Ministry of Public Works
The Netherlands

CLOSING TIDAL CHANNELS IN BANGLADESH

An Inventory

Annex F,

HASKONING
Royal Dutch Consulting
Engineers and Architects

February 1989

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Description of

The Amtali Closure

Based on the sixth interim report of the Early Implementation Projects on Flood Control and Irrigation in Bangladesh.

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CHAPTER I

SUMMARY

The closure of the Amtali Khal was executed in the period December '81 to March '82 as a further experiment of the "Study of Methods for Closing Tidal Channels in Bangladesh". The closure was executed as an Early Implementation Project on Flood Control and Irrigation in Bangladesh, financed by Netherlands Technical Assistance Programme. A team of three dutch experts of HASKONING Consulting Engineers from the Netherlands, already involved during the past 5 years with introducing new closure techniques in Bangladesh, assisted the Bangladesh Water Development Board - engineers and the contractor with the execution of the work according to the designed closure method. The method was based on a gradual build up of an underwater sill on top of the riverbottom, which was protected in advance by special mattresses to prevent any scour due to the currents. When the sill had reached a certain level, it also was protected with special mattresses with the same purpose. Then a bridge type cofferdam construction was built across the river on top of the sill and the current was stopped by filling the cofferdam in two stages with clay filled gunny bags.

The tidal range at Amtali was 2.4m at spring tides and 0.9m at neap tides. The tidal volume at spring tide was about 4×10^6 m^3, and the channel's cross-section at mean water-level was 640 m^2. The width at the waterline was 123m and the maximum depth of the channel was 7.8m-PWD. More detailed information on the conditions at site are given in chapter 3.

In chapter 4 the design and execution method are further elaborated. The major phases into which the work can be divided are:

- The construction and sinking of special bottom protection mattresses, made of bamboo and reed, sunk by means of ballasting with clay filled gunny bags.
- The construction of an under-water sill by means of dumping clay filled gunnybags from barges.
- The coverings of the sill by means of special sill mattresses, made of bamboo and reed, to protect against scouring by currents.
- Building of a cofferdam on top of the sill.
- Actual closure operation in two stages by filling the cofferdam with clay filled gunny bags.
- Earthwork to complete the dam and the embankment upto specified dimensions.

The execution of the work encountered no serious probleme, in fact most of the activities could be performed as routine jobs after the skills were picked up again by the labourers, of which quite a number also had been involved in the closure of the Chakamaya Khal in 1979. Again the reliability of the closure method was proved and the whole process was controlled throughout. Although some delays occured in the initial phase, the actual works could start earlier than ever before, and because some of the lost time could be made good, it was possible to close the Amtali Khal on March 5-'82, only 2 weeks behind the original schedule.

The experience gained with the closure method applied in Amtali and Chakamay give confidence for the taking up of larger and more complicated tidal rivers, which could be closed successfully. However, the method presently used has it's limits regarding the depth and width of the river. Depths should not exceed 10m measured from river bottom to high tide level. This depth is limited by the length of available bullah piles.

The width of a closure also has it's limits; determinant is the transport capacity of carrying gunny bags by head-load to fill the cofferdam for final closure. For wider closures, a combination of both the horizontal and vertical closure method might bring a solution.

Although practical execution proved to cause no serious problems for both the Water Board engineers and the contractor's staff, it was still evident that in the field of planning the operations as well short term (in relation to the tide) as long-term (supply of materials and equipment and labourers), the pursuing attention of expatriate staff cannot be disposed of. Contracts that require strict adherance to a timeschedule and dedicated supervision of the contractor in case the work is not done on the basis of a lump sum contract,will be difficult to manage, as the Water Board set-up is not adequate in number of personnel and experience, to cope with such major works.

CHAPTER 2

INTRODUCTION

2.1 PROJECT HISTORY

Amtali Khal is the main natural drainage channel in the polder 43/1. Embankments and sluices for this polder were constructed in the sixties under the Coastal Embankment Project. Except for some miles of embankment in the extreme north of the polder, which were completed last year, and the closing of the Amtali Khal, the polder was completed.
The closure of this Khal was selected by Early Implementation Projects - staff in early 1979 to be executed in the construction season 1979-1980.
However, the contractor selected to do the work, applying the traditional Bengali mata-method, failed that season and also the '80-'81 season, in closing the Amtali Khal at a cross-section close to the debouchment into the Buriswar River. (See Figure 1).
The reason for his consecutive failures were in both cases: too late with starting construction activities, insufficient labour force at final closing stage and difficulties with surmounting labour problems.

In order to reduce the risk of another failure, and to speed up the closure of the last remaining gap in the polder, it was decided to apply the dutch closure method, which had already successfully been applied at Chakamaya Closure - Polder 44, in early 1979. The decision was made immediately after the second failure was a fact in April 1981.
A new closure site had to be selected about one mile upstream because at the original site not sufficient land was available to be used as borrow-pit for yet another closure.
Permission was obtained from the Netherlands Government and preparations for additional field investigations started. HASKONING Consulting Engineers, previously involved with closure works in Bangladesh, during which the dutch method was introduced on an experimental base, was given the assignment to design and supervise the work and assist BWDB engineers and contractor with the execution.

2.2 THE TEAM OF EXPERTS

As with previous EIP closure works in which the dutch method was used, a team of experts was assigned by the

Netherlands Government to assist the Bangladesh Water Development Board engineers at site with the supervision of the work and to help the contractor with the construction and sinking of bottomprotection mattresses and the overall waterborne operations which are quite new for Bangladesh.

The team consisted of:

Mr. J.W. Burger,	civil engineer of HASKONING who was already residing in Bangladesh and working for the Delta Development Project. For the time of the execution of the Amtali closure, he was temporary relieved from his DDP-duties.
Mr. R.J. Visser,	Expert on construction and sinking of bottomprotection mattresses, of A.C.Z. a dutch international contractor specialised in this kind of work. Mr. Visser was also involved in two previous EIP-closures.
Mr. B. v.d. Heuvel,	Expert on bottommattress construction, also of A.C.Z.
Mr. E.C. Smith,	Closure Expert of HASKONING. He assisted the team during the initial weeks of starting the job and during final closure operations.

CHAPTER - 3

INFORMATION ON LOCATION, TIDES, WATERLEVELS, DISCHARGES WATERDEPTHS AND SOIL CONDITIONS

3.1 GENERAL INFORMATION ON POLDER- 43/1

The polder is located in the southern part of the Bangladesh Delta Area, west of the mouth of the Tetulia River. The western embankment of the polder borders the Buriswar River, which is one of the major fresh water arteries coming from the Barisal-Patuakhali Area and is debouching in the Bay Bengal.
The polder resorts under the Patuakhali-II-Division of the Barisal-Circle of the BWDB, which offices are located in Barguna, some 15 km west of the polder-43/1.
The polder encloses a total area of 16.500 Ha and is extensively used for rice cropping. The surrounding rivers contain fresh water during most part of the year. At the end of the dry season the salinity is raised. E.C. - value recorded in March '78 was 5000 mmho/cm. The main purpose of the closure of the Amtali Khal was the completion of the flood protecting embankment around the area and to stop salt water intrusion at the end of the dry season. Alternatively some 25 km of embankment would have had to be constructed along the banks of the Amtali Khal. This solution would also exclude a lot of fertile land along the banks.
It is estimated that the incremental benefits for agriculture will be Tk. 53 lakh financially and Tk. 65 lakh economically.

3.2 WATER LEVELS AND TIDES

At Amtali Bandar an auto river gauge was operated and maintained by the Directorate of Surface Water Hydrology of the BWDB, upto mid 1978. Since 1978 gauge readings are taken from a staff only at high and low tide during daytime hours. Several years of automatic continuous water level recordings were available at Dacca.
For the project, an analyses of gauge readings has been made of the years April 1973 - March 1978, regarding the maximum and minimum waterlevels and the average water level for the period december to april of each year. Figure 2 shows the average mean waterlevel as derived from the gauge records.
During the execution of the project an additional gauge was installed near the closure site, 450 ft downstream of the proposed alignment of the dam. The "0" of this gauge was levelled to make gauge readings directly related to P.W.D.+) Readings from this gauge are shown in Annex 1. As from the moment that the sill was completed upto design level, a second gauge was installed upstream of the sill. From both gauges, readings were taken twice daily at low and high tide. On March 1,2,3 readings from both gauges were taken every 30 minutes during daytime hours.

+) Public Works Datum

Tidal predictions for the project were made with the help of the tide table of Bangladesh as published by BIWTA - Department of Hydrography.

Tide table predictions for Chalna were compared with actual measured water levels and time, during two identical moon appearances, (i.e. full moon to full moon). Average differences in time and height of the low and high waters were then used to predict the Amtali tide from the Chalna predictions, by adding or subtracting these differences to the Chalna predictions for the next period. In annex 2 an example for the months of December-81 to Januari-82 is presented.
For the January '82-tides at Amtali, it can be seen that the high waters are 4.8 ft below the Chalna predictions, (although the two levels are not related), and 75 minutes later, and the low tide is 5.1 ft lower than the Chalna prediction and 115 minutes later.
It was found that the time shift between the Chalna and Amtali tides during low water neap tides deviated considerably from the calculated predicted averages. Probably the remainings of the old closuredam, where a considerable narrowing still exists, causes this retarded low tide.

For the tidal computations, executed to design the sill level, use was made of the tidal information gathered during the discharge measurements of 18 March 1978 and 22 and 28 September 1981. The subject is further highlighted in paragraph 3.3.

3.3 DISCHARGE MEASUREMENTS

For the project a total of 3 tidal discharge measurements have been executed in order to gather sufficient information on tides and currents. The measurements were executed during the neap tides of March 18, 1978 and September 22, 1981 and the spring tide of 28 September, 1981. The measurements consisted of 13 hours monitoring of the current at one hour intervals ('78) or half hour intervals ('81) with an Ott current meter. The '78 measurement was a one point measurement; in '81, two vessels were involved and measurements were done at two points in a cross-section simultaneously.

The following discharges were recorded during eb and flood tide:

date	eb	flood	
18-3-'78	1.93 x $10^6 m^3$	2.46 x $10^6 m^3$	neap tide
22-9-'81	4.15 "	3.54 "	" "
28-9-'81	11.15 "	12.23 "	spring tide

The shown volumes are corrected for rainfall influences.
Since the tidal volume can be expressed as B x Δh, in which
B = tidal storage area (m^2),
Δh= tidal difference in waterlevel (m),
and the increase in tidal storage area can be assumed to be a function of the average water level ($\bar{h}$), a graph has been prepared showing the tidal volume V against the product of the average waterlevel $\bar{h}$ and the tidal difference Δh. (see figure 3-a)

$$V = \Delta h \times B, \qquad B = f(\bar{h}) \qquad V = f(\bar{h}.\Delta h)$$

For the computer calculations a tidal volume of $4 \times 10^6 m^3$ was used at an average water level during February and a tidal difference of 1.75 m.
From the tidal discharge measurements and the soundings taken it was found that the cross-sectional profile of the Amtali Khal was as indicated in figure 3-b.

WATER DEPTHS

3.4 A bathymetric survey, taking cross-sections every 200 ft from the Buriswar River upto 3800 ft upstream of the old closure site, was executed in April '78. The survey was repeated and extended to 5200 ft upstream of the old closure site in May '81. Location of the cross-sections are shown in Figure 4 and a long section - (talweg-profile)- of this stretch of the Amtali Khal is shown in Figure 5. From these surveys it can be seen that the river depth has decreased for about 8 ft between the cross-section 1800 and 4000. This is probably caused as a result of sedimentation of material scoured away from the old closuredam. Further upstream depths have only slightly decreased.

During the execution of the closure works, regular surveys were made of the area from 450 ft upstream to 450 ft downstream of the proposed closure dam. Water depths were taken by means of sounding pole and for the deeper parts with the help of a lead-line. All depths were converted to PWD. Cross-sections for these surveys were established by pegs on both banks and transversal control was obtained by a long line with markers every 10 ft, which was spanned across the river between the pegs of a cross-section to be surveyed.
Setting out of all pegs was done by means of measuring tape and checks were made by taking some sextant angles.
Annex 3 gives a listing of all surveys executed during the works.

3.5 SOIL CONDITIONS

For the closure works of the '79-'80 and the'80-'81 season no soil investigations were executed.
Therefore a programme was made to acquire information on the sub-soil at the new closure site and of the earth available for the work. Disturbed and undisturbed samples were

taken by borings from the river bed and auger drills were made at the borrow pits on both banks. The borings were performed by the BWDB - Ground Water Division-I and the location of the samples is shown in Figure 6.
Soil analyses were executed at the laboratories of the BWDB - River Research Institute, Soilmechanics and Materials Division and by Soiltech, a private firm, who's assistance was called in view of the short time available for the analyses of all samples.
The soil borings were taking in two campaigns. Five holes were drilled in June '81 (boreholes A,B,C,D, and E) to a depth of 52 ft below the riverbed. A total number of 50 disturbed samples were taken and visually examined and for representative samples grainsize distributions and liquid/plastic limits were determined. Moisture content was determined for all cohesive samples. An abstract of the results is presented in Annex 4.1
During the second campaign, in September '81, again five holes were drilled to a depth of 67 ft (borings 1,2,3,4 and 5), during which both disturbed and undisturbed samples were collected:

boring	no. of dist. S.	no. of undist. S.	total	riverbed at
1	8	6	14	PWD - 7'
2	8	5	13	- 12'
3	9	4	13	- 16'
4	9	4	13	- 21'
5	12	1	13	- 17'

Moisture content, grainsize distribution and specific gravity was determined for all samples. Furthermore a selection of samples were subjected to various tests including: liquid/plastic limits, wet/dry density, permeability and consolidated undrained triaxial shear test. An abstract of the laboratory results is presented in Annex 4.2.

From the soil analyses it appears that the soil consists of fine sands with silt to silt with fine sands, the latter more concentrated to the east bank of the Amtali Khal where shallower depths occur. In the deeper part, against the west bank, the soil is more sandier.
Furthermore it appears that the consistency of the cohesive samples varies considerably from soft to stiff and the relative density of non-cohesive samples varies from loose to medium dense, density increasing with the depth.
For further details reference is made to annex 4 and the soil reports.

It can be concluded that the soil conditions at the choosen site are fairly good. Below 25 ft, SPT values

are all over 5 and in the western (deeper) part of the Khal, even above 10. In this western part fine sands with D50 around 0.080-0.115 mm prevail.
In the eastern half of the khal the silt content of the samples is clearly higher, SPT values are slightly less but clay - and moisture content and angle of internal friction ranging from 16° to 36° do not give reason for special precautious measures regarding the foundation of the dam.
No changes in the design were therefore deemed necessary.

The results of the auger drillings show a rather constant picture. The analyses of one of the auger holes is presented below:

depth	% sand	% silt	% clay	
0' - 3'	43.6	19.2	37.2	clay loam
3' - 6'	16.6	44.9	38.5	silty clay loam
6' - 9'	2.1	56.9	41.0	silty clay
9' - 12'	4.6	52.6	42.8	silty clay
12'- 15'	2.1	58.1	39.7	silty clay loam

CHAPTER - 4

DESIGN AND EXECUTION METHOD

4.1 GENERAL

The design and execution method for the Amtali Khal closure was based on the original design as was prepared for the Chakamaya Closure (1979), with amendments based on experience during the Chakamaya and Madargong Closures and adapted to the conditions prevailing at Amtali. The most significant changes in the original design reflect on the following items:

- The mattresses as specified in the contract were to consist of bamboo and reed only. No intermediate layer of brushwood or golpata leaves was required. The reason was to reduce the costs, as reed is less expensive than the other materials. Moreover, golpata might not be available before december in view of cutting restrictions.
- In the sill-mattresses extra split bamboo was to be used to reduce the mesh width of the grating, improving thus the wash-out-resistance of the reed, in case gunny bags would wash away in high currents.
- The gaps between the walk paths on top of the cofferdam bridge were increased from 4 ft to 5 ft wide to facilitate easy and un-damaged dumping of gunny bags. Also the number of walk paths was increased from three to four to increase dumping capacity. This resulted in a total width of the bridge of 37.5 ft. (Chakamaya 24 ft).
- For the girders of the cofferdam bridge, sized wood 4" x 8" was to be used instead of double half sawn bullah's.
- For bracings half sawn bullah's were to be used in stead of bamboo.
- No abutments were to be made at the beginning and end of the bridge to prevent leakage after closure.

During the execution some additional amendments were carried out, regarding minor details. They will be discussed in Chapter 5.

The major phases into which the works can be divided are:

- Construction and sinking of bottomprotection mattresses.
- Construction of a sill upto the required level, crest width and slopes by dumping gunny bags filled with clay from barges.
- Protection of the completed sill with mattresses to prevent damage during stages with high currents.
- Building of a cofferdam on top of the sill.
- Actual closure operation in two stages by dumping gunny bags filled with clay from the cofferdam bridge .
- Earthwork to complete the closure dam upto specified dimensions.

