MINISTRY OF WATER RESOURCES

BANGLADESH WATER DEVELOPMENT BOARD

MES II
MEGHNA ESTUARY STUDY

MES PILOT PROJECTS

TECHNICAL NOTE MES-039

HAIMCHAR & KHORKI EROSION CONTROL PILOT SCHEMES

June 2001

DHV CONSULTANTS BV

in association with

DEVCONSULTANTS LTD
SURFACE WATER MODELLING CENTRE

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

HAIMCHAR & KHORKI EROSION CONTROL PILOT SCHEMES

Erosion control pilot schemes were executed in 1998 in two locations. These are:

i. Haimchar erosion control pilot scheme at Haimchar about 20km down to Chandpur.
ii. Khorki erosion control pilot scheme at Khorki, south east of Bhola island.

A description of both pilot schemes with the lessons learnt will be given in this regard.

The location of these pilot projects is shown in Fig-1.

Overview of the pilot scheme

1. Components of the scheme at both sites are:

   - Installation of 5 Nos. Spurs
   - Installation of 120 nos. Bottom Vane screens
   - Installation of Profix System

2. Items of works at Haimchar include

   - Manufacturing and Installation of Bed Protection Mattress
   - Manufacturing and installation of 2 nos. permeable spurs
   - Dumping of earth filled synthetic bags inside caissons upto 2m height
   - Construction of connecting dike by earth filled gunny bags
   - Manufacturing of 12 nos. Bottom Vane Screens with woven geotextile materials and PVC pipe floats.
   - Installation of Bottom vane screens with help of Twin Hull Pontoon
   - Manufacturing and Installation of Profix system

3. Items of works at Khorki include

   - Manufacturing and Installation of Bed Protection Mattress
   - Manufacturing and installation of 3 nos. permeable spurs
   - Dumping of concrete blocks inside caissons upto 2m height.
   - Construction of connecting dike by C.C. blocks
   - Manufacturing of 108 nos. Bottom Vane Screens with woven geotextile materials and PVC pipe floats.
   - Installation of Bottom vane screens with the help of Twin Hull Pontoon
   - Manufacturing and Installation of Profix system

HAIMCHAR EROSION CONTROL PILOT SCHEME

1. SITE DESCRIPTION

1.1 Location, site selection and time schedule

The Haimchar bank protection works are located in the upper part of the Meghna Estuary on the left bank of the Meghna River in the Chandpur district 20 km south of Chandpur. The central coordinates are 565550 m east and 549700 north (BTM). The location is shown on Fig-1. This location was chosen because of the more severe hydrological circumstances and the existence of the Chandpur irrigation works.

To find out a low cost technology to combat the problems, a pilot project was taken up. Implementation of the works was done between March 30 and April 27 1998. Monitoring of the project was done during July until November 1998.

1.2 Soils

The deposits are predominantly loamy: Silt loam on ridges and clay loam in depressions. Close to the riverbanks the deposits are slightly calcareous because of the input of the Ganges watershed (ref. 19). The area is mainly agricultural, but is densely populated. Some 35 percent of the surface is occupied by settlements. The area is shallowly flooded in the rainy season. Constraints on the further agricultural development are mainly caused by riverbank erosion by the Meghna River, cyclones and storm surges, flooding and a lack of zinc and sulphur.

The median grainsize is 0.068 mm as determined by MES and LRP, see appendix A.

A stable under water slope angle would be 12.1 degrees or V:H equals 1:4.6.

1.3 History

The area has suffered severe erosion for a long time, see Fig- A2. The digitized bank lines show that the river has widened ever since 1973. No satellite images are available from earlier dates. Between 1984 and 1993, an island has emerged in the middle of the channel, separating and deflecting the current to both sides on the mainland. The main river has widened eight kilometer at this point from four to twelve kilometer. This is the distance from the Haimchar to Gosairhat. This includes the island in the middle, which is five kilometer wide. The erosion rate is 72 meters per year over the 1973-2000 period.
It is expected that erosion continues in the future. These erosive problems threaten the Chandpur Irrigation Project Embankment. The embankment has been retreated several times and present erosion has reached up to its toe line (ref. 4).

1.4 Bathymetry

The large-scale bathymetry is presented in Fig- A3. It is based on the 2000 survey, because the full spatial coverage in that year. The main channel is split in two by the char in the middle of the river. The east channel is generally deeper than the west channel. The pilot is located just south of the place where the main channel leaves the east bank of the river. This was not the case in 1998 as can be seen from the cross section in Fig- A4, the main channel was very close to the bank. The deepest part of the channel near the spurs is -6.25 m. PWD. The bathymetric changes during the 1997-2000 period are shown in Fig- A8. In general, the west channel has accreted on the east side and eroded along the outer part of the curve. This showed the tendency of the island to build out towards the west. The east channel on the other hand hardly shows any accretion over this period indicating the tendency to become the more important channel of the two.

The slope of the bank is almost vertical above the high waterline. The underwater slope is maximum 33 degrees, where a safe angle would be 12.1 degrees.

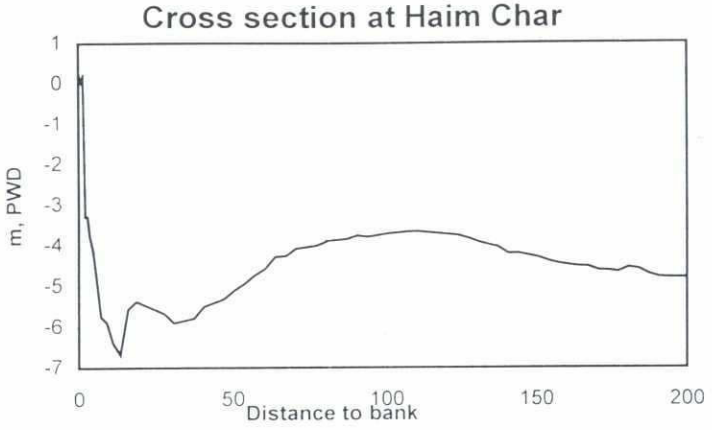


Fig- A4, Cross-section at Haimchar, December 1998

The bathymetric changes in the 1997 - 2000 period are shown in Fig- A5. The eastern part of the East channel has deepened more than five meters. Locally, in the western part of the East channel some accretion has occurred.

1.5 Flow

No flow measurements were taken during the installation. In the monitoring fase, float tracking was done along the spur heads. During the third monsoon after the implementation (2000), current velocities were taken in August, September and October. At August 28 the velocities varied between 1.5 and 2.2 m/s. Velocities varied between 2.5 and 3.3 m/s on September 27 during peak monsoon discharge. Although the spurs were gone, still some remnants of the spurs deflected the current.

From the ADCP measurements it is clear that the discharge of the east channel is higher than in the west channel, although the width is smaller. This indicates the growing importance of the east channel with regard to discharge.

2. THE PILOT SCHEME

2.1 Objectives

Objectives of the pilot schemes include:

a) gaining experience on assembling a permeable spur using local materials like bullah and bamboo.
b) gaining experience on installation of such spur under prevailing conditions as at Meghna Estuary
c) testing the stability of a rectangular box type permeable spur
d) testing the durability of bullah, bamboo and nylon rope used in the spur
e) gaining experience on installation of geotextile bed mattress on a tidal river bed like lower Meghna
f) testing use of specially designed and manufactured Twin Hull Pontoon (THP) during installation of spur and bed mattress
g) testing the functionality of permeable spur
h) testing functionality of profix system against bank erosion
i) testing functionality of Bottom Vane Screens
j) preparing a trained up group of personnel for implementation of such project on such innovative type of design.

3. DESIGN

3.1 Background

As per ToR, the Meghna Estuary Study (MES) has to develop advanced techniques for land reclamation and erosion control incorporating the use of local technologies, labour and construction materials. Accordingly a low cost method alternative to the conventional way of erosion control and bank protection has been developed by MES. These measures include use of relatively cheap geotextile materials, bamboos and wooden bullahs.

The following protection measures have been considered:

1. Caisson Spurs
2. Screen Arrays
3. Cross - Dams

In bank protection pilot schemes both at Haimchar and Khorki site the above first two measures have been tested.

3.2 Caisson Spur and Bed Mattress

3.2.1 General concept

Spurs or permeable groins, consist of one or several rows of vertical piles placed perpendicular to the riverbank. Conventionally these piles are driven into the river-bed with water borne equipment. Due to high current velocities in the Meghna river this can only be done during slack water, when the current velocity is low. It needs bullah driving over an eroding bed that goes off very soon. Thus the whole activity gets washed away quite easily. Again, under strong current where bed mattress is an effective method of bed protection, bullahs connot be driven over the mattress.

MES developed the concept of spurs made of wooden "box shaped" caissons. Sections of the caisson can be partly prefabricated on shore, after which the caisson can be assembled above

the water surface using a special pontoon. Installation of the caisson can be done in relatively short time during slack water.

The caisson spurs are placed on a geotextile bed-protection mattress and initially ballasted with a layer of gunny bags. On top of these gunny bags concrete blocks are dumped inside the spur. The tip of the spur is protected by a geotextile bed mattress to which concrete blocks are attached. This mattress will act as falling apron in case of bed erosion at the tip of the spurs.

As the caissons require a minimum water depth to be installed they cannot be placed right up to the shore line (Fig-3 & 4). The connection between the caisson and the shore can be realized by constructing a connecting dam of gunny bags. This connecting dam will be placed on a geotextile mattress and covered by concrete blocks. This mattress will be extended a certain distance onto the shore, in anticipation of initial scouring at the sides of the spurs.

3.2.2 Design parameters and considerations

Spur caisson and bed mattress

The dimensions of a caisson spur will eventually be determined by local conditions at the location to be protected. These local conditions will include river-bed profile in the spur area, scour depth, flow condition, water depth and water level variation range. The spurs tested by MES, however can be considered representative for many locations along the Meghna river.

The standard dimensions of caissons used during the pilot schemes are 12 meter long, 4 meter wide and 6 meter high to ensure stability of the structure. Bamboo poles are placed in between the bullah frames with an interval of 25 cm (Fig-5). The caissons are stabilized by dumping earthfilled gunny bags upto height of 2 meters. Top of this dike is covered by geotextile and stabilized by concrete block loads.

The geotextile mattress is 15m long and 20m wide. The mattress is 3 meters longer than the caisson to allow for an overlap. Steel anchors or concrete blocks with hooks are used to fix the edges of the mattress to the riverbed and to ascertain that the mattress will follow the decline of the riverbed in case of erosion at the edges. The mattress is of composite type geotextile with a woven layer at top and non-woven layer at bottom. The woven layer will take care of load while the non-woven layer will act as a filter.

Depended on the required length of the spur, several caissons can be placed in line with each other. During the pilot schemes at Haimchar and Khorki it was arbitrarily decided to install spurs with a length of 18 meter (1.5 caisson) at 250 meters interval. The half caisson was placed at the riverside of the spur and the protruding 12meter length of geotextile mattress will serve as a bed protection at the tip of the spur. However, the length of the downstream spur (spur no. 1) at Haimchar site had to be limited to a length of 12 meters (1 caisson) as the spot levels indicated steep slope at the spur site. The distance between two spurs at Haimchar had to be limited to 210 meters to find out a suitable bed profile for installation of the spurs.

Materials	Specification
Bullah	15 cm diameter
Bamboo	7, 5 cm diameter
Geotextile	Propex 6284 + RIG EDY 200.1, Propex 6288 + RIG EDY 200.1
Concrete blocks	40 x 40 x 30 cm^3 with steel hook
Geo bags	Propex 6082 with non-woven inner-bag, 1 m long 25 cm dia
Gunny bags	New bags; 50 kg capacity
Earth	Borrow pit at site

3.3 Screen Arrays

3.3.1 Design parameters

Based on design concept described at article no. 3.3 of Char Alexander Bank Protection Pilot Scheme, Vertical submerged screens acting as Bottom vanes were designed.

3.3.2 Design Consideration

The actual dimensions and layout of the screens were quite arbitrary. Based on the results of previous tests and the advise of Prof. Odgaard of the university of IOWA, a scheme was devised, which theoretically should induce the required physical phenomena (deflection of the sediment rich bottom flow) and was practical to install.

The screens are 5 meter wide and 4 meter high. The screen is kept upright by floats, (Fig-6). To keep the screen close to the bottom it is connected to two concrete weight anchors. The anchors are designed such that they have a large resistance to the current forces applied to the screen (Fig-7). A PVC beam filled with reinforced concrete is fixed at the bottom of the screen to keep the screen in horizontal position (Fig- 8)

Materials	Specification
Geotextile	Propex 6088
Beam	I PVC pipe filled with reinforced concrete
Floaters	3 PVC pipe 8" diameter; 5.2m long
Anchors	2 Concrete blocks; 0.5 m3 each pair

During the pilot schemes a screen configuration has been used consisting of pairs of screens, 5 meters apart from each other and 30m to 40m from the shore. The pairs have been placed at intervals of 20 m along 115 m of riverbank at an angle 45^0 to the flow direction. However, future research might develop more effective configurations (Fig-2)

3.4 Profix System

The Profix system consists of two non-woven geotextile sheets sewn together in parallel lines to make long tubes of 25cm diameter. These tubes are filled with coarse sand by water jetting method. The sheet is placed on the slope of the shore near the spurs. Since the system is quite heavy and durable it is expected to protect the shore slope against wave action. The workable size of the sheet was found to be 12m x 4m.

4. EXPECTED IMPACT

In the pilot scheme at Haimchar site 2 nos. permeable spurs over geotextile bed mattress have been installed at a spacing of 210 m in between. 12 numbers of Bottom Vane Submerged screens have been installed at upstream of the spur no. 2.

The bottom vane screens are expected to divert the silt laden bottom flow towards the bank and top flow away from the bank. Thus deposition of silt is expected near the bank-line.

The permeable spurs and the connecting dykes will reduce the flow velocity in between the spurs and also at downstream of spur no. 1.

The combined effect of both the screens and spurs is expected to stop erosion and induce silt deposition in the area.

5. COST ESTIMATE

Cost estimate for both Haimchar and Khorki erosion control projects is shown together at "Khorki Erosion Control Project" chapter.

6. IMPLEMENTATION

6.1 Implementation Period

March - April 1998

6.2 Preparation

6.2.1 Bottom vane screens

A geotextile screen measuring 5m x 4m size with 3 nos. 0.20m dia PVC float pipes at top and 0.20m dia R.C.C beam covered by PVC pipe at bottom requires the following materials. (Fig-6,7).

- Geotextile material propex 6288 = 5.2m x 6.5m.
- 0.20m dia 5.20m long PVC float pipes = 3 nos.
- 0.20m dia 5.20m long both ends open PVC pipe = 1 no.
- 0.20m dia R.C.C beam covered by the above mentioned PVC pipe = 1no, see (Fig-8)
- 22mm dia 6mm thick PVC pipe = 4 nos.
- Anchor blocks 1.5m x 1.5m x 0.125m size = 4 nos.
- Sewing yarn
- D Shackles 4" size = 4 nos.

For sewing each screen 12 nos. skilled labourers (textile worker) were needed.

The PVC float elements were fixed tightly to the geotextile screen. Special yarn was used and special care was taken to the sewing to prevent failure of the seam; every 15 cm a fixation knot was applied and extra PVC rods 22 mm dia were fixed to the seam to prevent rupture of the textile. Geotextile fixed with PVC floats could still be handled on shore. The concrete beam was fixed to the geotextile with the same care as the PVC floats. The package of geotextile, PVC floats and concrete beam was tied together in a roll and lowered into the water. In this way it could be easily transported to the installation site in floating condition.

6.2.2 Anchor base slab

A pair of concrete slabs one over the other measuring 1.5m x 1.5m x 0.125m each was used at each end of the screens as anchor slabs to hold the screens in position at the river bed. To increase the stability of the screens the bottom slabs were rested on 4 anchor legs 20cm long made of mild steel angles. The idea of these legs is that the legs will sink into the river bed to give better anchorage (Fig-7). A 10cm dia 1.0 meter long hook made of 25mm dia mild steel rod was fixed to the bottom slab to tie the system with the screen through steel chain or flexible steel wire through D-shackles. The stability of the screen was increased by tying 20 nos. of synthetic bags filled with soil to each anchor slab.

6.2.3 Bed mattress

Preparation of geotextile mattress

The geotextile mattress was sewn together at the work site to make bed mattresses of required size. Bamboo poles 8 meter long were fixed to the mattress through nylon rope. When ready,

the mattress could be folded and rolled up into a compact package. This package was rolled into the water and floated to the installation site (Fig-5a).

The mattress was prepared by using two types of woven Geotextile, propex 6284 & Propex 6288 with another non-woven filter fabric RIG EDY 200.1 sewn together. Propex 6288 is stronger than propex 6284.

Propex 6288 with RIG EDY 200.1 is placed under the caisson base to carry load of caisson itself and ballast materials.

One bed mattress of 15m x 20m size requires the materials and labourers:

- Geotextile materials = 312 m^2
  (Propex 6284 + RIG EDY-200.1 and propex 6288 + RIG EDY 200.1)
- Bamboos = 61 nos.
- Nylon rope = 5 kg.
- Steel anchor 15 kg wt. = 6 nos.
- Skilled labour = 12 nos.
- Divers = 2 nos

6.2.4 Spur caisson

Construction of the side panels of the caissons

The side panels of the caissons were constructed on the shore at the work site. The bullah poles were connected to each other by steel bolts and the bamboo was connected by steel wire and nylon rope. The panels were pulled into the water by manpower and floated to the installation site.

Preparation of one caisson 12m long 4m wide and 6m high needs the following materials and manpower

- 15m dia wooden bullah = 425m
- 7.5 cm dia bamboo = 450m
- Nylon rope = 15 kg
- G.I. wire = 15 kg
- Skilled labourers = 32 nos.

6.3 Installation

6.3.1 Working schedule for installation

Working schedule as followed for installation of spurs and screens at Haimchar site

Date	Remarks
29.03.98-31.03.98	Stormy weather
02.04.98	Lowering of 12m caisson at spur-1
	Eid-ul-Azha holidays during 1st week of April and site work resumed after mid April.
07.04.98	Stormy weather
17.04.98	Stormy weather
19.04.98	Lowering of 12m caisson at spur-2
20.04.98	Lowering of rest 6m caisson at spur-2
	Storm and rain continues since 20.04.98. Norwester on 23.04.98.

Date	Remarks
24.04.98	2 screens installed at 4-00 pm. Rain & Strong wind continues.
25.04.98	4 screens installed. 2 nos. at 12-30 pm. And 2 nos at 4-30 pm.
26.04.98	4 screens installed.
27.04.98	2 screens installed.
	Total 2 spurs and 12 screens installed at Haimchar.

6.3.2 Positioning of installation pontoon

An installation pontoon named Twin Hull Pontoon (THP) was used for installation of the bed mattress perpendicular to the shore (Fig-9). The same pontoon will be used to assemble the caissons also. The pontoon was positioned at the required location using small tugboat and anchor wires fixed to the shore as well as to anchors.

6.3.3 Installation of bed mattress under and in front of caisson

Placing in position

After preparation of the bed mattress with bamboos fixed, it is rolled down from shore to water in a tied bundle form, floated to caisson site by labourers and tender boat or even by tug boat depending on distance and tide condition. It is placed under caisson (caisson is still hanging to the THP beams) or in front of it as per position to place. The bottom portion of the bullahs and bamboos of the caisson are tied firmly to the bamboos of the bed mattress at an interval not more than 50 cm.

In case of bed protection in front of the caisson the mattress is placed with 3m overlap with the mattress under the caisson. Sometimes it was observed that the mattress under the caisson did not have sufficient or at all extension beyond the caisson end. This case appeared due to two reasons.

1. The bed mattress could not be stretched sufficiently in floating condition under the caisson (hanging) due to friction.

2. To adjust overlap to the upper (shore side) bed mattress.

In such cases to provide 3m overlap between the mattress under the caisson and that in front of it the lap portion of the front mattress including attached bamboos is cut along the caisson length at two points to go inside the toe end of the caisson. Thus the problem was solved.

Spreading of flap portion

The bed mattress has 6m flap portions both at upstream and downstream side beyond the attached 8m long bamboos. Spreading of the mattress flaps through underneath the THP was done by 2 divers and one helper.

Anchoring

Initially during design stage it was conceived of using 1.5m x 1.5m x 0.125m R.C.C. Slabs as anchors to spread the bed mattress at upstream and downstream ends. But due to heavy weight of the slabs it was found difficult to handle them under water. Instead it was found easy and serving the purpose to use fishing boat anchors made of Mild steel. 3 nos. 12 kg to 16 kg weight anchors were used at each upstream and downstream side for each bed mattress of 15m length across the river. Divers initially fixed the anchors in proper place with a nylon rope / anchor wire through the ring fixed with the anchors. One end of the rope was tied to the edge of the mattress and the other end to a tackle block over THP. This end was pulled through the tackle block to spread the mattress gradually. To resist this pull force by the steel anchors two geo-bags filled with soil were tied to the anchors to make them more strong. (Fig- 9.4)

Two rows of 25 cm dia 1.25m long sausage type geo-bags filled with soil were tied at the upstream and downstream of all mattresses and also at front side of the front mattress.

6.3.4 Assembling and Installation of caissons

The sequence of assembling and installation the caissons is as follows (Fig – 9.2, 9.3):

- floating side panels in between hulls of pontoon
- lifting side panels with lifting frame
- floating folded geotextile in between hulls of pontoon
- inter-connecting side panels with cross-beams and diagonals
- connecting side panels to bottom frame on geotextile
- pre-ballasting caisson with gunny bags
- lowering caisson to channel bed
- placing steel anchors or concrete anchor blocks
- connecting geotextile to anchor blocks
- spreading out geotextile
- dumping ballast bags on geotextile

Site selection

Before site selection for installation of caissons the bed of the river was checked whether there were any tree roots, abrupt changes in slope, steep slope etc. The bed was checked by divers beyond the caisson end also to install bed protection geo-mattress. At two points site had to be changed at Khorki after checking by the divers. The bed profile was then surveyed through sounding ropes to determine the slope. A gentle slope of about. 1:10 or less was found ideal for installation of caisson.

Fabrication

After preparation of 6m long 4 panels for one caisson, they were floated on water and dragged to site by manual labour / tug boat. They were hung by the lifting frames in position, drilled by using 2 power drills to fabricate into a caisson through nut bolt joints. During fabrication materials and manpower were needed as follows:

- Labourers = 14 nos. skilled + 10 unskilled
- Generator (20 kw) = 1 no.
- Power drill = 2 nos.
- Nut bolts = 44 nos.
- Tie rope = 10 kg.
- THP, Tug boat & Tender boat.

It took about 8 hours for the above party for fabrication of one caisson through drilling and connecting by nut bolts.

Sinking of caisson

The bed mattress is brought underneath the caisson (caisson panels are hanging to the THP lifting frames) and tied to it. At slack period sinking work starts. Initial ballasting is done by earth filled gunny bags dumped inside the caisson and outside it over the bed mattress in scattered position. Care should be taken so that the flap portion of mattress outside bamboos remain free from loading. The flaps are stretched out to tie with previously placed anchors. The tide direction should be followed during stretching out the mattress flaps when water velocity is significant. Although the sinking process was always started during slack time sometimes slack period was not sufficient to complete the process. Water velocity started increasing during spreading the Geotextile and in such case the tide direction had to be followed.

Sinking of caisson was done upto water depth of 6m without problem. Quick initial ballasting upto 1.00m height during neap tide made it stable. However dumping of more synthetic bags or c.c blocks was done upto 2.00m height before spring tide.

For sinking purpose the following man power and materials were used:

- Skilled labourers = 14 nos.
- Unskilled labourers = 20 nos.
- Divers with equipment = 2 nos.
- THP & Tender boat.
- Floating rafts = 5 nos.
- Earth filled synthetic bags = 1500 nos.

For dumping earth filled synthetic bags inside a caisson it was initially thought of using walkway over it to be used by labourers. But after installation of caisson on a slope bed it was observed that a walkway could not be placed over it because the top did not attain a regular level or regular slope. But however, if the caisson is placed on river bed of minimum slope the idea may be suitable which will help dumping the bags quickly and efficiently by labourers. However, care should be taken when the caisson will jerk and settle during loading process.

6.3.5 Installation of shore mattress

The geotextile mattress between the caissons and the shore was installed manually. The floating mattress package is unpacked and positioned in alignment of the shore end of the caisson. Divers fix the end of the mattress to the bottom of the caisson and the mattress is spread out onto the shore with manpower. Gunny bags are dumped onto the mattress starting from the caisson towards the shore.

6.3.6 Construction of connection dam

The connection between the caisson and the shore is established by constructing a 4 meter wide dam consisting of a core gunny bags. To protect the gunny bag core from wave action it was covered by geotextile sheets loaded with concrete blocks.

6.3.7 Placing of ProFix bank protection

Before placing the ProFix on the bank, the bank profile was adjusted to make a slope in place of abrupt drops. The ProFix is filled with coarse sand in its installation position with the assistance of sawn off PVC pipe and a water pump.

6.3.8 Installation of screens

The twin hull pontoon was used for installation of screens. The pontoon consists of two hulls connected by two lifting frames. The screens were lifted off a pontoon positioned inside the two hull and the anchors were attached to the screens. The installation pontoon was maneuvered into the required position by means of a set of mooring anchors. Two of these anchors may be fixed to the shore. The current velocity should be limited during the lowering of the screens to the riverbed. Therefore installation of the screens will take place during high or low water slack. After lowering the first screen, the installation pontoon was slightly repositioned to install the second. The positions of the screens were marked by marker buoys and the exact location of the anchors were fixed.

The pilot schemes showed that using one installation pontoon, an average of 4 screens a day could be installed.

6.3.9 Copy of daily activity report as recorded at site

Monday 30-3/98

Main activity: Preparing geotextile 1B onshore (bamboo's fixed), Fig-3 & 4.

Water board Chandpur: Rent of a self propelled pontoon, meant for transport of concrete anchors, not possible due to insurance problem.

In the evening we studied the results of the soundings done at the proposed installation site. We planned to place two full caissons, 8-20 and 20-32 meter from the shore. However, the slope in the area 20-32 meter was too steep and not flat enough for the caisson. The caisson should damage when filling it with gunny bags. Therefore we cancelled this position.

Tuesday 31-3

Main activity: Lifting a panel in THP.

The planning of this day was to lift the anchors from the auxiliary pontoon with the boom on the THP and place them already on the riverbed. This operation was required because we needed this pontoon for transport of the anchors from Khorki to Haimchar. However maneuvering with the pontoon and the tugboat went so difficult and took so much time that we cancelled the operation. Therefore we decided to use the largest fisherman anchors instead of the concrete anchors for the geotextile under the caisson. In the afternoon we lifted for trial a panel in the THP.

After this we placed the anchors of the THP with the engine boat and marked them with buoys.

Wednesday 1-4

Main activity: Lifting panels in THP and assembling caisson 1B.

During high water slack we moved the THP with his anchor winches to the correct position. This moving lasted about an hour. Then we lifted the panels in the THP and assembled the caisson. We made the connections first with ropes and after that with bolts.

The labor didn't use pulleys to pull the panels together in spite of our explanation.

Thursday 2-4

Main activity: Installation of caisson IB, installation of geotextile 1C, Fig- 3.

During rising tide we rolled the geotextile mattress in the water, pulled it before the caisson and unrolled the geotextile under the caisson.

Although we lifted the caisson as much as possible, we couldn't lift it completely out of the water. It was very difficult, therefore, to pull the geotextile under the caisson and stretch it. So the height of the next panels have to be 5.7 in stead of 6 meter.

There are only bamboo's sewed on the middle part of the geotextile IB, meant for spreading the weight of the caisson. We folded the edges on this middle part. Once unrolled under the caisson, we had to pull this edges aside to fix the bamboo's to the caisson. At that time the current pulled a part of the upstream edge under the middle part. It was rather difficult to pull it back, so we have to be aware of it.

During lowering of the caisson the back part (a full caisson consists of two panels 6 meter wide) turned a little, most probably because of the irregularity of the riverbed.

We placed geotextile IC on the shore and fixed geobags on it building the gunny bag dam and filling the caisson spur with gunny bags. It proved to be difficult to walk on the geotextile on the slope, so we made steps of gunny bags.

Friday 3-4

Main activity: Installation of geotextile IA, Fig-3.

We moved first the THP with his anchors in front of the caisson spur and brought the geotextile in the THP. This time we planned to stretch the edges from the geotextile by pulling on the anchor ropes with bamboo's while people stand on deck of the THP. The first time the divers stretched the geotextile, but that was difficult because of the soft riverbed. So we pulled first the anchor ropes along the bottom of the THP and fixed bamboo's to them. Then we lowered the middle part of the geotextile with the I-beams and dumped gunny bags upon it. And after that we stretched the edges and fixed anchors and geobags to it. When the tide turned we did the other edge.

Tuesday 7-4

This day there was a storm (north-west) in Haimchar. Because of this storm the caisson spur deformed more, like leaning ahead. The storm attacked especially the gunny bag dam just behind the caisson spur at the north side. Also a lot of gunny bags all around are washed out.

Friday 17-4

Main activity: Installation of geotextile 2A, Fig-4.

This morning we prepared everything for placing the outer geotextile 2A. However, when the diver checked the riverbed he found great heaps of bricks of old gabions. Some of them were about a meter high. These gabions and the remains of steel wire would certainly damage the geotextile. We decided not to place the geotextile also because the bricks would give some protection to the spur.

About at 18.00 hrs a storm came. This kind of storms people call a "Norwester". The anchors of the THP dragged and after the storm the pontoon lay on the shore. This time there appeared a real gap in caisson spur I. The width of the gunny bag dam decreased half a meter, at the same point as during the previous storm. Further we lost about 200 gunny bags that laid on the rafts.

Saturday 18-4

Main activity: Lifting panels in THP and assembling of caisson 2B, Fig-4, 9.2 & 9.3.

We used the high tide at about 9.00 a.m. for pulling the THP from the shore. Lifting of the THP-anchors took much time and about seven peoples pulling on the engine boat. It was also difficult to find people for it.

Maybe concrete anchor bases could be used. There are enough of them, their grip is better and they are heavier. These anchors could be placed with the auxiliary pontoon and the crane and will be left behind after use.

Floating the panels in the THP was difficult. The THP was positioned far from the shore (part 2B of the caisson spur) and the current was strong.

We shortened the out sticking bamboo's at the top of the caisson and lifted the caisson as much as possible to make floating the geotextile under it easier.

We agreed at the end of the day with the contractor he would finish connecting the panels before the next day. However the next day it was not completed because of too much wind during the night.

Sunday 19-4

Main activity: Installation of caisson 2B, Fig- 9.7 & 9.9.

Depth soundings were made around caisson spur 1 on 15th April, 1998.
After floating the geotextile in the THP it proved to be easier to fix the upstream edge on deck of the THP instead of folding it next to the caisson (Fig-9.4). Pulling the upper ends of the panels in position went faster using ropes instead of chain-tackles. When chain-tackles are used they have to be connected with extending-ropes. Using winches is also not preferable because their operation is very slow.

During floating the geotextile under the caisson in the THP, the end folded under the geotextile but with a rope around a caisson-bullah, we could pull it back easily.

The divers fixed most geotextile anchors in old gabions or trees on the riverbed, because this way they couldn't be lifted by the winches (Fig-9.4). They fixed the other anchors behind bamboo's which they placed in the riverbed.

Monday 20-4

Main activity: Installation of caisson 2C, Fig-9.2 to 9.6.
This morning again a heavy Norwester passed which pushed the THP against caisson 2B. Because of this the north side of the caisson lifted about 10 to 20 centimeter. The anchors of geotextile 2B also moved. When it was possible we pulled the THP from the caisson spur and detached the anchors.

During repositioning after the storm a shore anchor broke and the THP hit again the caisson spur.

But the engine boat pushed immediately the THP away so there was no damage.

The divers lifted the anchors from geotextile 2B and placed them for the installation of geotextile 2C. Installation of caisson 2C went smoothly. During evening slack they placed the anchors of geotextile 2B again.

Tuesday 21-4

Main activity: Installation of geotextile 2A, Fig- 9.7 to 9.9.

Depth soundings were made in the screen area of caisson spur 2.
In the morning the divers checked all edges of the geotextile mattresses. The edges were stretched and a continuous row of geobags is placed along the edges. Today also the pontoon arrived from Khorki with screens and screen anchors.
After a discussion with the teamleader we decided to place geotextile 2A in spite of the gabions. The reason is the strong current at this point.

When we installed geotextile 2A, there was a strong wind and high waves. The lifting frames pushed the geotextile under water but they slipped from bamboo's because of the waves. When the connection with caisson 2B broke and the geotextile floated out of the THP, it almost tangled in the anchor wires of the THP. Therefore we cancelled the installation. For safety we moved the THP to the shore.

Wednesday 22-4

Main activity: Installation of geotextile 2D, Fig- 9.7 to 9.9.

Today we pulled 6 concrete beams from the auxiliary pontoon and started sewing them in the screens. In the afternoon we tried to rearrange screen anchors on the auxiliary pontoon with the tripod. It went rather slow: two slabs in 2.5 hour. Installation of geotextile 2D went successfully.

Thursday 23-4

Main activity: Installation of screen 1,2,3 and 4, failed.

In the morning we prepared the four screen-anchors complete with geobags on top of them. We connected the chain tackles at the I-beams and placed the slabs on the bases. This went very fast, three slabs in 45 minutes.

We fixed the chain tackles for lifting of the anchors at the end of the I-beams to provide a distance of four meter between them. Then we started lifting. During lifting one of the I-beams bended. This happened because of many forces in the I-beams, in different directions. First the eyes for the hooks on the I-beams were not placed straight under the pullys. Also the chain tackles should have been fixed above the anchors at the I-beam.

In a discussion with the team leader we decided to place the two screens without the 1-beams and the THP pulled in an angle of 45 degrees.

Today we started also to cover the gunny bag dam of caisson spur I with geotextile.

Friday 24-4

Main activity: Installation of screen 1 and 2 and geotextile 2E, Fig- 10.1 to 10.8.

Screen 1 and 2 were installed with the new method described above. The first attempt failed because of the difficulty of turning the THP with an angle of 45 degrees. Also a strong wind and high waves made the situation worse. The next try we found out another anchor line had to be loosened. Because we had to turn the THP, it was too difficult to lower the screens with the right orientation. The THP tended also to lay in an angle less than 45 degrees. This had to be corrected with the engine boat.

Therefore it was decided to place the screens the next days one by one. This way it is possible to assemble the screen in the angle of 45 degrees (Fig-10.7). Shifting the THP 5 meter for the next screen proved to be easy.

Saturday 25-4

Main Activity: Installation of screen 3 until 6, Fig- 10.3 until 10.8.
Installation of geotextile 2F (Fig-4).

Everything went as planned today. After installation of geotextile 2F on the shore people started building the gunny bag dam.

Sunday 26-4

Main activity: Installation of screen 7 until 10, Fig-2.

Monday 27-4

Main activity: Installation of screen 11 and 12.

Installation of screen 11 took about two hours. It took so long because we found again heaps of gabions. We placed this screen east of these gabions.

7. MONITORING AND EVALUATION

Installation of the project was completed in April, 1998. After installation monitoring of the project started.

7.1 Brief description of monitoring results

A brief description of the monitoring results are given below.

The performance of the Haimchar Pilot Scheme has been monitored very closely because of the dangerous situation of the flood protection embankment of the Chandpur Irrigation Scheme.

The works have been subjected to the very strong currents of the 1998 monsoon flooding. Until mid August 1998 the depth of the scour holes downstream of the spurs was 2 m - 4 m below the original depth. After this the currents became too strong for reliable systematic measurements of the bed levels by rope were not possible. Spot level measurements of the bed indicated scour holes of more than 10 m compared to the levels before construction of the spurs.

Although some damages of the spurs occurred already during August, the works implemented by MES were nearly destroyed during September flooding and during the recession of the peak floods when the currents were strongest.

It was found again that current and waves empty the gunny bags filled with local soil in a relatively short time. Wave and current action also removed the foundation material below a protective cover of composite (woven and non-woven) geotextile.

The Profix system that has been functioned successfully elsewhere in the world also did not stabilise the riverbank down to the low water line. The local soils are very fine, appear to have very limited cohesion and it was observed that are very easily washed out by waves/currents.

Since the area covered with composite geotextile and Profix was rather limited and did not extend sufficiently into the river, the spurs were outflanked on the landside due to progressive eastward erosion in August and September 1998.

The concrete block pitching placed on a non-woven filter layer, installed by BWDB over a distance of 380 m upstream, in between and downstream of the spurs installed by MES had slipped into the river after the channel at the toe of the protection had deepened by scour.

Of the 12 bottom screens installed at Haimchar, 6 screens were found back after the flooding of 1998. Even after the 1999 flooding some of the screens were still causing turbulence at the water surface some of the screens had been displaced by scouring or current forces and it also was found that PVC floats were damaged either by water pressure or an anchor.

In November 2000 no signs indicating the presence of screens was observed any longer. During monitoring it was not possible to detect any effect of the bottom screen on scouring/deposition patterns that may be interpreted as positive in respect to erosion control.

For Haim Char detailed bathymetric surveys have been done in an area 50 * 50 m surrounding the spurs. Measurements were taken every 2 m in the direction perpendicular to the shore and 5 m parallel to the shore. On two occasions measurements were taken:

- 3-4 July 1998
- 13-14 August 1998

An attempt has been made to calculate scour depths from this data, but the survey area was too confined to get a clear picture

7.2 Monitoring details

Site Surveys from June to September 1998

Deflection of the current was observed near the screens where water turbulence was noted at the surface. However riverbank erosion in between the spurs continued and some of the Profix sheets were displaced or damaged by wave and current action. These sheets were repaired as well as new Profix sheets were placed and loaded with scattered concrete blocks. Simultaneously some concrete blocks were dumped in scouring areas. By this action the situation improved, erosion was stopped and silt deposition in between the spurs was indicated.

Chandpur BWDB executed 370 m of block pitching in the entire project area in June and July 1998 (Fig-11, 13 & Picture 5).

During the last week of July 1998 water levels started rising, current velocities increased and thus the devastating flood of 1998 started.

The flow velocity reached to about 2.0 m/sec. One of the 12 bottom vane screens was washed away due to a broken anchor hook at one end of the R.C.C. beam and a failing D-shackle at the other end (Fig-14). By outflanking the connecting dyke of spur 2 a secondary channel was formed in between the spur and riverbank through which a strong current force hit the bank angularly at South-East direction in between the spurs. Bank erosion started again and scour holes developed near the toe line of the embankment. Blocks pitched down near the toe of the embankment started sliding down and thus the Chandpur Irrigation Project was threatened.

To save the embankment from breaching and to save the spurs, 3000 nos. of concrete blocks of size 45 cm x 45 cm x 45 cm were dumped on emergency basis in the damaged connecting dyke portion of both spurs to reduce the hitting force to the embankment. Simultaneously the Chandpur BWDB constructed one retired embankment (Picture 6). They also dumped 12000 concrete blocks, branches of trees and gunny bags filled with bricks in the scouring areas. A responsive result was observed, the erosion was controlled and the embankment was saved.

On August 2nd, 1998 an attempt was made to check the position of the spurs. As water was flowing above the top levels of the spurs with a strong current force it was impossible to do so.

Bed levels 25 meters upstream and 25 meters downstream from the center lines of spur 1 and spur 2 and extending up to 50 meters into the river at a 5 meters interval along the shore line and at a 2 meters interval across the river were recorded. This took place before the flood on July 3rd and 4th, 1998 and during the flood on August 13th and 14th, 1998. Soundings around spur 1 are shown in tables 1 and 3 and soundings near spur 2 in tables 2 and 4 respectively. These data indicate the extent of the erosion through strong current forces in the area during flood. Depth of the erosion varies between 2 to 4 meters locally.

High flood level continued during September, 1998. Monitoring was limited to recording water levels only. The maximum and minimum water levels in meter PWD were recorded during September:

Date	Maximum Level (meter PWD)	Minimum Level (meter PWD)
09.09.98	+4.61	-
13.09.98	+3.90	+3.27
14.09.98	+3.70	+3.27
15.09.98	+3.56	+3.13
16.09.98	+3.55	+2.95
17.09.98	+3.50	+2.88
18.09.98	+3.50	+2.84

From September 16 to 19, 1998 the following observations were recorded.

- Turbulence and a change in flow direction is observed on the water surface when it passes the downstream location of the spur indicating existence of the spur under water.
- But in the upstream location of the spur no change of water flow direction or any turbulence is observed on the water surface.
- 255 meter out of the 370 m length of block pitching done by the Chandpur BWDB has slided down (Fig- 11 & Picture 7).
- Bottom levels were measured at some locations as shown in Fig-12 & 13.

From September 24 to 26, 1998 the following observations were recorded at site (Fig-13).

- The remaining length of 30 meter of the upstream block pitching by the BWDB as recorded from September 16 to 19, 1998 has slided (Fig-12 & Picture 8).
- 85 meter length of block pitching on the downstream side has slided.
- The erosion area started from the downstream spur towards the north.
- Turbulence of water movement on top of the bottom vane screen area was recorded.

During October, 1998 flood water receded, water level in the river went down and the flow velocity reduced.

November 1998 Site Survey

From November 21 to 24, 1998 a detailed site investigation was made with the help of divers. The following observations were made.

7.2.1 Spurs

- The downstream spur (spur 1) was found in place but in damaged condition. Its shore side half (about 6m) was found in tilted position towards the downstream side. But the riverside half of the spur was completely damaged and lying on the riverbed. Most of the bullahs and bamboos were found in damaged condition.
- The bed protective geotextile mattress on both upstream and downstream sides from the spur was displaced from its position and found in a folded condition along the spur.
- As the downstream spur was partially damaged, the synthetic bags and concrete blocks came out of the spur core.

- The upstream spur was completely washed away. Only some concrete blocks were found in the area where the connecting dyke had been. The bed protection was also gone.
- Connecting dykes of both spurs were washed away.
- Synthetic bags and geotextile bags filled with local soil were found getting empty due to current and wave action.

7.2.2 B.V. Screens:

- Out of 12 nos. of bottom vane screens installed upstream of the upstream spur (spur 2), one screen was washed away during the peak of the flood period. It was salvaged by an MES guard with the help of fishermen. Its anchor hook was broken at one end and at the other end the D-Shackle was missing.

- Out of the remaining 11 screens only 6 nos. were found at the riverbed by the diver. 5 screens are suspected to be washed away during the flood. In more detail:

- Screen no. 1 was in its original position at 45° angle to the flow, but the other one of the pair i.e. number 2 was displaced slightly in orientation to an angle of 30° to the flow.

- Screens nos. 5 & 6 were found lying flat on the river bed. The end seals of the PVC float pipes were missing. One top float pipe was found in bruised condition indicating a hit by a river vessel.

- Screens nos. 11 and 12 were found in place but in changed orientation from the installation angle of 45°. These were at about perpendicular to the flow. One float pipe of screen no. 11 was open at both ends, but other float pipes were OK.

- Around the anchor slabs scouring was observed resulting in settlement of the slabs.

- Fishing nets were found inter winded with several number of screens.

7.3 Evaluation

As mentioned already it was clear from the start that the works at Haimchar were too small scale in relation to the severe site conditions; in particular the number of spurs to be installed should have been much more to cover a greater length of the riverbank. The protection should start where the rate of bank erosion is small to prevent outflanking of the spurs from the upstream (also from downstream in tidal areas).

Only two spurs have been installed at Haimchar to prevent breaching of the flood protection embankment of the Chandpur Irrigation Project and snapping of an important road connection in the area.

Initially the main problem was the continued erosion of the riverbank upstream and downstream of the spurs by currents and waves. This, in combination with failure of the bank protection at the landside of the spur, after some time caused outflanking of the riverside of the spurs.

This landside protection of the spur, basically a composite geotextile sheet covering the reshaped riverbank (slope 1: 2) which was ballasted with gunny bags and concrete blocks, was undermined by wave action in combination with currents. Apparently the filter capabilities of the non-woven part of the composite geotextile did not properly match the properties of the riverbank soils. Even protection with Profix (two layers of geotextile with a coarse sand filter in between) failed to stabilise the riverbank after some time.

After completion of the spurs BWDB has installed a revetment on the riverbank upstream, in between and downstream of the spurs installed by MES in a desperate attempt to prevent breaching of the embankment.

Several thousands concrete blocks were dumped in the connecting dam between the upstream spur and the BWDB revetment to prevent outflanking of this spur. These measures were successful. However later on the strong currents of the 1998 monsoon flooding resulted in deep scour holes and eventual collapse of the caisson/open spur. Still during the 1999 and 2000 monsoons the presence of the spurs could still be observed; eddies were still visible indicating (remnants of) an underwater dam extending into the river.

Although implemented separately 'from the MES pilot schemes some remarks on the design, implementation and performance of the protective works installed by BWDB are deemed of importance for future erosion control works.

The protective works by BWDB at Haimchar started in May 1998, in fact already in the pre-monsoon period when execution of works in the river is already hampered by waves, the occasional nor'wester and rising water levels in the river.

For a number of reasons the protective revetment reached only 0.5 – 1.0 m below the lowest prevailing water line while the deeper channel near to the bank to be protected had a depth of at least 6m below PWD. The maximum scouring depth found during MES surveys was almost 15m below PWD. The revetment consisted of concrete slabs on a layer of now-woven geotextile to prevent washout of the foundation material of the revetment. It was found that whenever scouring occurred at the toe of the revetment sliding of the bank occurred and the concrete blocks fell into the scour hole. Dumping of extra blocks in the scour hole only gave temporary protection until the scour hole had deepened sufficiently to swallow the heap of blocks also.

From these observations it has to be concluded that the protective measures installed by BWDB provide only limited and short-lived protection against riverbank erosion by currents combined with wave attack. Although the design may have been prepared according to established design rules, the available budget, timing and installation methodology does not allow execution as per design.

Unless BDWB installs a revetment (based on traditional design) at Haimchar with the slope protection extended to the deepest part of the river channel and with a launching apron of proper dimensions to take care of the scour holes that will develop, these protective measures will be far from adequate to prevent continuous bank erosion and subsequent breaching of the flood protection embankment.

8. OVERALL IMPACT AND LESSON LEARNED

8.1 Overall Impact

Two numbers of permeable spurs installed at Haimchar were too inadequate to combat the severe erosion condition there. After installation of the spurs the big flood of 1998 started and due to high flow specially during recession of the peak flood the spurs were heavily damaged. Thus the spurs failed to exert an overall impact on the area.

After installation of the cluster of 12 numbers Bottom Vane screens turbulence of water could be observed on the surface. Thus it could be understood that the screens were able to deflect the current upto some extent. But the number of screens was also inadequate to have an overall impact on the area.

8.2 Lessons Learned

Based on observation of the two spurs implemented by MES at Haimchar it is concluded:

- the caisson type spur made of bamboo and bullah is not sufficiently durable under field conditions
- the hydraulic performance of the caissons under the prevailing conditions was adequate
- the dimensions of the bed protection below the caisson should be increased in view of the size of the scour hole
- gunny bags filled with local soil will be washed out quickly by wave and current. Adding an inner bags of polythene sheet will reduce this problem
- the protection of the riverbank slope was not adequate. The soil was rapidly removed at both end of the protection.
- the composite geotextile did not prevent gradual washout of the local soils though openings in the layer of ballast bags
- measures have to be taken in the layout and design of protective work to prevent outflanking at spur type erosion control works
- no conclusion could be drawn with regard to the functionality of bottom screens as sediment diverter since the number installed was too small and rapid bank erosion during the 1998 monsoon left the screens too far from the bank to be effective in any case.

26

KHORKI EROSION CONTROL PILOT SCHEME

1. SITE DESCRIPTION

1.1 Location, site selection and time schedule

The Khorki bank protection works are located in the upper part of the Meghna Estuary on the right hand bank of the Meghna River in the Bhola district 10 km northeast of Bhola. The coordinates are 569335 m east and 517250 m north (BTM). The location is shown on Fig-1.
This site was selected because of the varying hydraulic impact along the spurs. The upriver spurs would be located in a relatively protected area so that outflanking would not occur. The upriver spurs in their turn would protect the downriver spurs that were under more serious attack from erosion.
Implementation of the works was done between May 7 and June 15 1998. Monitoring of the project was done during June until November 1998.

1.2 Soils

According to Brammer (1996, ref.19) the soils can be classified the same as the Haimchar soils. MES and LRP found a much lower median grainsize for the bed material: 0.023 mm. This is probably caused by the fact that at Khorki the samples were not collected near on transects, but along the eroding bankline effectively recording the grainsize of the banks.

1.3 History

The Bhola Island on which the Khorki pilot was located has been separated from the main channel by a series of chars ever since 1973. From Fig- B2, it can be seen that the location of these islands has shifted more and more to the west and the south. It can also be seen that in 1984 no protecting islands were present.
Although the chars protect the land from the main current, the water is conveyed to the west causing erosion. Three small chars are combined since 1993 forming a larger char in 2000. This directs more water in the channel west of the Bhola island.
The pilot location on the northeast of the Bhola Island eroded at an average rate of 73 m/year (ref. 4) over the 1973-2000 period. There is a decline in the erosion rate as calculated from the three periods, see table 1. However, looking at the graph of the bank retreat, Fig-1.10 this decline in erosion rate is not so clear. The overall average also fits well in the 1996 - 2000 period, but the bank retreat is lower now. From the Fig-, it can be seen that the ongoing erosion, since the implementation of the pilot, has been strong, leaving the former location of the spurs well within the channel.
In future, it is expected that the erosion will continue (ref. 17).

	1973-1990	1990-1996	1996-2000	1973-2000
Khorki Spur - 2	77	105	10	73

Table 1 Erosion rates at Khorki spur 2, from satellite images

1.4 Bathymetry

The large-scale bathymetry from 2000 is presented here, see Fig- B3. This is chosen because of the partial spatial coverage of the bathymetric survey in 1997. Detailed bathymetric surveys have been done at the pilot location in the monitoring fase. This will be described in the chapter on monitoring.
In the main channel, three minor channels are located. The thalweg is in the middle, with lowest bedlevels of -14 m PWD. The western part of the channel is bounded by a series of newly emerged chars. Smaller channels divide these chars to convey the current to the north, to the Tetulia River and south along the Bhola Island. Scour occurs as the water is divided in a northern and a southern direction.

The pilot was not located at a point with the deepest scour hole as can be seen from the cross section in Fig-1.12. The maximum depth was 6 meters. The under water slope angle was 45 degrees, which indicates a very instable point. A safe angle would be 11.7 degrees.

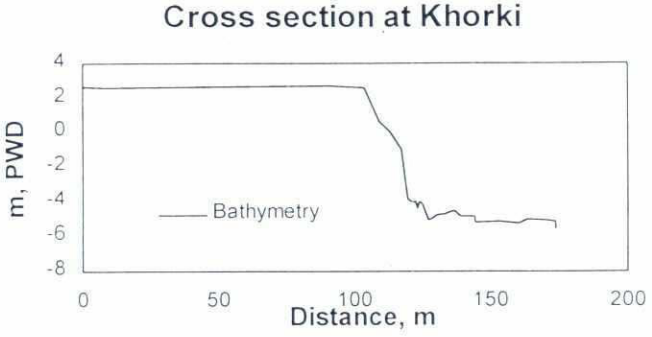


Fig- B4. Cross section at Khorki

The bathymetric changes between 1997 and 2000 can be seen from Fig- B5. Some erosion occurred along the bankline at the pilot location. In general the bottom level has come up over this period. This is consistant with the low erosion rate calculated from the satellite images for the 1996-2000 period.

1.5 Flow

No flow measurements were done at Khorki, but in general, the following can be said:
The area is in the mixed energy zone in the dry season (ref. 1). This means that there is influence from river energy and tidal energy. The flow pattern in this period shows a bi-directional current. The tide comes in from the South leaving the spurs relatively sheltered. The ebb flow comes from the north. Water is being conveyed from the main channel to the pilot location hitting the bank at an angle. This causes extra erosion.
In the monsoon period, the whole area is river dominated, with no change in current direction over the tidal cycle. Only the current speed changes during a tidal cycle. This means that during monsoon the water continuously hits the bank at an unfavorable angle and that the current velocities are larger than in the dry period.

2. THE PILOT SCHEME

2.1 Objectives

3 numbers permeable screens will be installed at Khorki site where bank erosion through bed scouring is in progress. The extent of bank erosion at downstream of the site is very long and continues upto 40 km south. However at north of the site the bank is having a mild slope where bed scouring is not present. Only mild erosion due to wave action is visible there.

The objective of the pilot scheme is to test the stability and effectiveness of the upstream 2 spurs installed at comparatively less dynamic area and also of 1 spur at south end placed at more dynamic area where heavy bed scouring is in progress towards north continuing from far south.

Effectiveness of Profix system will be tested at this site.

Stability and functionality of the Bottom Vane Screens placed both upstream and downstream of the spurs also will be tested in this pilot scheme.

3. DESIGN

3.1 Design Consideration

Design considerations for design of spur, bed mattress, screen and profix were same as at Haimchar site. 3 nos. of permeable spurs each of length 18 meters and 108 nos. of submerged Bottom Vane screens were decided to be installed arbitrarily as per plan shown in Fig-2.1. It was expected that design criteria will come out from the monitoring reports of the pilot scheme.

3.2 Design of Caisson Spur

3 numbers of permeable spurs are planned to be installed each of length 18 meters. The distance in between spurs was planned to be 250 meters arbitrarily. But during implementation of spurs the distance between two spurs at upstream had to be reduced to 210 meters as the bed profile of the first spur at upstream (KC1) was found unsuitable for installation of bed mattress as there were big roots of trees and bamboo clusters (Fig-2.1). A gentle slope without any abrupt change in level was found at a distance of 15m from the bank line where the spurs could be installed.

The design procedure of spurs were same as at Haimchar.

The spurs at Haimchar were stabilized through dumping earth-filled gunny bags. But the gunny bags got empty soon through wave action and current force. So it was decided to use concrete blocks as stabilizing material of spurs at Khorki. The spurs were stabilized through dumping concrete blocks inside the spurs upto height of 2 meters.

3.3 Bed mattress

Bed mattress was designed similar as used at Haimchar site. However, since earth-filled gunny bags did not prove to be durable as ballasting materials at Haimchar, concrete blocks of size 40 cm x 40 cm x 40 cm were used here. The bed mattress at shore side was extended upto 5 meters inside the shore (Fig-2.1.

3.4 Profix

Profix sheet of 12m x 5m were used at Khorki site to cover an area of 12m x 9m at each end of the spurs. Design of profix was same as used at Haimchar.

3.5 Connecting dike

A connecting dike upto height of 2 meters with 1 meter top width was constructed in between the spur and bankline by dumping concrete blocks of size 40 cm x 40 cm x 40 cm.

3.6 Screen Arrays

Design and design consideration of Bottom Vane Screens was same as used at Haimchar. The screen array was planned as per Fig-2.1 on arbitrary basis. However since flow velocity and erosion condition was severe near and to downstream of spur KC3 an array of 54 screens consisting of each set of 3 screens in parallel line is placed to combat the situation there.

4. EXPECTED IMPACT

The effect of the permeable spurs will reduce the flow velocity considerably in between them and thus scour action will be reduced and silt will be deposited. The direction of flow will be diverted reducing the attacking force on the downstream area.

The Bottom Vane screens will divert bottom flow carrying silt towards the shore. Thus combined effect of the spurs and screens will reduce erosion and induce accretion in the area.

5. COST ESTIMATE OF HAIMCHAR AND KHORKI EROSION CONTROL PILOT SCHEMES

The cost of implementation can be divided in the following items

1. Manpower
2. Equipment
3. Supply

Category	Amount		Equivalent cost in NLG	Remarks
	Taka	NLG		
Manpower	2,339,000			20% cost of manufacturing Twin Hull Pontoon (THP) is considered.
Equipment	3,168,000			
THP (20%)	1,085,000			
Supply & others	9,095,000	156,000		
Total	15,687,000	156,000	787000	

6. IMPLEMENTATION

6.1 Preparation

Preparation procedure of bed mattress, spur caisson, bottom vane screens and profix sheet was same as followed at Haimchar site. However, for ballasting purpose some old worn out concrete blocks of size 40 cm x 40 cm x 40 cm made with brick – chips were available from BWDB, Bhola and was used at Khorki site.

6.2 Installation

Working schedule for installation of spurs and screens at Khorki site

Date	Remarks
07.05.98-	One full 12m caisson installed at KC-3.
08.05.98	One half 6m caisson installed at KC-3. Spring tide starts.
11.05.98	2 screens installed.
14.05.98	One full 12m caisson installed at KC-2.
15.05.98	One half 6m caisson installed at KC-2.
17.05.98	One full 12m caisson installed at KC-1.
18.05.98	One half 6m caisson installed at KC-1.
19.05.98	Storm signal no. 7. Anwesha shifted to Kaligonj, a safe place at Mehendigonj thana.
21.05.98	2 nos screens installed.
22.05.98	4 nos screens installed.
23.05.98	4 nos screens installed.
24.05.98	9-30 am low water slack. 2 screens dropped. Strong wind. 3-30 pm high water slack. 2 screens dropped. Strong wind.
25.05.98	Stormy weather. New moon spring tide.
26.05.98	Stormy weather. New moon spring tide.
27.05.98	Storm & Rain. New moon spring tide.
28.05.98	Storm & Rain. New moon spring tide.
29.05.98	Cloudy. Spring tide.
30.05.98	4 screens installed.
31.05.98	8 screens installed. Neap tide starts.
01.06.98	8 screens installed.
02.06.98	10 screens installed.
03.06.98	6 screens installed. Norwester in the afternoon.
04.06.98	9 screens installed.
05.06.98	9 screens installed.
06.06.98	6 screens installed.
07.06.98	9 screens installed.
08.06.98	6 screens installed. New moon spring tide starts. High waves.
09.06.98	Norwester. THP tears off from anchors. Weather signal no. 2 continues.
10.06.98	Storm signal no. 3.
13.06.98	4 screens installed.
14.06.98	5 screens installed.
15.06.98	8 screens installed
	Total 3 spurs and 108 screens installed at Khorki.

6.2.1 Installation method

Installation method of all the components of the project at Khorki site other than B.V. screen was similar to that followed at Haimchar. However regarding installation of Bottom Vane screens the method was improved at Khorki site that made it possible to install more numbers of B.V. screens a day. The procedure is described below:

❑ Installation of bottom vane screens

For installation of screen the following equipment were used:

- Twin Hull Pontoon (THP) - 1 no.
- Flat top auxiliary pontoon 6.00m wide and 16m long - 1no.
- Tug boat 250 - 300 BHP -1 no.
- Tender boat -1 no.

