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MINISTRY OF WATER RESOURCES
WATER RESOURCES PLANNING ORGANIZATION

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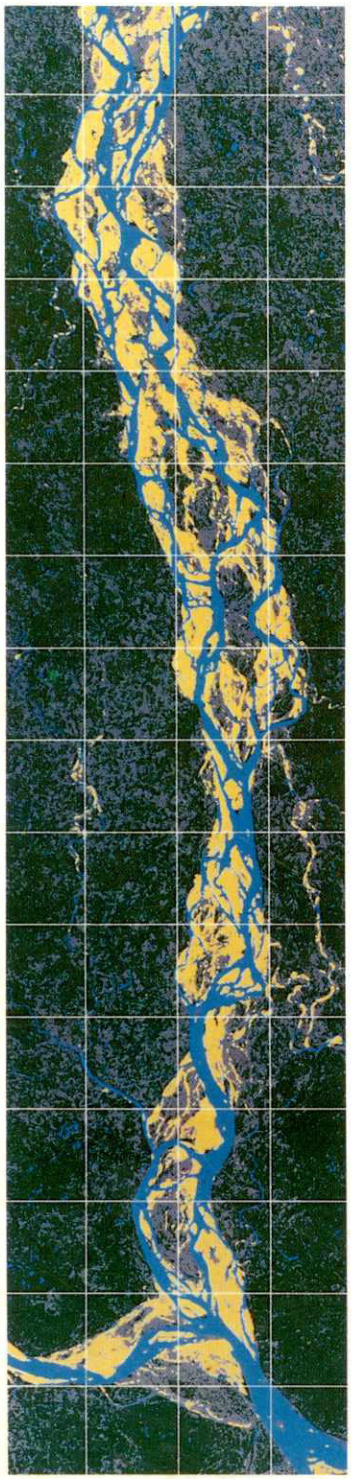

BANK PROTECTION AND RIVER TRAINING (AFPM) PILOT PROJECT FAP 21/22

TEST AND IMPLEMENTATION PHASE

REPORTS ON SUB-WATER INVESTIGATIONS OF FALLING AND LAUNCHING APRONS: A. VISUAL INSPECTION BY DIVING, AND B. SIDE SCAN SONAR SURVEY AT TEST SITE II - BAHADURABAD

FEBRUARY AND MARCH, 1999

JAMUNA TEST WORKS CONSULTANTS, JOINT VENTURE
CONSULTING CONSORTIUM FAP 21/22

RHEIN-RUHR ING.-GES.MBH, DORTMUND/GERMANY

COMPAGNIE NATIONALE DU RHONE, LYON/FRANCE
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BANK PROTECTION AND RIVER TRAINING
(AFPM) PILOT PROJECT
FAP 21/22

TEST AND IMPLEMENTATION PHASE

REPORT ON SUB-WATER INSPECTION AND INVESTIGATION OF FALLING AND LAUNCHING APRONS AT TEST SITE II - BAHDAURABAD

A. VISUAL INSPECTION BY DIVING

FEBRUARY 1999

BANK PROTECTION AND RIVER TRAINING/AFPM PILOT PROJECT
FAP 21/22

SUB-WATER INSPECTION AND INVESTIGATION OF FALLING AND LAUNCHING APRON AT BAHADURABAD

Table of Contents

1 INTRODUCTION

After construction of the Revetment Test Structure in the pre-monsoon period of 1997, two consecutive floods passed away, the last one in 1998, being the longest lasting one in the memory of the people. The visible changes above water and information collected using electronic monitoring system of the sub-water bed profile indicated that the falling aprons of all the section and launching aprons of B and C sections acted in the line of design principles. To compliment the understanding a programme of in-place visual inspection was taken and was carried out by a team of professional divers. The operation was supervised by the consultants engineers.

2 THE TASK

The task of the divers comprises:

a. To check materials on the slopes

a) limit of coverage up to bottom of the channel;
b) quality of coverage: dense, loose, connected, and
c) sedimentation on material

b. Special attention for RENO-Mattress at Section-C

a) how far the material is in good shape ?
b) is the reno mesh broken ? how big are the broken part ?
c) are gravels out of the cage or loose ?
d) where is the end of RENO on the slope ? and
e) are still geo-containers on the slope up to the bottom of the channel ? how dense?

c. What is left on the slope of Section B?

d. Falling aprons of Sections D to G (cc-blocks and geo-container): what is laying on the slope ? how deep, dense, loose etc.?

e. Sections G and H: how far is the sedimentation?

To accomplish the above task in answering the questions and to provide information on the sub-water conditions of the part of the structure in falling and launching aprons a professional diving team supervised by the consultant was engaged and detail information was collected of the sub-water part of the structure after visual inspection.

3 DIVING TEAM

The diving team comprises:

1. Mr. Sufi Mohammed Atiqur Rahman, Diving Inspector;
2. Mr. Bashir Uddin, Diver, and
3. One support staff. from Oceanic Scuba Diving Service, 45 Dilkusha C/A, Dhaka

4 SUPERVISION

1. Mr. Syed Mohiuddin Mansur, Deputy Project Manager, JTWC;
2. Mr. Pankaj Kumar Maitra, Monitoring Engineer, JTWC, and
3. Mr. Golam Kader, Supervision Engineer, JTWC.

5 DIVING OPERATIONS AND FINDINGS

The followings are the chronological descriptions of the diving operation and the findings. The operation was carried out just after mid-February when water level in Brahmaputra-Jamuna reaches almost its minimum to facilitate the inspection.

Date: February 16, 1999 Water Level: 13.20 m PWD

Under water investigation of falling apron in section B of the Revetment Test Structure

Diver: Mr. Sufi Atiqur Rahman
Start: 15.00 hrs. End: 16.00 hrs.

Investigated Transition of Section A and B:
Transition of Section A and B: General observation is as follows:
Existence of cc-blocks was found approx. 10 m from waterline. The blocks were scattered and did not form the slope, also nor in evenline. The slope is covered by thick deposit of clayee loam at the beginning of section B. Slightly upstream of the section start of a scour hole was located. Approximately the hole is 3 m x 3 m x 1.5 m in size at water depth of 4 m.

Geo-sand container was found in Section B as continuous cover over bed material up to 15 m from waterline. The bags were intact, undulating in slope. Scattered cc-locks were also found in this section up to 24 m from waterline. Rest of the slope was composed of soil and hard clayee soil lumps.

REMARKS: The scattered cc-blocks found at the bottom of the slope are the remaining ones in the stack yard at natural cofferdam after the structure section. With the first disappearance of the cofferdam by erosion of the river, probably the blocks settled directly at that location.

Diver: Mr. Bashir Uddin
Start: 16.15 hrs. End: 17.15 hrs.

Investigated mid-section of B and transition of section B and C:
At mid Section of B:
Approx. 12 m from waterline the bed was found in uniform gentle slope and then a sudden drop, then again uniform slope, Up to 12 m, the slope is covered by Geo-sand container covering the bed material more or less completely. After the drop, no more geo-sand container – the slope is covered by clayee soil.

Transition of Section B and C:
Close to the transition and up to 10 m upstream in section B, the slope is covered by random cc-blocks and sand bags – scattered and few in numbers.

From transition to downstream in Section C, RENO-mattress in double layers was found. Geotextile sheet separating two layers of Reno-Mattress and top layer RENO-mattress were found in good condition. Bottom layer appeared to have been rusted. Beneath RENO-mattress Geo-sand containers were found. This was up to 14 m in slope from waterline.

After this 14 m, further 16 m of slope was covered by geo-sand container in uniform slope and then scattered geo-sand container.

Date: February 17, 1999 Water Level: 13.18 m PWD

Diver: Sufi Atique
Start: 8.15 hrs. End: 9.45 hrs.

Diver: Bashiruddin
Start: 10.00 hrs. End: 12.30 hrs.

Investigated Section C – Falling and Launching Apron and Section D,E,F,G,H - Falling Aprons:
Upstream Transition of C:
Slope was covered by RENO-Mattress up to distance of 12 m from the waterline. The connecting wire between adjacent first and second RENO compartment at a distance of about 3 m from waterline was torn away and the mattress rolled upward. Few gravels were lost from the top.

Geo-sand container covered the slope from 12 m to 36 m. These were not in uniform thickness, rather were found in single, double or even in triple layer. Between geo-sand containers, free soil surface was encountered, but this gap of free soil surface were small. Deposit of silty loam type soil in dense layer was found after the end of geo-sand container to the bottom of the slope. Over the geo-sand container no soil deposit was encountered, but algae type growth was detected.

Intermediate part of Section C
RENO-mattresses cover extended from waterline to 7 m down the slope and was in good condition. No rupture or damage was detected. No deposit of soil was encountered over RENO. Geo-sand containers took the position from 7 m to 25 m down the slope. The slope was not uniform. At end of Geo-sand containers, a vertical trench like formation in north-south direction for a short distance was found. All the containers were intact. Loose deposit of sand was found between gaps of the containers.

Section D: End of Falling Apron was detected at a distance of 24 m from waterline. Falling apron cc-blocks has taken non-uniform slope up to the end and between these coarse sand deposit was found. A sunken country boat propelled by engine was found at the end of falling apron block. Falling pattern was the same as is seen above waterline.

Section E-1: End of Falling Apron
CC-blocks were found up to a distance of 12 to 15 m from waterline, but not in uniform pattern. Intermediate gaps were between 2 to 3 meters and uncovered soil was seen in these gaps. At the end, bed has raised slightly.

Section E-2:
Scattered gabion sacks were found with intermittent gaps of 2 to 3 meters. In gaps, soil cover only with coarse sand deposit was found and extended up to 15 to 18 m from waterline. End raised slightly.

Section F:
CC-blocks covered a length of 13 m in to the river. The total length has not been covered by blocks. In some place in this area, block was heaped together and in other place, no block at all. The heap is quite vertical and seemed that would collapse with small disturbance. Uniform channel like formation between blocks in longitudinal direction was found.

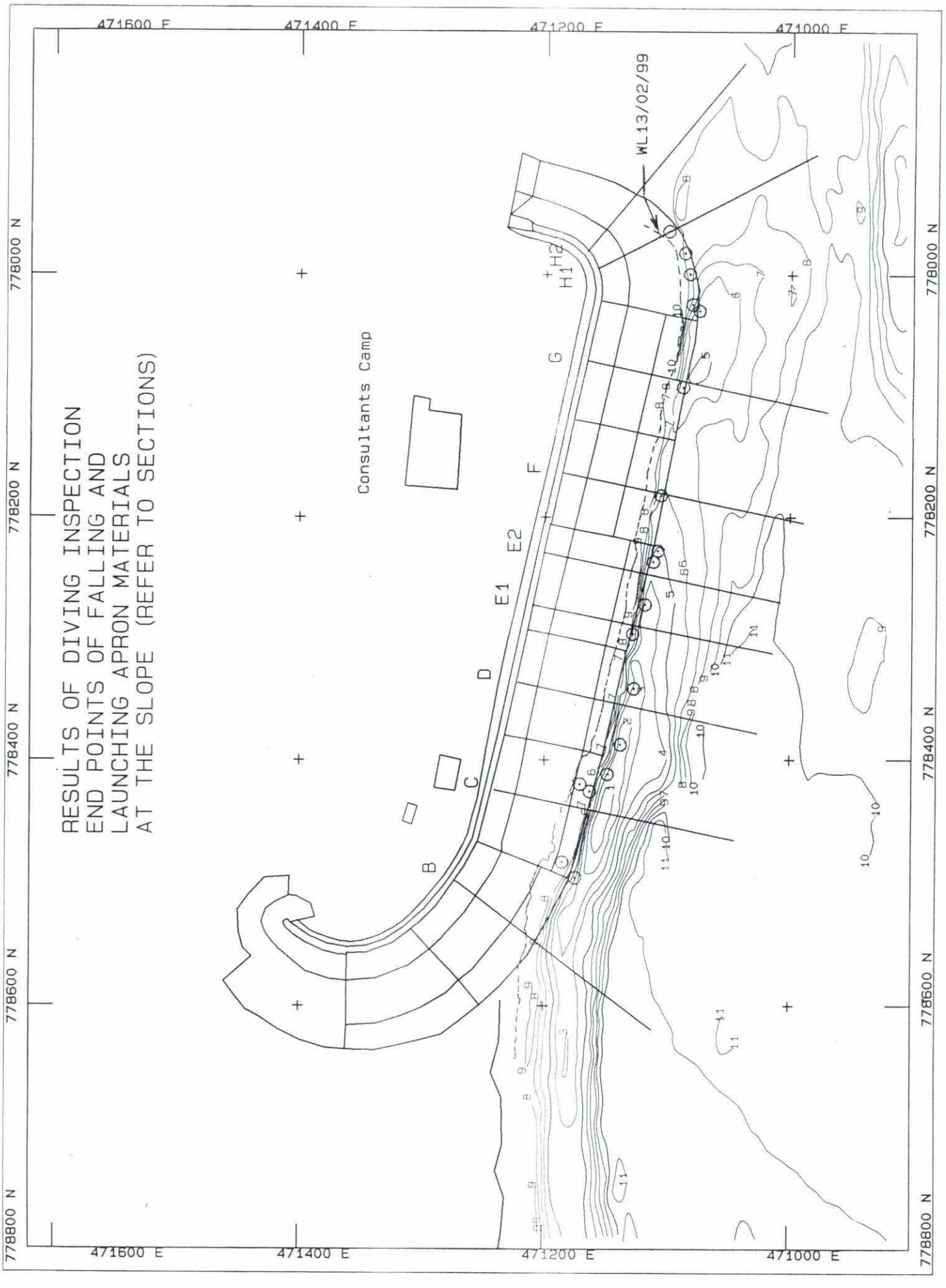
Section G:
Scattered blocks with gaps in between but not very big was found up to a distance of 15 m from the waterline. Number of gaps were large. Raised sand of 1 m width in longitudinal direction in some part was found.

Section H:
Scattered cc-blocks were found after the slopped cc-blocks extending more or less uniformly from a distance of 16 m to 8 m in upstream to downstream direction. Clay soil was encountered after cc-block. Bed is more or less uniform.

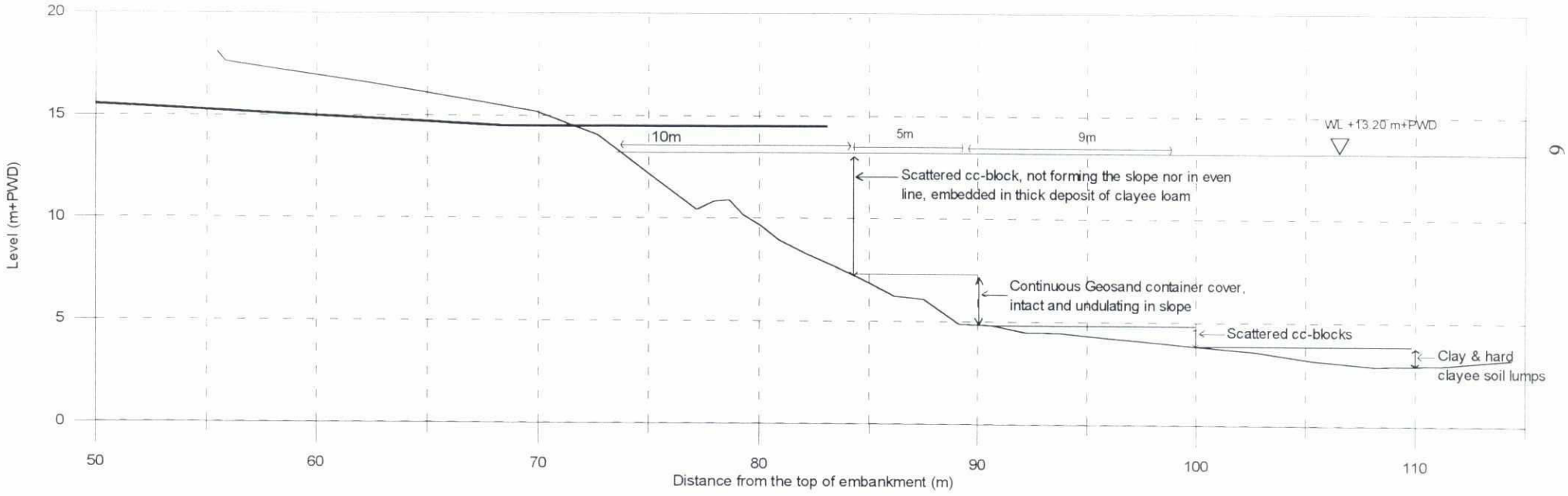
6 GRAPHICAL PRESENTATION OF RESULTS

End Points: End points of falling and launching aprons in the plan view of the structure with bathymetry contour line of bed profile and waterline on 13.02.99 have been presented.

