	+37.3	33.6	234
	4	+5.4	+27.6	25.9	236
	6	-0.7	+13.9	10.8	125
	(bottom)			Ave. 23.4	Ave. 218.0
150 m	2	+32.6	+52.6	47.7	243
	4	+28.7	+37.6	37.6	248
	6	+15.1	+24.9	21.1	255
	8	+11.0	+22.2	24.7	236
	10	+7.6	+21.6	22.8	202
	12	+12.9	+26.8	28.1	212
	14	+16.4	+23.1	24.8	263
	15.5	+0.5	+2.3	3.0	226
	(bottom)			Ave. 26.2	Ave. 237.8
250 m	2	+52.2	+55.5	59.7	252
	4	+47.9	+53.0	56.5	245
	6	+56.0	+48.0	54.2	247
	8	+39.4	+49.3	50.5	246
	10	+41.8	+44.2	44.2	252
	12	+27.8	+30.0	35.3	261
	12.5	+31.7	+25.3	38.3	259
	(bottom)			Ave. 48.4	Ave. 250.9
350 m	2	+15.4	+38.9	32.4	252
	4	+37.9	+55.3	45.7	243
	6	+34.6	+53.8	51.2	252
	8	+23.1	+49.2	42.3	255
	10	+34.6	+55.6	49.6	242
	12	+25.5	+44.2	41.6	247
	14	+8.5	+13.5	12.5	211
	(bottom)			Ave. 39.3	Ave. 237.0
450 m	2	+53.1	+62.4	67.1	269
	4	+59.1	+51.7	57.0	262
	6	+32.4	+57.6	48.4	262
	8	+34.5	+44.9	45.4	268
	10	+29.1	+46.5	37.5	253
	11	+6.4	+30.3	30.5	291
	(bottom)			Ave. 47.7	Ave. 266.5
550 m	2	+31.5	+39.9	36.3	256
	4	+17.1	+46.7	33.5	228
	5	+17.2	+7.0	11.1	265
	(bottom)			Ave. 27.0	Ave. 245.6
650 m	2	+30.2	+45.7	49.1	266
	4	+36.7	+14.2	22.2	247
	(bottom)			Ave. 35.7	Ave. 260.1
750 m	1.5	-6.1	+15.3	17.3	266
(70 m from RD1)	(bottom)			Ave. 17.3	Ave. 266.0
(Say)					

PROTECTION WORKS FOR MEGHNA BRIDGE	Table 6.5.1 Survey Result of Flow Velocity and Direction (3/6)

Section : Bridge Axis
Water Level : RL. +4.25 m

Date : August 10, 1997

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Middle of Pier 1 & 2	2	+9.2	+22.0	23.9	260
	2.5	-1.7	+12.9	13.5	254
	(bottom)			Ave. 18.7	Ave. 257.8
Middle of P2 & P3	2	+9.2	+49.2	38.4	253
	4	+11.2	+40.6	30.5	267
	4.5	-2.6	+9.3	11.8	253
	(bottom)			Ave. 26.9	Ave. 258.3
Middle of P3 & P4	2	-17.2	+56.9	42.2	247
	4	-24.1	+47.5	41.8	237
	4.8	-8.1	+26.7	21.9	274
	(bottom)			Ave. 35.3	Ave. 248.6
Middle of P4 & P5	2	-38.5	+58.9	54.8	246
	4	-24.7	+36.4	34.4	250
	5.5	-34.8	+40.7	34.7	239
	(bottom)			Ave. 41.3	Ave. 245.2
Middle of P5 & P6	2	+5.1	+57.6	45.9	249
	4	+1.1	+52.3	35.4	244
	6	-15.8	+38.4	27.4	231
	(bottom)			Ave. 36.2	Ave. 242.8
Middle of P6 & P7	2	-8.7	+63.7	49.6	249
	4	-1.9	+60.7	44.8	264
	6	-11.8	+63.5	48.5	263
	8	-6.3	+58.6	48.5	250
	10	+1.1	+41.7	31.0	253
	12	+4.2	+31.4	25.5	260
	14	+1.8	+35.7	31.1	267
	16	+0.5	+24.5	19.0	239
	18	+0.1	+27.2	19.2	266
	(bottom)			Ave. 35.2	Ave. 256.9
Middle of P7 & P8	2	+0.3	+56.6	40.8	260
	4	-2.7	+60.0	43.4	256
	6	-0.2	+60.0	44.8	257
	8	+1.9	+59.9	48.5	258
	10	+0.4	+63.4	47.4	263
	12	-0.8	+66.6	43.9	262
	14	-0.6	+58.6	45.0	261
	16	+1.4	+56.1	41.5	262
	18	-2.7	+54.4	36.9	257
	20	+3.0	+60.1	45.3	268
	22	+1.4	+50.7	38.3	258
	24	-0.1	+50.6	35.2	268
	26	-0.3	+45.8	40.1	258
	28	-3.5	+41.6	25.3	253
	(not reached to bottom)			Ave. 41.2	Ave. 260.3
Middle of P8 & P9	2	-33.1	+62.4	56.1	258
	4	-32.8	+65.6	53.3	258
	6	-38.8	+76.0	67.9	258
	8	-33.7	+67.1	56.6	259
	10	-42.7	+67.7	58.2	252
	12	-31.4	+38.9	48.3	247
	14	-35.7	+57.7	48.2	252
	16	-35.2	+54.0	47.9	248
	18	-23.1	+57.0	41.2	246
	20	-30.3	+55.1	46.8	240
	22	-25.1	+50.0	43.5	246
	24	-23.6	+48.7	42.2	257
	26	-25.4	+48.6	42.0	251
	28	-29.3	+51.0	45.6	257
	(not reached to bottom)			Ave. 49.8	Ave. 252.5

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Middle of P9 & P10	2	-44.7	+60.7	56.8	241
	4	-48.9	+67.4	60.0	234
	6	-41.4	+56.6	55.3	255
	8	-34.9	+64.0	51.4	254
	10	-44.8	+59.1	57.7	243
	12	-40.6	+59.3	53.8	237
	14	-36.9	+50.9	48.5	236
	16	-33.1	+59.5	47.4	247
	18	-28.3	+22.2	44.8	248
	20	-20.3	+30.0	27.3	285
	21	-0.1	+5.1	9.2	344
	(bottom)			Ave. 46.6	Ave. 247.7
Middle of P10 & P11	2	-23.3	+33.5	33.5	246
	3	-13.3	+22.7	18.4	243
	(bottom)			Ave. 28.0	Ave. 245.0

PROTECTION WORKS FOR MEGHNA BRIDGE	Table 6.5.1 Survey Result of Flow Velocity and Direction (4/6)

Section : 9 Date : August 10, 1997
Water Level : Rl. +4.25 m

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Left to Right					
60 m	2	+8.8	+15.9	25.1	265
(C1)	4	+10.6	+35.3	23.3	262
	6	+7.6	+31.0	28.1	95
	8	+6.2	+13.0	13.2	123
	10	-6.0	+8.0	8.3	43
	12	+3.0	+4.6	3.9	305
	14	-2.5	+4.4	5.2	346
	16	-6.6	+6.1	7.7	206
	18	-7.3	+19.1	10.1	166
	20	+4.6	-0.6	5.2	358
	22	-9.3	+5.1	5.5	46
	(bottom)			Ave. 12.3	Ave. 190.1
110 m	2	+29.0	+62.2	51.7	264
(C2)	4	+42.0	+52.5	58.4	262
	6	+34.1	+54.0	52.0	259
	8	+39.0	+60.0	57.7	261
	10	+36.9	+56.1	48.6	260
	12	+39.5	+63.9	59.0	267
	14	+40.2	+62.0	59.7	260
	16	+36.1	+57.4	52.9	266
	18	+33.2	+55.4	50.8	272
	20	+31.3	+55.2	45.4	273
	22	+31.2	+42.5	40.4	274
	24	+33.2	+59.1	52.7	263
	26	+27.6	+36.0	36.4	277
	28	+27.9	+50.0	43.9	284
	(not reached to bottom)			Ave. 50.7	Ave. 266.6
160 m	2	+23.1	+29.0	40.8	259
(C3)	4	+26.3	+46.0	39.8	263
	6	+32.7	+47.6	50.1	255
	8	+33.8	+50.2	52.2	261
	10	+21.8	+32.2	30.2	262
	12	+23.1	+41.3	41.0	275
	14	+27.7	+42.2	41.3	279
	16	+23.1	+20.5	28.4	284
	18	+22.3	+45.3	34.4	260
	20	+18.5	+28.8	22.3	274
	22	+9.1	+23.4	16.4	256
	24	+10.3	+23.4	15.7	260
	26	+10.8	+11.6	10.3	290
	26.5	-6.2	-15.3	17.6	223
	(bottom)			Ave. 31.5	Ave. 264.4

Section : 7 Date : August 10, 1997
Water Level : Rl. +4.25 m

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Left to Right					
60 m	2	+18.5	+23.3	35.1	71
(C4)	4	-2.0	-1.4	8.9	209
	6	+7.8	-2.2	6.0	331
	8	+6.9	-10.4	9.0	255
	10	+2.1	-4.6	2.9	8
	12	+18.9	+2.2	15.0	46
	14	-0.7	+13.7	6.9	344
	16	+6.7	+1.9	7.5	61
	18	-10.1	+9.8	8.0	212
	20	+14.7	+12.2	18.0	316
	21.5	+4.4	+4.2	8.6	308
	(bottom)			Ave. 11.4	Ave. 176.4
110 m	2	+18.6	+63.1	52.9	263
(C5)	4	+33.8	+79.2	63.8	270
	6	+24.7	+73.2	57.6	270
	8	+23.7	+70.3	58.0	264
	10	+23.3	+61.2	52.2	281
	12	+22.6	+57.1	48.6	276
	14	+17.8	+57.3	45.2	276
	16	+21.1	+57.0	43.0	277
	18	+15.0	+44.0	34.3	280
	20	+27.1	+64.2	69.1	268
	22	+17.4	+63.4	50.3	278
	24	+20.6	+53.3	41.9	284
	26	+18.2	+52.2	42.3	273
	28	+22.2	+49.2	47.3	284
	(not reached to bottom)			Ave. 50.5	Ave. 273.8
160 m	2	+1.7	+49.9	37.5	256
(C6)	4	+9.5	+43.8	33.6	276
	6	+6.8	+61.7	44.2	275
	8	+5.9	+42.0	25.8	289
	10	+2.9	+25.9	15.2	282
	12	+3.4	+34.6	25.5	259
	14	+2.6	+52.7	35.7	276
	16	+5.1	+36.7	30.3	287
	18	+9.8	+55.9	35.6	276
	20	+14.9	+79.0	62.8	277
	22	+6.3	+55.0	43.9	269
	24	+6.4	+34.7	26.5	276
	26	-12.9	+36.1	19.1	284
	28	-13.4	+24.2	25.3	272
	(not reached to bottom)			Ave. 32.9	Ave. 274.6

PROTECTION WORKS FOR MEGHNA BRIDGE	Table 6.5.1 Survey Result of Flow Velocity and Direction (5/6)

Section : 4 Date : August 10, 1997
Water Level : RL. +4.25 m

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Left to Right					
60 m	2	+30.3	+62.2	59.9	287
(C7)	4	+35.5	+70.9	64.0	284
	6	+34.5	+75.2	65.5	284
	8	+29.7	+62.3	51.6	281
	10	+28.4	+48.0	41.0	306
	12	+18.0	+48.0	39.1	293
	14	+31.9	+44.6	34.9	304
	15.5	+5.6	+23.4	21.7	294
	(bottom)			Ave. 47.2	Ave. 289.8
110 m	2	-16.3	+72.1	58.2	271
(C8)	4	+16.5	+69.1	49.2	271
	6	-16.3	+70.9	63.1	270
	8	-20.1	+65.5	37.6	266
	10	-16.8	+72.1	60.0	278
	12	-18.1	+68.1	54.4	266
	14	-17.6	+56.6	37.4	269
	16	-16.3	+18.1	22.4	254
	(bottom)			Ave. 47.8	Ave. 269.5
160 m	2	-36.9	+63.1	57.8	266
(C9)	4	-28.9	+56.4	50.5	278
	6	-22.3	+50.0	38.0	270
	8	-29.8	+60.6	49.3	273
	10	-32.6	+63.3	49.6	260
	12	-32.3	+61.7	50.8	263
	14	-36.3	+52.2	53.8	259
	14.5	-25.9	+40.6	32.1	231
	(bottom)			Ave. 47.7	Ave. 267.1