- Mobile crane of 3 ton capacity with boom length of 6m - 1 no.
- Diver's equipment -2 sets.
- Chain Pully - 1 ton capacity - 2 nos.
  500 kg capacity -3 nos.
- Tripod stand -2 ton capacity - 2 nos.
- Push Trolly - 3 nos.

Twenty nos. of skilled and 4 nos. unskilled labourers were divided into two groups 12 nos. in each for installation of screens.

8 nos. skilled labourers with 4 more unskilled ones were engaged in loading the anchor blocks from the shore to the auxiliary pontoon with the help of tripod stand, push trolly and mobile crane. This group loaded anchor blocks sufficient for 8 screens per day. Their activity were confined preferably at night time.

The next group of 12 no. of skilled labourers were engaged in dropping the screens. 2 nos. divers helped them in releasing the wire connections under water. 4 winch operators where engaged in winches. This group of workers initially could install 4 screens per day at 2 slack water periods available. But experience helped to install upto maximum 9 screens per day afterwards at Khorki site. However, considering re-positioning of the THP with anchors planning for installation of 8 screens per day is ideal during early monsoon. During monsoon spring tide no installation was possible for one week time.

At Haimchar site low water slack was more favourable for working condition as high tide velocity was less than the low tide velocity. But at Khorki site the case was reverse. High water slack was more favourable than low water slack. This is due to the distance of the sites from the outfall point of the river Meghna.

At Haimchar site attempt was taken to use the lifting frames in lifting four anchor blocks to install two screens at a time. But one of the lifting frames failed to carry the load as the loading point was in between the lifting points. Afterwards work was continued with one screen at a time without the help of lifting frames. In this process at Khorki site it was possible to install 4 screens per day. Later on the system was improved by lifting 4 pairs of anchor blocks at a time at 4 lifting points by 4 winches. The auxiliary pontoon was removed and the first screen was lowered by using two pairs of blocks at correct angle of the screen. Then the rest two pairs of blocks were transferred in hanging position to the correct hooks through winches and the next screen was installed by shifting the THP in right position. This system took about an hour to install two screens which made it possible to install 8 to 9 screens a day at two slack periods.

At Khorki in between spurs KC-1 & KC-2 and also north of KC-1 the depth of water was shallow (less than 6 m) and as such it was necessary to reduce the screen height from 4 meters to 3 meters. However, in between KC-2 and KC-3 and also at downstream of KC-3 the depth was more and found no problem with 4m height screen. But during high water slack the length of the winch chord was found short to reach bed of the river with screens. The depth of water measured at that time was 13 m at south of KC-3 spur.

❑ Working time

Fabrication of screens, geobags and bed mattress was started at Dhaka on 1st March and was completed in mid April by average 30 textile workers per day. Installation of screens at Haimchar was done in the month of April, and that at Khorki in the months of May and June, 1998.

It was a time just before monsoon when the tidal effect of the Meghna river has increased, tide range and current velocity both were high. The available slack period was very short, some times half an hour, which was not adequate for installation of screens in proper angle. As such it is proposed that such type of work should be done during period November to mid March and not later than end of March.

Table of working schedule at article 6.2 provides an overview of the time frame in which the works were accomplished, including date of unworkable and inclement weather conditions.

7. MONITORING AND EVALUATION

7.1 Monitoring

It is concluded that the erosion control works at Khorki have functioned as anticipated and that the erosion in between the spurs as well as upstream of the spurs has been halted by the combined effect of spurs and bottom screens.

Although the 1998 flooding was very heavy and prolonged, the currents along the river bank at the Khorki works were not very strong because the deeper channels happened to be at some distance. These deeper channels were found close to the shore about 1 km downstream of Spur KC-3 where bank erosion continued as before. After November 1998 the deep channel shifted to the North and eroded the bank downstream of KC-3 until the spur was outflanked on the land side. Gradually the deep channel moved further to the North and the spurs KC-2 and KC-1 were outflanked also during the 1999 monsoon flooding. All three spurs had been destroyed after the 1999 flood season.

It was observed that without around the clock guarding, local people were removing pieces of the geotextile bed protection. Apparently sharp edges of concrete blocks also has caused tears in the bed protection. The Profix system remained in better condition than at Haimchar but in some placing the stitching was loose and coarse sand fill was lost.

For Khorki detailed bathymetric surveys have been done in an area 50 * 50 surrounding the spur. Measurements were taken every 2 m in the direction perpendicular to the shore and 5 m parallel to the shore. On four occasions measurements were taken:

- 11-13 June 1998
- 23-28 July 1998
- 11-12 August 1998
- 28-29 September 1998

An attempt has been made to calculate scour depths from this data, but the survey area was too confined to get a clear picture

7.2 Monitoring details

7.2.1 Site surveys from June to September 1998

One month after installation, July 11 to 13 1998, some deposition of silt was observed in between and around the spurs. This becomes clear when comparing the soundings from June and July 1998. These are presented in tables 5 & 8 (KC-1), tables 6 & 9 (KC-2) and tables 7 & 10 (KC-3). In most locations the siltation varies between 10 to 50 cm.

The devastating flood started the last week of July. Water levels increased and along the river banks areas inundated. Current velocities increased considerably. However the soundings recorded in the middle of August (tables 11, 12 & 13) still show about the same pattern as in July 1998. In August and September 1998 flood levels were still high with strong current velocities causing much erosion in areas adjacent to the project site. The areas around the spurs also suffered erosion. This becomes obvious when comparing the soundings from August and September: tables 11 & 14 (KC-1), tables 12 & 15 (KC-2) and tables 13 & 16 (KC-3). In between the spurs the extent of the erosion seemed to have decreased and also no shoreline regression has been observed. The combined effect of the bottom vane screens and the spurs

proved to be effective. At the downside of the downstream spur (KC-3) the screens were the only protective measures. The increased water depth decreased the screens effective diverting the flow. Also intense scouring is observed at the downside of KC-3. During the flood 4 screens were found being swept away, 3 of them could be rescued. The types of failures are explained in more detail in Fig-14.

7.2.2 Site Survey November 1998

After the flood a detailed survey was performed the end of November to monitor the situation in the area. Divers were engaged and the observations are described next.

❑ **Spur**

1. Spurs KC1 and KC2
   Both spurs were found OK (Picture 11). Siltation was observed on the geotextile bed mattresses around the spurs. The Profix was in place.

2. Spur KC-3
   It was hit by a big river vessel and was tilted towards north (Picture 12). But the spur as a unit was in position. However some of its bullahs and bamboos were damaged. Bank erosion downstream of spur 3 has reached up to the spur. 2 nos. of Profix blankets were washed away exposing the river bank slope near the spur.

30 meters downstream of spur KC-3, 13 meters erosion was recorded (picture 13). No shoreline regression was observed in between the spurs KC-1, KC-2 and KC-3. In picture 14 the unharmed shoreline upstream of the upstream spur (KC-1) is shown. The siltation pattern at the upstream side of the middle spur (KC-2) can be seen in picture 15. Siltation is visible at the upstream side of the downstream spur (KC-3, Picture 16).

❑ **Screens**

One screen was disconnected from the riverbed on November 15th 1998. The one meter long lifting hook was separated from the anchor slab (Picture 17). The top float pipe was flattened. It might have been hit by a river vessel which might have dragged the screen causing failure of the lifting hook.

❑ **An overview:**

1. Upstream of KC-1

   - 18 nos. bottom vane screens were installed out of which 14 nos. were found.
   - 2 screens were lying flat on the riverbed.
   - 5 nos. float pipes of the above 2 damaged screens were found open, 3 of them at both ends and 2 at one end. The end seals failed.
   - Alignments of the screens were found OK.

2. In between spur KC1 and KC2

   - 16 nos. bottom vane screens were installed in this area out of which 11 nos. were found existing in place.
   - 3 screens were found lying flat on the river bed.
   - 4 float pipes of the above 3 screens were found both ends open and 2 float pipes had one open end. The end seals failed.
   - One screen was disconnected from the anchor slab at one end. The other connection was found OK.

3. In between spur KC2 and KC3

- 20 nos. bottom vane screens were installed in this zone, out of which 12 nos. were detected to be in place.
- 4 nos. anchor slabs were detected without any screen indicating the screens had been swept away.
- Alignments of all remaining screens were found OK.
- 2 float pipes attached to the screens were found open at both ends.

4. Downstream of Spur KC-3

- 54 nos. bottom vane screens were installed in this zone out of which only 28 nos. were found in place.
- 3 screens were lying flat on the river bed.
- Out of 9 float pipes, from the above 3 screens, 7 were found open at both ends and 2 were open at one end. The end seals failed, both the welding at the glass fiber attachment.
- 2 float pipes were squeezed and flattened partially. They might have been hit by a river vessel.
- 27 nos. screens were found having a proper orientation. 1 was found perpendicular to the flow.
- Over around 70 m near the outfall of the side channel, no screens were found.
- On numerous locations fishing nets were found inter-winded with the screens.

During high tide the water levels were recorded as shown in Fig-16.
Failures of the screens as observed in the ones rescued are shown in detail in Fig- 14.

7.3 Evaluation

As mentioned already the spurs installed at Khorki before the monsoon of 1998 were not attacked seriously during that monsoon. In the course of 1999 the flow pattern along the Northeast coast of Bhola changed and the spurs came under attack by the incoming tide. One after another the spurs were outflanked as a result of continuous erosion.

Based on observation of the three spurs and 108 bottom screens implemented by MES at Khorki it is concluded that most of the observation at Haimchar also apply at Khorki in addition it was found that:

- ballast blocks cast with brick chips as coarse aggregate will gradually be dissolved by current and waves.
- when geotextile bed protection is exposed above water for some time and guarding is limited, pieces of geotextile will be cut by fishermen and farmers in the night
- the seam in the Profix system were torn either by forces due to hanging or on purpose cut by people
- initially the combination of spurs and bottom screens appeared to induce deposition of sand on the river bank. However this occurred only at low flow velocities. After the incoming tide gained strength compared to the outgoing tide the effect of the bottom screens was lost because of the fixed orientation of the screens that causes deflection of the bottom current towards the bank at out going tide only.

8 OVERALL IMPACT AND LESSONS LEARNED

8.1 Overall Impact

- at Haimchar the erosion control works were not sufficient to withstand the strong currents that developed when the very heavy flooding of the 1998 monsoon receded in September 1998. More extensive works as well as improved design will be required under such conditions. In particular outflanking of the spurs should be prevented.

- at Khorki the erosion in between and upstream of the three spurs was stopped; sand was deposited along the banks. Downstream of the spurs erosion continued due to strong tidal current attack of the river bank.

- until the permeable spurs at Haimchar were washed by strong currents during recession of the 1998 flood, the local scour around the nose of the spurs was limited. Local scour at Khorki has been limited throughout the monsoon season except downstream of spur no 3.

- the effectiveness of bottom screens could not be ascertained sufficiently because of weaknesses in the design. However before the strong currents of the 1998 flooding damaged the screens, the effect could be observed at Khorki. The number of screens installed at Haimchar was too small to have discernable effect on the movement of sediment; however the effect on the current was clearly visible at the surface during period without waves.

8.2 Lesson Learned

Lessons learned and recommendations for improvement are as follows:

- Permeable spurs have functioned successfully as erosion control device through deposition of sand in between spurs till the flow velocity was limited. If the spur can be made stable against high flow velocity the system will be effective.
- The bullahs and bamboos used to build the spurs proved to be too weak and limited in durability. More durable materials such as galvanized steel members may be used in place. Nylon rope used was rotten within 6 months. Galvanized nutbolts and shackles may be used in place of nylon rope.
- The size of caissons used at this pilot scheme is of rectangular type, 6m (ht.) x 4m (width) x 12 m (length). Since the main members of the caisson are vertical in position, they could not exert sufficient counter force to resist the horizontal current force (Fig-5, 5.3). The design of the spur needs to be changed to be more stable to resist the strong current force. In place of vertical members, inclined members will be used to make the structure stable against horizontal force. The spur will be manufactured by triangular A- frames instead of square size caisson.
- The size pf bed protection mattress used is 15 m x 20 m (Fig-5.1). This size provides protection to insufficient area of riverbed. Such small size of bed mattress increases the number of joints also if more area is to be covered. The size of the bed protection mattress has to be increased in order to reduce the number of overlaps; the currents may sweep up the edges, exposing the foundation material to scour. The length of the overlap provided in between two mattresses is 3.0m which is not sufficient (Fig-5.2). Further while providing this joint under water it is difficult to maintain proper lap length. As such the length of the overlap should be increased taking into account the accuracy of the installation as well as movement due to settlement after installation. A 5m overlap may be sufficient for the purpose.
- The existing slope near riverbank was sometimes having abrupt changes and too steep (steeper than 1:3) to install the caisson. In that case the caissons became unstable. Spur

may be placed inside the shoreline on a horizontal bed at a level below the lowest water level so that wave action cannot erode the spur bed.

- The functionality of PROFIX bed protection is doubtful, in particular in relation to the high cost of this system. Instead a thicker non-woven could be selected in case loss of foundation material from underneath the protection is anticipated.
- Dumping of concrete blocks should be done more accurately, piles of blocks will induce an irregular flow pattern
- Synthetic bags have to be filled with more coarse material than local soil. Alternatively to reduce the cost, synthetic bags may be filled with local soil with an inner layer of polyethylene sheet so that the fine particles of soil cannot be washed out. However, the inner polythene bag will have to be perforated at several places to let out the entrapped air inside.
- The synthetic bags should form the bottom layer of the spur and should be covered by concrete blocks.
- The geobags should be filled with sand coarser than the local soil.
- The anchor blocks were designed with attachment of 1 m ling lifting hook (Fig-7). The Bottom Vane Screens are attached to this hook. During installation also these hooks are used for shifting purpose of the blocks. Thus the hooks are subjected to force in various directions. Failure of these hooks was observed during monitoring period (Picture-17). The lifting hooks of the anchor slabs need to be strengthened to handle the pulling force in all directions.
- The length of the lifting hook has to be reduced from 100 cm to 60 cm.
- Failure of anchor hook of RCC beam attached to bottom vane screens has been observed during monitoring period (Fig-14). The anchor hooks at both ends of the R.C.C. beam need to be strengthened.
- The sealing method of the PVC float pipes needs improvement. The end seals were attached to the float pipes through double welding. The outer seal plate was reinforced through fiber-reinforced polyester resin (FRP) system. It is recommended that both the inner and outer end seal plates will be double welded and further reinforced by the FRP system to increase the strength of the float pipes.

Most of the problems faced were due to the late working season. Some times the weather was foul with strong wind, high velocity of current and high fluctuation of tidal range (about 2.5m at Khorki). Such type of work should be completed by not later than end of March.

Use of the THP is vital in such project. The present facilities attached to THP needs to be improved as follows to adjust with the requirements at site:

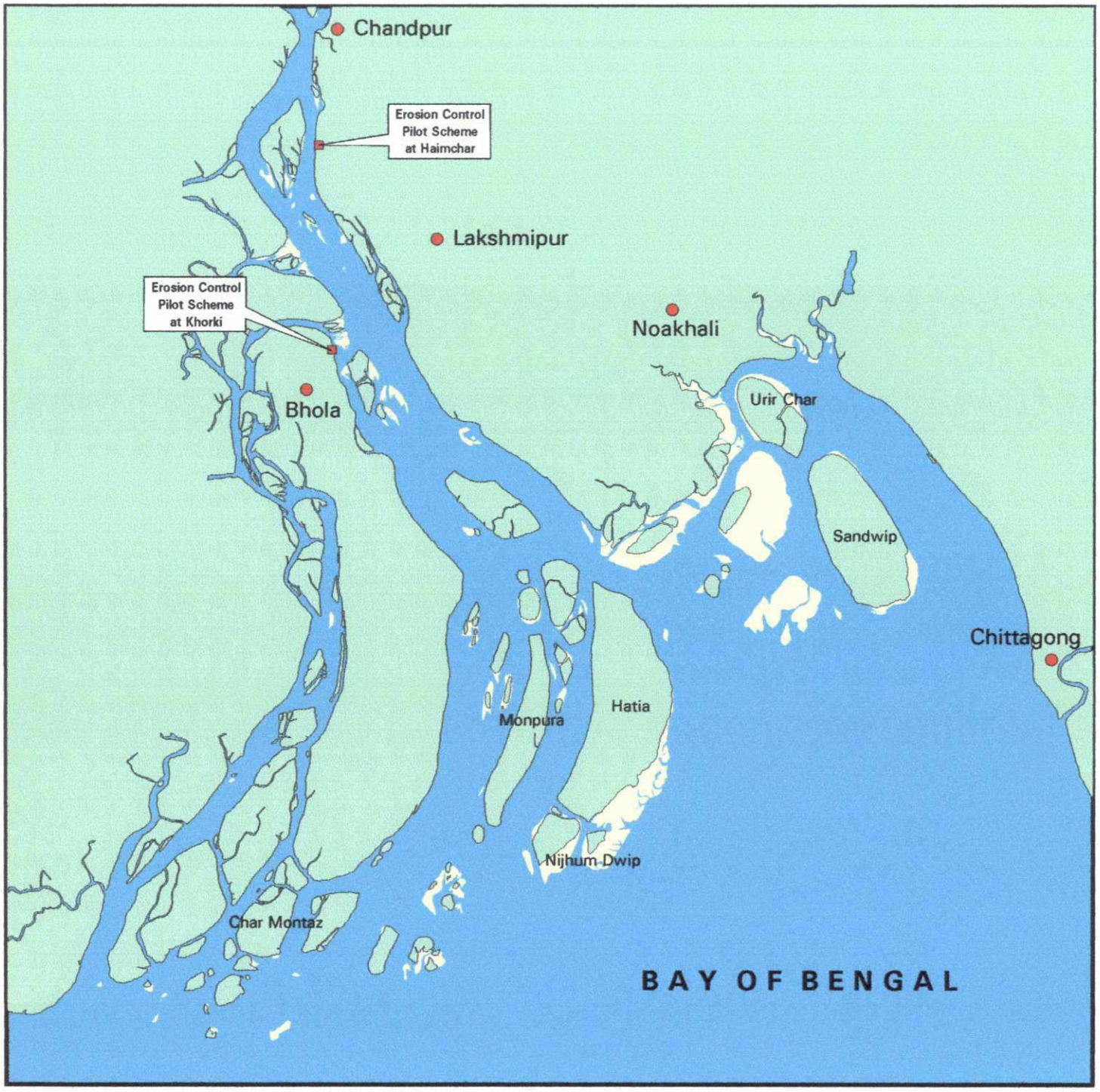
- The anchor chords 6mm dia were found sometimes too weak to keep the THP in position. During stormy weather or spring tide they failed several times resulting in missing of anchors. 10mm dia chords may be ideal.
- The lifting points of the lifting frame are not placed vertically in position. These should be corrected.
- The lifting frames are not strong enough to carry required load. These may be strengthened by welding extra steel plates at the mid section of the frames.
- A lifting frame set may be devised in such a way so that two screens can be placed in proper angle at a time without shifting the THP.
- While maneuvering the THP through tug boat most of the small winches were disturbed and some of them were damaged.
- The mooring point at the shore side was sometimes more than 60m far and the anchor chords were short to reach there.

- Two of the 5 ton capacity big winches were disturbing. Their safety device some times failed and moved freely causing accident to the winch operators while lowering with anchor blocks. These need to be repaired.
- The two booms attached to the THP came to no use to the work as they could be rotated or moved neither on horizontal plane nor on vertical one. These could come to great use if installed properly with horizontal and vertical movement provisions.
- The two side winches used for anchoring purpose are fixed at outer corners of each of the rafts of the THP at 90° angle to the body. Normally the anchor is placed at about 45° angle. So there was problem. It damaged the anchor wires through wear & tear. These should be turned to 45° angle.
- Initially lifting the anchors for repositioning the THP was problem. It took 12 labourers to lift it. But afterwards it became easier and possible by 4 labourers only by tying the lifting rope with the bottom end of the anchors instead of top hook of the anchor stem. However it needs help of the tender boat also. An easier mechanical lifting device may be thought of.

FIGURES

Figure - 1

Location map of pilot schemes at Haimchar and Khorki



Legend:

- Land of 2000
- Mudflat
- Water body
- Location of Pilot Scheme(s)
- District HQ

MES II **Meghna Estuary Study - II**

10 0 40km

SCALE

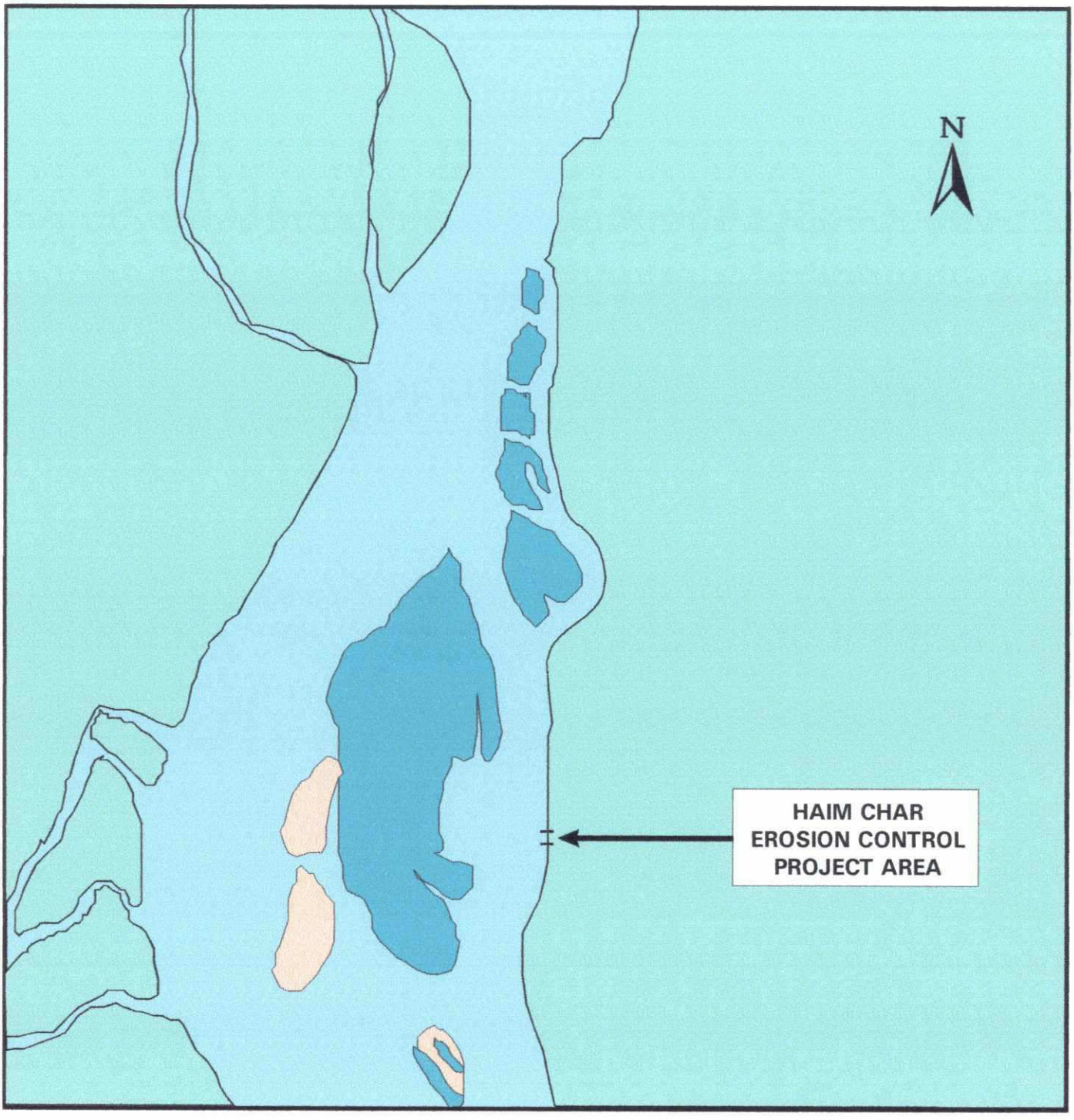
Prepared by: GIS/RS/CAD Section of Meghna Estuary Study II

Note: Bankline were digitized from the Landsat TM imagery of January 2000

File- E:\MES-II\Civil\Emdad\Haim-Khorki-loc.cdr

Figure - 1.1

Location of erosion control works at Haimchar



LEGEND

STUDY AREA

TIDAL MUD FLATS

WATER BODY

SPURS

MEGHNA ESTUARY STUDY	
LOCATION OF EROSION CONTROL WORKS AT HAIMCHAR	
PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996
PRODUCED BY	MES CE&R, GIS/RS/CAD UNIT
PRODUCED BY	MES CE&R, GIS/RS/CAD UNIT

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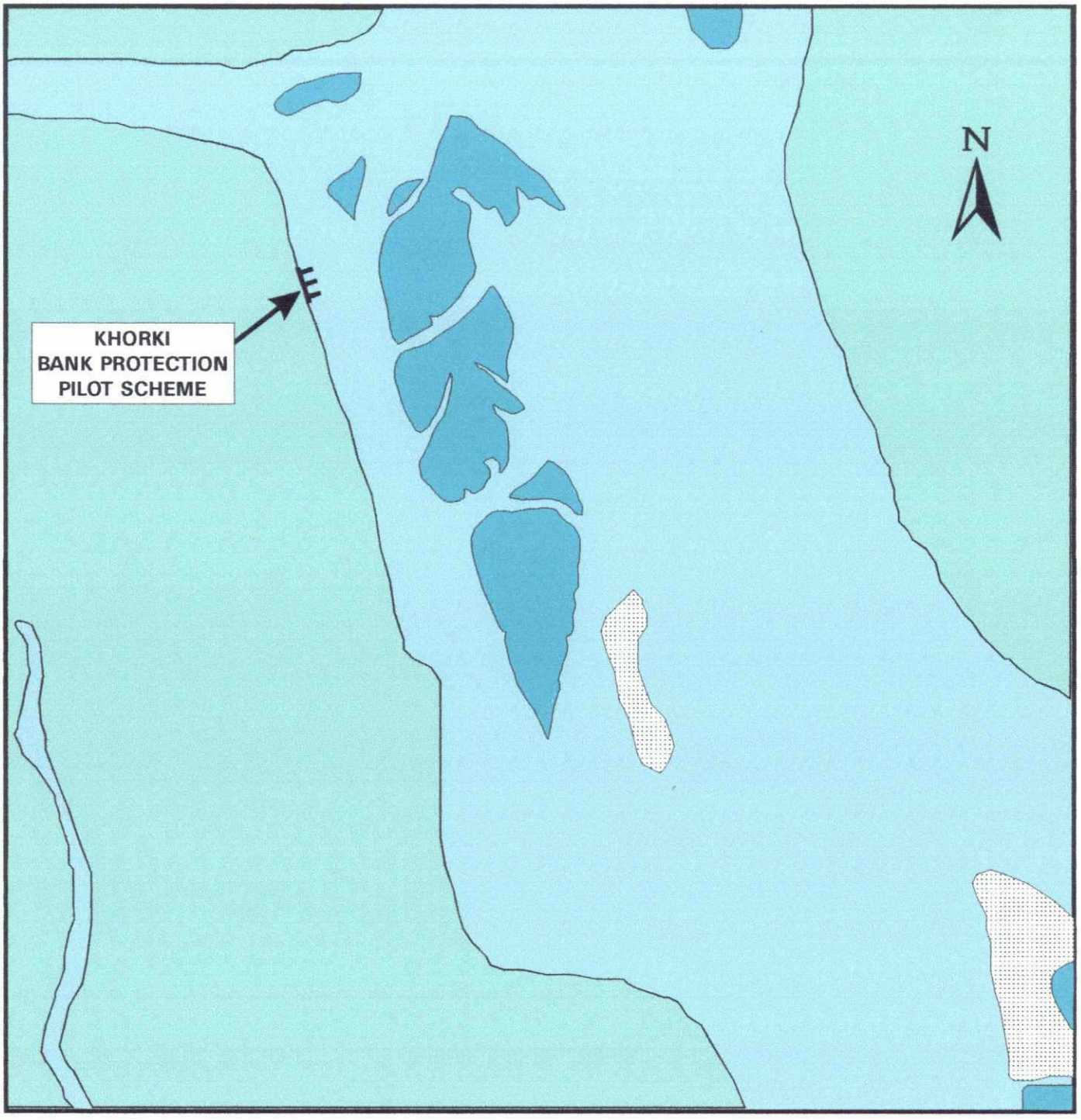
Figure - 1.2

Khorki bank protection pilot scheme



LEGEND

STUDY AREA

TIDAL MUD FLATS

WATER BODY

SPURS

MEGHNA ESTUARY STUDY	
KHORKI BANK PROTECTION PILOT SCHEME	
PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996
PRODUCED BY	MES CE&R, GIS/RS/CAD UNIT

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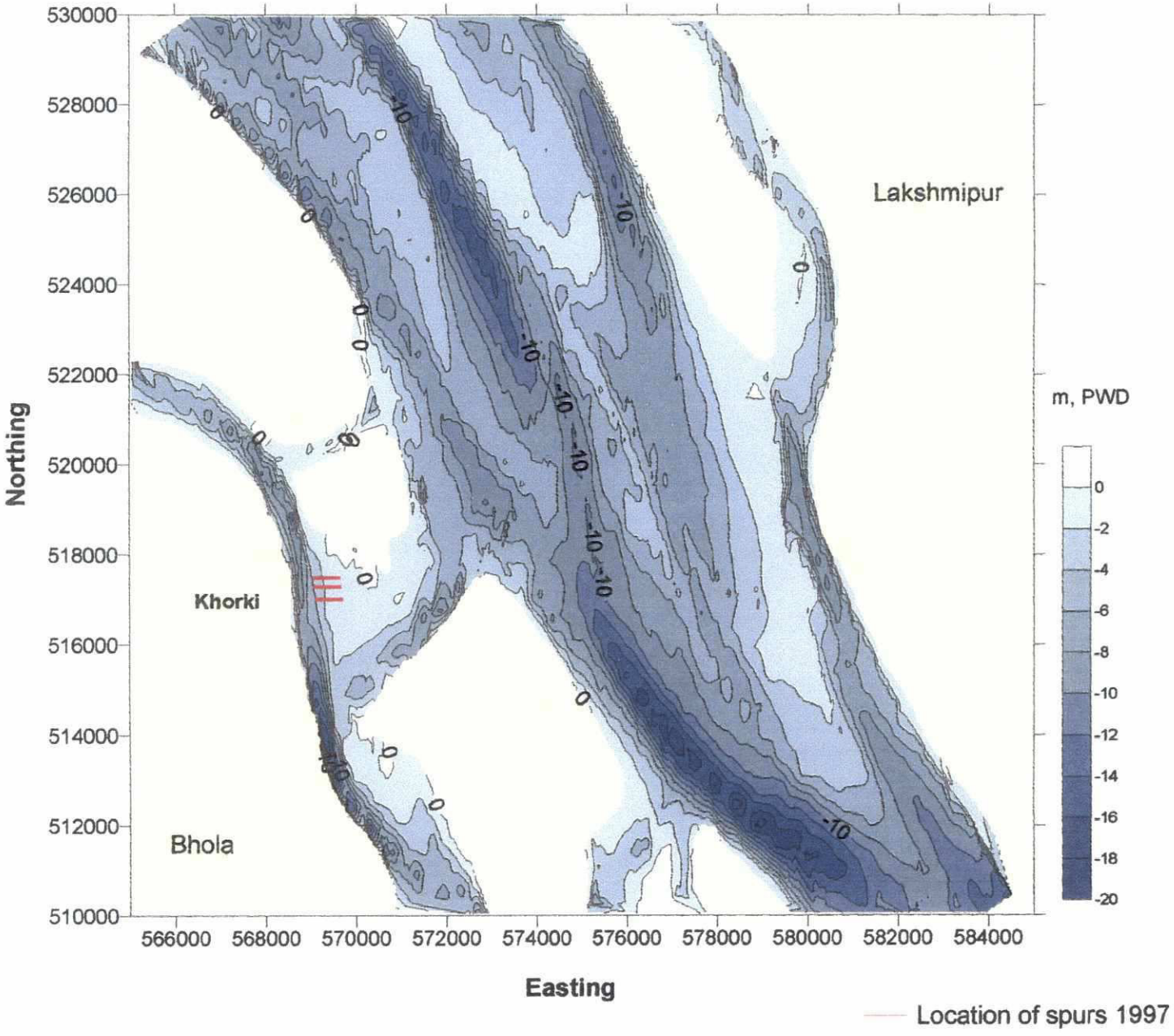
Figure B3 Bathymetry at Khorki May 2000



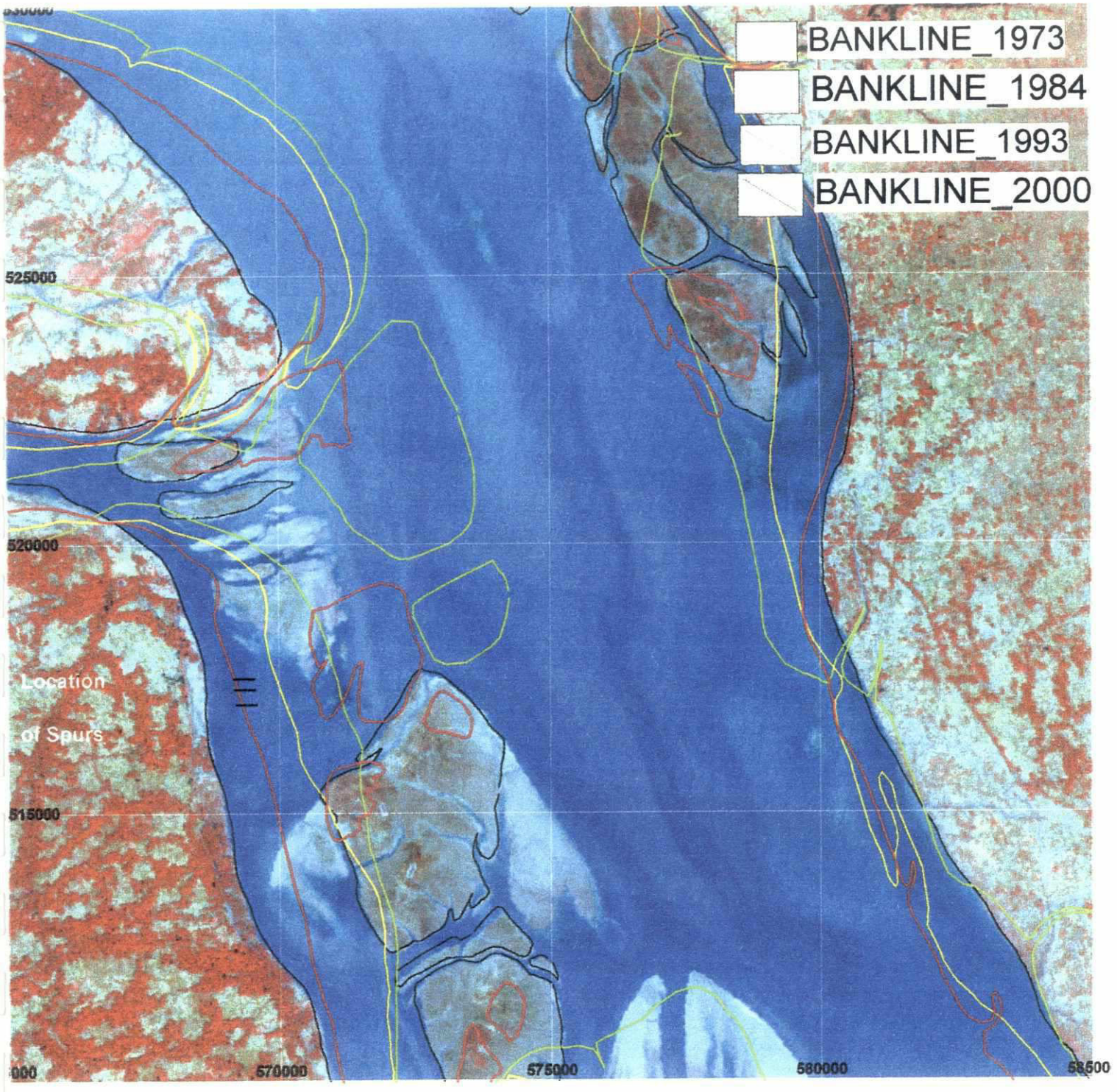
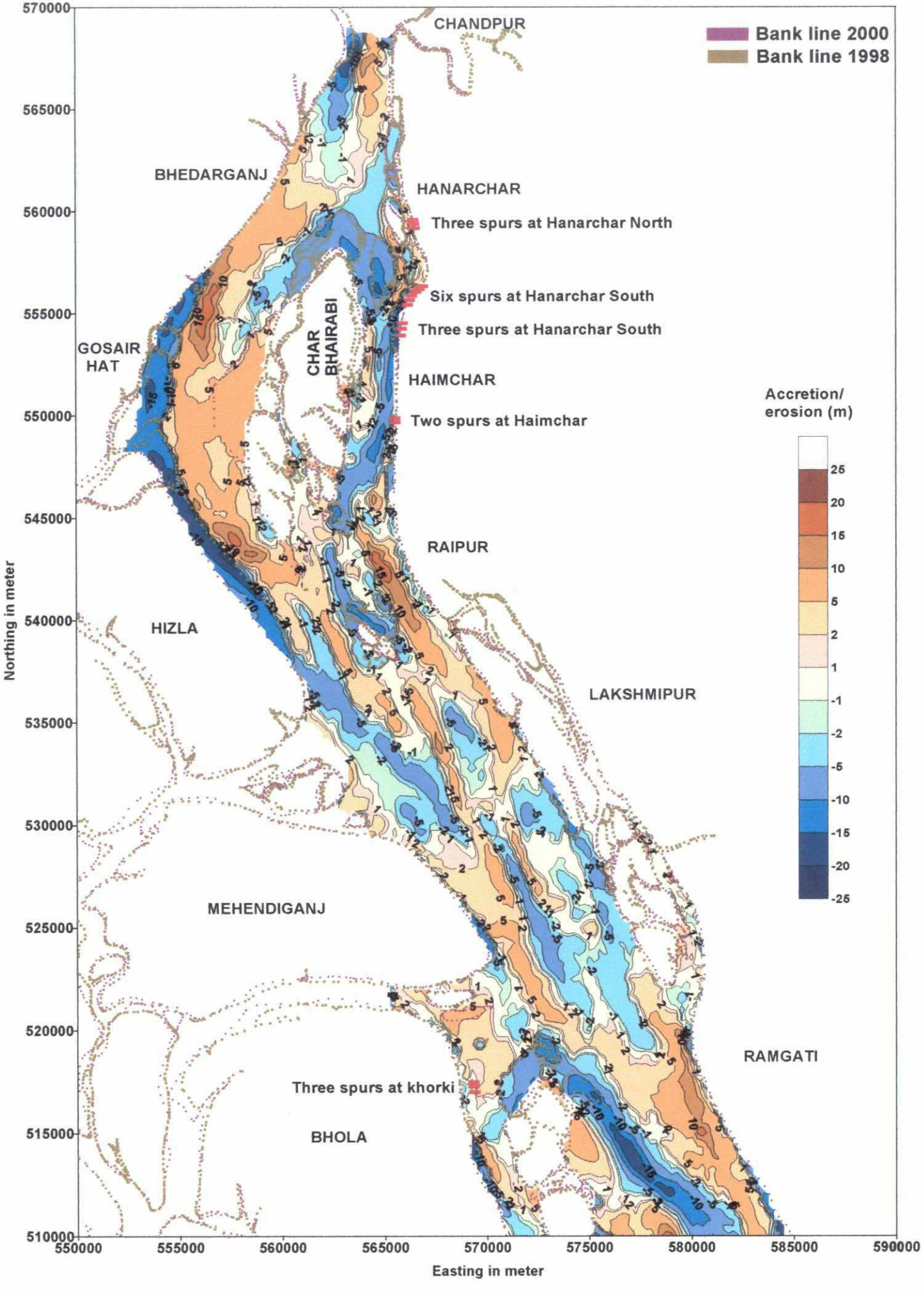


Figure B2: Bankline changes in different years at Khorki

Figure B5 : Accretion/erosion (bathymetric change) map for area 1



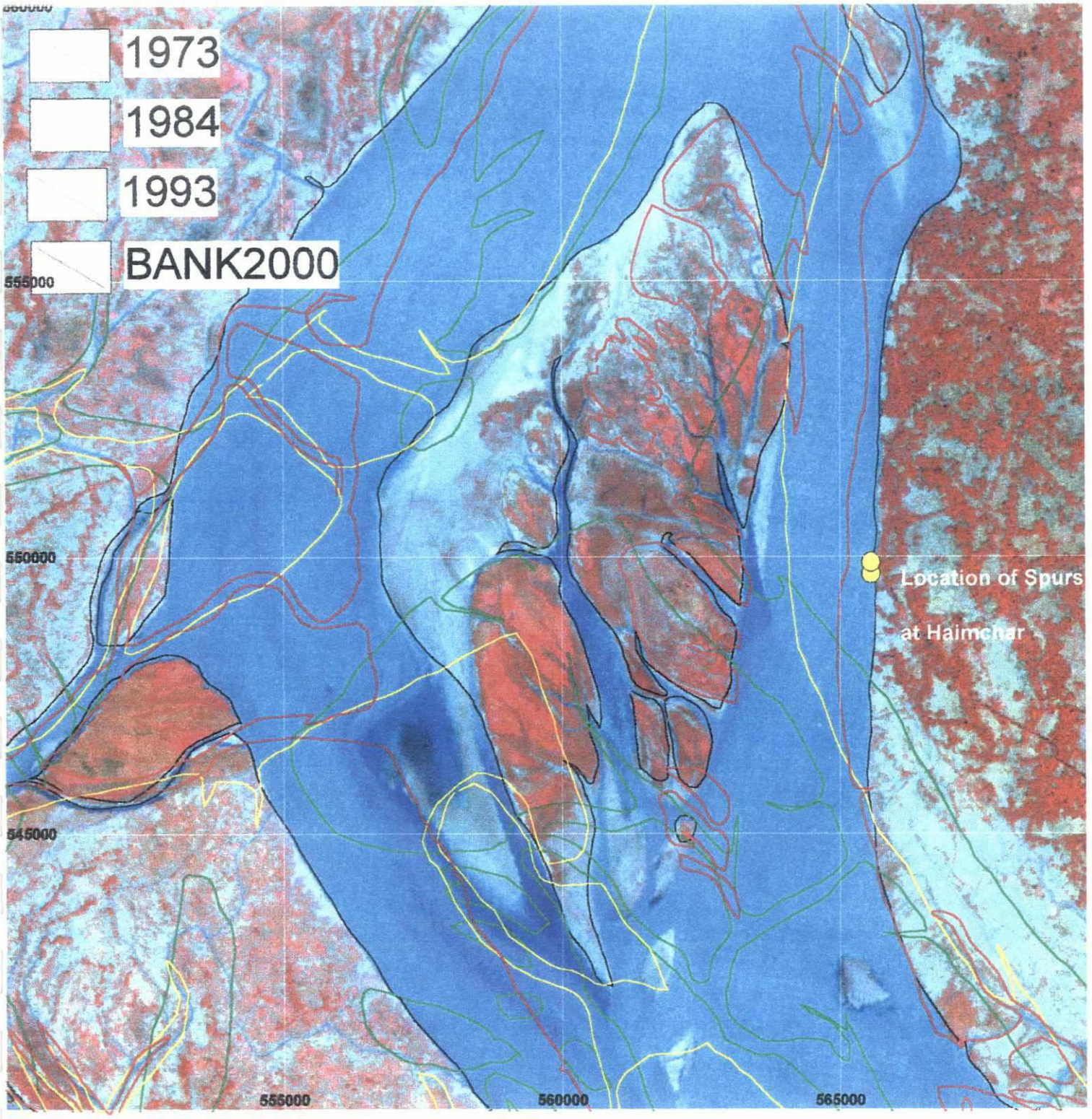


Figure A2: Bankline changes in different years at Haimchar

Figure A 3. **Bathymetry at Haim Char 2000**

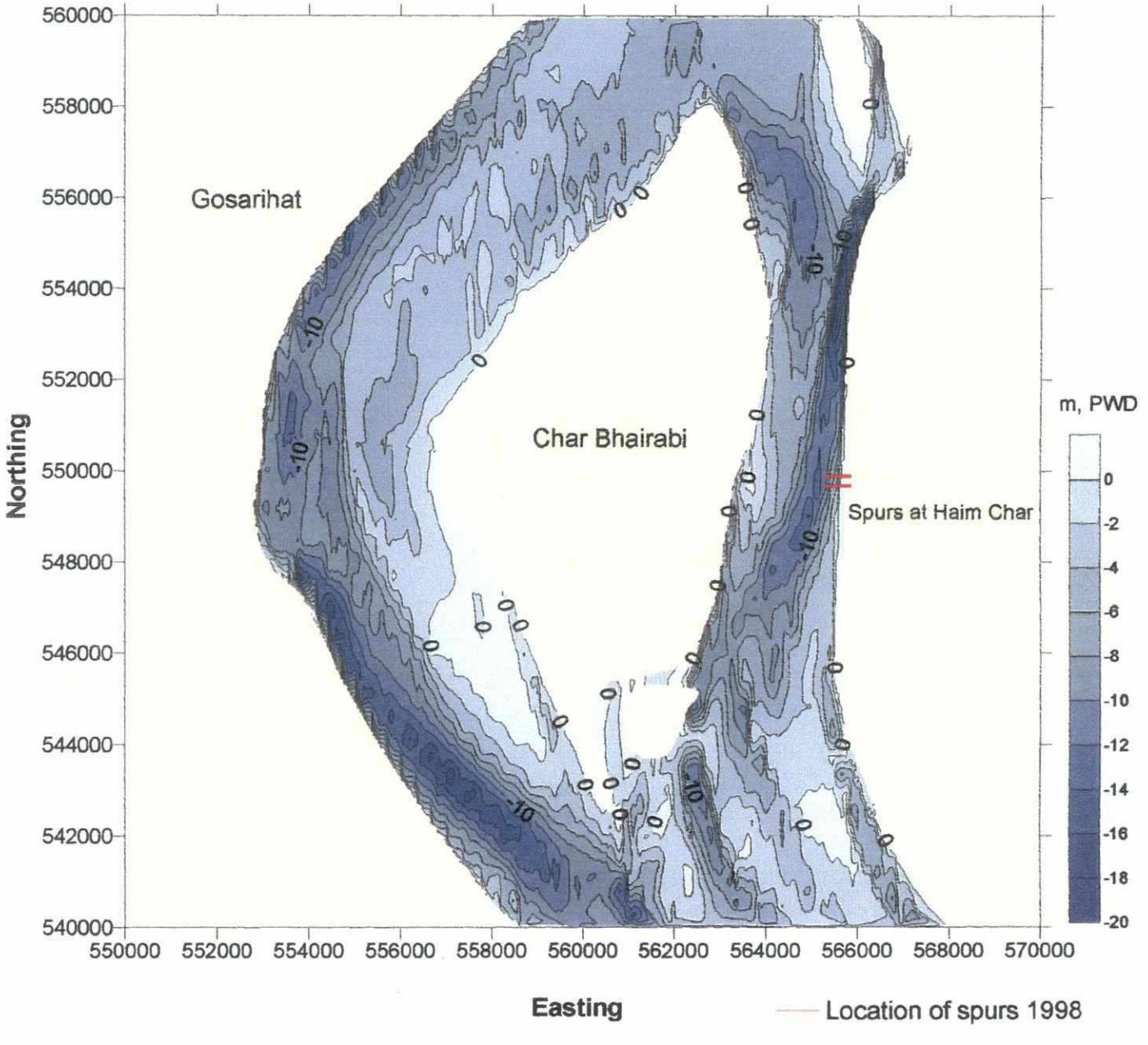
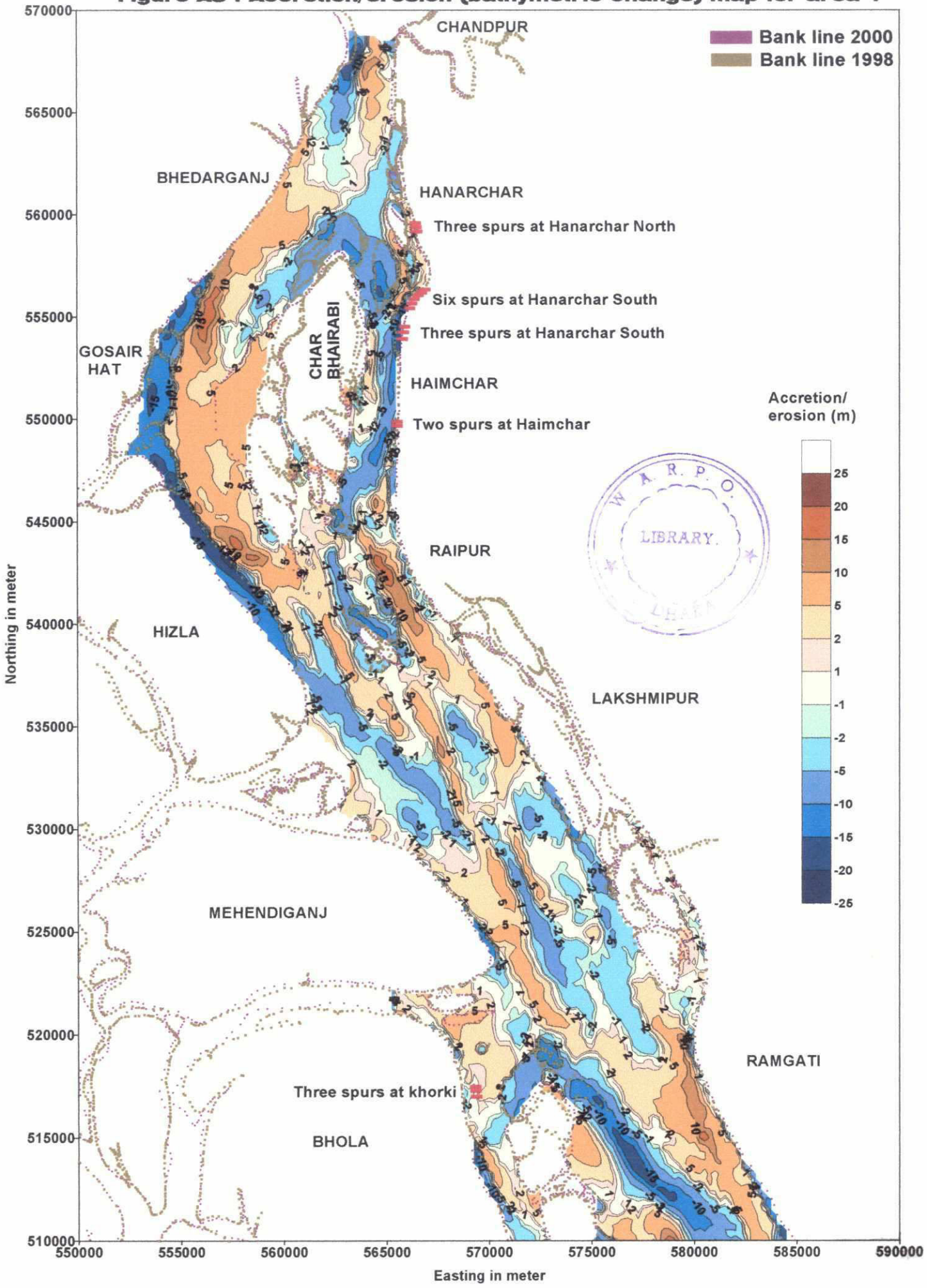


Figure A5 : Accretion/erosion (bathymetric change) map for area 1



Realised Erosion Protection at Haim Char

(scale 1:2000)

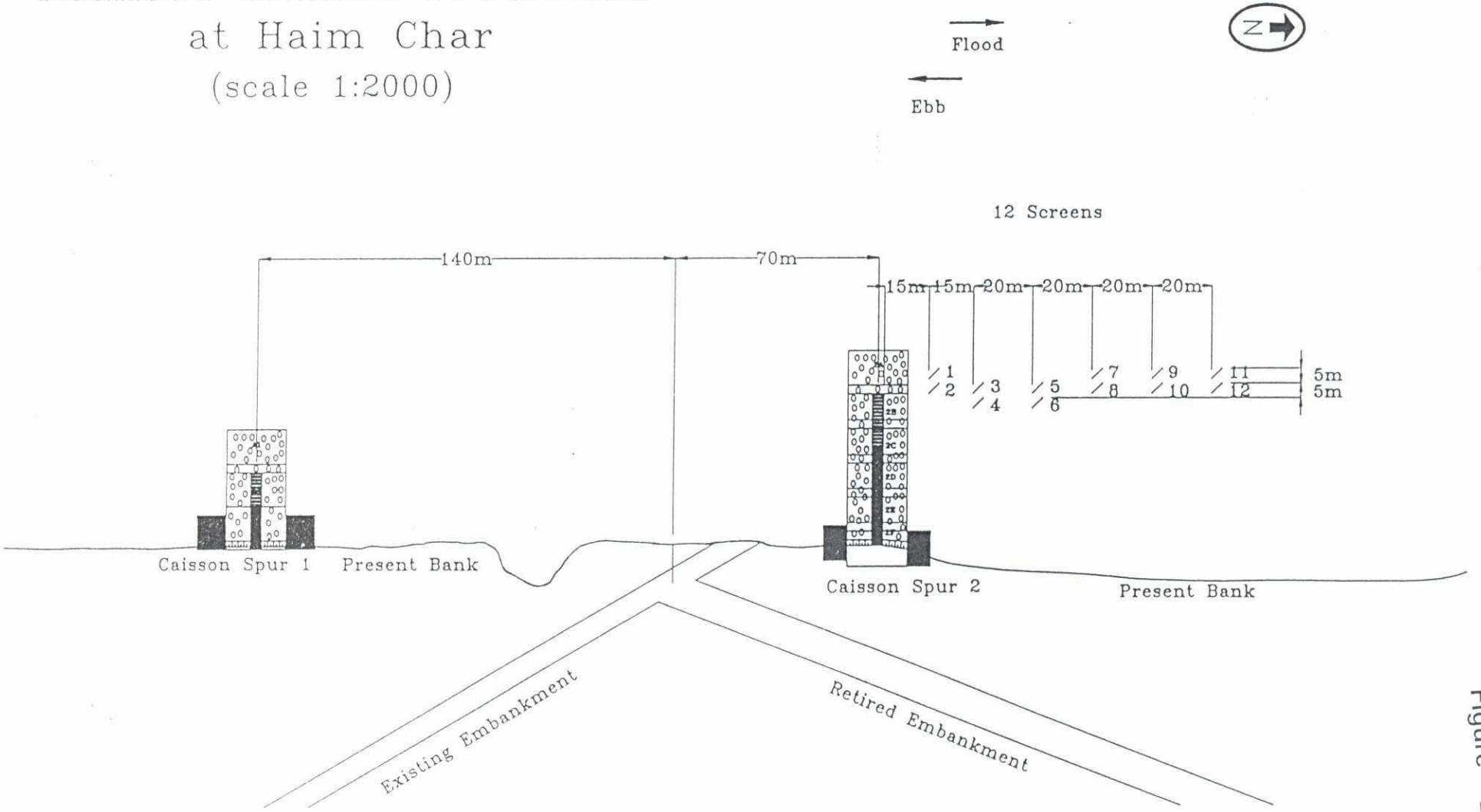


Figure - 2

Outline Khorki Bank Protection Pilot Scheme

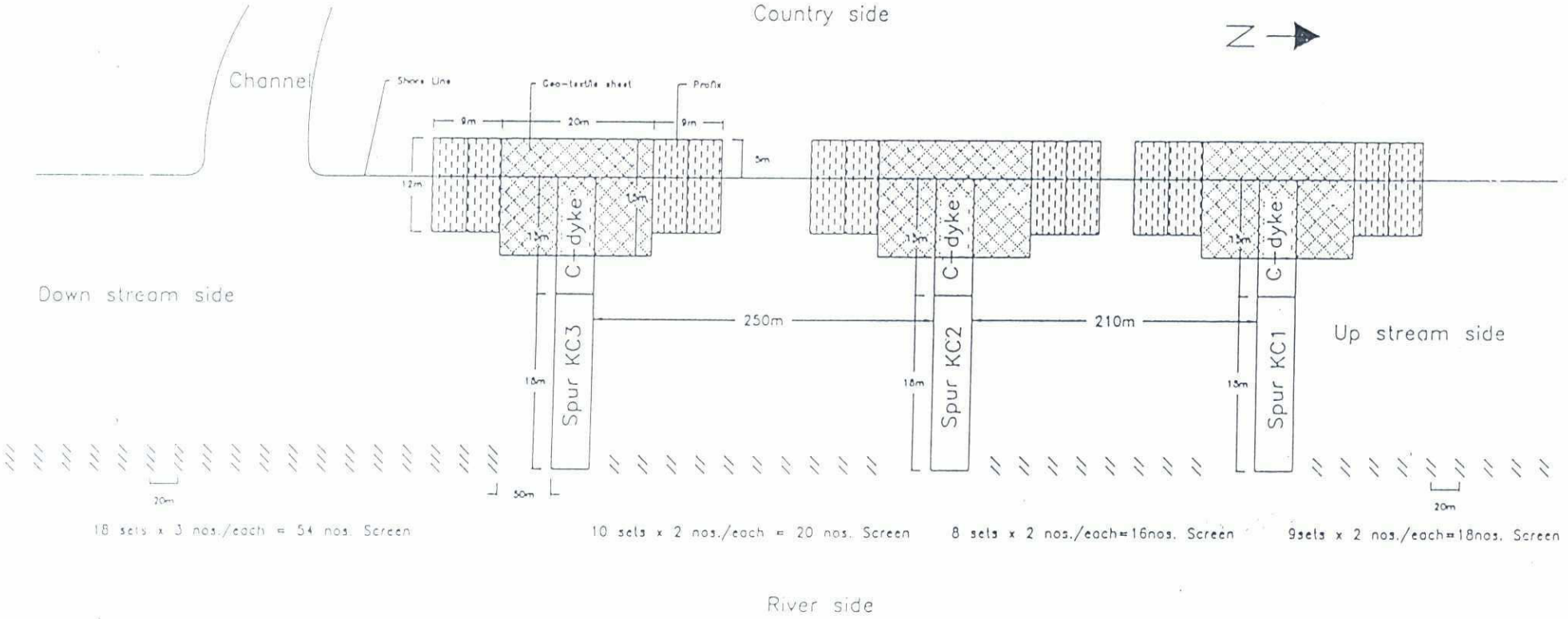


Figure - 2.1

Realised Erosion Protection at Haim Char, Caisson Spur 1

(schaal 1:500)

SECTION	PART OF CAISSON SPUR	LxB (M)
1A	GEOTEXTILE MATTRESS	15 x 20
1B	CAISSON	12 x 4
1B	GEOTEXTILE MATTRESS	15 x 20
1C	GUNNY BAG DAM	15 x 4
1C	GEOTEXTILE MATTRESS	15 x 20
1D	PROFIX	12 x 4