In the following paragraphs these six phases will be discussed briefly.

4.2 CONSTRUCTION AND SINKING OF BOTTOM PROTECTION MATTRESSES.

For the construction of mattresses a sloping terrace has to be excavated of 80 ft wide and 190 ft long (80 ft perpendicular to the river) on which all mattresses can be constructed. The level of this terrace should be such that at high tides it is sufficiently submerged to allow the mattress to float. On the other hand the level should be low enough so that sufficient time is available (4-5 hours) to construct a mattress during low tide when the terrace is dry.
Based on the available tide information at Amtali, the level of the terrace was set at P.W.D. + 3 ft at the country side and P.W.D. + 2 ft at the riverside.
For sinking operations during high tide slack water the terrace has to be at the downstream end of the sinking area, for sinking during low tide slack water the location of the terrace has to be at the upstream end of the sinking area. In both cases however the terrace has to be within the area demarkated by the anchor blocks.
These anchor blocks (concrete 3'x3'x3') are to be placed in position 450 ft upstream and 450 ft downstream of the sinking area to anchor barges and mattress during the sinking operations. Each block is positioned in the centre line of a mattress as indicated in figure 7 and is provided with an anchor hawser 50 ft long, 1 3/4" dia.
The bottom protection mattress is a sandwich construction composed of an under grating of full bamboo, spaced 3 ft broadwise and 2.5 ft along the length of the mattress.
On top three layers of reed are spread out, the bottom layer length wise, the middle layer broad wise and the top layer length wise. This package is covered with a second full bamboo grate with spacings the same as for the under grate. Then both under and top grating are tied together at the crossings of the bamboos with jute binding rope. (See figure 8).
The under grate is to be made on a dry piece of land adjacent to the terrace, on which the spacings of the bamboo are marked with hetal pegs. If the under grate is completed then it is to be carried by 120 labourers to the terrace for final completion during the low tide preceeding the tide that the mattress is to be sunk. When the mattress is completed in this way, at each end five sink strops (14 rft each, 1½" dia) are fixed to crossings of the under grate, with a loop on top of the mattress.
The sinking procedure at high water slack tide, is as follows:
When the mattress starts to float, (it is still anchored on the submerged terrace) a barge loaded with 3500 gunny bags filled with clay is moored head-on against the shore just downstream of the terrace. Anchor lines are fixed between the barge and relevant anchor blocks and the mattress is towed out by labour force and fixed to the

barge with five sink lines (50 rft each, 1" dia) between the barge bollards and the sink strops on top of the mattress. As soon as the mattress is floating out in the river, the second barge, loaded with 2000 filled gunny bags, is anchored to the five sinkstrops at the other end of the mattress and the convoy is drifted on the end of the flood tide to the sinking location. Steering is provided by the anchor lines and by barge power.
As soon as the convoy is on position, the second barge is bringing out her anchor lines to the anchor blocks and all anchor lines are fixed as tight as possible. For transversal position fixation, both barges bring out side lines to the shore. Barge anchor lines and shore lines are of various lengths (200 rft to 600 rft, 1½" dia). The anchored position of the convoy just prior to the actual sinking is indicated in figure 7.

When the mattress is anchored in the proper position, gunny bags filled with clay are put on top of the mattress to sink it. Ballasting has to start before slack high water when current velocities have almost reduced to zero. Very slight flood current is still running. The total number of gunny bags filled with clay, necessary to sink a mattress of 7500 sqft is 5500. The required bags are to be loaded on the barges, 3500 on the first barge, 2000 on the second barge, prior to the sinking operation.
Ballasting of a mattress is to start from the middle of the mattress. Therefore the bags are carried by headload from the first barge. Ballasting progresses towards the first barge gradually as the mattress is submerging. To facilitate walking over the floating mattress, bamboo gangplanks are put on top of it.
At the end of the mattress extra bags are dumped to increase the weight to ensure quick sinking to the bottom.
When sufficient ballast is dumped the sinking lines of the first barge are released simultaneously and the end of the mattress sinks to the bottom. Then the first barge is pulled by labour force towards the second barge, which remains anchored at it's position. The anchor lines of the first barge are run out and gunny bags are dumped on top of the sinking mattress as the first barge is pulled across.
When the first barge has approached the second one close enough, the other end of the mattress is heavily ballasted as well by dumping the remaining bags from the first barge and some additional bags from the second barge. Then the remaining sinklines are released simultaneously and the mattress sinks to the bottom.
At this moment the current should be zero, or at least, not yet reversed to ebb-current.
The first barge, which is empty by now, is pulled back to its original position and anchor lines are fixed tightly again. The second barge is then pulled towards the first

would cause current concentration resulting in scour of bags.
The second stage of the closure in which the current is stopped definitely, should start at such a time that the final closure gap can be closed at the turn of the tide in the closure gap. Calculations have shown that at this stage the water level at the country side of the dam will then be approximately equal to the average tide level. Before the second stage of final closure starts, a third bamboo screen is to be piled, with the same purpose as the other two bamboo pilings. In this second stage the gunny bags are filled to a level of 2 ft above the maximum tide that can be expected during the construction period.
After the flow has been stopped the labourers should re-adjust the dumped bags to the profile shown in figure 12.

4.7 EARTHWORK

Immediately after the closure, earthwork has to start. Sufficient labourers have to carry earth by head load into the dam profile. The earthwork should proceed at such a speed that before the next spring tide an earth dam is completed against the gunny bag dam upto the same level as the gunny bags, to guarantee the safety of the construction.
As soon as the cross dam is completed to the required dimensions the embankment has to be constructed on top but first the girders have to be removed to prevent the forming of gaps under them due to settlements of the under laying material.

4.8 HYDRAULIC COMPUTATIONS FOR THE SILL LEVEL

The maximum velocities on top of the sill should not exceed 2.5 m/s (8 ft/s), otherwise gunny bags would be washed away and the sill could be damaged. Slightly higher velocities upto 3 m/s (10 ft/s) are acceptable during short periods.
Experience with Chakamaya and Madargong closures have learned that actual velocities in prototype will be 80% less than the calculated ones.
The velocities that will occur during spring tide on top of the sill are determined by means of step by step floodrouting calculations, similar to the ones used in the design of sluices. For the computation use was made of a computor programme.
For the calculation of the maximum occuring velocities a springtide of 1.75 m (5.7 ft) difference between high and low tide was selected, corresponding with the predicted spring tide at Amtali during the end of January '82.
The tidal amplitude of 1.75m (5.7 ft), the basin area of 230 ha (570 acres) and the width of the sill 105m

(350 ft) were entered into the computer and velocities were calculated for different sill levels, ranging from -3.5 to -2.5 to -1.5 to -0.5m below average tide level. Annex 5 shows an example of the computer output and in figure 13 the results of various runs are plotted.
As can be seen from figure 13, the computed maximum velocities during the flooding tide will exceed 3.0 m/s (10 ft/s) if the sill would be raised to a level of 1m below the average tide level. To keep this maximum velocity below the 2,5m/s (8 ft/s) the maximum sill level would have to be 1.4m below the average tide level.
From figure 2 it can be seen that the average water level during the month of February at Amtali is PWD+0.38m and thus the sill level would have to be PWD - 1.02m (-3.4 ft).
For practical reasons the design sill level was set at PWD -4 ft.

CHAPTER - 5

EXECUTION OF THE WORKS

5.1 EXECUTION

After the work order was issued to the contractor on 10th November 1981 the works physically commenced on the 30th of that month, when surveyors started to set out the work in detail and the first bush was cleared.
The execution further proceeded as prescribed in the tender documents and according to the procedures discussed in chapter 4 to which is referred.
Only at some points the execution deviated or was slightly amended. The applied ammendments and deviations from the design and the prescribed execution method are:

- For the construction of a mattress under grate a dry level field was to be available next to the sloping terrace required for completing the mattress at low tide. Normally this level field lies parallel with the river, but in Amtali it was pegged out perpendicular to the river axis to reduce bush clearing and to save some homesteads from demolishment. The consequence was that the under grate, when carried out to the river, had to be turned. This proved to be no problem. The under grate was carried across the bund at high tide, floated out into the river, turned in the proper way and then pulled back into the submerged terrace.
- Although the contract specified precisely the construction and thickness of all ropes to be made, the contractor deviated to some extend from the requirements.
  For binding rope, 3-ply was required. The 2-ply rope delivered was accepted because pulling strength was sufficient. Still previous recommendations, to use 3-ply rope remain valid, because this will "run" easier. 2-ply rope is however quicker produced and consumes less jute.
  Where 5-ply hawsers and anchor ropes were required, the contractor delivered ready-made 16 ply rope and site-made 4-ply ropes of sufficient strength. The ready made rope was of excellent quality and served very well, 4-ply ropes was the maximum that could be made on the hand-powered rope machine.
  During the dumping operations it appeared that the ready made 8-ply ropes of 3/4" dia were much handier to be used as sidelines than the envisaged 1" dia ropes which were to be made at site. The ¾" dia rope was much lighter, more evenly made, and therefore easier to handle and as strong or stronger than the 3-ply 1" dia site-made ropes.

- Due to the short supply of reeds, in a number of mattresses the middle layer of reed was exchanged by golpata leaves. Instead of reed, 10 to 15 half split golpata leaves were used per compartment . As the short supply of reed was going to cause serious delays in the time schedule, for which he could be penalized, the contractor choose to use golpata in the construction of 7 bottom mattresses and the last two sill mattresses.
- Transversal dumping of gunny bags, as prescribed in the contract was not executed, as this required considerably more time in positioning and anchoring of the barges and the pulling of the barge across the dumping area in a smooth and even way proved to be quite difficult. Therefore the dumping of gunny bags for the sill was only done with the barges anchored on stream. If sufficient care is taken while dumping and the pulling across is done with the help of the capstan, the result is satisfactory as was proved by the soundings.
- Gunny bags filled with bricks were not employed as extra ballast on top of the sill mattresses. Instead they were used to fill some notorious scouring places in the sill after the sill mattresses were placed and clay-bags were washed away from depressions that were formed due to settlement of the sill. After repair of this spots with brick-bags no appreciable scour could be detected anymore. It should be noted that the piling work did not experience any difficulty to drive a pile through a 2 ft layer of brick-bags.
- The construction of a sill mattress was amended slightly, by ommitting the top full bamboo of the upper grate at the place where a reed roll had to be fitted. It was experienced that this bamboo was laying quite loose after the reed roll was tied to the mattress and did not have any relevant function. At the same time the double bamboo in the centre of the reed roll was extended for 3 ft so that it protruded upto the edge of the mattresses. Altogether the reed roll could be fixed much tighter and it would not be liable to swaying back and forward in the current.
- The contractor interpreted sized wood 4" x 8" as bullahs which he intended to saw at site to the required size. Practice proved that the average size of sized wood which could be cut out of the bullah's was 3" x 6". In the interest of the work this size was accepted, but adjustments in the rates were to be made. Where necessary double girderswere fitted to reduce bending. The bridge after completion, proved to be a very solid one and no repairs or maintenance was necessary.
- Six days after the actual closure the bracings of the bridge were cut in order to facilitate settlements of bags in the holes that were formed under thise bracings as a result of settlement and shrinkage of the dam. After the bracings were cut, the settlement of the crest was backfilled with the spare gunny bags upto the level

of PWD + 8 ft again. The seepage through the dam stopped within a few hours and further settlements were only minor.

All gunny bags that were used for the mattress sinking and the sill dumping were filled at the obsolete brickfield outside the embankment of the polder 43/1 near the WAPDA colony in Amtali. The quality of the clay there was very good, the site was close to the water, barges could be loaded without a barge jetty being necessary. Sailing time for the barges from this filling site to the closure site was approximately 30 minutes and did not influence or delay the dumping works since loading time was the critical activity in the loading - unloading cycle.
The optimal cycle time for a barge was:

sailing from dumping location to loading field	:	20 min.
mooring at loading point	:	5 "
loading 3500 gunny bags filled with clay	:	90 "
sailing from loading field to the dam	:	30 "
positioning at right location	:	30 "
dumping gunny bags	:	35 "
		210 "

Considering that dumping cannot start before 08.00 hrs (too cold), and should be completed before 18.00 hrs (too dark), and that only one barge can be engaged with positioning and anchoring at the time, the theoretical maximum number of barges that could be dumped in one day with three barges is 9. Maximum out-put was seven barges dumped in one day. Normal output was 6 barges loaded and 5 barges dumped on one day or 5 barges loaded and six barges dumped on one day, which was equal to the Chakamaya output.

Although the contract provided for the filling of 8000 bags with 100.000 bricks, it became clear during the execution that one gunny bag with normal size 2'-6" x 1'-6" cannot contain more than the equivalent of 7-8 bricks if broken bricks and overburned broken bricks, as available in Amtali, are used. The weight of a brick-filled gunny bag therefore was only 0.8 times the weight of a clay-filled bag and more bags are to be used to arrive at the required ballast weight of a mattress. The bricks used in Amtali were gathered from the same obsolete brickfield where the gunny bags were filled with clay.

As a sort of examination or test, the last sill mattress was sunk without any assistance from the dutch experts. The sinking operation was controlled by joint BWDB and contractor's staff only. Although some details were not fully according to the instructions given, in general the sinking operation went without problems and the sill mattress was grounded in a proper way at the right location. However it should also be considered that this mattress was not the most difficult one, and that the circumstances during sinking were very favourable. Successfull sinking of one mattress does not mean yet that the planning and management of a complete sinking work can be conducted.

The filling of gunny bags was checked by measuring the borrow pits, keeping record of the bags filled and by taking regular soundings of the sill under construction. On January 12th-'82 the measurements of the borrow-pits gave a total of 161,333 cft. excavated. According to the records 133,500 bags were filled upto that date, resulting in a filling of 1.21 cft per bag measured in the borrow-pits.
Comparison of the soundings of December 3-'81 (pre-work) and of March 1-'82 yields a filling of 1.13 cft per bag measured in the sill between cross-section 175 north and 175 south of the centre line. The total number of bags dumped from the barges, inclusive the bags used for the sinking of mattresses was upto that date 478,000. The total volume increase of the sill compared with the pre-work sounding was 586,500 cft. If it is assumed that the materials for bottom and sill mattresses represents a volume of 55,000 cft, than the filling per bag measured in the work is 1.11 cft.
If it is further assumed that the filling of the gunny bags has remained on the same level as upto 12 January, than the difference between 1.21 cft and 1.11 cft per bag should be accounted to the wash-out and wash-away of bags. But also scouring of the original bottom took place during and after the placing of bottom mattresses as clearly can be seen on the sounding map of 13-14 January. (See figure 14). On this map clearly the contours of bottom mattress no.7 can be seen and to the east of it, a scouring gully just along the edge of the mattress.

Most of the gunny bag losses have occured during the final stage of sill construction. Especially on the crest and the southern slope of the sill, bags were washed away during the spring tide period. An area of 4200 sqft was studied, between cross-section 5 and 65 south of the centre-line, and between distances 125 to 195 from the east bank peg line. In the period from February 1st to February 7th bags were dumped in this area which should have resulted in an average bottom rise of 3 ft. If the soundings of February 1 and February 11 are compared, than an average rise of only 1.3 ft is measured. I.e.,1.7 ft of fill has been lost during the spring tide around February 10 due to wash-out and wash-away of bags, but also settlement of the dam has contributed to this.
After the gunny bags on the sill have had the time to settle during neap tide period, with modest currents, the scouring resistance is much higher, as was studied from the soundings of February 17, 26 and March 1, which show an almost constant average level of the area of P.W.D.-5 ft with only small deviations that should be contributed to shrinkage, settlements and measurement inaccuracies.

After the final closure a total average settlement of the gunny bag dam between March-5 and 24 was 0.8 ft, measured

on top of the girders. In the same period the crest of the dam had been refilled with a layer of 4-5 gunny bags with a thickness of 3.5 ft on the average. So it can be concluded that the dam as a whole did settle 0.8 ft into the sub-soil and that the gunny bag fill which was in the average 24 ft thick, shrunk 3.5 ft or 15%.

Earth work started on March 7-'82 with 1600 labourers, but within a few days this number decreased to 800-1000. On March 24 a progress survey was made which revealed that 30% of the total earth work was completed. A check survey of May 16 revealed a completion % of 77.

5.2 MANPOWER, MATERIALS AND EQUIPMENT USED

Figure 17 shows the manpower involved with the project. Upto the start of the earth work on 6 March 1982, a total of 27380 mandays have been spend with the execution. Some typical labour output figures are:

- mattress making : 50 men during one day can complete one mattress.
- mattress sinking : 100 men in total to ballast the mattress.
- sill dumping : 50 men can dump one barge load (3500)in 35 minutes .
- pile driving : party of 20 men can drive 12 to 16 piles of 28 to 34 ft per day if currents are not too high.
- filling 1000 gunny bags with earth: 15 mandays
- earth work 1000 cft measured in borrow pit, less then
  200 ft lead : 15 mandays
  900 ft lead : 37 mandays
- loading barge with 3500 filled gunny bags: 150 men during 1½ hour.