Section : PP3 Date : August 10, 1997
Water Level : RL. +4.25 m

Location	Depth (m)	Current (cm/s) X	Y	Composite	Direct (Deg.)
Left to Right					
60 m	2	-11.2	+29.8	29.9	264
(C10)	4	-8.7	+26.4	16.4	285
	6	-26.4	+49.9	44.5	275
	8	-23.3	+48.2	40.5	280
	10	-31.2	+44.9	42.2	263
	12	-13.5	+30.2	25.0	289
	14	-1.9	+19.9	15.4	289
	(bottom)			Ave. 30.6	Ave. 275.5
120 m	2	-9.1	+24.1	25.0	244
(C11)	4	-18.9	+59.4	41.9	285
	6	-27.0	+52.7	46.5	272
	8	-22.2	+47.7	41.1	278
	10	-18.4	+48.8	41.4	288
	12	-26.6	+40.0	38.4	278
	14	-20.4	+34.6	38.6	280
	15	-11.3	+19.5	17.3	267
	(bottom)			Ave. 36.3	Ave. 276.2
170 m	2	-22.0	+44.1	44.6	242
(C12)	4	-20.5	+31.8	29.1	241
	6	-20.2	+34.4	26.2	253
	8	-17.8	+35.0	29.0	264
	10	-19.6	+35.4	30.7	266
	12	-17.1	+36.6	31.3	286
	14	-21.6	+39.9	34.4	283
	15	-19.6	+17.2	24.4	281
	(bottom)			Ave. 31.2	Ave. 263.5

PROTECTION WORKS FOR MEGHNA BRIDGE	Table 6.5.1 Survey Result of Flow Velocity and Direction (6/6)

Table 6.5.2 Estimation of Discharge (1/2)

Section No. : RD1 ~ LD1

Date : August 9, 1997

Water Level : RL. +4.20 m

Slice No.	Position (m)	Distance (m)	Area (sq.m)	Velocity (m/s)	Discharge (cu.m/s)
1 (L)	0 - 105	105	861	0.234	201
2	105 - 245	140	2128	0.262	557
3	245 - 375	130	1950	0.484	943
4	375 - 510	135	2079	0.393	817
5	510 - 655	145	1740	0.477	830
6	655 - 790	135	736	0.270	198
7	790 - 910	120	474	0.357	169
8(L)	910 - 1060	150	255	0.193	44
	Total				3759

Section No. : R1 ~ L1

Date : August 9, 1997

Water Level : RL. +4.20 m

Slice No.	Position (m)	Distance (m)	Area (sq.m)	Velocity (m/s)	Discharge (cu.m/s)
1 (L)	0 - 140	140	1953	0.457	892
2	140 - 260	120	2496	0.584	1457
3	260 - 390	130	2210	0.296	654
4	390 - 550	160	1264	0.377	476
5	550 - 735	185	1092	0.390	425
6 (R)	735 - 930	195	1034	0.332	343
	Total				4247

Table 6.5.2 Estimation of Discharge (2/2)

Section No. : R3 ~ L3 Date : August 9, 1997

Water Level : RL. +4.20 m

Slice No.	Position (m)	Distance (m)	Area (sq.m)	Velocity (m/s)	Discharge (cu.m/s)
1 (L)	0 - 115	115	1064	0.375	398
2	115 - 225	110	1771	0.333	589
3	225 - 335	110	1980	0.203	401
4	335 - 460	125	1400	0.252	352
5	460 - 605	145	696	0.348	242
6	605 - 735	130	371	0.307	113
7	735 - 855	120	342	0.215	73
8	855 - 985	130	338	0.117	39
9	985 - 1115	130	663	0.320	212
10	1115 - 1260	145	1276	0.210	267
11	1260 - 1415	155	1194	0.393	469
12	1415 - 1555	140	686	0.279	191
13 (R)	1555 - 1630	135	277	0.287	79
	Total				**3425**

Section No. : R10 ~ L10 Date : August 7, 1997

Water Level : RL. +4.25 m

Slice No.	Position (m)	Distance (m)	Area (sq.m)	Velocity (m/s)	Discharge (cu.m/s)
1 (L)	0 - 105	150	750	0.225	191
2	105 - 315	165	1485	0.596	885
3	315 - 485	170	1972	0.316	623
4	485 - 655	170	2261	0.308	696
5	655 - 825	170	2295	0.405	929
6	825 - 995	170	3570	0.196	699
7	995 - 1165	170	2916	0.264	769
8(L)	1165 - 1310	145	612	0.080	48
	Total				**4840**

Table 6.5.3 Test Result of SS Contents

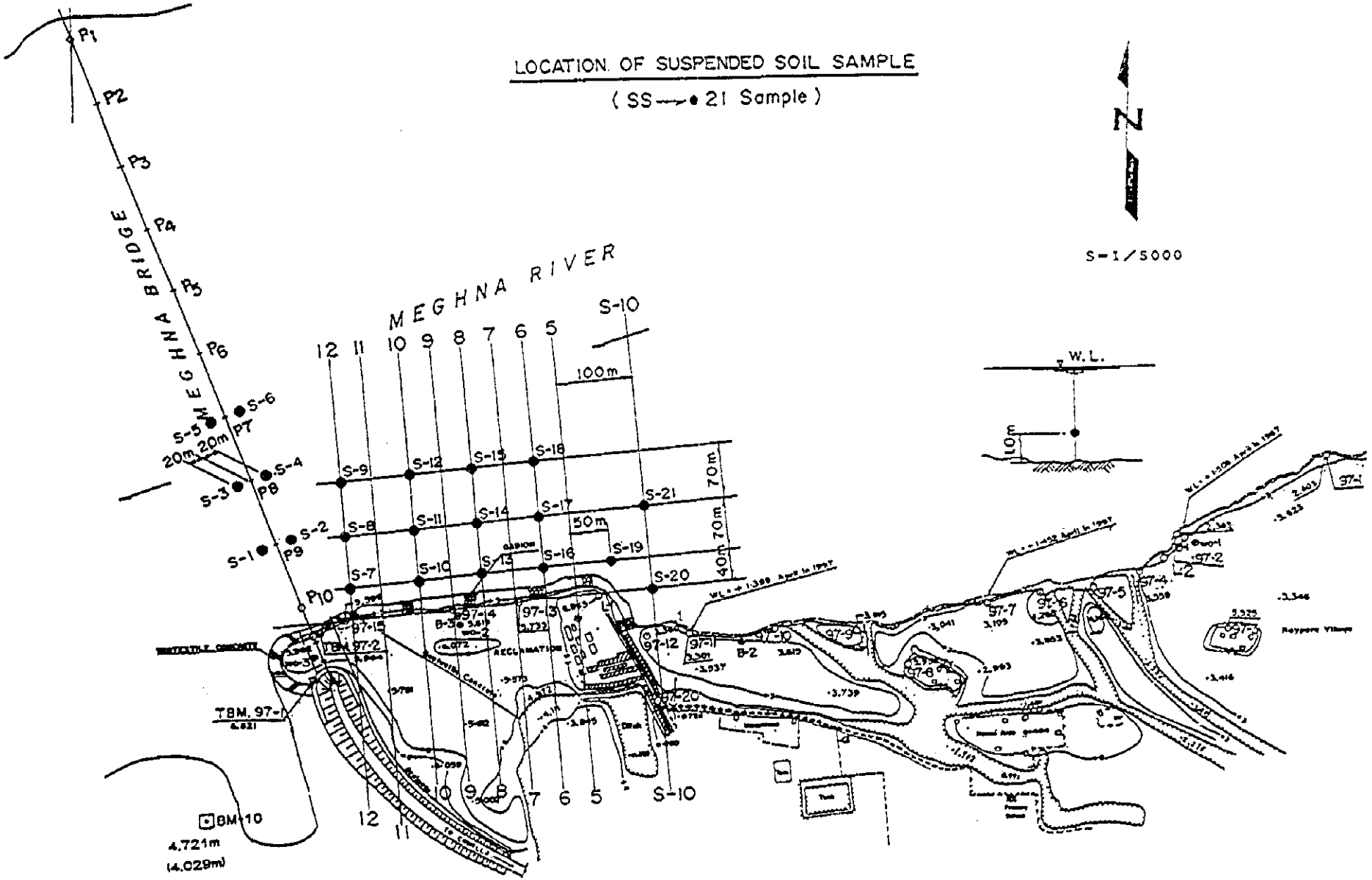
Date of Sampling : August 10 - 20 / 1997

Date of Testing : August 10 - 20 / 1997

Meghna River Protection Project

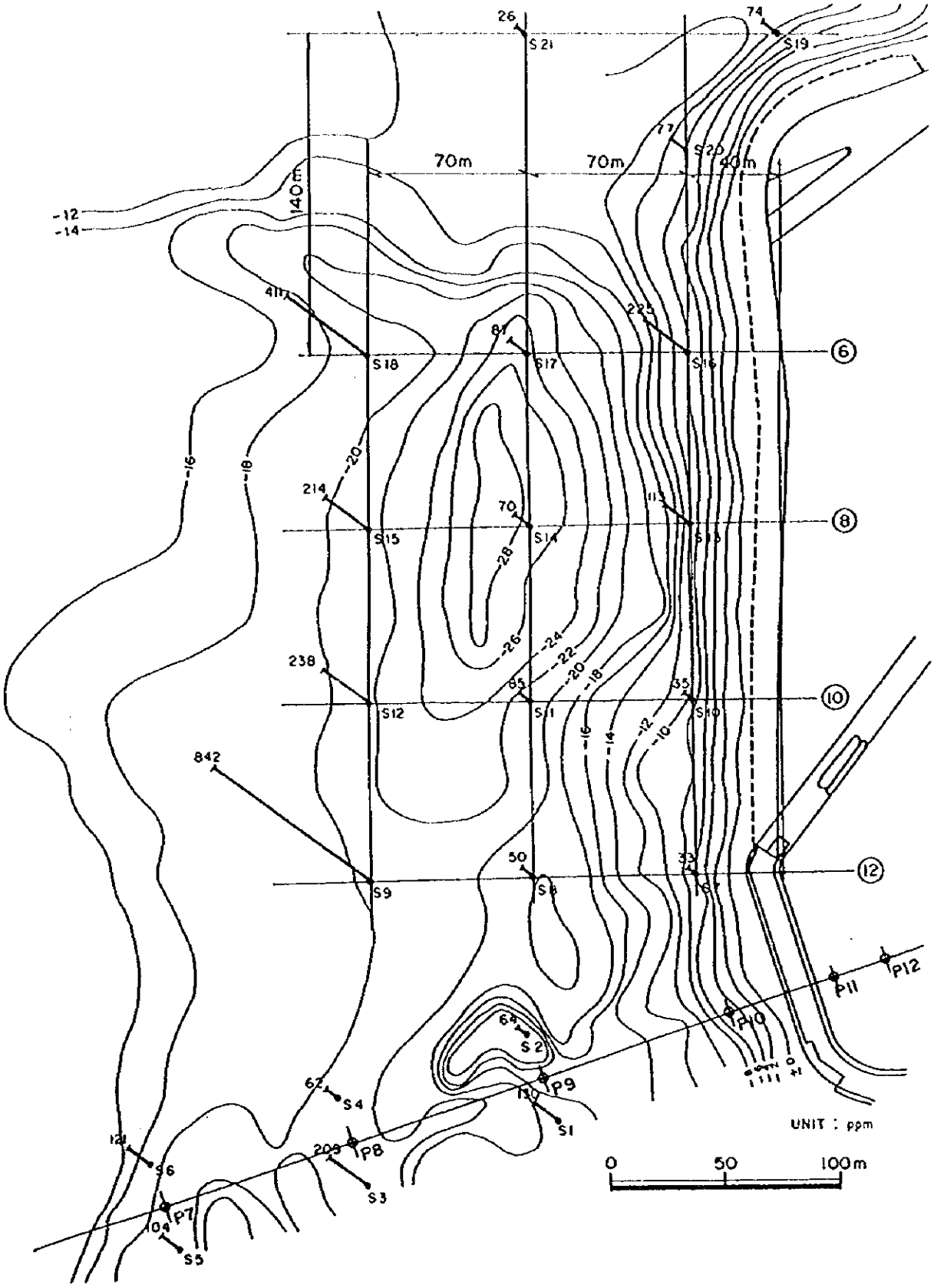
Sample No	Depth of Sample	Grain Size Analysis						D50	D60	D10	Cu = D60/D10	Unified soil classification symbol (USCS)	Remarks
		Gravel 76.1-4.76 mm	Coarse sand 4.76-2.0 mm	Medium sand 2.0-0.425 mm	Fine sand 0.425-0.075 mm	Silt 0.075-0.002 mm	Clay <0.002 mm						
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(mm)	(mm)	(mm)			
D - 1	River bed	Nil	Nil	0.6	94.4	5.0	Nil	0.19	0.21	0.09	2.33	SP	Fine sand, trace silt, grey, NP
D - 2	River bed	Nil	Nil	3.9	92.2	3.9	Nil	0.22	0.25	0.15	1.67	SP	Fine sand, trace silt, grey, NP
D - 3	River bed	Nil	Nil	1.3	95.4	3.3	Nil	0.12	0.15	0.08	1.88	SP	Fine sand, trace silt, grey, NP
D - 4	River bed	Nil	Nil	1.0	85.3	13.7	Nil	0.11	0.13	0.045	2.89	SM	Fine sand, little silt, grey, NP
D - 5	River bed	Nil	Nil	0.4	68.6	31.0	Nil	0.11	0.13	0.009	14.44	SM	Fine sand, some silt, grey, NP
D - 6	River bed	Nil	Nil	2.7	95.5	1.8	Nil	0.21	0.24	0.15	1.60	SP	Fine sand, trace silt, grey, NP
D - 10	River bed	Nil	Nil	Nil	54.8	45.2	Nil	0.08	0.10	0.026	3.85	SM	Fine sand and silt, grey, NP