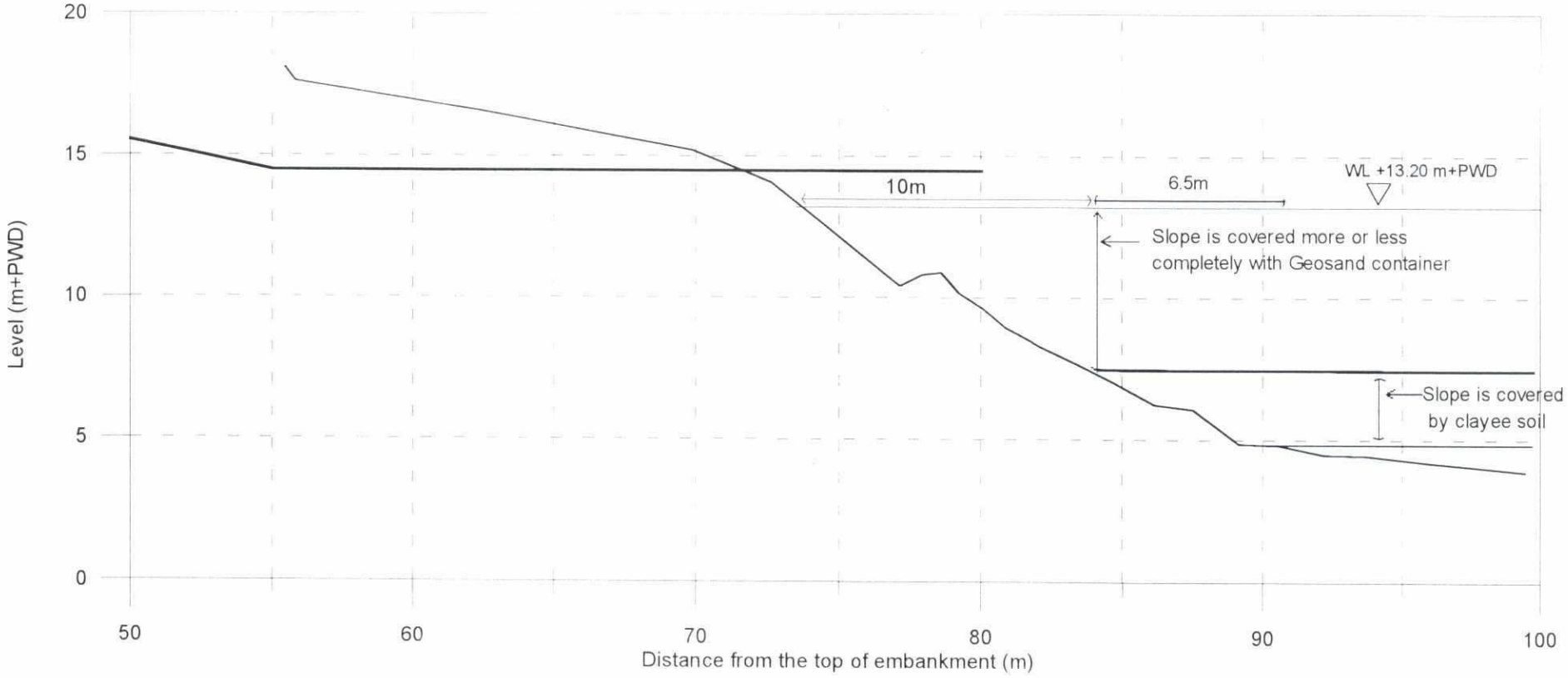
Sectional View: The findings of the diving inspection and investigation have been presented in brief in the cross-sections.


RESULTS OF DIVING INSPECTION
END POINTS OF FALLING AND
LAUNCHING APRON MATERIALS
AT THE SLOPE (REFER TO SECTIONS)
WL13/02/99
Consultants Camp
471600 E
471400 E
471200 E
471000 E
778000 N
778200 N
778400 N
778600 N
778800 N
B
C
D
E1
E2
F
G
H1
H2

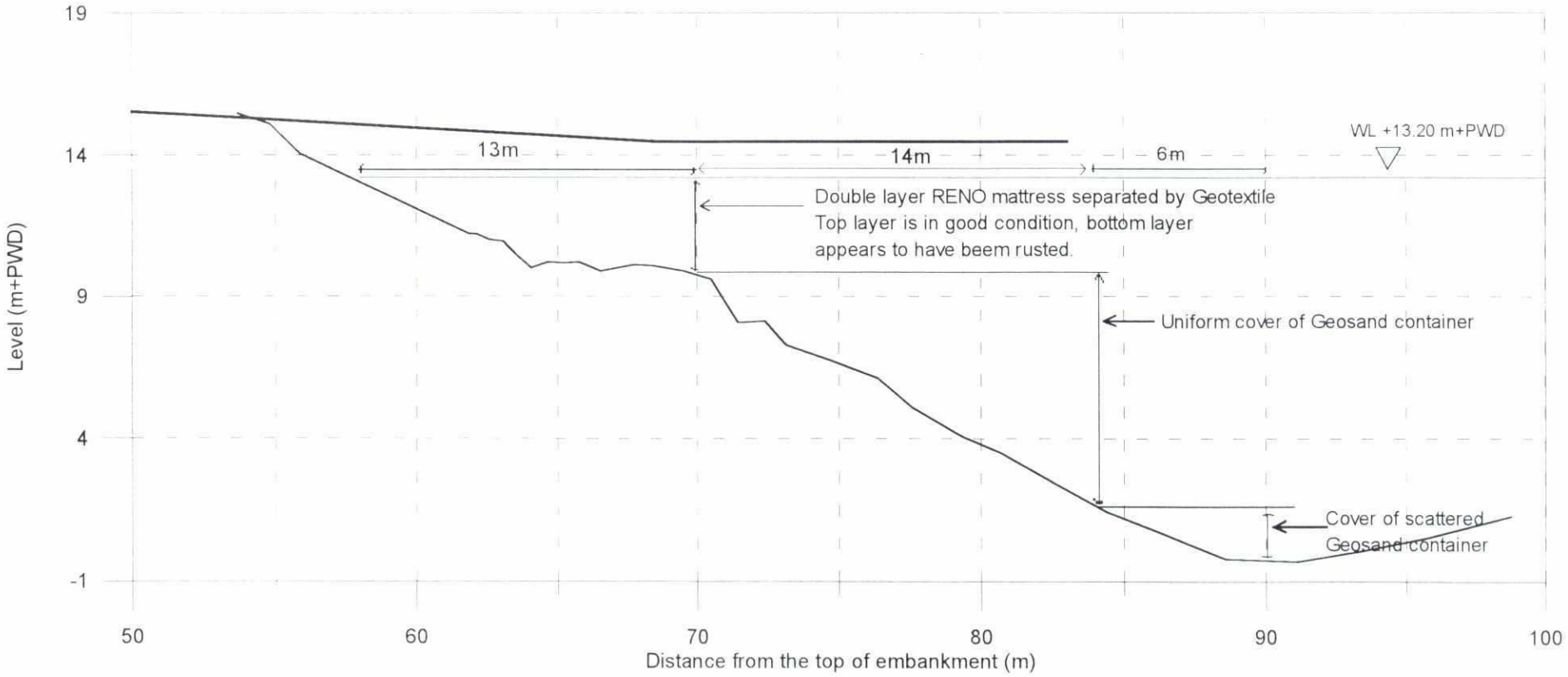
Results of Inspection by Diving
Bahadurabad Test Site
Upstream Transition of X_sec: B [16/02/99]



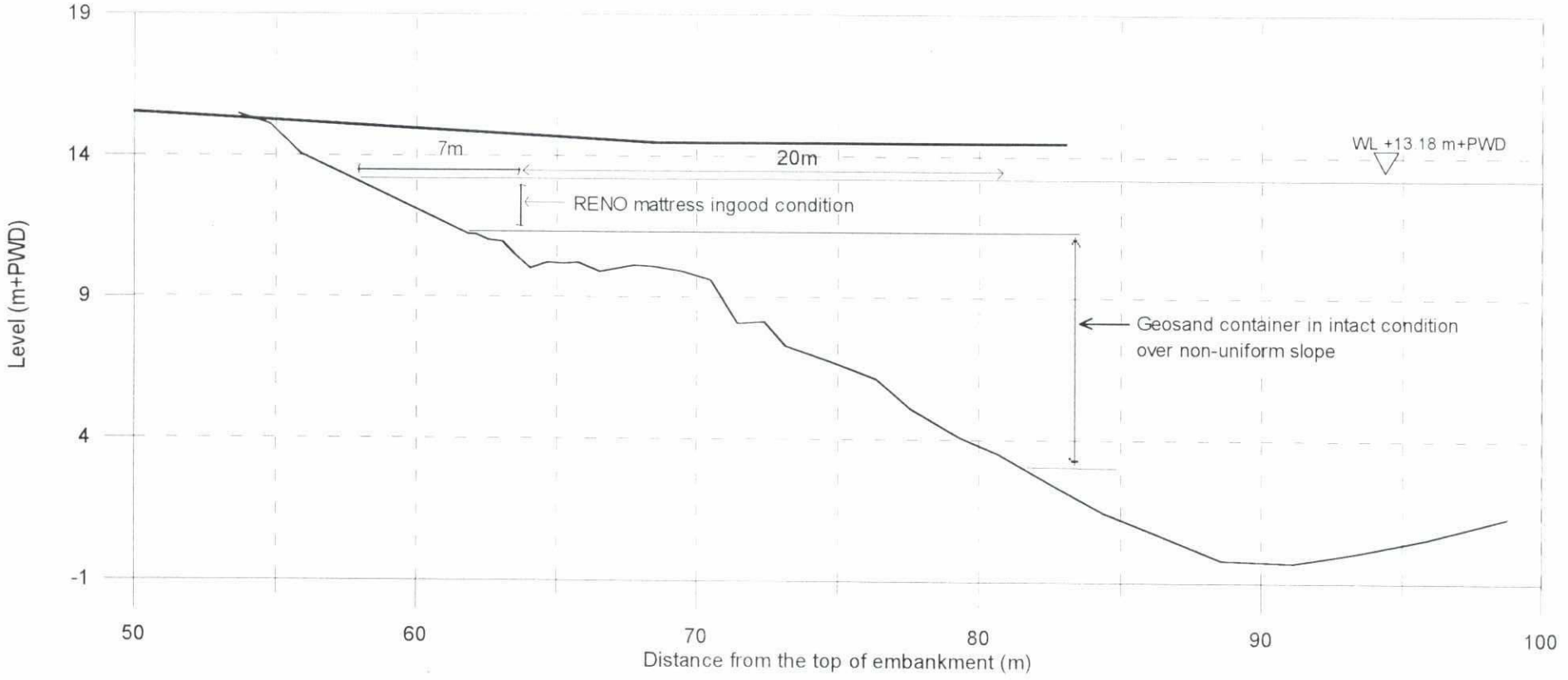
Results of Inspection by Diving
Bahadurabad Test Site
Mid of X_sec: B [17/02/99]

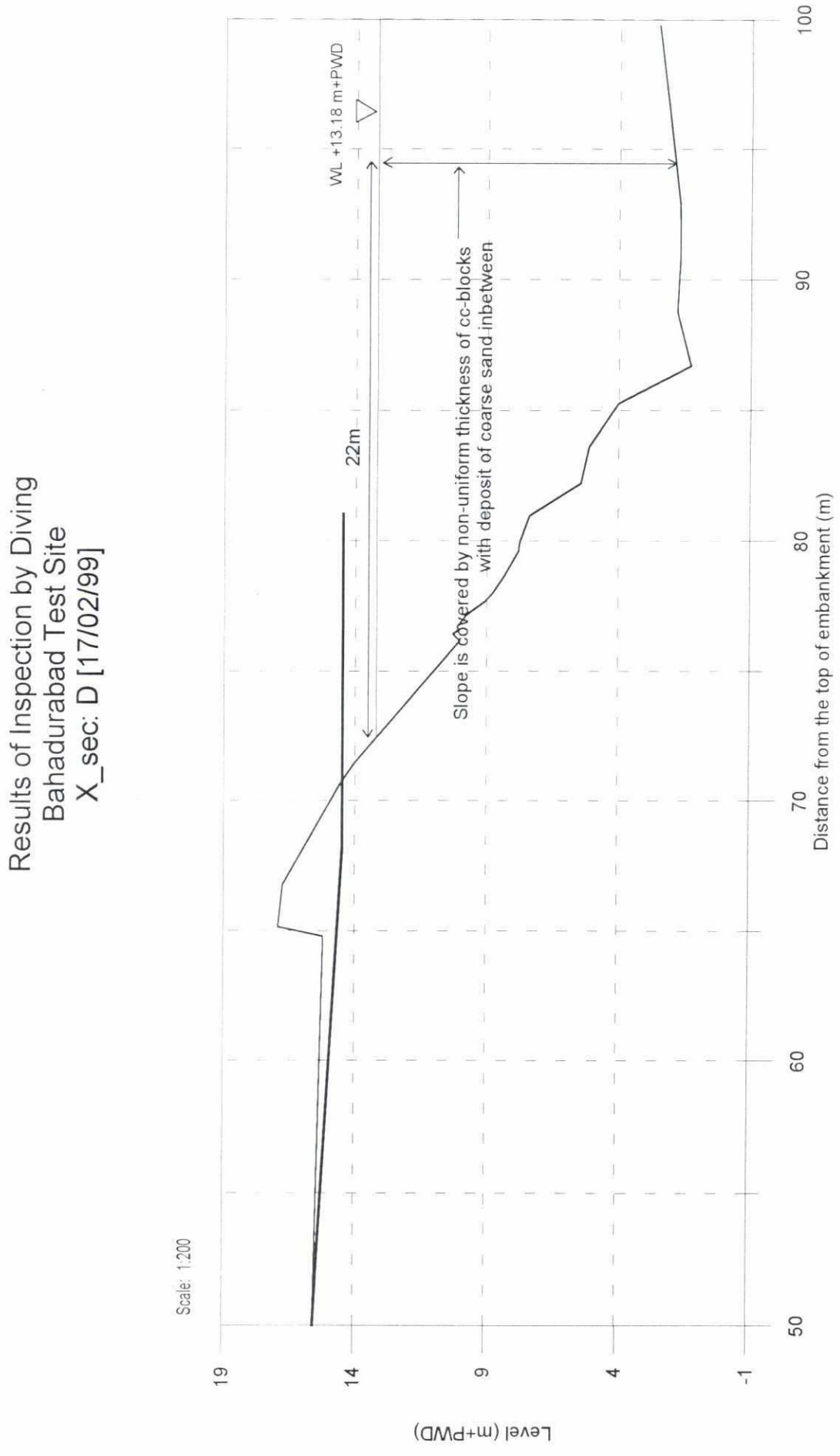


Results of Inspection by Diving
Bahadurabad Test Site
Transition of X_sec: B & C [16/02/99]

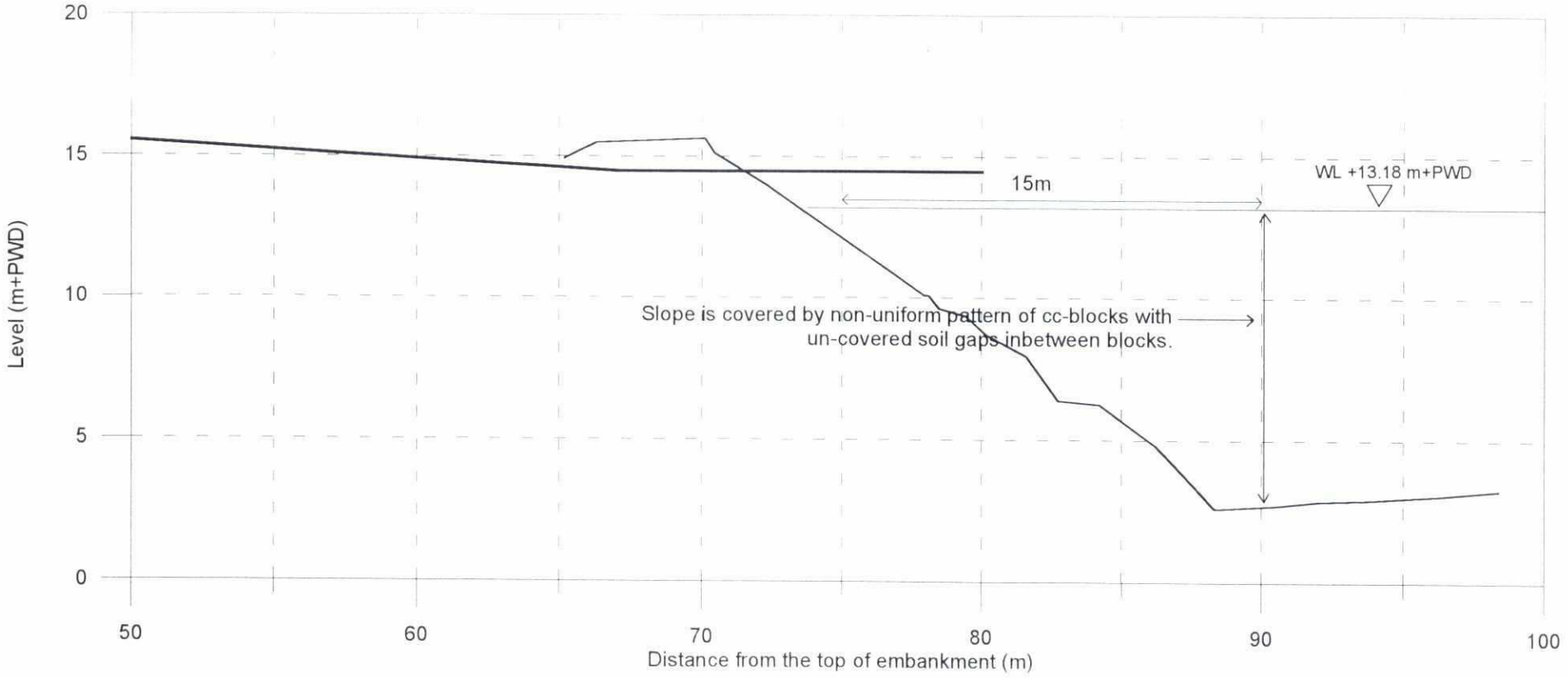


Results of Inspection by Diving
Bahadurabad Test Site
Transition of X_sec: C [17/02/99]