The following jute ropes were used during the work:

type	circumference	dia	length	no.	total rft.
-hawser at anchor block	5.5"	1¾"	50'	16	800
-barge anchor lines	4.7"	1½"	600'	8	4800
			400'	2	800
			300'	3	900
			200'	8	1600
-sink strops on mattress			14'	252	3528
-sink lines	3.2"	1"	14'	50	700
-side lines			400'	2	800
			300'	6	1800
			200'	2	400
-auxillary ropes	2.7	¾"	200'	10	2000
				total	18,128rft

For mattress making, cofferdam and walkpaths, bamboo piling, speedboat jetty and other various purposes 222,152 rft of

binding rope was used.

For the construction of mattresses the materials actually used correspond with the quoted quantities in the schedules which are presented in Annex 6.
For the mattresses in which the middle layer of reed was replaced by golpata, the total number of reed bundles and golpata leaves used was:

	reed bundles	golpata leaves	
- mixed reed/gol. bottom-mattress (54'x150')	3240	12960	+)
- " " sill-mattress (54'x130')	2844	11232	
- " " sill-mattress (45'x130')	2376	9360	

+) average 12 leaves per compartment.

The total golpata used in 7 bottom mattresses and 2 sill mattresses is 111,312 half split leaves = 87 kahon (=1,280 half split leaves). The number of reed bundles saved by this is (2,160 x 7) + 1,872 + 1,560 = 18,552 which is 14% of the total estimated reed bundles required (132,800).

The second hand gunny bags used for the works were to be supplied in 6 contingencies of 100.000 bags each and two contingencies of 100.000 bags attached to the supply of bullah's and girders. One allotment of 100.000 gunny bags and the attached supply of half the required bullah piles and girders was compulsary for the main contractor to include in his bid for the closure dam and the earth work. The 6 separate gunny bag tenders were allotted to 6 different suppliers. Because of short supply of some suppliers, others were requested to delivery additional quantities. However, two weeks before the final closure operation, still a shortage of bags existed and BWDB had to replenish the stock by acquiring 60.000 bags additionally.
The gunny bags for the work were eventually supplied in the following allotments: 206,950 - 162,150 - 97,000 - 100,000- 23.000 - 94,550 - 27,670 and 60,000, delivered by the six supppliers, the main contractor and the BWDB, totalling 771,320 no.
Of this total 760,320 were filled with clay and 11.000 were filled with bricks and broken bricks.
During filling, carrying, stacking and loading on barges and because of pilferage and domestic use by the labourers, the number of bags actually used in the work is less than the total figure. According to the records, the following quantities were used:
- loaded on the barges for mattress sinking and sill dumping 478,000
- dumped from bridge for maintenance and final closure 211,000

total: 689,100

Thus of the total quantity of gunny bags supplied, 89.5% was actually used in the closure dam.

The bullah piles required for the work were all supplied by the main contractor. Although the number of long piles required was the bare minimum, the quality of all piles was excellent, 95% was very straight and of sufficient thickness, which favoured the quality of the piling work considerably. Only very few piles were driven oblique and only one had to be pulled out and redriven. Inspite of the less experienced pile driving crews, the piling work was satisfactory, however rather slow.
The following bullah piles were used:

16 pc of 20'	1 pc of 34'	
32 pc of 28'	40 pc of 36'	
52 pc of 32'	16 pc of 38'	Total 166 piles, 5286 rft.

Total drive was 2873 ft or 17.3 rft per bullah.

For girders, bullah's were sawn at site to maximum possible size of sawn wood. Still only very few girders met the required size of 4" x 8". Average size of the girders delivered was 3" x 6".
Total used 58 pc of 14'
42 pc of 27' total 1946 rft.
The complete schedule of all materials used in the work is presented in Annex 7.

The equipment used for the closure works comprised:
- CEP barge no. 3 from Barisal
- CEP barge no. 10 from Bhola
- CEP barge no. 4 from Barguna

The barges were repaired and reconditioned before they were sent to Amtali. The deck crane was removed and additional bollards were placed for the mattress sinking operations.
Except for one minor breakdown on two of the barges, all performed well throughout the works.
One new outboard engine 40 HP was made available by the Netherlands Embassy and two very old outboard engines were kept in running condition by BWDB drivers who have to be admired for this job. For rope making two simple machines were brought at site by the rope makers, a heavy one for the anchor ropes and a smaller one for making binding rope.
For the pile driving work two bamboo rigs were built on top of two country boats. For the first row of piles a ladder type rig was made to drive these piles from the shore. Pile driving was done in the conventional way by labour force using ram weights of 4 and 7 maunds (160 and 280 kg).

5.3 TIME SCHEDULE AND WORKS DIARY

The original time schedule is shown in Annex 8. The dotted bars indicate the actual time that was needed to complete the works. If a comparison is made, it can be seen that the work started one month behind schedule. Various factors have caused this delay, amongst others the

explicable and expectable attitude of wait and see during and immediately after the presidential elections on November-15, 1981. The work order was issued to the contractor on 10th November (original plan 15th October) and as far as could be checked, the contractor-started with preparations for the works quite soon afterwards. Still, all activities of the time schedule of Annex 8 started one month later than planned. The physical start of the work i.e. construction and sinking of the first bottom mattress again was delayed for two more weeks because of the difficulties the contractor had with the supply of reed and some disputes with riparians about compensation notice for the land to be acquired. The delay in reed supply was mainly caused by the cyclonic storm that swept across the reed fields on 10 December 1981 and blow away a considerably stockpile of already cut reed bundles. After the reed supply was re-arranged, part of the lost time was made good during the dumping of gunny bags for the sill and the sinking of sill mattresses which was completed within 40 days after the first bottom mattress was sunk. (Originally scheduled to take 62 days). Instead of the scheduled 15 February, the Amtali Khal was closed on March-5, 1982. Considering all, it is a prove of the contractor's thight grip on his labourers and the organisation of the work, that the closure date had only to be shifted one neap tide.

CHAPTER - 6

COST AND CONTRACTUAL MATTERS

The contract consisted of the following four parts:

PART "A" : Construction of a cross dam applying mattresses and gunny bags filled with clay.
PART "B"-1 : Supply of half the required bullah piles and girders plus 100,000 second hand gunny bags.
-2 " do "
PART "C" : Earthwork of cross dam, approach embankment and embankment on top of the cross dam.
PART "D"-1 : Supply of 100,000 second hand gunny bags.
-2 : " do "
-3 : " do "
-4 : " do "
-5 : " do "
-6 : " do "

Tenderers were requested to quote rates for part A and part B and a lump sum for part C. Part A and C and one of the two parts B were compulsary for the main closure contractor.
After several retenderings and additional negotiations the contract was eventually awarded to Ms. Abdul Jalil Miah, an "A"-class contractor from Kepupara-Patuakhali district for the sum of Tk. 49,63,000.-, which was 29% above the estimate.
Upon completion of the work the final bill was settled at Tk. 44,62,000.-

For the second consignment of the bullah piles and girders plus 100,000 gunny bags tenders were called five times. Rates quoted were extremely high and on the last two calls even no response was received at all. Therefore it was decided to negotiate with the main contractor the supply of the remaining bullah's and girders against a favourable rate.

Six contractors were awarded to supply gunny bags against rates varying from Tk.3.34 to Tk.3.62 per bag. The estimated rate was Tk.2.80. Average purchase price was Tk.3.52 per bag, 25.7% above the estimate.

The following table presents a summary of all estimates, contract sums and final bills paid.

Contract	estimated	contract sum	Final bill
PART "A" - Closure works	Tk. 19.07.226	25.88.000	23.62.690
PART "B"-1- Bullah's + 100.000 bags	Tk. 3.70.280	4.96.000	2.99.733
PART "B"-2- " do "	3.70.280	77.185	1.34.302+)
PART "C" - Earth work	Tk. 15.62.636	18.79.000	18.79.000 (L.S.)

+) excluding gunny bags

PART "D"-1 - 100.00 bags	Tk.	2.80.000	3.34.000	5.41.581
" -2 - "	Tk.	2.80.000	3.62.000	7.49.159
-3 - "	Tk.	2.80.000	3.52.000	3.41.440
-4 - "	Tk.	2.80.000	3.59.000	3.39.435
-5 - "	Tk.	2.80.000	3.52.000	3.52.000
-6 - "	Tk.	2.80.000	3.55.000	81.650
ADDITIONAL PURCHASE 60.000 bags	Tk.			2.11.200
TOTAL	TK.	58.90.422	71.54.185	72.92.190

Add to this the costs of the use of three barges and speedboats, estimated at Tk.7.45.000.-, then the total cost for the Amtali closure was Tk. 80.37 lakh. The cost of land acquisition and BWDB establishment are not included in this amount.
The tendered rate for the previous contract to close the Amtali Khal following Bengali method was Tk. 60 lakh. Taking into account a yearly inflation of 15% this would be Tk.79 lakh at present price level. This shows that closing a tidal channel following the Dutch method can be done for the same costs as the Bengali method. However the comparison has only limited value because it is not known which % of the Bangladesh-method costs comprises material and labour cost and which part is contractors overhead for risks and profit. Indirect cost for BWDB due to the two closure attempts were already Tk.24.96 lakh. Moreover some re-excavation works of diversion channels leading towards drainage sluices would not have been necessary or at least much reduced in case the first closure attempt would have been successful. Also the extra cost for land acquisition would not have been necessary and the cost of 1.5 mile of embankment of Tk.3.31 lakh could have been saved.

Against the total project cost of Tk.110 lakh,which amount includes land acquisition and sluice repair and maintenance cost, there is an estimated increament of benefit for the polder due to the closure of Tk.53 lakh (financially) and Tk.65 lakh (economically).

Considering the terms and conditions of the contract used, it is felt necessary to include a compensation for the contractor in case the number of gunny bags actually used for the works is substantially less due to the good filling with clay. The contract prescribes that gunny bags should contain at least one cft clay measured in the borrow pit. During the Amtali works it became clear that the filling was more than this 1 cft and the strong impression existed that the contractors objective was to save in this way a good number of bags, which saving would be credited to him. Unfortunately no provision was available in the present contract for such gain. However, proper filling of gunny bags should be stimulated because not only costly bags are saved but scouring resistance of properly filled bags is much better than of poorly filled bags. It is therefore recommended to exclude the supply of gunny bags from the main contract. All required gunny bags are to be supplied by separate contractors to the BWDB, who is issuing the bags out to the closure contractor, who is responsible to fill all issued bags and use them in the work. For the filling, sewing and stacking

he is to be paid a unit rate which is progressive with the cft's filled per bag. In this progressive rate it should be expressed that contractor is punished for bad filling but he is sharing in the profit made by requiring less bags.

CHAPTER - 7

EVALUATION AND TECHNICAL RECOMMENDATIONS

After the successfull closure of the Amtali Khal it can be concluded that the experimental phase of introducing Dutch methods in closing tidal inlets in Bangladesh has ended. Although technically the Amtali Khal was not a very difficult test case, due to fairly moderate tidal amplitude and favourable soil conditions, it is still a proof of the technical ability of both Water Board and contractor to complete this kind of work without many problems. The best example is the successful sinking of the last sill mattress by contractor under Water Board guidance and supervision only.

However the training and knowledge transfer to Bangladesh engineers and the managerial involvement was still too limited. Generally the following BWDB staff is estimated to have been involved with the execution as follows.

staff	at site	in office	
XEN	0.75 manmonth	1.0 manmonth	
SDE	2.75 "	0.3 "	
SO	3.0 "	0.2 "	
BWDB	6.5 "	1.5 "	total 8 manmonths
Expatr.	7.2 "	.25 "	" 7.5 "

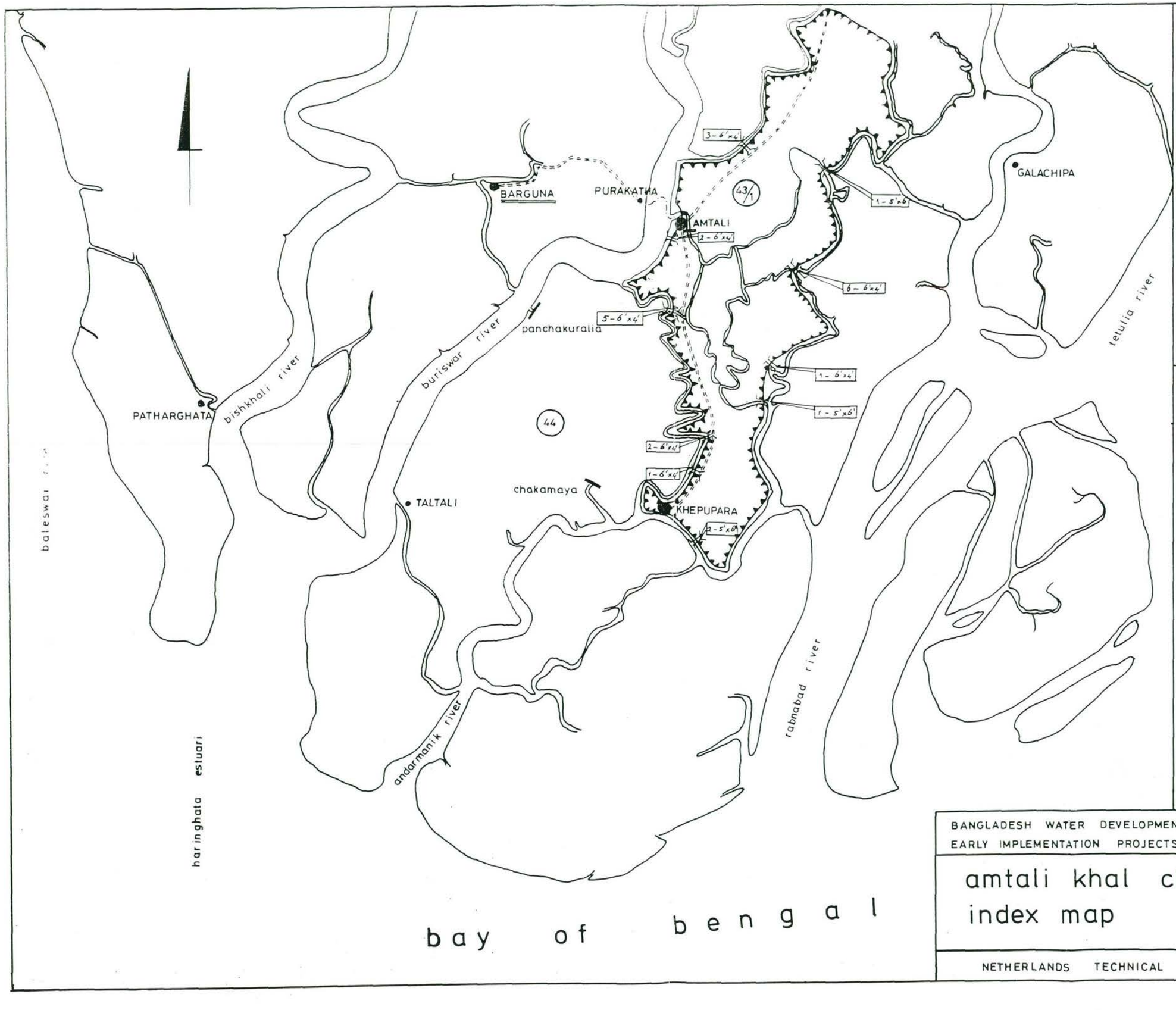
Total duration of the project from 22 November 1981 to 12 March 1982 is 3.5 months.
It is clear that the number of BWDB officers should be increased considerably. It is felt imperative that three S.O.'s should be at site instead of one only, and the SDE should have the assistance of one A.E. permanently. Also the number of supporting staff like store keepers, surveyors and work assistants should be higher.