Note : NP = Non-plastic



PROTECTION WORKS FOR MEGHNA BRIDGE

Figure 6.5.6 Location Map of Water Sampling for SS Contents



PROTECTION WORKS FOR MEGHNA BRIDGE	Figure 6.5.7 Result of Laboratory Tests of SS Contents

flow area due to the gap of the shoreline between the existing revetment and its upstream stretch. Accordingly, the turbulence of suspended solid accumulated on the riverbed due to vortexes is deemed as one of the reason for high concentration. As a whole, the observed values near the revetment are higher than those at on the downstream side of the piers.

Further, the condition of surface flow in front of the revetment and propagation of vortexes downstream of each pier are illustrated based on the field observation made at 4 p. m. (RL. +4.70 m) on Aug. 18, 1997 (Fig. 6.5.8).

The boundary of the dead flow area extends almost up to the center of P8 and P9. On the other hand, the flow direction at the sites located outside the survey line along the extension from P9 is uniformly toward downstream. Thus, it is judged that this area might be out of the dead flow area. The measurement of flow velocity and direction was carried out on Aug. 10 when the water level was at RL. +4.20 to +4.25 m. The boundary of the dead flow area shifted closer to the shoreline because the water level was 50 cm lower on Aug. 18 when the observation of water surface condition was conducted.

6.5.2 Chronological Feature of the Scoured Pool in front of the Existing Left Bank Revetment

(1) Contour Map of Riverbed

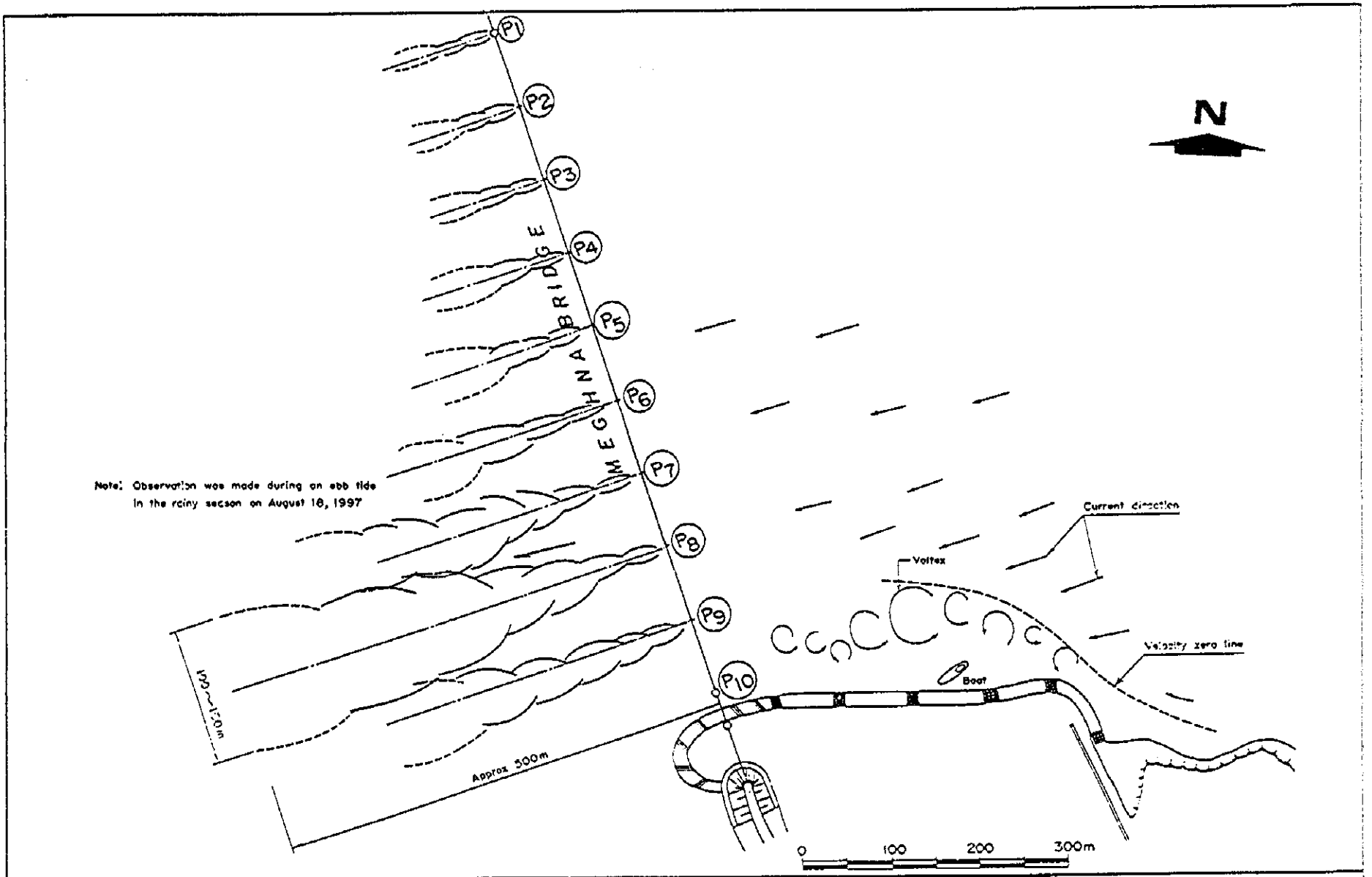
In order to investigate the chronological changes of the scoured pool in front of the existing left bank revetment, the results of river survey were arranged as shown in Fig. 6.5.9. The periods of river survey were as follows:

- April 1989
- June 1992
- January 1994
- February 1995
- August 1997

(2) Chronological Features of Scoured Pool

a) Indices for comparison

In order to clarify chronological features of the scoured pool, the following 8 indices were set up and measured on the individual contour map. The results are tabulated in Table 6.5.4.



PROTECTION WORKS FOR MEGHNA BRIDGE

Figure 6.5.8 Observed Result of Surface Vortex

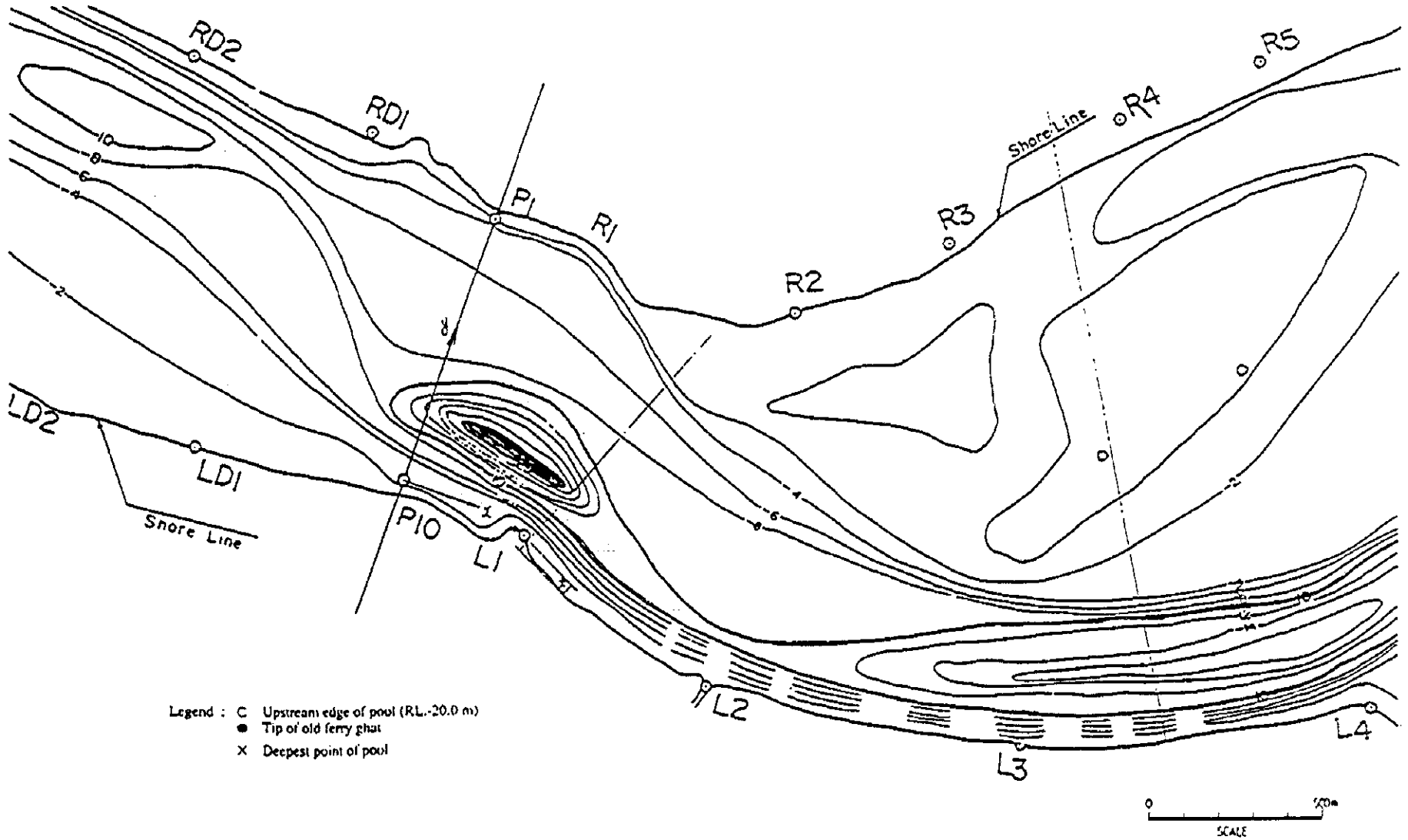


Figure 6.5.9 Contour Map of Riverbed (April 1989)