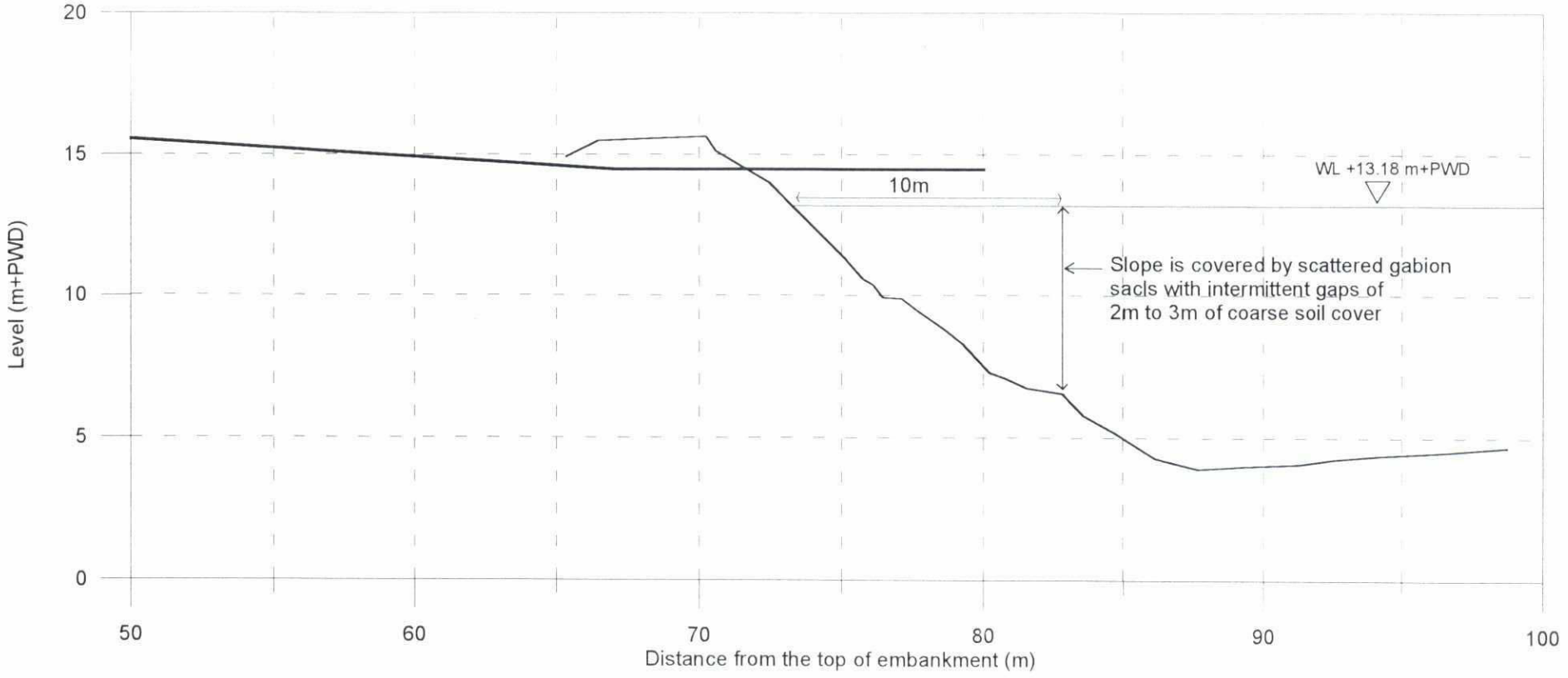


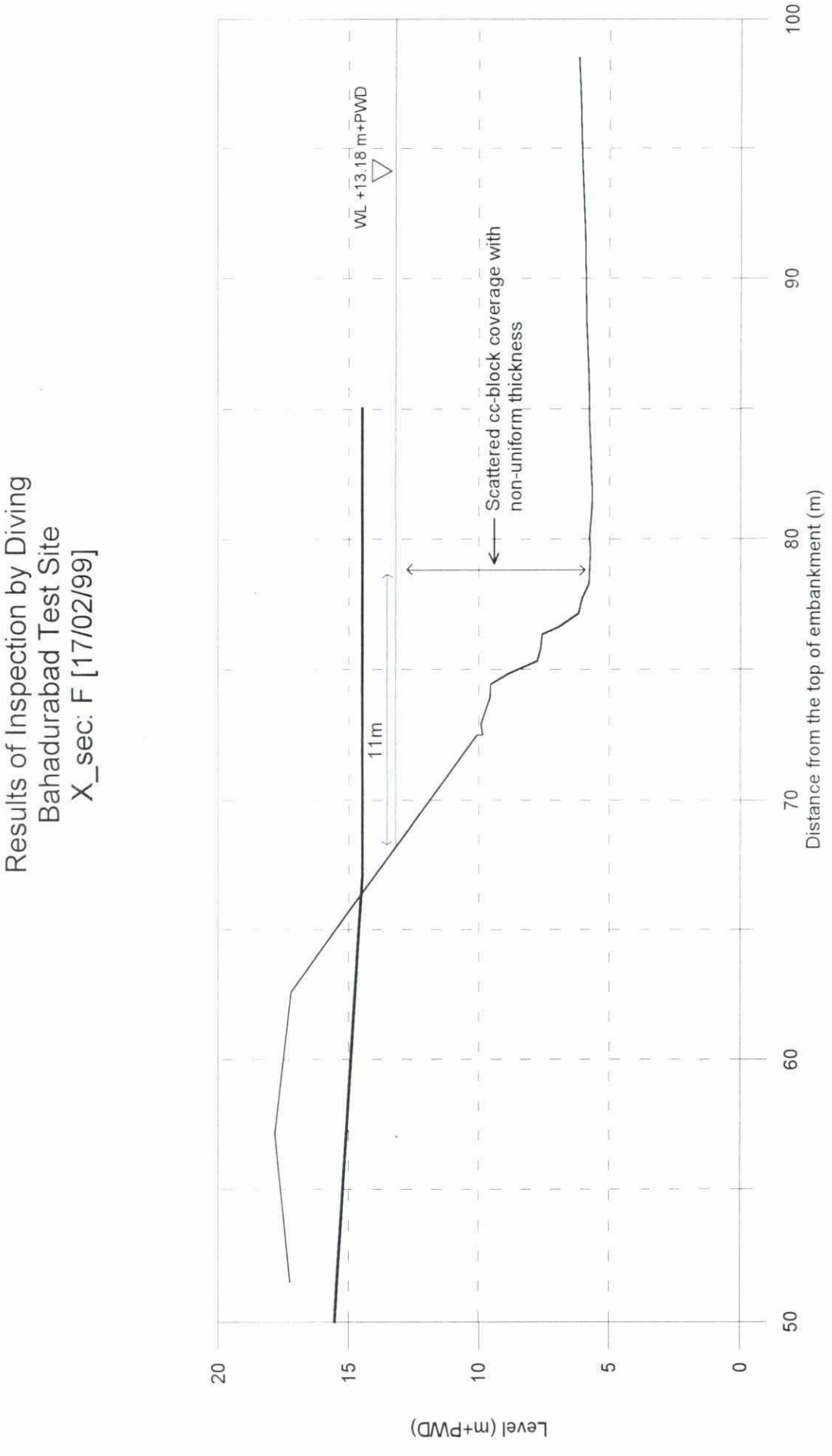

Results of Inspection by Diving
Bahadurabad Test Site
X_sec: D [17/02/99]
Scale: 1:200
WL +13.18 m+PWD
22m
Slope is covered by non-uniform thickness of cc-blocks
with deposit of coarse sand inbetween
Level (m+PWD)
19
14
9
4
-1
50
60
70
80
90
100
Distance from the top of embankment (m)

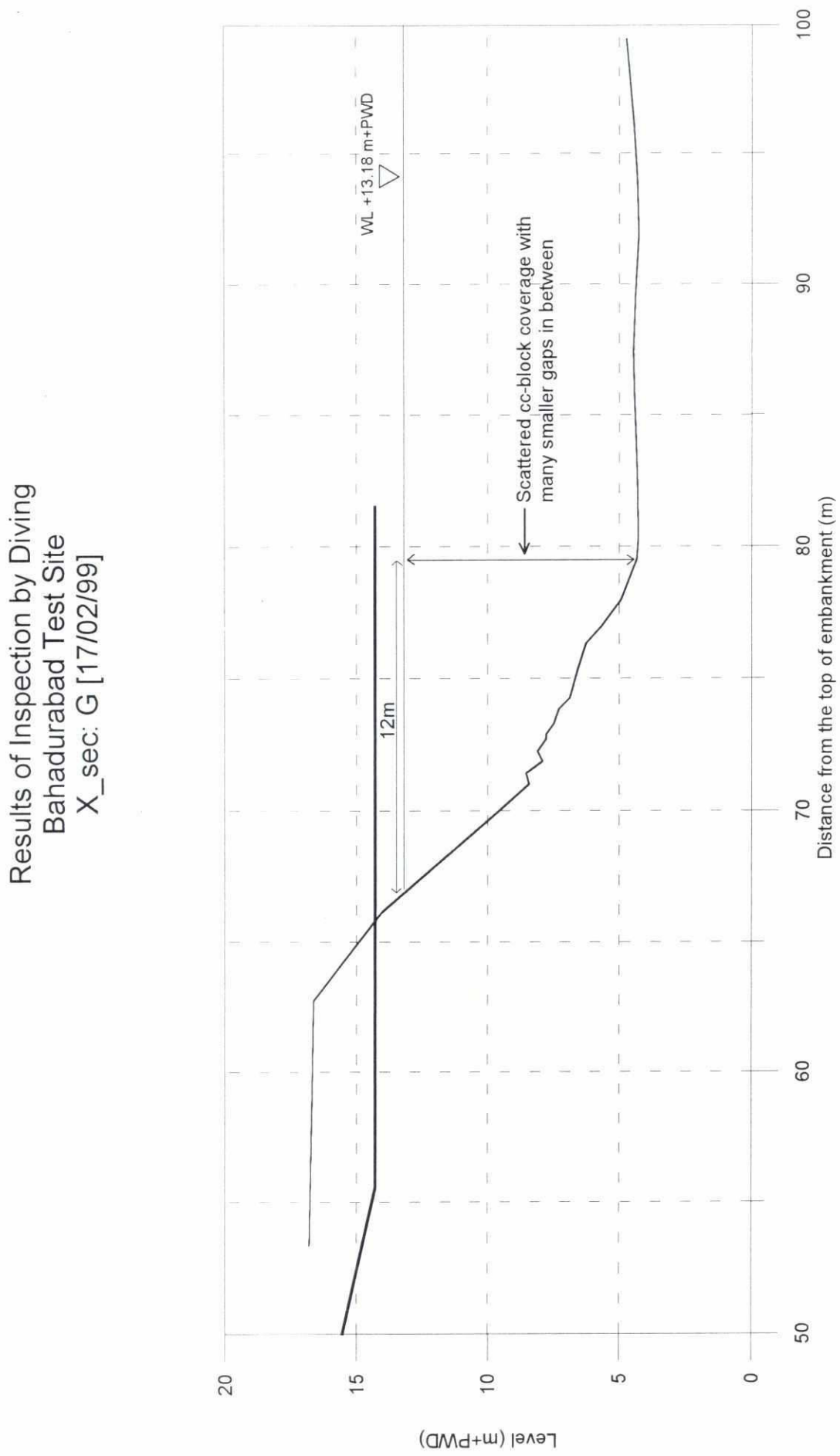
Results of Inspection by Diving
Bahadurabad Test Site
X_sec: E1 [17/02/99]

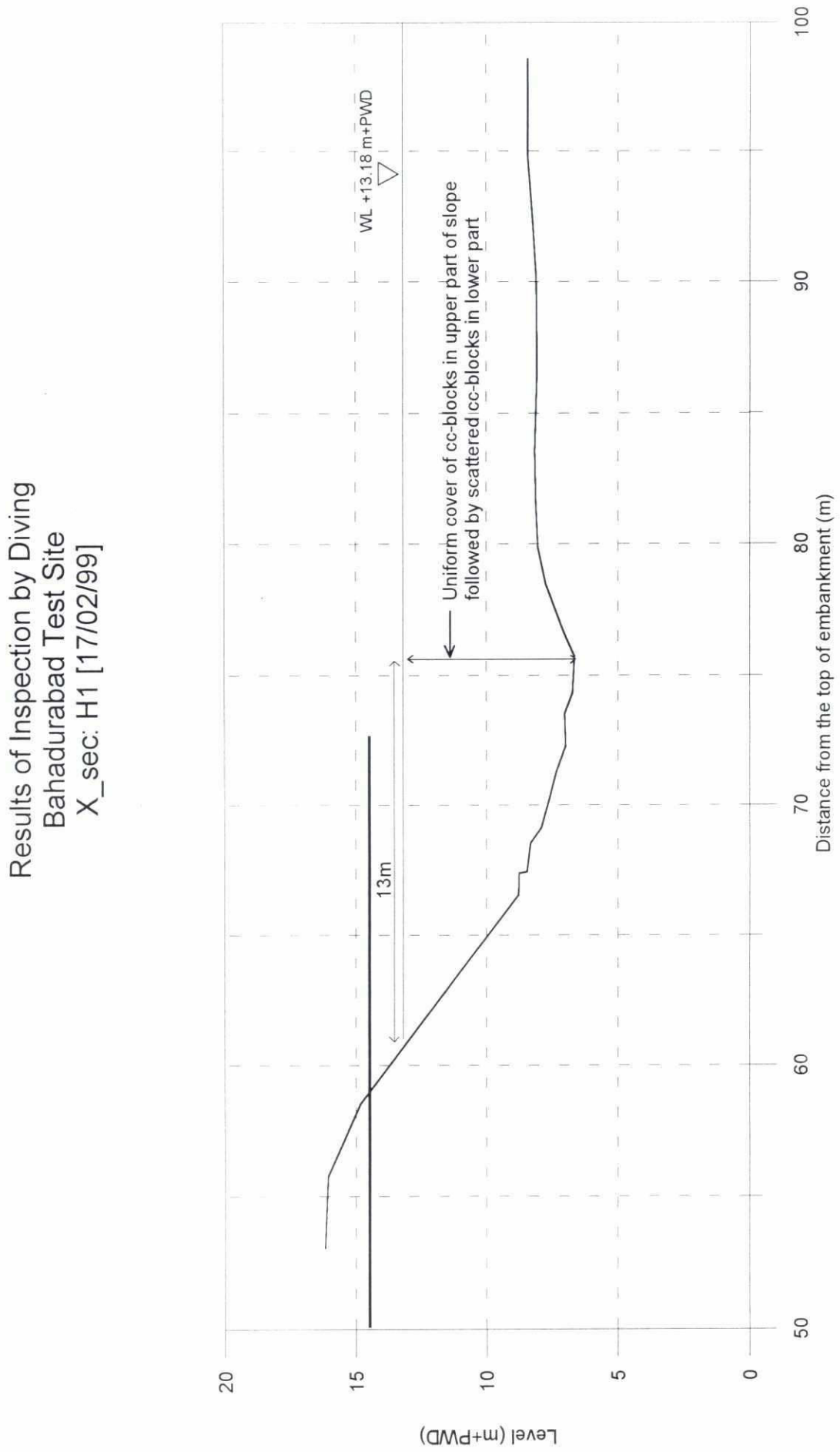


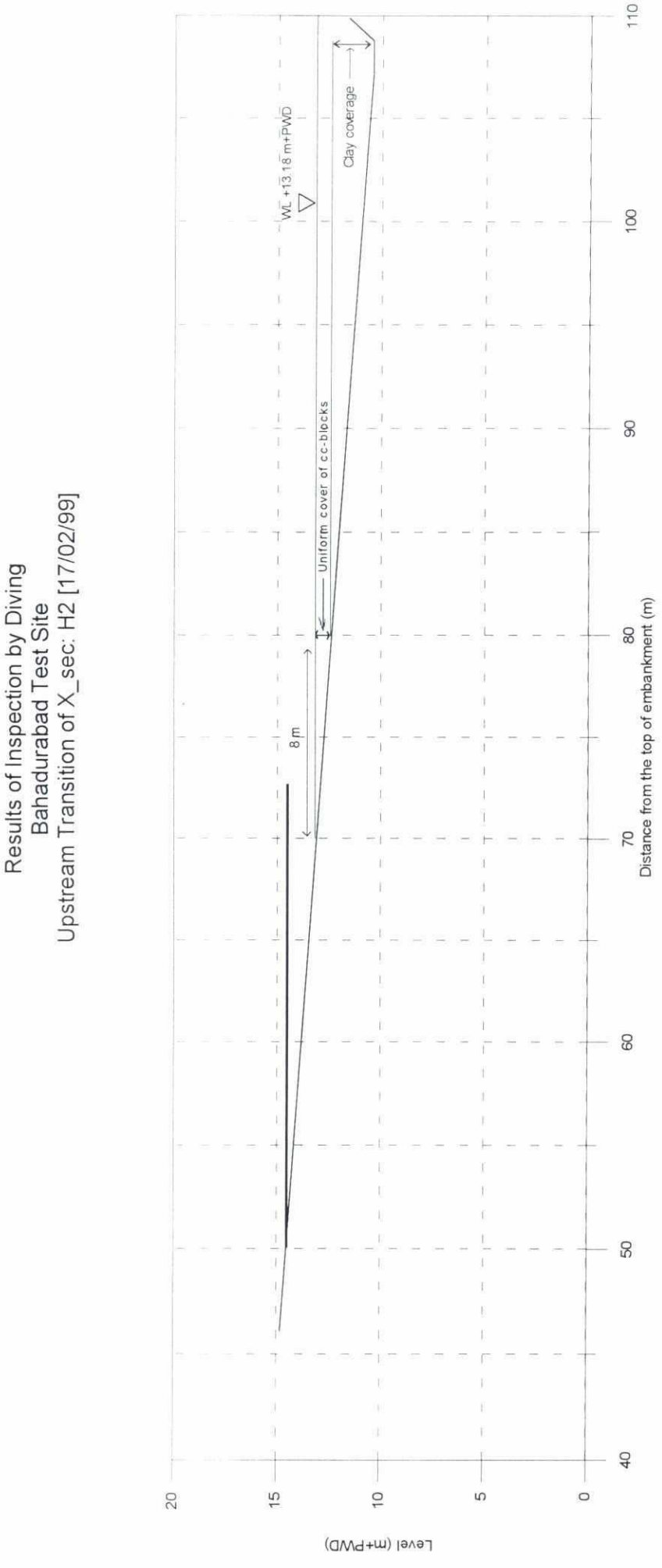
Results of Inspection by Diving
Bahadurabad Test Site
X_sec: E2 [17/02/99]




Results of Inspection by Diving
Bahadurabad Test Site
X_sec: F [17/02/99]
WL +13.18 m+PWD
Scattered cc-block coverage with
non-uniform thickness
11m
Level (m+PWD)
Distance from the top of embankment (m)
20
15
10
5
0
50
60
70
80
90
100


Results of Inspection by Diving
Bahadurabad Test Site
X_sec: G [17/02/99]
WL +13.18 m+PWD
Scattered cc-block coverage with
many smaller gaps in between
12m
Level (m+PWD)
Distance from the top of embankment (m)
20
15
10
5
0
50
60
70
80
90
100


Results of Inspection by Diving
Bahadurabad Test Site
X_sec: H1 [17/02/99]
WL +13.18 m+PWD
Uniform cover of cc-blocks in upper part of slope
followed by scattered cc-blocks in lower part
13m
Level (m+PWD)
Distance from the top of embankment (m)
20
15
10
5
0
50
60
70
80
90
100


Results of Inspection by Diving
Bahadurabad Test Site
Upstream Transition of X_sec: H2 [17/02/99]
WL +13.18 m+PWD
Clay coverage
Uniform cover of cc-blocks
8 m
Level (m+PWD)
Distance from the top of embankment (m)
20
15
10
5
0
40
50
60
70
80
90
100
110

20

BANK PROTECTION AND RIVER TRAINING
(AFPM) PILOT PROJECT
FAP 21/22

TEST AND IMPLEMENTATION PHASE

REPORT ON SUB-WATER INSPECTION AND INVESTIGATION OF FALLING AND LAUNCHING APRONS AT TEST SITE II - BAHDAURABAD

B. SIDE SCAN SONAR SURVEY

MARCH 1999

BANK PROTECTION AND RIVER TRAINING/AFPM PILOT PROJECT
FAP 21/22

SIDE SCAN SONAR SURVEY

Table of Contents

1 SURVEY DESCRIPTION

1.1 GENERAL

On 1st and 2nd of March '99 Side Scan Sonar (SSS) surveys have been carried out at Bahadurabad. The task is to investigate the sub-water part of the falling and the launching apron of the structure. Subjects of interest are to check the condition of the apron along the structure, to look for any inhomogeneous part of the apron and to survey whether construction material can be detected in front of the falling apron. On 2nd of March '99 bathymetric cross-sections have been taken as well. The cross-sections are given as additional information in Annex A.