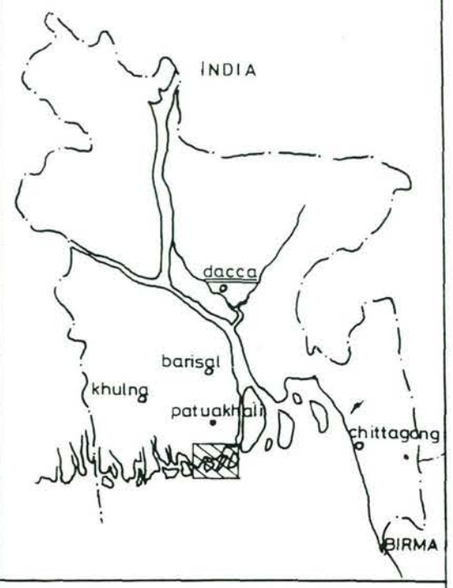
Technically some recommendations can be made to improve on the existing procedures and methods.
- For the Amtali closure all required gunny bags for mattress sinking and sill dumping (total 478,000 no.) were filled at an area which was at some distance from the closure site. The advantages of using this area were:
  . Good quality clay (old brick field)
  . Easy accessable for the barges (loading was possible without a barge jetty)
  . No land acquisition problems and costs.
  . Clear separation between filling work and all other activities.
  The only disadvantage is the higher fuel consumption of the barges. Extra fuel consumption for carrying 104 bargeloads for dumping plus 42 barge loads for mattress sinking is

estimated to have been 500 gallons.[+)]

- The amendment made in the construction of the sill mattress with respect to the fixing of the reed rolls saves construction time and materials and the reed roll is fixed much tighter to the mattress.
- For future use in mattress sinking operations and dumping of gunny bags it is recommended to remove the columns at both sides of the barges. The columns were used in the past to fix and handle the ferry ramps that were attached, but they have no function any more. Also a bollard should be fixed at the middle of the bow of each barge to guide the anchor line if the barge is anchored on stream.
- The use of brick-filled gunny bags is only recommended incase serious wash-out of the earth from the gunny bags occures, followed by washing away due to the lesser earth-contents. In case sufficient brick-bags are used the reduced weight of these bags may be compensated by a better hooking together of the bags filled with bricks.
- For closure of 200 ft wide or more it is advisable to make use of a portable echosounder. The work for the surveyors, using sounding pole and measuring line is very streneous and monotonous. They regularly loose track of their transversal position and have to work long hours including plotting of the results in the evening hours at candle light. Especially for wider closures the accuracy and general quality of the work will be much better if a simple echo sounder is used. A suitable echosounder may be borrowed from the River Research Institute - stores.
- To stimulate and renumerate the contractor to fill the gunny bags as good as possible, the contract should provide for reduced rates in case more bags are used than the estimated together with a bonus for every bag that is used less than the estimated quantity. The present contract did not specify any benefits for the contractor if filling was done in a proper way, as was the case during the Amtali closure.

+) based on 75 HP installer on each barge.





legend

- embankment
- road
- ferry
- sluice
- no of vents, size
- proposed closure dam
- completed .. ..

SCALE: (miles)

0 1 2 3 4 5 6

1 0,5

BANGLADESH WATER DEVELOPMENT BOARD
EARLY IMPLEMENTATION PROJECTS

amtali khal closure index map

fig 1.

NETHERLANDS TECHNICAL ASSISTANCE PROGRAMME

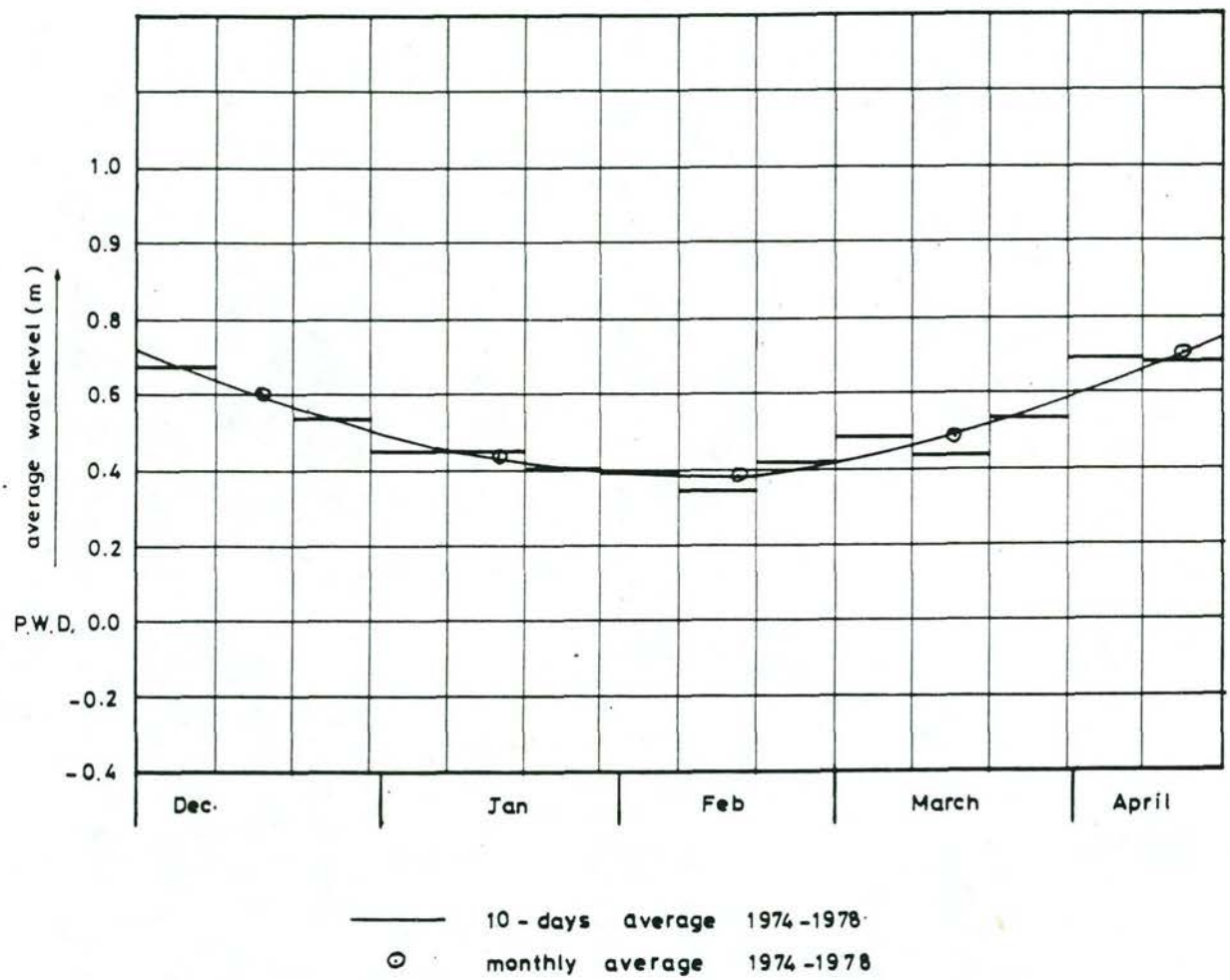


figure 2. Average Waterlevels at Amtali Bandar.

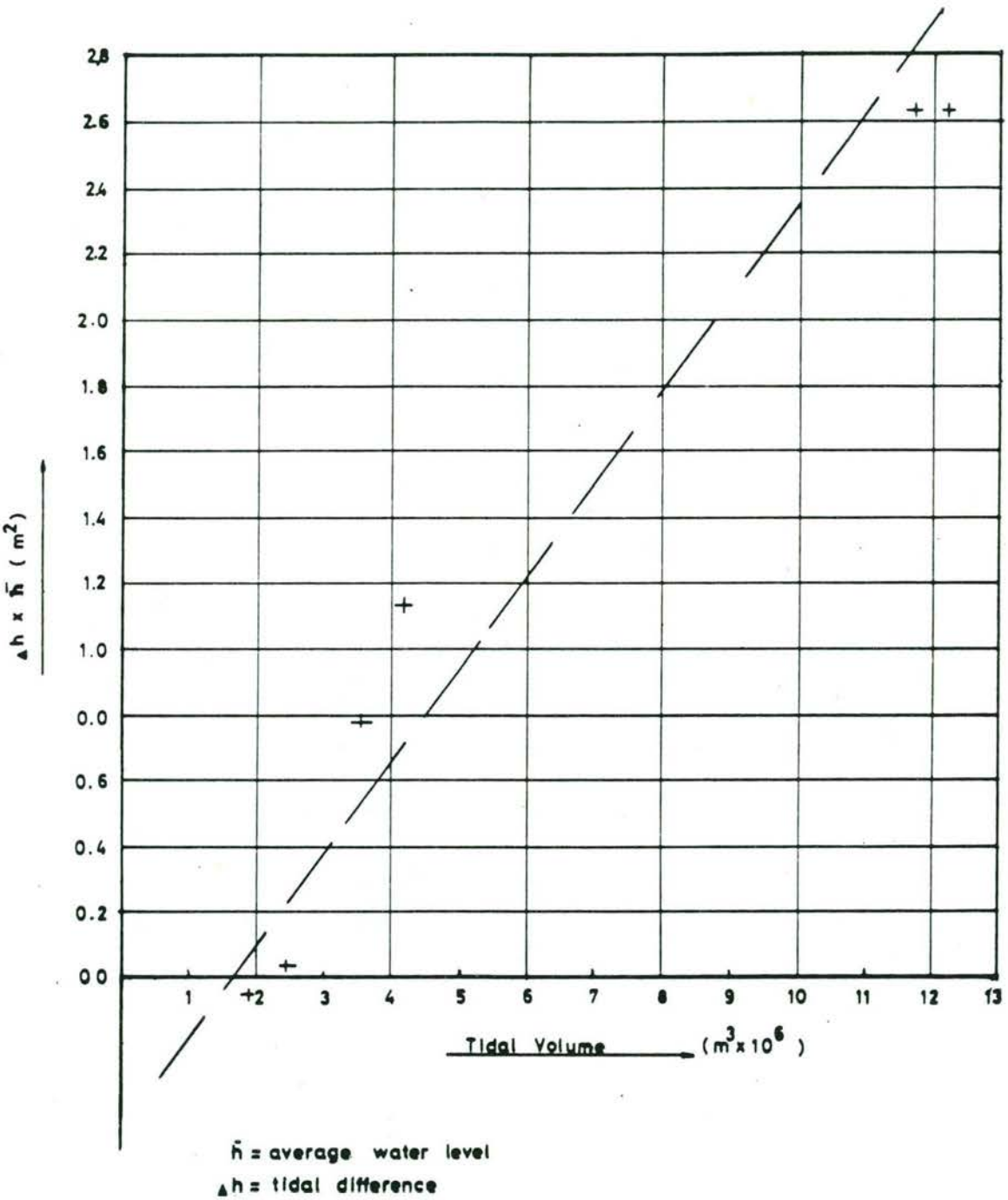


figure 3 -a. Tidal Volume of Amtali Khal.

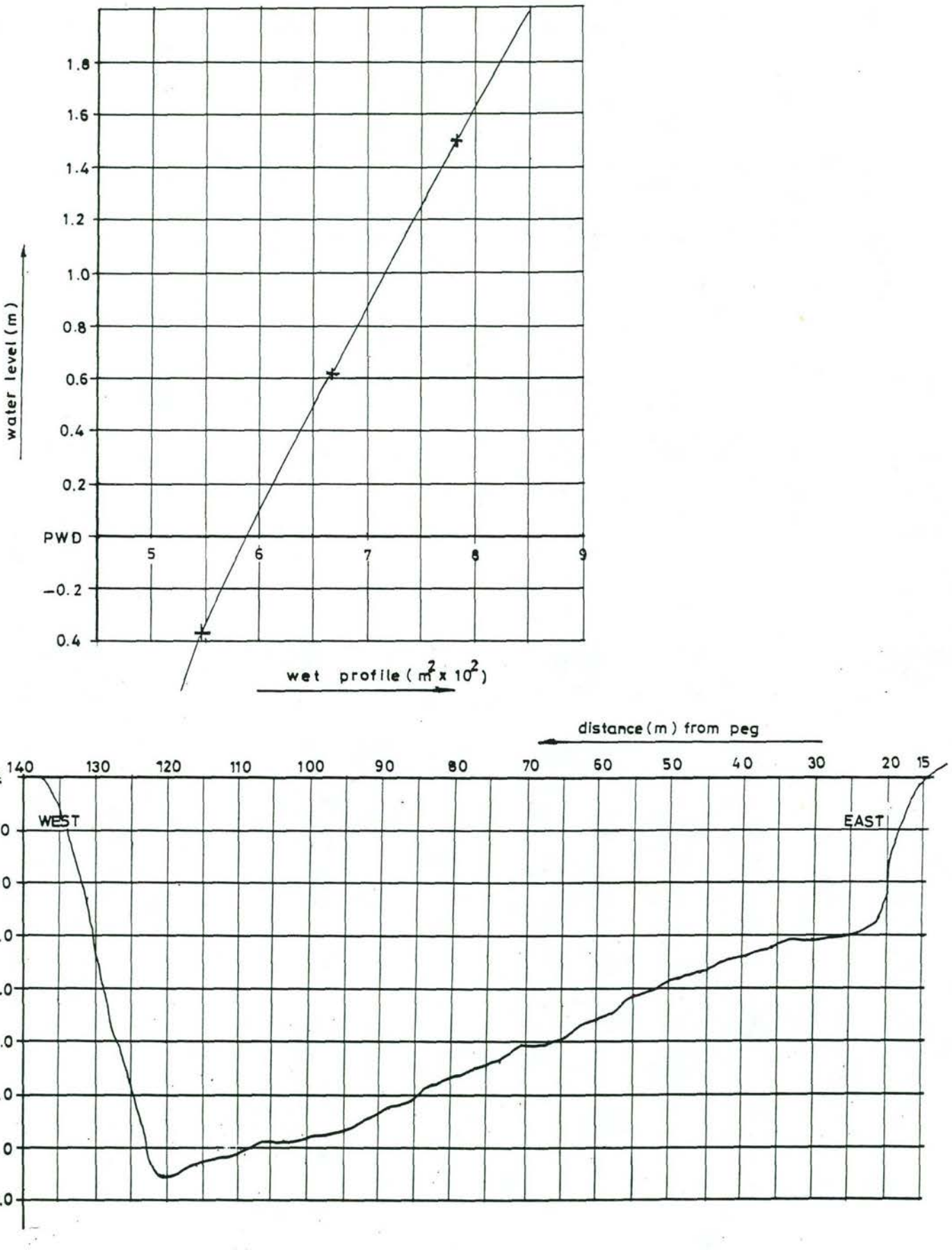


figure 3-b Cross-section area of Amtali Khal.

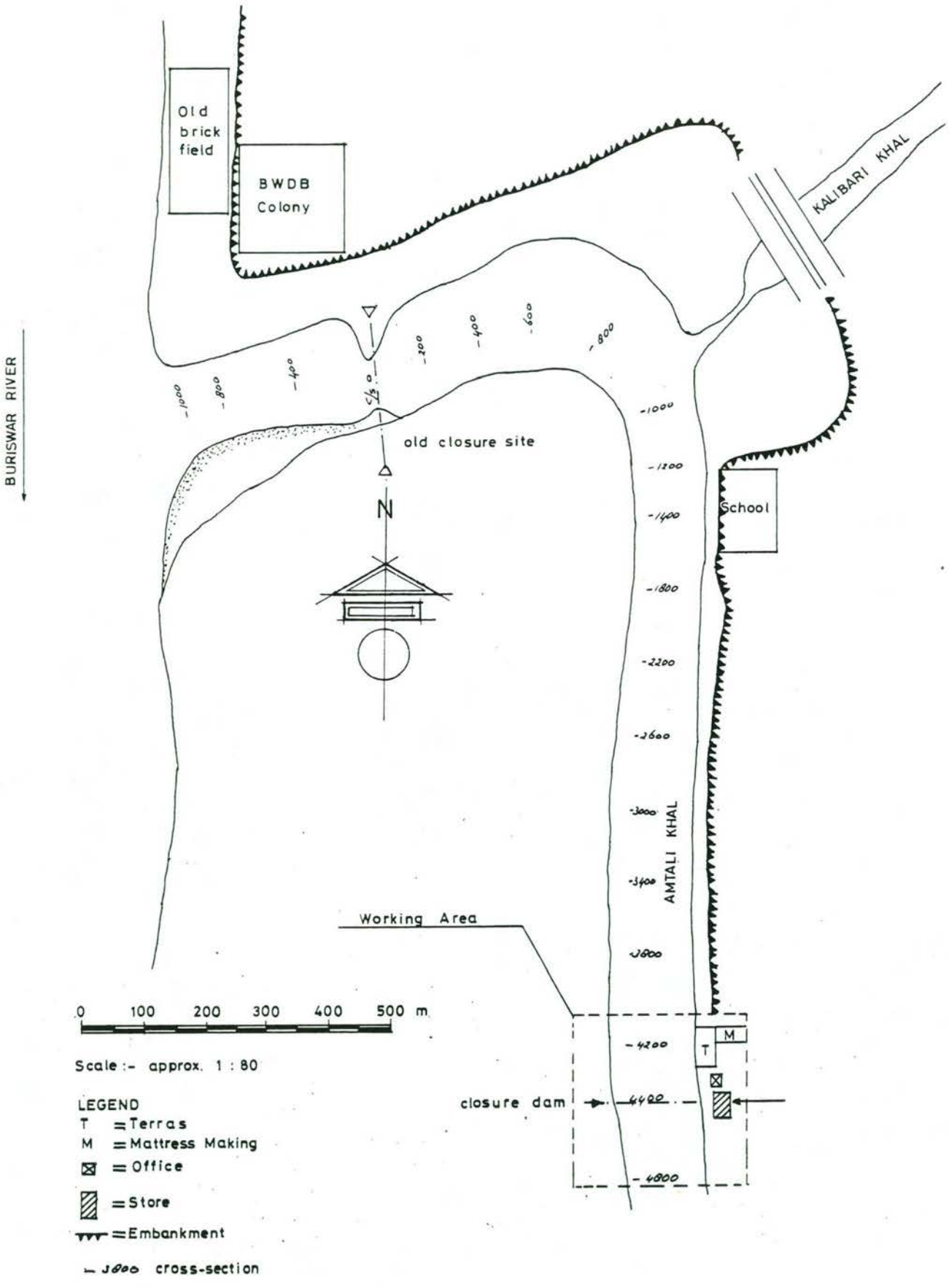


figure 4. Location of closure site.