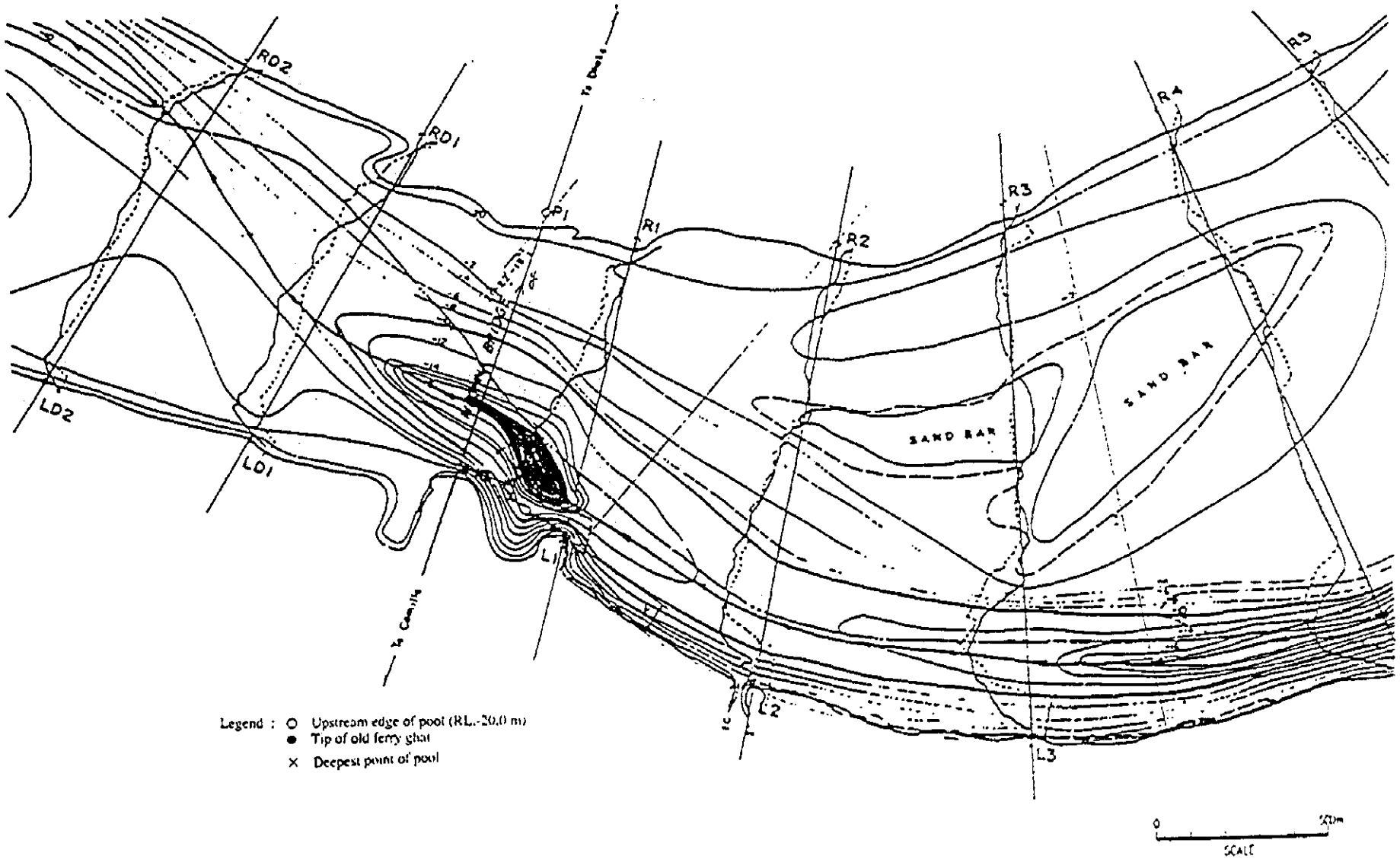


Figure 6.5.9 Contour Map of Riverbed (June 1992)

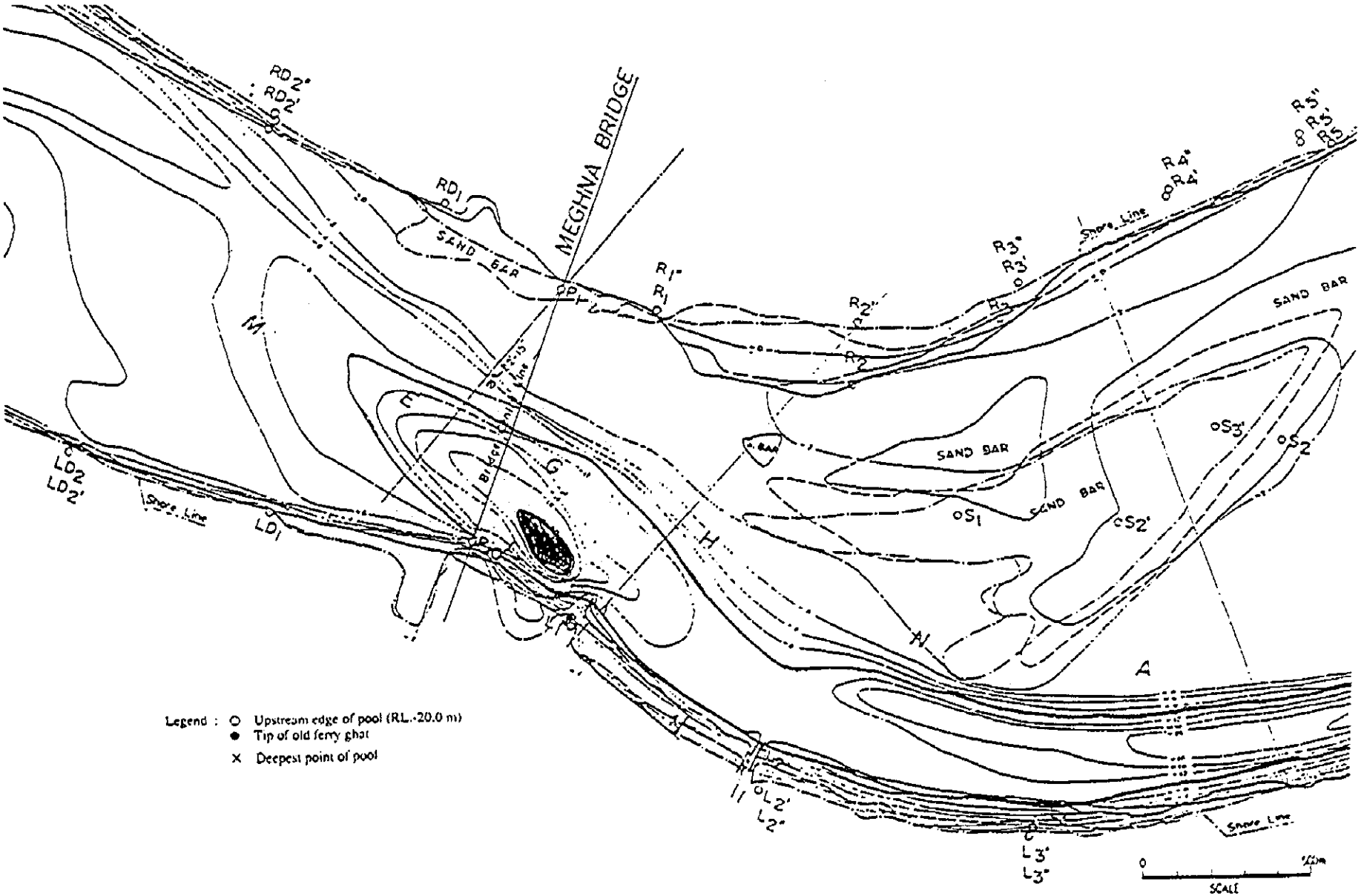


Figure 6.5.9 Contour Map of Riverbed (Jan. 1994)

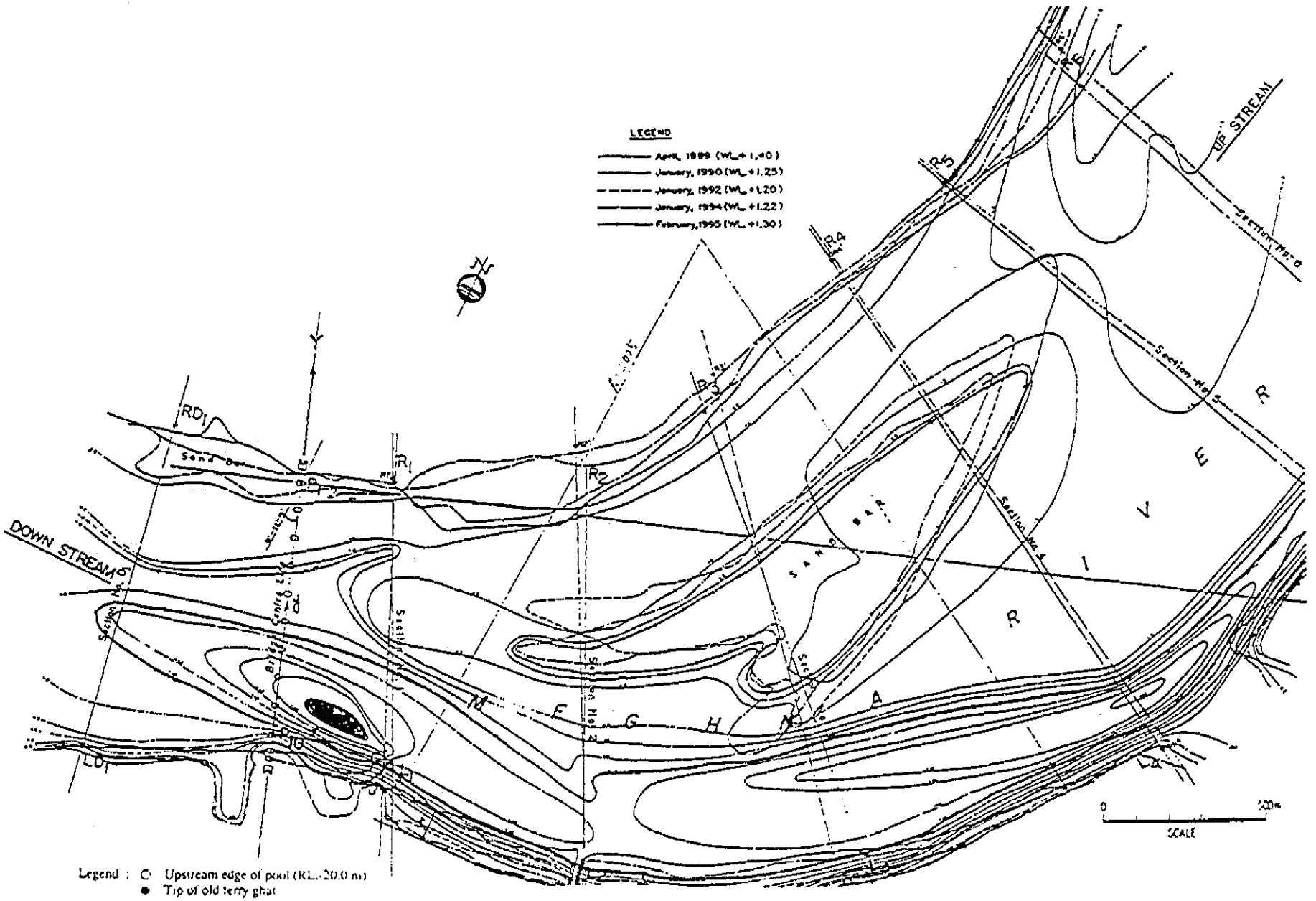


Figure 6.5.9 Contour Map of Riverbed (Feb. 1995)