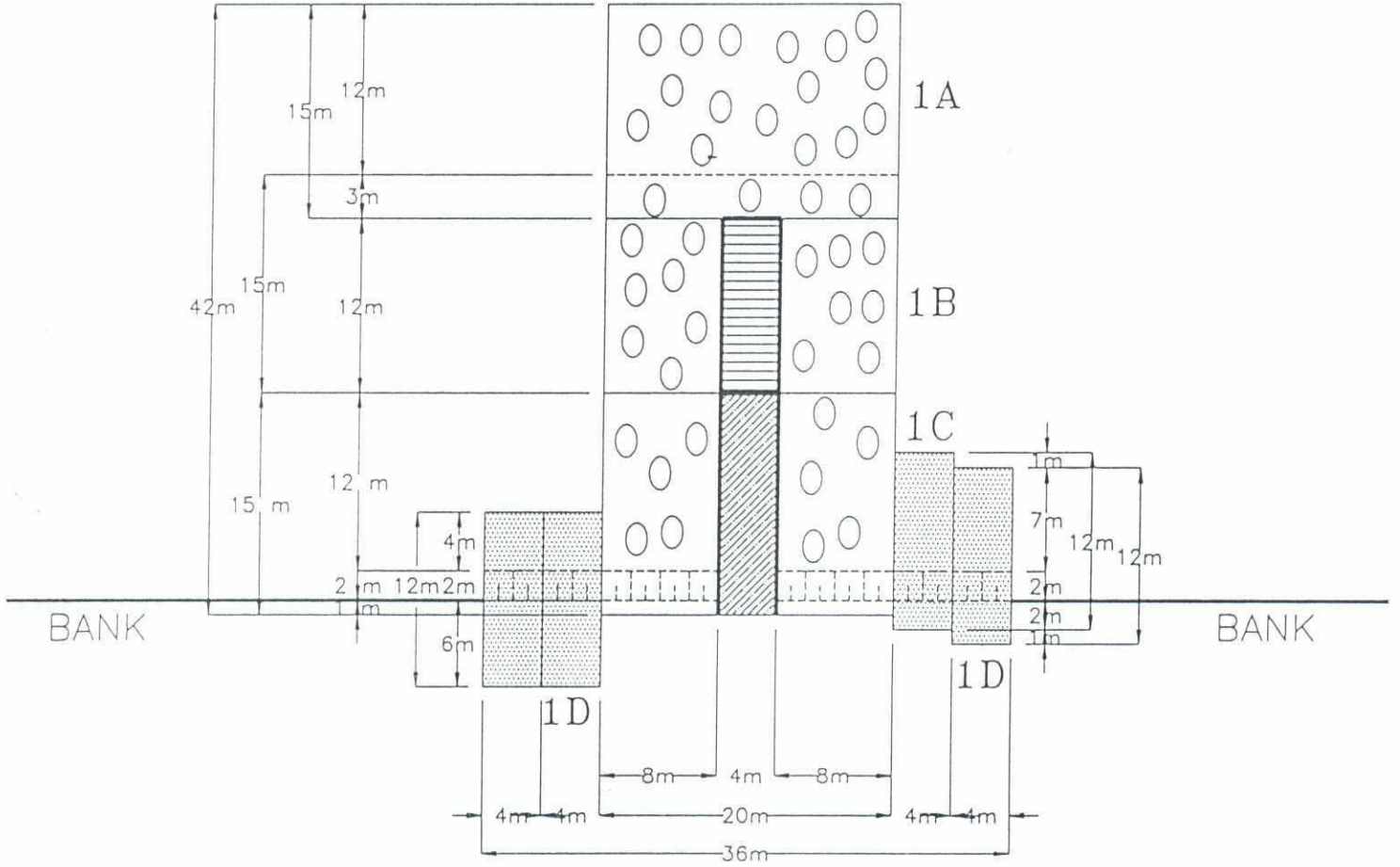
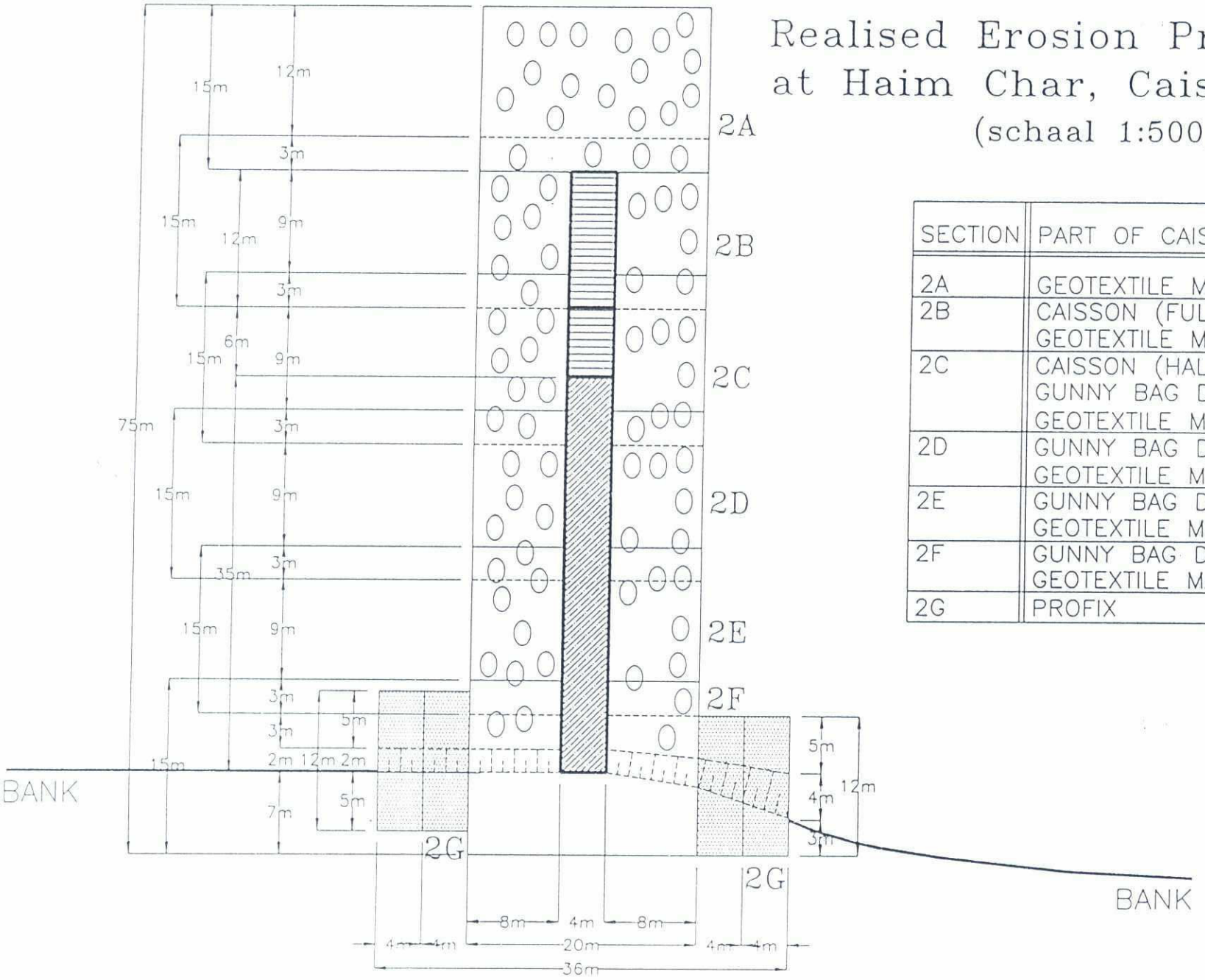


Figure - 3

Realised Erosion Protection at Haim Char, Caisson Spur 2

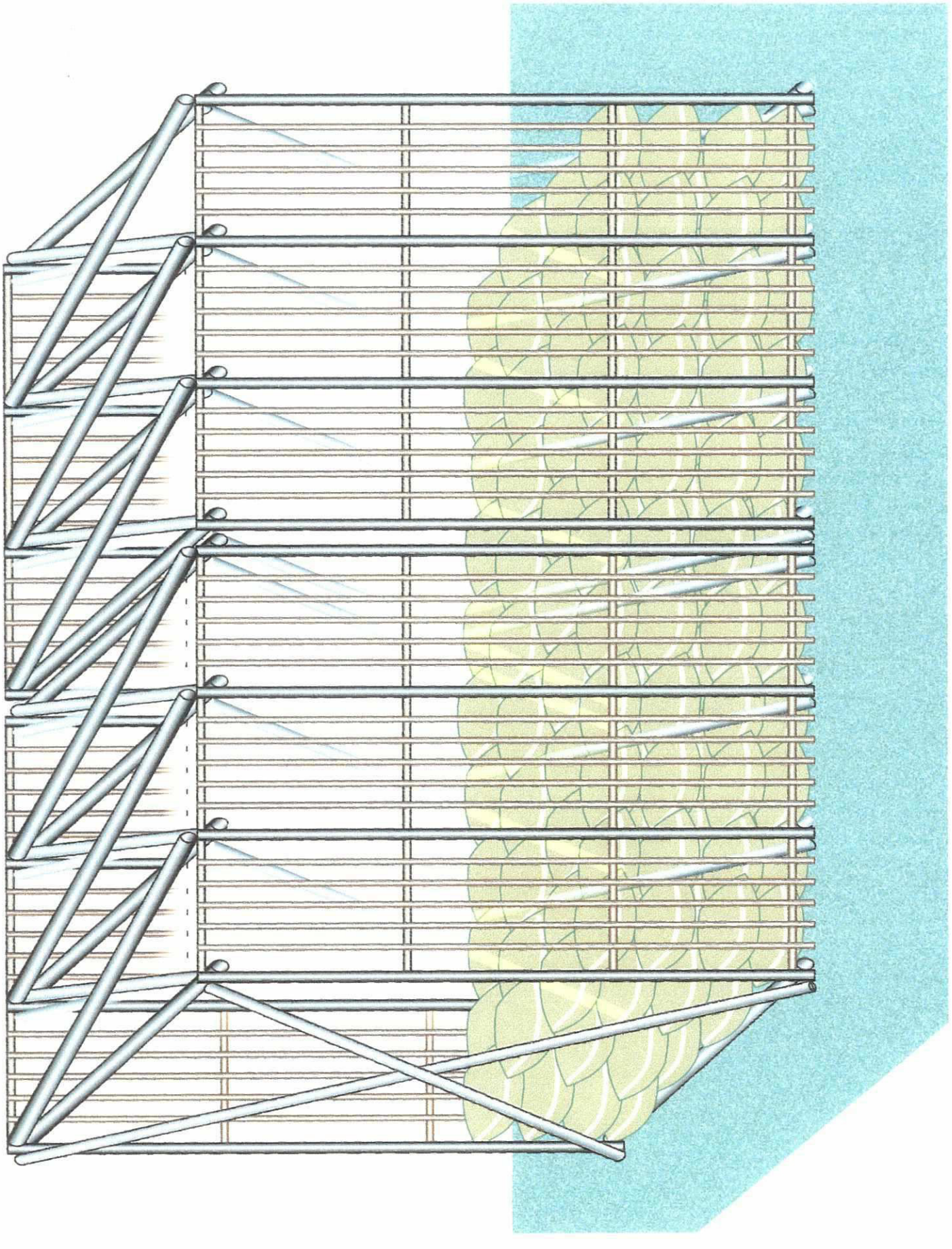
(schaal 1:500)



SECTION	PART OF CAISSON SPUR	LxB (M)
2A	GEOTEXTILE MATTRESS	15 x 20
2B	CAISSON (FULL)	12 x 4
	GEOTEXTILE MATTRESS	15 x 20
2C	CAISSON (HALF)	6 x 4
	GUNNY BAG DAM (1)	6 x 4
	GEOTEXTILE MATTRESS	15 x 20
2D	GUNNY BAG DAM (2)	12 x 4
	GEOTEXTILE MATTRESS	15 x 4
2E	GUNNY BAG DAM (3)	12 x 4
	GEOTEXTILE MATTRESS	15 x 20
2F	GUNNY BAG DAM (4)	5 x 4
	GEOTEXTILE MATTRESS	15 x 20
2G	PROFIX	12 x4

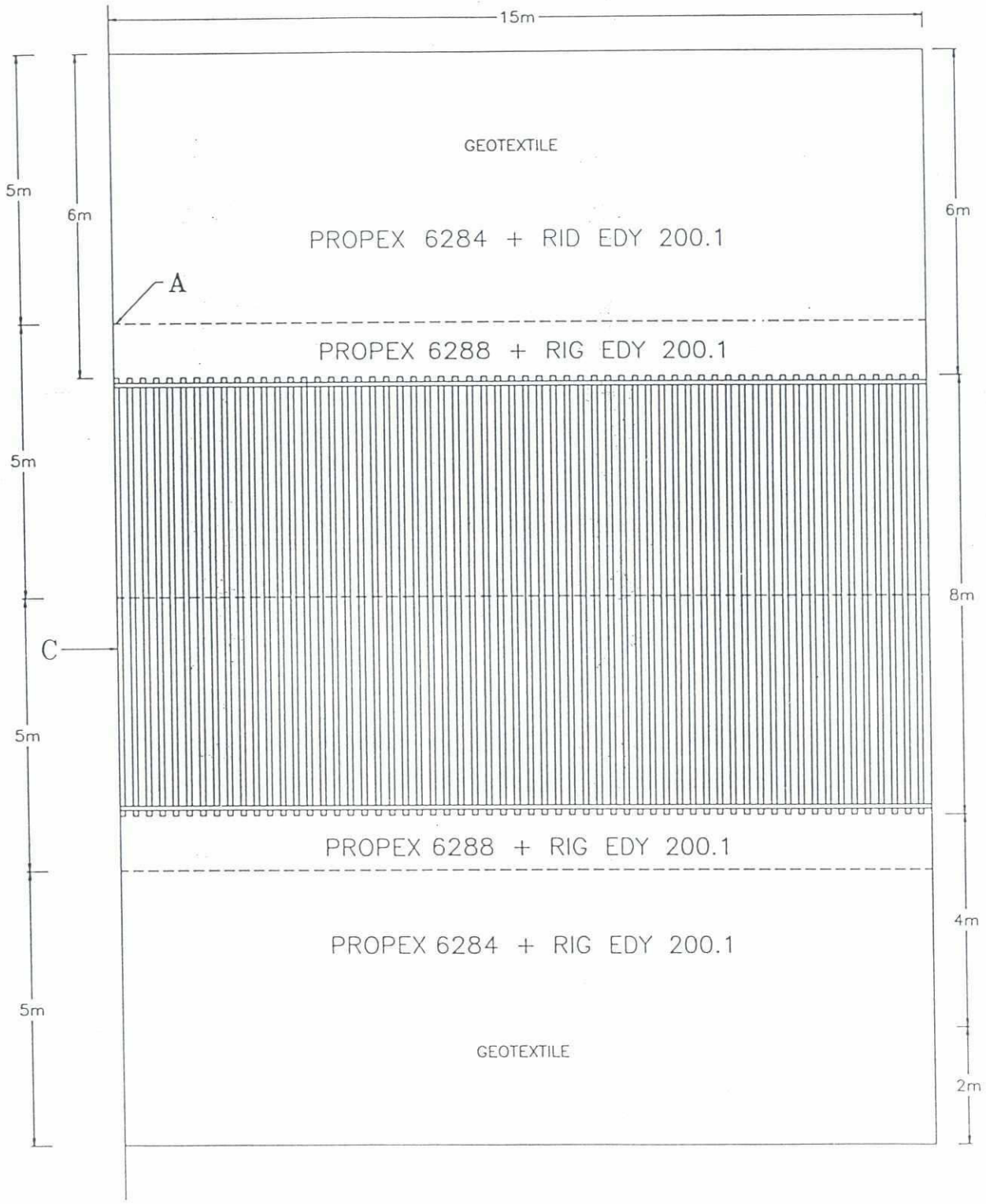
Figure - 4

Figure - 5



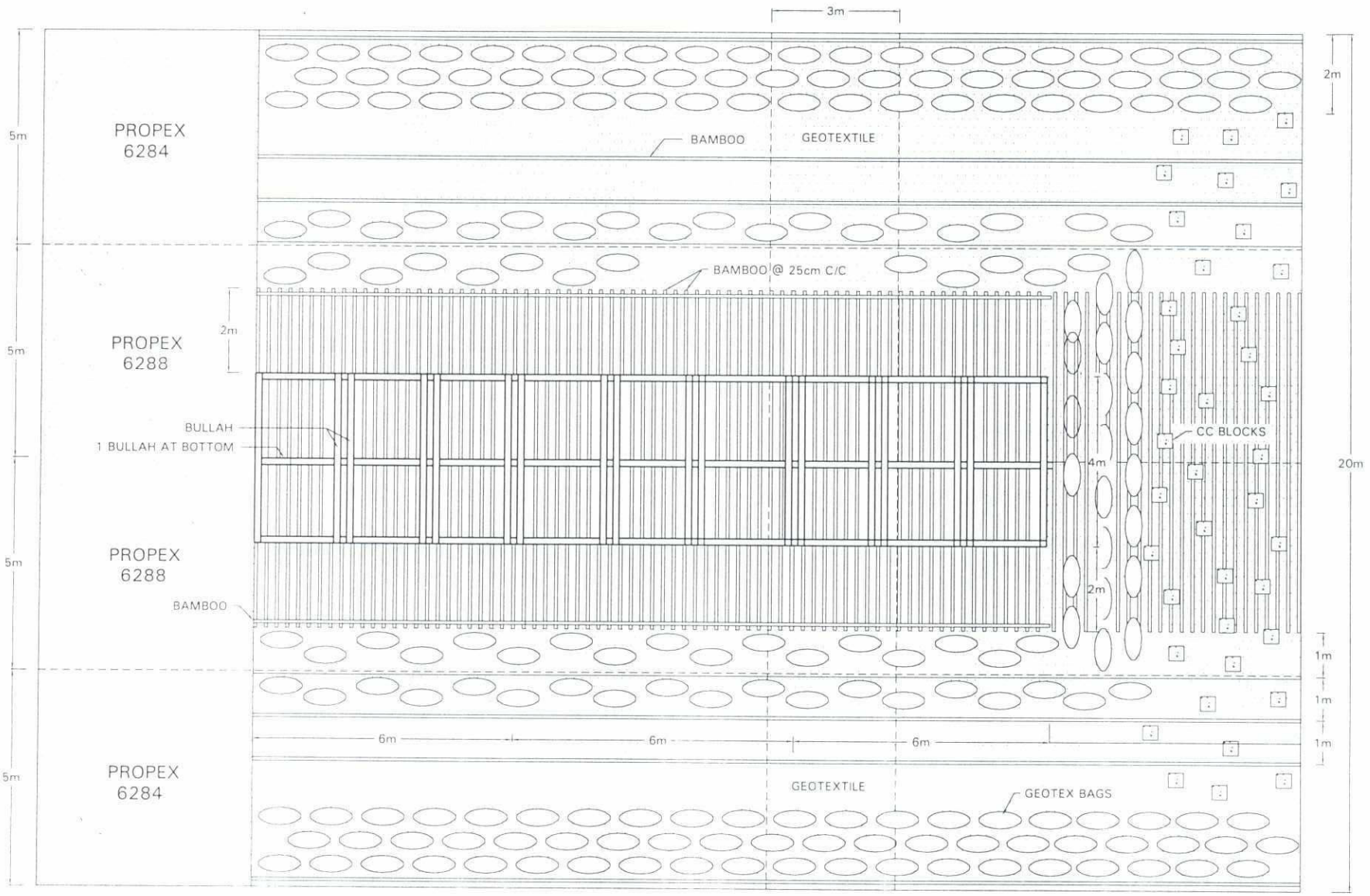
Spur Caisson. Fig - 5.