1.2 SYSTEM CONFIGURATION

The survey boat 'Obelix' has been used to carry out the Side Scan Sonar Survey. For navigation and positioning the same setup as for bathymetric surveys can be used. The Masterchart data logging format has been chosen as follows:

Time, Fix number, Easting, Northing, depth, speed made good (SMG), distance along line (DAL) distance offline (DOL).

Every second one data string is logged in the navigation file. The side scan sonar recorder provides only analog records. It is not equipped with a navigation interface board, i.e. navigation data from Masterchart cannot automatically be read in by the recorder. Therefore the side scan sonar operator has to release manual fixes given by the navigation operator. By this manual fixing the side scan sonar records can be related to the navigation data. A fix interval of 10 seconds has been chosen. That means the side scan sonar records are provided every 15m with a position fix.

The side scan sonar towfish has been mounted 1m starboard front side of the survey boat, and could be lowered by the anchor winch. The offset of the towfish in relation to the GPS antenna was used as input to Masterchart to get navigation and logging of the towfish position.

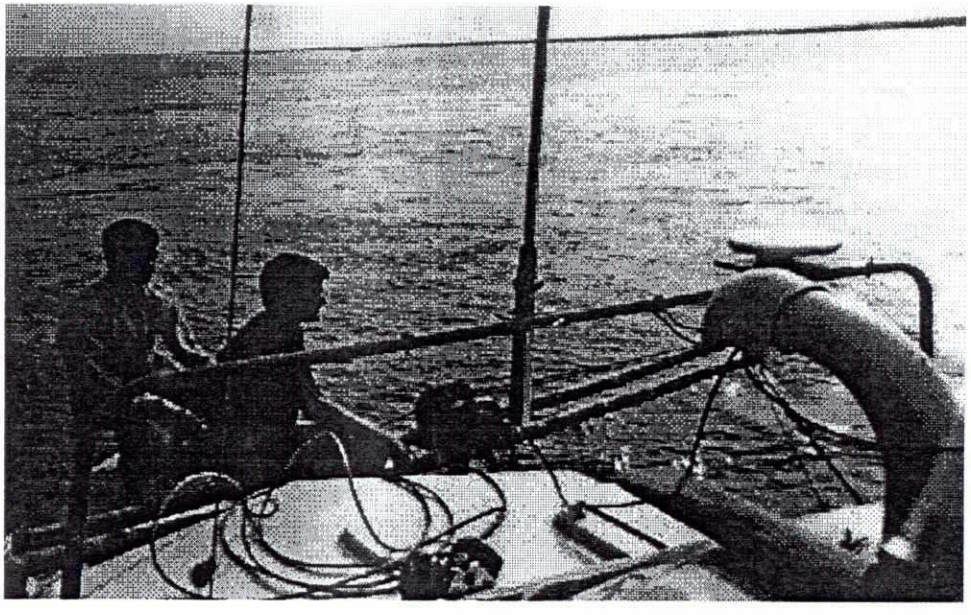


Photo 1: Towfish mounting by bamboo at the starboard front side of the boat

First tests to tow the fish by the valeport winch at the port rear side of the survey boat have shown an interference with the noise of the engine and the generator. To get best results the towfish should be located far off any boat noise. During survey operation only the port engine has been running.

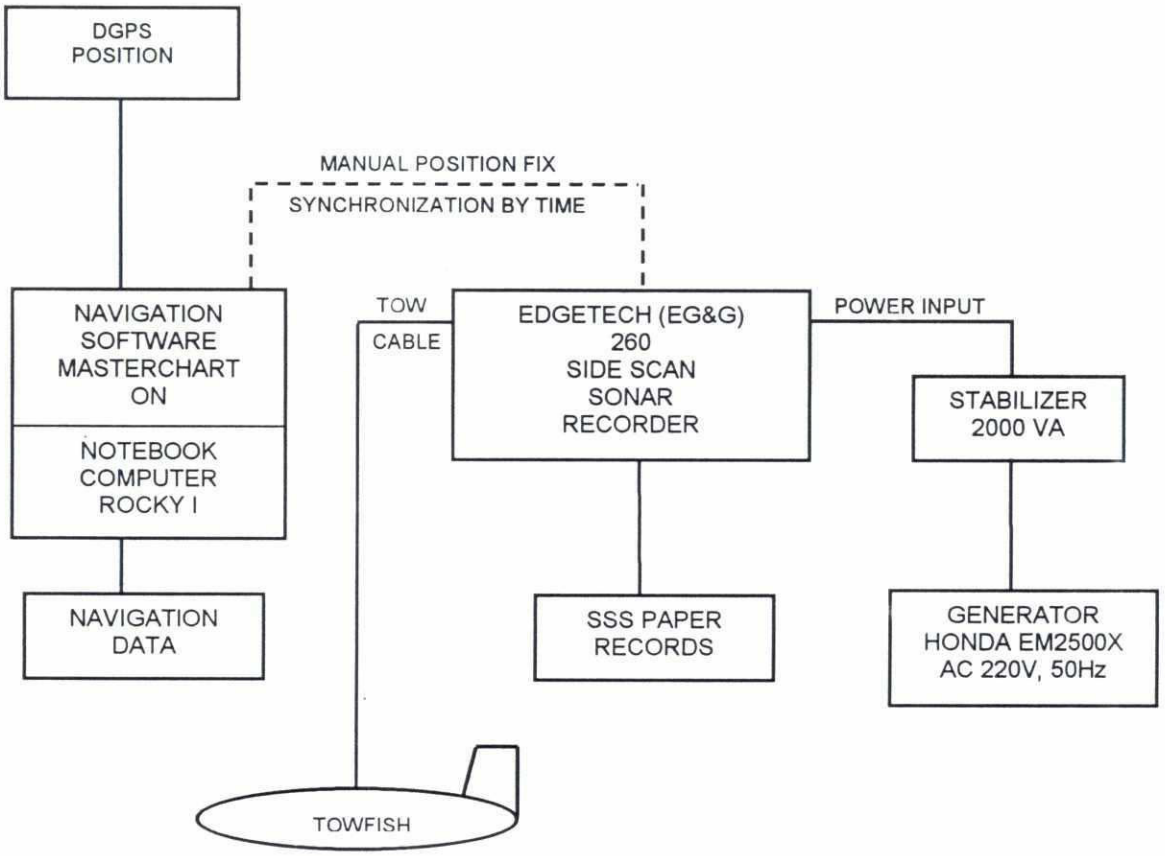


Fig.1: Side scan sonar system configuration

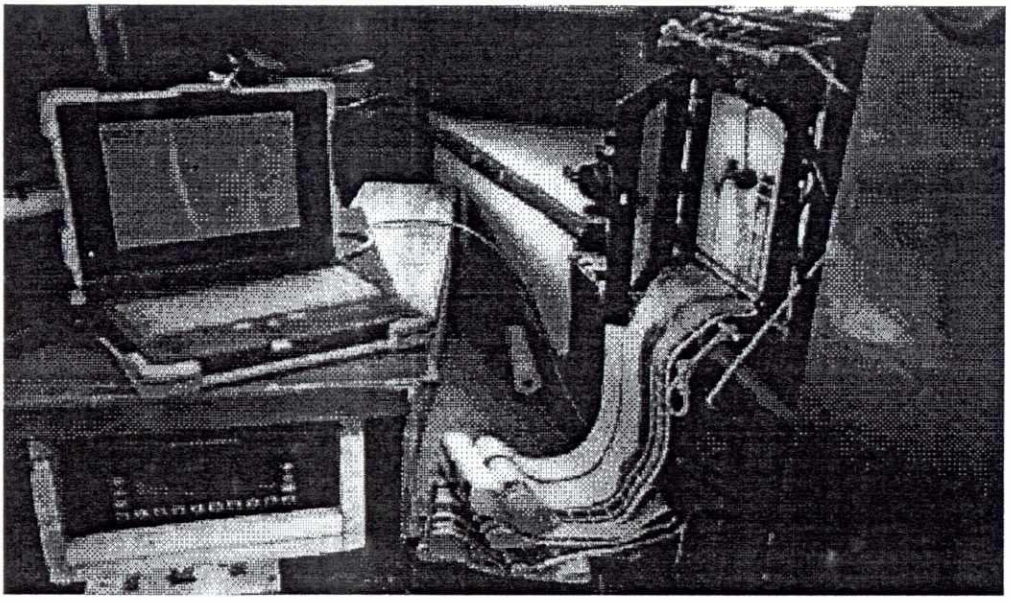


Photo 2: Side scan sonar recorder and navigation setup

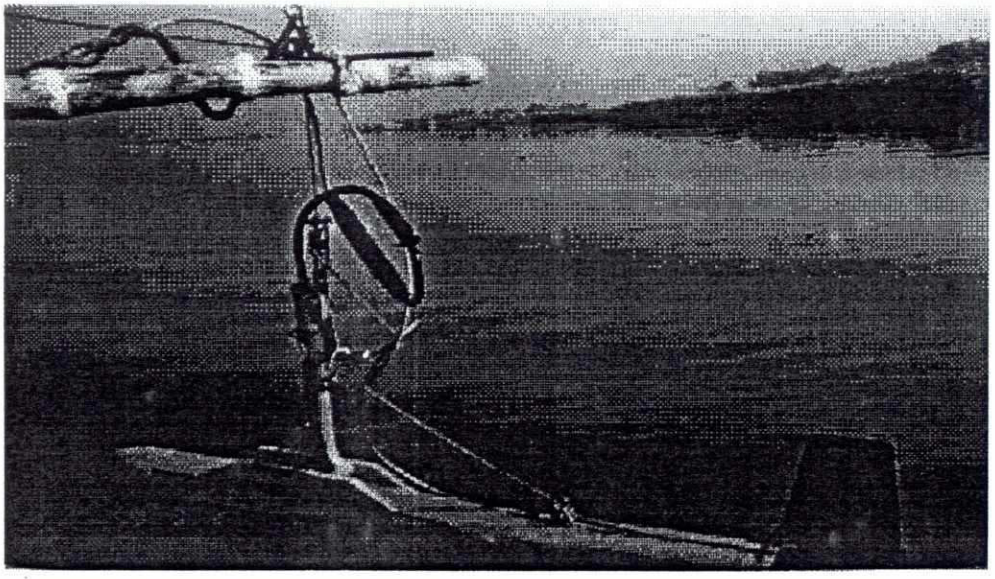


Photo 3: Side scan sonar towfish

1.3 SYSTEM DESCRIPTION

A Side Scan Sonar survey provides a plan view map of the riverbed. The sonar is scanning the river bottom by emitting pulses in a thin, fanshaped pattern that spreads downward to either side of the towed fish in a plane perpendicular to its path. It derives its information from reflected acoustic energy.

Depending on the backscattered strength of the signal the recorder prints an image graphic of 16 different grey tones (sonograph). Good acoustic reflectors like cc-blocks, boulders or sand ripples are represented by darkened areas on the record. Depressions or other features scanned from the acoustic beam are indicated by light areas. The high system resolution (pixel size of 1/8 mm) enables to recognises single stones or boulders on the recorded image. Other objects like ropes, fishing nets can be detected as well. Objects can be positioned on the sonograph like on a map scaled 1:250 (selected range of 25m). More details are given in the References Nos. 1 to 3.

1.4 SURVEY ROUTE PLANNING

The survey tracks have been sailed parallel to the structure heading from South to North (against the current). Section C to section G are fully covered by the SSS records, whereas section B and section H1 are covered partly due to shallow water.

The centre trackline is defined 20m off from the original as built end of falling apron. Parallel lines can be selected to both sides of the centreline with 5m separation interval. Best coverage has been archived at 10m and 15m east from the centreline, i.e. 10m from the original end of falling apron 5m respectively. The coordinates of the centre trackline are as follows:

1. 471063E 777978N
2. 471055E 778042N
3. 471158E 778504N
4. 471236E 778612N

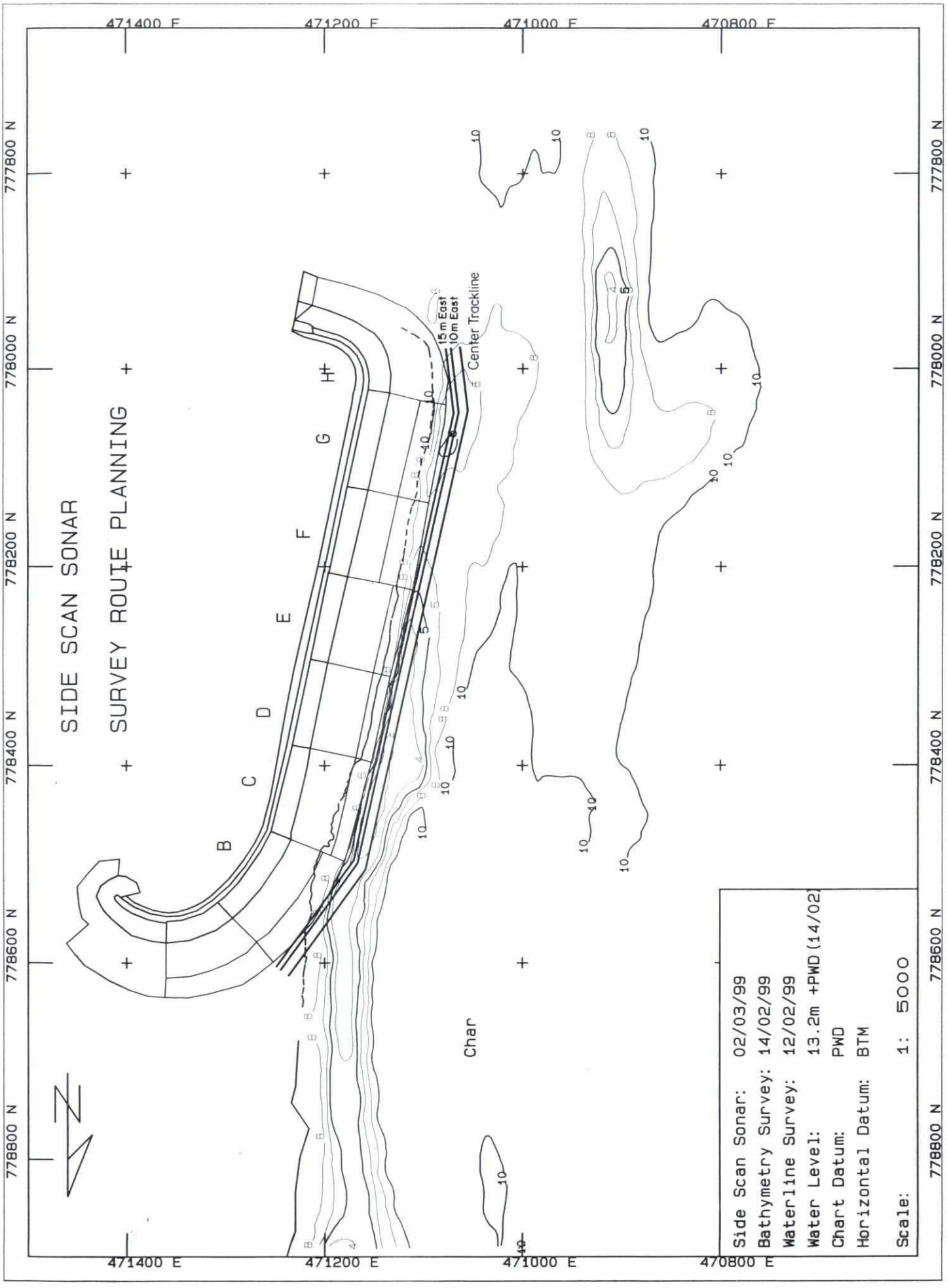


Fig. 2: Survey route planning

1.5 PARAMETER SETTINGS

Best results are archived with following parameter settings of the side scan sonar:

Fish depth: 1m
Range: 25m (25m range to each side of the fish)
Survey speed: 3kn (1.5m/s),manual input
Frequency: 500kHz
Fish height: 5m, manual input
Gain: 0-1
Contrast: Normal

A fish depth of 1 m has been chosen to avoid bottom collision and to archive a maximum recording of the apron (up to 1 m below the water level). The range of 25 m is minimum setting and guarantees maximum resolution.