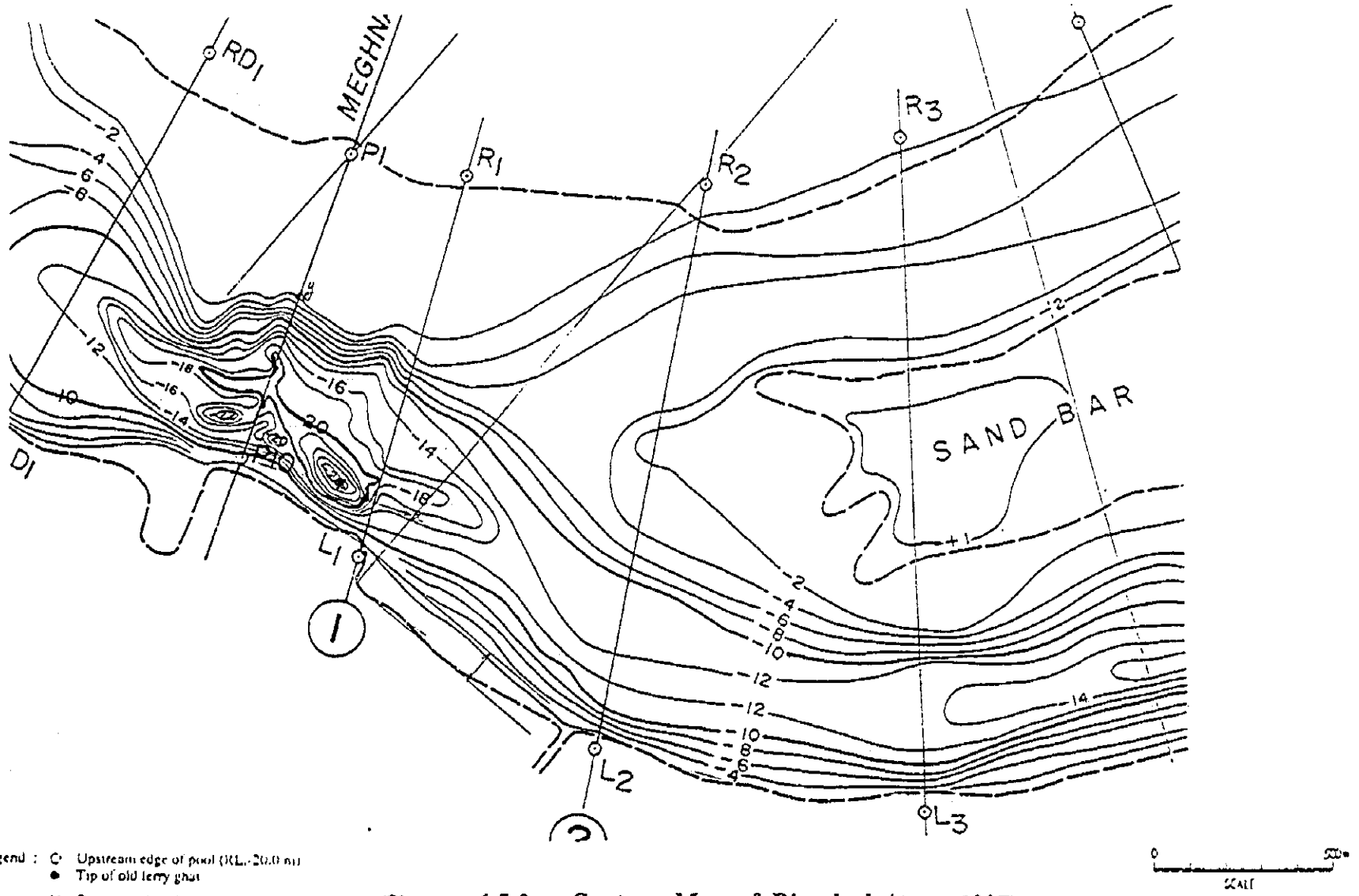


Figure 6.5.9 Contour Map of Riverbed (Aug. 1997)

Table 6.5.4 Feature of Scoured Pool

Time surveyed	Feature of scoured pool							Distance from tip of old ferry ghat to deepest point (m)	Gap of river bank at old ferry ghat (m)	Radius of circular arc at left bank (m)
	Width (m)	Length (m)	Area (m2)	Deepest point		Upstream edge				
				x (m)	y (m)	x (m)	y (m)			
Apr.1989	45	340	11,000	350	165	435	130	185	40	2,160
Jun.1992	105	430	30,000	245	50	330	0	175	60	2,085
Jan.1994	95	250	18,000	265	40	305	0	180	75	2,110
Feb.1995	65	260	10,000	235	50	285	30	195	90	2,025
Aug.1997	130	530	33,000	250	25	325	0	170	95	2,180

- Width of contour line RL. -20.0 m (perpendicular to flow direction) : Index A
- Length of contour line RL. -20.0 m (flow direction) : Index B
- Area of contour line RL. -20.0 m : Index C
- Location of the deepest point : Index D
- Location of upstream end along contour line RL. -20.0 m : Index E
- Distance between the tip of the old ferry ghat and the deepest point of the pool : Index F
- Gap between the tip of the old ferry ghat and upstream left bank : Index G
- Radius of circular arc on the left bank : Index H

Regarding the locations of the deepest point and the upstream end of the RL. -20.0 m contour line, an origin and an axis were set to locate the points by x-y coordinates on a plane.

b) Change of each indice

The indices in Table 6.5.4 are plotted in a graph as shown in Fig. 6.5.10. The features of each indice are explained in Table 6.5.5.

Table 6.5.5 Change of Each Indice

Index	Feature	Tendency
A	No certain tendency is confirmed.	↗
B	No certain tendency isconfirmed.	↗
C	No certain tendency is confirmed.	↗
D	Moved toward downstream and approached closer to the front of the existing pitched stone revetment.	x ↘ y ↘
E	Together with movement of the deepest point, a similar tendency is confirmed.	x ↘ y ↘
F	Almost constant	→
G	A tendency of gradual development can be seen, but it is being moderated.	↗
H	No distinct change is confirmed.	→

From 1989 to 1992, the scoured pool moved toward the shoreline and downstream due to the large scale landslide at the site of the existing revetment. However, after the completion of the revetment in February 1994, significant movement of the pool has not occurred. Further, the speed of development of the gap between the tip of the old ferry ghat and the upstream shoreline seems to become moderate after 1995. In this regard, it is closely related to the tendency of development of the right side small channel.

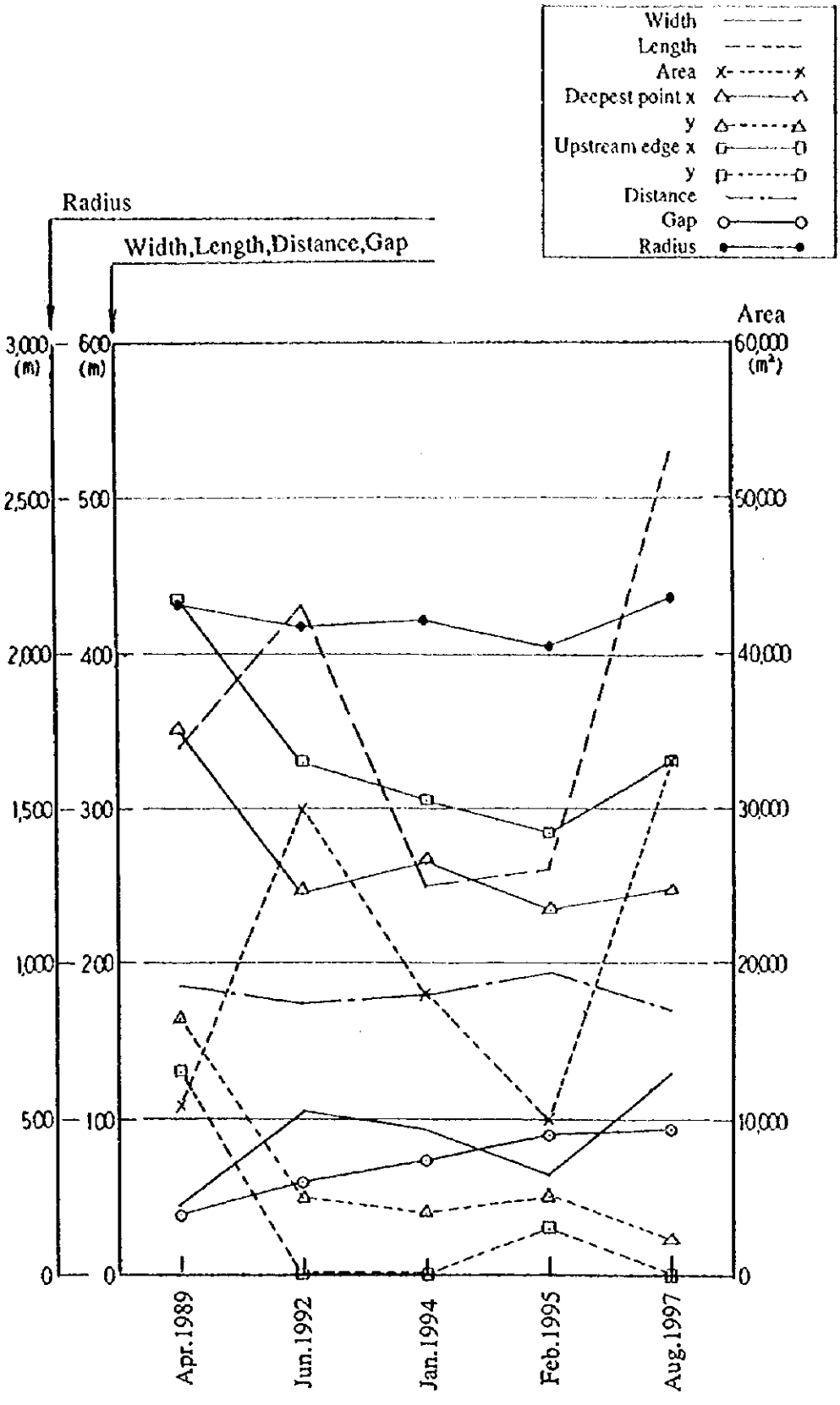


Figure 6.5.10 Trend of Deep Scoured Pool

CHAPTER 7

VERIFICATION OF STABILITY OF EXISTING REVETMENT

CHAPTER 7 VERIFICATION OF STABILITY OF EXISTING REVETMENT

7.1 General

The stability of the existing revetment at Section 8-8 where the deepest riverbed scouring (Figure 7.1), was checked.