Figure - 5.1



Layout of geotextile foundation

File D:\Peter\Report\Spur2.dwg

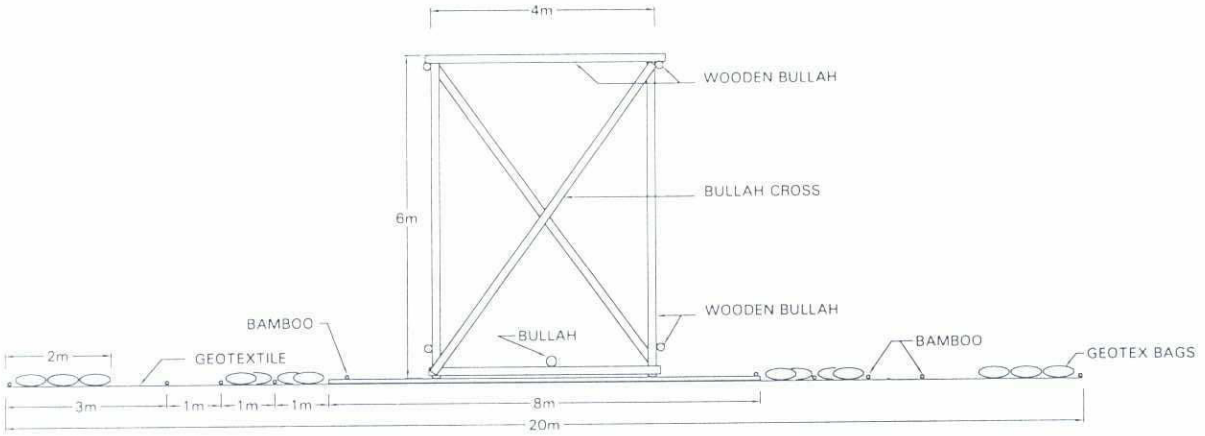


TYPICAL PLAN

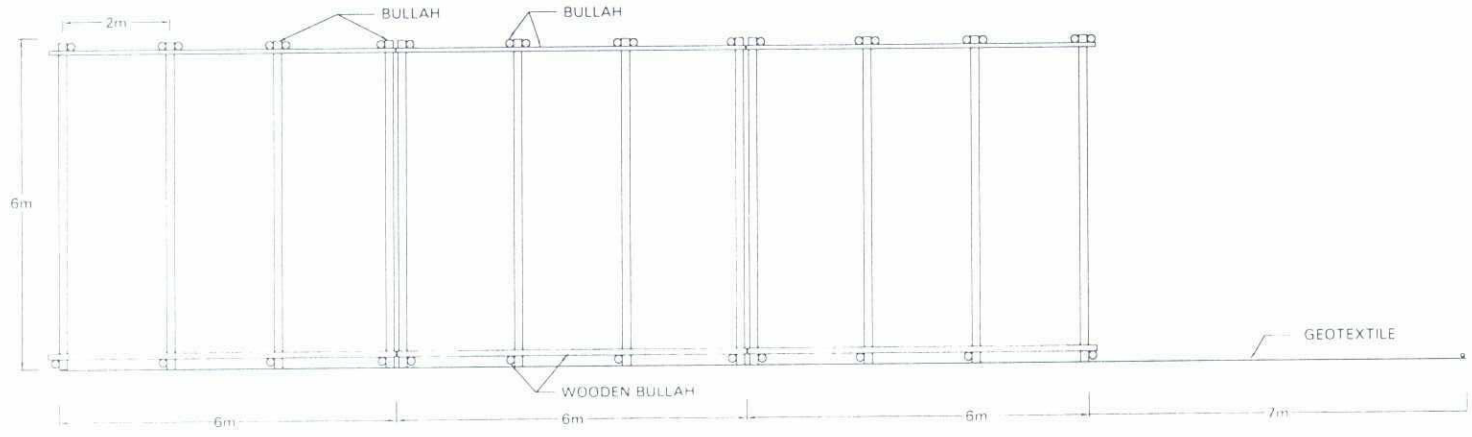
Topview of Bamboo Caisson

Figure - 5.2

DRAWING OF CAISSON

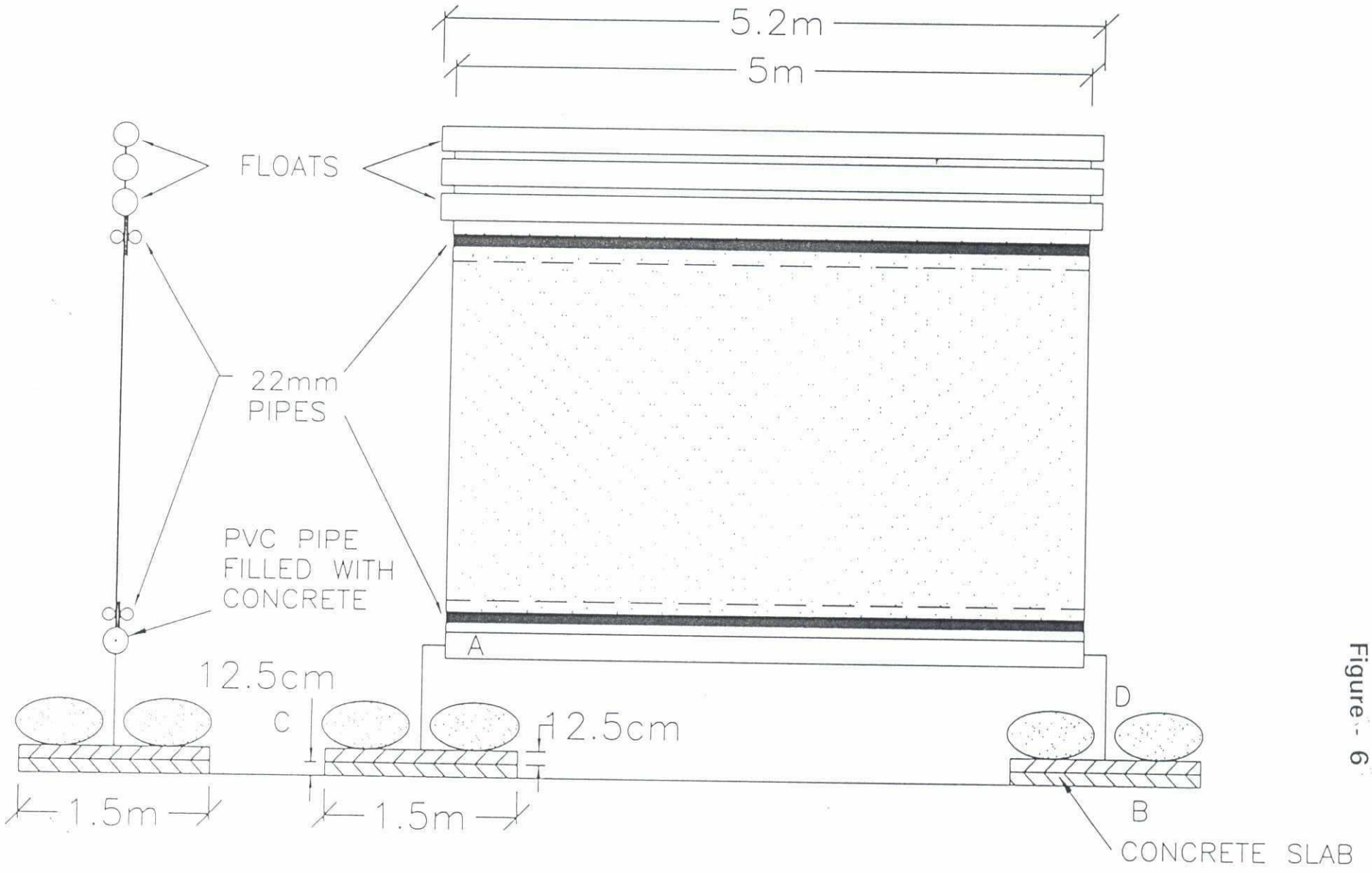


CROSS SECTION



SIDE VIEW

Figure - 5.3



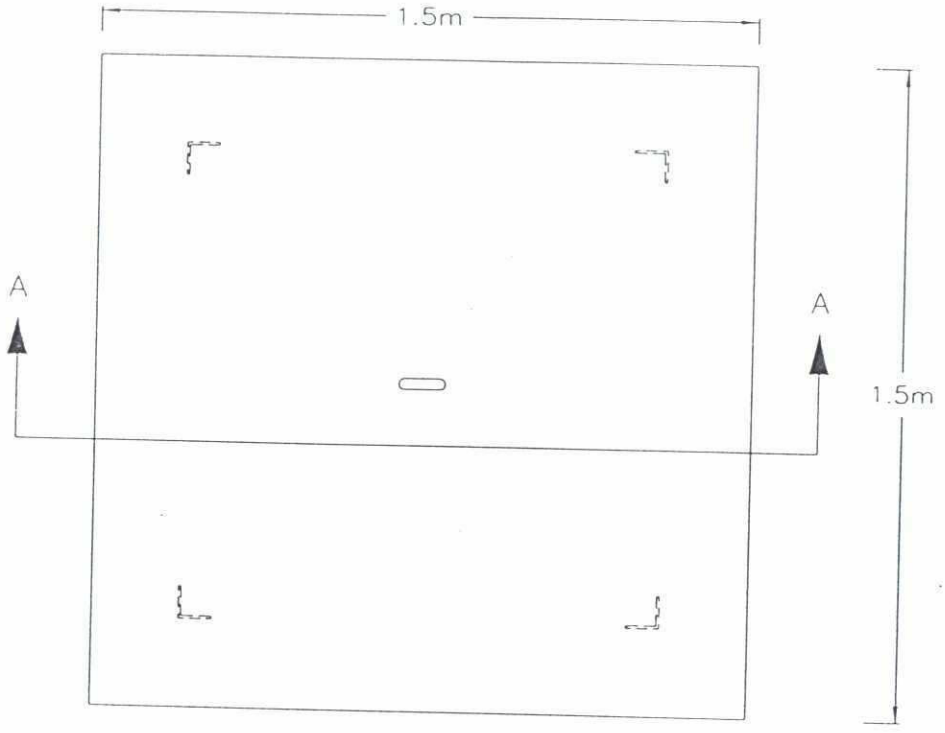
Assembling geo-textile screen

Figure:- 6

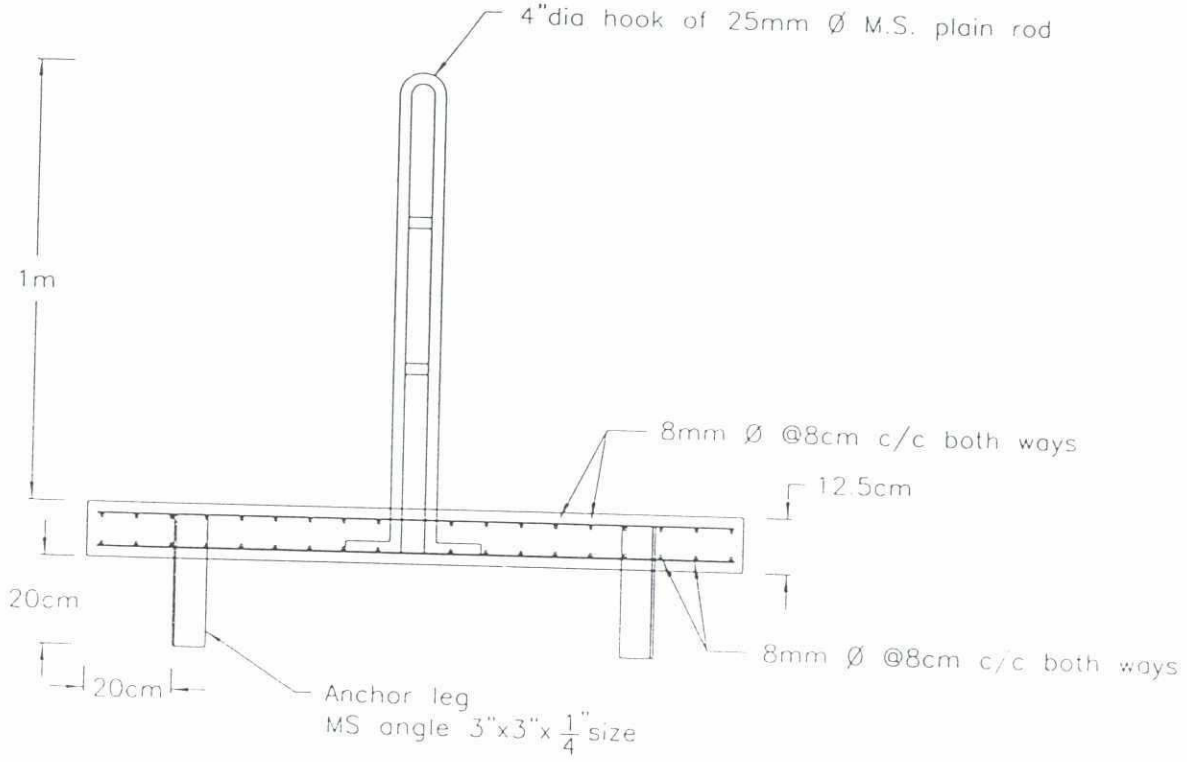
[GIS-01]d:\teamlead\42bp2jun.dwg

DESIGN OF ANCHOR BLOCKS

Figure - 7



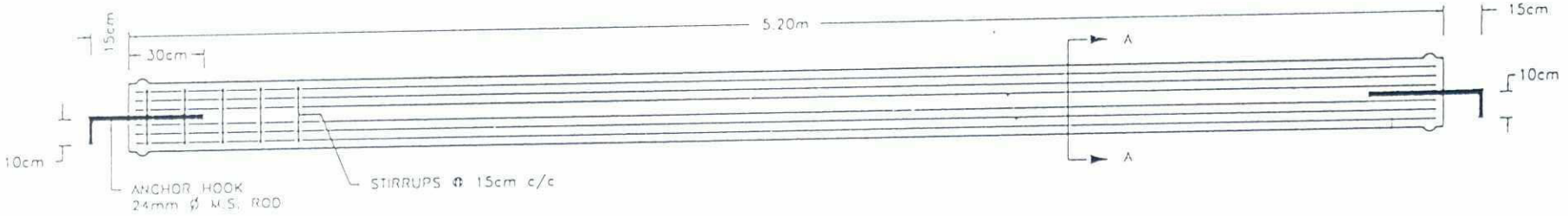
PLAN

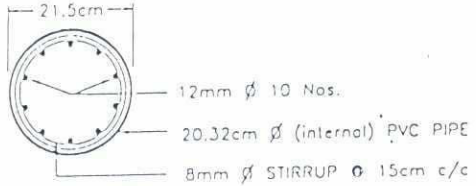


SECTION A–A

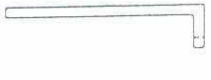
FILE (GISOT): D:\CML\A-BLOCK3.dwg

DRAWING OF R.C.C BEAM

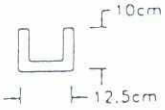




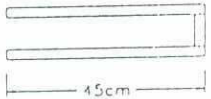
SECTION A–A



FRONT SIDE VIEW



END SIDE VIEW



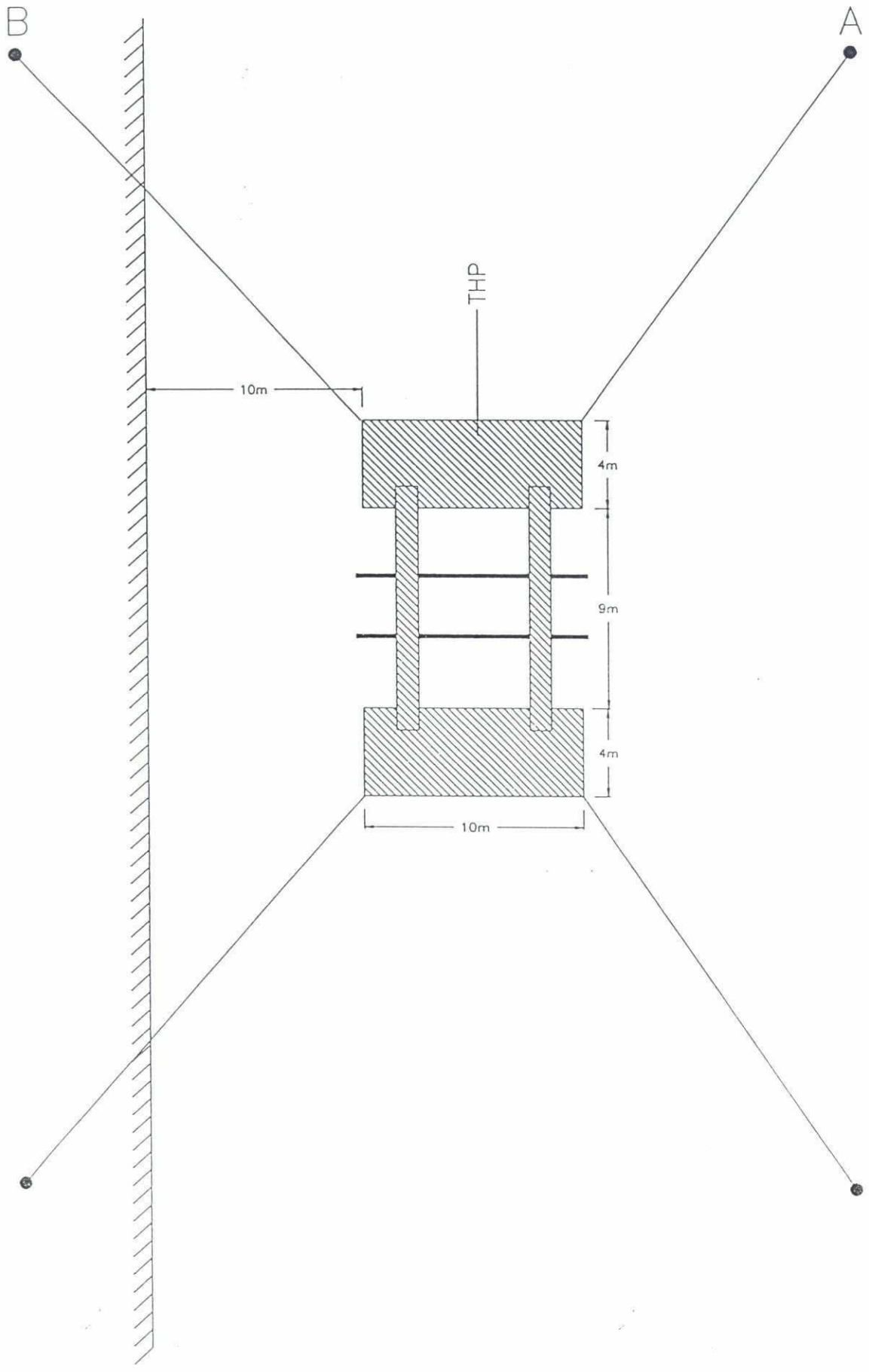
TOP VIEW

DETAIL OF ANCHOR HOOK

Figure : R.C.C BEAM

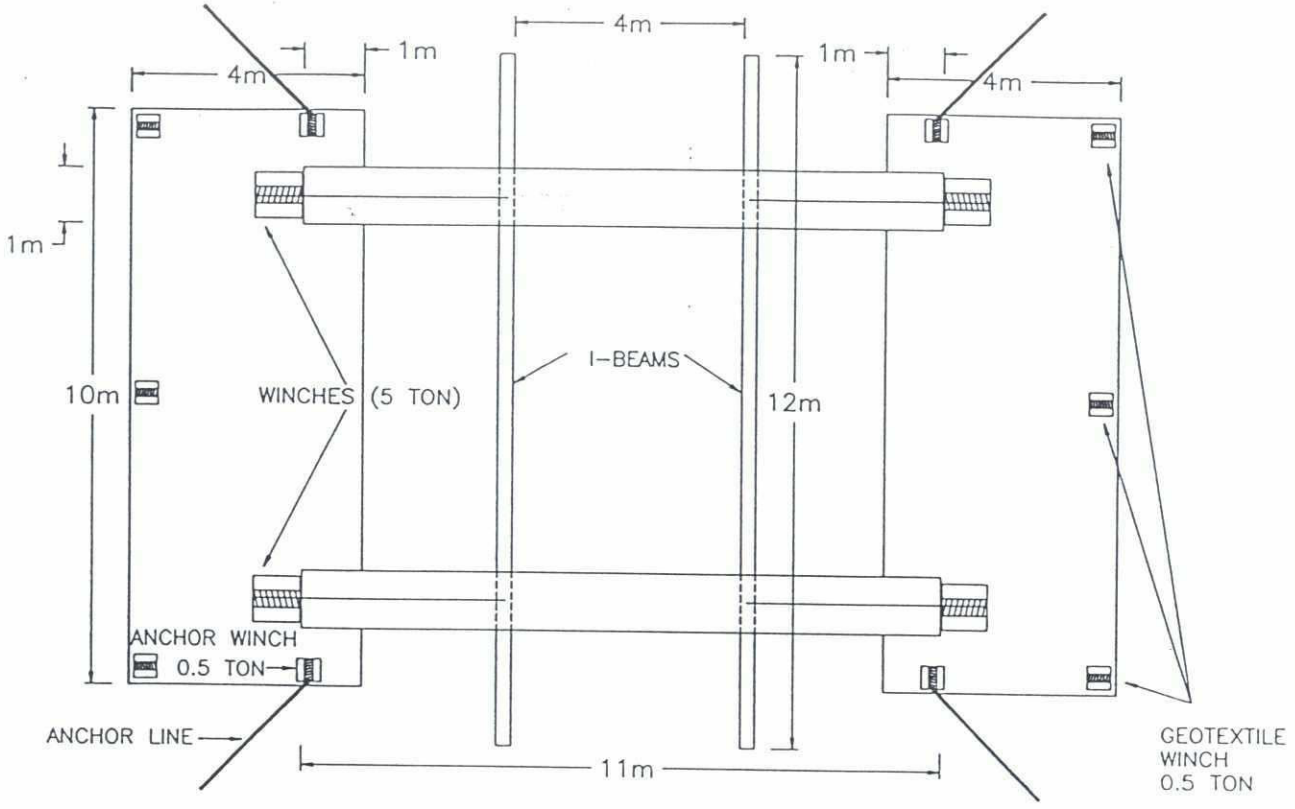
Figure - 8

Figure - 9

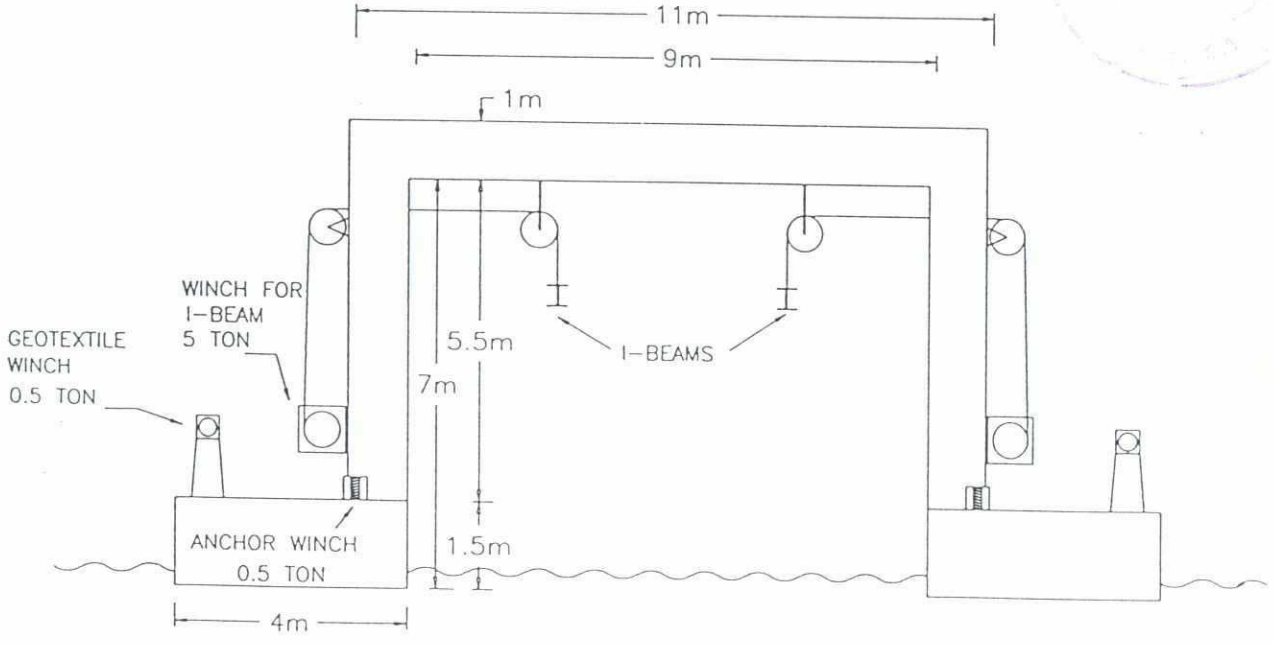


Positioning of THP

Figure - 9.1



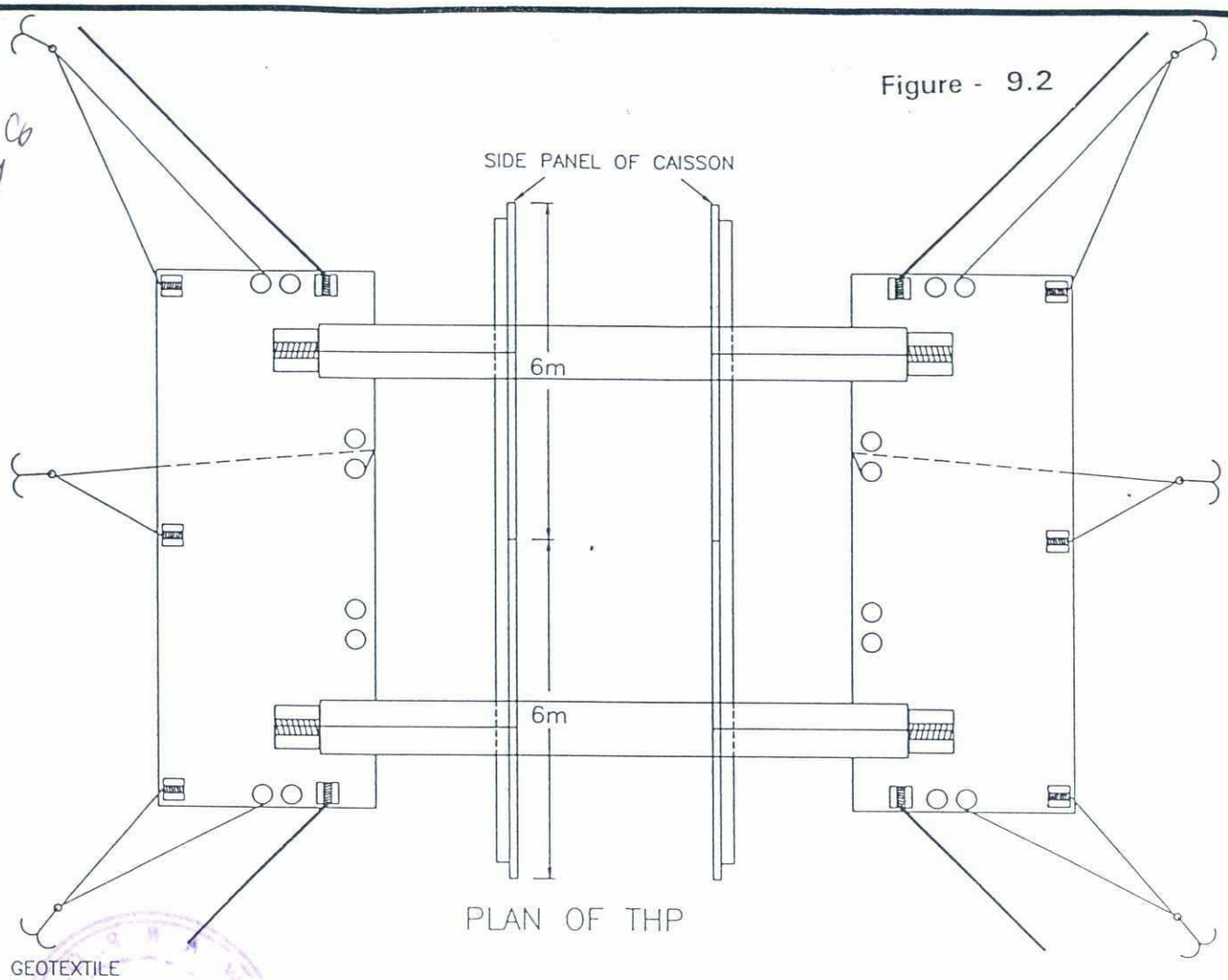
PLAN OF TWIN HULL PONTOON

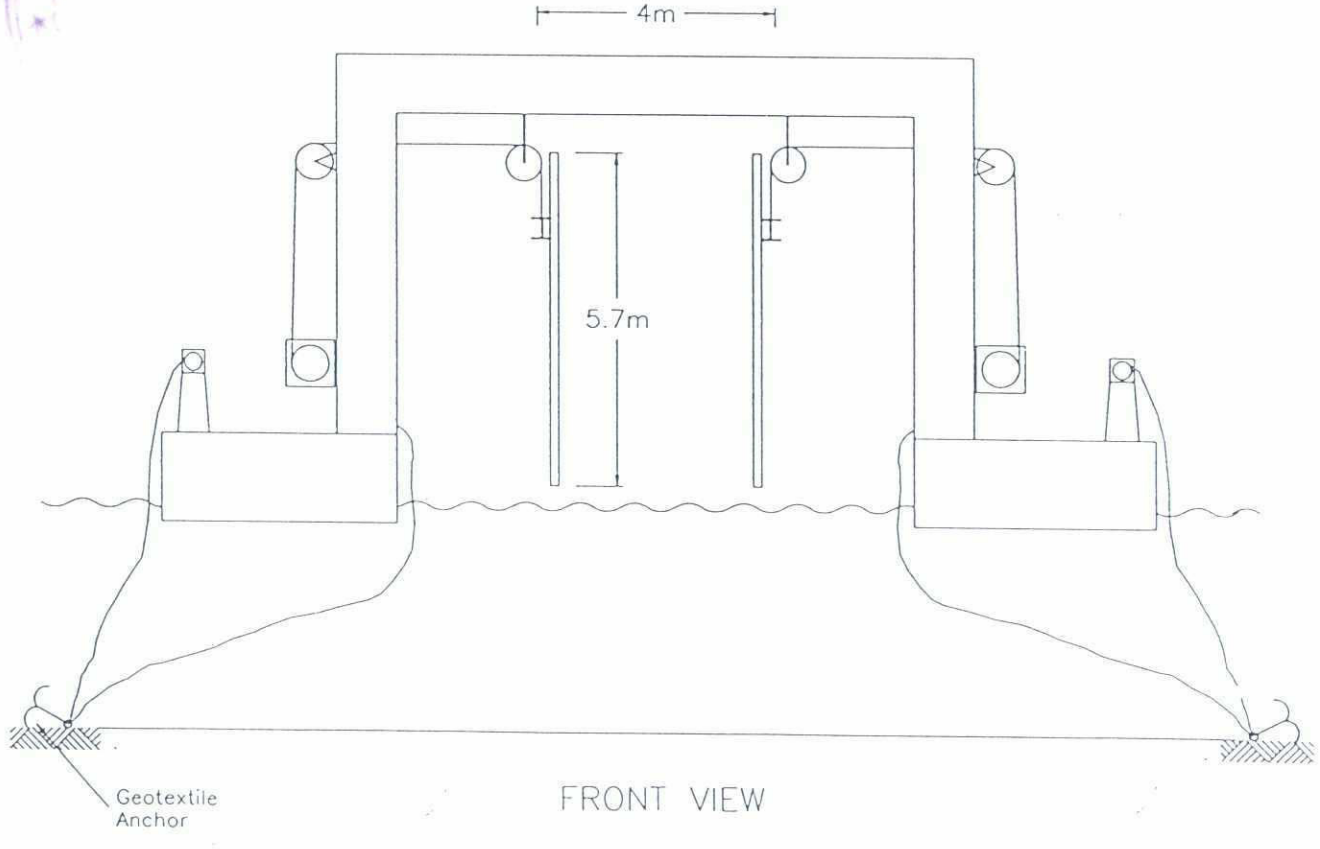


FRONT VIEW OF TWIN HULL PONTOON

Pontoon layout

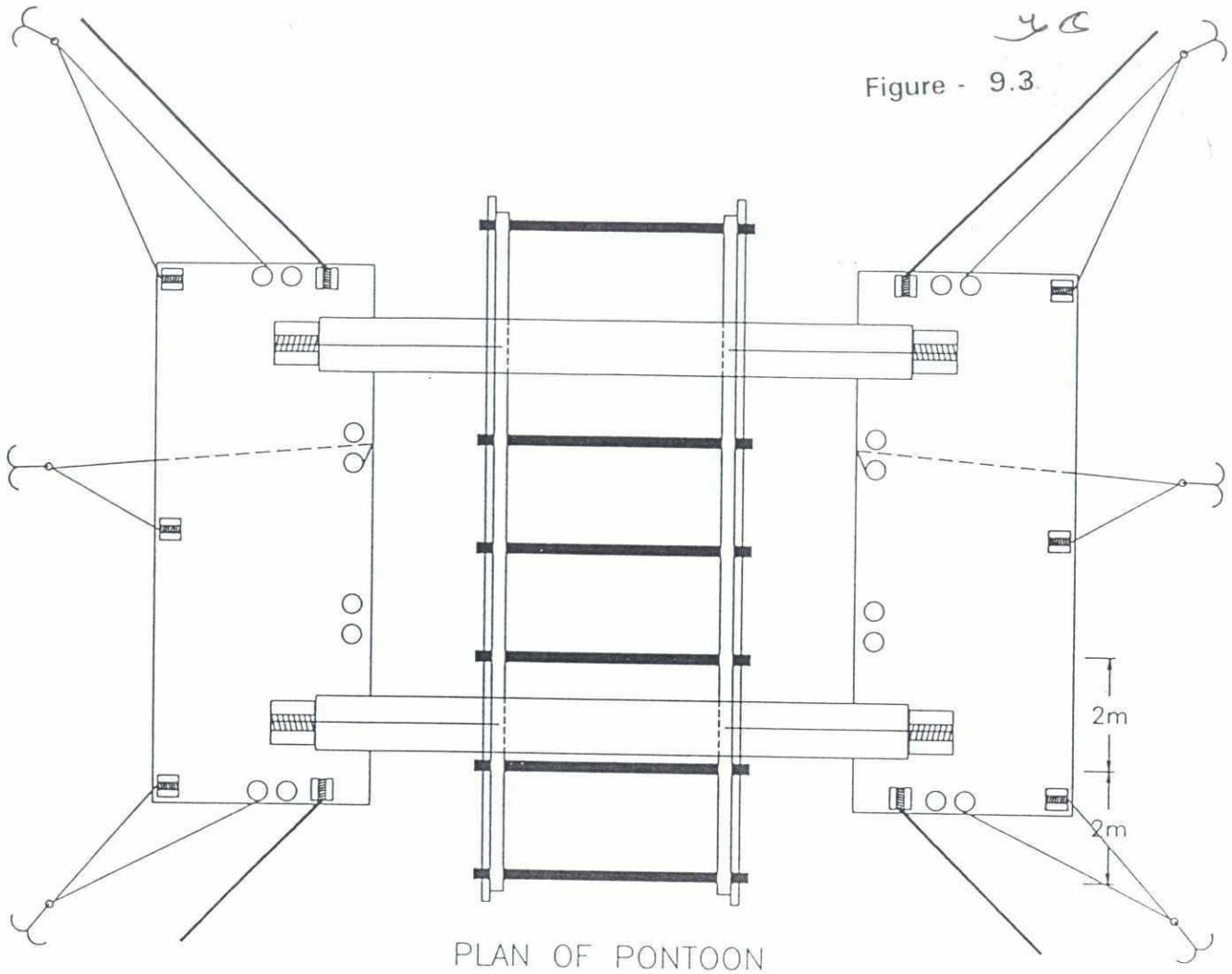
Figure - 9.2



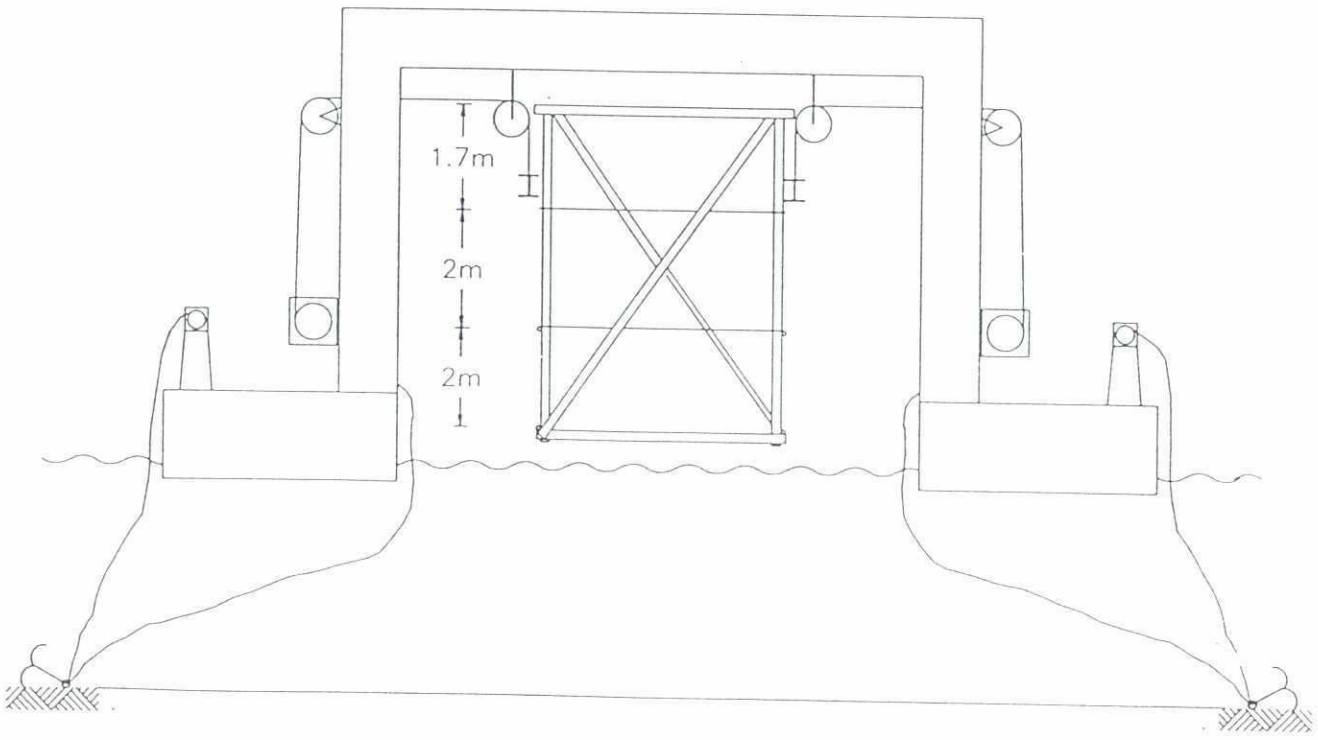


Lifting side panels of caisson
and installation of Geo-Textile anchors

Figure - 9.3



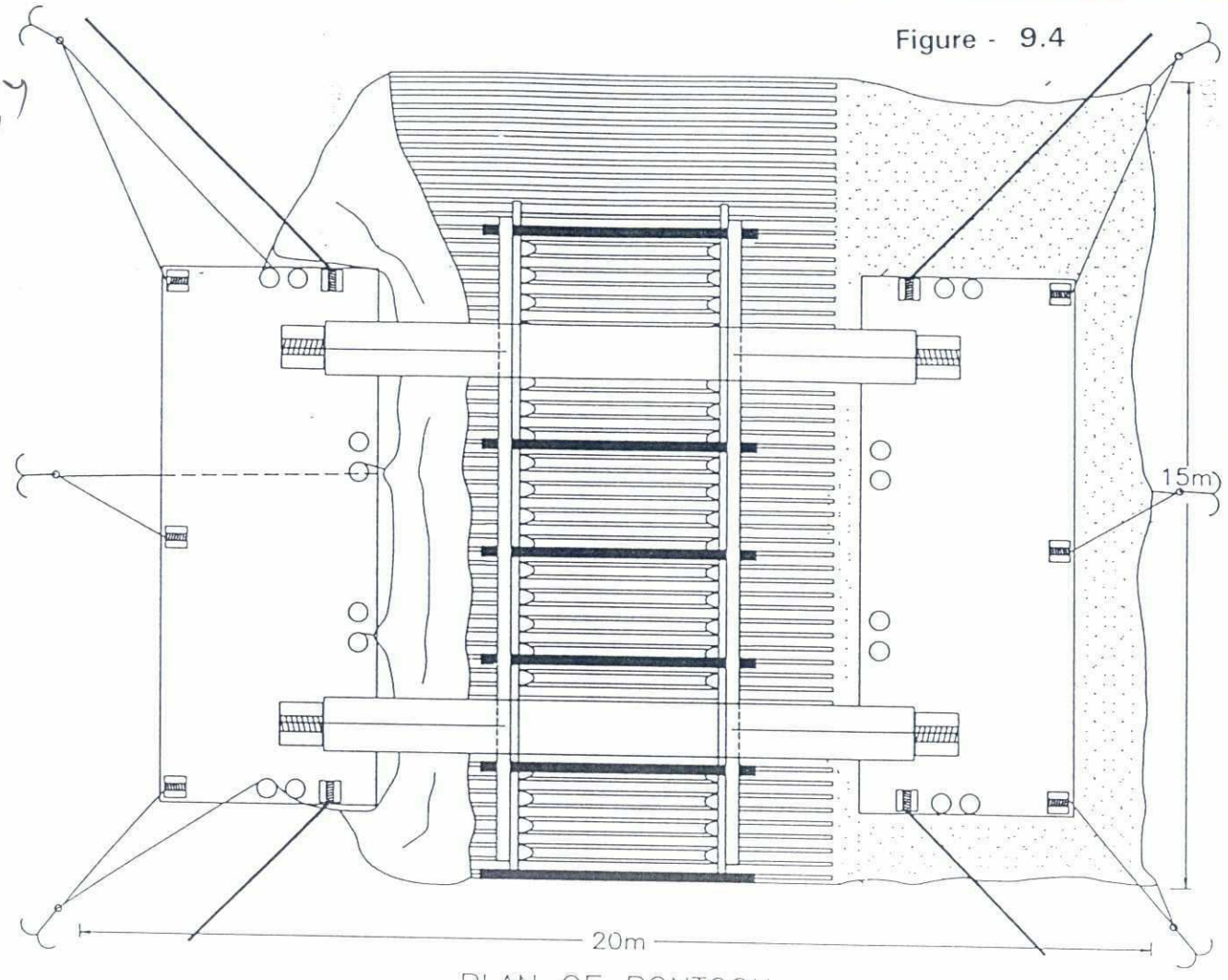
PLAN OF PONTOON



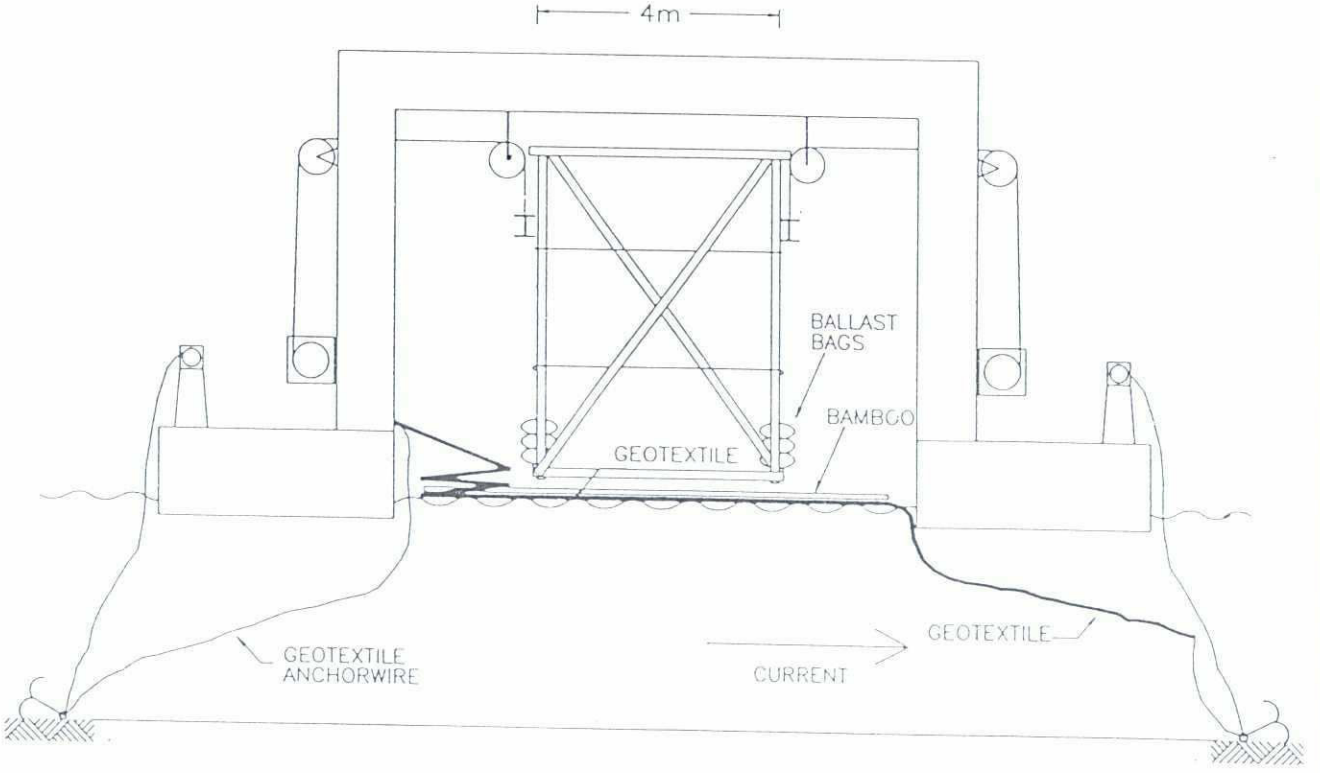
FRONT VIEW

Assembling caisson

Figure - 9.4



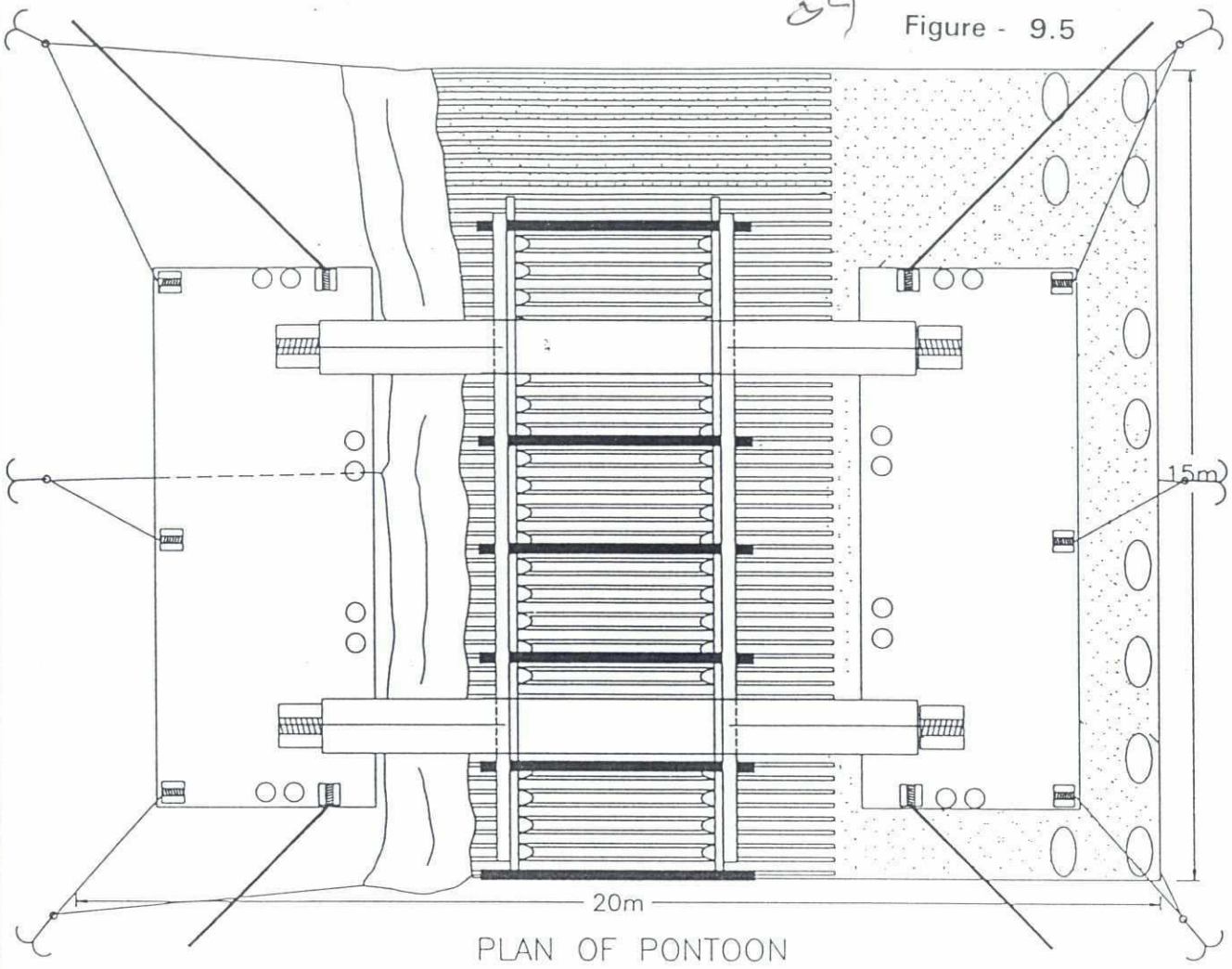
PLAN OF PONTOON



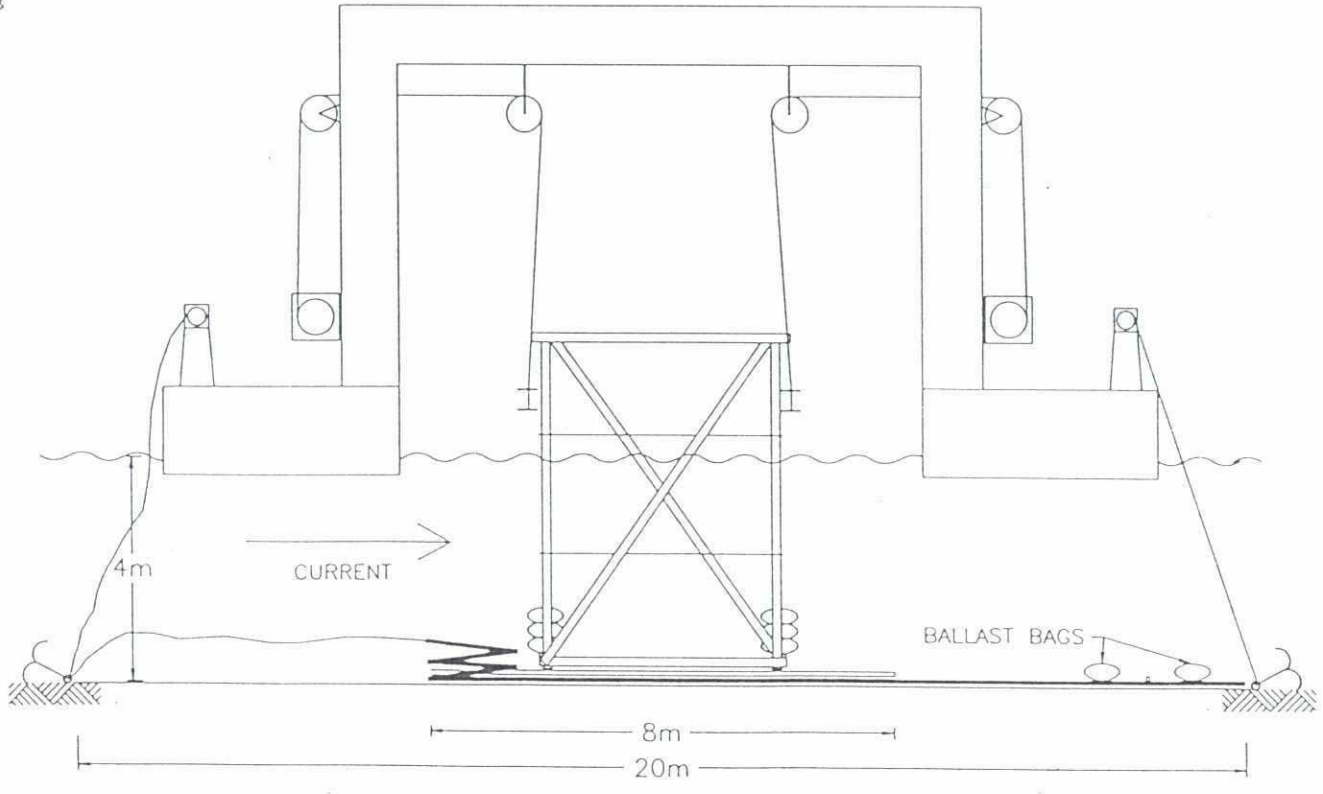
FRONT VIEW

Float geotextile inside THP

Figure - 9.5



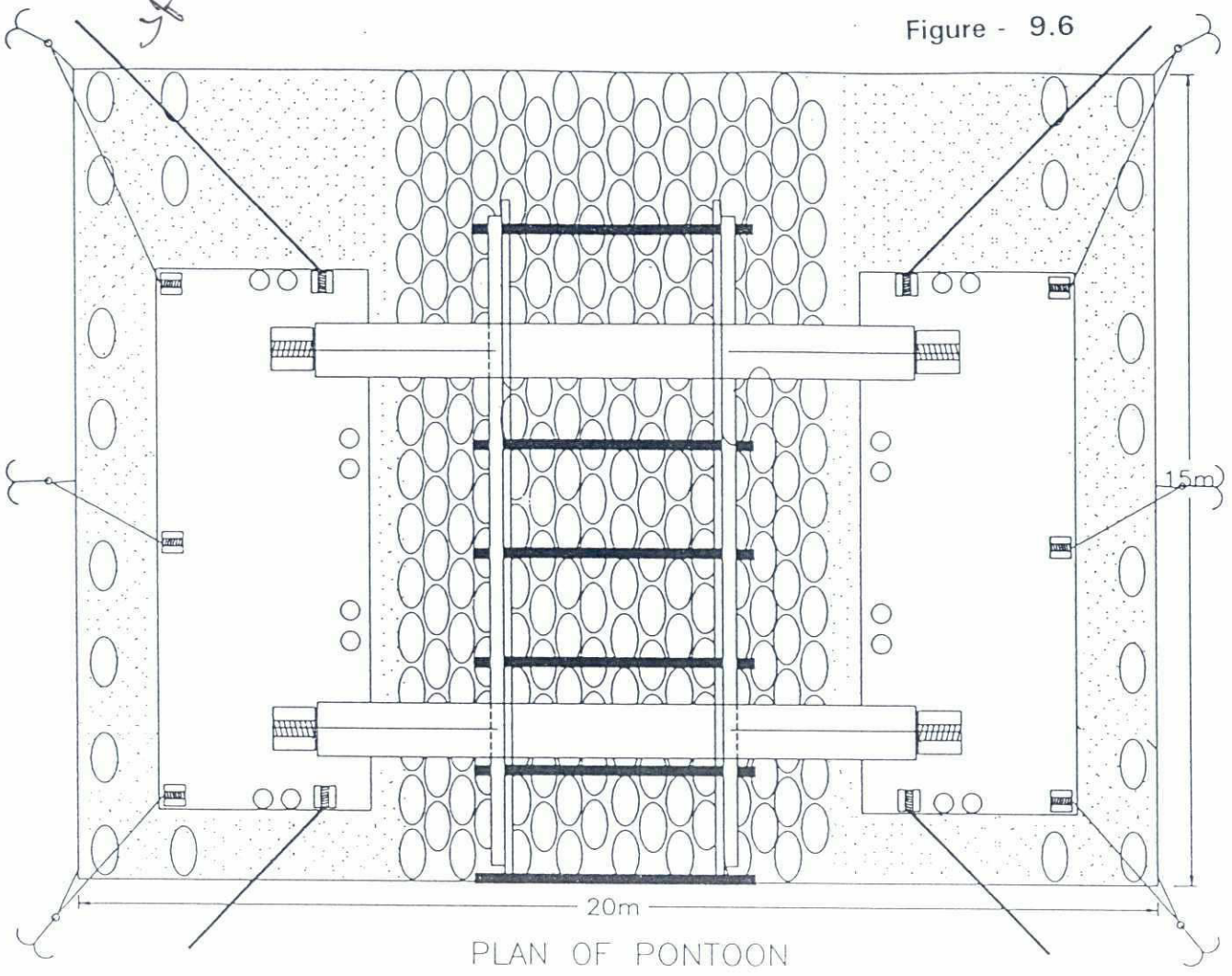
PLAN OF PONTOON



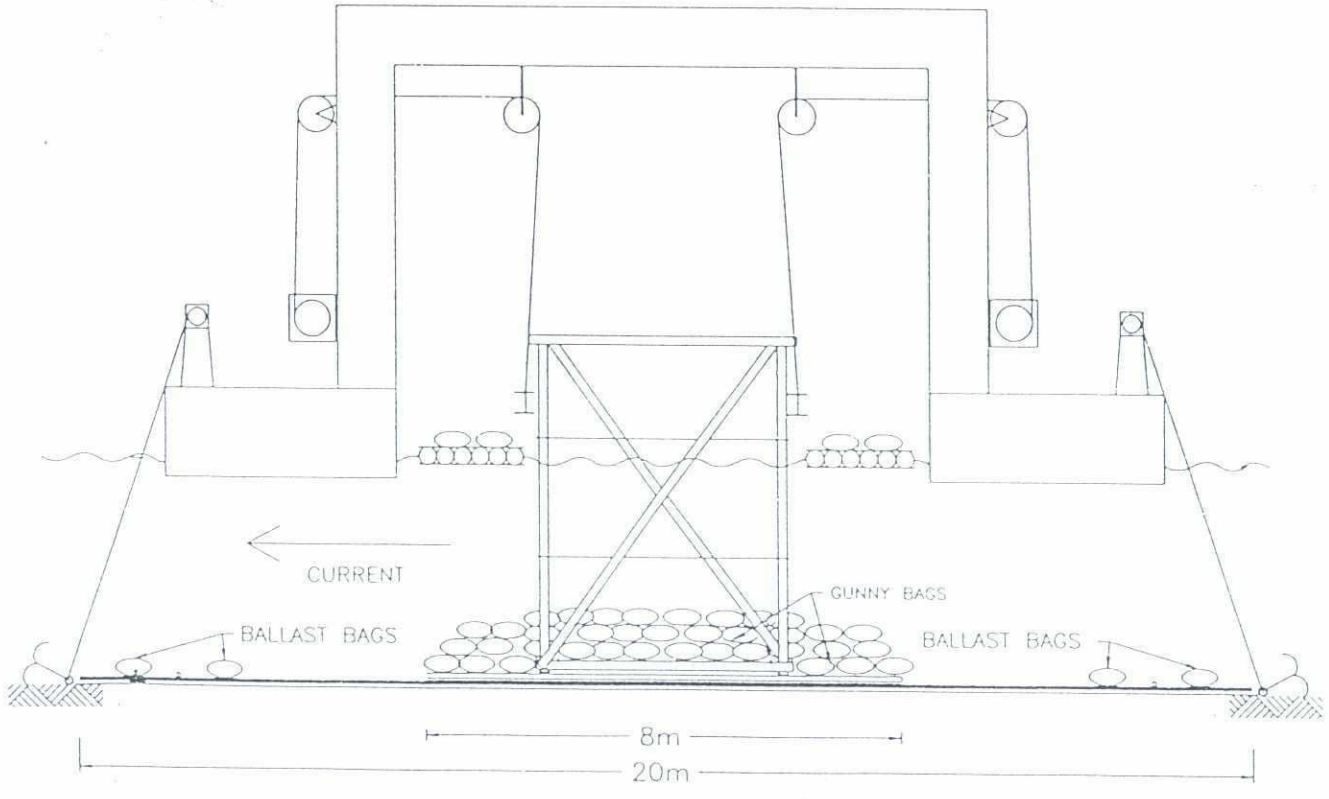
FRONT VIEW

Lowering caisson and positioning downstream end of Geo-Textile

Figure - 9.6



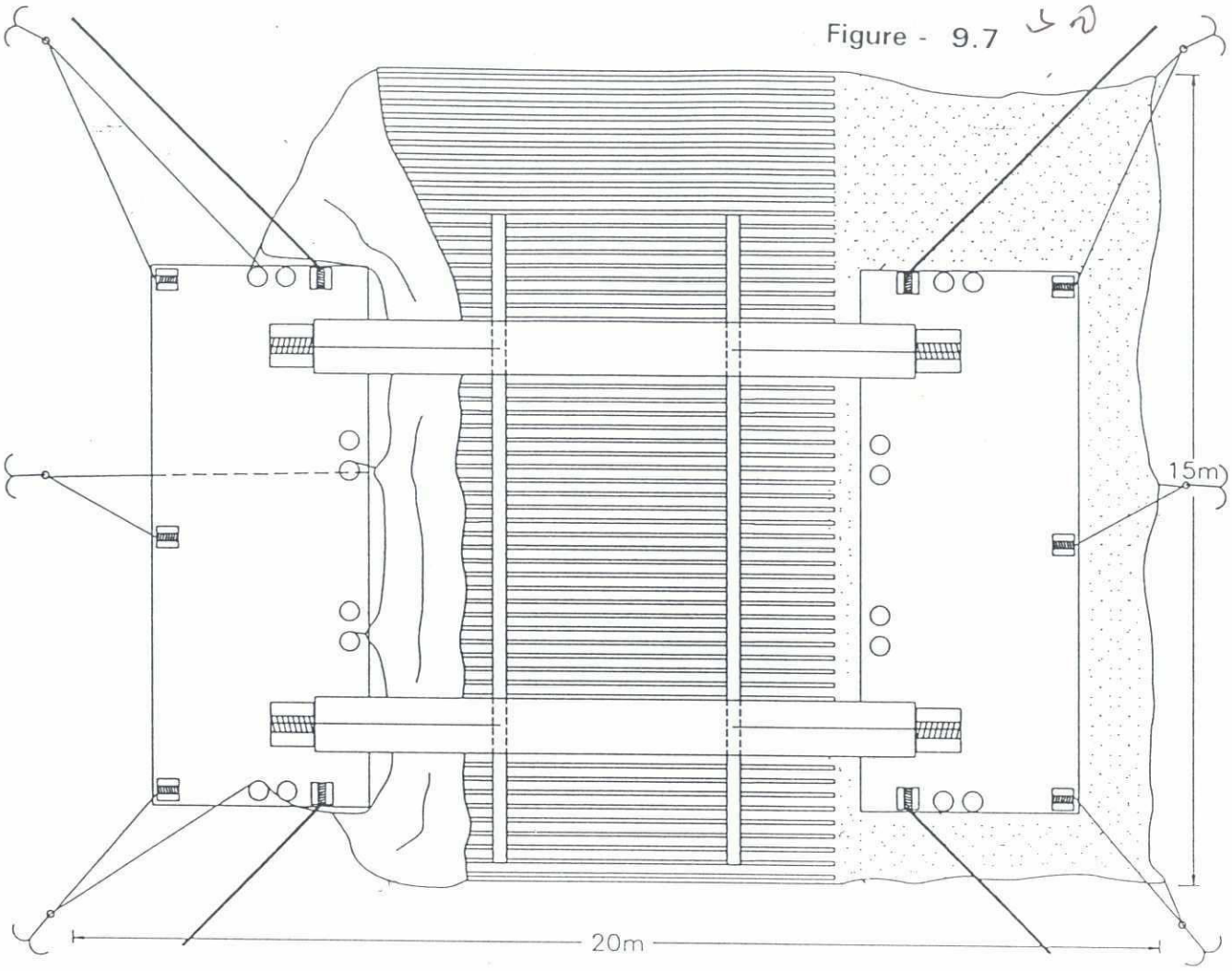
PLAN OF PONTOON



FRONT VIEW

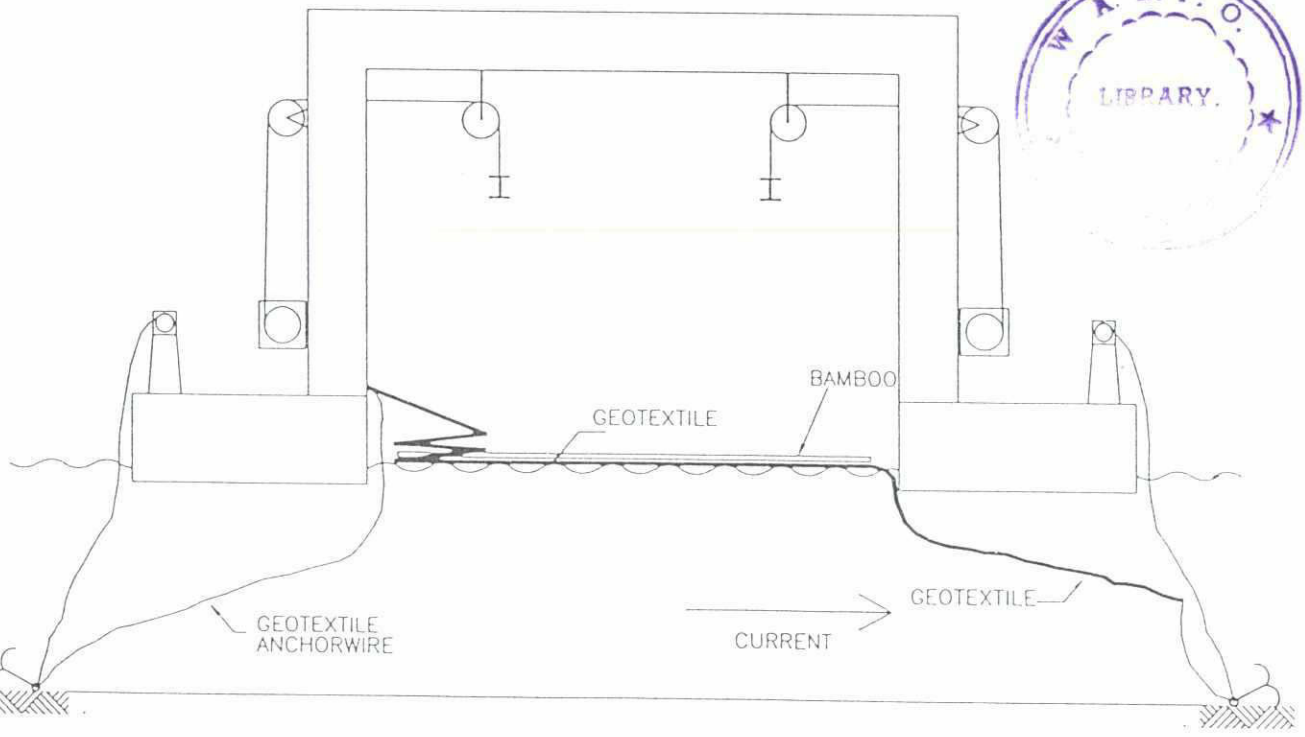
Dumping gunnybags and positioning of other end of Geo-Textile

Figure - 9.7



PLAN OF PONTOON

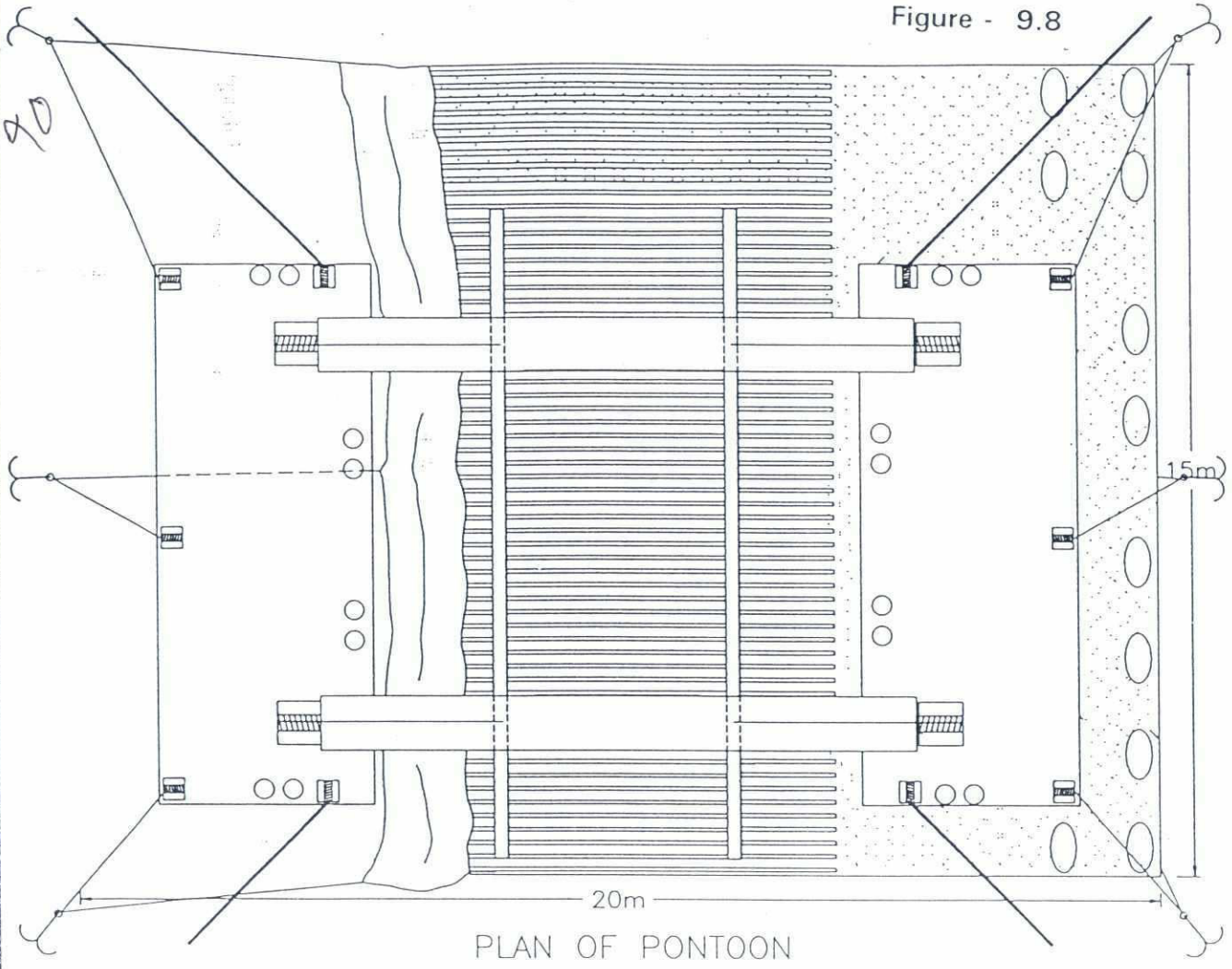
4m



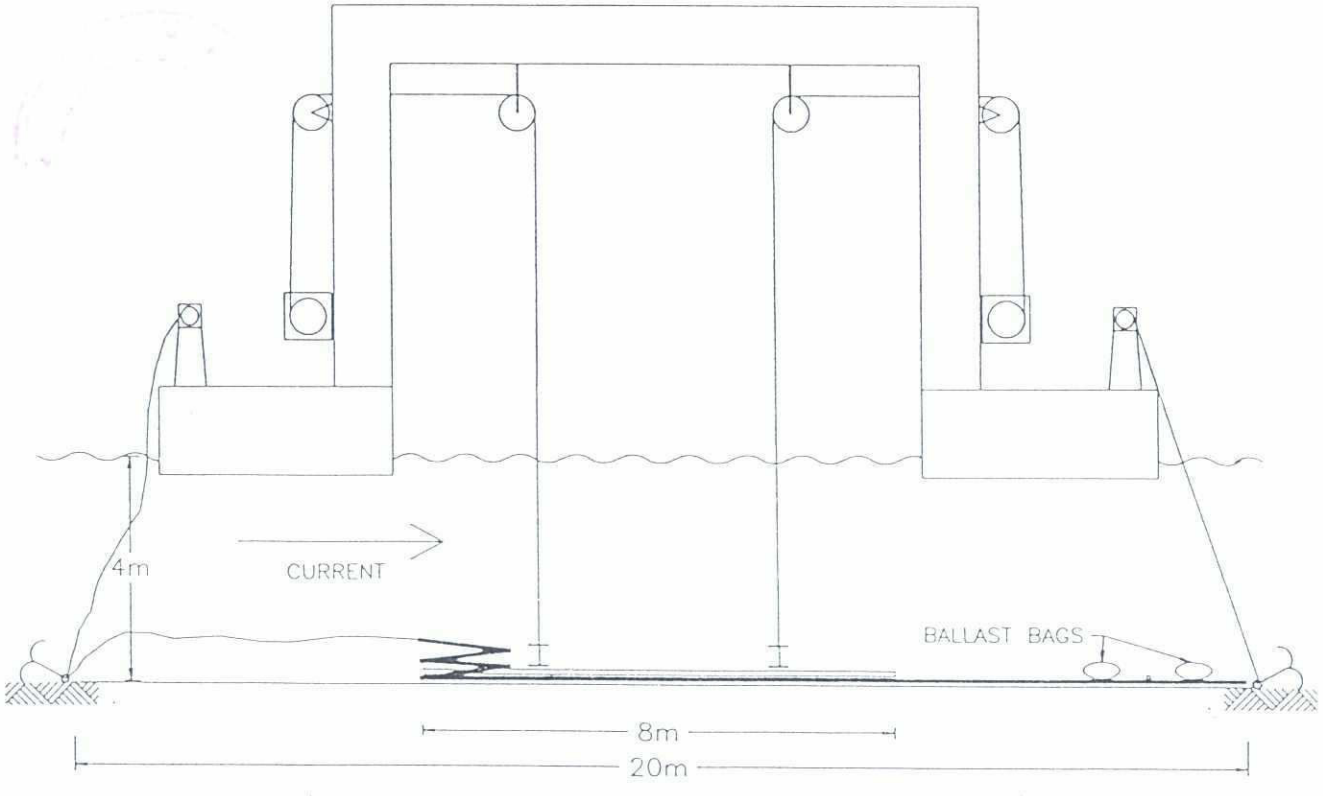
FRONT VIEW

Float geotextile inside THP

Figure - 9.8



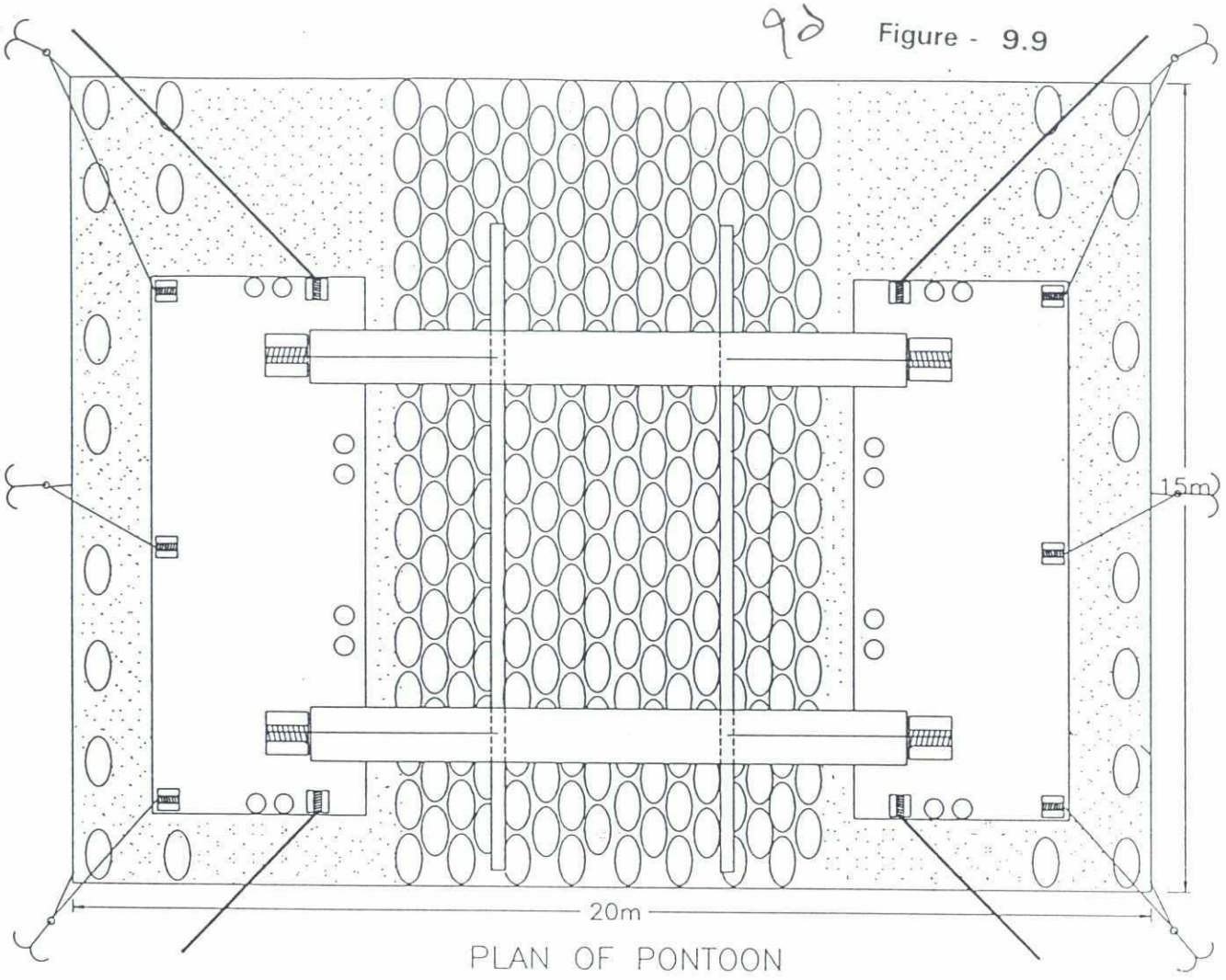
PLAN OF PONTOON



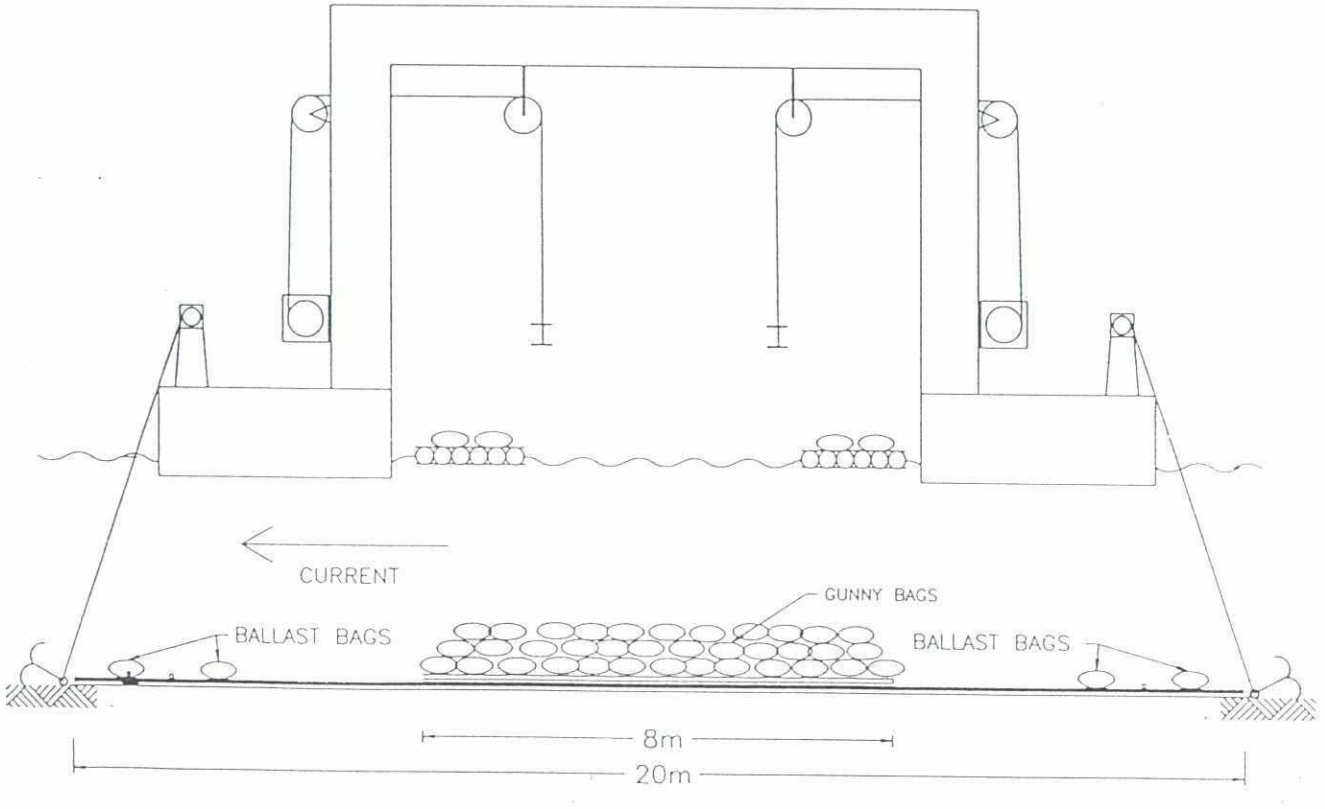
FRONT VIEW

Lowering Geo-Textile and positioning downstream end

Figure - 9.9



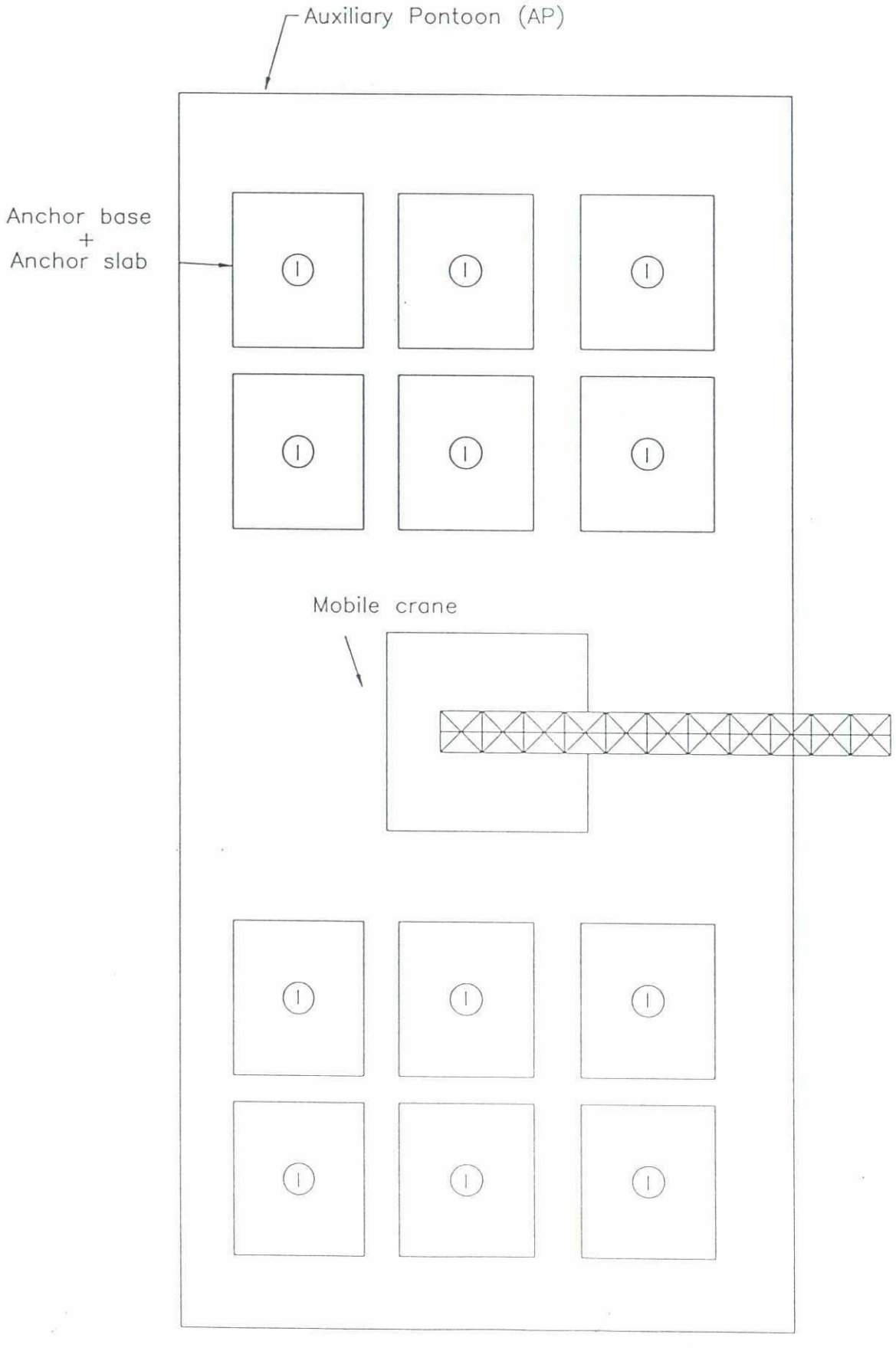
PLAN OF PONTOON



FRONT VIEW

Dumping gunnybags and positioning of other end of Geo-Textile

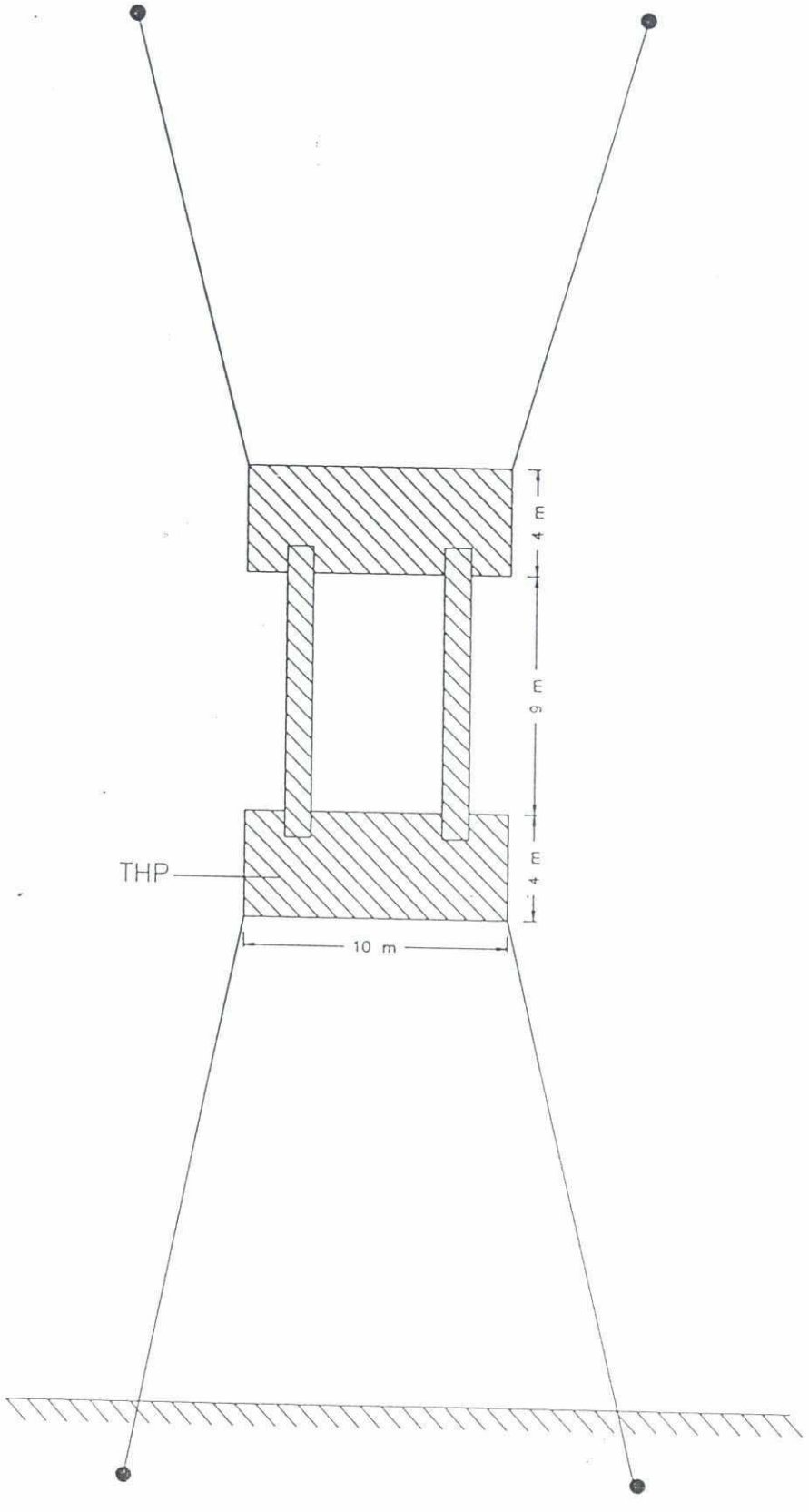
Figure - 10



Screen anchors loaded on auxiliary pontoon

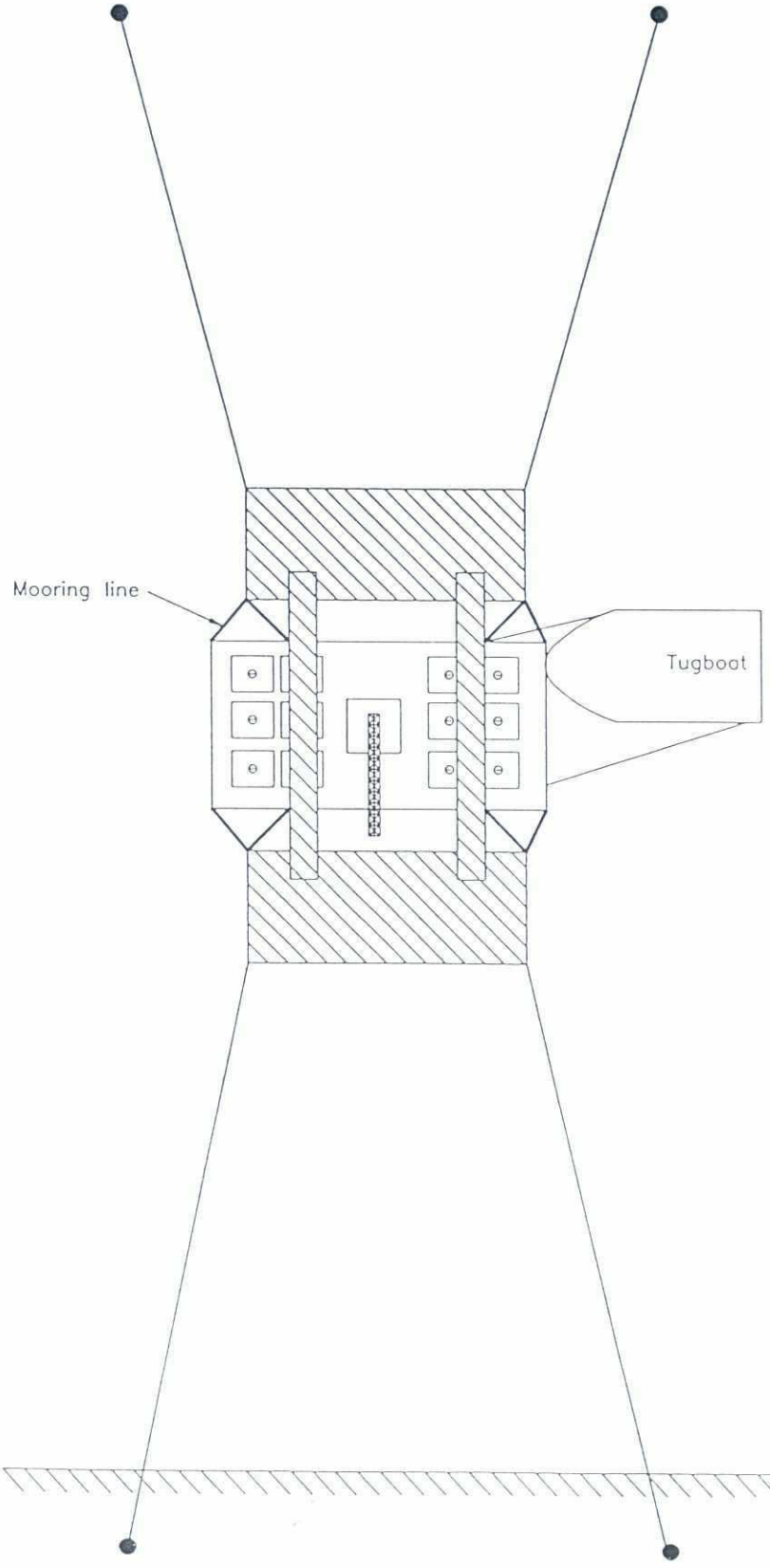
D:\PETER\SCREENS\FIG7

Figure - 10.1



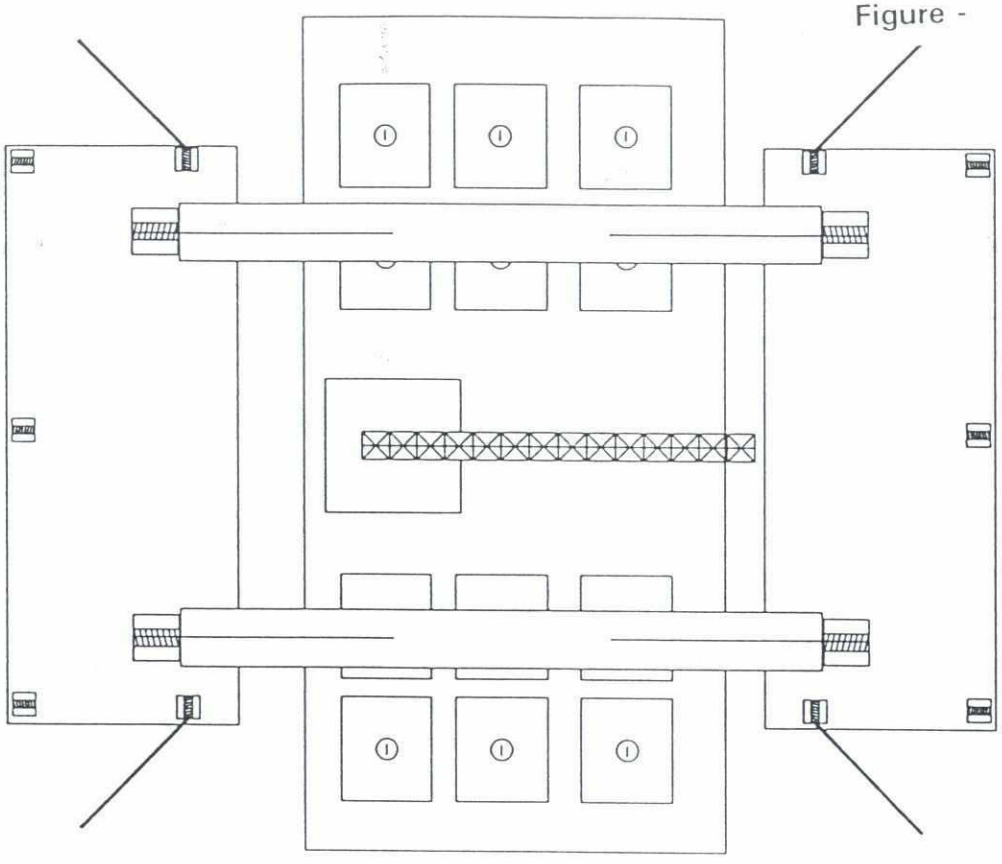
Positioning of THP

Figure - 10.2

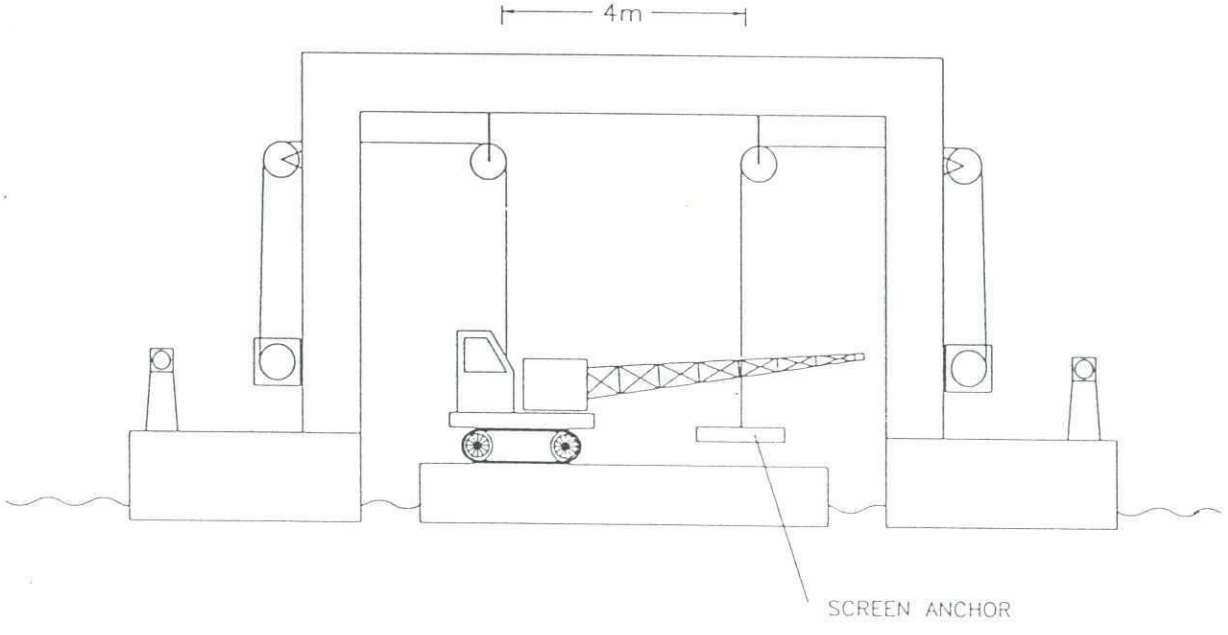


Mooring auxiliary pontoon inside THP.