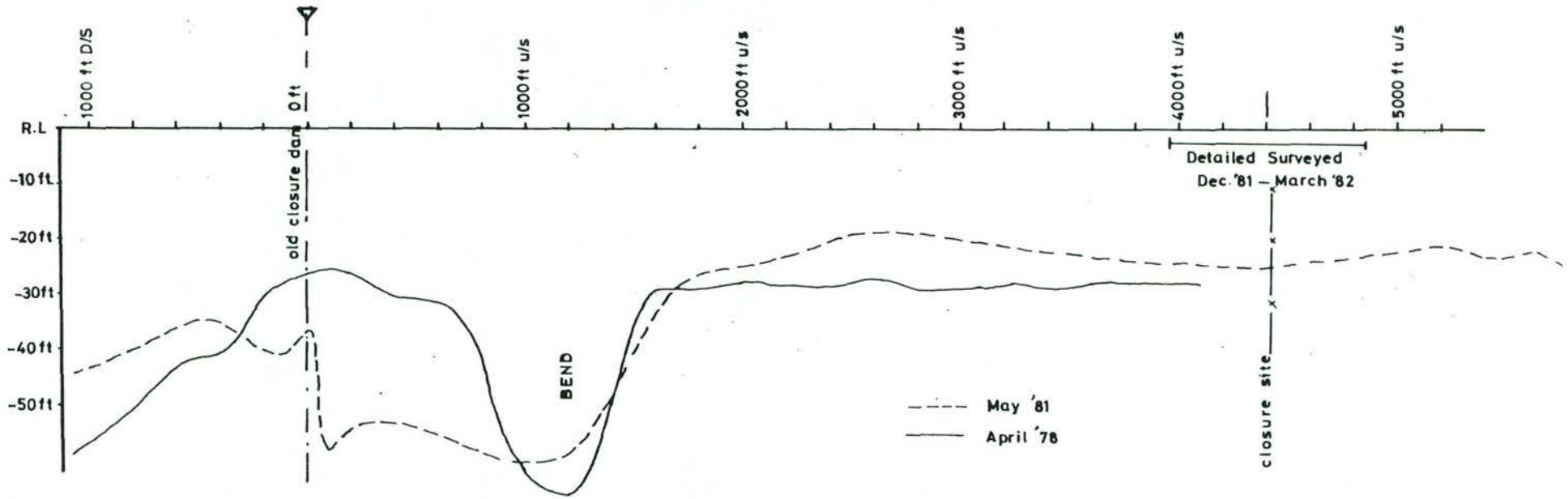


Figure 5. Talweg sounding of Amtali Khal.

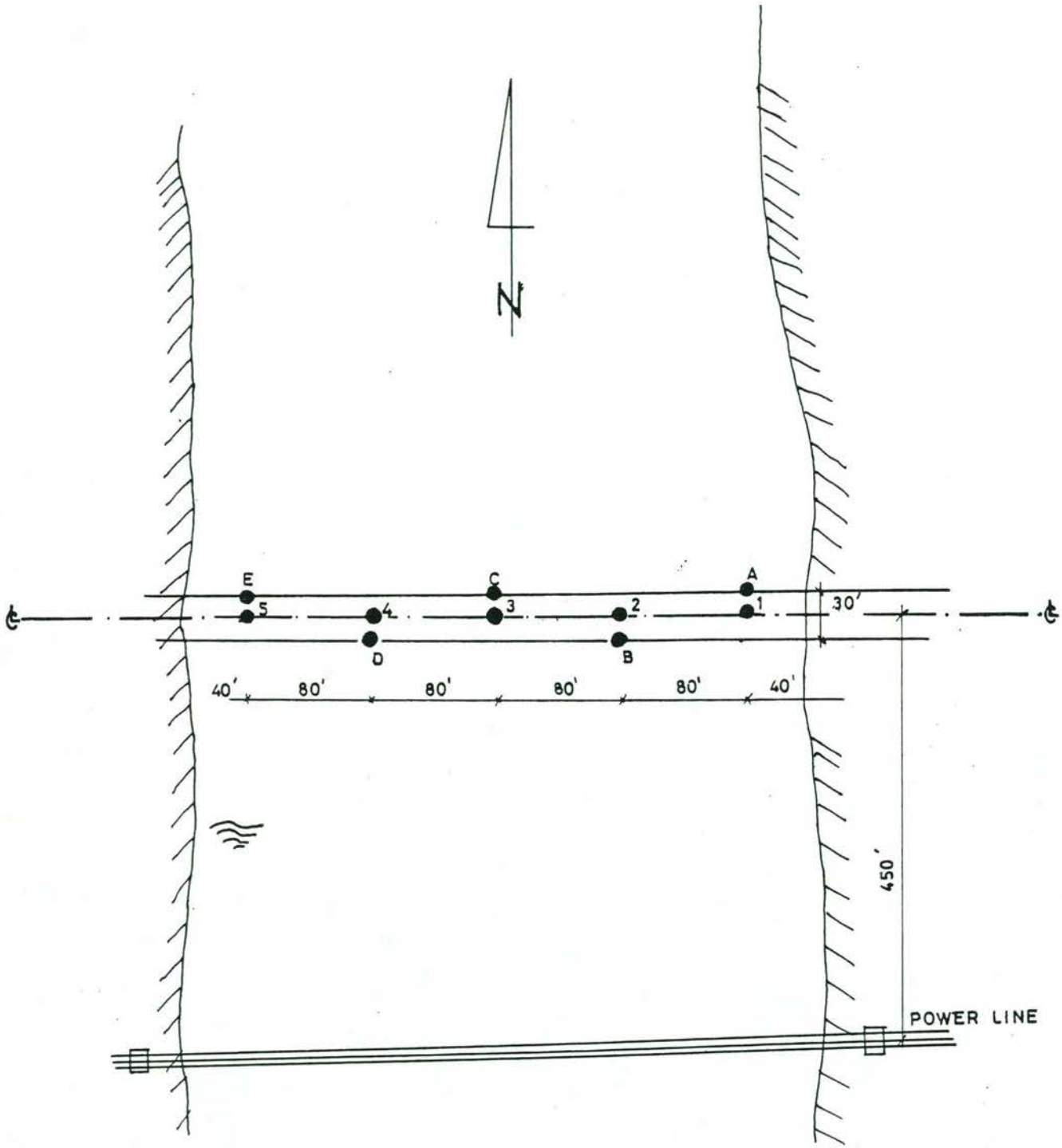


Figure 6. Location of borings.

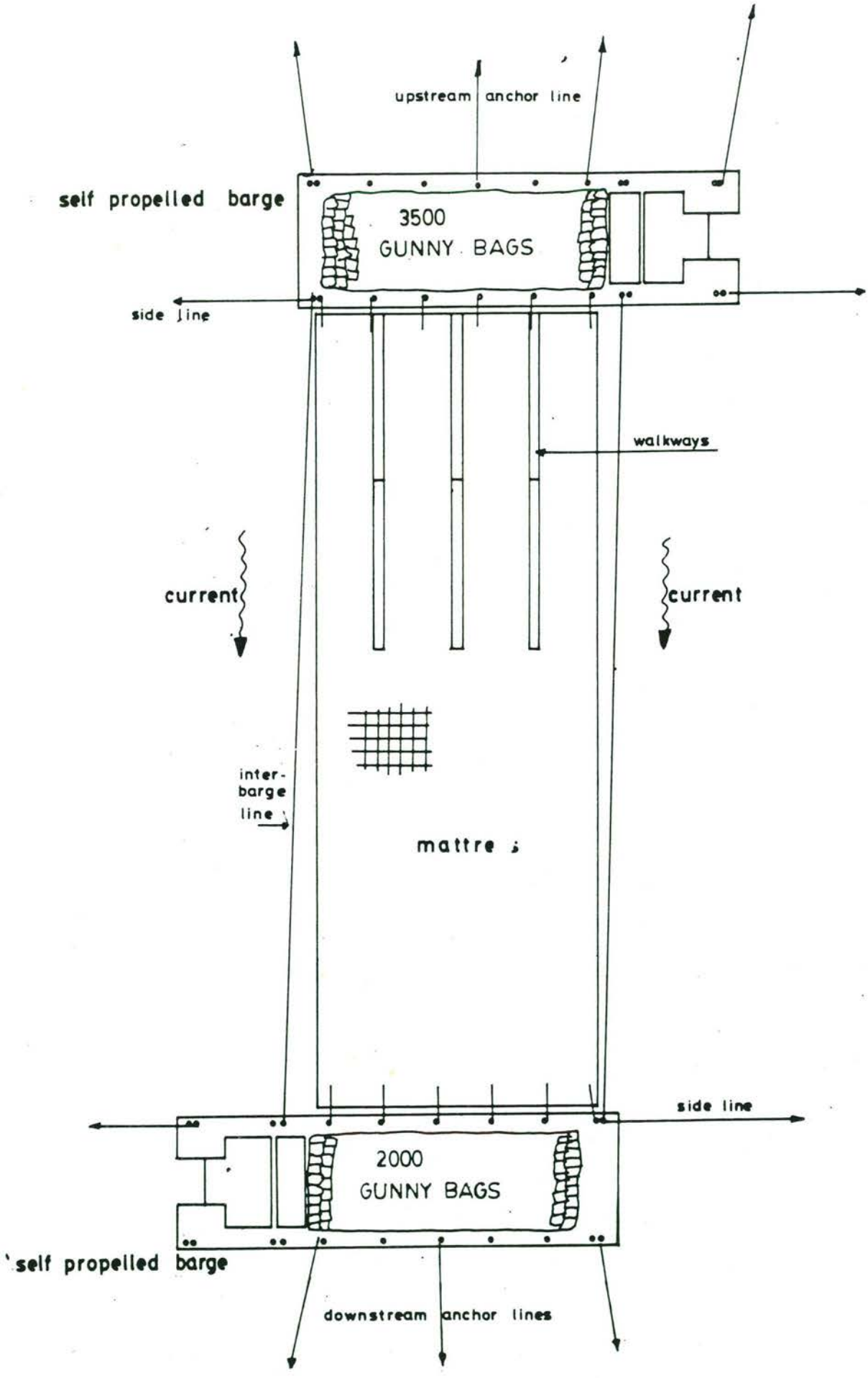


Figure 7. Lay-out of barges and mattress anchored in position prior to sinking.operation.

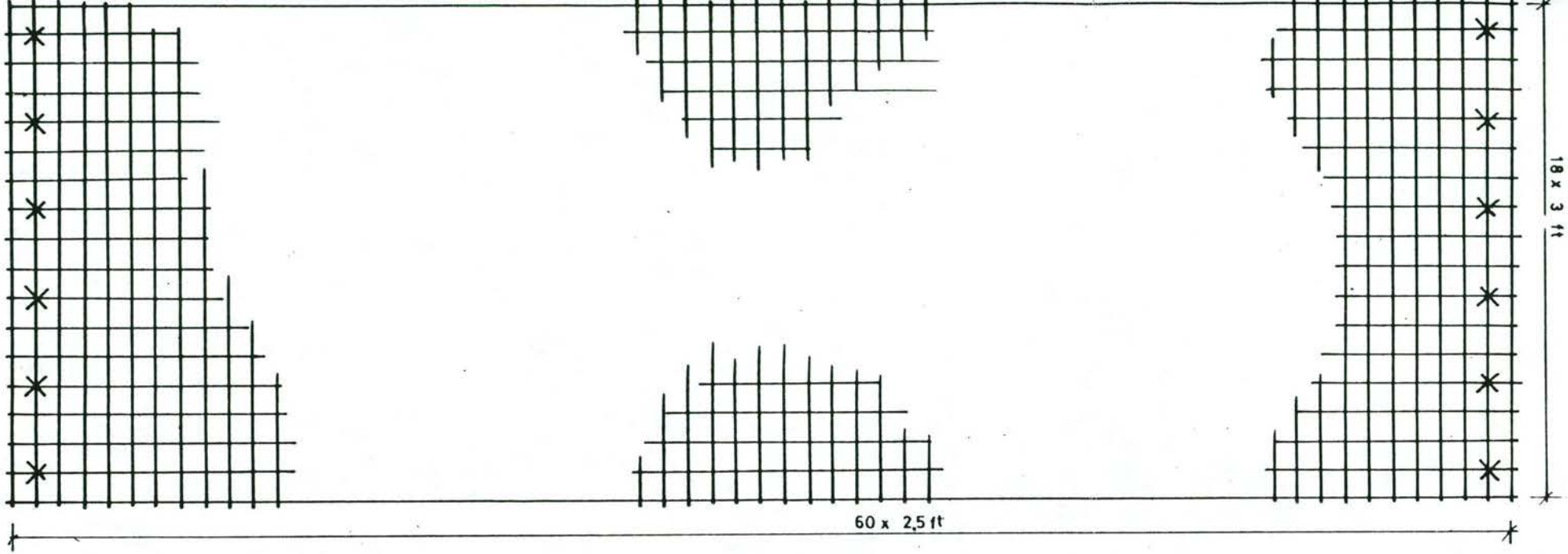


Figure 8. Construction of bottom protection mattress.

under grate: broadwise full bamboo, upto 54 ft length, covered with lengthwise full bamboo upto 150 ft length, overlap at joints of bamboos to be across three crossings at least, bamboos jointed at crossings with jute binding-rope, 7 ft long, pulling strength 300 lbs.
Undergrate to be made on dry area where spacings have been pegged out. To be carried to the mattress terrace after completion.

top grate : same as bottom grate; broadwise bamboo below.
Top grate to be constructed after reed-filling is completed on mattress terrace.

Connecting points for sink strops. Both broadwise and lengthwise bamboo should be made double upto 18' from crossings.

200 N | 150 N | 100 N | 50 N | ℄ | 50 S | 100 S | 150 S | 200 S

Bamboo flag-line

sill-crest

CHS 50
CHS 100
CHS 150
CHS 200
CHS 250
CHS 300
CHS 350
CHS 400
CHS 450
CHS 470 pegged

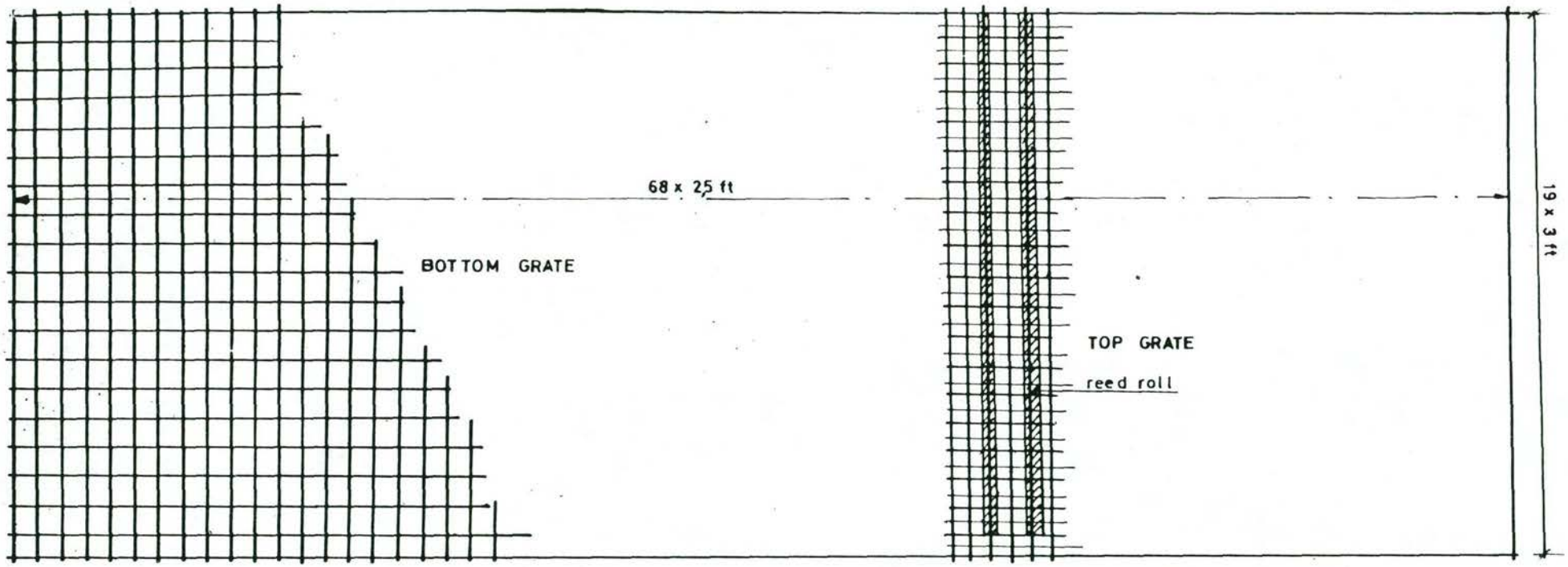


Figure 10. Construction of sillmattress.

undergrate: broadwise full bamboo below, on top lengthwise half split bamboo, overlapping joints across three crossings, bamboos to be jointed on crossings with jute binding rope 8 ft length, pulling strength 300 lbs. Under grate to be made on dry area where spacings have been pegged out. To be carried to the mattress terrace after completion.

top grate : broadwise half split bamboo c/c 2½ ft, at mid-grid; covered with lengthwise bamboo (half split), c/c 1½ ft, covered with broadwise bamboo, c/c 2½ ft. Every second full broadwise bamboo to be provided with reed roll dia 1½ ft, length 3 ft shorter than width of the mattress.

reed roll : dia 1½ ft Circular binding rope c/c 3 ft strength 150 lbs, tied to broadwise full bamboo with jute binding rope pull strength 300 lbs, c/c 3 ft.