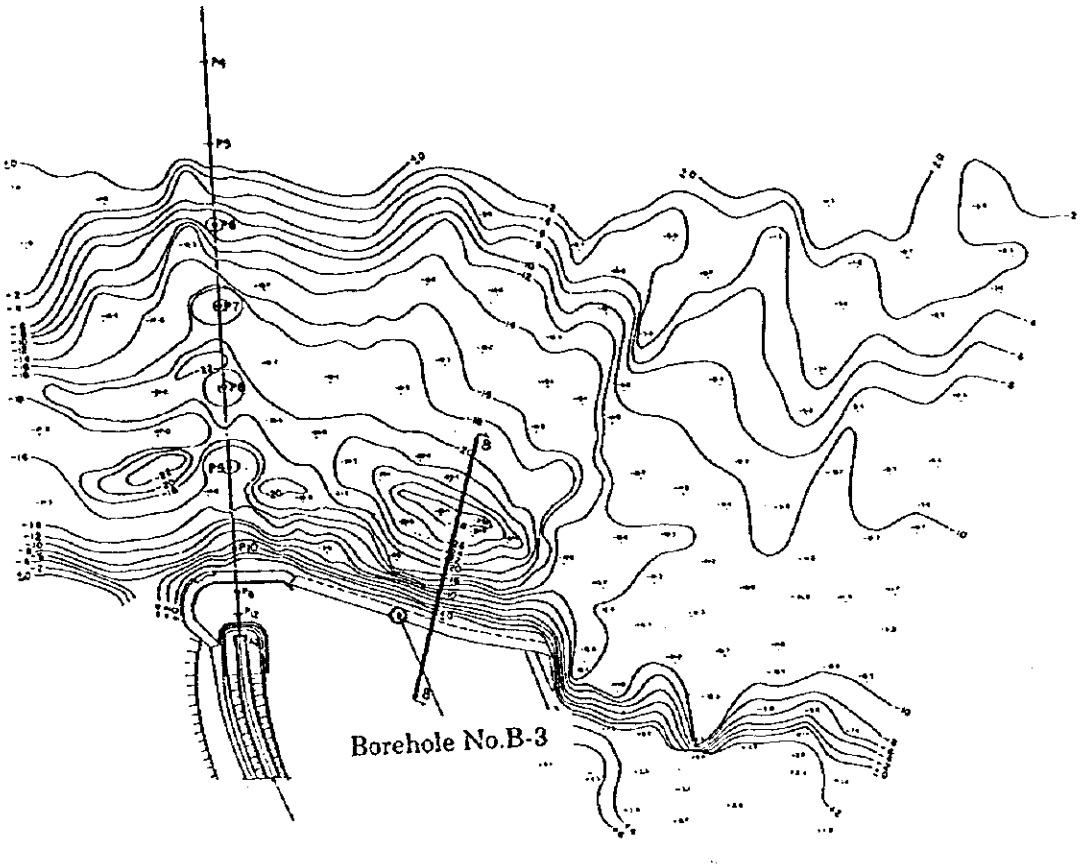


Figure 7.1 Location of Stability Verification of Revetment

To provide soils data for stability analysis, borings and laboratory tests were carried out. Figure 7.2 shows the boring log of Borehole No. B-3 (see Figure 7.1 for the location).

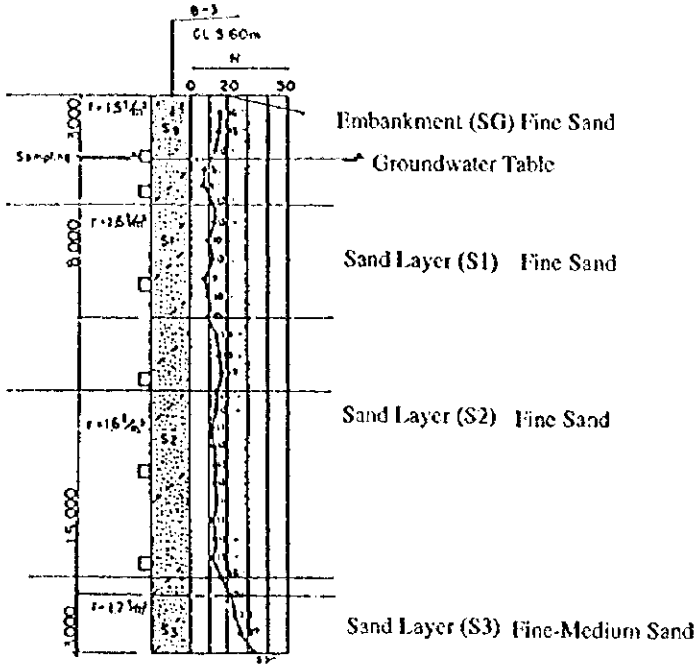


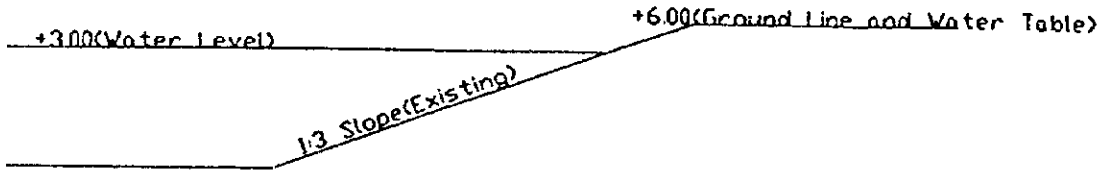
Figure 7.2 Boring Log of Borehole No. B-3

7.2 Stability Analysis

(1) Conditions of Analysis

The conditions of stability analysis are shown in Figure 7.3 (Cases 1 and 2).

Case 1 : During High Water Season



Case 2 : During Normal Water Season

Figure 7.3 Conditions of Stability Analysis (Case 1 and 2)

The following soil conditions were applied for the stability analysis

Layer	:	Sand Layer
Unit Weight (γ)	:	1.5 - 1.7 ton/m^3
Internal Friction Angle (ϕ)	:	25° - 35°

(2) Result of Stability Analysis

The results of stability analysis are given in Table 7.1 below.

Table 7.1 Results of the Stability Analysis in Each Case

Method of Analysis	Safety Factor	
	Case 1	Case 2
Circular Arc Method	Top of Slope: 1.2 ≥ 1.2	Top of Slope: 1.3 > 1.2
	Middle of Slope: 5.1 > 1.2	Middle of Slope: 4.3 > 1.2
	Toe of Slope: 10.6 > 1.2	Toe of Slope: 9.4 > 1.2

Note: No liquefaction will occur in foundation and embankment sandy soils when a seismic coefficient of 1.5 is applied.

CHAPTER 8

NECESSITY OF SHORT-TERM PROTECTION WORKS

CHAPTER 8 NECESSITY OF SHORT-TERM PROTECTION WORKS

8.1 Scouring around the Bridge Pier Foundations

The stability of piers was analyzed as mentioned in the Section 6.4 and the result of analysis concluded 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, which are located in the riverbed lowering area, are covered with stone mats provided for the protection of pier foundations and the existing stone mats are forming lenticular shapes. The riverbed between stone mats is composed of a hard sand layer (N-value; 30 to 40), therefore scouring would not proceed easily. However, the thickness of the said sand layer is relatively small. The stratum below R.L. -24 m to -26 m is composed of silty sand layers. Therefore in the case the existing exposed sand layer is eroded, further scouring may occur unexpectedly rapidly.

In view of the above situation, the provision of additional protection works by stone pitching around the existing stone mats is recommended.

8.2 Armoring of Riverbed in Front of Existing Revetment

In Chapter 7 a study was made whether the existing revetment at about 350 m upstream of the bridge will have enough safety against sliding in several souring conditions or not.

The result revealed that no major sliding would occur even if the face of slope becomes extremely steeper (about 1 to 1) due to scouring of riverbed.

The deep scouring area, the lowest riverbed elevation R.L. -29 m, in front of the existing revetment has been basically remaining at the same location and depth since 1994. At present it can be said from the above situations that the existing revetment is stable.

However if the riverbed scouring proceeds and changes the location downstream due to eventual future large floods, it will affect the stability of the 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. Armoring will be done with sacked

gravel (using jute bags) considering the balance of textures of the riverbed and the pitched material.

8.3 Grading Work

When the rear side of the revetment can not drain rainwater properly, both the embankment and the revetment will be affected by excess pore water pressure and surface water seepage. In particular, near the abutment where the existing geotextile form concrete is located grading work is recommended to enhance surface drainage and to increase the stability of the revetment.

CHAPTER 9

DESIGN OF SHORT-TERM PROTECTION WORKS

CHAPTER 9 DESIGN OF SHORT-TERM PROTECTION WORKS

The proposed short-term protection works are designed as follows:

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

- One meter thick stone mat protection.

b. River bed 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.

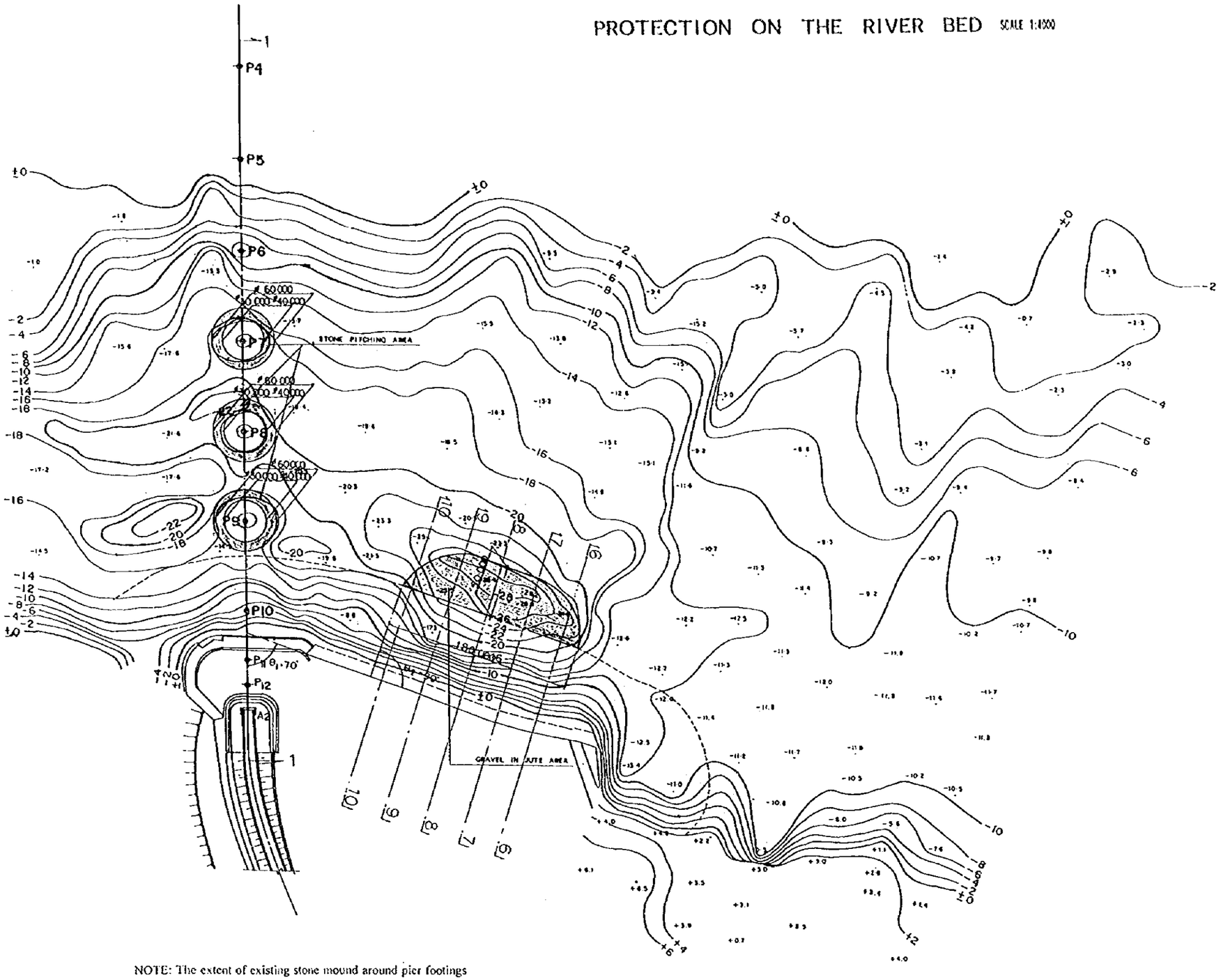
c. Grading work around the Comilla side abutment and the repair of the existing revetment

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

The result of quantity take-off is presented in Table 9.1.

Table 9.1 Quantity List

Item		Unit	Quantity	Remarks
Stone Pitching around Piers	P7 Pier	Cu • m	1,865	Thickness 1.0 m
	P8 Pier	Cu • m	1,865	- do -
	P9 Pier	Cu • m	1,865	- do -
	Total	Cu • m	5,595	Total Area 5,595 Sq • m
Sacked-Gravel in front of Revetment		Cu • m	7,839	Area 7,839 Sq • m
Grading Work	Supply of Satisfactory Material	Cu • m	1,597	
	Leveling and Compaction	Sq • m	3,866	
Demolition of Damaged Concrete Filled Fabric Tubes		Sq • m	84	
Gabion Work		Cu • m	134	



NOTE: The extent of existing stone mound around pier footings shall be checked prior to the stone pitching work.