Figure - 10.3

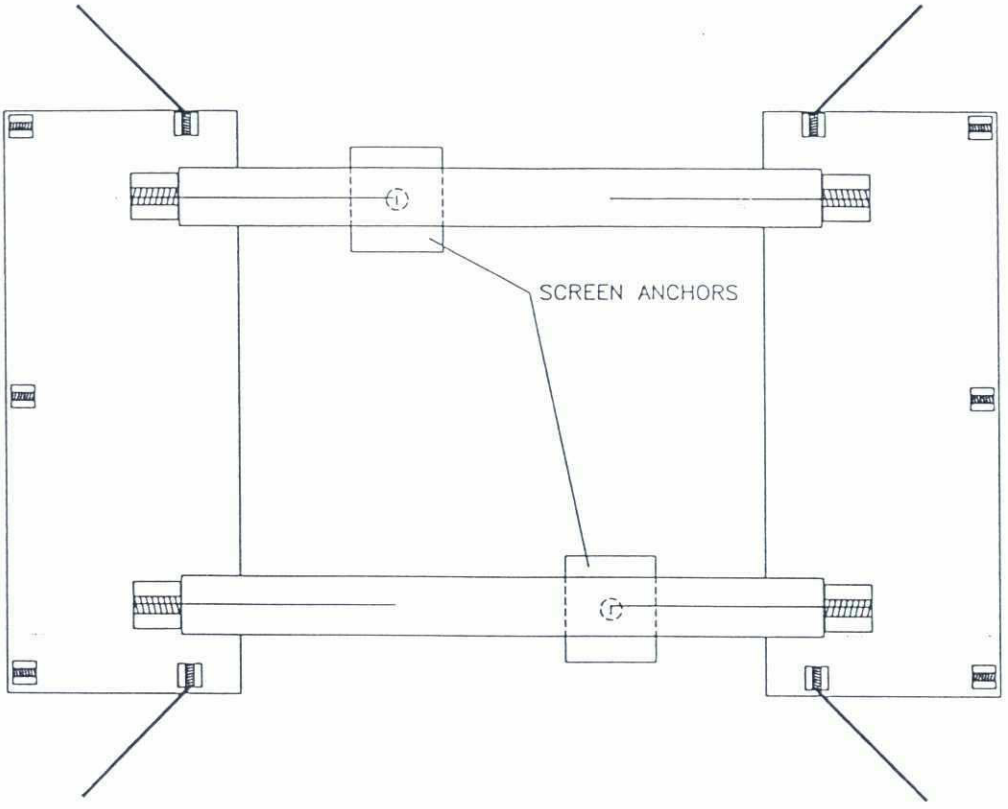


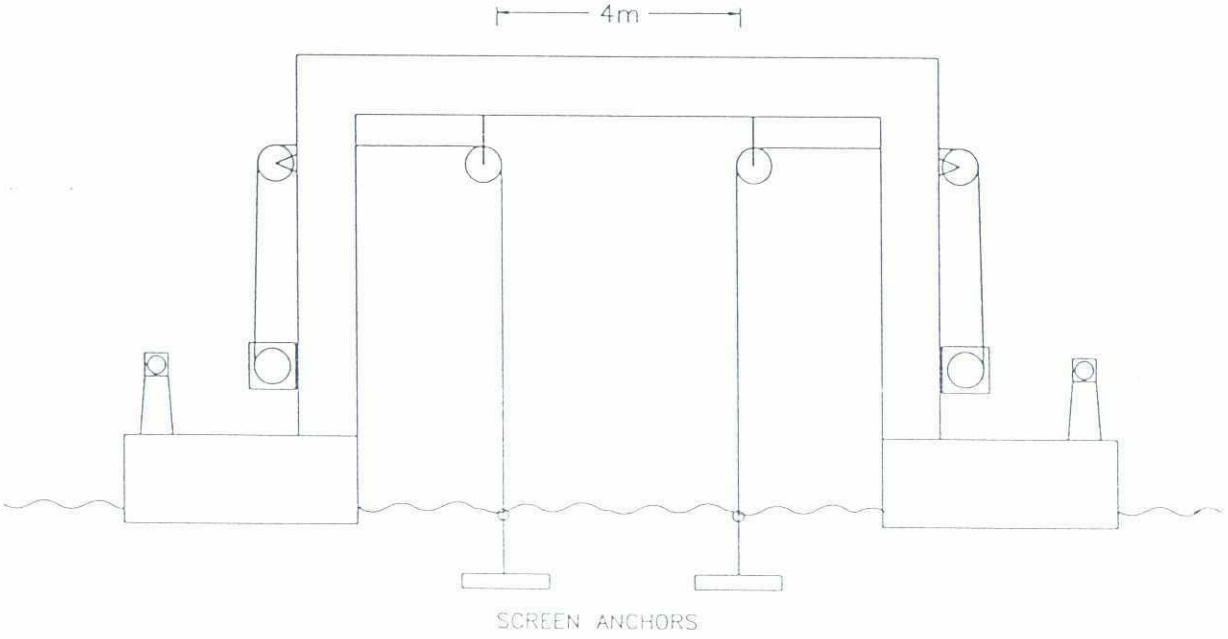
AUXILIARY PONTOON



Lifting of screen anchors

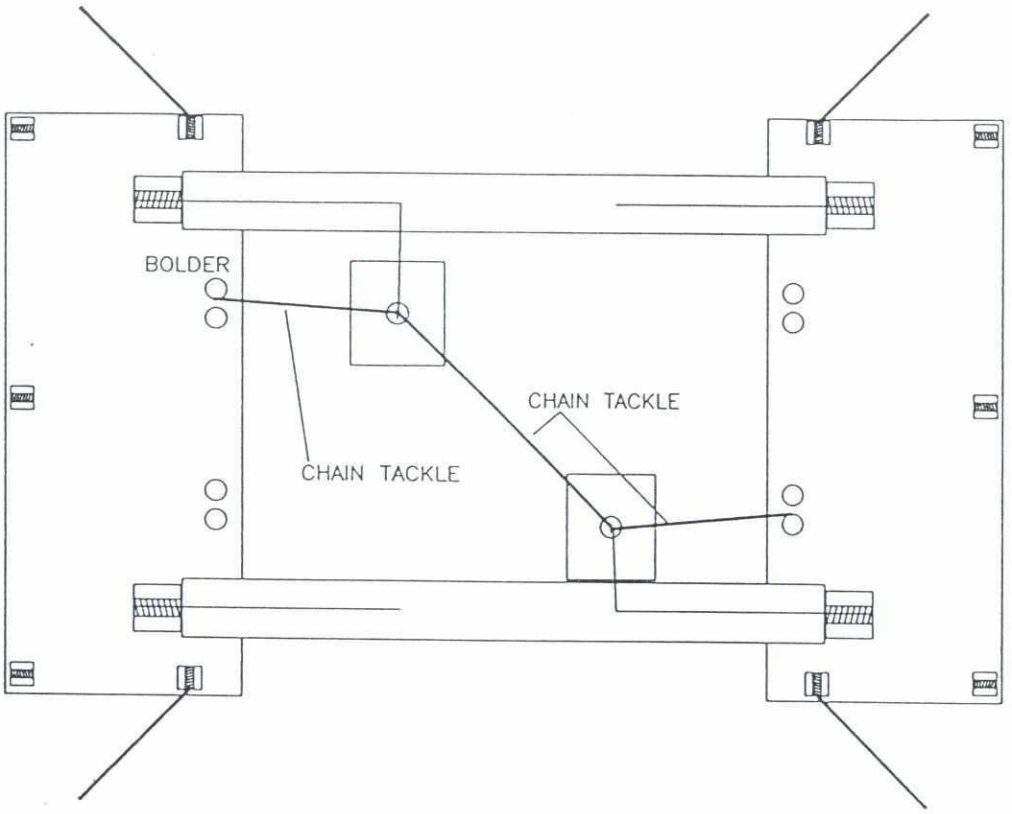
Figure - 10.4

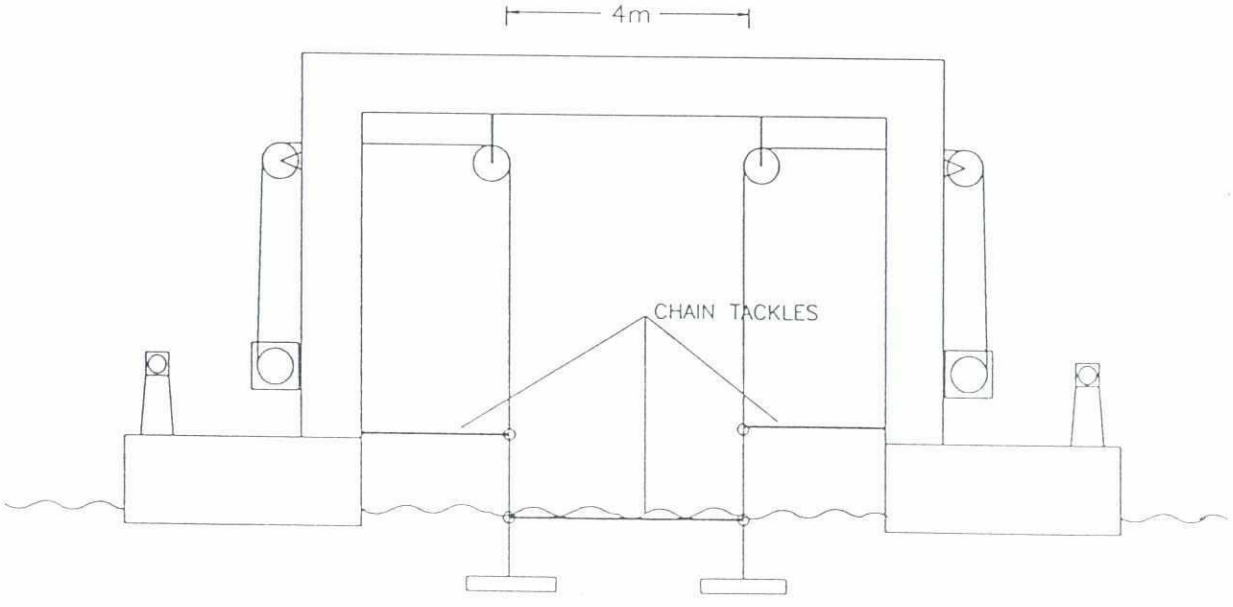




Lowering of screen anchors

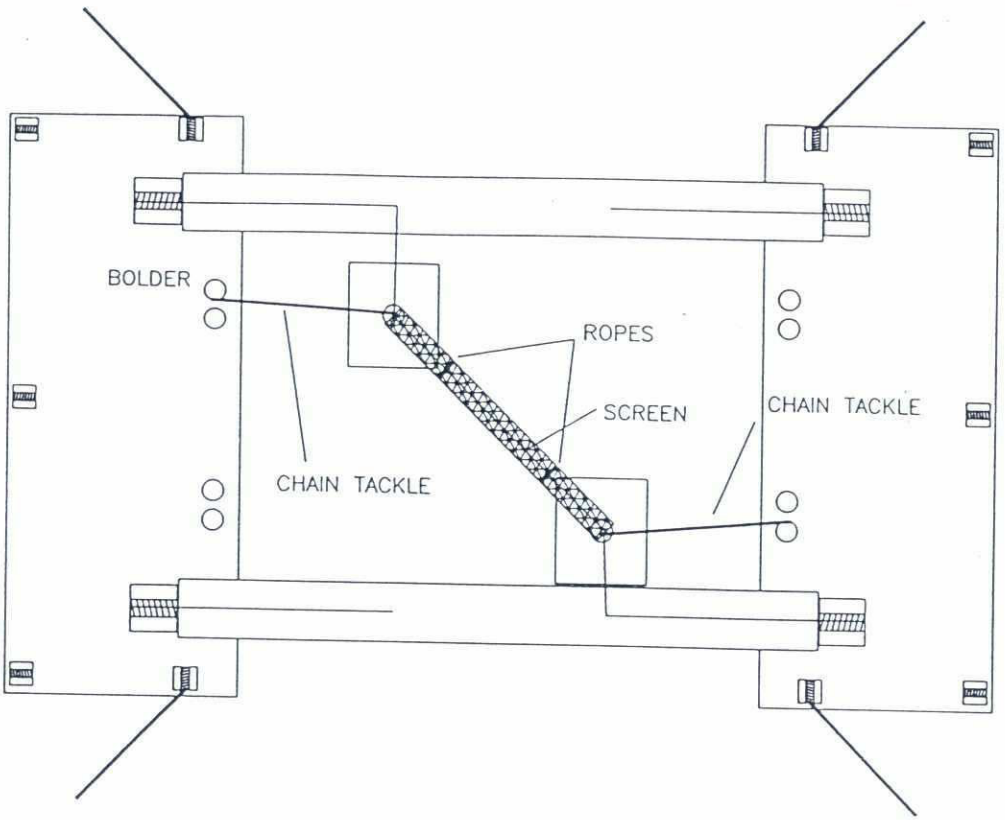
Figure - 10.5

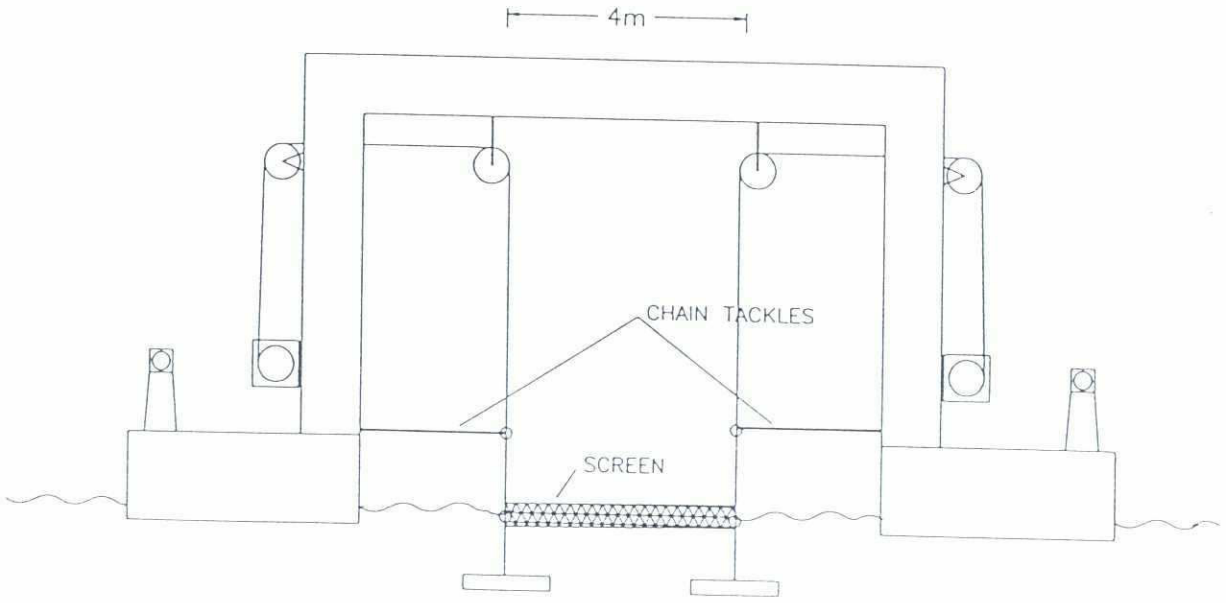




Attaching of chain tackles

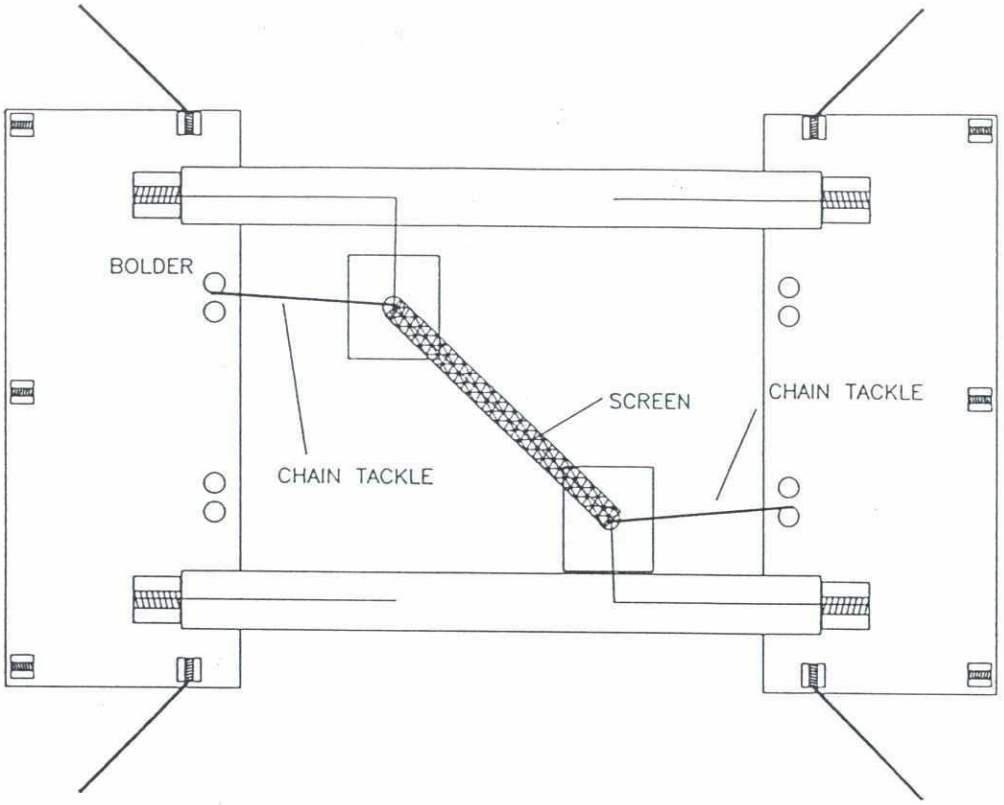
Figure - 10.6

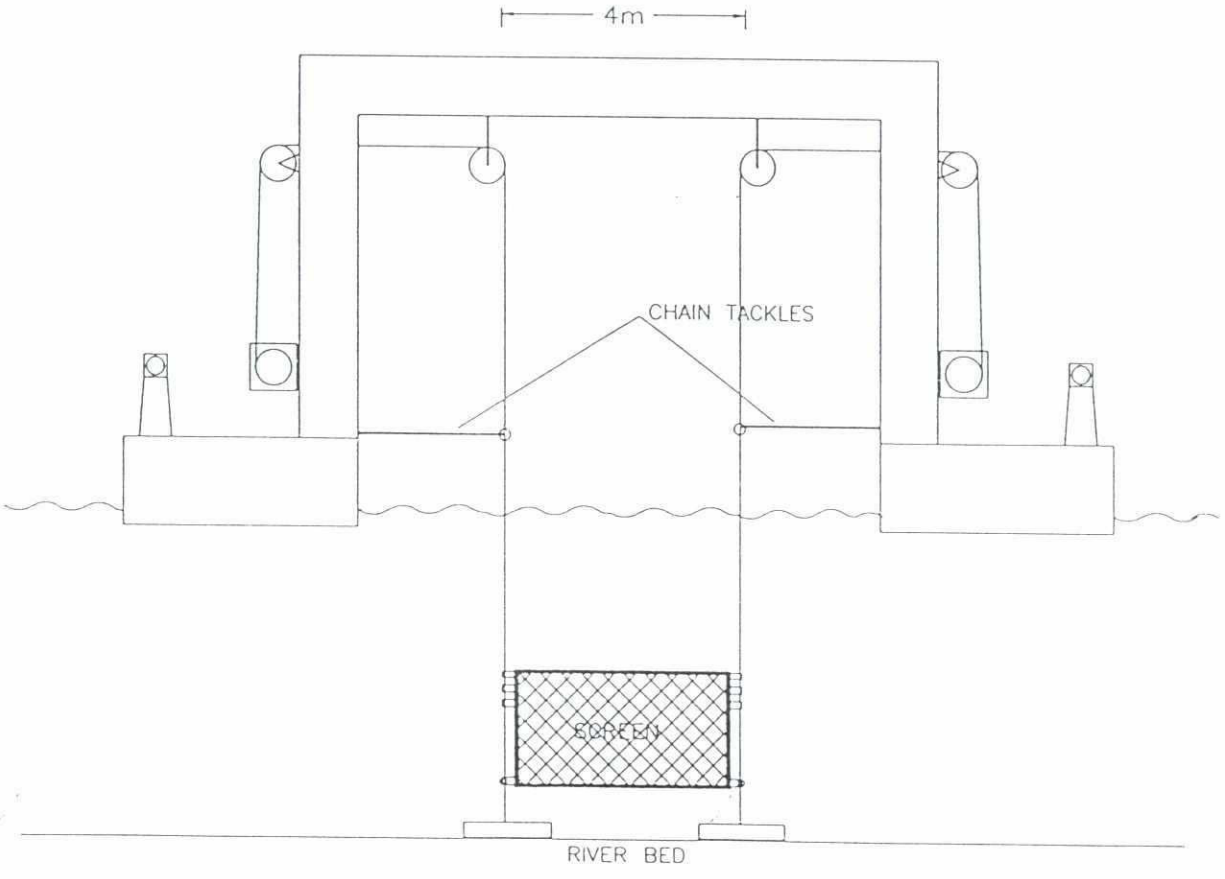




Attaching of screen, removing ropes

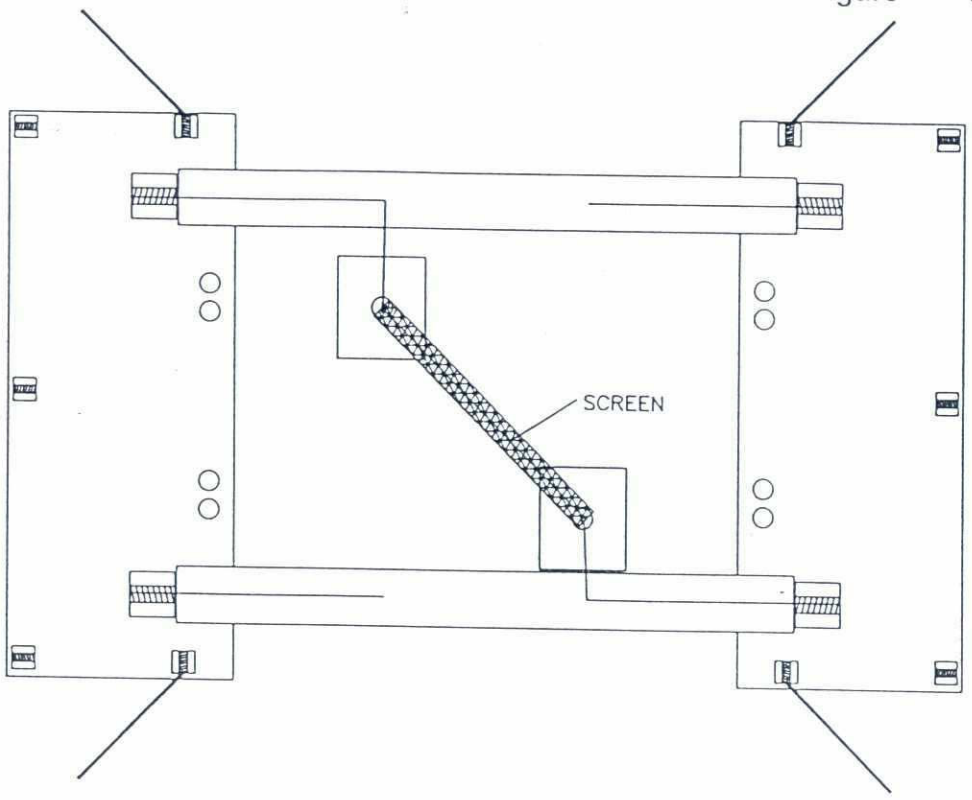
Figure - 10.7

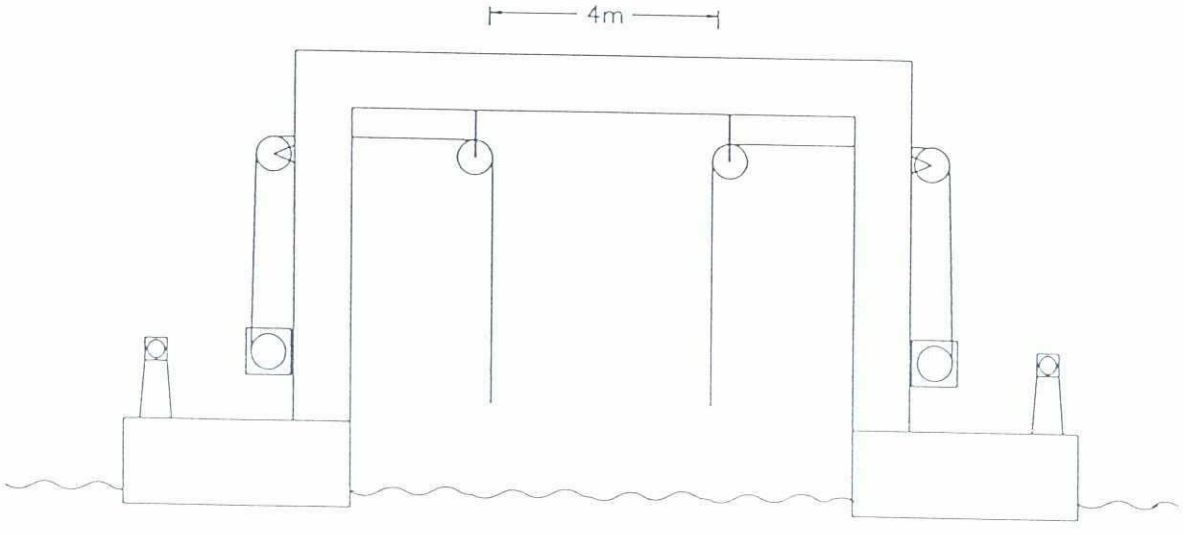


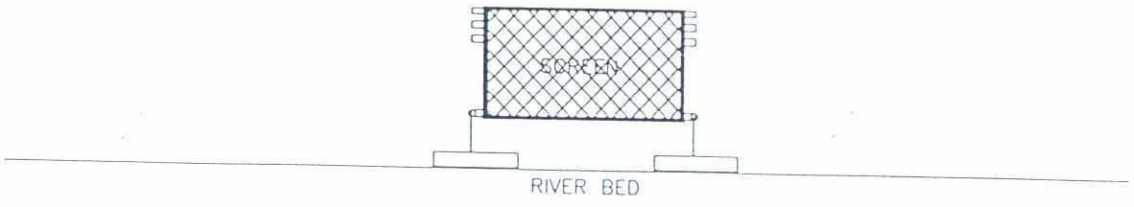


Installation of screen

Figure - 10.8

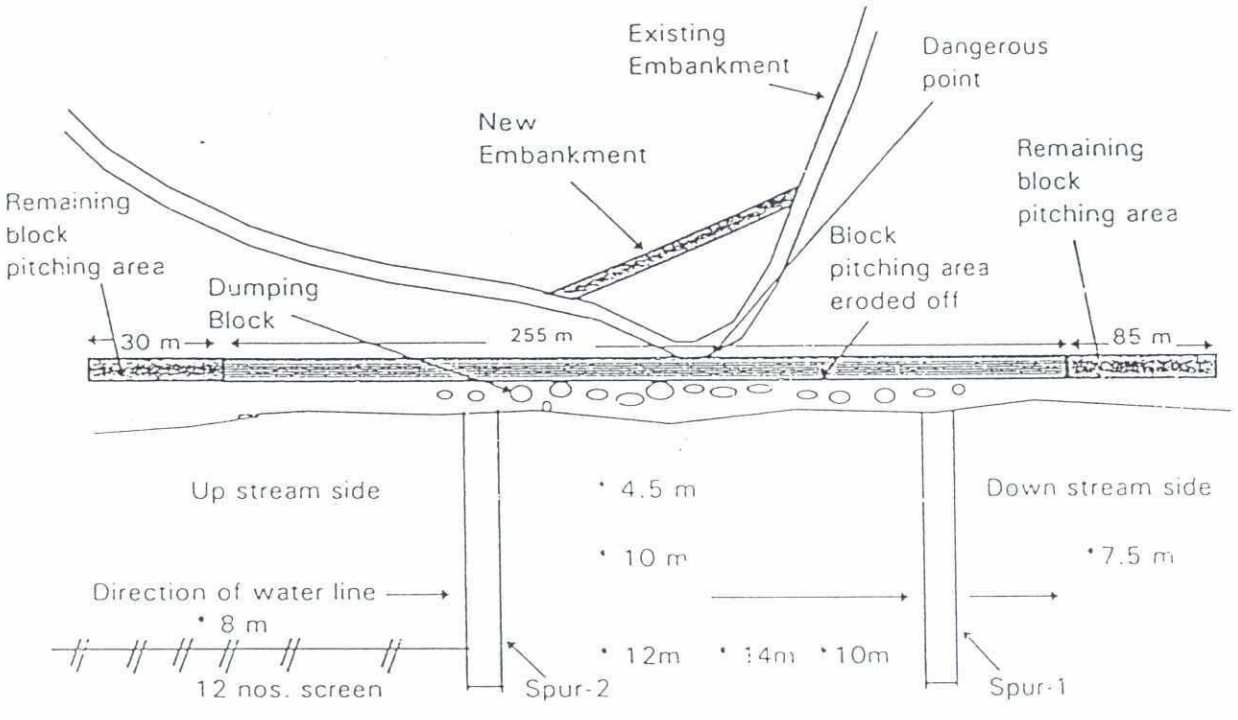






Detaching screen and chain tackles

Monitoring September 16-19, 1998



• indicates point of measuring depth

Sounding Report of Haimchar Site, Chandpur as on 25.09.98

~~FIG - 7~~

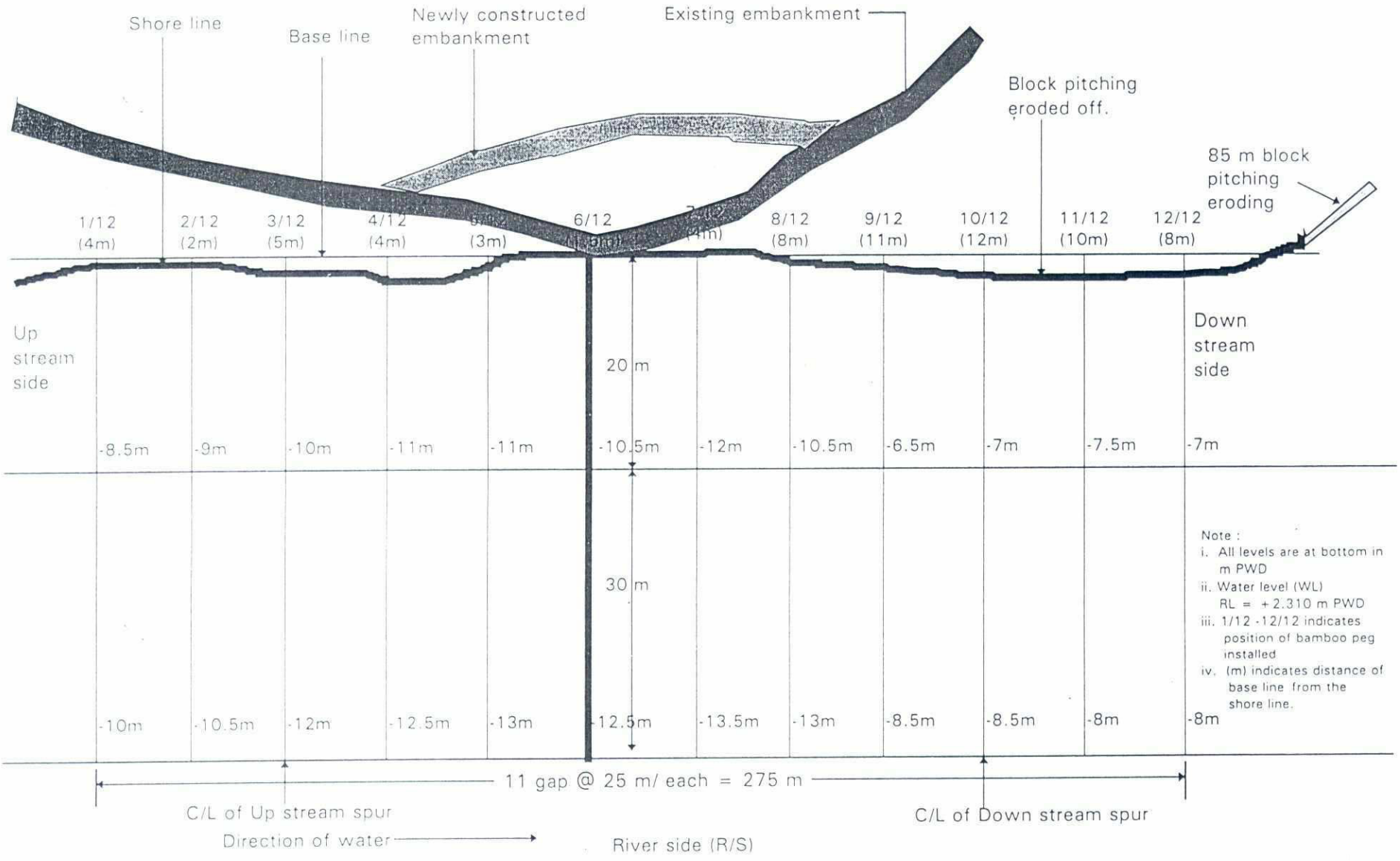
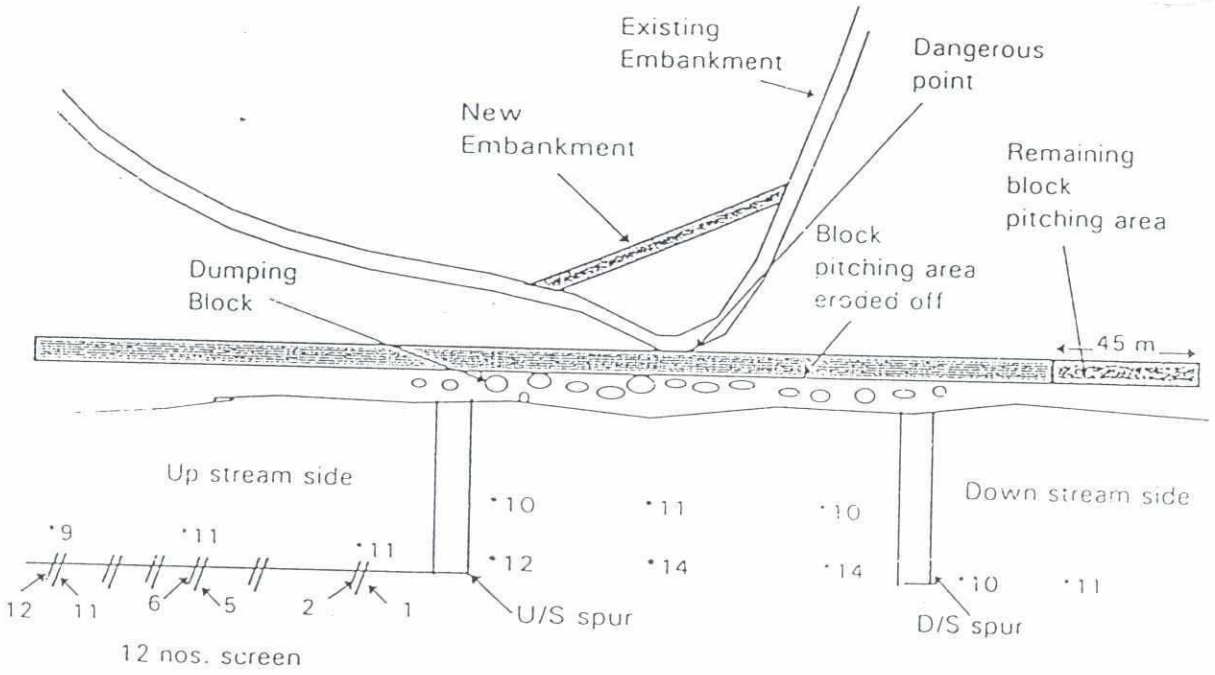


Figure - 12

Figure - 13

Monitoring September 24-26, 1998



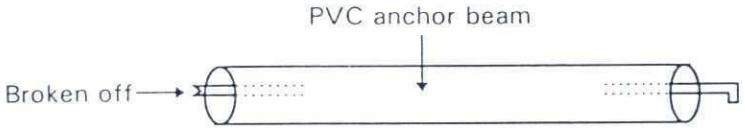
· Indicates water depths measured in meter.

Figure - 14

DETAILS OF DISCONNECTED SCREEN

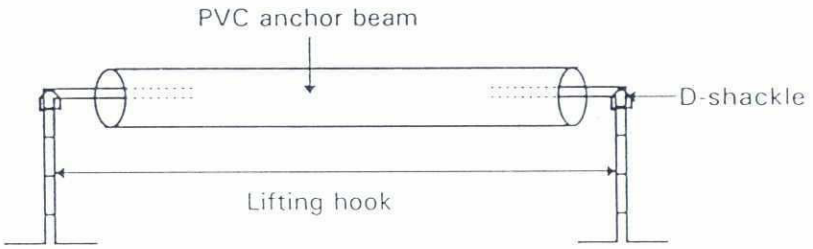
HAIMCHAR, CHANDPUR

1. The screen was disconnected on dt. 26.07.98 by breaking off the anchor beam hook at one end and the other end was found without D-shackle.

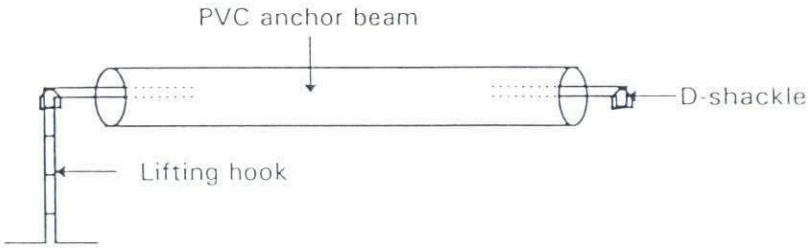


KHORKI, BHOLA

1. The screen was disconnected on dt. 11.08.98 by disconnecting both the lifting hooks at bottom from the anchor slabs.



2. The screen was disconnected on dt. 23.09.98 by disconnecting the lifting hook from one anchor slab at bottom but on the other side the anchor beam hook was found with D-shackle.



3. The screen was disconnected on dt. 23.09.98, some fishermen has seen it being swept away but it could not be rescued.

4. The screen was disconnected on dt. 25.09.98 but D-shackles with the anchor beam hook of both sides were absent.

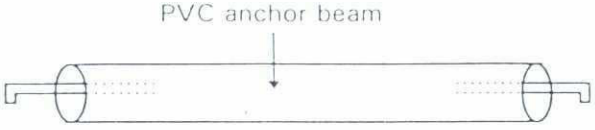


Figure - 15.1

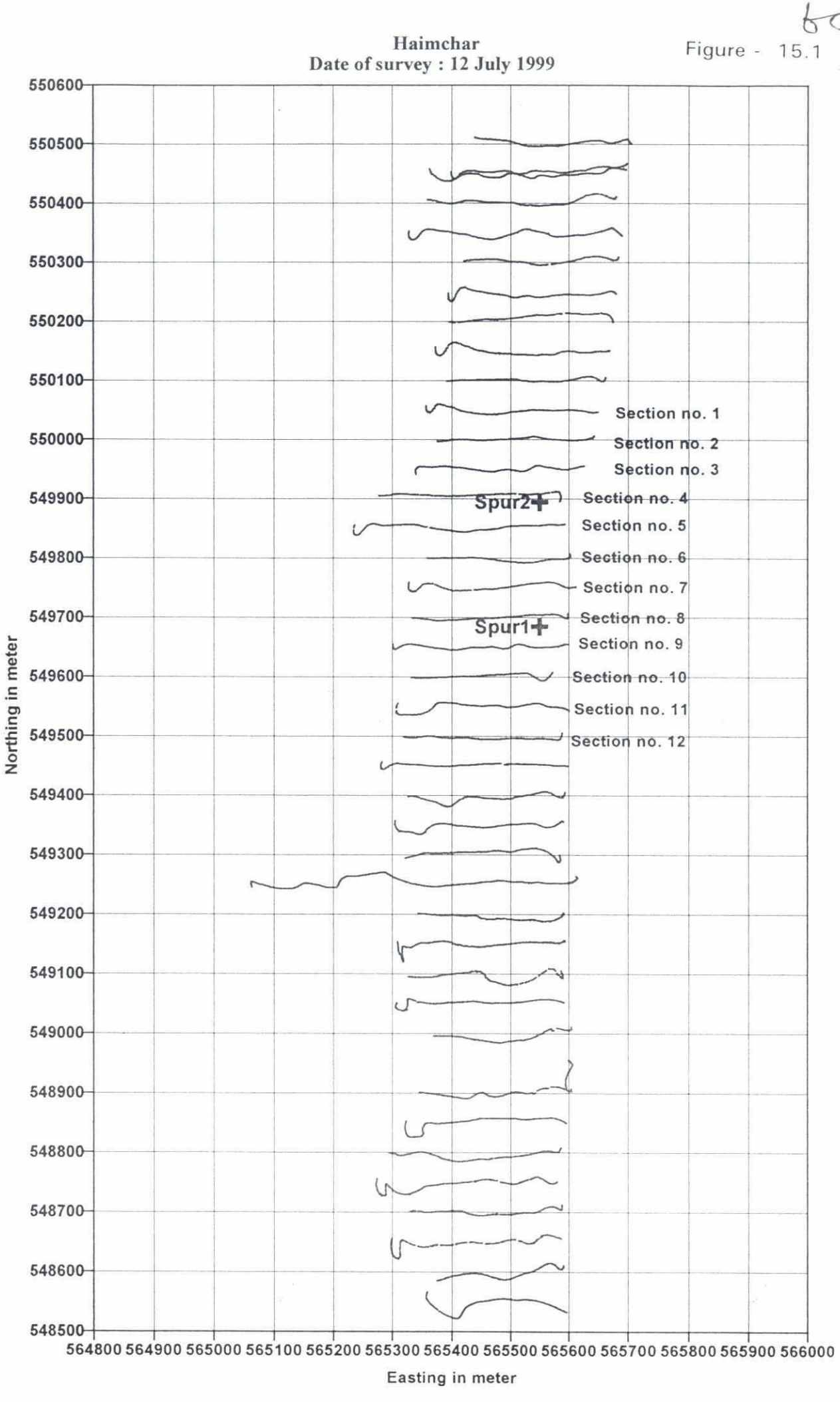
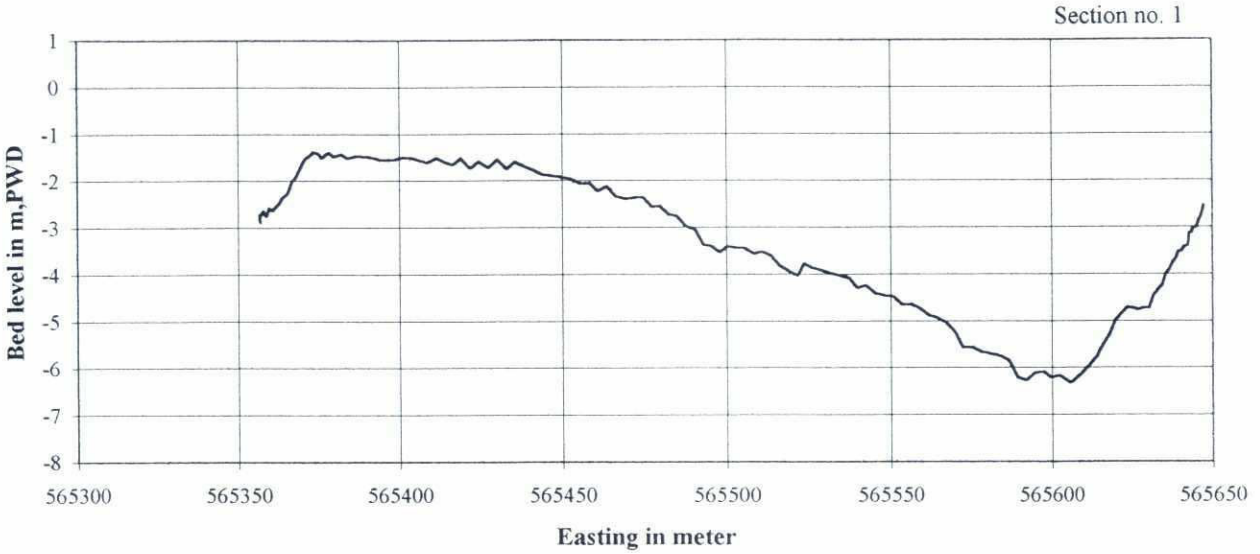
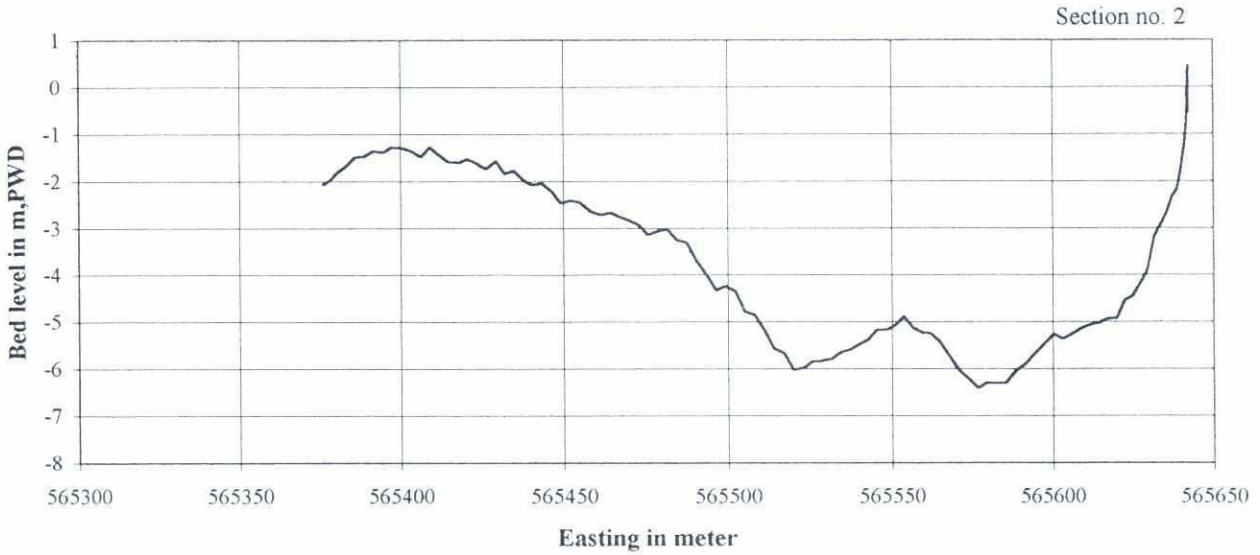

Haimchar
Date of survey : 12 July 1999
Section no. 1
Section no. 2
Section no. 3
Spur2
Section no. 4
Section no. 5
Section no. 6
Section no. 7
Section no. 8
Spur1
Section no. 9
Section no. 10
Section no. 11
Section no. 12
Northing in meter
550600
550500
550400
550300
550200
550100
550000
549900
549800
549700
549600
549500
549400
549300
549200
549100
549000
548900
548800
548700
548600
548500
564800 564900 565000 565100 565200 565300 565400 565500 565600 565700 565800 565900 566000
Easting in meter

Figure Typical sections of river channel at Haimchar near spur site

Date of survey : 12 July 1999





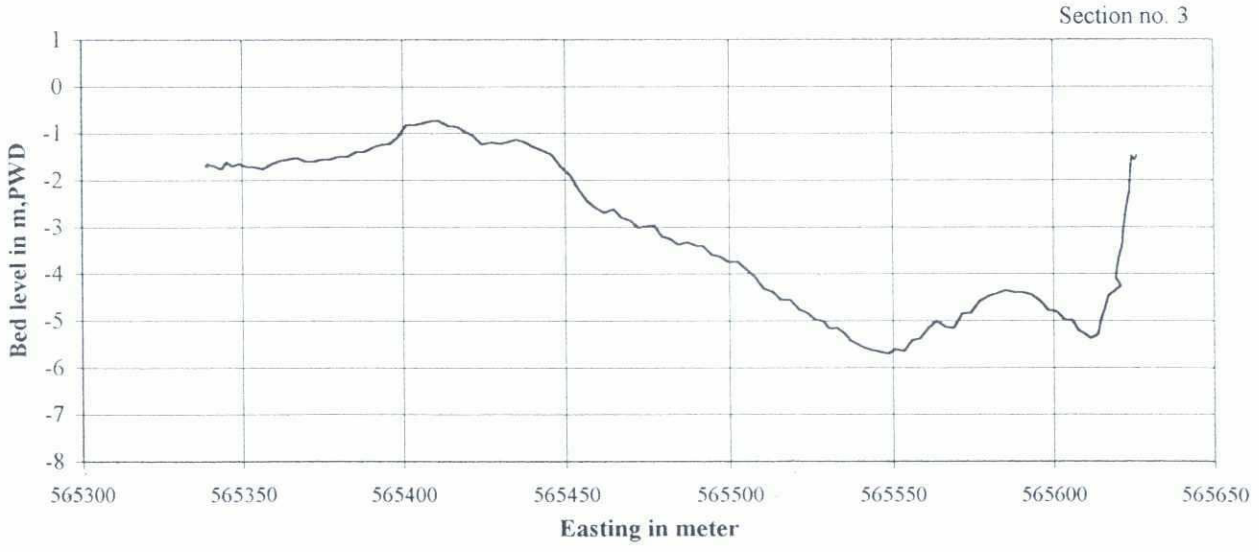
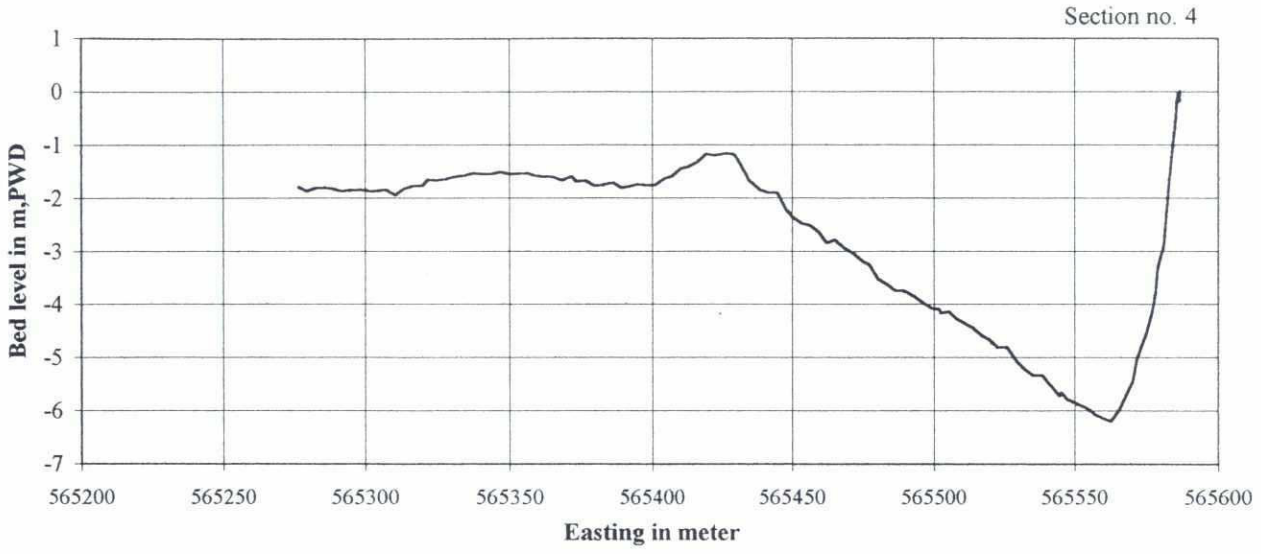
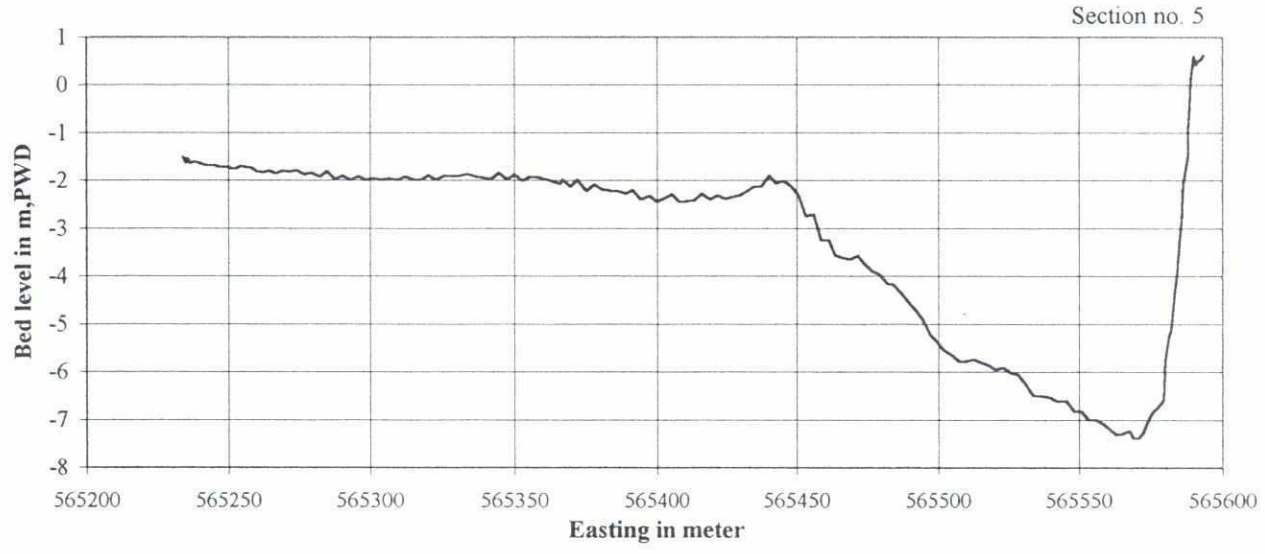


Figure - 15.3

Figure Typical sections of river channel at Haimchar near spur site

Date of survey : 12 July 1999





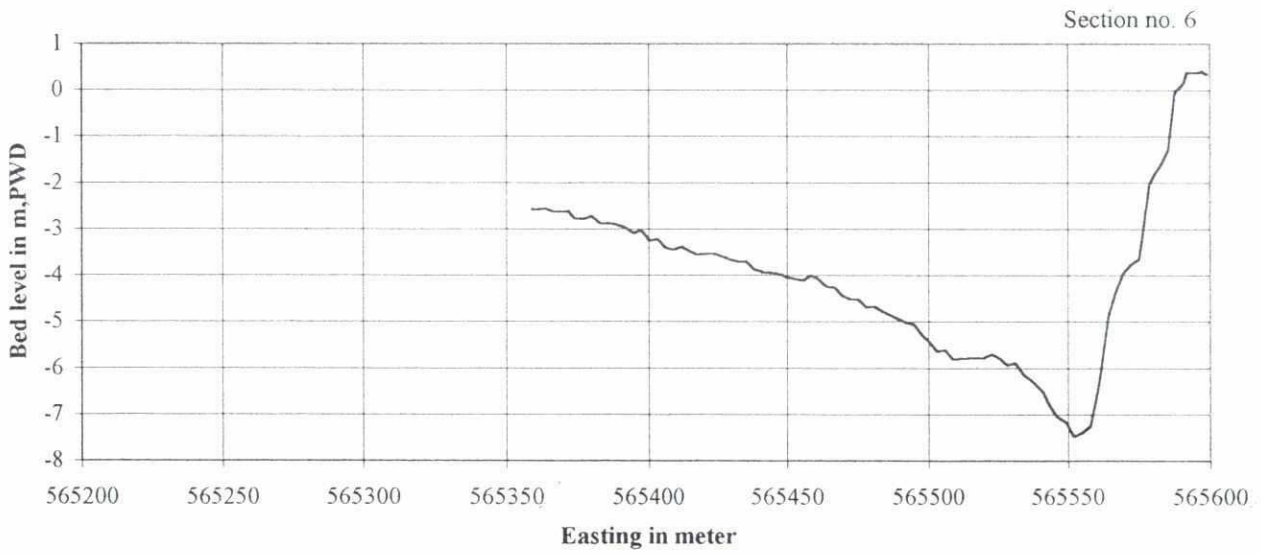
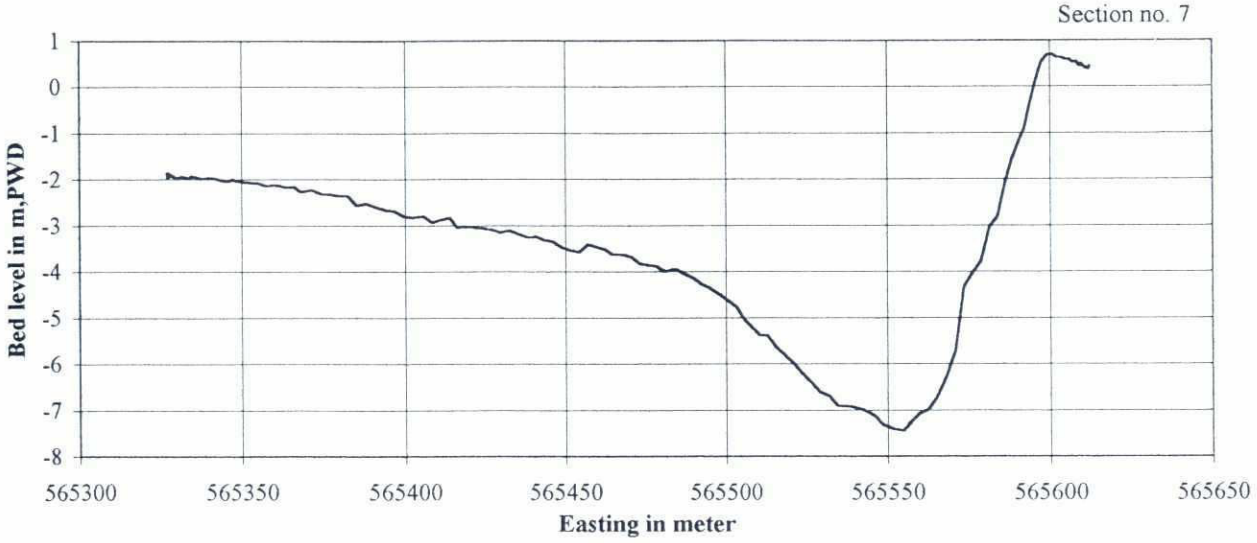
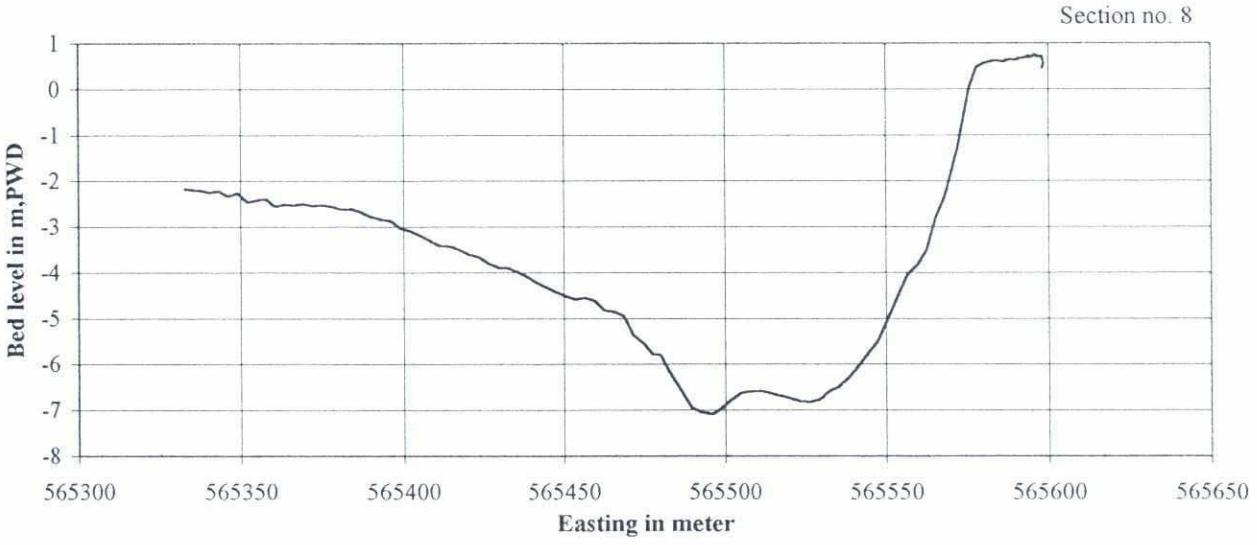