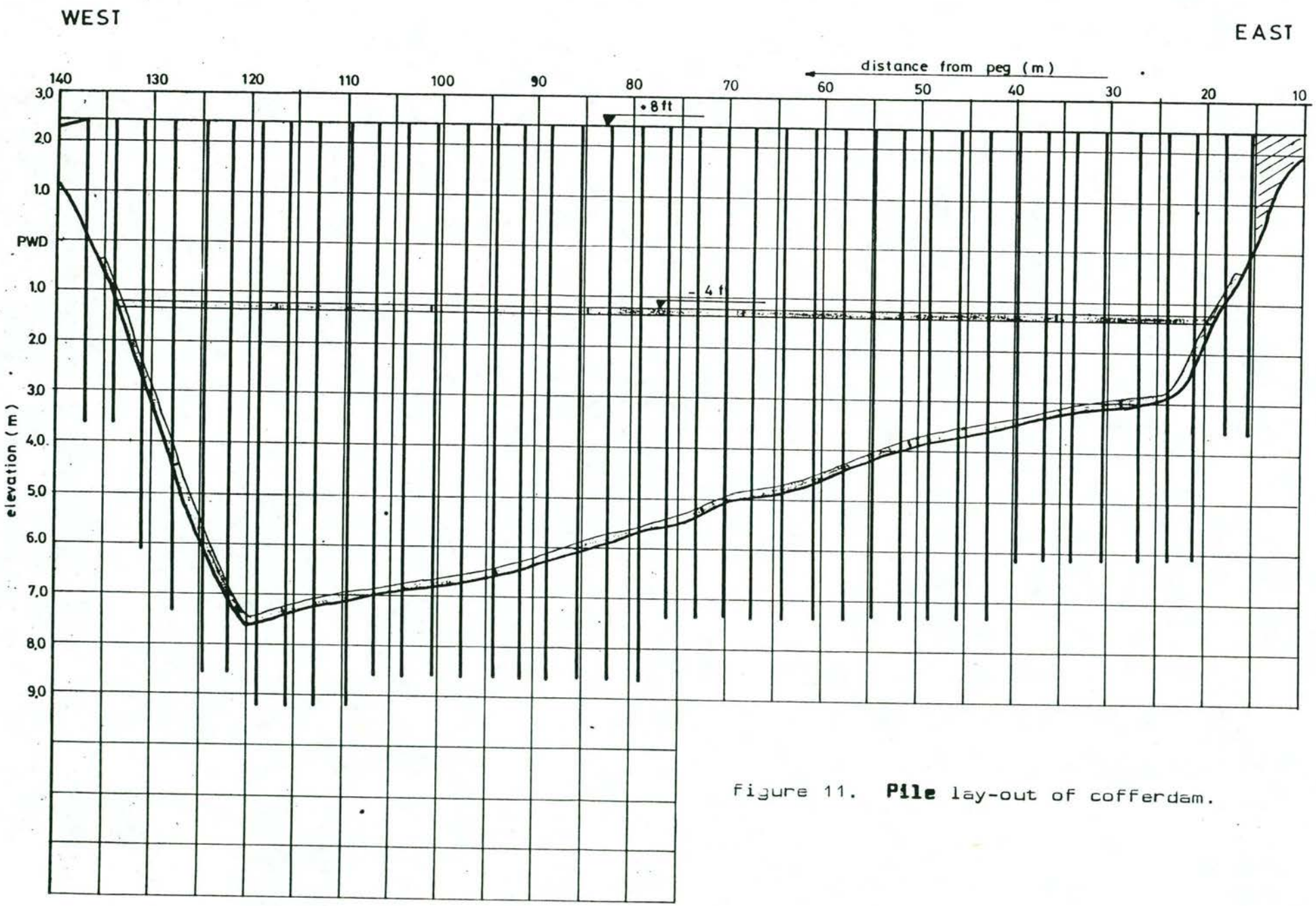


Figure 11. **Pile** lay-out of cofferdam.

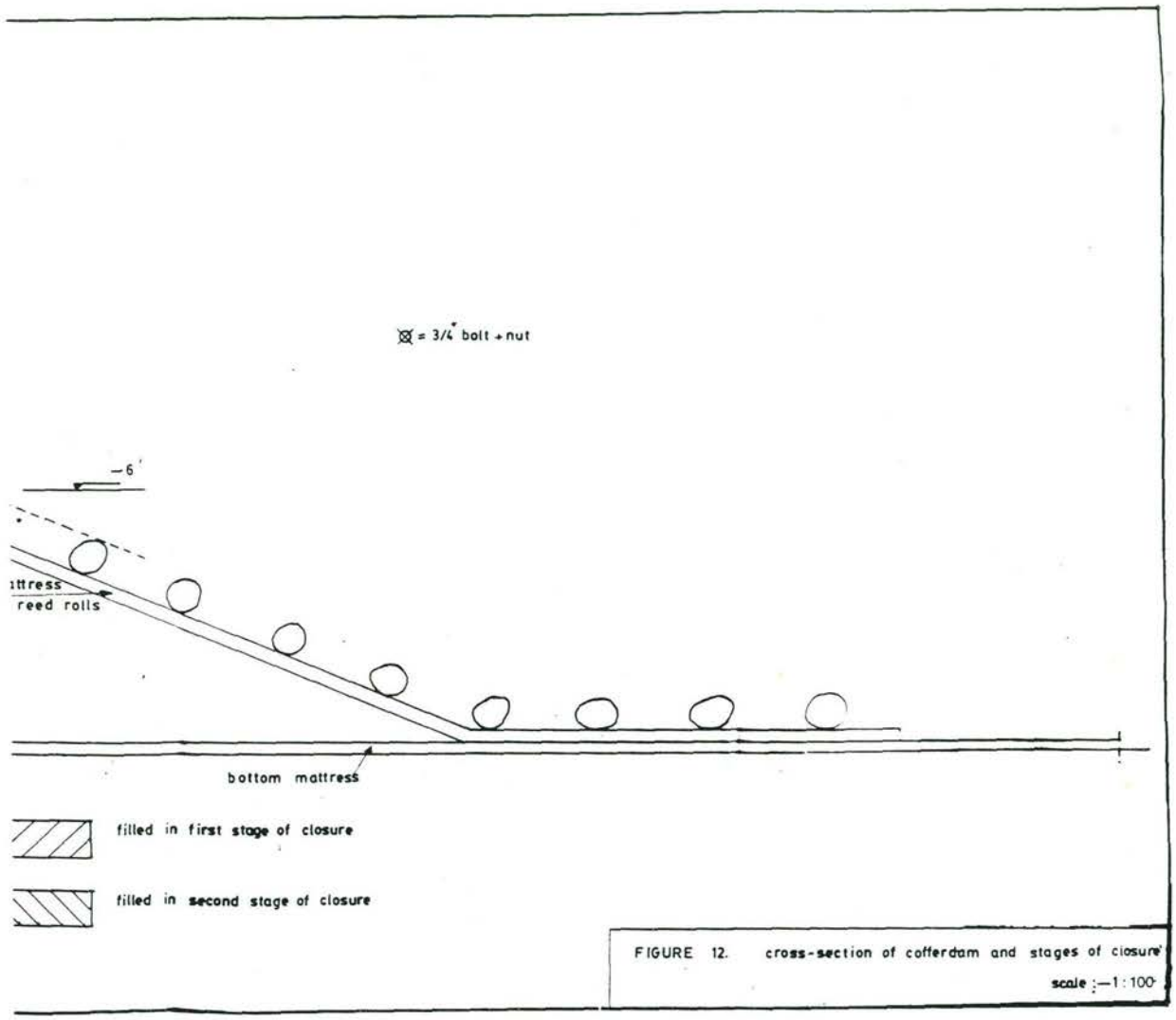
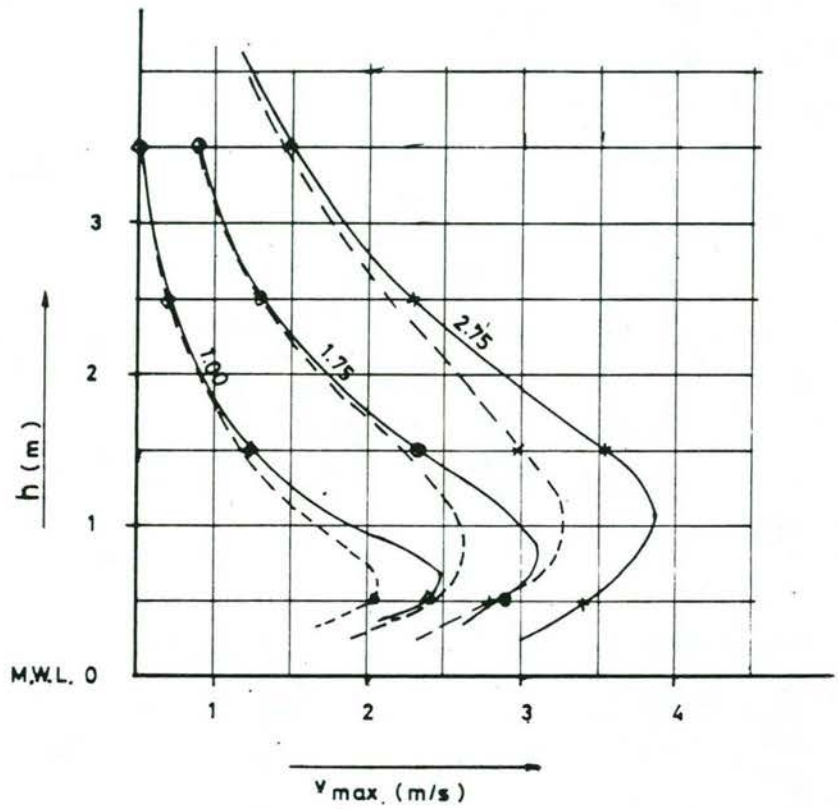


FIGURE 12. cross-section of cofferdam and stages of closure
scale :—1 : 100



BASIN AREA 230 ha (570 acres)

× Tide 2.75 m (9.2′)

○ ,, 1.75 m (5.8′)

□ ,, 1.00 m (3.3′)

——— Flood current

– – – – – Ebb current

M.W.L. = 0·38 m + PWD

h = Waterdepth on top of sill at M.W.L

Figure 13. Computed maximum velocities against sill level.