Figure 9.1 Protection on the Riverbed

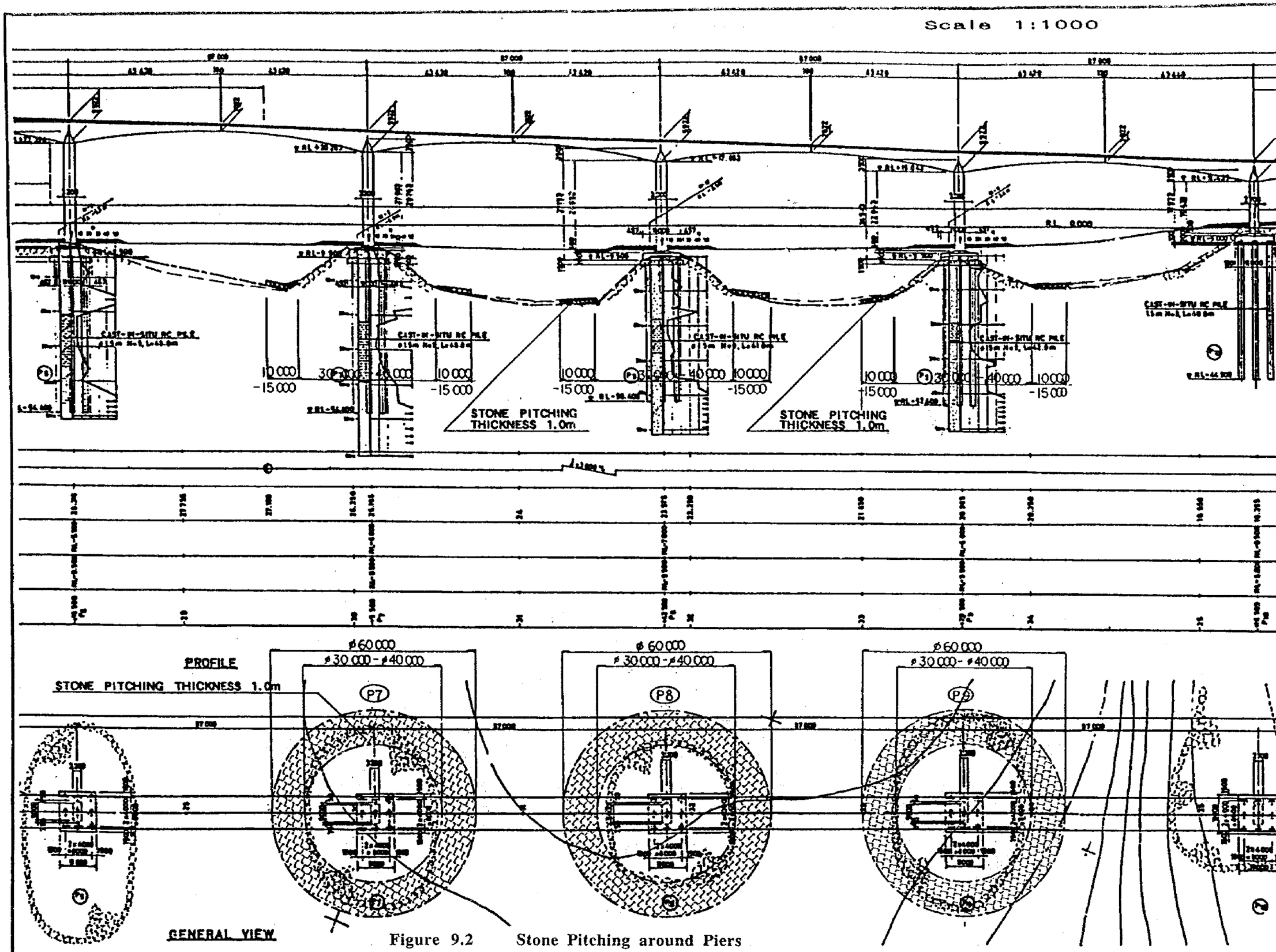
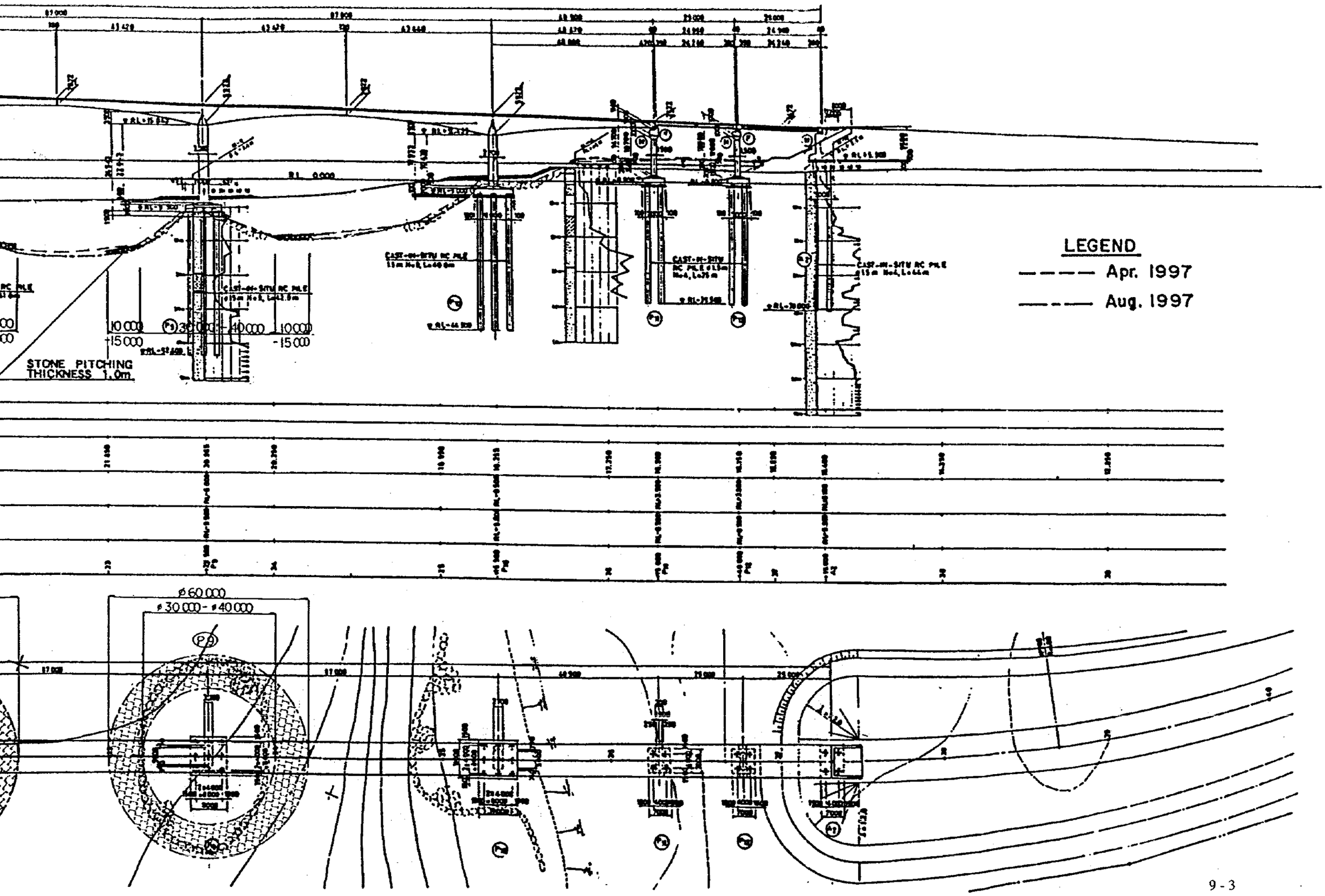


Figure 9.2 Stone Pitching around Piers

Scale 1:1000


STONE PITCHING
THICKNESS 1.0m
LEGEND
Apr. 1997
Aug. 1997
ø60.000
ø30.000 - ø40.000

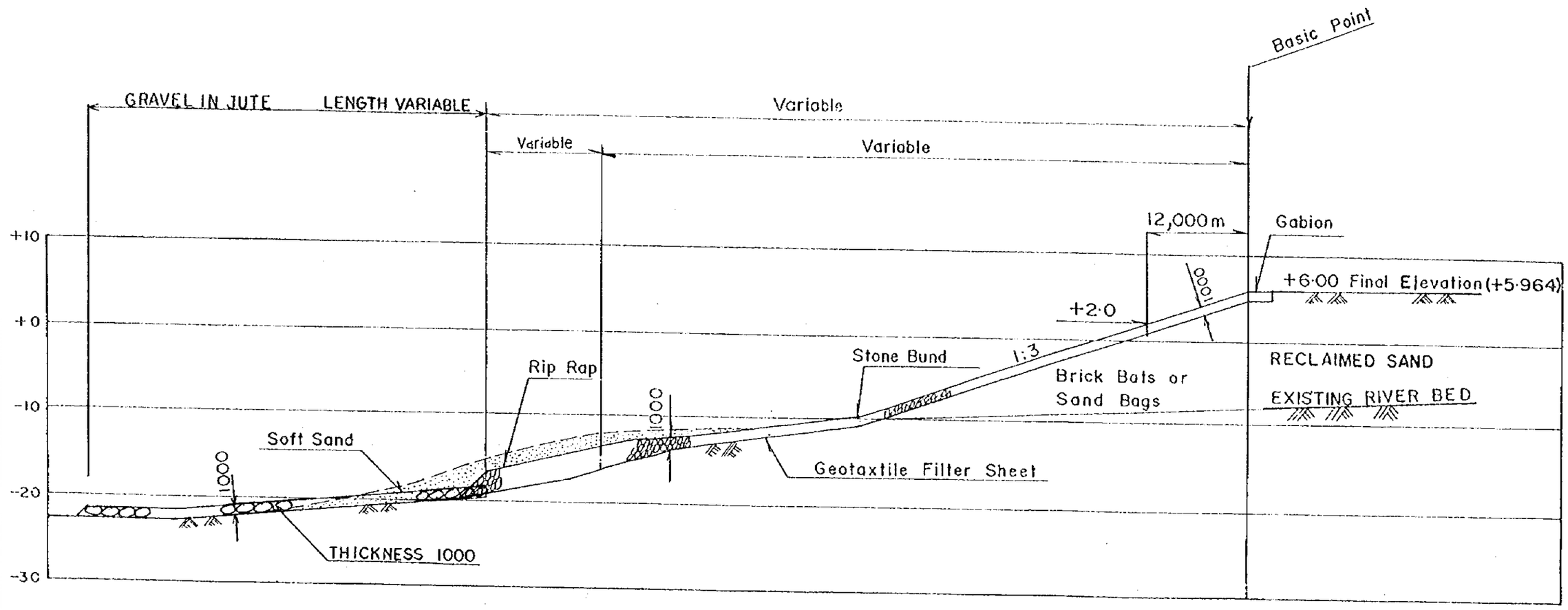
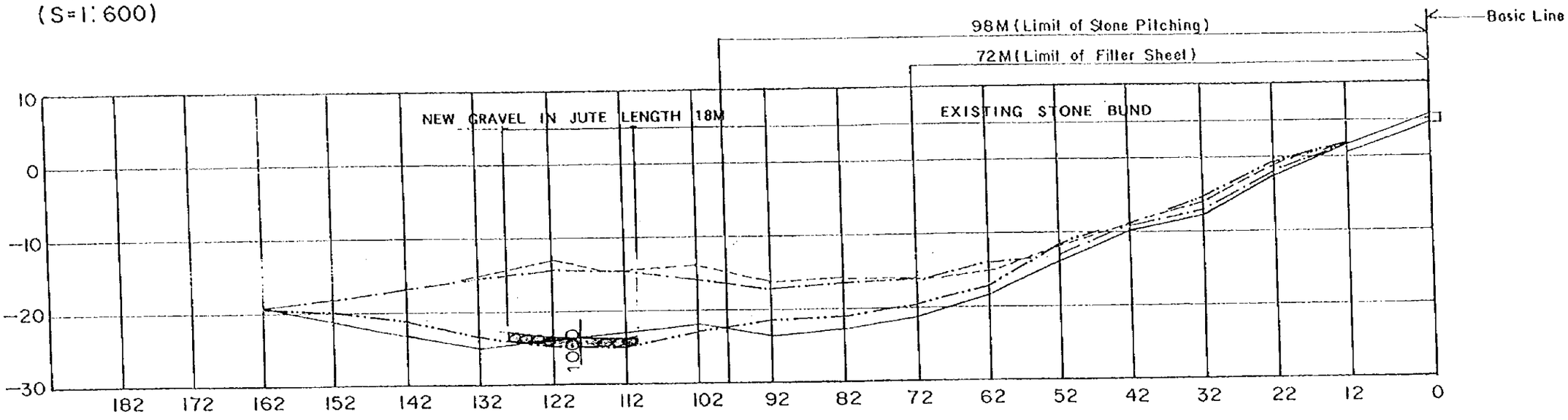