The survey speed is controlling the paper transport speed of the recording and thereby a true scaling in sailing direction. Therefore it is substantial to keep the speed during the survey. The survey speed is given by DGPS and is logged for post processing on the navigation computer.

For SSS surveys in shallow waters and a small range selected a transmitting frequency of 500kHz should be chosen for high resolution instead of optional 100kHz.

The fish height has to be set manual to a mean value, because the automatic bottom tracking has been found not stable due to rapid changes of the water depth. Losing the bottom tracking during the survey is affecting the quality of the recording.

Because of the strong reflectors of the apron and shallow waters a minimum gain is recommended. Higher gain results noise on the records which let to misinterpretations.

2 RESULTS

The side scan sonar results as detailed below are presented separated for each section on the sonographs (Fig.3 to Fig.10). The figures can be copied from the original side scan sonar recording paper without any information lost. However the original paper rolls are archived in Dhaka monitoring office as well as the navigation files. The scale of the sonographs is 1:250. A depth profile below the towfish is displayed on the right part of the sonograph. This profile is a tool for the operator to monitor the towfish height and bottom tracking during the survey. It is not needed for the analysing of the side scan sonar results. The markings at the centreline of the sonar image representing the fix numbers, which are corresponding to the navigation file.

The most information is given by the selected tracklines 10m or 15m east of the centreline, i.e. 10m from the original end of falling apron 5m respectively. Besides the selected frequency of 500 kHz, the selected range, gain and an internal recorder time is printed on the sonograph. The corresponding navigation filename is given in the bottom right corner. Construction material like single cc-blocks in front of the falling apron are not detected at all.

It must be noted, that the detected end of the falling apron by the side scan sonar must not be the final end. After the deep channel creation in front of the structure in 1997, the channel almost closed by high sedimentation in July 1998 before the channel opened again but not as deep as in 1997 (Ref. No. 5). Therefore it must be considered that the end of the falling apron is still covered by sediments and cannot be detected by the side scan sonar!

2.1 SECTION B

Section B is covered by the SSS-records up to 36m upstream of the transition to section C (Fig.3, Fix 280-283). The corresponding Masterchart File is 15B02.LOG. The trackline is selected 15m east of the centreline and is maintained 0-2.4m offline from the selected trackline.

The falling apron and partly the launching apron of section B is shown on the right side of the sonograph. A total width of 18m falling apron is recorded. Section B is characterized by parallel strong but none continuous reflections representing the geo-sand containers. The bottom part of the falling apron is covered by sediments (white area) and could therefore not be recorded by the side scan sonar.

The orientation of the reflections between fix number 280 and 281 is shifted by more than 10 degrees in comparison with the northern area.

A part of the launching apron can be recognized by the darker and more homogenous reflection at fix number 281. The shape of the slided portion of the launching apron can be well recognized.
Upstream of that portion an almost white area is shown, which is indicating that sedimentation has taken place upstream of launched cc-blocks. Single darker spots are located in a row perpendicular to the structure. 5m downstream of fix number 281. These single stronger reflections could be cc-blocks from the launching apron.

At the end of the detected falling apron more darker reflections occur, which could be caused by down slided cc-blocks from the launching apron. This is verified by the diver inspections carried out 2 weeks earlier (Ref. No. 6).

In general the lower part of the falling apron shows more lighter areas than the upper part, i.e. the lower part is more sedimented than the upper part.

The reflections on the left side of the sonograph show sand sediment reflections and the contour of the beginning gradient towards to opposite char. After fix number 283 the recording becomes useless due to shallow water.

2.2 SECTION C

Two sonographs of section C are shown in Fig.4 and Fig.5. The sailed survey profile 5m off from the original end of falling apron, is presented in Fig.4, whereas Fig.5 shows the side scan sonar track 5m more off. Both survey profiles have been maintained 0-1m offline from the selected trackline. Fig.4 is a little bit stretched in comparison to Fig.5 due to lower speed. The launching apron (RENO-mattress) can be nicely distinguished from the falling apron (geo-sand container) on the sonographs.

The right end of the sonograph represents the contour of the launching apron 1m below the water surface (Fig.4). At fix number 276 (app. 50m from of the transition to section B) the launching apron has slided farthest downwards to the river. Downstream of that part light areas indicate sediment deposition same as generally in front of the launching apron. From fix number 278 to 12m more upstream the launching apron has moved further towards the river compared to the surrounding area. Less than 5m of the launching apron is submerged at this place. Whereas at fix number 276 a width of 10m launching apron is detected by the side scan sonar.

The left side of both sonographs shows the contour of the western edge of the river channel.

2.3 SECTION D

The submerged part of the falling apron of section D is completely covered by the side scan sonar profile 10m off from the original end of falling apron (Fig.6, Fix 349-354). The survey profile has been maintained 0-2m offline from the selected trackline. The corresponding Masterchart Filename is 10B02.LOG. A strip of more than 10m width is detected by the side scan sonar all over the section. The predominant darkness of the reflection in section D is characterized by the cc-blocks of the falling apron. Lighter areas in between should be caused by some sand deposition. In the area of fix number 352 the falling apron has moved farthest towards the river. The left side of the sonograph shows the contour of the western edge of the river channel.

2.4 SECTION E1 AND SECTION E2

The sonograph (Fig.7, Fix 343-348) shows the submerged part of the falling apron at section E1 and section E2. The trackline has been selected 10m off from the original end of falling apron. The corresponding Masterchart Filename is 10B02.LOG. The survey profile has been maintained 0-1m offline from the selected trackline.

Section E1 can be compared with section D. The predominant strong homogeneous reflection is characterized by the cc-blocks of the falling apron. In contrast to section E1 the falling apron of section E2 is characterized by geo-sand containers like in section B and C, which is shown on the sonograph by strong but inhomogeneous reflections.

The boundary between the two different type of material used in the falling apron of section E can be easily identified on the sonograph. It shows a 5m overlapping area of cc-blocks of section E1 to section E2, which is confirmed by the as built drawings (Ref. No.7)

Farthest movement of the falling apron is detected in section E2 in front of the beginning of transition to section F. The left side of the sonograph shows the contour of the western edge of the river channel.

2.5 SECTION F

The sonograph (Fig.8, Fix 337-343) shows the submerged part of the falling apron at section F. The trackline has been selected 10m off from the original end of falling apron. The corresponding Masterchart Filename is 10B02.LOG. The survey profile has been maintained 0-1m offline from the selected trackline.

Remarkable is the point downstream of fix number 341, where the falling apron has move farthest towards the river. Further downstream the falling apron is characterized by more lighter areas, which indicates more sand deposition between the cc-blocks.

The spreaded irregular dots in front of the falling apron area resulted by noise. The left side of the sonograph shows the contour of the western edge of the river channel.

2.6 SECTION G

The sonograph (Fig.9, Fix 248-254) shows the submerged part of the falling apron at section G. The trackline has been selected 5m off from the original end of falling apron. The corresponding Masterchart Filename is 15B02.LOG. The survey profile has been maintained 0-2.6m offline from the selected trackline.

The sonograph is similar to the downstream part of section F characterized by the reflection of cc-blocks interrupted by sediment reflection. The left side of the sonograph shows the contour of the western edge of the river channel.

2.7 SECTION H1

The sonograph (Fig.10, Fix 243-248) shows the submerged part of the falling apron at section H1. The section is covered by side scan sonar 60m downstream from the transition to section G. The trackline has been selected 5m off from the original end of falling apron. The corresponding Masterchart Filename is 15B02.LOG.

Section H1 shows large white areas, i.e. more sand deposition between the boulders and cc-blocks. Between fix number 243 and 245 it is too shallow to get good results beneath the towfish.