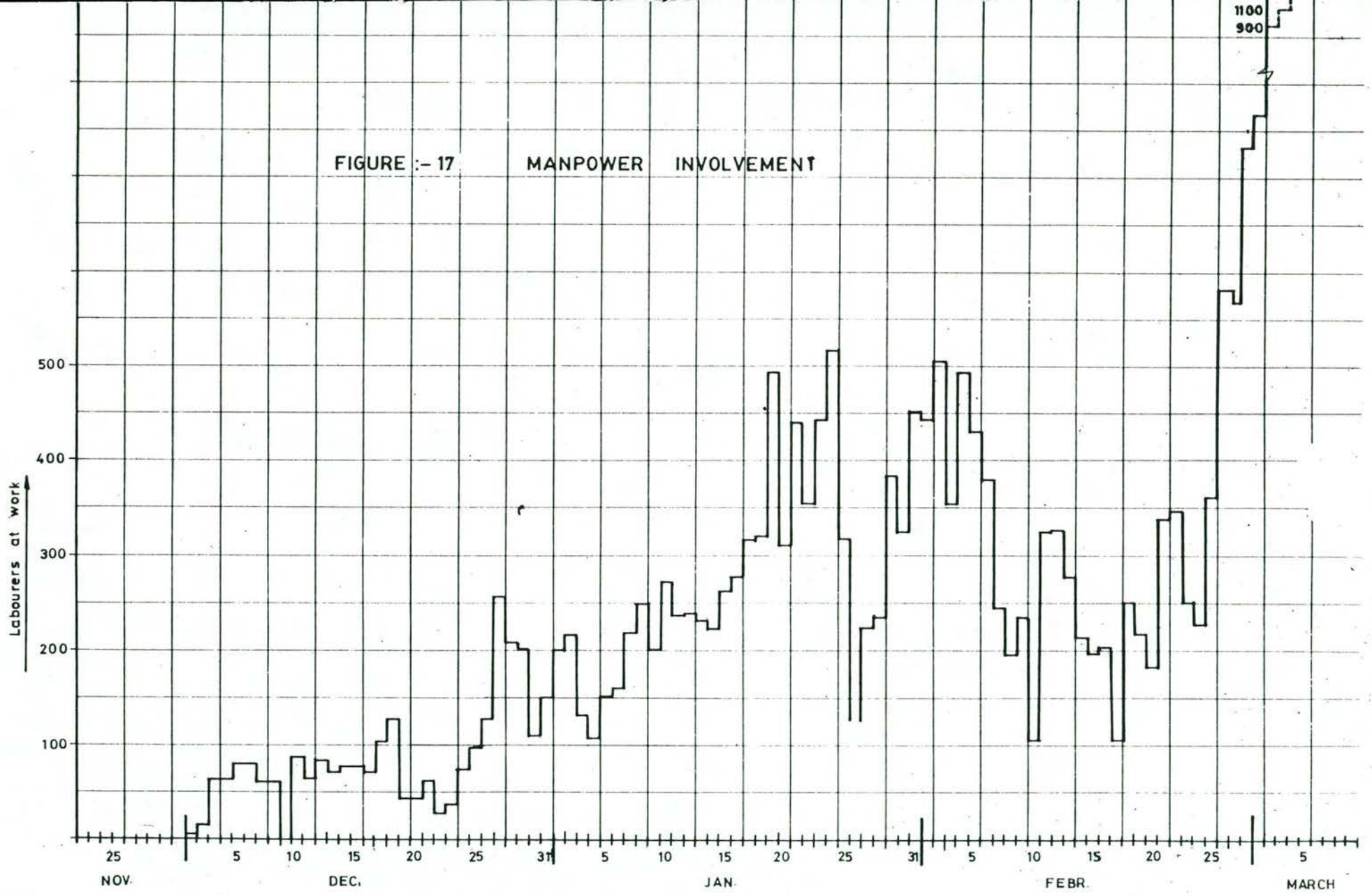


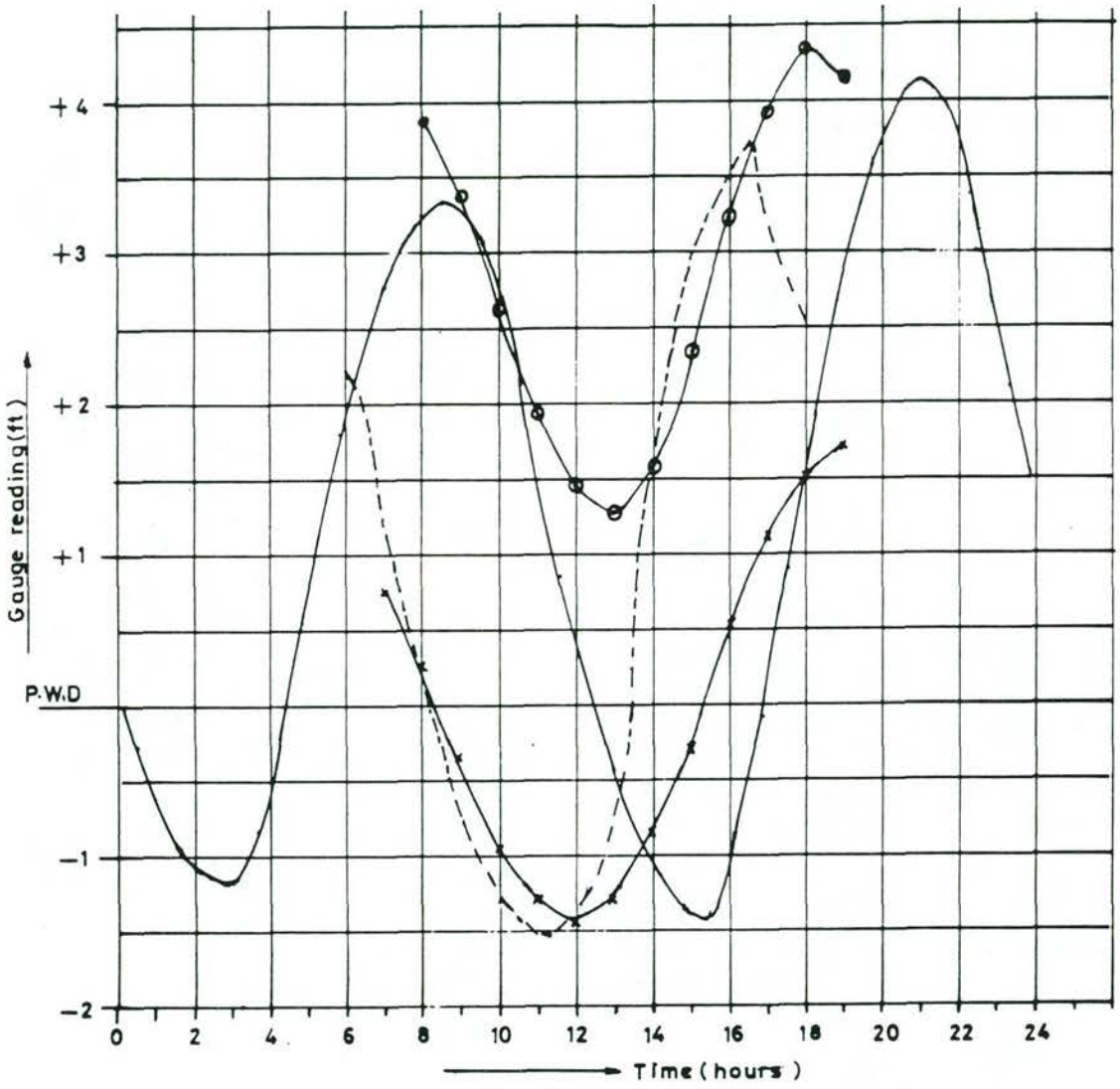
FIGURE :- 17 MANPOWER INVOLVEMENT

ANNEX 1. GAUGE READINGS - PROJECT GAUGE

	DECEMBER '81				JANUARY '82			
day	H.W.L.		L.W.L.		H.W.L.		L.W.L.	
	time.	ft + PWD.	time.	ft + PWD.	time.	ft + PWD.	time.	ft + PWD
1					15.30	3.7	10.30	-0.9
2					16.00	3.6	11.00	-0.8
3					17.00	3.5	11.30	-0.6
4					18.00	3.5	12.00	-0.8
5					06.30	3.6	13.00	-1.0
6					08.00	3.8	13.30	-1.0
7					09.00	4.0	15.30	-1.0
8					10.30	4.4	17.00	-1.2
9					11.30	4.4	06.30	-1.5
10					12.00	4.9	07.00	-1.5
11					13.00	4.7	08.00	-1.5
12					13.30	4.5	09.00	-1.4
13					14.00	4.2	09.30	-1.5
14	13.30	5.5	09.00	-0.7	15.00	4.0	10.00	-1.5
15	14.30	5.3	10.00	-0.7	16.00	3.7	10.30	-1.4
16	15.00	5.0	10.30	-0.6	16.30	3.4	11.00	-1.3
17	16.00	3.9	11.30	-0.6	17.00	3.2	11.30	-1.2
18	17.30	3.6	12.30	-0.5	06.00	2.9	12.00	-1.2
19	06.00	3.4	13.30	-0.6	07.30	2.8	13.30	-0.9
20	07.00	3.4	14.30	-0.5	08.30	2.7	14.30	-1.1
21	08.00	3.5	15.00	-0.7	09.30	3.0	16.00	-1.3
22	09.00	3.6	16.00	-1.0	10.00	3.3	17.00	-1.3
23	10.00	3.7	17.00	-1.3	10.30	3.6	18.00	-1.5
24	10.30	3.8	17.30	-1.5	11.00	4.0	18.00	-1.5
25	11.30	4.0	06.00	-1.7	11.30	4.1	07.00	-1.5
26	12.00	4.4	07.00	-1.6	12.00	4.4	07.30	-1.5
27	12.30	4.4	08.00	-1.4	13.00	4.7	08.30	-1.5
28	13.00	4.4	08.30	-1.0	13.30	4.8	09.00	-1.5
29	13.30	4.5	09.00	-0.8	14.00	4.3	09.30	-1.4
30	14.00	4.3	09.30	-0.9	14.30	4.3	10.00	-1.4
31	14.30	3.9	10.00	-0.9	15.00	4.1	10.30	-1.3

ANNEX - 1 (contd) GAUGE READINGS - PROJECT GAUGE

	FEBRUARY '82				MARCH'82			
	H.W.L.		L.W.L.		H.W.L.		L.W.L.	
day	time.	ft + PWD.	time.	ft + PWD.	time.	ft + PWD.	time	ft + PWD
1	15.30	3.9	11.00	-1.2	15.30	4.6	10.30	-1.8
2	16.30	3.5	12.00	-1.1	16.30	3.8	11.30	-2.0
3	07.00	3.2	13.30	-1.1	17.00	3.4	12.00	-1.8
4	08.00	3.2	14.00	-1.1	17.30	3.4	13.00	-1.6
5	09.00	3.5	15.00	-1.3	08.00	3.6	14.00	-1.6
6	10.00	3.7	16.00	-1.4	08.30	4.0	15.00	-1.3
7	10.30	4.0	17.00	-1.4	09.00	4.2	16.00	-1.5
8	11.00	4.4	07.00	-1.5	09.30	4.3	17.00	-1.6
9	11.30	4.8	08.00	-1.6	10.00	4.5	06.30	-1.8
10	12.00	5.3	08.30	-1.7	11.30	4.6	07.30	-2.0
11	13.00	5.6	09.00	-1.7	12.30	4.7	08.00	-2.0
12	13.30	4.9	09.30	-1.7	13.00	5.1	08.30	-2.0
13	14.00	4.6	10.00	-1.4	13.30	5.0	09.00	-1.8
14	14.30	4.0	10.30	-1.2	14.00	4.6	09.30	-1.7
15	15.00	3.5	11.00	-1.2	14.30	4.1	10.00	-1.5
16	16.30	3.2	11.30	-1.1	15.00	3.7	11.00	-1.4
17	17.30	2.9	12.00	-0.8	15.30	3.4	11.30	-1.3
18	07.00	2.6	13.00	-0.8	16.00	3.2	12.00	-1.0
19	08.30	2.8	14.30	-0.7	17.00	3.1	12.30	-0.7
20	09.00	3.0	16.00	-1.4	18.00	2.9	13.00	-0.8
21	10.00	3.5	18.00	-1.4	08.00	3.0	13.30	-1.0
22	11.30	4.0	07.00	-1.5	09.00	3.4	14.30	-1.4
23	12.00	4.3	08.00	-0.8	10.00	3.9	15.30	-1.7
24	12.30	4.6	08.30	-1.9	11.30	4.8	17.00	-1.9
25	13.00	4.8	09.00	-2.0	12.30	5.4	06.00	-2.0
26	13.30	4.8	09.30	-2.0	13.30	5.5	07.30	-2.0
27	14.00	4.7	09.45	-2.0	14.00	5.6	08.00	-2.2
28	14.30	4.5	10.00	-1.8	14.30	5.8	08.45	-2.2
29					15.00	5.6	09.00	-2.1
30							09.30	-2.0



NEAP TIDES :

——— 2 april 1978

-x- 18 march 1978

o——o 22 sept. 1981

– – – – 2 march 1982

ANNEX II TIDE PREDICTION FOR AMTALI
(levels in ft)

		DECEMBER												JANUARI								
		daytime high waters						daytime low waters						day time high waters				day time low waters				
moon	day	Chalna prediction		Amtali gauge		differences		Chalna predictions		Amtali gauge		differences		Chalna predictions		Amtali predictions		Chalna predictions		Amtali predictions		
		h	t	h	t	∆h	∆t	h	t	h	t	∆h	∆t	h	t	h	t	h	t	h	t	
column	no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	1	8.9	12.50					4.3	07.14					8.5	14.20	4.0	15.33	3.9	08.27	-1.1	10.29	
	2	8.5	13.35					4.6	07.55					8.2	15.14	3.7	16.27	3.9	09.14	-1.1	11.16	
	3	8.5	14.29					4.9	08.43					8.2	16.19	3.7	17.32	3.9	10.09	-1.1	12.11	◐
◐	4	8.2	15.36					4.9	09.42					8.5	17.36	4.0	18.49	3.9	11.18	-1.1	13.20	
	5	8.2	17.02					4.9	10.51					8.5	05.39	4.0	06.52	3.9	12.31	-1.1	14.33	
	6	8.9	05.15					4.6	12.05					8.5	06.59	4.0	08.12	3.3	13.38	-1.7	15.40	
	7	9.2	06.28					3.9	13.10					8.5	08.08	4.0	09.21	3.0	14.39	-2.0	16.41	
	8	9.5	07.30					3.3	14.09					8.9	09.07	4.4	10.20	2.6	15.34	-2.4	17.36	
	9	9.5	08.25					3.0	15.01					9.2	09.59	4.7	11.12	2.3	16.23	-2.7	18.25	
	10	9.8	09.15					2.6	15.50					9.5	10.47	5.0	12.00	2.6	05.15	-2.4	07.17	○
○	11	10.2	10.03					2.3	16.35					9.5	11.34	5.0	12.47	2.3	06.01	-2.7	08.03	
	12	10.2	10.51					2.3	17.20					9.5	12.21	5.0	13.34	2.3	06.45	-2.7	08.47	
	13	9.8	11.40					3.0	06.10					9.2	13.09	4.7	14.22	2.6	07.27	-2.4	09.29	
	14	9.5	12.31	5.5	13.30	4.0	59	3.0	06.56	-0.7	09.00	3.7	124	8.9	13.55	4.4	15.08	3.0	08.09	-2.0	10.11	
	15	9.2	13.21	5.3	14.30	3.9	69	3.3	07.44	-0.7	10.08	4.0	136	8.5	14.42	4.0	15.55	3.6	08.51	-1.4	10.53	
	16	8.9	14.15	5.0	15.00	3.9	45	3.9	08.33	-0.6	10.30	4.5	117	8.2	15.31	3.7	16.34	3.9	09.34	-1.1	11.36	
	17	8.5	15.14	3.9	16.00	4.6	46	4.3	09.27	-0.6	11.30	4.9	123	7.9	16.26	3.4	17.39	4.3	10.20	-0.7	12.22	◑
◑	18	8.2	16.21	3.6	17.30	4.6	69	4.3	10.26	-0.5	12.30	4.8	124	7.9	17.36	3.4	18.49	4.6	11.18	-0.4	13.20	
	19	8.9	04.35	3.4	06.00	5.5	85	4.6	11.27	-0.6	13.30	5.2	123	7.5	05.33	3.0	06.46	4.6	12.28	-0.4	14.30	
	20	8.5	05.44	3.4	07.00	5.1	76	4.6	12.29	-0.5	14.30	5.1	121	7.2	07.06	2.7	08.19	4.3	13.37	-0.7	15.39	
	21	8.2	06.59	3.5	08.00	4.6	61	4.3	13.30	-0.7	15.00	5.0	90	7.5	08.26	3.0	09.39	3.9	14.33	-1.1	16.35	
	22	8.2	08.02	3.6	09.00	4.6	58	4.3	14.20	-1.0	16.00	5.3	100	7.5	09.12	3.0	10.25	3.6	15.18	-1.4	17.20	
	23	8.5	08.49	3.7	10.00	4.8	71	3.9	15.03	-1.3	17.00	5.2	117	7.9	09.49	3.4	11.02	3.3	15.56	-1.7	17.58	
	24	8.5	09.25	3.8	10.30	4.7	65	3.6	15.39	-1.5	17.30	5.1	111	8.2	10.21	3.7	11.34	3.0	16.30	-2.0	18.32	
	25	8.5	09.57	4.0	11.30	4.5	93	3.9	04.23	-1.7	06.00	5.6	97	8.2	10.52	3.7	12.05	3.3	05.18	-1.7	07.20	
●	26	8.5	10.28	4.4	12.00	4.1	92	3.9	04.57	-1.6	07.00	5.5	123	8.5	11.23	4.0	12.36	3.0	05.49	-2.0	07.51	●
	27	8.5	10.58	4.4	12.30	4.1	92	3.6	05.29	-1.4	08.00	5.0	151	8.5	12.00	4.0	13.13	3.0	06.21	-2.0	08.23	
	28	8.9	11.30	4.4	13.00	4.5	90	3.6	06.00	-1.0	08.30	4.6	150	8.9	12.38	4.4	13.51	3.0	06.55	-2.0	08.57	
	29	8.9	12.07	4.5	13.30	4.4	83	3.6	06.32	-0.8	09.00	4.4	148	8.9	13.19	4.4	14.32	3.0	07.30	-2.0	09.32	
	30	8.5	12.48	4.3	14.00	4.2	72	3.6	07.07	-0.9	09.30	4.5	143	8.5	14.01	4.0	15.14	3.0	08.05	-2.0	10.07	
	31	8.5	13.33	3.9	14.30	4.6	57	3.6	07.45	-0.9	10.00	4.5	135	8.5	14.46	4.0	15.59	3.3	08.43	-1.7	10.45	

$\bar{\Delta h}$ = 4.5 $\bar{\Delta t}$ = 73 min.

$\bar{\Delta h}$ = 5.0 $\bar{\Delta t}$ = 122 min.

◐ first quarter

○ full moon

◑ last quarter

● new moon

ANNEX III LIST OF HYDROGRAPHIC SURVEYS EXECUTED DURING THE WORK

date	cross sections	transversal - sections
3 Dec. - 81	450 N - 450 S	
13 Jan. - 82	200 N - 200 S	
23 Jan.	450 N - 450 S	
25 Jan.	90 N - 90 S	250 - 450
27 Jan.	70 N - 70 S	250 - 440
29 Jan.	90 N - 90 S	250 - 440
30	40 N - C.L.	250 - 440
31	80 N - 100 S	250 - 440
1 Febr.	70 N - 70 S	
2 Febr.	50 N - 70 S	60 - 300
3 Febr.	40 N - 40 S	150 - 300
11 Febr.	450 N - 450 S	
17 Febr.	60 N 60 S	
26 Febr.	80 N 80 S	
28 Febr.	80 N - 80 S	
1 March	450 N - 450 S	
6 March	80 N - 20 N	
21 March	20 S - 150 S	
24 March	150 N - C.L.	