Figure 9.3 Typical Cross-Section of Sacked Gravel Mat



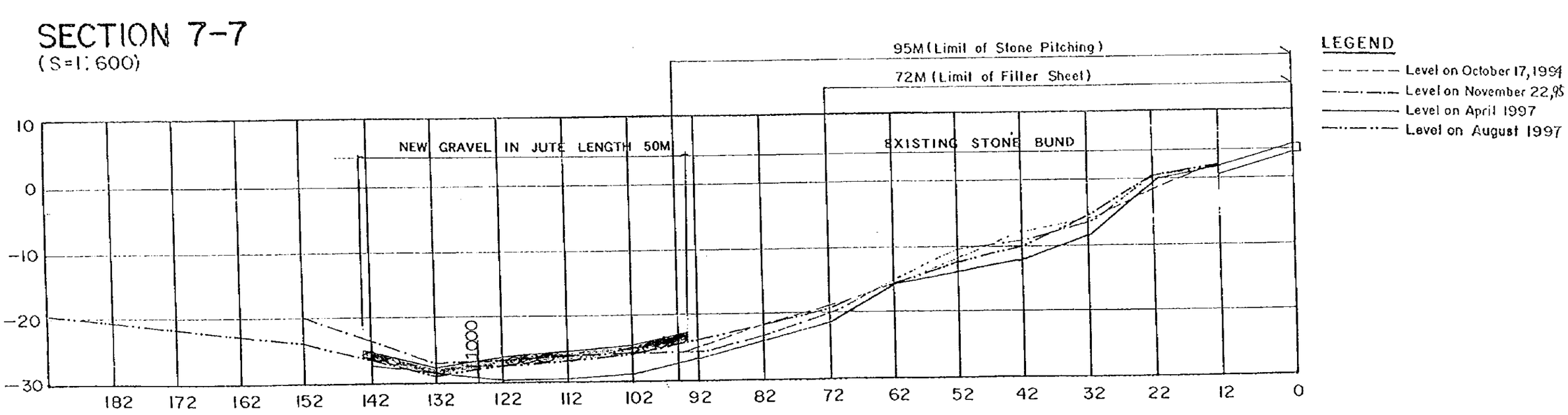
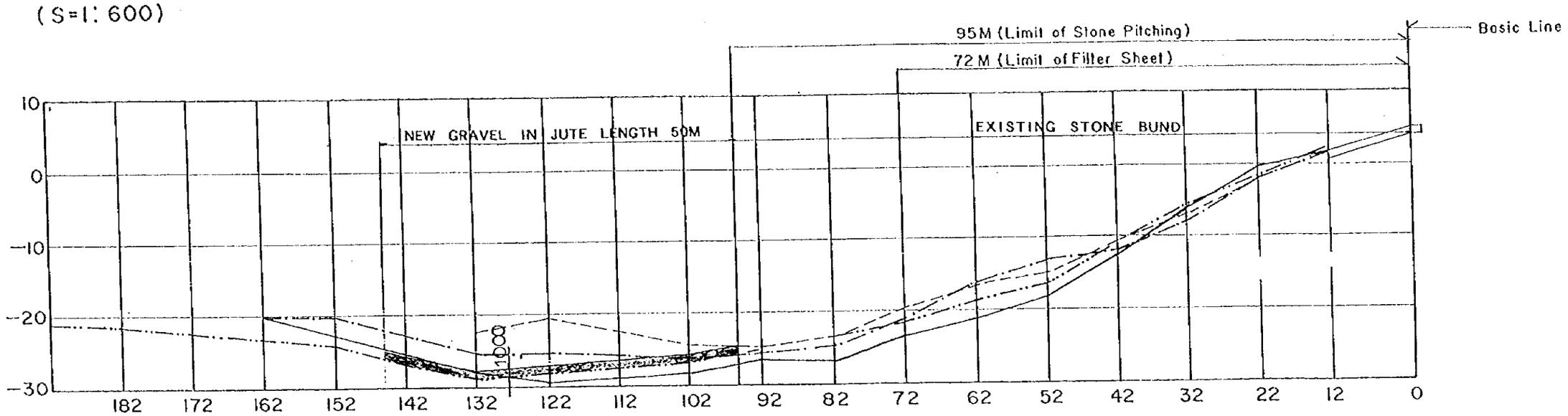


Figure 9.4 Locations of Sacked Gravel Mat (1/3)

SECTION 8-8
(S=1: 600)



SECTION 9-9
(S=1: 600)

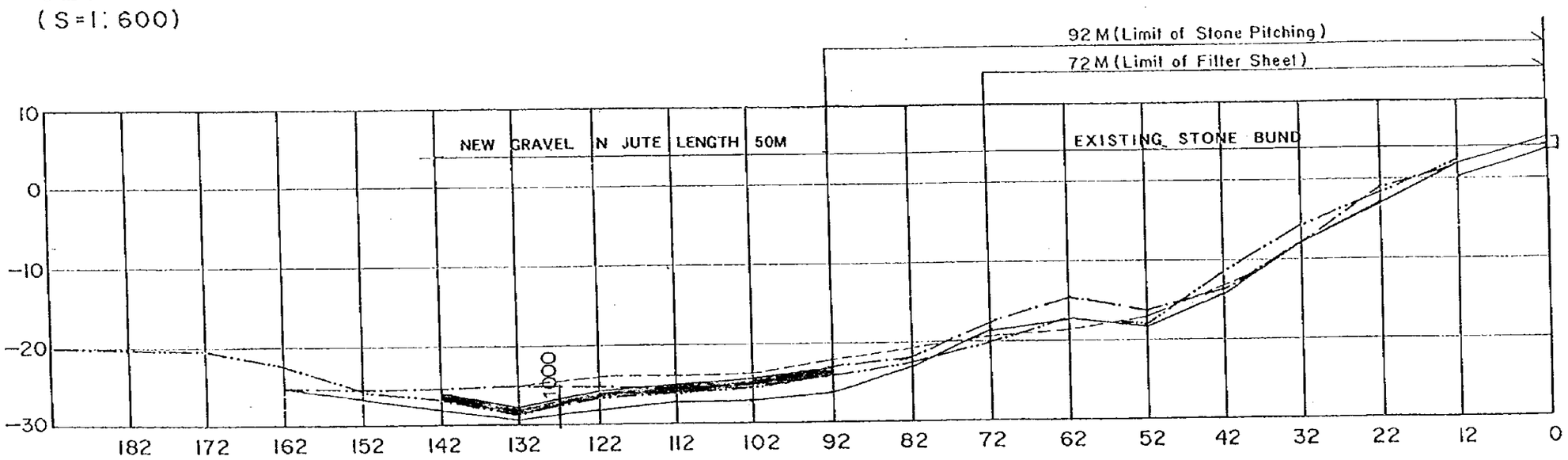


Figure 9.4 Locations of Sacked Gravel Mat (2/3)

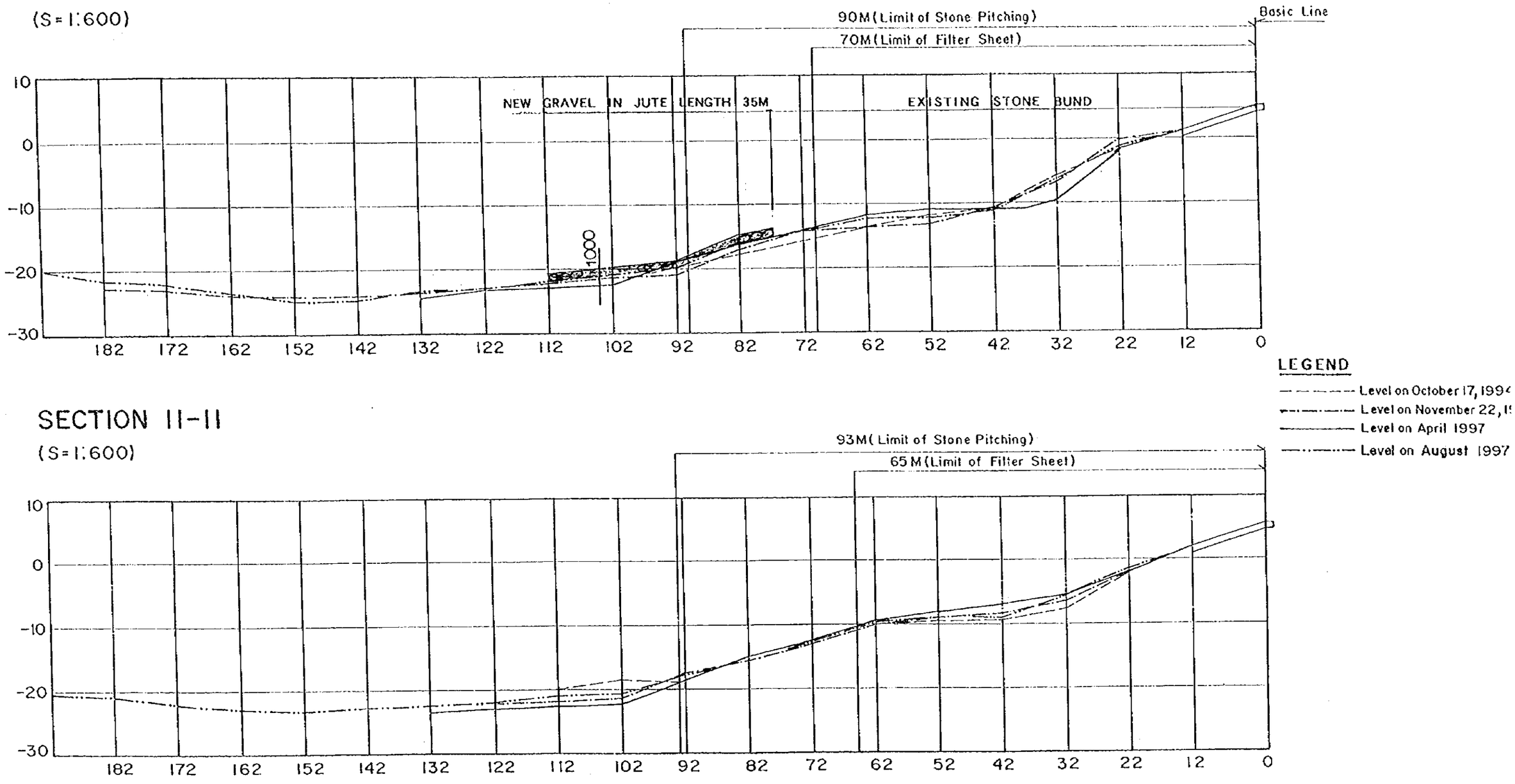
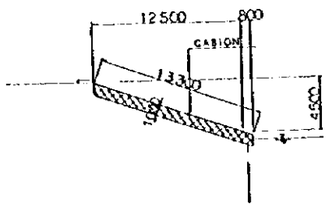


Figure 9.4 Locations of Sacked Gravel Mat (3/3)

EMBANKMENT AND REPLACEMENT FOR REVETMENT SCALE 1:5000

SECTION B-B



CROSS SECTION
A-A

Figure 9.5 Grading and Gabion Works