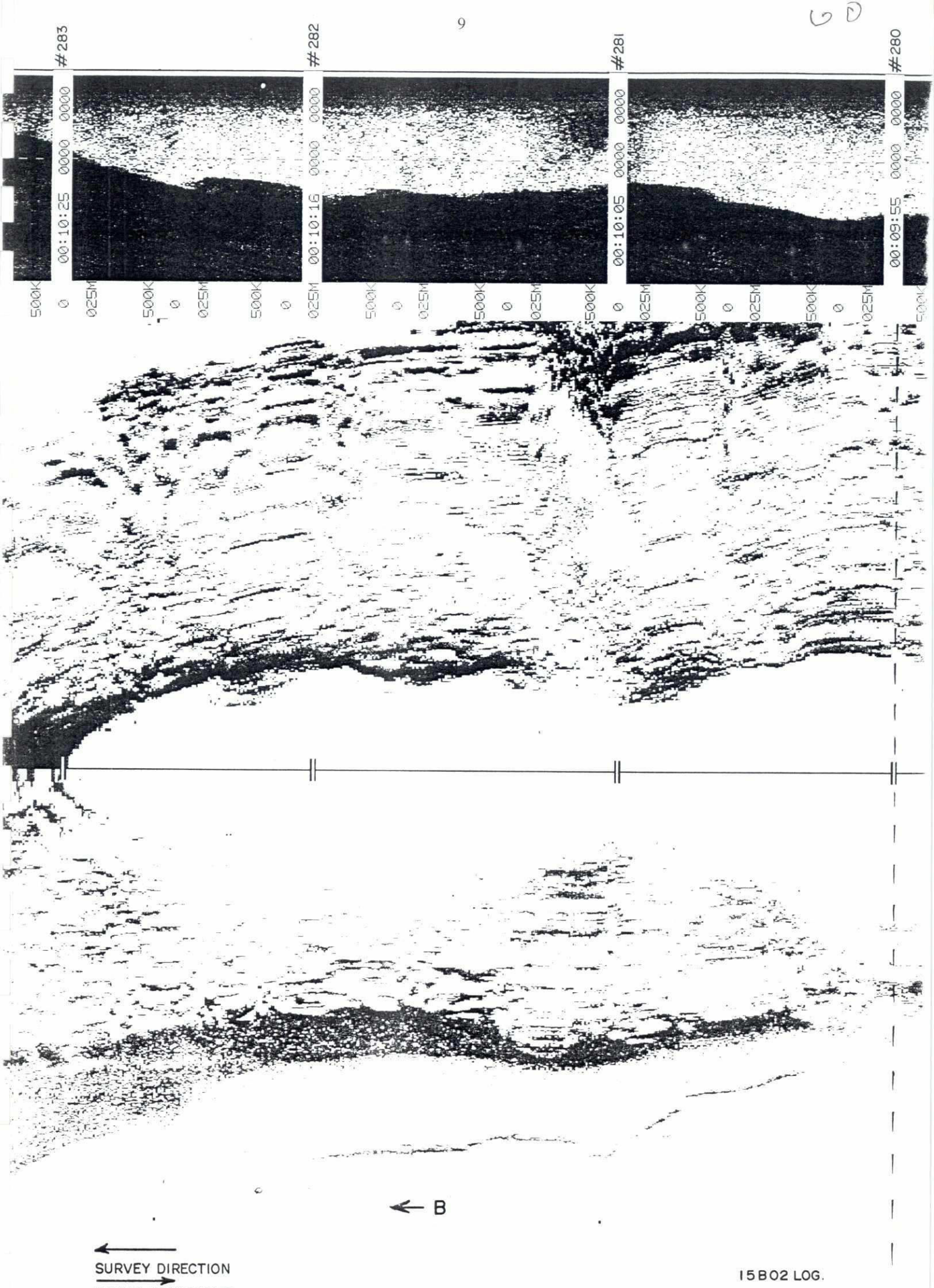


Fig. 3: Section B side scan sonar record

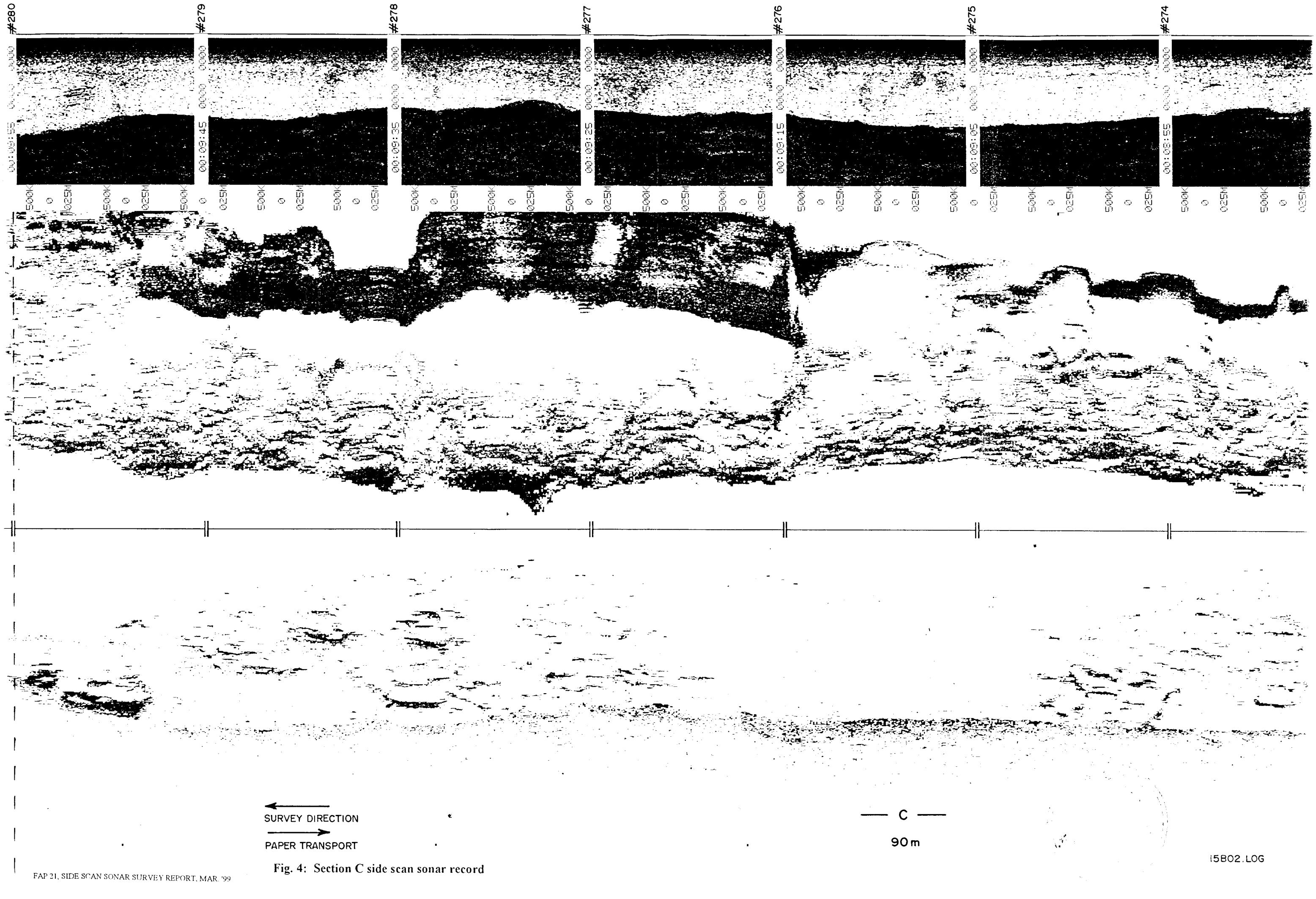


Fig. 4: Section C side scan sonar record

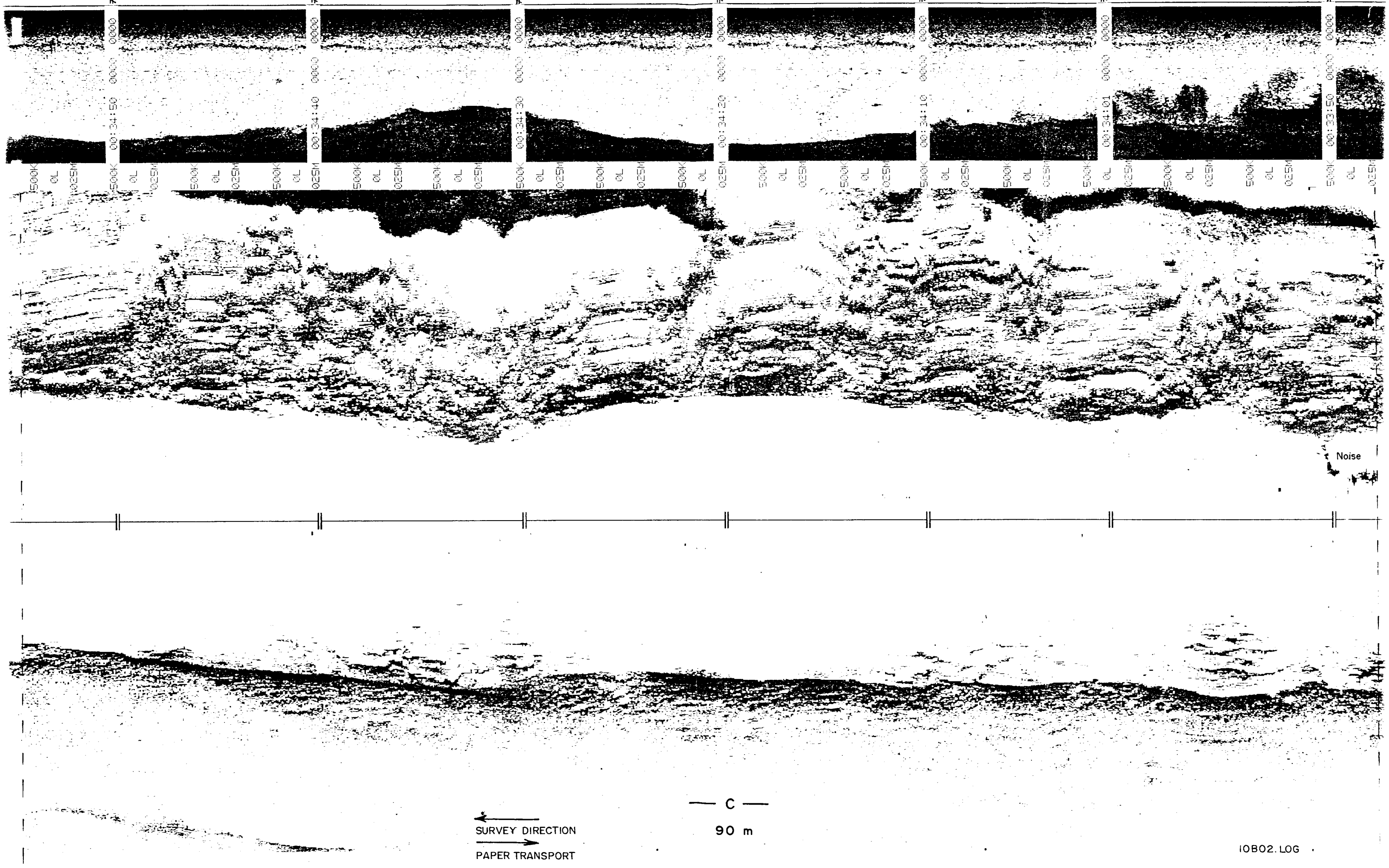


Fig. 5: Section C side scan sonar record

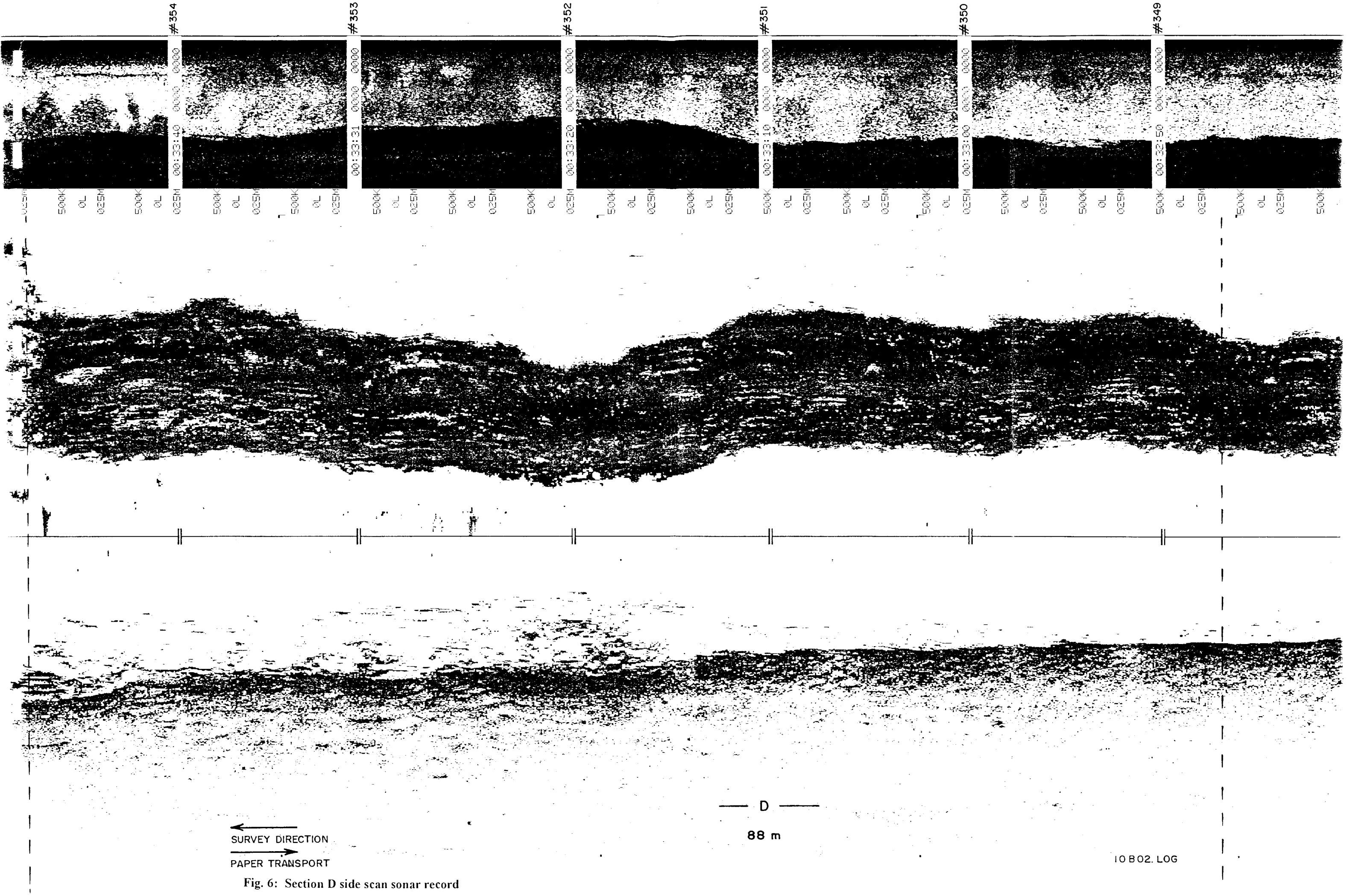


Fig. 6: Section D side scan sonar record

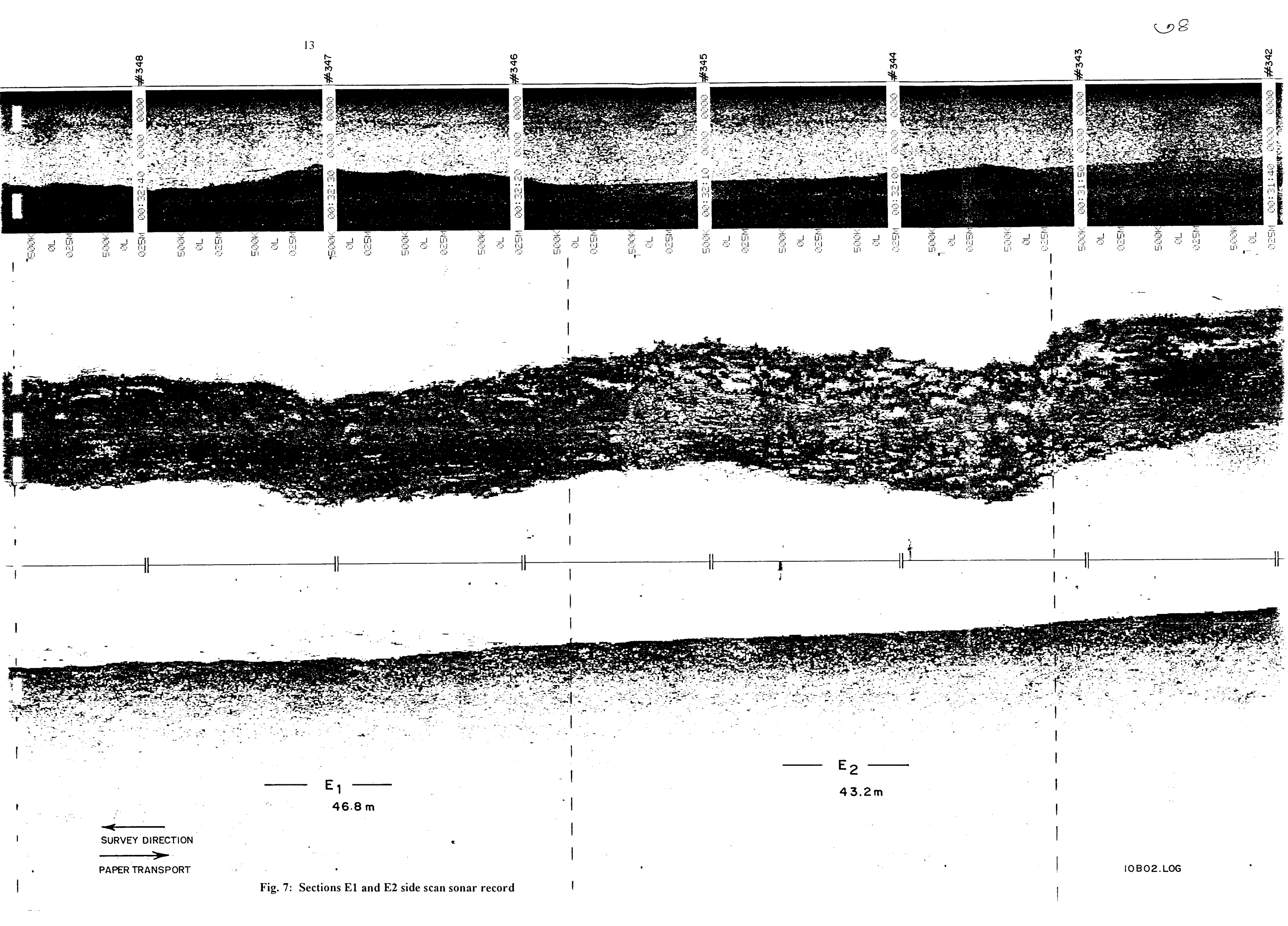


Fig. 7: Sections E1 and E2 side scan sonar record

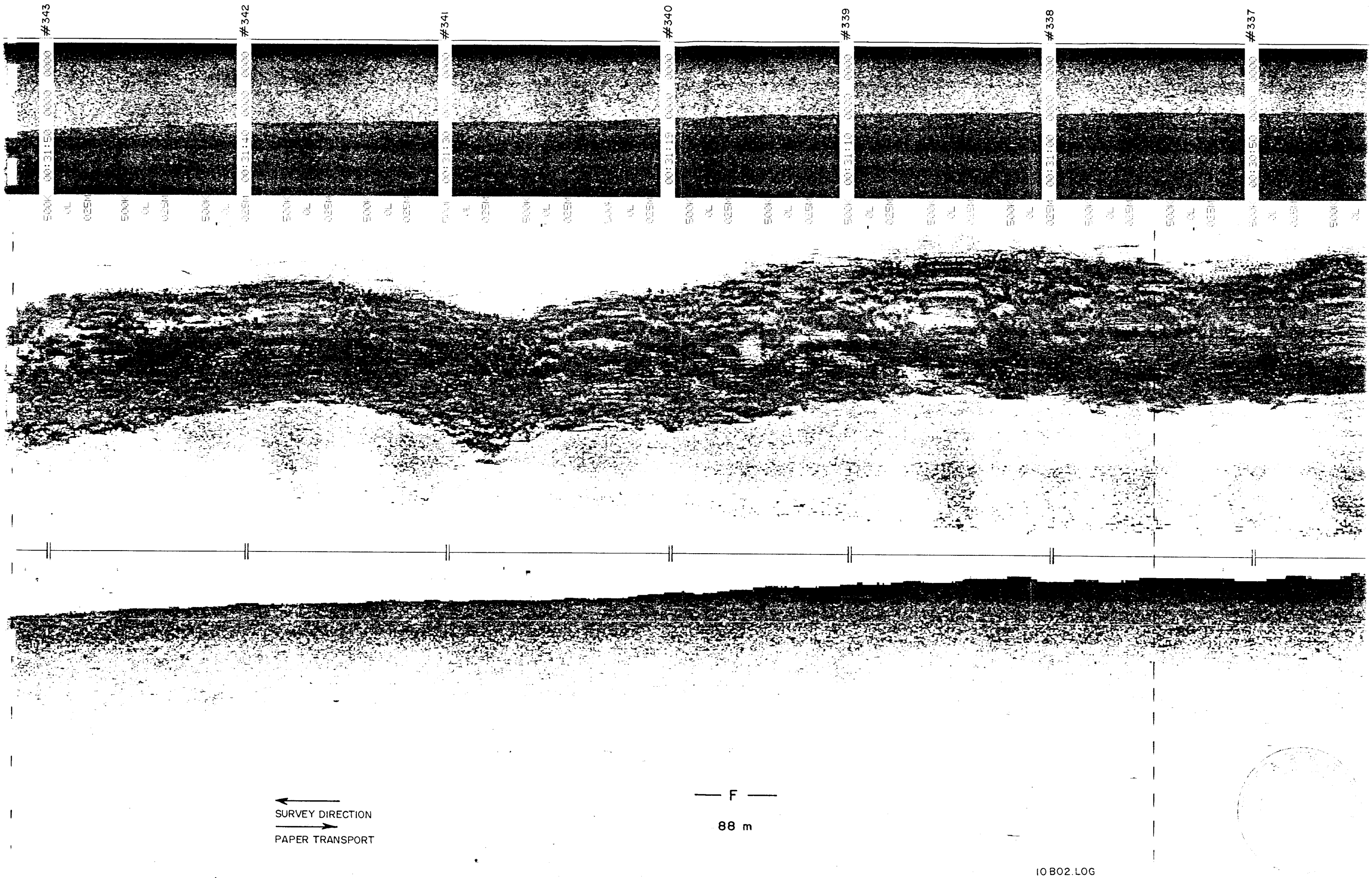


Fig. 8: Section F side scan sonar record

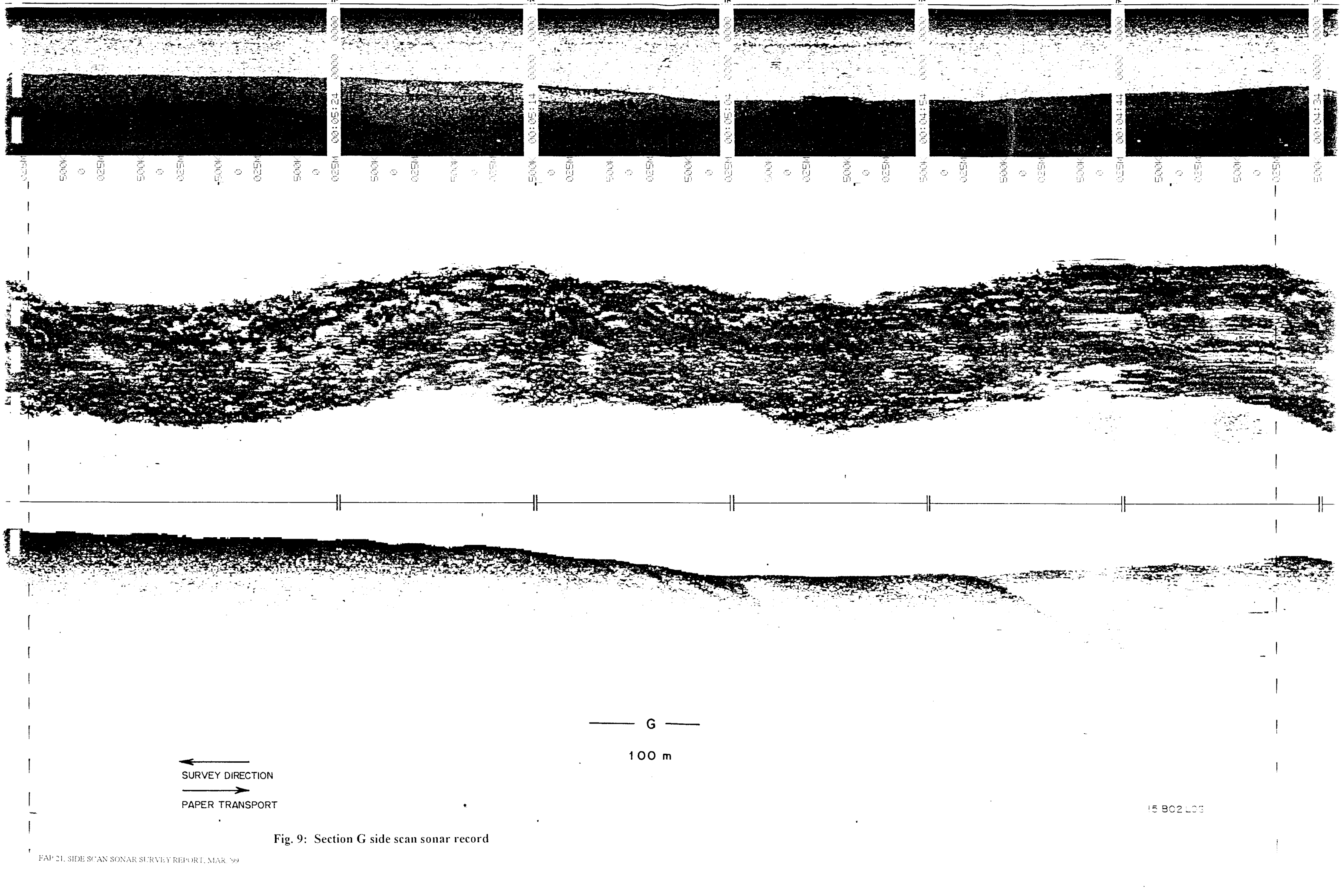


Fig. 9: Section G side scan sonar record

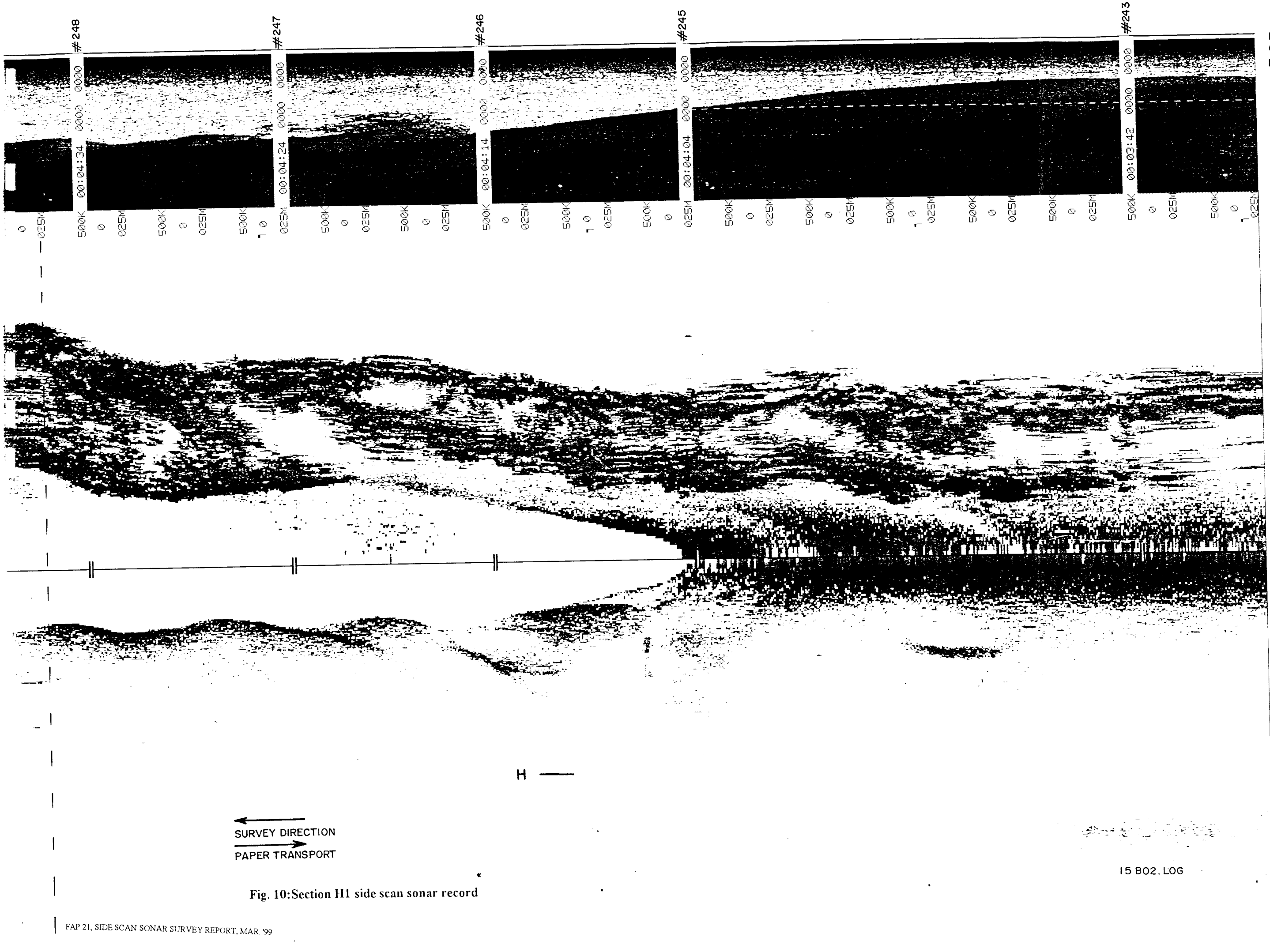


Fig. 10:Section H1 side scan sonar record

3 CONCLUSIONS AND RECOMMENDATIONS

The side scan sonar is a suitable tool to investigate the condition of the apron of the test structure at Bahadurabad. The records of the side scan sonar inform about the sub-water limits of material coverage on the slopes and distinguish between different type of material. Areas, where the slope is covered by sediments are defined by the side scan sonar. The size, shape and the direction of the construction material can be analysed especially the slides. The channel depression in front of the falling apron is positioned by the side scan sonar as well.

All detected features on the sonographs can be measured and positioned within app. 2m. Areas of the apron which have moved farthest to the channel can be further investigated by comparison with the changes of the riverbed morphology and flow distribution provided by the continuous monitoring of the structure.

The bottom part of the falling apron can not be detected by the side scan sonar as long it is covered by sediments.

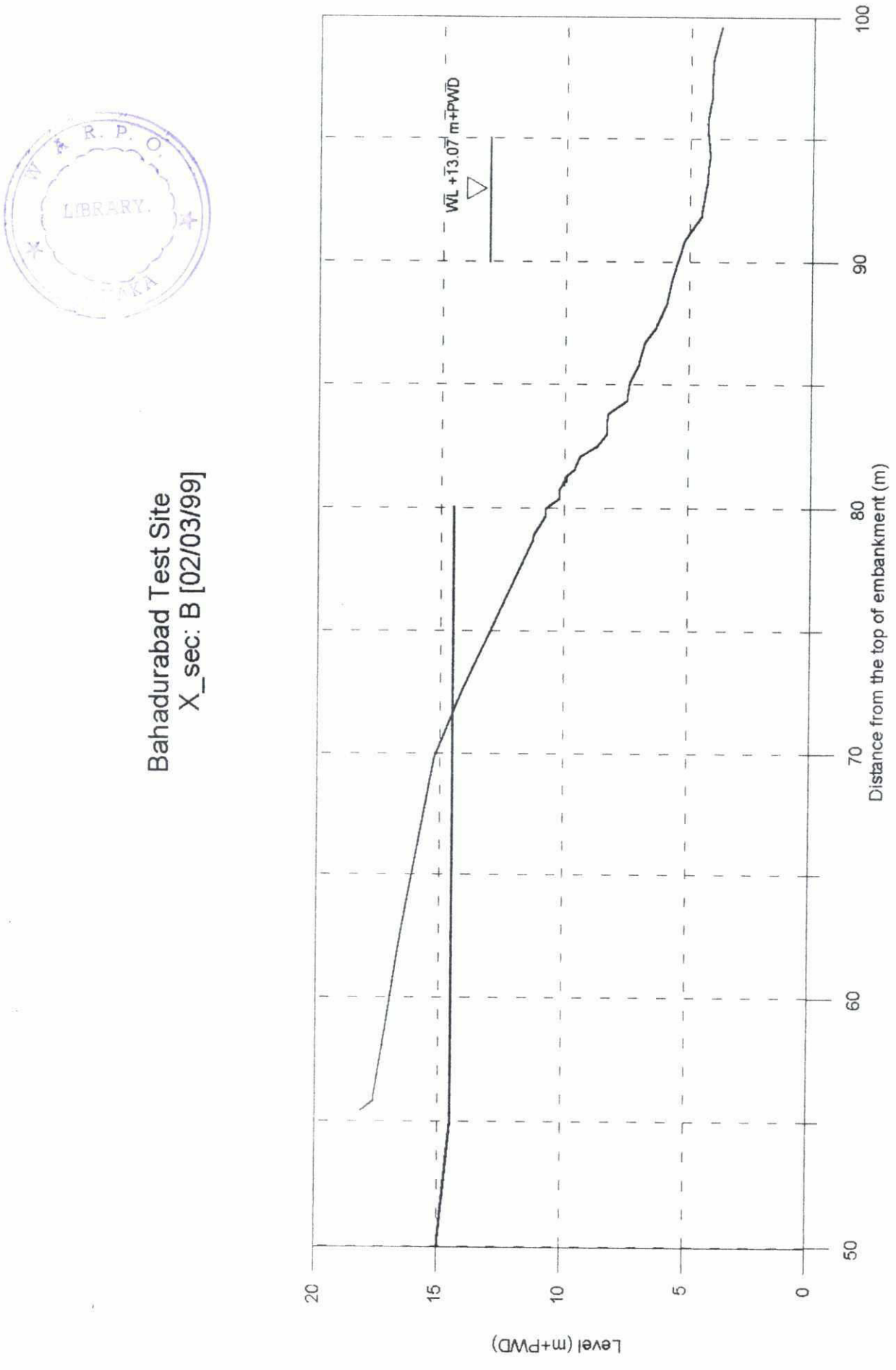