Figure Typical sections of river channel at Haimchar near spur site

Figure - 15.4

Date of survey : 12 July 1999





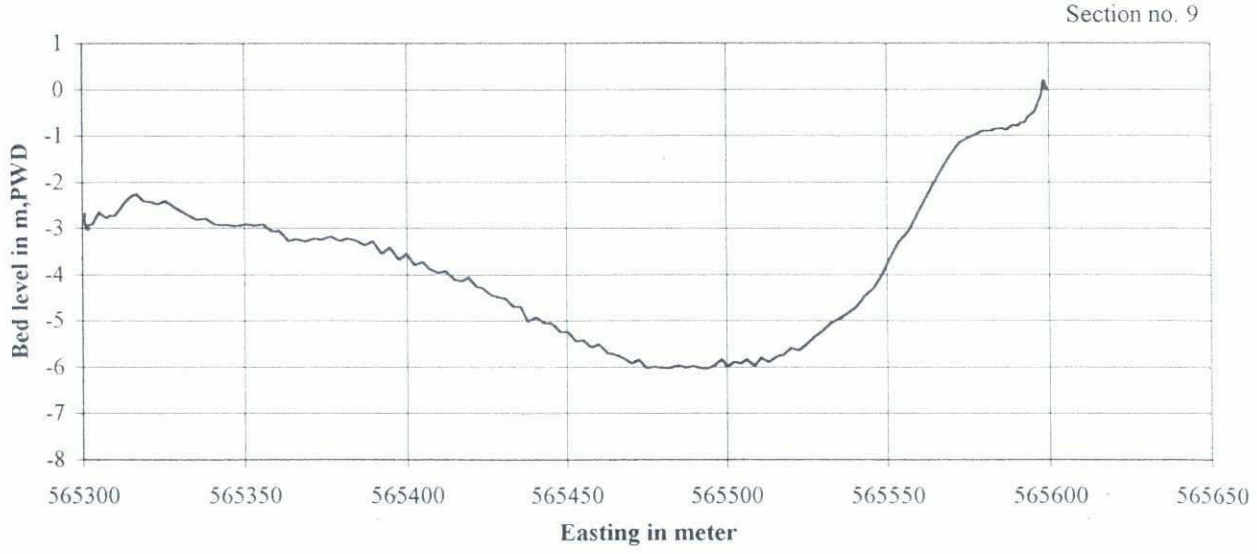
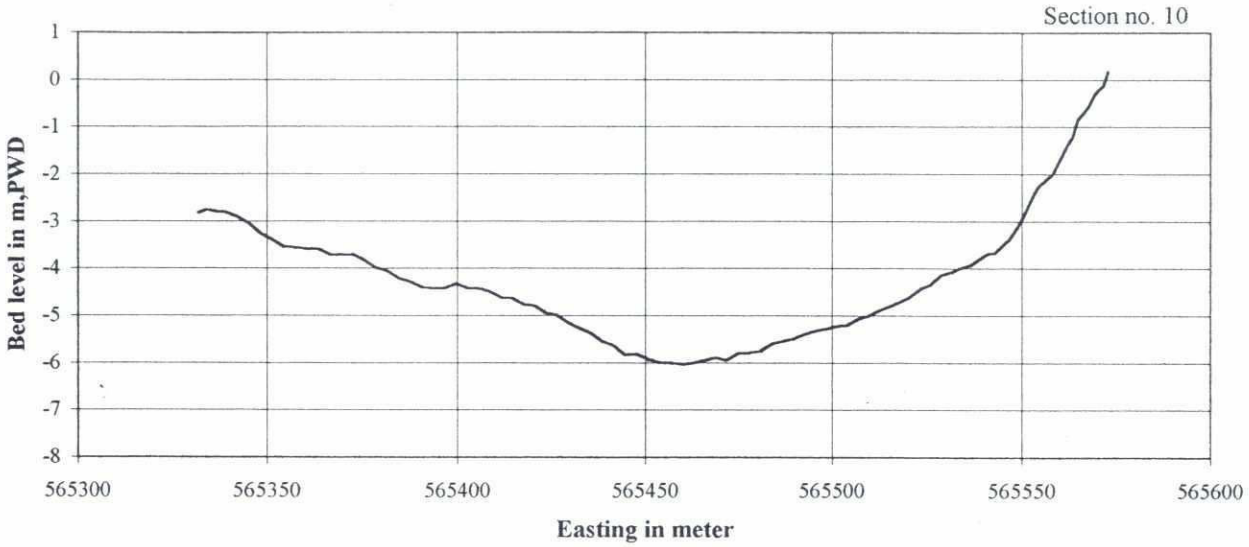
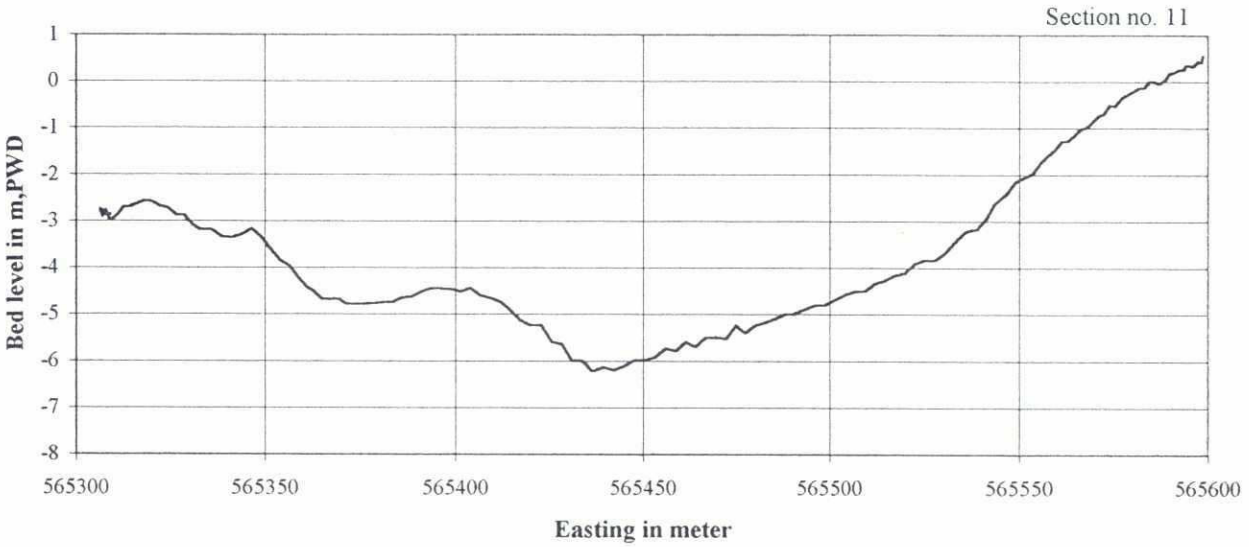


Figure Typical sections of river channel at Haimchar near spur site

Figure - 15.5

Date of survey : 12 July 1999





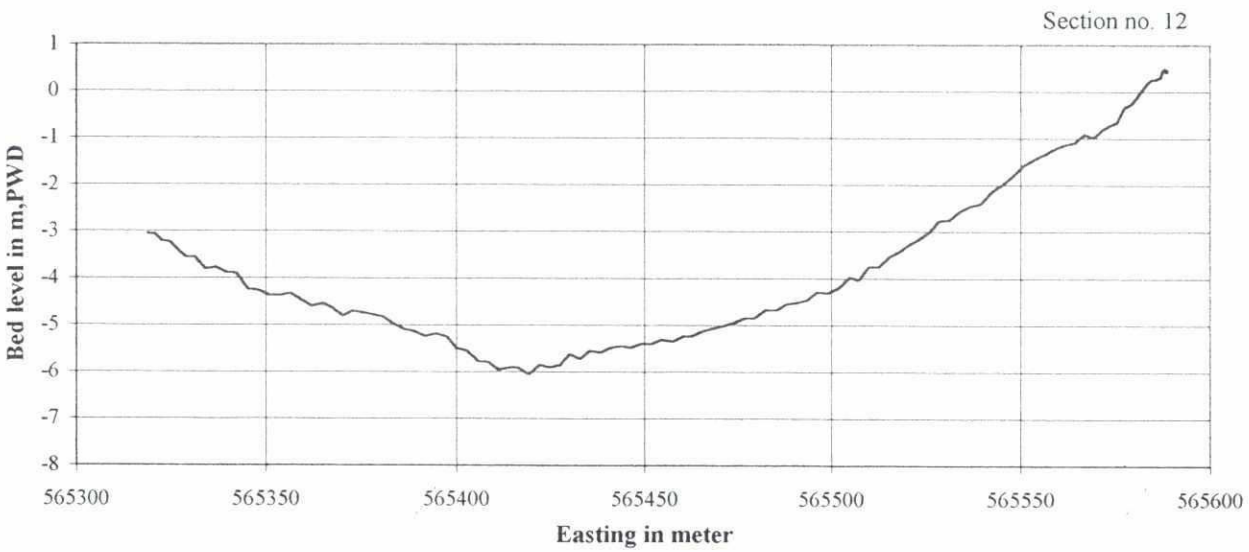


Figure 16: Monitoring November 15, 1998

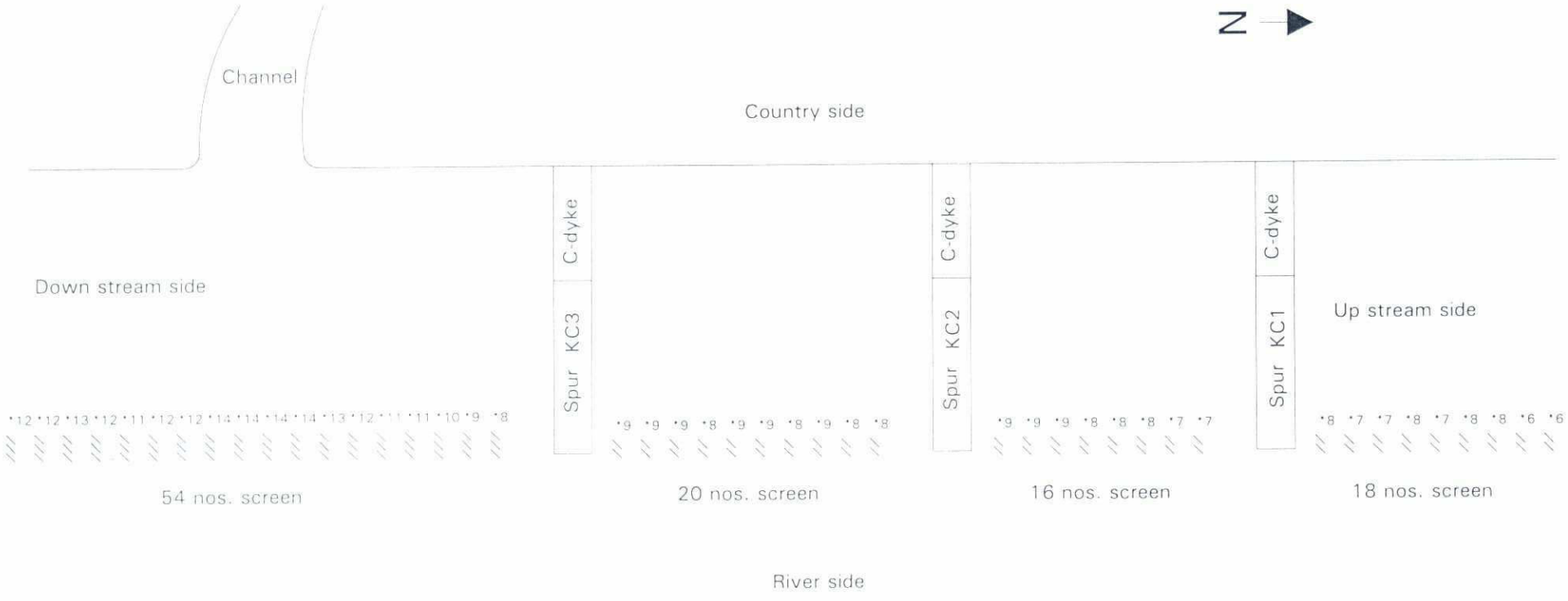


Figure - 16

APPENDICES

APPENDIX-1

TABLES

Haimchar Erosion Control Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter, PWD
Date of survey : 03 Jul 98

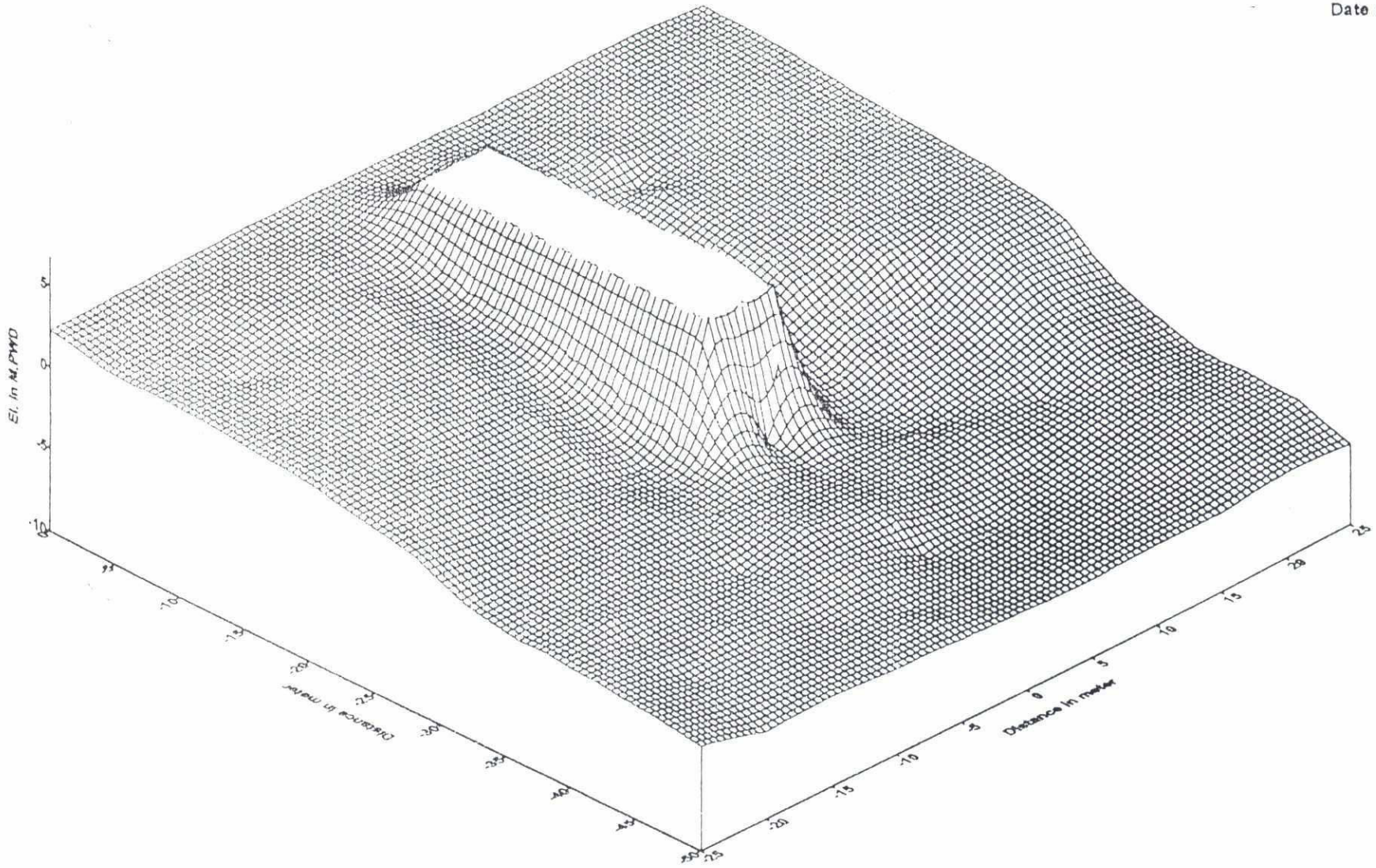
Distance in meter	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30
5													
0	2.30	2.40	2.50	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.25		
-5	2.00	2.05	2.30	2.40	2.60	2.50	2.47	2.35	2.50	2.50	2.25		
-10	1.50	1.72	2.30	2.40	2.60	2.50	2.47	2.35	2.50	2.45	2.25		
-15	1.35	1.50	2.30	2.40	2.60		2.47	2.35	2.40	2.22	2.15		
-20	1.40	1.40	2.00	1.90	2.35		2.37	2.20	2.10	2.07	2.00		
-25	1.30	0.90	1.40	1.85	1.75		1.92	0.90	1.60	1.92	1.85		
-30	1.20	1.20	1.25	1.30	1.20		1.32	1.60	1.50	1.77	1.65		
-35	1.05	0.70	1.00	1.05	1.10		1.07	1.25	1.40	1.57	1.55		
-40	0.85	0.80	0.80	0.60	0.90		0.87	1.00	1.30	1.47	1.40		
-45	0.75	0.60	0.60	0.30	0.75		0.72	0.80	1.15	1.42	1.30		
-50	0.55	0.30	0.25	-0.30	0.25		0.22	0.40	1.05	1.22	1.15		
-55	0.20	0.05	-0.40	-0.50	-0.20		-0.03	-0.10	0.80	0.82	1.05		
	-0.05	-0.20	-0.90	-1.00	-0.90		-1.18	-1.20	0.40	0.77	0.75		
	-0.30	-0.70	-1.30	-1.60	-1.30		-1.58	-1.70	-0.80	0.47	0.50		
	-0.60	-1.30	-1.50	-2.40	-1.90		-2.28	-2.30	-1.70	-0.03	0.05		
	-1.30	-1.80	-2.00	-2.40	-2.40	-2.85	-3.18	-3.00	-2.15	-0.73	-1.25		
	-1.95	-2.00	-2.40	-2.50	-2.60	-3.25	-3.58	-3.60	-2.83	-1.63	-2.25		
	-2.20	-2.30	-2.50	-2.80	-2.90	-3.45	-3.58	-4.00	-3.23	-2.23	-2.85		
	-2.50	-2.50	-2.70	-3.10	-3.00	-3.35	-3.78	-3.70	-3.98	-2.93	-3.35		
	-2.40	-2.40	-2.85	-3.70	-2.90	-3.35	-4.18	-4.00	-3.83	-3.33	-3.85		
	-2.60	-3.00	-3.30	-3.50	-3.50	-3.70	-4.58	-4.70	-3.93	-3.78	-3.95		
	-2.65	-3.10	-3.30	-3.70	-3.70	-5.00	-5.18	-4.90	-4.23	-3.73	-3.85		
	-2.90	-3.70	-3.80	-4.20	-4.20	-4.98	-5.18	-5.00	-4.43	-3.93	-4.00		
	-3.00	-3.70	-4.00	-4.30	-4.70	-5.08	-5.28	-5.00	-4.83	-4.33	-4.05		
	-3.25	-4.10	-4.30	-4.45	-4.50	-5.18	-5.10	-5.15	-5.03	-4.63	-4.65		
	-3.50	-4.60	-4.40	-4.70	-4.90	-5.08	-5.30	-5.20	-5.33	-4.93	-5.15		

Distance in meter

Table - 1

Haimchar Erosion Control Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter PWD
Date of survey : 03 Jul 98



Color scale :

5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10

Haimchar Erosion Control Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter, PWD
Date of survey : 04 Jul 98

0.19	0.73	0.97	1.01	1.93		3.00	2.90	2.80	2.70	2.60
0.19	0.43	0.47	0.71	1.73		2.60	2.20	2.40	2.25	2.20
-0.01	0.23	0.37	0.56	1.23		2.40	2.00	2.20	2.20	2.20
-0.11	0.23	0.37	0.51	0.75		1.90	1.40	2.00	2.05	2.05
-0.41	0.03	0.27	0.41	0.55		1.15	0.90	1.50	1.90	1.95
-0.56	-0.57	0.17	0.31	0.35		0.75	0.40	1.00	1.70	1.80
-1.11	-1.27	-0.03	0.11	0.25		0.55	-0.20	0.85	1.45	1.60
-2.21	-1.97	-0.53	-0.19	0.05		0.35	-0.80	0.30	1.05	1.30
-2.71	-2.32	-0.93	-0.09	-0.25		-0.15	-1.00	0.00	0.60	0.95
-2.81	-2.57	-1.53	-0.69	-0.45		-0.15	-1.50	-0.30	0.30	0.90
-3.01	-2.97	-2.23	-1.39	-0.35		-0.90	-1.75	-0.65	0.00	0.15
-3.41	-3.27	-2.43	-1.69	-1.35		-1.30	-2.05	-1.90	-0.45	-0.70
-3.61	-3.67	-2.93	-2.04	-1.80		-1.70	-1.85	-1.90	-1.45	-1.50
-4.09	-3.97	-3.03	-2.44	-2.05		-1.45	-2.00	-2.00	-1.80	-2.00
-4.49	-4.12	-3.43	-2.54	-2.20		-1.90	-1.90	-1.95	-2.20	-2.10
-4.69	-4.27	-3.63	-2.99	-2.65		-1.90	-2.60	-2.20	-2.15	-2.25
-4.59	-4.47	-3.83	-3.04	-2.85		-2.00	-2.50	-2.50	-2.20	-2.30
-4.89	-4.67	-4.12	-3.49	-3.05		-2.30	-2.70	-2.55	-2.80	-2.40
-4.89	-4.97	-4.48	-3.59	-3.35		-1.50	-2.75	-2.55	-2.80	-2.70
-5.19	-4.77	-4.57	-3.93	-3.35		-1.50	-2.80	-2.70	-2.70	-2.70
-4.69	-4.47	-4.77	-4.13	-3.65		-1.80	-2.70	-2.65	-2.60	-2.90
-5.19	-5.37	-5.07	-4.53	-4.00		-2.00	-5.00	-2.50	-2.70	-2.80
-5.89	-6.17	-5.37	-5.23	-4.40		-3.10	-4.30	-3.80	-3.00	-2.90
-6.39	-7.10	-5.57	-5.83	-4.65	-3.79	-3.58	-4.30	-4.10	-3.80	-3.00
-7.29	-7.57	-6.17	-4.73	-4.95	-4.19	-4.10	-4.10	-4.10	-4.30	-3.60
-8.59	-7.77	-6.67	-4.53	-5.05	-4.69	-4.60	-4.10	-4.30	-4.40	-4.20

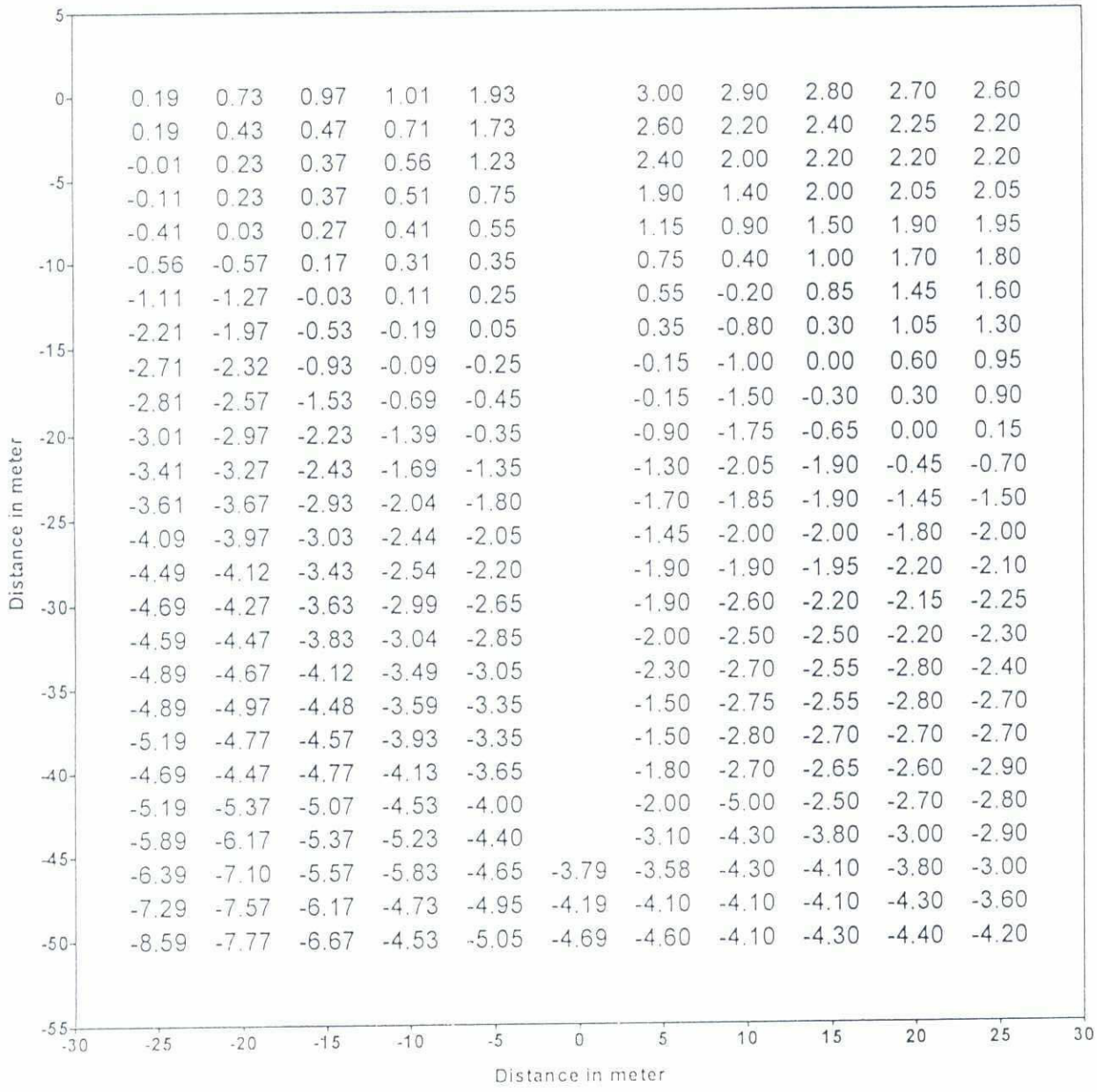
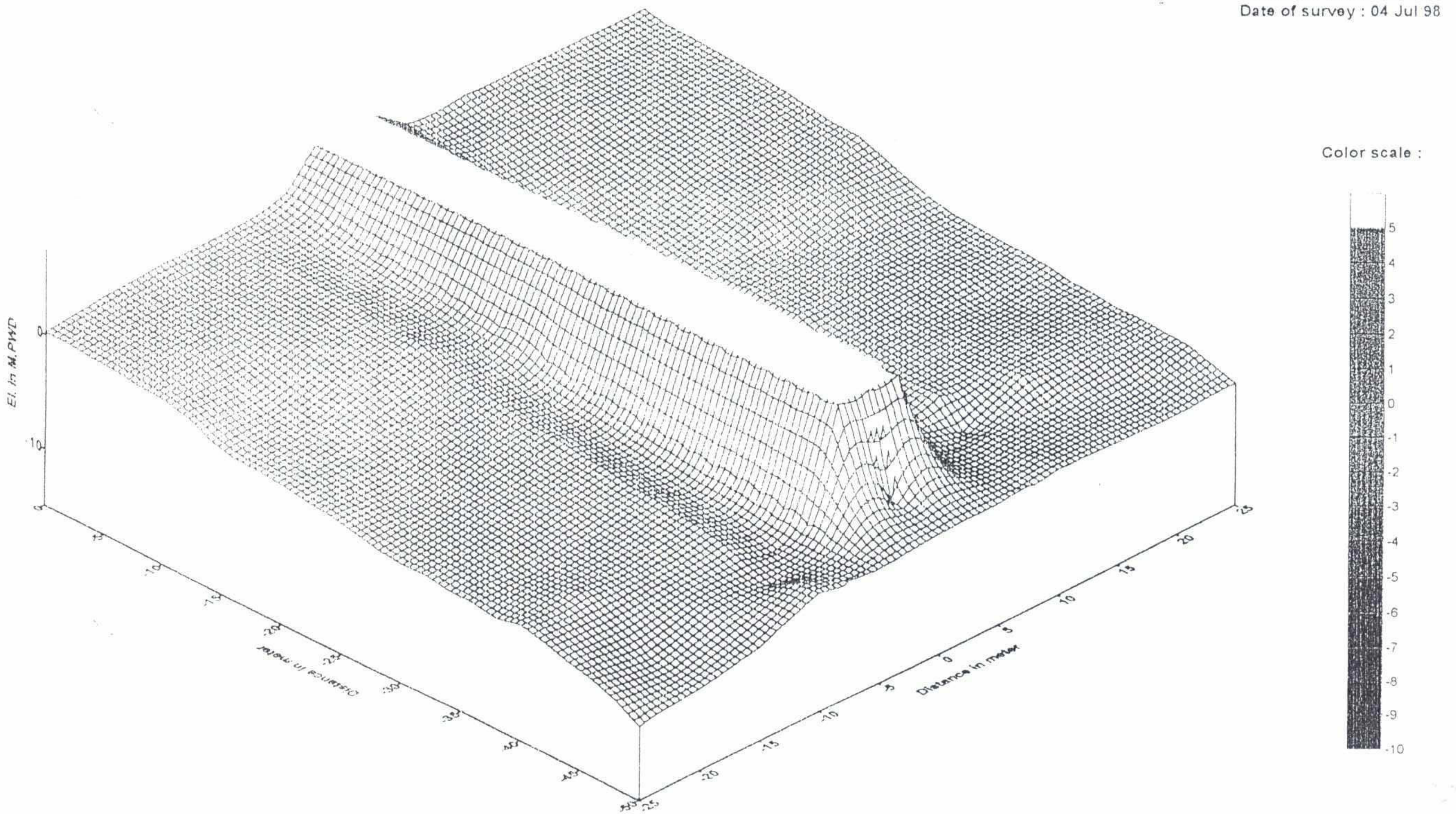


Table - 2

Haimchar Erosion Control Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter PWD
Date of survey : 04 Jul 98



Haimchar Erosion Control Pilot Scheme

Table -

Bed levels around SPUR-1
Levels are in Meter, PWD
Date of survey : 13 Aug 98

2.30	2.40	2.50	2.65	2.65	2.65	2.65	2.65	2.65	2.40	2.40
2.20	1.80	1.80	1.70	1.70	1.80	1.70	2.00	1.80	1.50	1.50
1.35	0.80	0.90	0.00	-0.30	-0.50	-0.40	0.50	0.40	0.30	0.00
-0.90	-0.60	0.00	-1.25	-2.00		-1.90	-0.60	-0.70	-0.10	0.00
-0.70	-1.50	-0.60	-2.10	-1.00		-1.80	-0.75	-1.25	-2.00	0.00
-1.30	-2.50	-2.50	-2.50	-2.90		-2.00	-2.80	-2.00	-4.00	-2.25
-1.50	-3.00	-3.50	-3.00	-2.90		-2.50	-2.75	-2.00	-4.00	-3.00
-2.70	-3.50	-4.00	-3.50	-3.80		-3.00	-2.85	-2.50	-5.00	-3.90
-4.00	-4.20	-4.00	-3.80	-3.80		-3.80	-4.50	-4.50	-5.50	-6.00
-4.00	-4.30	-4.00	-4.90	-3.80		-3.50	-4.80	-3.75	-5.70	-6.10
-4.00	-4.50	-4.50	-5.00	-3.90		-3.50	-4.90	-3.75	-6.00	-5.80
-3.80	-4.60	-5.00	-5.00	-4.00		-3.50	-4.80	-6.00	-6.00	-5.50
-3.90	-4.30	-5.00	-4.90	-3.80		-3.50	-4.35	-6.00	-6.00	-5.30
-4.50	-4.30	-5.10	-5.00	-3.80		-3.60	-4.70	-5.80	-6.30	-5.70
-4.50	-4.80	-5.00	-4.90	-4.50		-3.90	-4.90	-6.00	-6.40	-5.50
-4.50	-5.50	-5.00	-4.90	-4.80	-4.80	-4.30	-4.90	-6.00	-6.50	-5.80
-4.60	-5.80	-5.50	-5.90	-4.90	-5.00	-4.80	-5.30	-7.00	-6.90	-6.80
-5.00	-6.00	-5.60	-6.00	-5.50	-5.40	-4.90	-5.50	-7.30	-6.90	-6.80
-5.10	-5.50	-5.90	-6.00	-5.40	-5.40	-5.00	-6.00	-7.40	-7.00	-7.00
-5.10	-5.80	-5.80	-6.00	-5.30	-5.50	-6.50	-7.30	-7.45	-8.50	-6.90
-5.10	-5.90	-6.10	-6.30	-5.30	-5.50	-6.70	-7.50	-7.85	-8.30	-8.20
-5.50	-5.90	-6.10	-6.50	-5.30	-5.40	-7.00	-8.00	-8.00	-8.40	-8.30
-6.00	-6.20	-6.50	-6.00	-5.40	-5.40	-7.50	-8.00	-8.00	-8.40	-8.50
-6.00	-6.30	-6.80	-5.80	-5.30	-5.40	-7.80	-8.00	-7.90	-8.50	-8.50
-6.70	-6.30	-6.80	-6.00	-6.40	-6.10	-7.90	-8.50	-8.10	-8.90	-9.00
-6.90	-6.50	-6.90	-6.50	-6.30	-7.00	-8.20	-9.00	-8.50	-8.70	-9.50

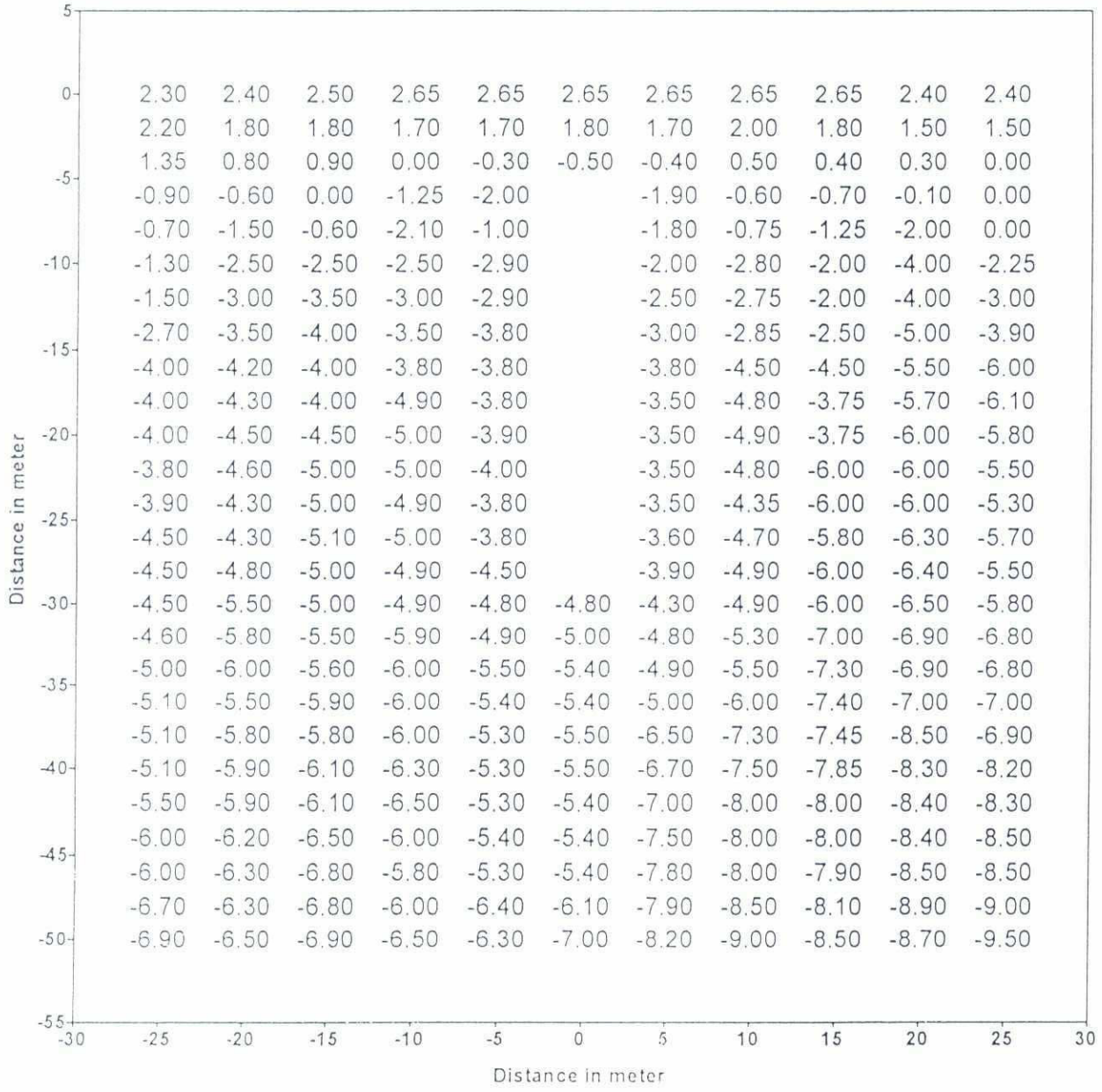
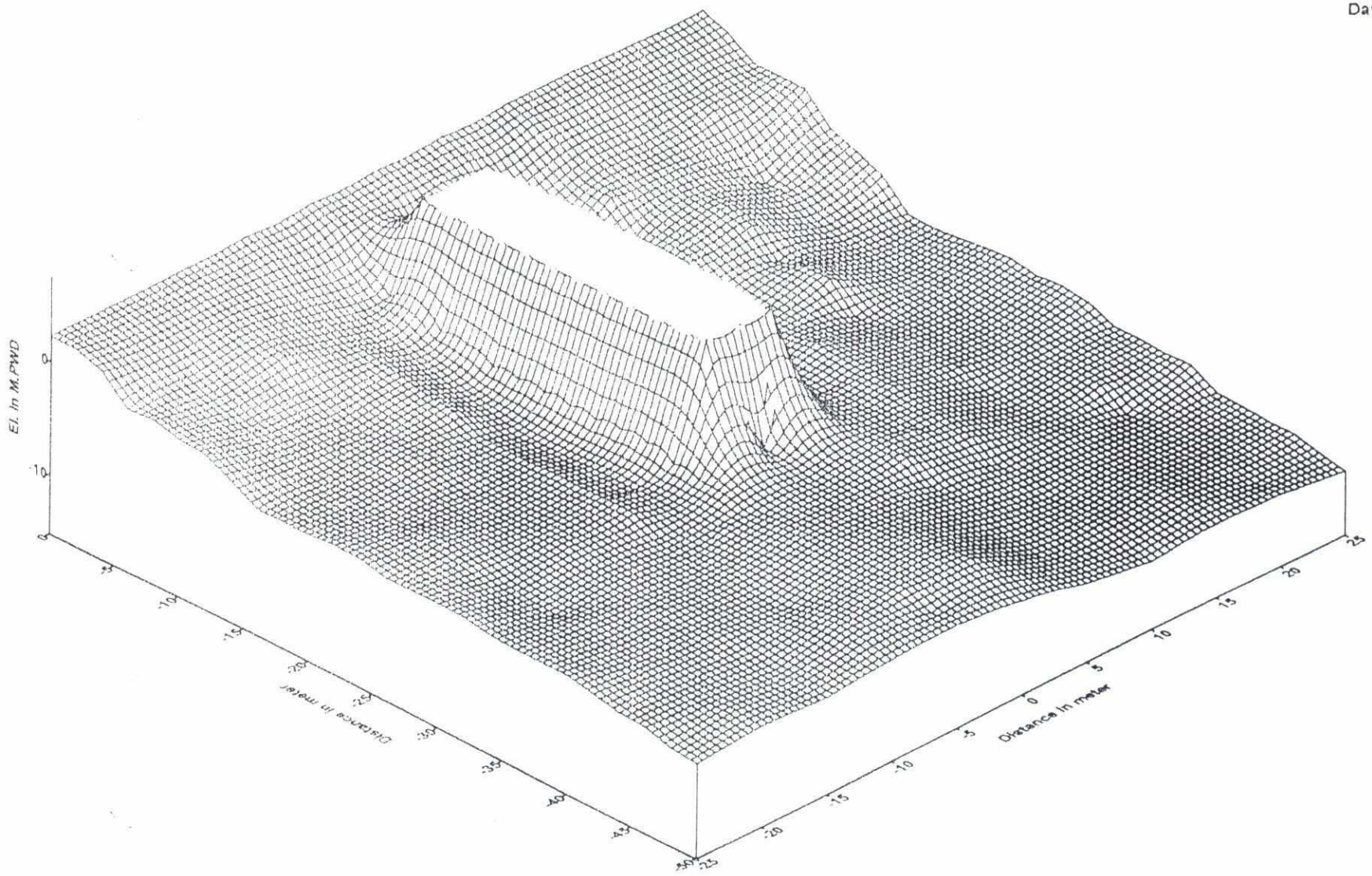


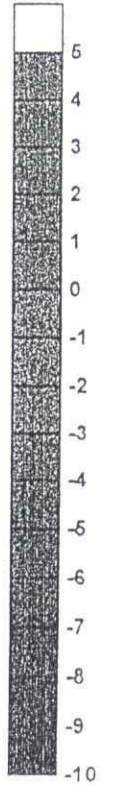
Table - 3

Haimchar Erosion Control Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter PWD
Date of survey : 13 Aug 98



Color scale :



92

Haimchar Erosion Control Pilot Scheme

Table.

Bed levels around SPUR-2
Levels are in Meter, PWD
Date of survey : 14 Aug 98

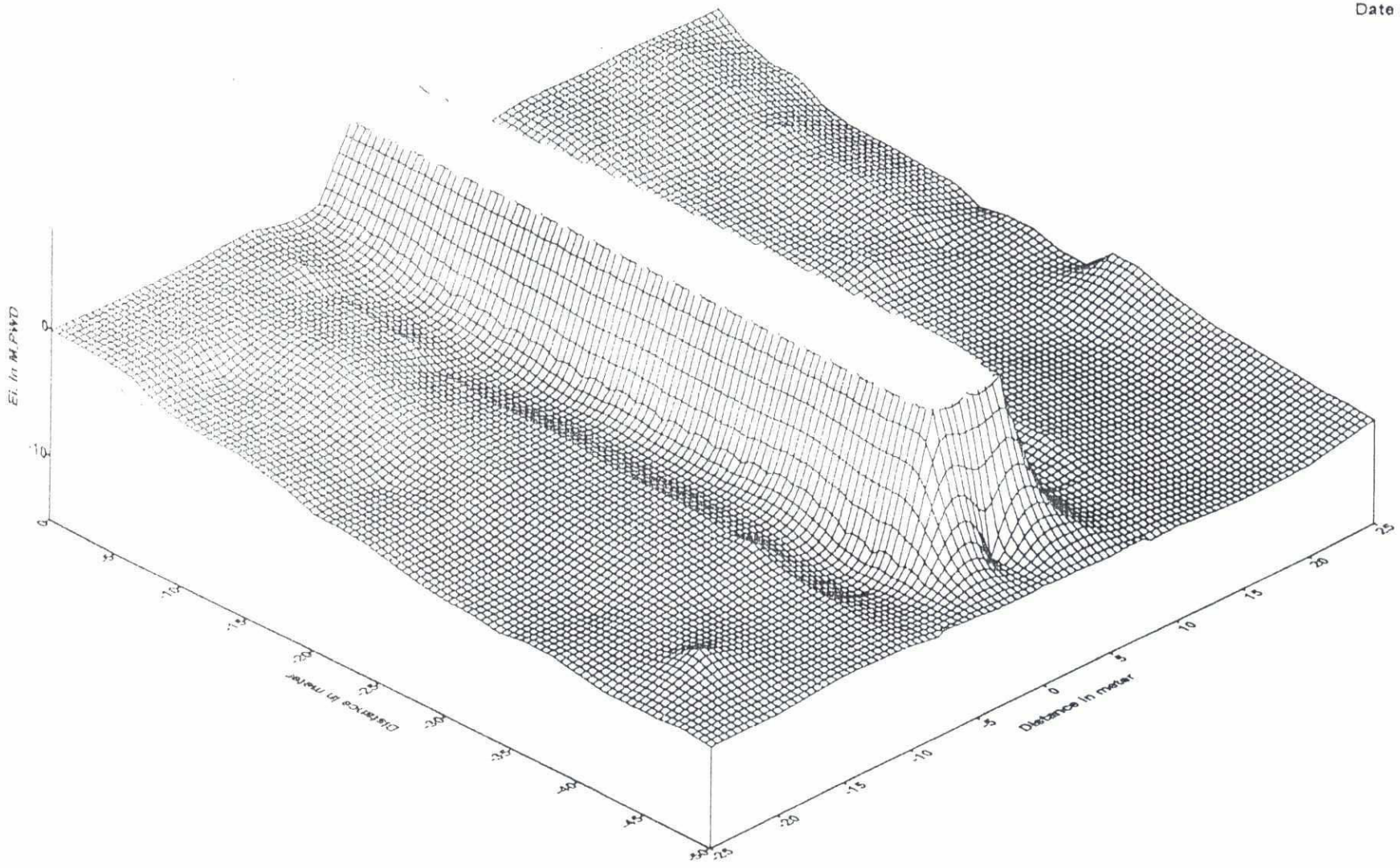
-0.10	-0.30	-0.40	-0.10	-0.60		-0.20	-0.30	-0.40	-0.30	-0.40
-0.20	-0.40	-0.50	-0.60	-0.70		-0.30	-0.40	-0.60	-0.10	-1.90
-0.30	-0.50	-0.50	-0.70	-0.90		-0.80	-0.60	-1.00	-0.70	-2.70
-0.60	-0.50	-0.90	-2.00	-1.25		-1.25	-1.20	-1.25	-1.00	-2.80
-1.70	-2.25	-0.90	-2.00	-2.00		-1.50	-1.75	-2.00	-2.00	-4.00
-2.20	-2.50	-0.90	-2.40	-2.50		-1.75	-2.50	-2.90	-2.00	-4.50
-2.50	-2.50	-1.25	-2.50	-2.50		-2.50	-2.50	-3.00	-2.90	-4.60
-2.50	-3.00	-1.70	-3.90	-3.00		-3.00	-3.00	-3.50	-2.85	-4.70
-3.00	-3.50	-2.50	-3.90	-3.00		-4.00	-3.50	-4.00	-3.00	-4.90
-3.50	-3.90	-3.00	-4.10	-3.50		-4.00	-4.00	-4.10	-3.50	-5.00
-4.30	-4.80	-3.50	-4.00	-3.80		-4.00	-4.25	-4.00	-4.00	-5.90
-4.30	-4.60	-3.90	-4.00	-3.70		-4.50	-4.90	-3.90	-5.50	-5.50
-4.50	-4.50	-3.90	-4.00	-3.60		-4.80	-5.10	-5.10	-5.50	-5.50
-5.00	-5.00	-4.50	-4.28	-4.00		-5.00	-5.50	-5.50	-6.00	-6.10
-5.50	-5.30	-4.50	-4.50	-4.00		-5.00	-5.10	-5.70	-6.10	-6.20
-5.80	-5.60	-4.60	-4.50	-4.10		-4.90	-5.00	-6.00	-6.30	-4.30
-5.90	-5.80	-4.70	-4.50	-4.20		-4.80	-5.00	-6.20	-6.70	-4.30
-6.30	-6.00	-4.80	-4.60	-4.00		-5.00	-5.00	-6.20	-6.90	-5.00
-6.00	-6.30	-5.00	-5.00	-3.90		-5.00	-5.50	-6.30	-6.90	-5.50
-6.10	-6.00	-5.30	-4.70	-4.50		-5.10	-5.60	-6.70	-7.00	-5.90
-6.50	-6.00	-6.00	-5.50	-5.50		-4.80	-5.60	-6.90	-7.10	-6.10
-6.90	-6.00	-6.20	-5.90	-6.00		-3.90	-6.00	-7.00	-7.30	-6.30
-6.90	-4.90	-6.30	-6.00	-6.00		-5.00	-6.50	-7.50	-7.50	-6.50
-6.90	-6.10	-6.50	-6.30	-6.50	-6.90	-5.50	-6.90	-8.00	-7.60	-6.70
-6.70	-6.70	-6.50	-6.50	-6.80	-7.00	-6.00	-7.30	-8.00	-7.80	-6.70
-7.00	-7.00	-6.50	-6.70	-6.90	-7.00	-7.28	-7.50	-8.00	-7.90	-6.90

Distance in meter

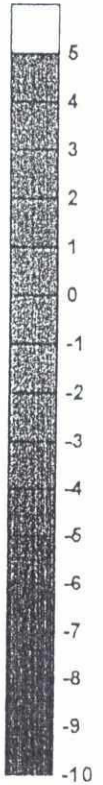
Table - 4

Haimchar Erosion Control Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter PWD
Date of survey : 14 Aug 98



Color scale :



Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter, PWD
Date of survey : 11 Jun 98

5											
0	2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
	2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
-5	1.97	1.97	2.03	2.03	2.13		2.23	2.23	2.03	2.03	2.03
	1.97	1.97	2.03	2.03	2.13		2.23	2.23	2.03	2.03	2.03
	1.97	1.97	2.03	1.43	2.13		2.23	2.03	1.83	1.93	1.93
-10	1.67	1.37	1.73	1.33	1.43		1.93	1.83	1.43	1.43	1.63
	1.57	1.27	1.43	0.93	1.43		1.33	0.93	1.03	1.33	1.43
	1.57	1.17	1.13	0.63	1.03		1.33	1.33	1.03	1.13	1.43
-15	0.67	0.87	0.93	0.53	0.73		1.33	1.33	0.83	1.13	1.33
	0.47	0.87	-0.13	0.23	0.33		0.43	0.83	0.13	0.83	0.93
-20	0.07	0.67	-0.13	0.23	0.39		0.43	0.83	0.13	0.63	0.93
	-0.33	0.47	-0.53	-0.23	0.13		-0.43	0.03	-0.43	0.43	0.63
	-0.33	0.17	-0.53	-0.23	-0.43		-0.43	-0.13	-0.63	0.13	0.63
-25	-0.33	-0.43	-0.63	-0.23	-0.63		-0.53	-0.63	-0.93	-0.23	0.43
	-0.43	-0.53	-0.63	-0.43	-0.63		-0.63	-0.93	-1.03	-0.43	-0.13
-30	-0.53	-0.53	-0.73	-0.43	-0.43		-0.63	-0.93	-1.03	-0.93	-0.43
	-0.53	-0.63	-0.73	-0.43	-1.03		-0.63	-1.03	-1.03	-0.93	-0.53
	-0.63	-0.63	-0.83	-0.43	-0.93		-0.93	-1.03	-1.03	-0.93	-0.83
-35	-0.43	-0.83	-0.83	-1.03	-0.93	-1.03	-1.43	-1.83	-1.63	-1.33	-1.13
	-0.93	-0.83	-0.93	-1.43	-0.93	-1.93	-1.63	-1.93	-1.93	-1.63	-1.43
-40	-1.03	-1.03	-1.23	-1.73	-1.73	-1.93	-1.93	-1.93	-2.43	-1.73	-1.83
	-1.33	-1.33	-1.63	-1.83	-1.93	-2.03	-2.93	-1.93	-2.43	-1.73	-1.93
	-1.63	-1.63	-1.43	-1.83	-2.13	-3.13	-2.63	-2.73	-3.43	-1.93	-2.13
-45	-1.93	-1.93	-2.73	-2.13	-2.93	-3.63	-3.63	-3.43	-3.83	-2.43	-2.63
	-2.33	-2.43	-3.13	-2.93	-3.43	-3.63	-3.63	-3.83	-3.83	-2.93	-2.93
-50	-3.43	-3.63	-3.93	-3.93	-3.63	-3.63	-3.83	-4.03	-3.83	-3.13	-2.93
-55											

Distance in meter

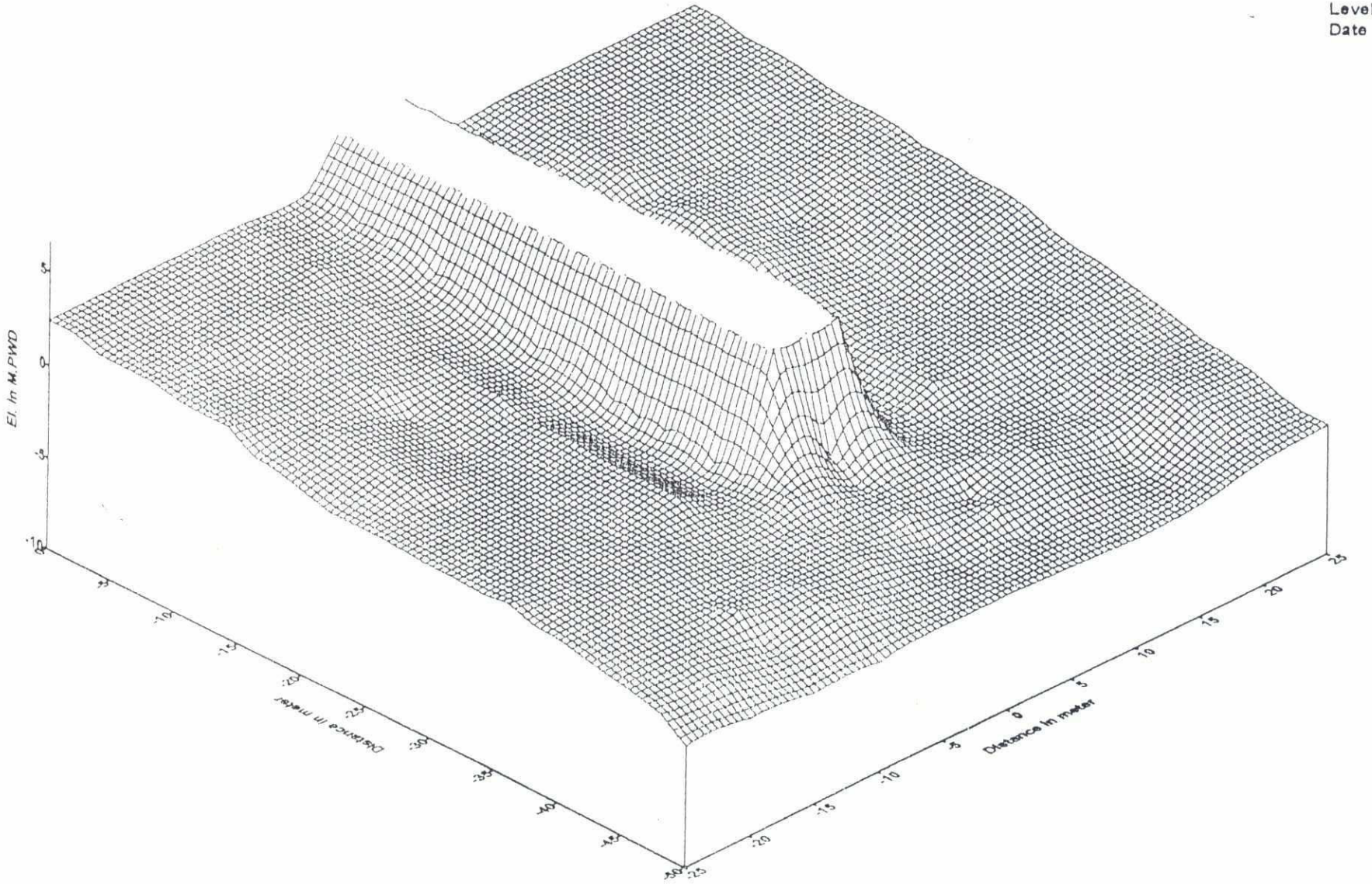
-30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30