In case of significant deepening of the channel or bigger changes of the apron further side scan sonar investigations should be carried out. Side scan sonar operations can be done during monsoon as well. It is recommended to do diver investigations after side scan sonar surveys. The locations for the inspection by the diver can be selected systematically from the side scan sonar records to verify and to classify the side scan sonar results.

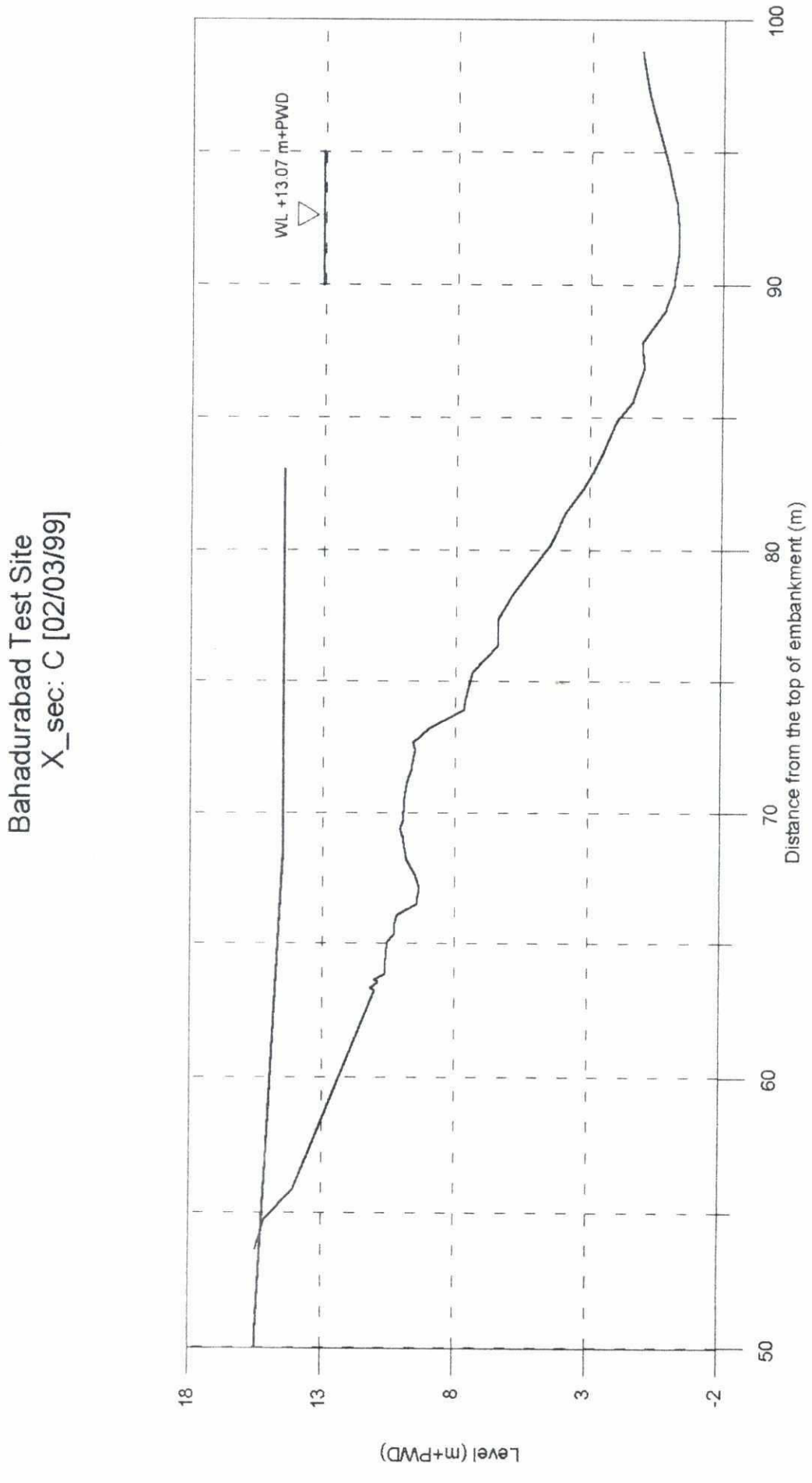
REFERENCES

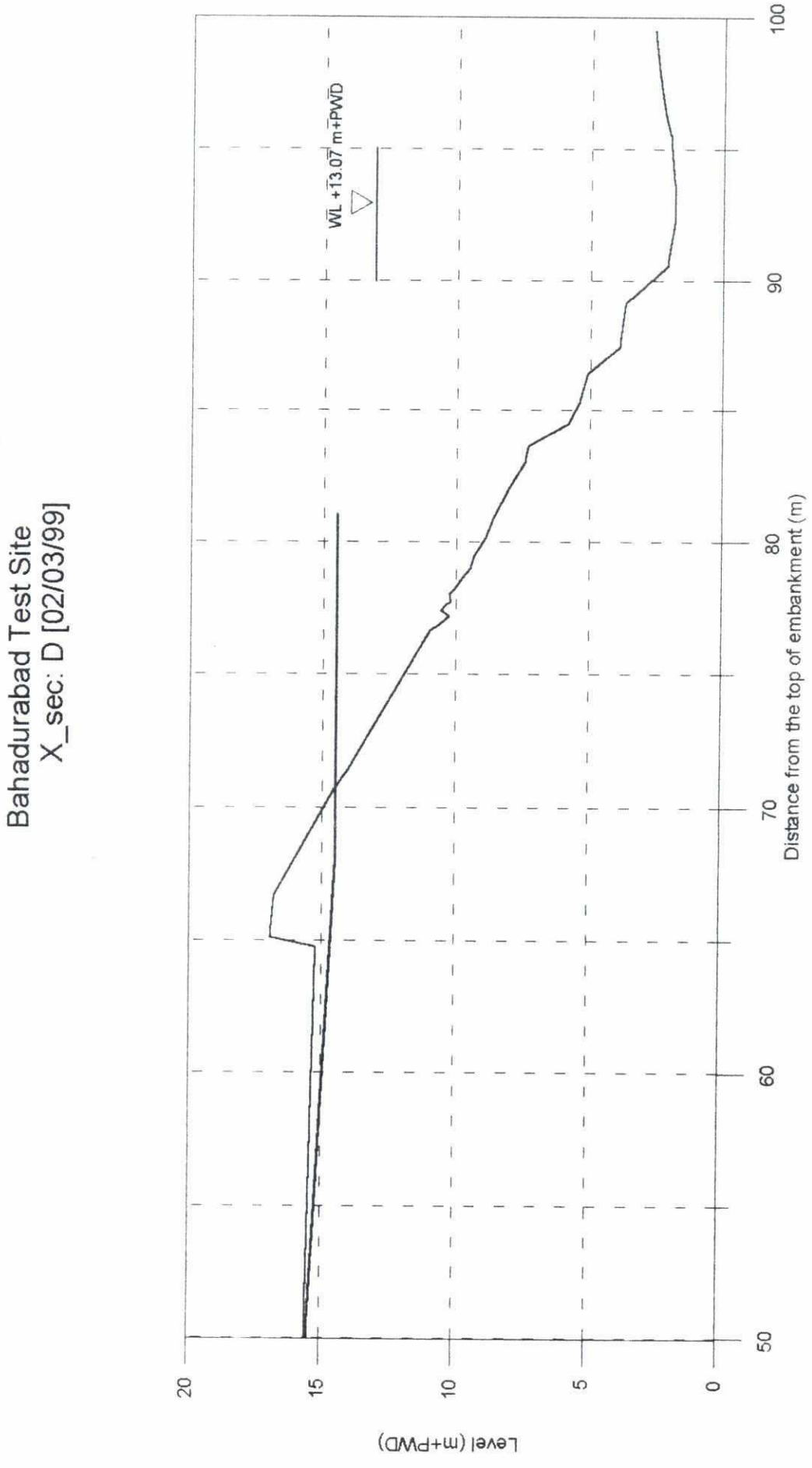
1. EG&G Environmental Equipment (August 1987),
   Image Correcting Side Scan Sonar, Model 260; (FAP 21/22 Library Book No. 708)
2. EG&G Environmental Instruments (June 1990),
   Dual-Frequency Tow Fish with TVG, Model 272-TD; (FAP 21/22 Library Book No. 709)
3. Peter Holler (October 1994),
   Arbeitsmethoden der marinen Geowissenschaften
4. Consulting Consortium FAP 21/22 (November 1998),
   Sonar and Subbottom Profiler Survey Report; (FAP 21/22 Library Book No. 752)
5. Consulting Consortium FAP 21/22 (January 1999),
   Monitoring Report, Monitoring of Test Structures, Kamarjani (FAP 21) at Test Site-I, Bahadurabad (FAP 21) Test Site-II; (FAP 21/22 Library Book No. 765)
6. Consulting Consortium FAP 21/22 (February 1999),
   Report on Sub-Water Inspection and Investigation of Falling Aprons and Launching Aprons at Test Site II – Bahadurabad; (FAP 21/22 Library Book No. 766)
7. Consulting Consortium FAP 21/22 (March 1998),
   As Built Drawings, Adaptation Works of the Test Structures, Volume V-4, Test Site II - Bahadurabad, Revetment Test Structure

ANNEX A

Cross-Sections




Bahadurabad Test Site
X_sec: C [02/03/99]
WL +13.07 m+PWD
Level (m+PWD)
18
13
8
3
-2
Distance from the top of embankment (m)
50
60
70
80
90
100