Distance in meter

Table - 5

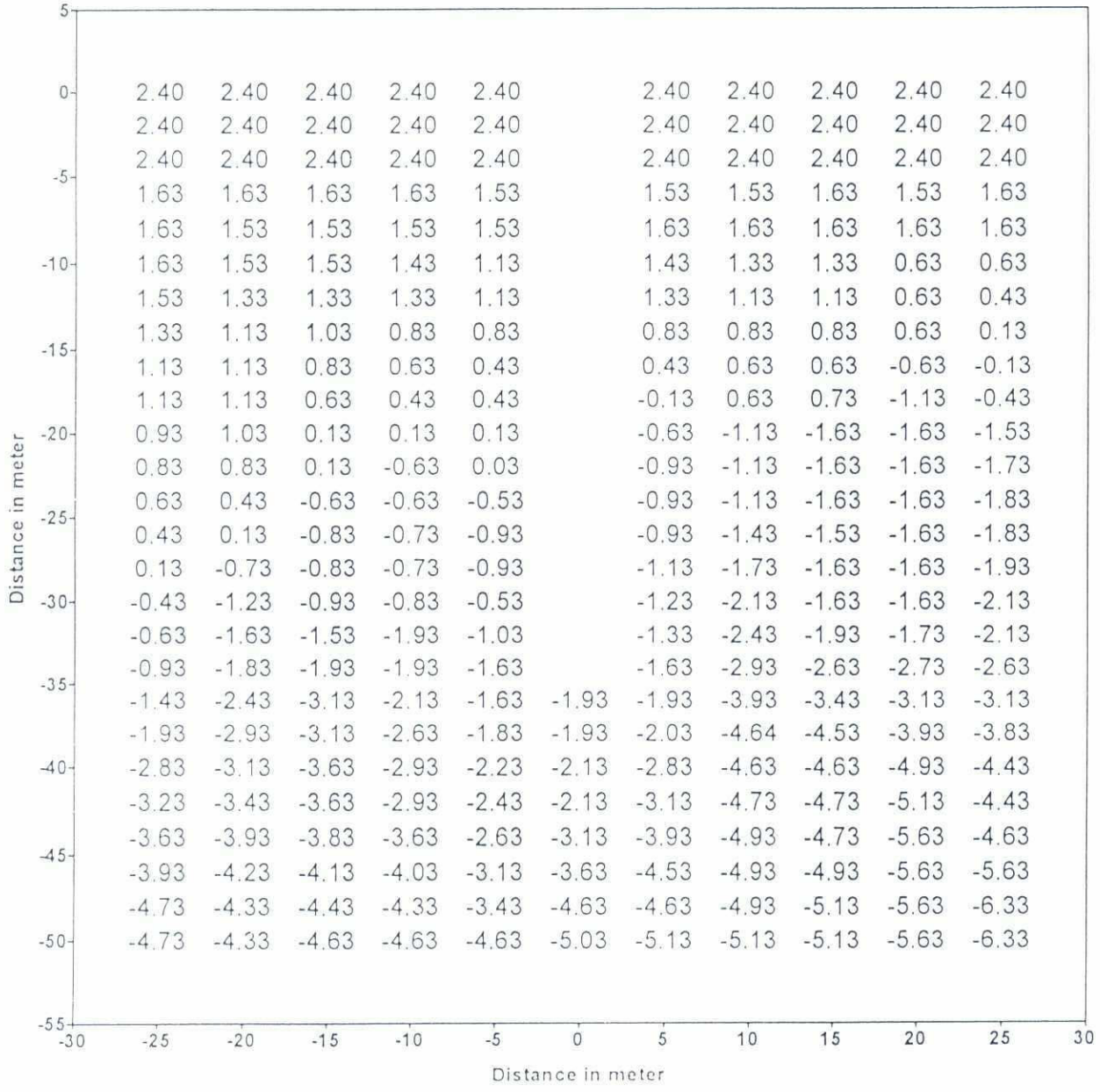
Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter PWD
Date of survey : 11 Jun 98



Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter, PWD
Date of survey : 12 Jun 98

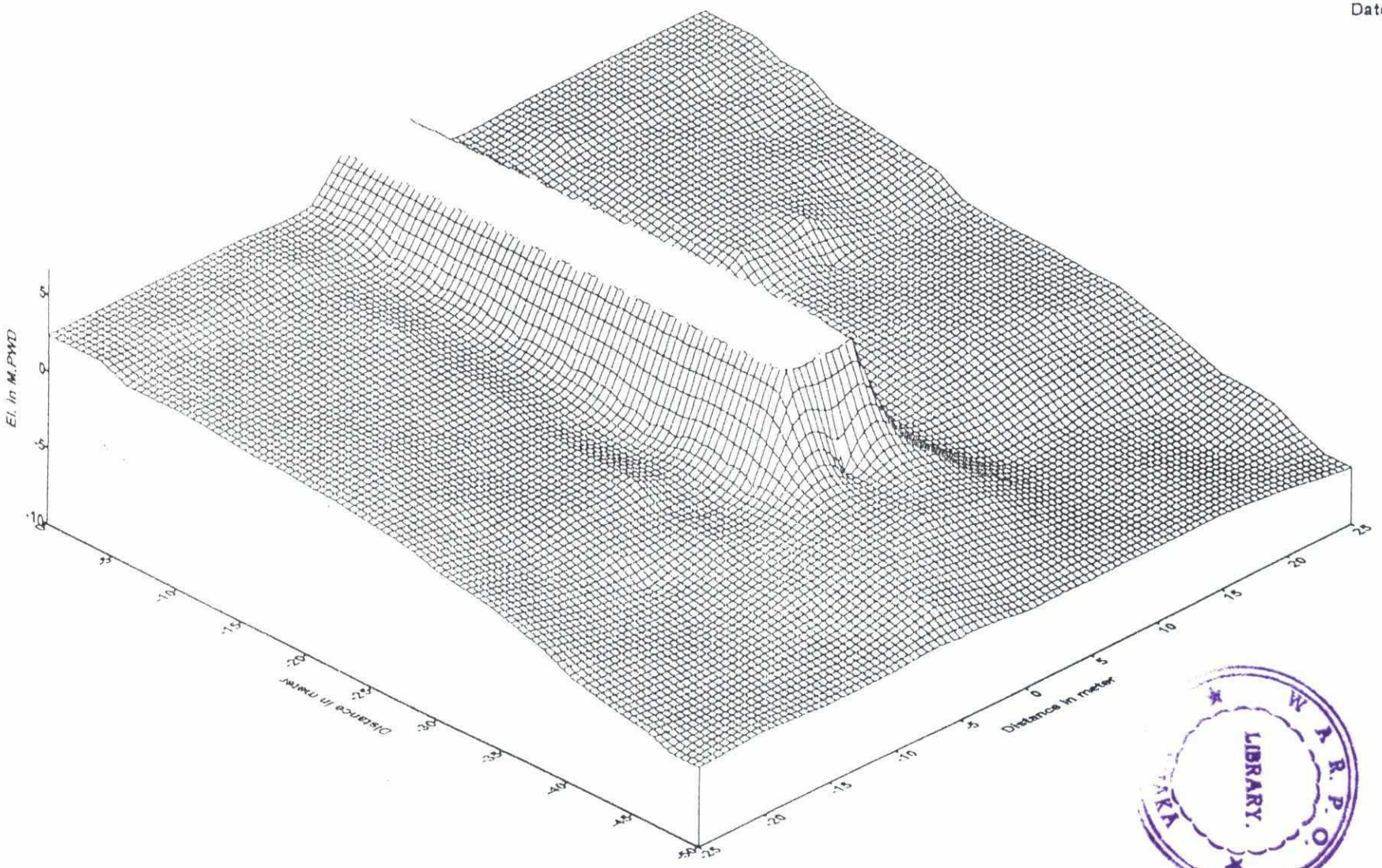


2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
1.63	1.63	1.63	1.63	1.53		1.53	1.53	1.63	1.53	1.63
1.63	1.53	1.53	1.53	1.53		1.63	1.63	1.63	1.63	1.63
1.63	1.53	1.53	1.43	1.13		1.43	1.33	1.33	0.63	0.63
1.53	1.33	1.33	1.33	1.13		1.33	1.13	1.13	0.63	0.43
1.33	1.13	1.03	0.83	0.83		0.83	0.83	0.83	0.63	0.13
1.13	1.13	0.83	0.63	0.43		0.43	0.63	0.63	-0.63	-0.13
1.13	1.13	0.63	0.43	0.43		-0.13	0.63	0.73	-1.13	-0.43
0.93	1.03	0.13	0.13	0.13		-0.63	-1.13	-1.63	-1.63	-1.53
0.83	0.83	0.13	-0.63	0.03		-0.93	-1.13	-1.63	-1.63	-1.73
0.63	0.43	-0.63	-0.63	-0.53		-0.93	-1.13	-1.63	-1.63	-1.83
0.43	0.13	-0.83	-0.73	-0.93		-0.93	-1.43	-1.53	-1.63	-1.83
0.13	-0.73	-0.83	-0.73	-0.93		-1.13	-1.73	-1.63	-1.63	-1.93
-0.43	-1.23	-0.93	-0.83	-0.53		-1.23	-2.13	-1.63	-1.63	-2.13
-0.63	-1.63	-1.53	-1.93	-1.03		-1.33	-2.43	-1.93	-1.73	-2.13
-0.93	-1.83	-1.93	-1.93	-1.63		-1.63	-2.93	-2.63	-2.73	-2.63
-1.43	-2.43	-3.13	-2.13	-1.63	-1.93	-1.93	-3.93	-3.43	-3.13	-3.13
-1.93	-2.93	-3.13	-2.63	-1.83	-1.93	-2.03	-4.64	-4.53	-3.93	-3.83
-2.83	-3.13	-3.63	-2.93	-2.23	-2.13	-2.83	-4.63	-4.63	-4.93	-4.43
-3.23	-3.43	-3.63	-2.93	-2.43	-2.13	-3.13	-4.73	-4.73	-5.13	-4.43
-3.63	-3.93	-3.83	-3.63	-2.63	-3.13	-3.93	-4.93	-4.73	-5.63	-4.63
-3.93	-4.23	-4.13	-4.03	-3.13	-3.63	-4.53	-4.93	-4.93	-5.63	-5.63
-4.73	-4.33	-4.43	-4.33	-3.43	-4.63	-4.63	-4.93	-5.13	-5.63	-6.33
-4.73	-4.33	-4.63	-4.63	-4.63	-5.03	-5.13	-5.13	-5.13	-5.63	-6.33

Table - 6

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter PWD
Date of survey : 12 Jun 98



Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-3
Levels are in Meter, PWD
Date of survey : 13 Jun 98

5											
0	2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
	2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
	2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
-5	1.95	1.95	1.95	1.95	1.85		1.85	1.95	1.75	1.75	1.85
	1.95	1.85	1.85	1.85	1.75		1.75	1.85	1.85	1.85	1.85
-10	1.65	1.55	1.45	1.45	1.45		1.45	1.65	1.45	1.25	1.25
	1.35	1.05	1.25	1.15	0.85		1.45	1.45	1.15	0.75	1.25
	0.95	1.05	1.25	0.85	0.85		1.05	1.15	0.45	0.65	1.05
-15	0.15	1.05	0.25	0.45	1.05		1.05	1.15	0.45	0.55	0.65
	-0.65	0.15	0.25	0.15	0.05		1.05	0.85	0.05	0.45	0.25
-20	-1.65	0.05	-1.45	-1.45	0.05		0.95	0.35	0.05	0.05	0.35
	-1.65	-1.45	-1.55	-1.45	-1.75		0.75	0.05	0.05	0.15	0.05
	-1.75	-1.65	-1.55	-2.15	-1.75		0.65	0.05	-1.45	-1.15	-1.05
-25	-1.95	-1.65	-1.95	-2.25	-2.35		0.15	-0.75	-2.05	-2.05	-2.35
	-2.15	-1.85	-2.25	-3.05	-2.85		0.05	-1.15	-2.05	-3.25	-2.65
-30	-2.15	-2.15	-2.75	-4.15	-3.95		-0.85	-1.25	-2.15	-3.35	-2.95
	-2.35	-2.15	-3.15	-4.45	-4.15		-1.45	-1.55	-2.45	-3.45	-2.95
	-3.15	-3.05	-3.45	-4.35	-4.35		-2.25	-1.85	-2.95	-3.95	-3.15
-35	-4.45	-3.95	-4.15	-4.55	-4.95	-3.95	-3.45	-2.75	-3.45	-4.15	-3.95
	-4.55	-4.65	-4.65	-4.95	-4.95	-3.95	-3.45	-3.45	-4.65	-4.85	-4.35
-40	-4.65	-4.95	-5.35	-5.45	-5.25	-3.95	-3.45	-3.95	-5.25	-5.65	-5.25
	-4.75	-5.05	-5.35	-6.05	-5.65	-4.05	-3.95	-4.95	-5.95	-5.85	-5.65
	-5.65	-5.45	-5.85	-6.05	-5.85	-4.85	-4.95	-5.65	-6.15	-5.95	-5.95
-45	-5.85	-5.95	-5.95	-6.15	-6.25	-4.85	-5.65	-5.95	-6.15	-6.35	-6.15
	-6.15	-6.15	-6.15	-6.35	-6.45	-6.15	-5.85	-5.95	-6.05	-6.35	-6.15
-50	-6.45	-6.35	-6.35	-6.65	-6.75	-6.45	-5.95	-6.15	-6.35	-6.35	-6.25
-55											

Distance in meter

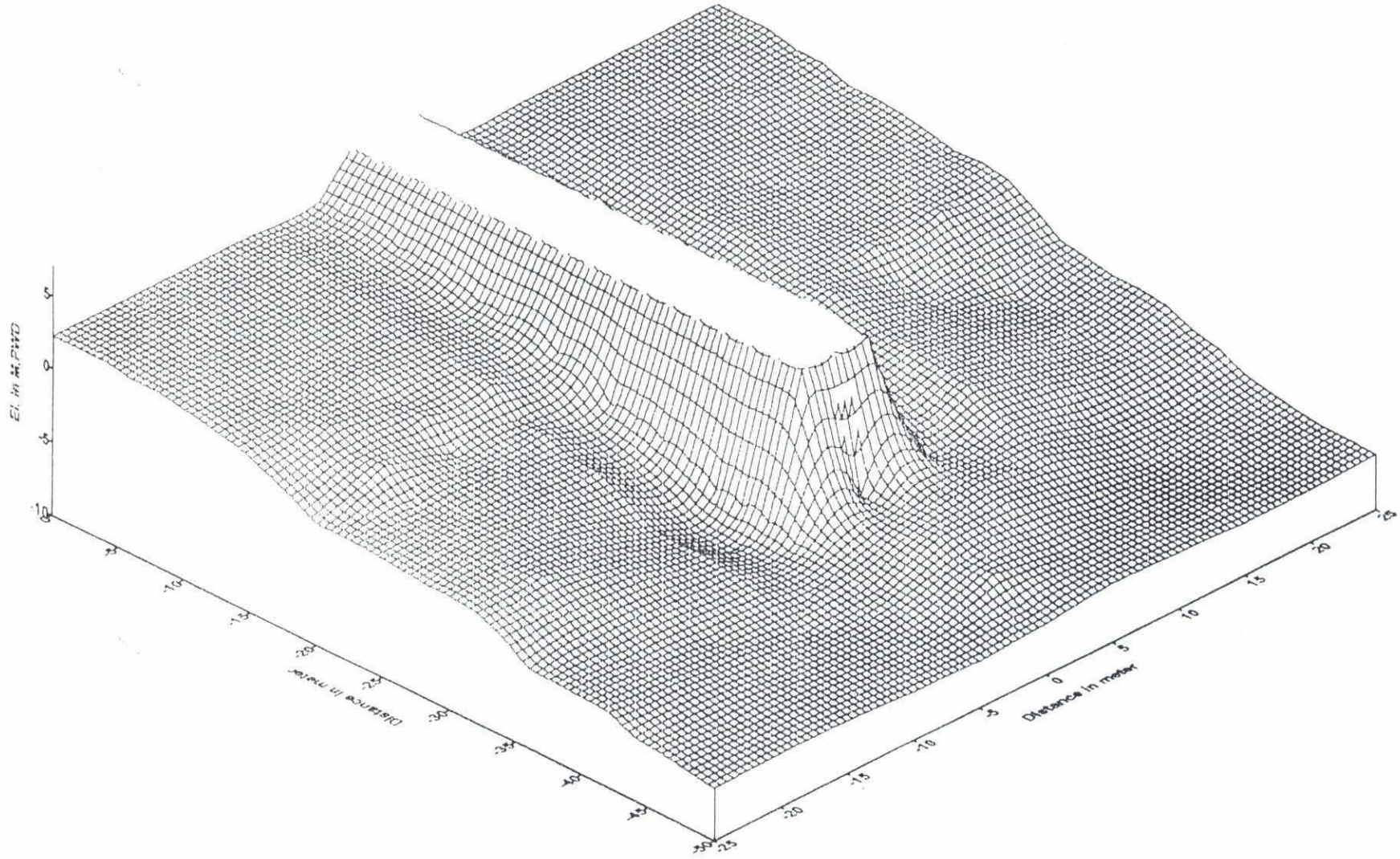
-30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30

Distance in meter

Table - 7

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-3
Levels are in Meter PWD
Date of survey : 13 Jun 98

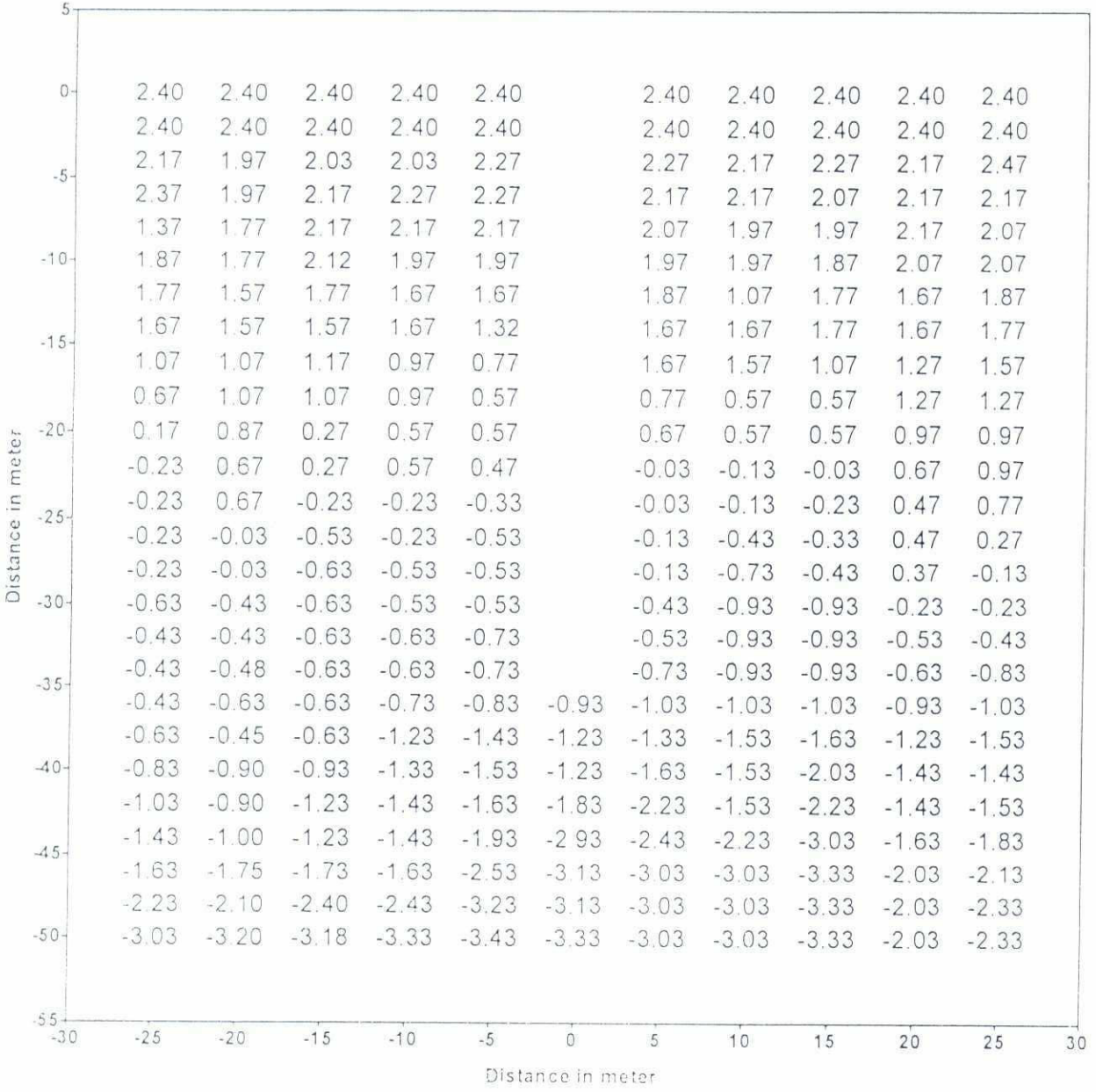


Color scale :

5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter, PWD
Date of survey : 23 Jul 98

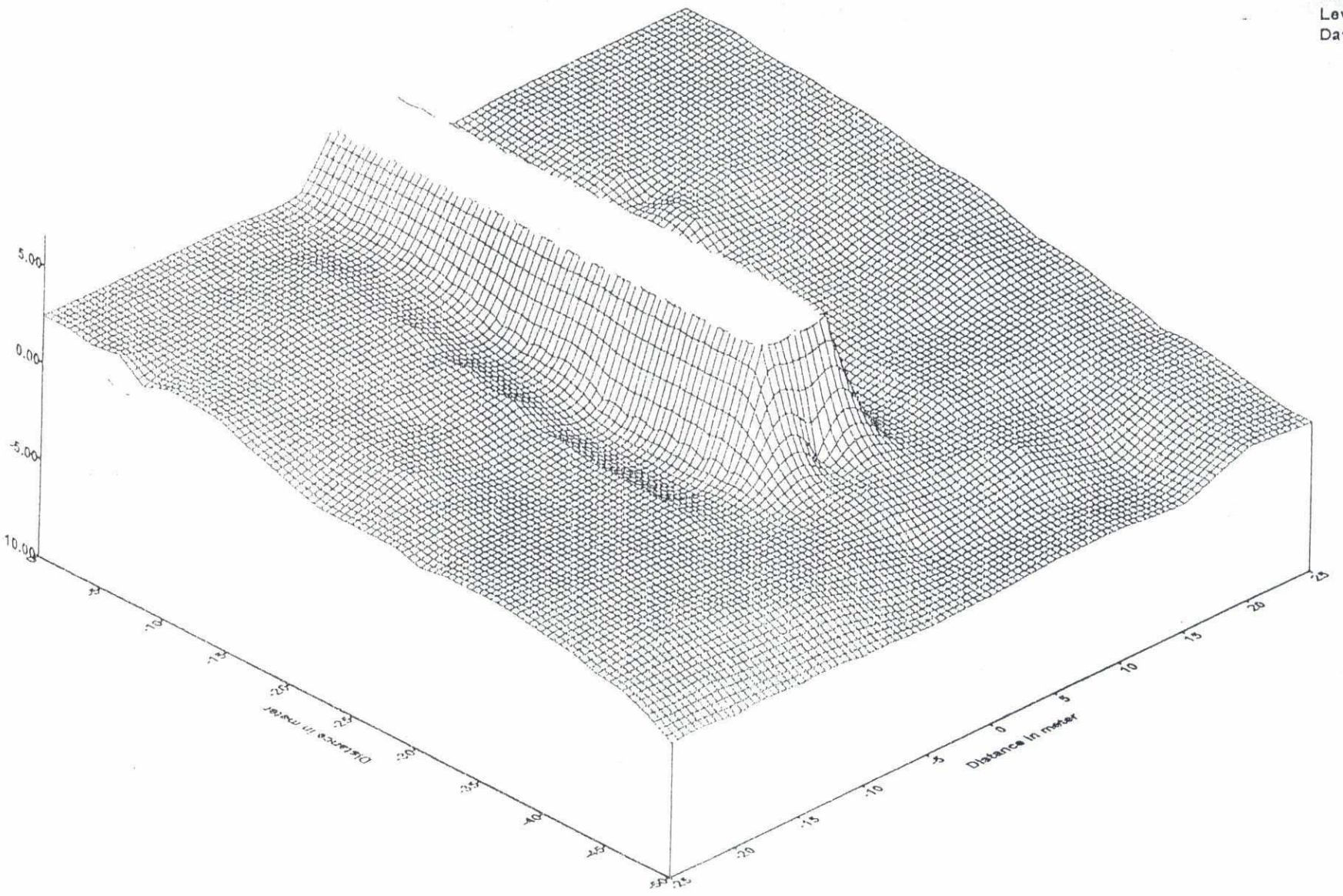


2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
2.17	1.97	2.03	2.03	2.27		2.27	2.17	2.27	2.17	2.47
2.37	1.97	2.17	2.27	2.27		2.17	2.17	2.07	2.17	2.17
1.37	1.77	2.17	2.17	2.17		2.07	1.97	1.97	2.17	2.07
1.87	1.77	2.12	1.97	1.97		1.97	1.97	1.87	2.07	2.07
1.77	1.57	1.77	1.67	1.67		1.87	1.07	1.77	1.67	1.87
1.67	1.57	1.57	1.67	1.32		1.67	1.67	1.77	1.67	1.77
1.07	1.07	1.17	0.97	0.77		1.67	1.57	1.07	1.27	1.57
0.67	1.07	1.07	0.97	0.57		0.77	0.57	0.57	1.27	1.27
0.17	0.87	0.27	0.57	0.57		0.67	0.57	0.57	0.97	0.97
-0.23	0.67	0.27	0.57	0.47		-0.03	-0.13	-0.03	0.67	0.97
-0.23	0.67	-0.23	-0.23	-0.33		-0.03	-0.13	-0.23	0.47	0.77
-0.23	-0.03	-0.53	-0.23	-0.53		-0.13	-0.43	-0.33	0.47	0.27
-0.23	-0.03	-0.63	-0.53	-0.53		-0.13	-0.73	-0.43	0.37	-0.13
-0.63	-0.43	-0.63	-0.53	-0.53		-0.43	-0.93	-0.93	-0.23	-0.23
-0.43	-0.43	-0.63	-0.63	-0.73		-0.53	-0.93	-0.93	-0.53	-0.43
-0.43	-0.48	-0.63	-0.63	-0.73		-0.73	-0.93	-0.93	-0.63	-0.83
-0.43	-0.63	-0.63	-0.73	-0.83	-0.93	-1.03	-1.03	-1.03	-0.93	-1.03
-0.63	-0.45	-0.63	-1.23	-1.43	-1.23	-1.33	-1.53	-1.63	-1.23	-1.53
-0.83	-0.90	-0.93	-1.33	-1.53	-1.23	-1.63	-1.53	-2.03	-1.43	-1.43
-1.03	-0.90	-1.23	-1.43	-1.63	-1.83	-2.23	-1.53	-2.23	-1.43	-1.53
-1.43	-1.00	-1.23	-1.43	-1.93	-2.93	-2.43	-2.23	-3.03	-1.63	-1.83
-1.63	-1.75	-1.73	-1.63	-2.53	-3.13	-3.03	-3.03	-3.33	-2.03	-2.13
-2.23	-2.10	-2.40	-2.43	-3.23	-3.13	-3.03	-3.03	-3.33	-2.03	-2.33
-3.03	-3.20	-3.18	-3.33	-3.43	-3.33	-3.03	-3.03	-3.33	-2.03	-2.33

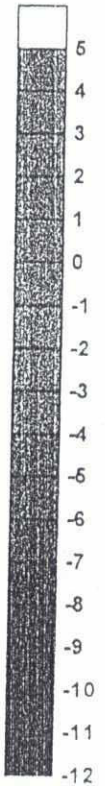
Table - 8

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter PWD
Date of survey : 23 Jul 98



Color scale :



9a2

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter, PWD
Date of survey : 24 Jul 98

5											
0	2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
	2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
-5	2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
	0.98	2.18	2.18	1.65	1.91		1.53	1.53	1.63	1.53	1.63
	1.97	1.97	1.68	1.68	1.62		1.93	1.93	1.74	1.82	1.74
-10	1.97	1.87	1.87	1.68	1.43		1.93	1.93	1.62	0.92	0.89
	1.76	1.57	1.62	1.62	1.32		1.93	1.84	1.00	0.92	0.62
	1.66	1.32	1.43	1.13	1.01		0.96	-1.03	-1.24	-0.34	0.26
-15	1.47	1.13	0.94	0.94	0.76		0.87	-0.94	-1.24	-0.44	-0.23
	1.37	1.37	0.94	0.74	0.76		-0.14	-0.83	-1.43	-0.83	-0.63
-20	1.37	1.34	0.44	0.34	0.37		-0.23	-0.83	-1.13	-1.34	-1.24
	1.37	0.94	0.63	-0.44	0.37		-0.63	-0.63	-0.74	-1.34	-1.34
	0.96	0.63	-0.83	-0.44	-0.44		-0.83	-0.63	-0.63	-1.34	-1.43
-25	0.76	0.83	-0.63	-0.63	-0.63		-0.83	-1.03	-0.94	-0.94	-1.24
	0.47	-0.74	-0.63	-0.63	-0.63		-0.93	-1.03	-0.94	-0.94	-0.83
-30	-0.06	-0.94	-0.94	-0.63	-0.83		-0.93	-1.84	-1.13	-1.24	-0.83
	-0.34	-1.34	-1.43	-1.53	-0.83		-1.23	-2.13	-1.53	-1.13	-1.24
	-1.24	-1.53	-1.43	-1.43	-1.13		-1.34	-2.93	-2.63	-2.93	-1.43
-35	-1.63	-1.93	-1.93	-1.74	-1.13	-1.63	-1.63	-3.84	-3.23	-3.35	-2.04
	-1.84	-2.93	-2.93	-1.84	-1.24	-1.63	-1.63	-4.24	-4.24	-4.64	-4.03
-40	-2.23	-2.93	-2.93	-2.34	-1.63	-1.93	-1.74	-4.24	-4.14	-4.74	-4.03
	-2.84	-2.93	-2.93	-2.34	-1.84	-2.73	-2.54	-4.53	-4.53	-4.84	-4.24
	-3.34	-3.84	-3.43	-3.43	-2.13	-3.73	-2.73	-4.53	-4.53	-5.74	-4.34
-45	-4.34	-4.03	-3.93	-3.73	-2.93	-4.34	-4.14	-4.53	-4.43	-5.74	-6.43
	-4.43	-4.03	-4.03	-4.03	-3.13	-4.74	-4.64	-4.84	-4.64	-5.74	-6.74
-50	-4.43	-4.03	-4.32	-4.24	-4.34	-4.74	-4.84	-4.84	-4.84	-5.14	-6.74
-55											

Distance in meter

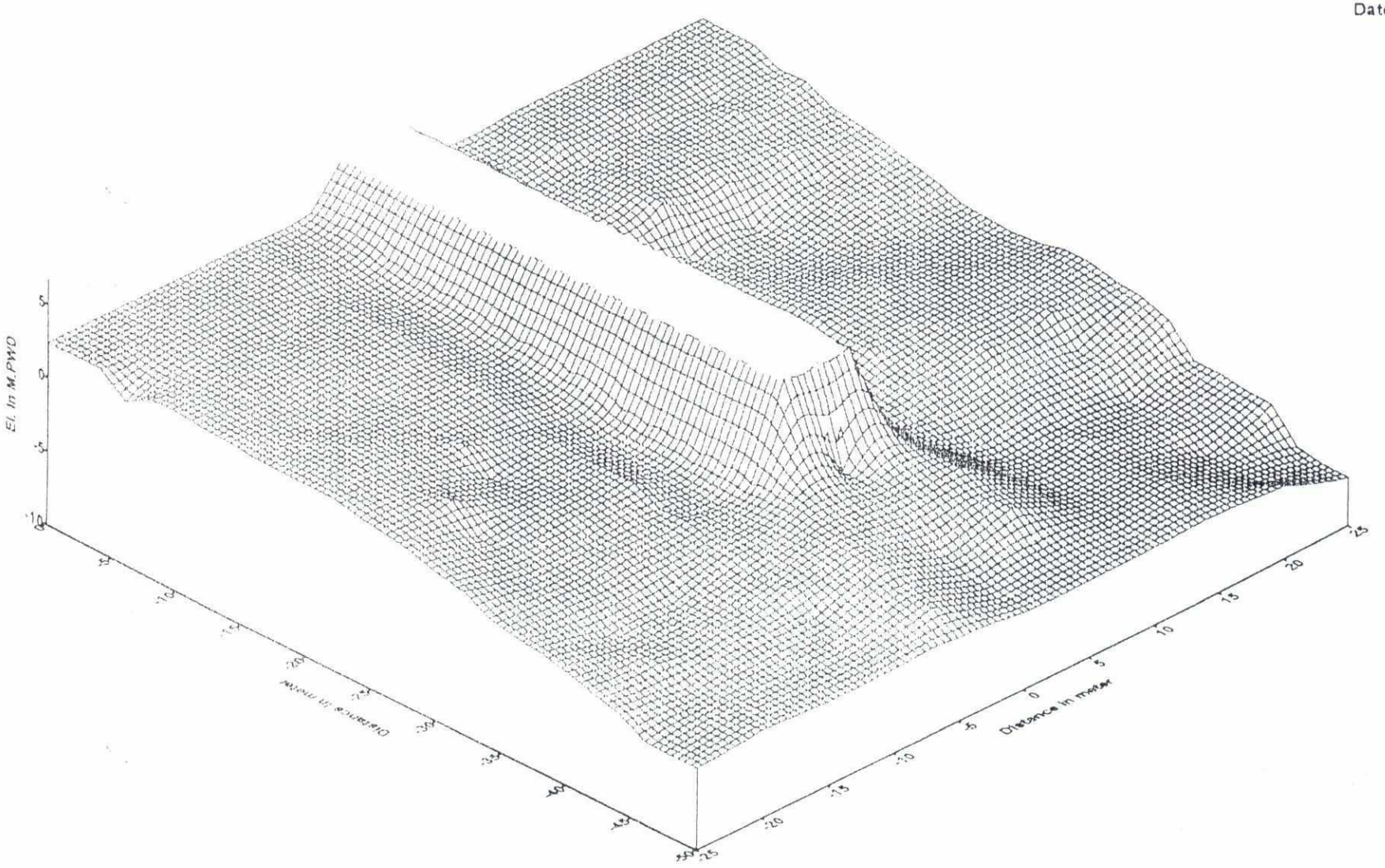
-30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30

Distance in meter

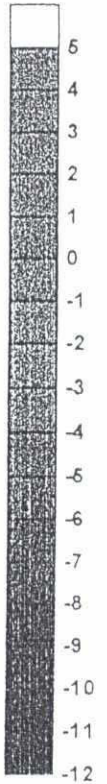
Table - 9

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter PWD
Date of survey : 24 Jul 98

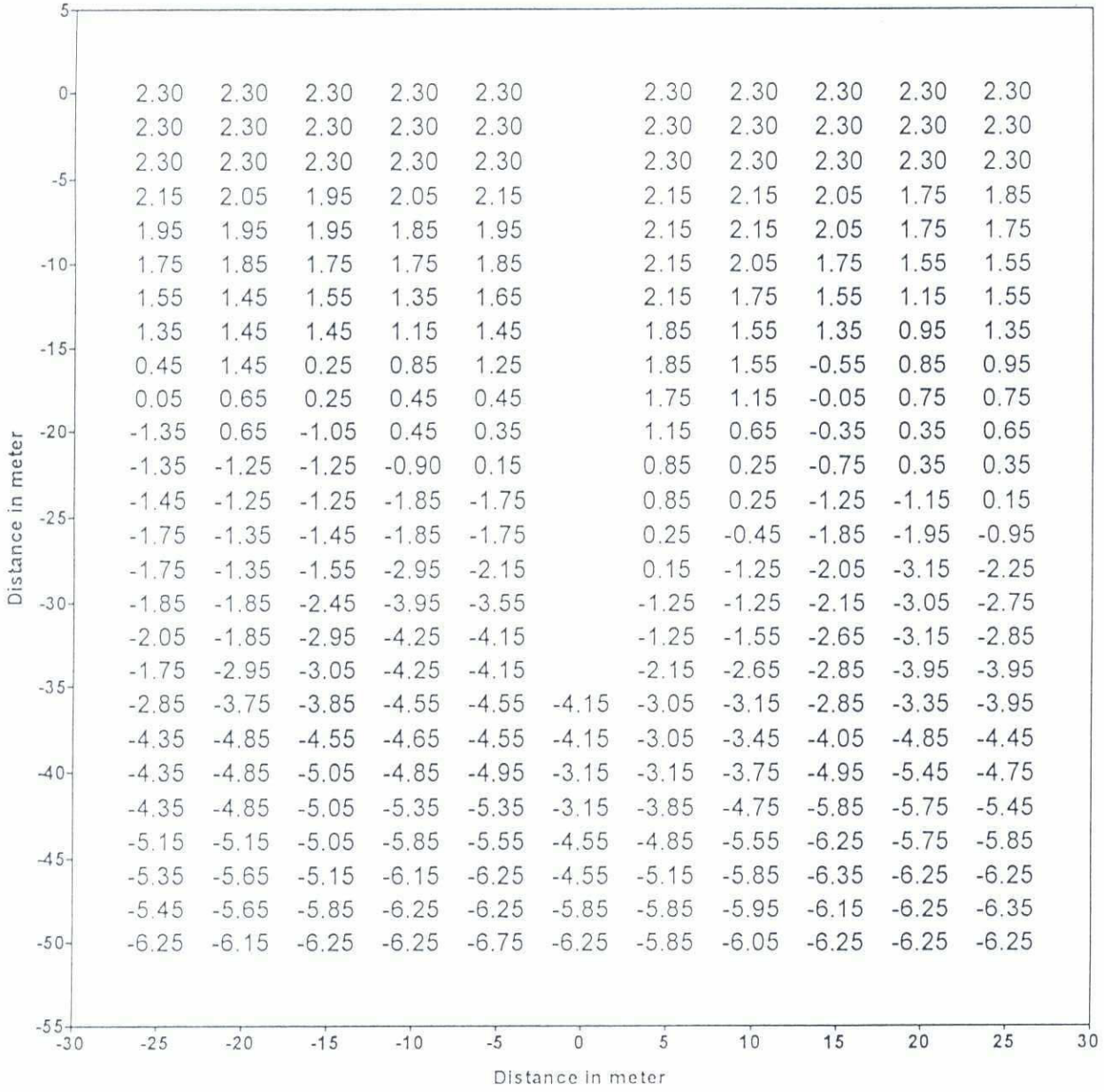


Color scale :



Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-3
Levels are in Meter, PWD
Date of survey : 28 Jul 98

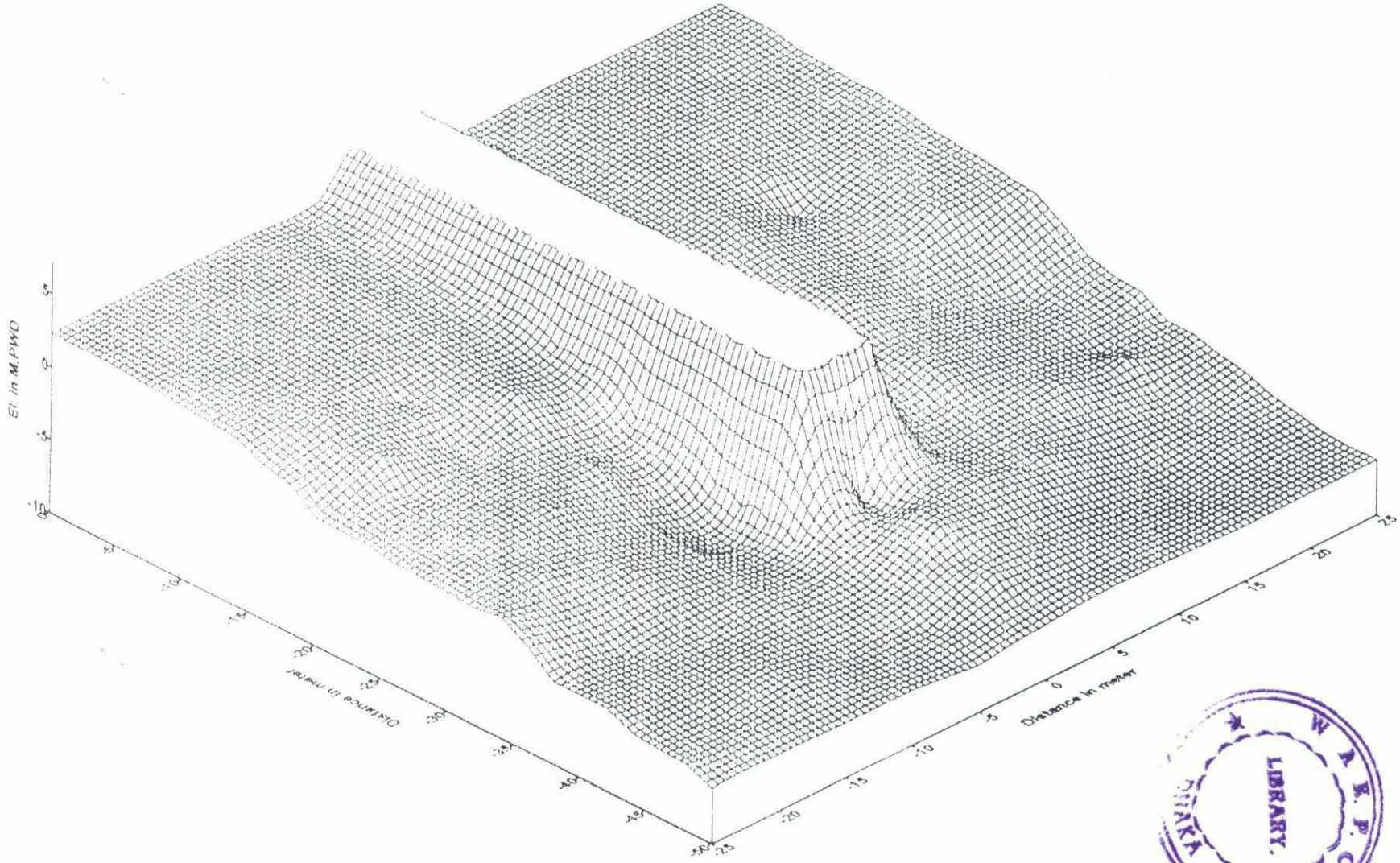


2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
2.15	2.05	1.95	2.05	2.15		2.15	2.15	2.05	1.75	1.85
1.95	1.95	1.95	1.85	1.95		2.15	2.15	2.05	1.75	1.75
1.75	1.85	1.75	1.75	1.85		2.15	2.05	1.75	1.55	1.55
1.55	1.45	1.55	1.35	1.65		2.15	1.75	1.55	1.15	1.55
1.35	1.45	1.45	1.15	1.45		1.85	1.55	1.35	0.95	1.35
0.45	1.45	0.25	0.85	1.25		1.85	1.55	-0.55	0.85	0.95
0.05	0.65	0.25	0.45	0.45		1.75	1.15	-0.05	0.75	0.75
-1.35	0.65	-1.05	0.45	0.35		1.15	0.65	-0.35	0.35	0.65
-1.35	-1.25	-1.25	-0.90	0.15		0.85	0.25	-0.75	0.35	0.35
-1.45	-1.25	-1.25	-1.85	-1.75		0.85	0.25	-1.25	-1.15	0.15
-1.75	-1.35	-1.45	-1.85	-1.75		0.25	-0.45	-1.85	-1.95	-0.95
-1.75	-1.35	-1.55	-2.95	-2.15		0.15	-1.25	-2.05	-3.15	-2.25
-1.85	-1.85	-2.45	-3.95	-3.55		-1.25	-1.25	-2.15	-3.05	-2.75
-2.05	-1.85	-2.95	-4.25	-4.15		-1.25	-1.55	-2.65	-3.15	-2.85
-1.75	-2.95	-3.05	-4.25	-4.15		-2.15	-2.65	-2.85	-3.95	-3.95
-2.85	-3.75	-3.85	-4.55	-4.55	-4.15	-3.05	-3.15	-2.85	-3.35	-3.95
-4.35	-4.85	-4.55	-4.65	-4.55	-4.15	-3.05	-3.45	-4.05	-4.85	-4.45
-4.35	-4.85	-5.05	-4.85	-4.95	-3.15	-3.15	-3.75	-4.95	-5.45	-4.75
-4.35	-4.85	-5.05	-5.35	-5.35	-3.15	-3.85	-4.75	-5.85	-5.75	-5.45
-5.15	-5.15	-5.05	-5.85	-5.55	-4.55	-4.85	-5.55	-6.25	-5.75	-5.85
-5.35	-5.65	-5.15	-6.15	-6.25	-4.55	-5.15	-5.85	-6.35	-6.25	-6.25
-5.45	-5.65	-5.85	-6.25	-6.25	-5.85	-5.85	-5.95	-6.15	-6.25	-6.35
-6.25	-6.15	-6.25	-6.25	-6.75	-6.25	-5.85	-6.05	-6.25	-6.25	-6.25

Table - 10

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-3
Levels are in Meter PWD
Date of survey : 28 Jul 98



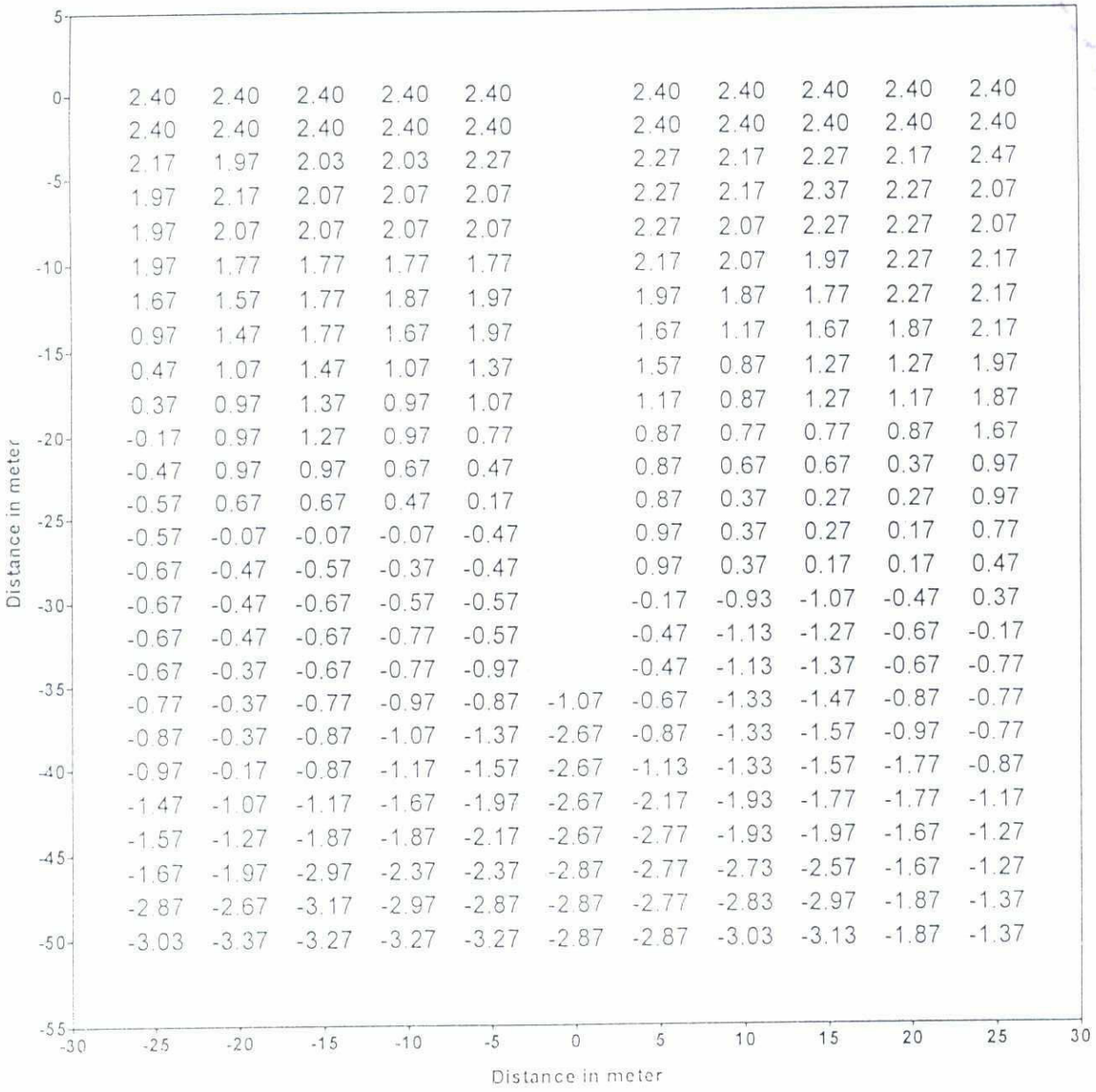
Color scale :

5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12

221

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter, PWD
Date of survey : 11 Aug 98

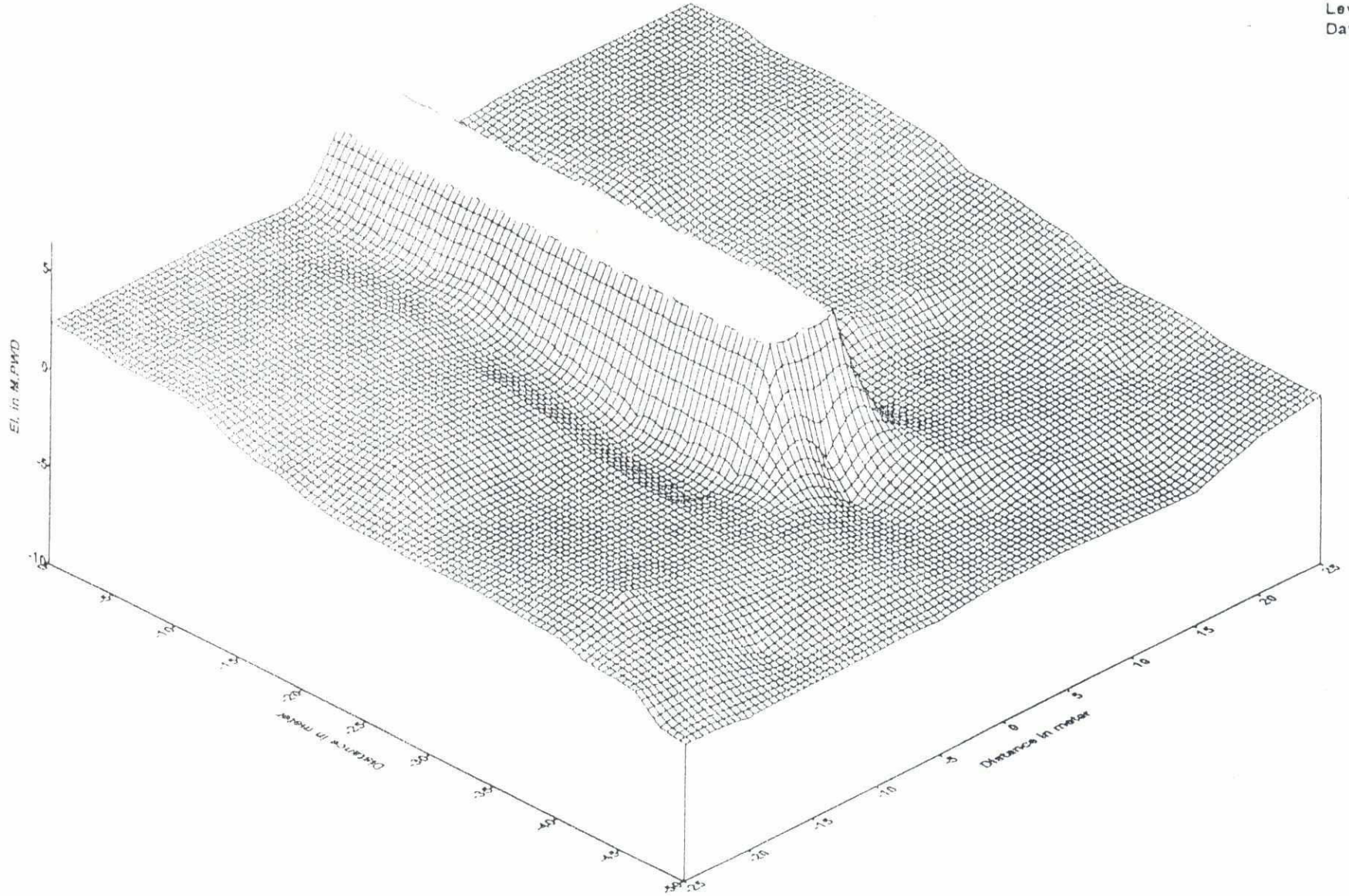


2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
2.17	1.97	2.03	2.03	2.27		2.27	2.17	2.27	2.17	2.47
1.97	2.17	2.07	2.07	2.07		2.27	2.17	2.37	2.27	2.07
1.97	2.07	2.07	2.07	2.07		2.27	2.07	2.27	2.27	2.07
1.97	1.77	1.77	1.77	1.77		2.17	2.07	1.97	2.27	2.17
1.67	1.57	1.77	1.87	1.97		1.97	1.87	1.77	2.27	2.17
0.97	1.47	1.77	1.67	1.97		1.67	1.17	1.67	1.87	2.17
0.47	1.07	1.47	1.07	1.37		1.57	0.87	1.27	1.27	1.97
0.37	0.97	1.37	0.97	1.07		1.17	0.87	1.27	1.17	1.87
-0.17	0.97	1.27	0.97	0.77		0.87	0.77	0.77	0.87	1.67
-0.47	0.97	0.97	0.67	0.47		0.87	0.67	0.67	0.37	0.97
-0.57	0.67	0.67	0.47	0.17		0.87	0.37	0.27	0.27	0.97
-0.57	-0.07	-0.07	-0.07	-0.47		0.97	0.37	0.27	0.17	0.77
-0.67	-0.47	-0.57	-0.37	-0.47		0.97	0.37	0.17	0.17	0.47
-0.67	-0.47	-0.67	-0.57	-0.57		-0.17	-0.93	-1.07	-0.47	0.37
-0.67	-0.47	-0.67	-0.77	-0.57		-0.47	-1.13	-1.27	-0.67	-0.17
-0.67	-0.37	-0.67	-0.77	-0.97		-0.47	-1.13	-1.37	-0.67	-0.77
-0.77	-0.37	-0.77	-0.97	-0.87	-1.07	-0.67	-1.33	-1.47	-0.87	-0.77
-0.87	-0.37	-0.87	-1.07	-1.37	-2.67	-0.87	-1.33	-1.57	-0.97	-0.77
-0.97	-0.17	-0.87	-1.17	-1.57	-2.67	-1.13	-1.33	-1.57	-1.77	-0.87
-1.47	-1.07	-1.17	-1.67	-1.97	-2.67	-2.17	-1.93	-1.77	-1.77	-1.17
-1.57	-1.27	-1.87	-1.87	-2.17	-2.67	-2.77	-1.93	-1.97	-1.67	-1.27
-1.67	-1.97	-2.97	-2.37	-2.37	-2.87	-2.77	-2.73	-2.57	-1.67	-1.27
-2.87	-2.67	-3.17	-2.97	-2.87	-2.87	-2.77	-2.83	-2.97	-1.87	-1.37
-3.03	-3.37	-3.27	-3.27	-3.27	-2.87	-2.87	-3.03	-3.13	-1.87	-1.37

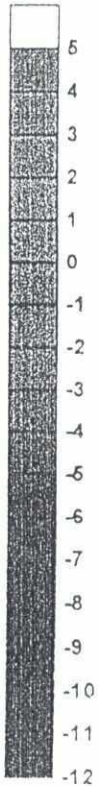
Table - 11

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter PWD
Date of survey : 11 Aug 98

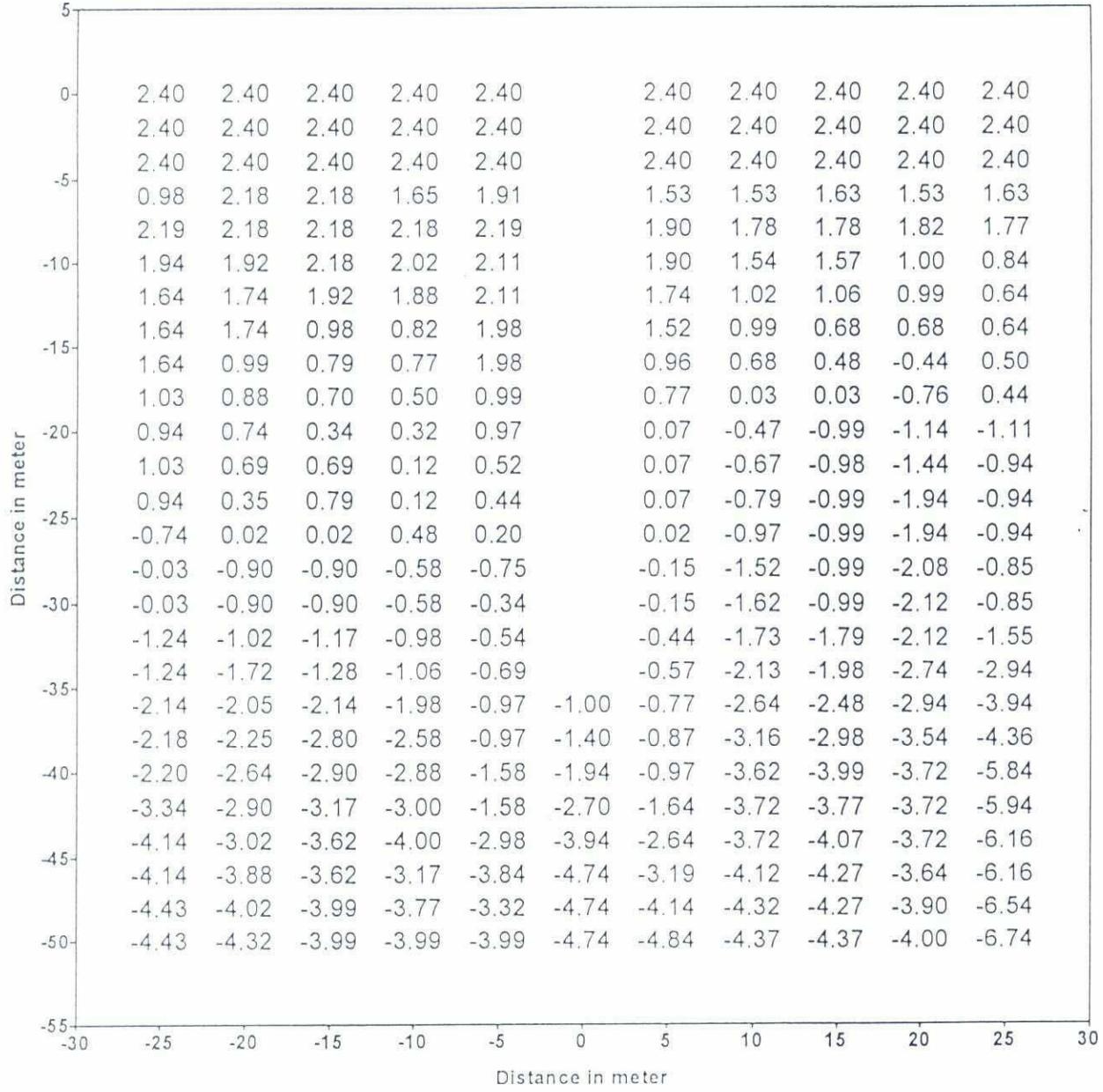


Color scale :



Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter, PWD
Date of survey : 11 Aug 98

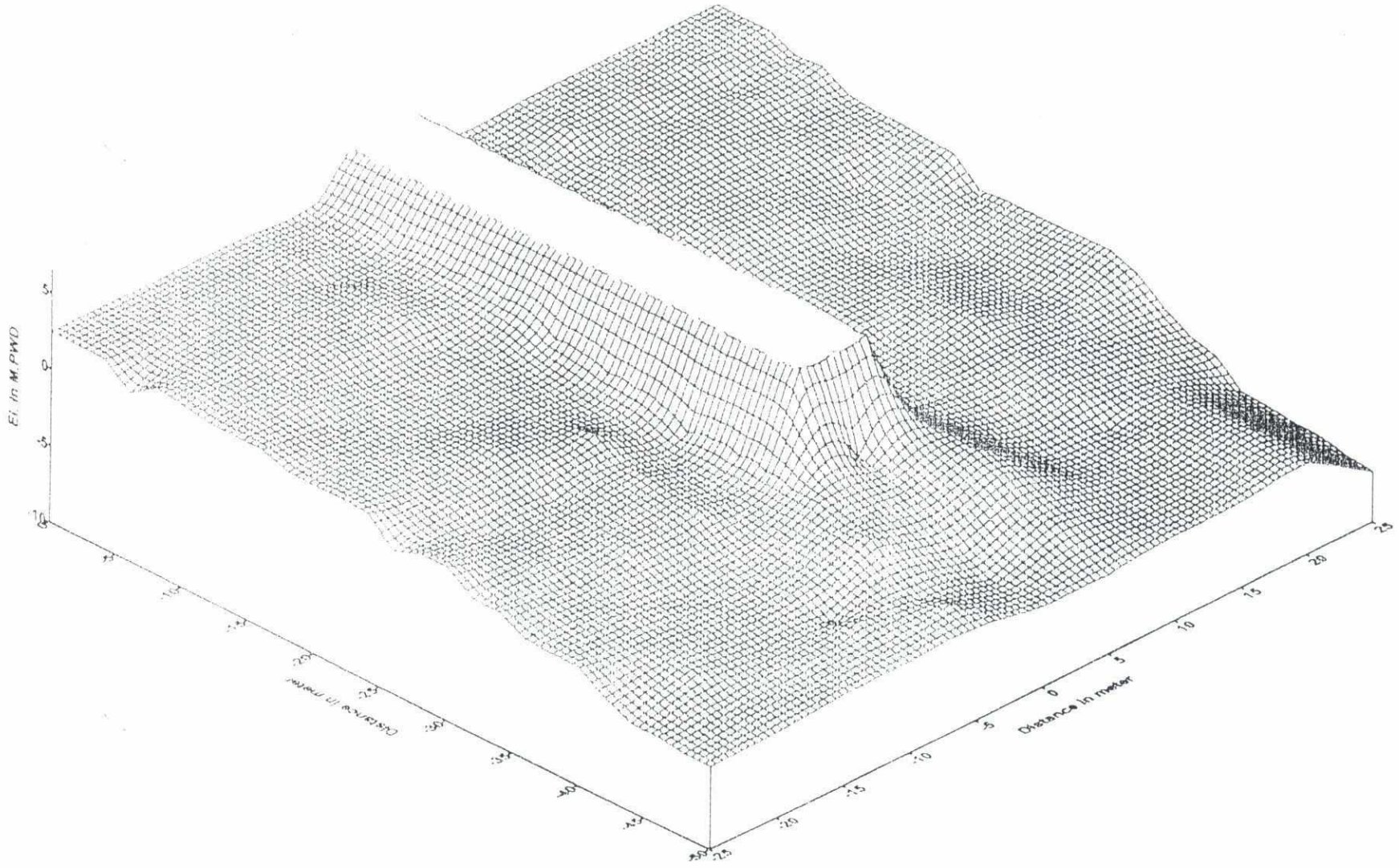


2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
0.98	2.18	2.18	1.65	1.91		1.53	1.53	1.63	1.53	1.63
2.19	2.18	2.18	2.18	2.19		1.90	1.78	1.78	1.82	1.77
1.94	1.92	2.18	2.02	2.11		1.90	1.54	1.57	1.00	0.84
1.64	1.74	1.92	1.88	2.11		1.74	1.02	1.06	0.99	0.64
1.64	1.74	0.98	0.82	1.98		1.52	0.99	0.68	0.68	0.64
1.64	0.99	0.79	0.77	1.98		0.96	0.68	0.48	-0.44	0.50
1.03	0.88	0.70	0.50	0.99		0.77	0.03	0.03	-0.76	0.44
0.94	0.74	0.34	0.32	0.97		0.07	-0.47	-0.99	-1.14	-1.11
1.03	0.69	0.69	0.12	0.52		0.07	-0.67	-0.98	-1.44	-0.94
0.94	0.35	0.79	0.12	0.44		0.07	-0.79	-0.99	-1.94	-0.94
-0.74	0.02	0.02	0.48	0.20		0.02	-0.97	-0.99	-1.94	-0.94
-0.03	-0.90	-0.90	-0.58	-0.75		-0.15	-1.52	-0.99	-2.08	-0.85
-0.03	-0.90	-0.90	-0.58	-0.34		-0.15	-1.62	-0.99	-2.12	-0.85
-1.24	-1.02	-1.17	-0.98	-0.54		-0.44	-1.73	-1.79	-2.12	-1.55
-1.24	-1.72	-1.28	-1.06	-0.69		-0.57	-2.13	-1.98	-2.74	-2.94
-2.14	-2.05	-2.14	-1.98	-0.97	-1.00	-0.77	-2.64	-2.48	-2.94	-3.94
-2.18	-2.25	-2.80	-2.58	-0.97	-1.40	-0.87	-3.16	-2.98	-3.54	-4.36
-2.20	-2.64	-2.90	-2.88	-1.58	-1.94	-0.97	-3.62	-3.99	-3.72	-5.84
-3.34	-2.90	-3.17	-3.00	-1.58	-2.70	-1.64	-3.72	-3.77	-3.72	-5.94
-4.14	-3.02	-3.62	-4.00	-2.98	-3.94	-2.64	-3.72	-4.07	-3.72	-6.16
-4.14	-3.88	-3.62	-3.17	-3.84	-4.74	-3.19	-4.12	-4.27	-3.64	-6.16
-4.43	-4.02	-3.99	-3.77	-3.32	-4.74	-4.14	-4.32	-4.27	-3.90	-6.54
-4.43	-4.32	-3.99	-3.99	-3.99	-4.74	-4.84	-4.37	-4.37	-4.00	-6.74

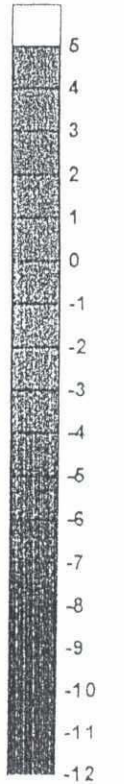
Table - 12

Khorki Bank Protection Pilot Scheme

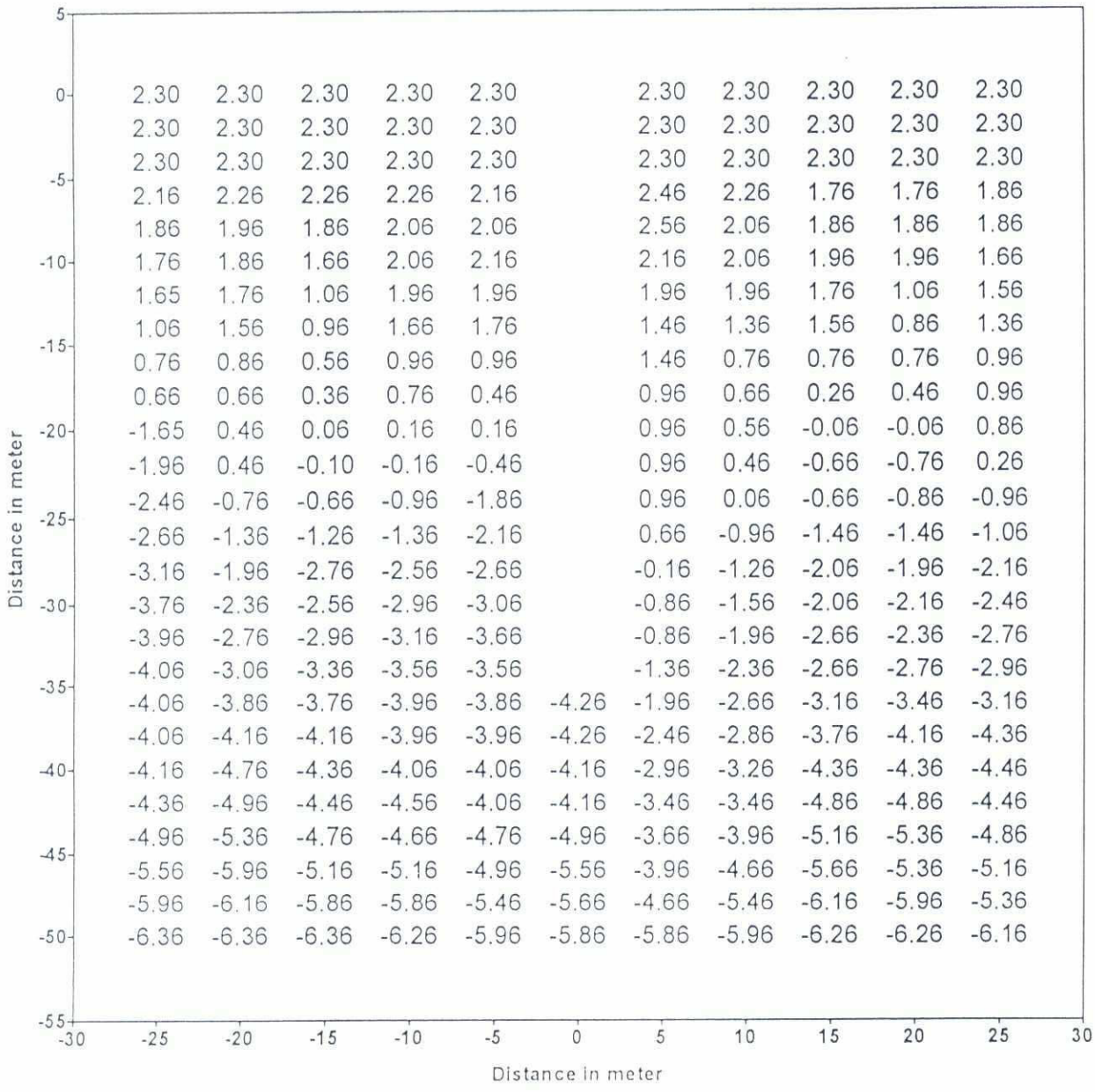
Bed levels around SPUR-2
Levels are in Meter PWD
Date of survey : 11 Aug 98



Color scale :



Khorki Bank Protection Pilot Scheme



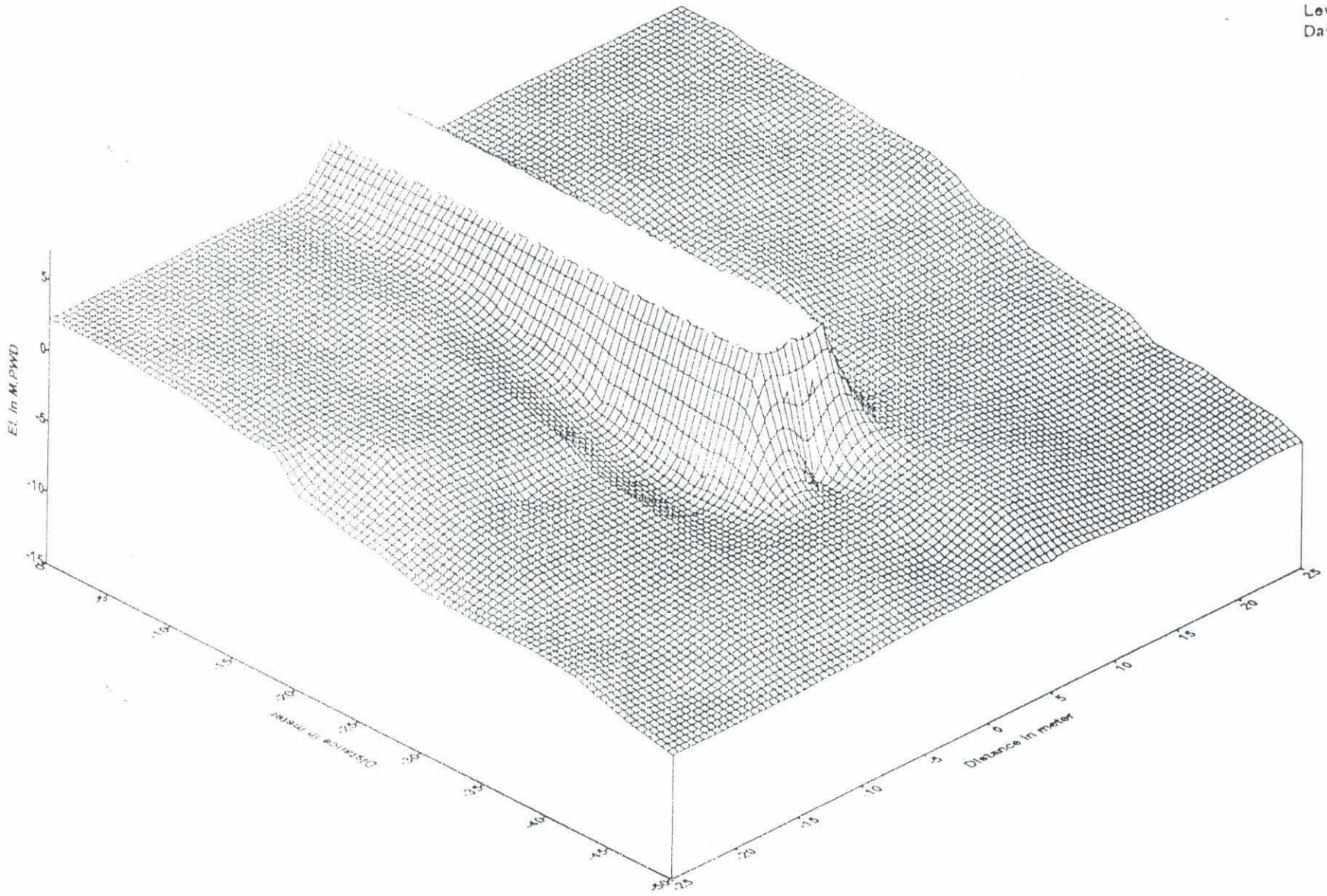
2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
2.16	2.26	2.26	2.26	2.16		2.46	2.26	1.76	1.76	1.86
1.86	1.96	1.86	2.06	2.06		2.56	2.06	1.86	1.86	1.86
1.76	1.86	1.66	2.06	2.16		2.16	2.06	1.96	1.96	1.66
1.65	1.76	1.06	1.96	1.96		1.96	1.96	1.76	1.06	1.56
1.06	1.56	0.96	1.66	1.76		1.46	1.36	1.56	0.86	1.36
0.76	0.86	0.56	0.96	0.96		1.46	0.76	0.76	0.76	0.96
0.66	0.66	0.36	0.76	0.46		0.96	0.66	0.26	0.46	0.96
-1.65	0.46	0.06	0.16	0.16		0.96	0.56	-0.06	-0.06	0.86
-1.96	0.46	-0.10	-0.16	-0.46		0.96	0.46	-0.66	-0.76	0.26
-2.46	-0.76	-0.66	-0.96	-1.86		0.96	0.06	-0.66	-0.86	-0.96
-2.66	-1.36	-1.26	-1.36	-2.16		0.66	-0.96	-1.46	-1.46	-1.06
-3.16	-1.96	-2.76	-2.56	-2.66		-0.16	-1.26	-2.06	-1.96	-2.16
-3.76	-2.36	-2.56	-2.96	-3.06		-0.86	-1.56	-2.06	-2.16	-2.46
-3.96	-2.76	-2.96	-3.16	-3.66		-0.86	-1.96	-2.66	-2.36	-2.76
-4.06	-3.06	-3.36	-3.56	-3.56		-1.36	-2.36	-2.66	-2.76	-2.96
-4.06	-3.86	-3.76	-3.96	-3.86	-4.26	-1.96	-2.66	-3.16	-3.46	-3.16
-4.06	-4.16	-4.16	-3.96	-3.96	-4.26	-2.46	-2.86	-3.76	-4.16	-4.36
-4.16	-4.76	-4.36	-4.06	-4.06	-4.16	-2.96	-3.26	-4.36	-4.36	-4.46
-4.36	-4.96	-4.46	-4.56	-4.06	-4.16	-3.46	-3.46	-4.86	-4.86	-4.46
-4.96	-5.36	-4.76	-4.66	-4.76	-4.96	-3.66	-3.96	-5.16	-5.36	-4.86
-5.56	-5.96	-5.16	-5.16	-4.96	-5.56	-3.96	-4.66	-5.66	-5.36	-5.16
-5.96	-6.16	-5.86	-5.86	-5.46	-5.66	-4.66	-5.46	-6.16	-5.96	-5.36
-6.36	-6.36	-6.36	-6.26	-5.96	-5.86	-5.86	-5.96	-6.26	-6.26	-6.16

Bed levels around SPUR-3
Levels are in Meter, PWD
Date of survey : 12 Aug 98

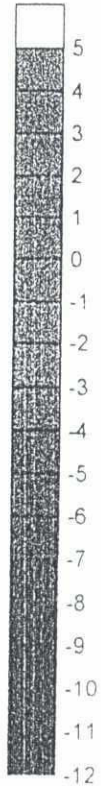
Table - 13

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-3
Levels are in Meter PWD
Date of survey : 12 Aug 98



Color scale :



306

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter, PWD
Date of survey : 28 Sep 98

5											
0	2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
	2.40	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
-5	2.17	1.97	2.03	2.03	2.27		2.27	2.17	2.27	2.17	2.47
	1.97	2.17	2.07	2.07	2.07		2.27	2.17	2.37	2.27	2.07
	1.97	2.07	2.07	2.07	2.07		2.27	2.07	2.27	2.27	2.07
-10	1.37	1.37	1.37	1.37	1.37		1.37	1.87	2.37	1.87	1.87
	0.37	0.37	1.37	0.87	0.87		0.87	1.37	1.37	1.37	0.87
	-0.37	0.37	0.87	0.87	1.37		0.87	0.87	0.87	0.37	0.87
-15	-0.37	0.37	0.37	0.87	0.87		0.37	0.37	0.87	0.87	0.37
	-0.37	0.37	0.37	0.37	0.37		0.37	0.87	0.87	0.87	0.37
-20	-0.37	-0.37	-0.37	-0.87	0.37		0.87	0.87	0.87	1.37	1.37
	-1.37	-0.87	-0.87	-0.87	0.37		0.87	1.37	0.37	0.87	0.87
	-0.87	-0.87	-0.87	-1.37	-0.37		-0.37	-0.37	-1.37	-1.37	-0.87
-25	-0.37	-1.37	-1.37	-0.87	-0.87		-0.37	-0.87	-1.37	-0.87	-1.37
	-0.87	-1.37	-1.37	-0.87	-0.87		-0.87	-0.87	-1.87	-1.37	-1.87
-30	-0.87	-0.87	-1.37	-0.87	-0.87		-0.87	-0.87	-0.87	-1.87	-1.87
	-0.87	-1.37	-1.37	-0.87	-0.87		-1.37	-0.87	-0.87	-1.87	-2.37
	-1.87	-1.87	-1.37	-1.37	-1.37		-1.87	-1.37	-1.37	-1.87	-2.37
-35	-1.87	-2.37	-1.37	-1.87	-1.87	-2.37	-2.37	-1.87	-2.87	-2.37	-3.37
	-2.37	-2.37	-2.87	-2.37	-1.87	-2.87	-2.37	-2.37	-2.87	-2.37	-3.37
-40	-2.37	-2.37	-2.37	-2.87	-1.87	-2.87	-2.87	-2.37	-2.87	-1.87	-2.37
	-2.87	-2.87	-3.37	-2.37	-1.87	-2.87	-3.37	-2.37	-3.37	-1.87	-2.87
	-3.37	-3.37	-3.87	-2.87	-2.37	-2.87	-3.87	-2.87	-4.37	-2.87	-2.87
-45	-3.37	-3.37	-2.87	-3.37	-2.87	-3.37	-3.87	-3.37	-4.37	-3.37	-3.37
	-3.37	-3.37	-2.87	-3.37	-3.37	-3.37	-4.37	-3.87	-4.87	-3.87	-3.37
-50	-4.37	-4.37	-2.87	-3.37	-3.37	-3.37	-3.87	-4.37	-4.37	-3.87	-3.37
-55											

Distance in meter

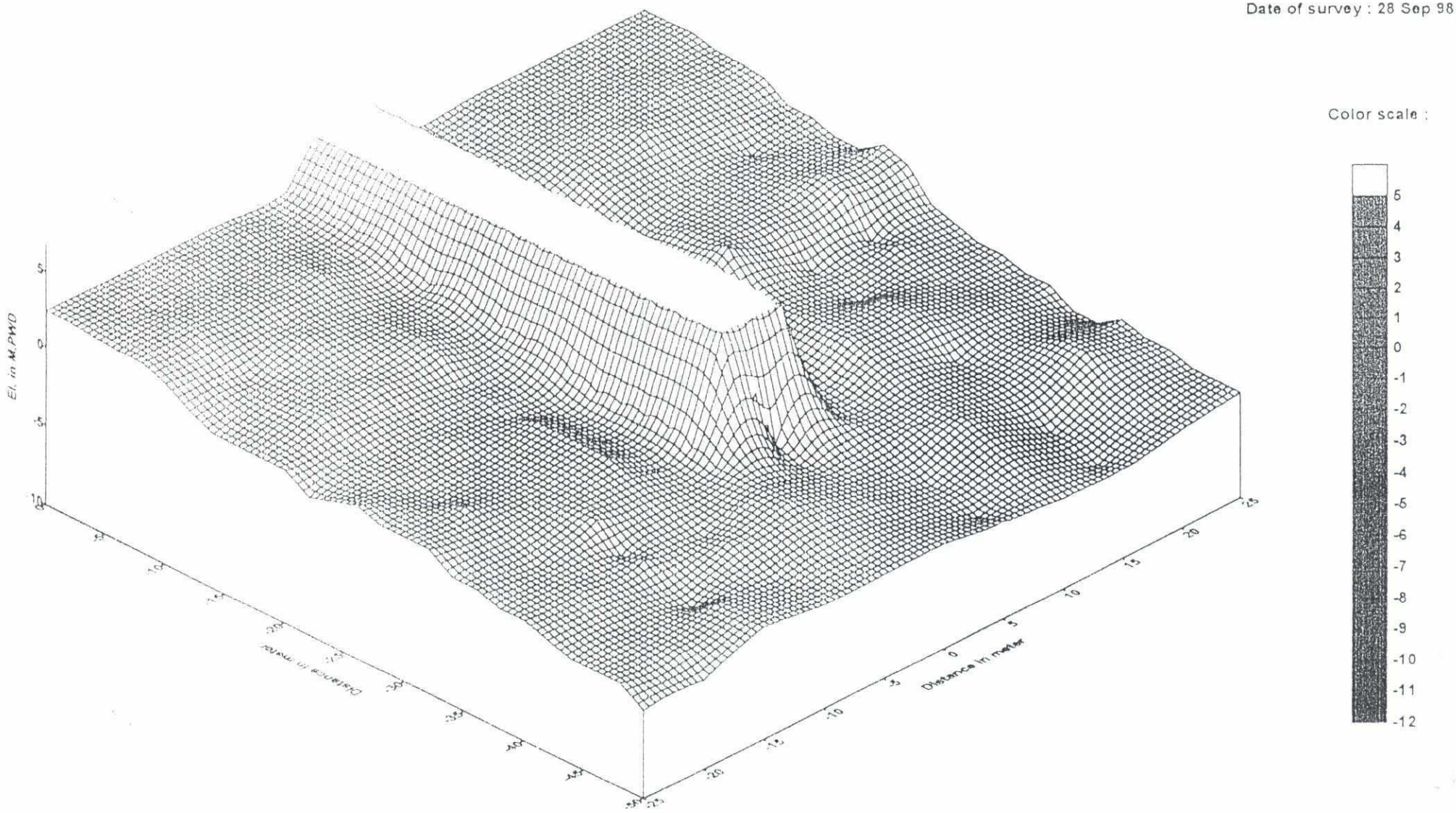
-30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30

Distance in meter

Table - 14

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-1
Levels are in Meter PWD
Date of survey : 28 Sep 98



Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter, PWD
Date of survey : 27 Sep 98

5										
0	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
-5	2.40	2.40	2.40	2.40		2.40	2.40	2.40	2.40	2.40
	2.18	2.18	1.65	1.91		1.53	1.53	1.63	1.53	1.63
	2.18	2.18	2.18	2.19		1.90	1.78	1.78	1.82	1.77
-10	1.07	1.07	1.07	1.07		1.07	1.07	1.07	1.07	1.07
	0.57	0.57	0.57	0.57		1.07	1.07	1.07	1.07	0.57
	0.07	0.57	0.57	0.07		0.57	1.07	0.57	0.57	0.37
-15	-0.07	-0.07	-0.37	-0.07		-0.37	-0.37	-0.37	0.37	0.37
	-0.37	-0.07	-0.37	-0.37		-1.07	-1.07	-0.37	-0.57	-0.07
-20	-0.07	-0.07	-0.57	-0.37		-1.07	-1.07	-1.07	-0.57	-0.57
	-0.07	-0.07	-0.57	-0.37		-1.07	-1.07	-0.57	-0.57	-1.07
	-0.77	-0.57	-0.57	-0.37		-1.07	-1.07	-0.57	-1.07	-1.07
-25	-0.77	-0.77	-0.77	-0.07		-0.57	-0.57	-2.07	-2.07	-1.07
	-1.07	-1.07	-1.07	-0.57		-0.57	-0.57	-2.07	-2.57	-1.37
-30	-1.37	-1.97	-1.07	-0.57		-0.57	-0.57	-2.07	-3.07	-1.07
	-1.07	-1.07	-1.07	-0.77		-0.57	-1.07	-2.07	-2.07	-2.07
	-2.07	-2.07	-2.07	-1.77		-2.57	-2.57	-3.07	-3.07	-3.57
-35	-2.97	-2.97	-3.07	-2.07	-3.57	-3.57	-3.07	-4.07	-3.57	-3.57
	-3.77	-3.07	-3.07	-2.37	-4.07	-4.07	-3.57	-4.07	-3.57	-4.07
-40	-2.97	-2.97	-3.37	-2.37	-4.37	-4.37	-4.37	-5.07	-4.07	-5.07
	-3.07	-3.07	-3.07	-2.77	-4.07	-4.07	-4.77	-4.77	-4.07	-4.07
	-3.07	-3.07	-3.07	-2.77	-4.07	-4.77	-4.77	-4.07	-4.07	-4.77
-45	-4.07	-3.37	-2.77	-3.07	-3.77	-4.07	-4.77	-4.77	-4.77	-4.77
	-4.07	-3.57	-3.07	-3.07	-4.07	-4.07	-4.77	-5.07	-5.77	-5.07
-50	-4.37	-3.57	-3.37	-3.07	-4.07	-4.37	-4.37	-5.07	-6.57	-5.57
-55										
	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30

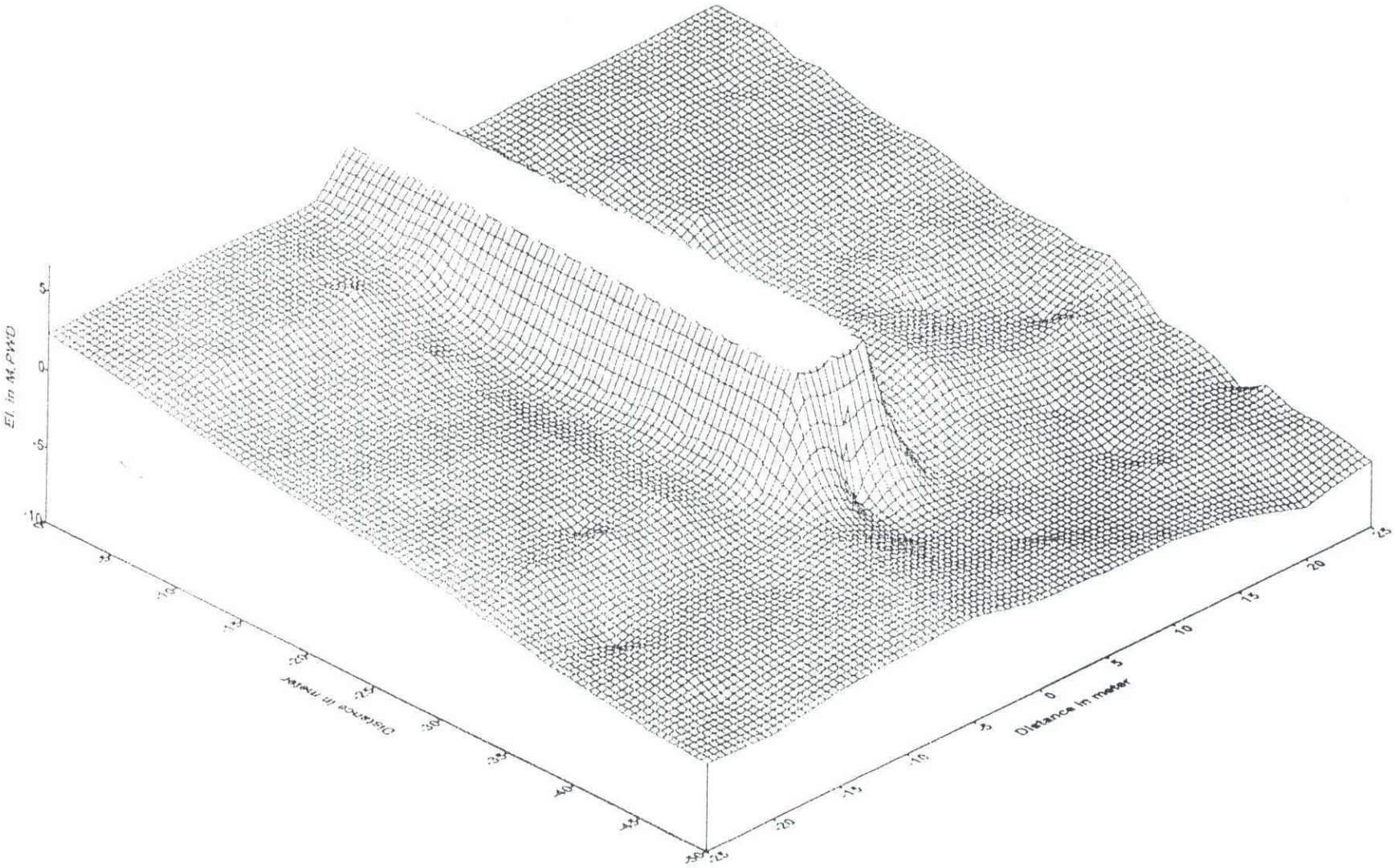
Distance in meter

Distance in meter

Table - 15

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-2
Levels are in Meter PWD
Date of survey : 27 Sep 98

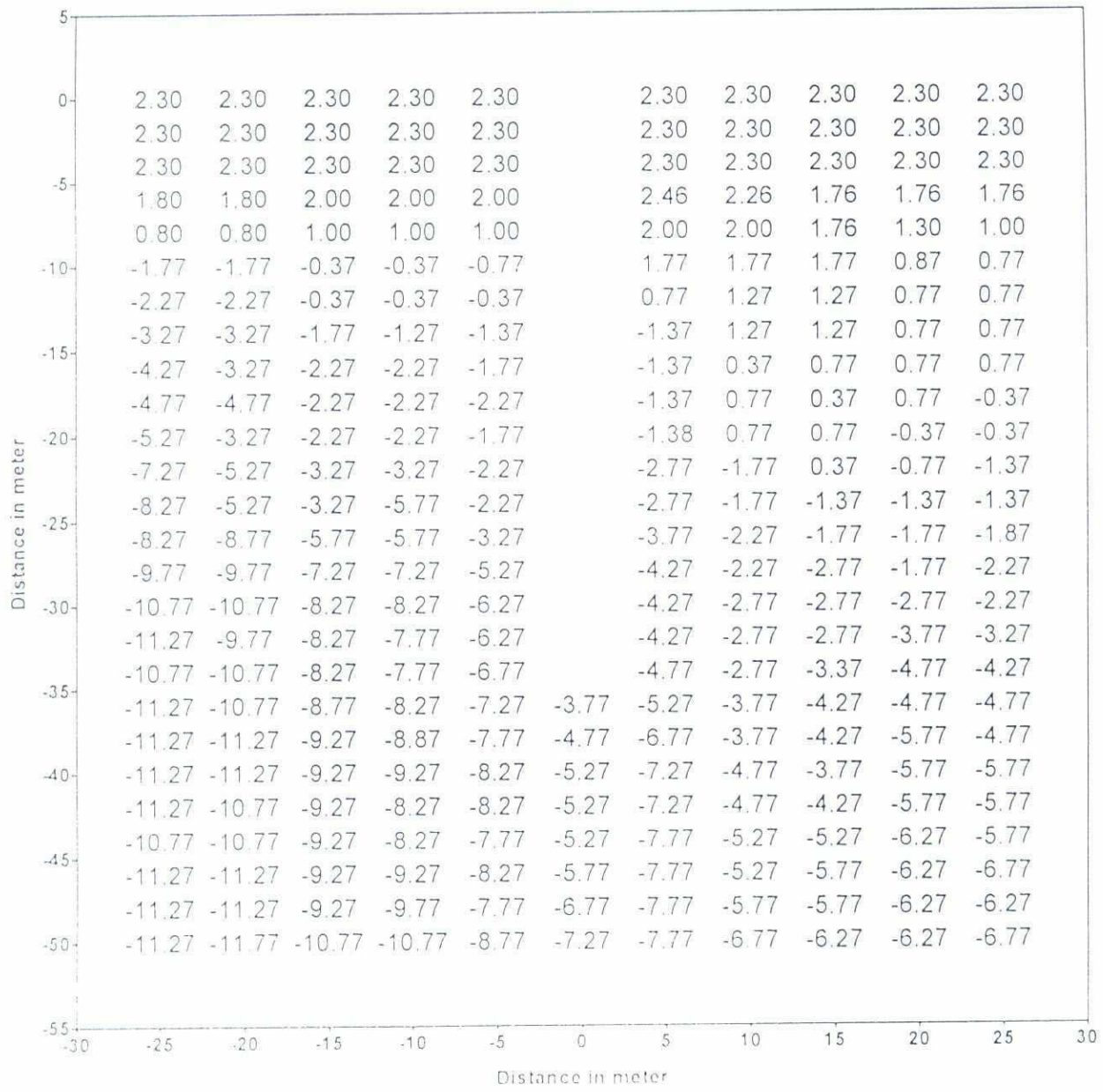


Color scale :

5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-3
Levels are in Meter, PWD
Date of survey : 29 Sep 98

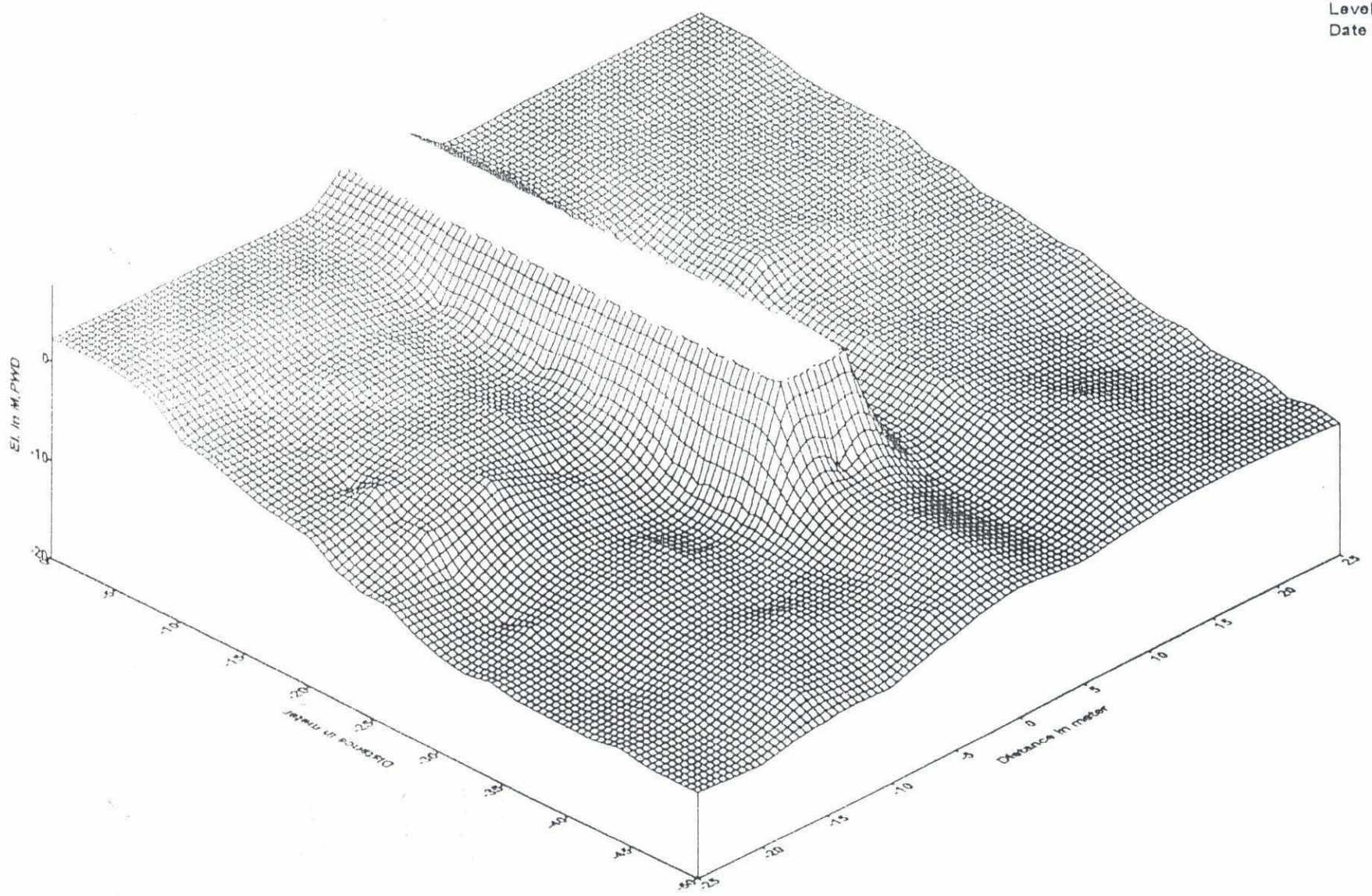


2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
2.30	2.30	2.30	2.30	2.30		2.30	2.30	2.30	2.30	2.30
1.80	1.80	2.00	2.00	2.00		2.46	2.26	1.76	1.76	1.76
0.80	0.80	1.00	1.00	1.00		2.00	2.00	1.76	1.30	1.00
-1.77	-1.77	-0.37	-0.37	-0.77		1.77	1.77	1.77	0.87	0.77
-2.27	-2.27	-0.37	-0.37	-0.37		0.77	1.27	1.27	0.77	0.77
-3.27	-3.27	-1.77	-1.27	-1.37		-1.37	1.27	1.27	0.77	0.77
-4.27	-3.27	-2.27	-2.27	-1.77		-1.37	0.37	0.77	0.77	0.77
-4.77	-4.77	-2.27	-2.27	-2.27		-1.37	0.77	0.37	0.77	-0.37
-5.27	-3.27	-2.27	-2.27	-1.77		-1.38	0.77	0.77	-0.37	-0.37
-7.27	-5.27	-3.27	-3.27	-2.27		-2.77	-1.77	0.37	-0.77	-1.37
-8.27	-5.27	-3.27	-5.77	-2.27		-2.77	-1.77	-1.37	-1.37	-1.37
-8.27	-8.77	-5.77	-5.77	-3.27		-3.77	-2.27	-1.77	-1.77	-1.87
-9.77	-9.77	-7.27	-7.27	-5.27		-4.27	-2.27	-2.77	-1.77	-2.27
-10.77	-10.77	-8.27	-8.27	-6.27		-4.27	-2.77	-2.77	-2.77	-2.27
-11.27	-9.77	-8.27	-7.77	-6.27		-4.27	-2.77	-2.77	-3.77	-3.27
-10.77	-10.77	-8.27	-7.77	-6.77		-4.77	-2.77	-3.37	-4.77	-4.27
-11.27	-10.77	-8.77	-8.27	-7.27	-3.77	-5.27	-3.77	-4.27	-4.77	-4.77
-11.27	-11.27	-9.27	-8.87	-7.77	-4.77	-6.77	-3.77	-4.27	-5.77	-4.77
-11.27	-11.27	-9.27	-9.27	-8.27	-5.27	-7.27	-4.77	-3.77	-5.77	-5.77
-11.27	-10.77	-9.27	-8.27	-8.27	-5.27	-7.27	-4.77	-4.27	-5.77	-5.77
-10.77	-10.77	-9.27	-8.27	-7.77	-5.27	-7.77	-5.27	-5.27	-6.27	-5.77
-11.27	-11.27	-9.27	-9.27	-8.27	-5.77	-7.77	-5.27	-5.77	-6.27	-6.77
-11.27	-11.27	-9.27	-9.77	-7.77	-6.77	-7.77	-5.77	-5.77	-6.27	-6.27
-11.27	-11.77	-10.77	-10.77	-8.77	-7.27	-7.77	-6.77	-6.27	-6.27	-6.77

Table - 16

Khorki Bank Protection Pilot Scheme

Bed levels around SPUR-3
Levels are in Meter PWD
Date of survey : 29 Sep 98



Color scale :

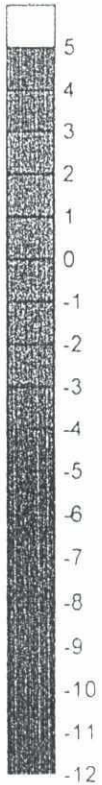


Table - 17

Haimchar Site
Spur No. 1

Water depths recorded to check bed slope
to determine length of Spur Caisson

Date: 27.3.98
Time: 1.15 P.M.

Depth in meter					
5	4	3	2	1	
					2m
		DRY			2m
					2m
					2m
• 0.27	• 0.20	• 0.33	• 0.35	• 0.30	2m
• 0.57	• 0.76	• 0.79	• 0.80	• 0.60	2m
• 0.98	• 1.17	• 1.10	• 1.20	• 1.13	2m
• 1.75	• 1.28	• 1.25	• 1.20	• 1.15	2m
• 2.62	• 2.79	• 2.99	• 3.32	• 2.40	2m
• 3.53	• 3.01	• 2.99	• 3.22	• 3.04	2m
• 3.78	• 3.78	• 3.65	• 3.60	• 3.76	2m
• 4.18	• 3.76	• 3.80	• 3.81	• 3.76	2m
• 4.28	• 4.19	• 4.19	• 4.17	• 4.10	2m
• 4.50	• 4.51	• 1.30	• 4.27	• 4.12	2m
• 4.58	• 4.52	• 4.51	• 4.50	• 4.28	2m
<----5m----->	<----5m----->	<----5m----->	<----5m----->	<----5m----->	

Table - 18.

Haimchar Site
Spur No. 2

Water depths recorded to check bed slope
to determine length of Spur Caisson

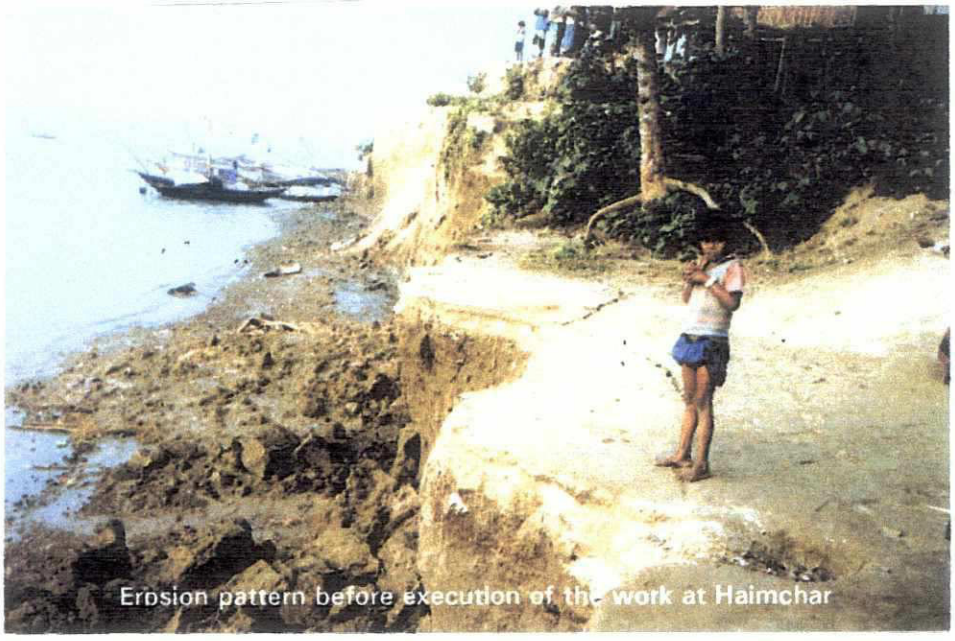
Date : 28.3.98
Time : 12.30 P.M.

Depth in meter					
5	4	3	2	1	
					2m
		DRY			2m
					2m
					2m
• 0.67	• 0.60	• 0.69	• 0.63	• 0.67	2m
• 1.58	• 1.26	• 1.29	• 1.25	• 1.27	2m
• 2.73	• 2.65	• 2.40	• 2.34	• 2.45	2m
• 2.44	• 2.85	• 2.65	• 2.82	• 2.70	2m
• 3.83	• 3.30	• 3.06	• 3.08	• 3.20	2m
• 4.09	• 3.71	• 3.60	• 3.84	• 3.90	2m
• 3.83	• 3.92	• 3.90	• 4.06	• 4.15	2m
• 4.09	• 4.28	• 4.20	• 4.20	• 4.16	2m
• 4.20	• 4.28	• 4.42	• 4.40	• 4.42	2m
• 4.44	• 4.42	• 4.45	• 4.42	• 4.47	2m
• 4.57	• 4.72	• 4.58	• 4.50	• 4.50	2m
<----5m----->	<----5m----->	<----5m----->	<----5m----->	<----5m----->	

APPENDIX–2

PICTURES

Picture 1 Haimchar

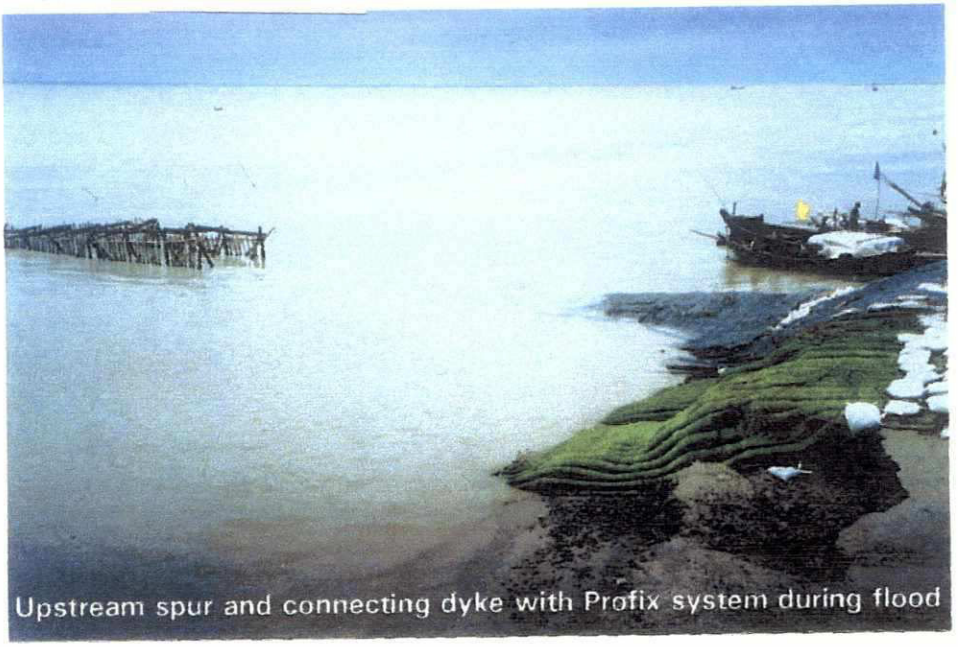


Erosion pattern before execution of the work at Haimchar

Picture 2 Haimchar

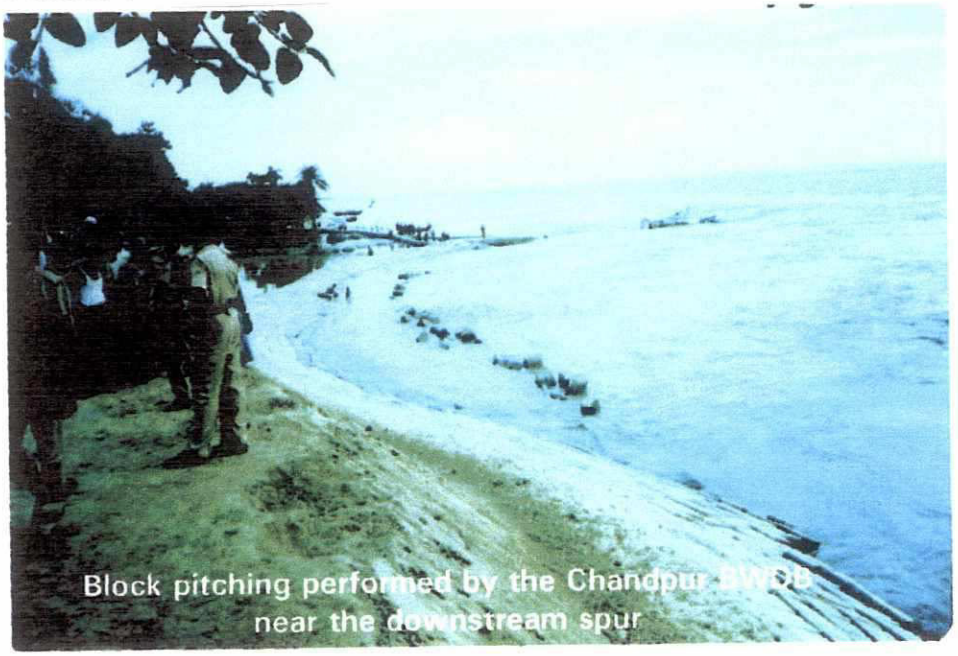
Downstream spur and connecting dyke with profix system

Picture 3 Haimchar



Upstream spur and connecting dyke with Profix system during flood

Picture 4 Haimchar

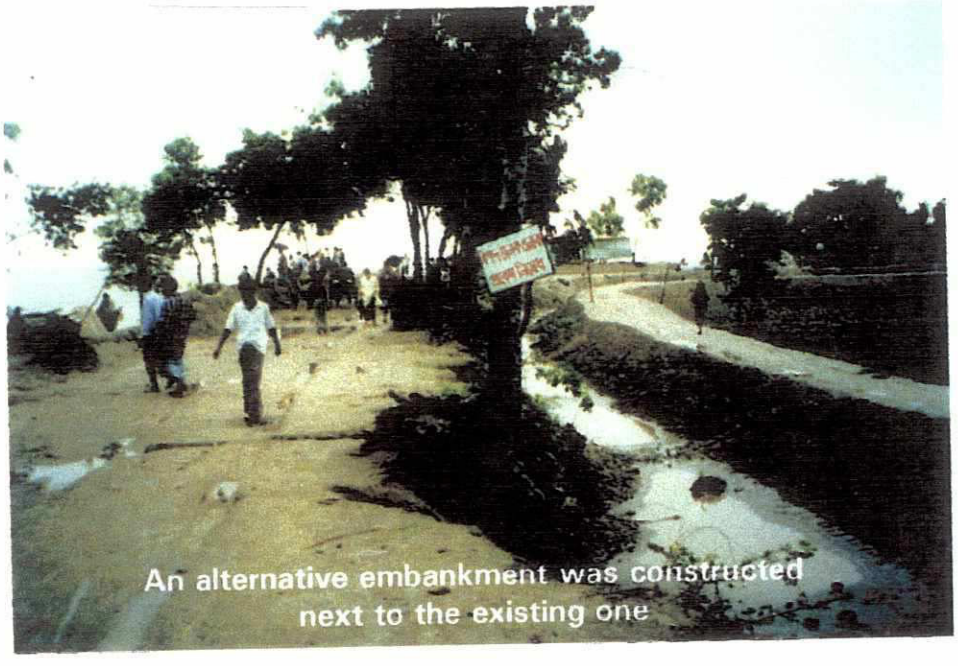


Block pitching performed by the Chandpur BWDB near the downstream spur

Picture 5 Haimchar

Block pitching performed by the Chandpur BWDB near the upstream spur

Picture 6 Haimchar



An alternative embankment was constructed next to the existing one

Picture 7 Haimchar

Picture 8 Haimchar

Picture 9 Haimchar

During the flood the downstream spur has disappeared at Haimchar

Picture 10 Khorki

The downstream spur (KC-3) after construction

Picture 11 Khorki

Picture 12 Khorki

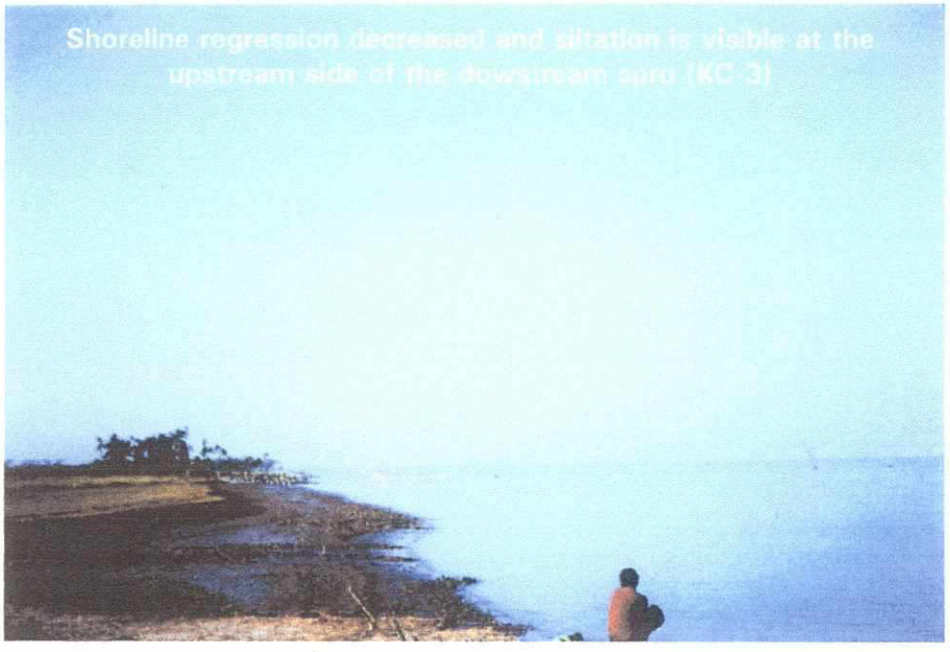
Picture 13 Khorki

Picture 14 Khorki

Picture 15 Khorki

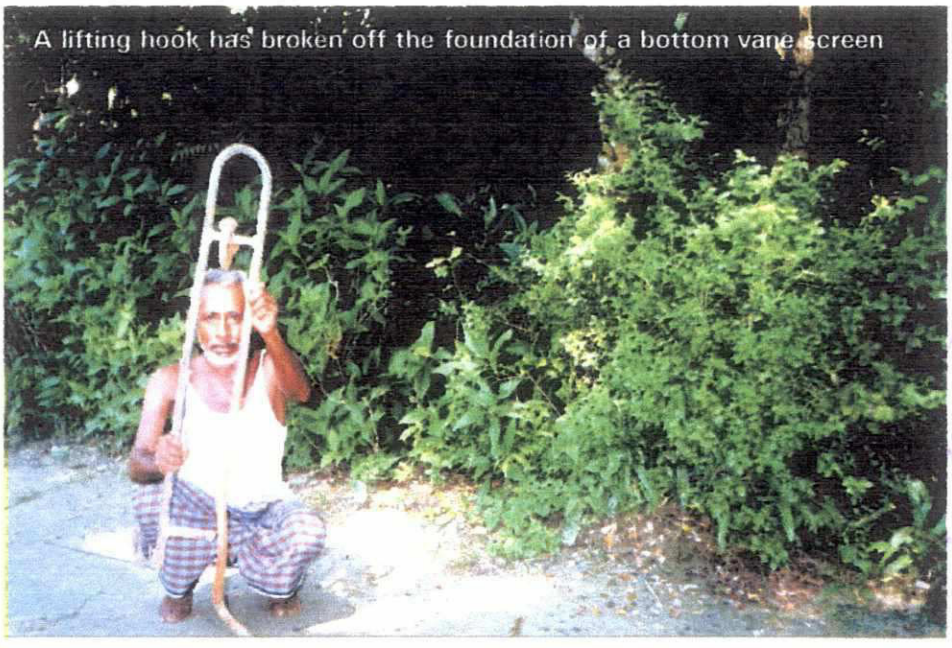
Siltation pattern at the upstream side of the downstream spur (KC-2)

Picture 16 Khorki



Shoreline regression decreased and siltation is visible at the upstream side of the downstream spur (KC-3)

Picture 17


A lifting hook has broken off the foundation of a bottom vane screen