Bahadurabad Test Site
X_sec: D [02/03/99]
WL +13.07 m+PWD
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5
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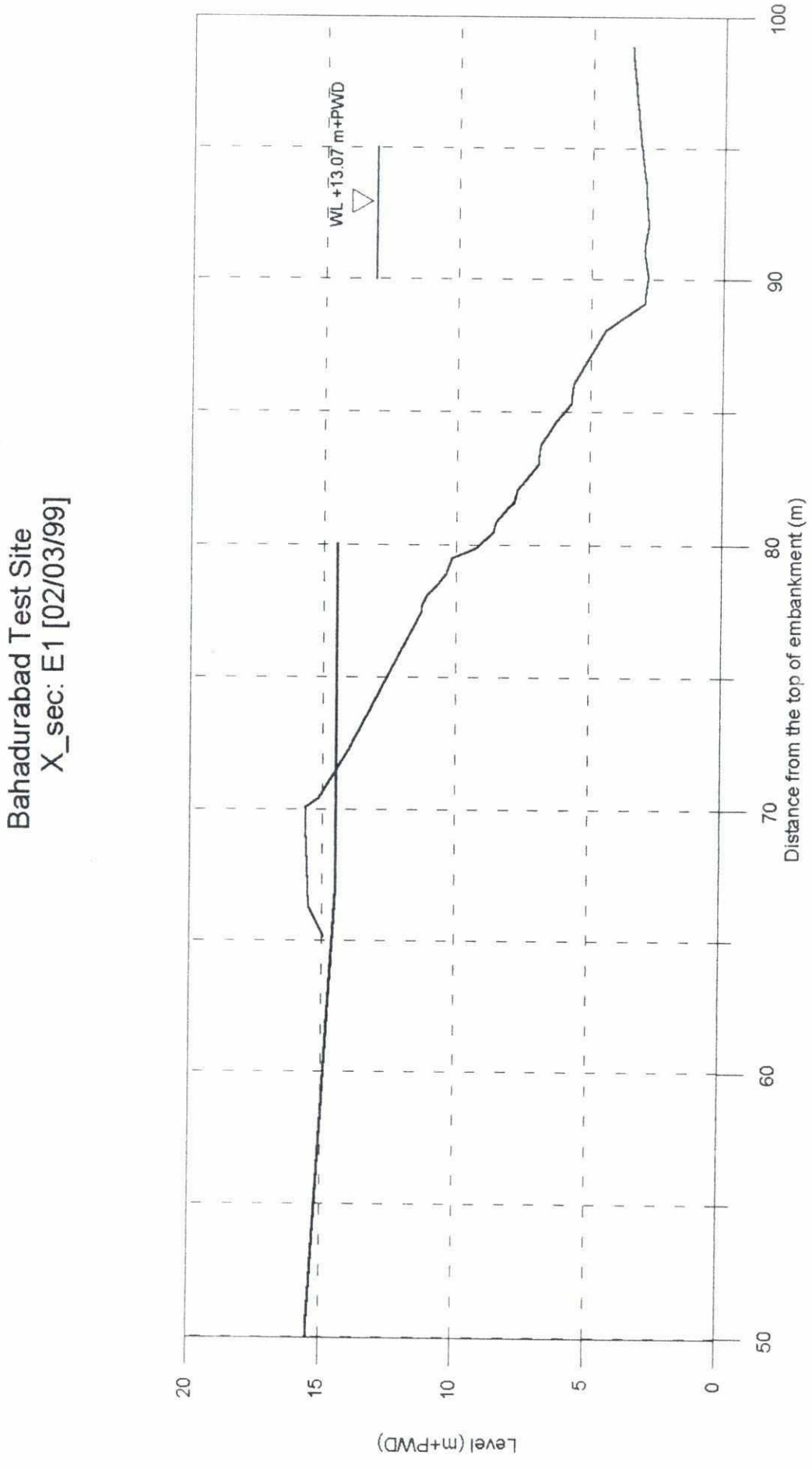
50
60
70
80
90
100
Distance from the top of embankment (m)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X_sec: E1 [02/03/99]
WL +13.07 m+PWD
Level (m+PWD)
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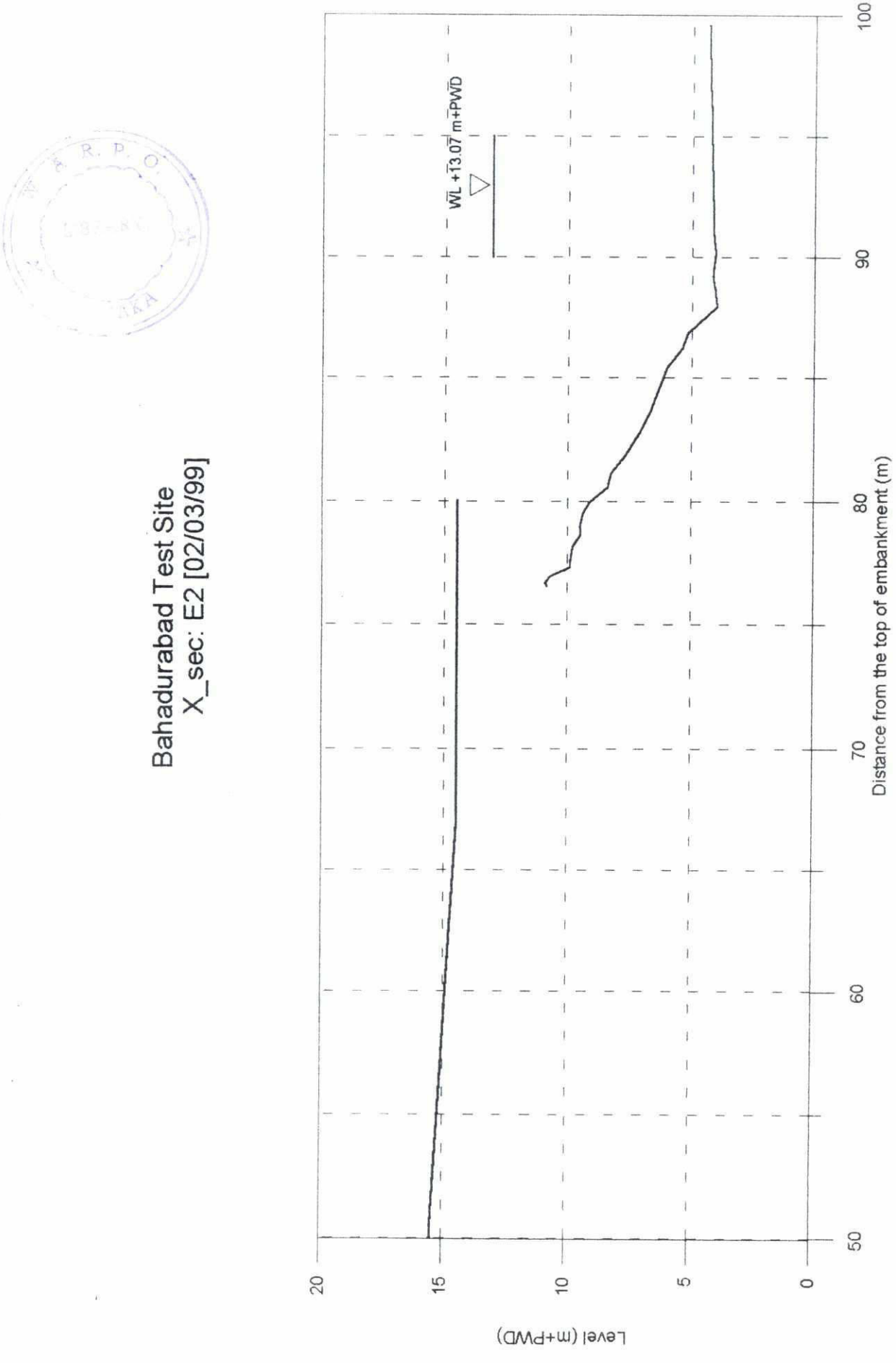
10
5
0
50
60
70
80
90
100
Distance from the top of embankment (m)

87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WL +13.07 m+PWD
Level (m+PWD)
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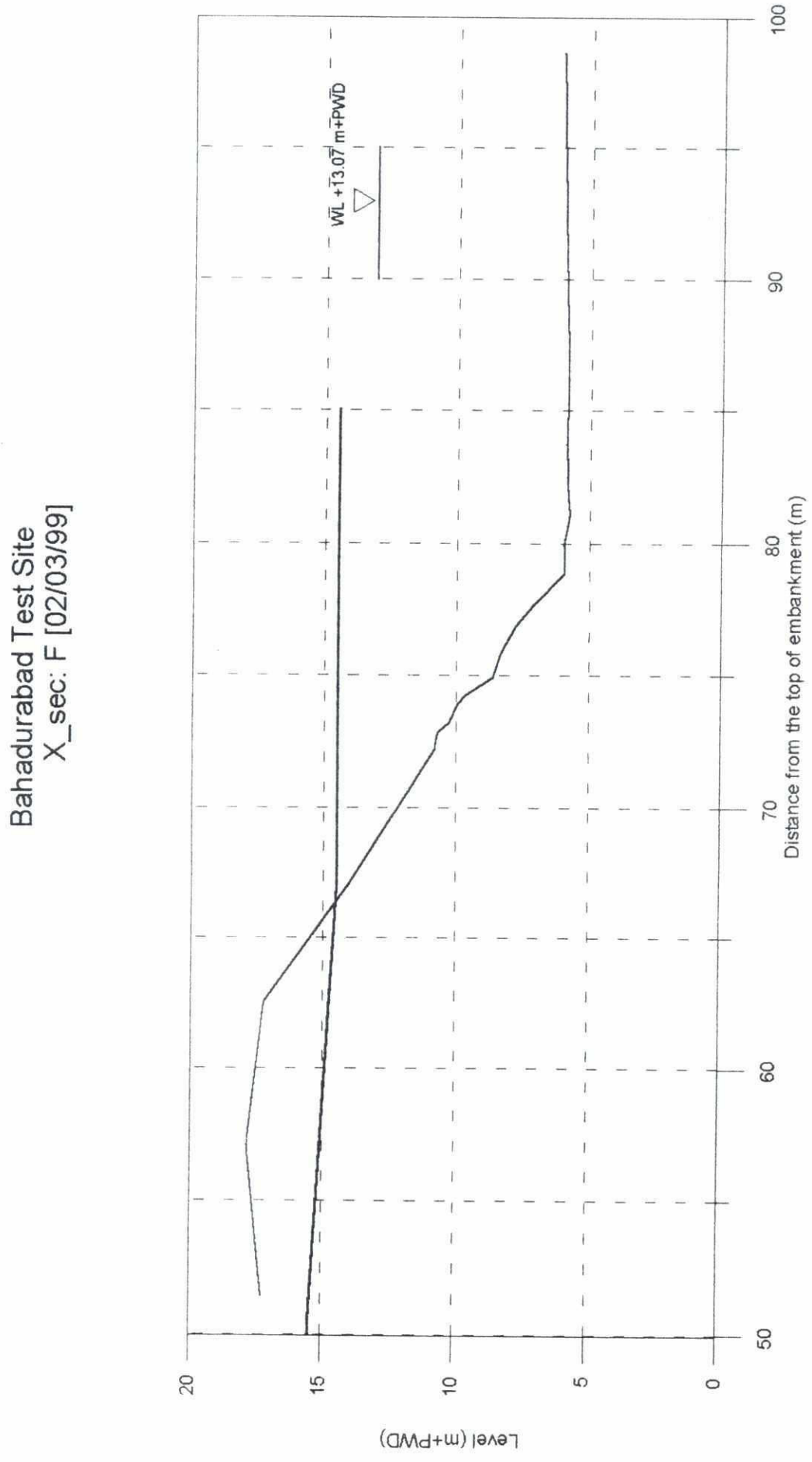
90
100
Distance from the top of embankment (m)


Bahadurabad Test Site
X_sec: F [02/03/99]
WL +13.07 m+PWD
Level (m+PWD)
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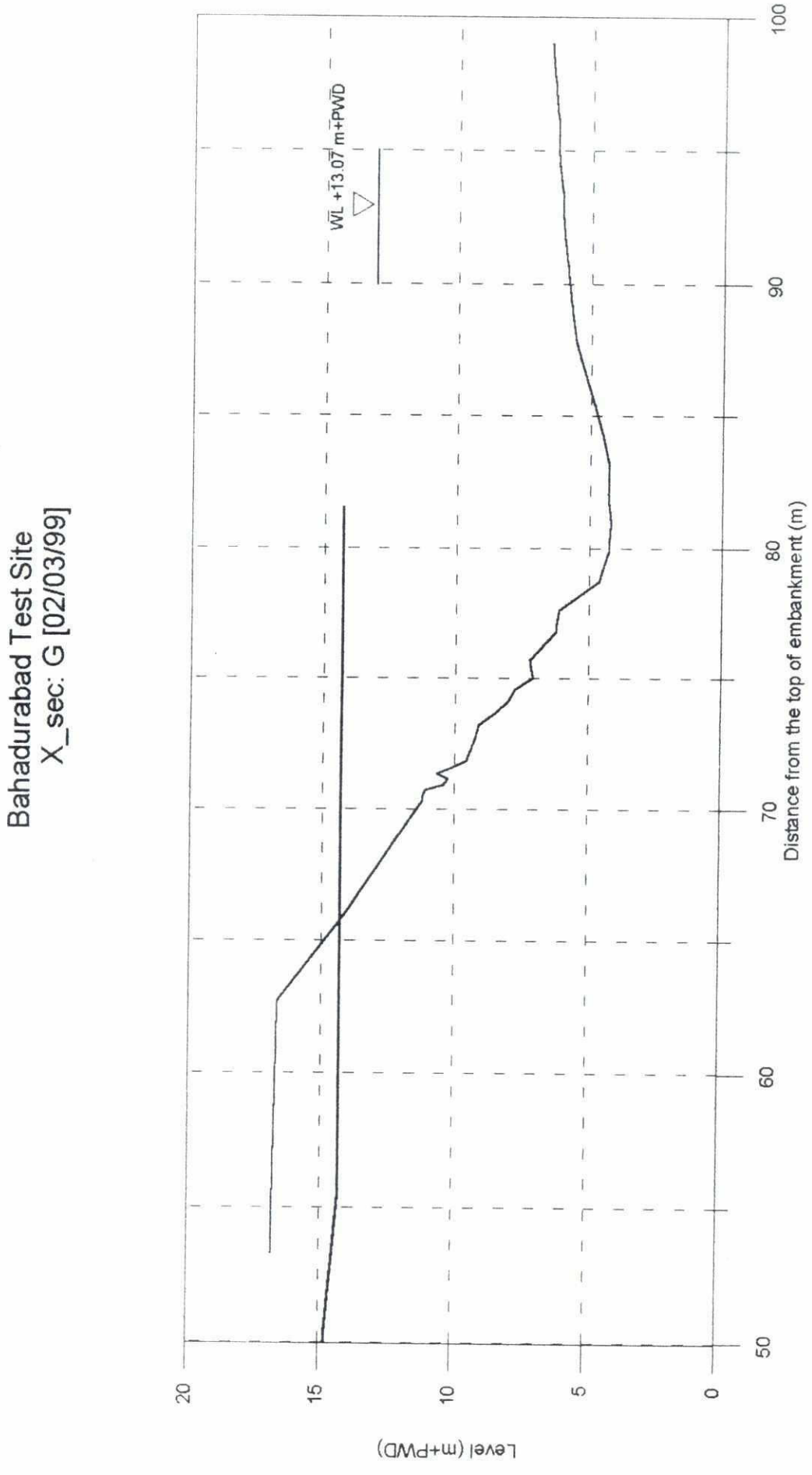
80
90
100
Distance from the top of embankment (m)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WL +13.07 m+PWD
Level (m+PWD)
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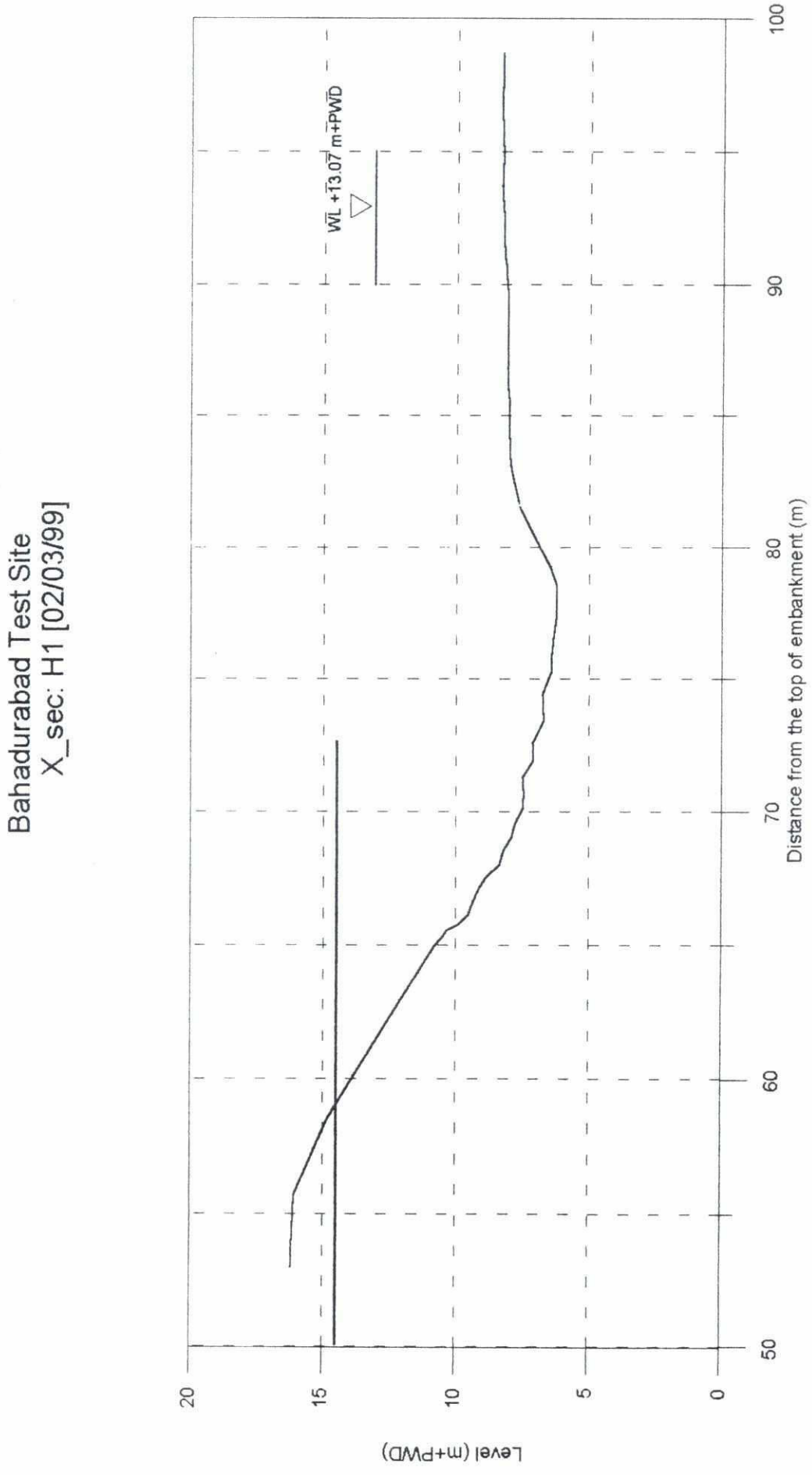
80
90
100
Distance from the top of embankment (m)


Bahadurabad Test Site
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WL +13.07 m+PWD
Level (m+PWD)
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50
60
70
80
90
100
Distance from the top of embankment (m)