ANNEX IV ABSTRACT OF SOIL ANALYSIS

4.1 Borings June '81

4.2 Borings September '81

ANNEX 4.1 SUMMARY OF SOIL ANALYSES FROM BORINGS D.D. JUNE 1981

Borehole No.	G.L. (ft) PWD	Sample No	Depth of Sample ft.	S.P.T.	M.C. %	L.L.	P.L.	%		
								Sand	Silt	Clay
Column 1	2	3	4	5	6	7	8	9	10	11
A	- 9	D - 3	15-17	9				76	24	-
		D - 5	25-27	7				56	43	1
		D - 6	30-32	8	33.1					
B	-12	D - 1	5-7	3				75	25	-
		D - 3	15-17	5	35	36	26	11	75	14
		D - 4	20-22	7	36.5					
		D - 5	25-27	6	33.6					
		D - 6	30-32	10	33.8					
		D - 7	35-37	9	34.1	35	25	8	76	16
		D - 8	40-42	8	38.4					
		D - 9	45-47	10	32.7					
		D -10	50-52	11						
C	-16	D - 3	15-17	2	34.9					
		D - 4	20-22	3	-			71	28	1
		D - 6	30-32	4	34.3					
D	-22	D - 1	5 - 7	6				93	7	-
		D - 3	15-17	6	32.6					
		D - 4	20-22	7	35.3					
		D - 7	35-37	9	-			78	21	1
		D - 8	40-42	10	34.7					
		D - 9	45-47	7	33.4					
		D -10	50-52	9	34	37	26	5	77	18
E	-23	D - 1	5-7	7				87	13	-
		D - 9	45-47	13	36.9					
		D -10	50-52	17	36					

ANNEX - 4.2

SUMMARY OF SOIL ANALYSES FROM BORINGS D.D. SEPTEMBER 1981

Borehole No.	G.L.(ft) PWD	Sample No.	Depth of sample (ft)	S.P.T.	M.C.%	L.L.	P.L.	Sand %	Silt %	Clay %	Spec. Grav.	Density Wet	Density Dry	Void Ratio	Rel. Den	Triaxial sh.t. φ degr.	Triaxial sh.t. c. kg/cm²	Perm cm/s
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	-7	D-1	0-2	2	28.2			23	74	3	2.652							
		U-1	5-7		33.6			27	62	11	2.67	108.73	78.62	1.067		16	0.255	
					32.9		+)T →	16	73	11								
		U-2	10-12		47.4		B →	62	37	1	2.65	107.64	76.98	1.091		23	0.14	
		U-3	15-17		40.6			51	46	3	2.64	101.88	71.89	1.229	77.2	22	0.10	
		U-4	20-22		42.0			65	34	1	2.67	109.49	78.11	1.158		25	0.10	
		D-2	25-27	5	32.1	33	24	7	85	8	2.676							
		U-5	30-32		31.2	35	25	6	83	11	2.668	126.1	96.1	0.732				303 x-6
		D-3	35-37	6	32.7			26	69	5	2.66							
							T →	10	88	2								
		U-6	40-42		34.5	39	25B →	4	79	17	2.67	118.61	89.62	0.938		19	0.45	
		D-4	45-47	8	32.7	34	25	8	77	15	2.654							
		D-5	50-52	10	29.6			11	83	6	2.66							
		D-6	55-57	11	33.9	36	25	6	80	14	2.65							
		D-7	60-62	13	31.1	33	25	9	82	9	2.67							
		D-8	65-67	14	29.2	31	24	12	88	-	2.66							
2	-12	U-1	5-7		27.8			12	86	2	2.659	112.26	87.82			29.5	0.13	
		D-1	10-12	7	27.6			44	56	-	2.682							
		U-2	15-17		26.9			23	77	-	2.671	123.02	96.93			36	0.14	
		D-2	20-22	7	30.6			32	68	-	2.674							
		U-3	25-27		36.9			6	83	11	2.654	110.76	80.88			19	0.28	
		D-3	30-32	8	42.3			14	86	-	2.668							
		U-4	35-37		45.9			5	88	7	2.657	109.02	74.9			17.5	0.39	
		D-4	40-42	9	38.1			1	79	11	2.654							
		U-5	45-47		41.1			9	77	14	2.662	112.64	79.85			8.5	0.16	
		D-5	50-52	10	34.0			23	77	-	2.659							
		D-6	55-57	12	30.3			11	87	2	2.668							
		D-7	60-62	17	38.3			2	83	15	2.657							
		D-8	65-67	15	47.9			5	84	11	2.662							

+) T → : top of sample
B → : bottom of sample

ANNEX 4.2 Contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	-16	U-1	5-7		33.1	37	26	12	81	7	2.671	119.19	89.61	0.977		26	0.10	
		D-1	10-12	6	29.5			77	21	2	2.656							
		U-2	15-17					46	51	3	2.662	116.38	85.14	0.890		20.5	0.15	
		D-2	20-22	7	47.5			54	39	7	2.66							
		U-3	25-27		34.9			23	70	7	2.65	118.20	90.00	0.862	90.1	33	0.05	
		D-3	30-32	10	32.1			73	23	4	2.663							
		U-4	35-37					13	74	13	2.673	116.07	06.17	0.937		21	0.15	
		D-4	40-42	15	34.5	39	27	33	55	12	2.652							
		D-5	45-47	18	30.1			79	20	1	2.664							
		D-6	50-52	13	28.8			83	17	-	2.66							
		D-7	55-57	24	29.2			77	21	2	2.658							
		D-8	60-62	26	31.1			79	21	-	2.66							
		D-9	65-67	23	30.2			81	18	1	2.654							
4	-21	U-1	5-7		36.6			6	79	15	2.654	116.11	85.0			21.75	0.25	
		U-2	10-12		38.5			4	85	11	2.655	115.20	83.20			24.5	0.28	
		U-3	15-17		38.3			1	91	8	2.651	114.92	83.10			33.5	0.14	
		D-1	20-22	8	32.2			41	59	-	2.662							
		D-2	25-27	9	28.2			32	68	-	2.660							
		D-3	30-32	12	26.5			26	74	-	2.671							
		U-4	35-37		32.2			3	83	14	2.657	119.69	90.62			36	0.14	
		D-4	40-42	17	35.7			42	58	-	2.665							
		D-5	45-47	18	28.0			49	51	-	2.671							
		D-6	50-52	23	30.5			42	58	-	2.665							
		D-7	55-57	21	36.2			45	55	-	2.662							
		D-8	60-62	18	32.0			33	67	-	2.668							
		D-9	65-67	21	37.6			13	85	2	2.671							
5	-17	U-1	5-7		42.2			19	80	1	2.66	108.01	75.14	1.225		29	0.15	
		D-1	10-12	9	32.0			17	82	1	2.658							
		D-2	15-17	11	32.1			20	80	-	2.655							
		D-3	20-22	12	34.0			20	80	-	2.652							
		D-4	25-27	14	43.9			79	21	-	2.646							
		D-5	30-32	16	30.3			77	23	-	2.656							
		D-6	35-37	13	31.3			78	22	-	2.66							
		D-7	40-42	12	35.9			83	17	-	2.647							
		D-8	45-47	15	27.2			85	15	-	2.654							
		D-9	50-52	18	30.9			75	24	1	2.657							
		D-10	55-57	22	35.5			86	14	-	2.65							
		D-11	60-62	18	28.4			89	11	-	2.644							
		D-12	65-67	23	25.4			77	23	-	2.655							

Soil designation: sand: passes through 0.074 mm sieve
silt: 0.074 - 0.005 mm
clay: smaller than 0.005 mm

ANNEX - V

Computer output for sill level/velocity calculations.

Sill level	= depth of sill crest in m below the mean water level M.W.L.
Width gap	= length of the sill in m from bank to bank.
Basin area	= storage area in m^2 divided by time step duration in seconds($230 \times 10^4/894$)
Contraction	= Contraction coefficient.
Tide factor	= tidal difference divided by two
Time step	= Seconds

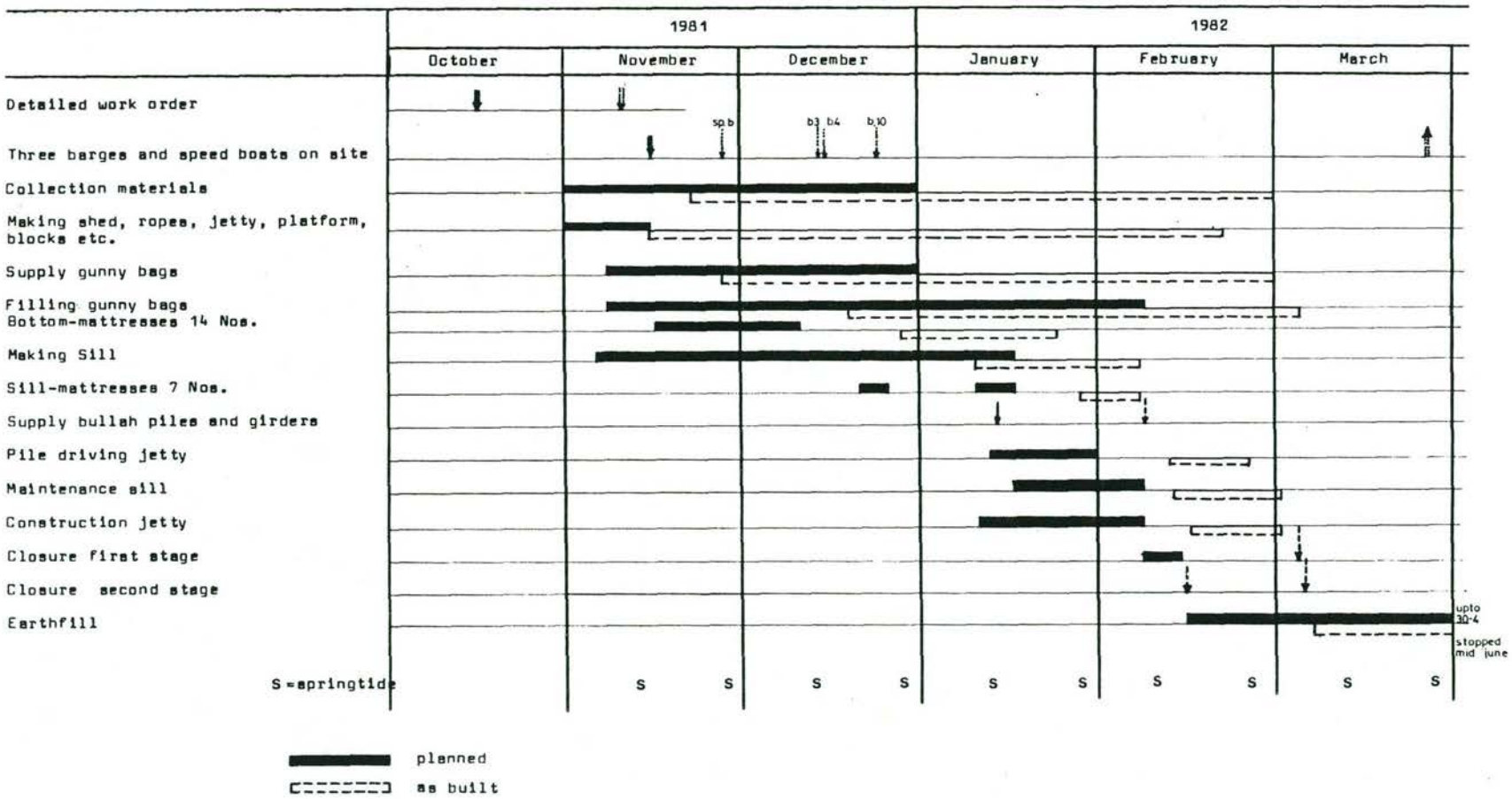
Waterlevels are noted in meters

Speed is water velocity in m/s.

SILL LEVEL = -1.50
WIDTH GAP = 105.00
BASIN AREA = 2572.71
CONTRACTION = 0.90
GRAVITATION = 9.81
TIDE FACTOR = 0.87
TIME STEP = 894.00
PRECISION = 0.01

OUTSIDE START	OUTSIDE END	INSIDE START	INSIDE END	HO	HI	DH	SPEED	VOLUME	CRITIC	STEPS
0.00	0.11	-0.27	-0.17	1.55	1.28	0.28	2.33	281.10	0	8
0.11	0.22	-0.17	-0.05	1.66	1.39	0.27	2.31	303.44	0	8
0.22	0.32	-0.05	0.08	1.77	1.51	0.26	2.24	320.51	0	8
0.32	0.42	0.08	0.21	1.87	1.64	0.23	2.15	330.08	0	6
0.42	0.51	0.21	0.33	1.97	1.77	0.20	1.98	330.21	0	8
0.51	0.60	0.33	0.46	2.06	1.89	0.16	1.78	319.12	0	9
0.60	0.67	0.46	0.57	2.14	2.01	0.12	1.55	294.69	0	8
0.67	0.74	0.57	0.67	2.21	2.12	0.08	1.28	257.57	0	4
0.74	0.79	0.67	0.75	2.27	2.21	0.05	1.00	209.79	0	8
0.79	0.83	0.75	0.82	2.31	2.29	0.03	0.72	156.09	0	6
0.83	0.86	0.82	0.87	2.35	2.34	0.01	0.46	100.95	0	8
0.86	0.87	0.85	0.87	2.37	2.36	0.00	0.21	47.46	0	9
0.87	0.87	0.87	0.87	2.37	2.37	0.00	0.00	0.00	0	8
0.87	0.86	0.87	0.85	2.37	2.37	0.00	0.14	30.27	0	9
0.86	0.83	0.85	0.82	2.35	2.35	0.00	0.27	60.53	0	8
0.83	0.79	0.84	0.75	2.31	2.32	-0.01	0.41	89.13	0	7
0.79	0.74	0.86	0.75	2.27	2.29	-0.02	0.54	116.38	0	8
0.74	0.67	0.76	0.70	2.21	2.23	-0.02	0.68	141.73	0	8
0.67	0.60	0.70	0.64	2.14	2.17	-0.03	0.82	164.87	0	7
0.60	0.51	0.64	0.57	2.06	2.10	-0.05	0.95	184.89	0	5
0.51	0.42	0.57	0.49	1.97	2.03	-0.06	1.08	201.00	0	8
0.42	0.32	0.49	0.40	1.87	1.95	-0.07	1.21	213.78	0	7
0.32	0.22	0.40	0.32	1.77	1.86	-0.09	1.34	224.12	0	8
0.22	0.11	0.32	0.23	1.66	1.77	-0.11	1.47	230.88	0	8
0.11	0.00	0.23	0.14	1.55	1.68	-0.13	1.59	233.28	0	9
0.00	-0.11	0.14	0.05	1.45	1.59	-0.15	1.70	232.29	0	7
-0.11	-0.22	0.05	-0.04	1.34	1.50	-0.17	1.81	228.31	0	8
-0.22	-0.32	-0.04	-0.13	1.23	1.42	-0.19	1.91	221.76	0	5
-0.32	-0.42	-0.13	-0.21	1.13	1.33	-0.20	2.00	213.05	0	9
-0.42	-0.51	-0.21	-0.29	1.03	1.25	-0.22	2.07	202.25	0	9
-0.51	-0.60	-0.29	-0.36	0.94	1.18	-0.23	2.13	190.11	0	9
-0.60	-0.67	-0.36	-0.43	0.86	1.10	-0.24	2.17	177.29	0	4
-0.67	-0.74	-0.43	-0.49	0.79	1.04	-0.24	2.19	164.19	0	10
-0.74	-0.79	-0.49	-0.55	0.73	0.98	-0.24	2.18	151.18	0	7
-0.79	-0.83	-0.55	-0.61	0.69	0.92	-0.23	2.13	138.68	0	10
-0.83	-0.86	-0.61	-0.66	0.65	0.87	-0.21	2.05	126.74	0	10
-0.86	-0.87	-0.66	-0.70	0.63	0.82	-0.19	1.92	114.97	0	9
-0.87	-0.87	-0.70	-0.74	0.63	0.78	-0.15	1.73	102.53	0	10
-0.87	-0.86	-0.74	-0.77	0.63	0.74	-0.11	1.46	87.56	0	10
-0.86	-0.83	-0.77	-0.80	0.65	0.71	-0.06	1.07	66.30	0	8
-0.83	-0.79	-0.80	-0.81	0.69	0.70	-0.01	0.37	24.36	0	8
-0.79	-0.74	-0.81	-0.79	0.73	0.70	0.03	0.81	53.89	0	9
-0.74	-0.67	-0.79	-0.76	0.79	0.73	0.07	1.14	78.51	0	5
-0.67	-0.60	-0.76	-0.72	0.86	0.76	0.10	1.41	101.51	0	8
-0.60	-0.51	-0.72	-0.67	0.94	0.81	0.14	1.64	124.95	0	10
-0.51	-0.42	-0.67	-0.61	1.03	0.86	0.17	1.84	149.41	0	9
-0.42	-0.32	-0.61	-0.54	1.13	0.92	0.21	2.04	175.68	0	8

ANNEX - VIII TIME SCHEDULE



ANNEX - IX Photographs

Project sign board

Casting concrete anchor blocks

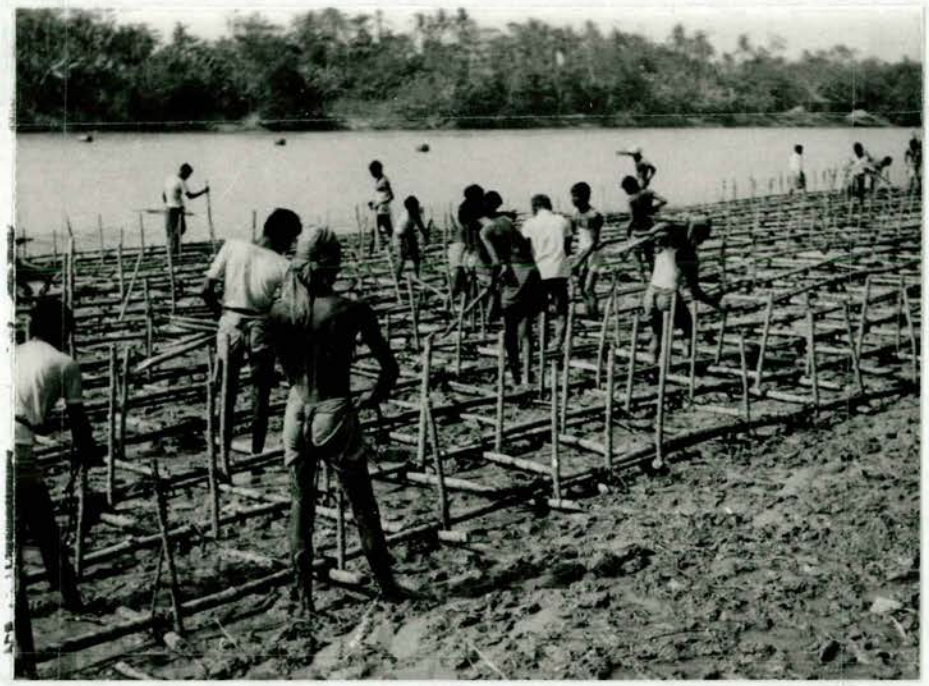
Placing anchor blocks in position

Filling and loading of gunny bags

Making under grating

Carrying under grating to submerged terrace

Turning the under grate in correct position



Placing metal pegs and fixing binding rope

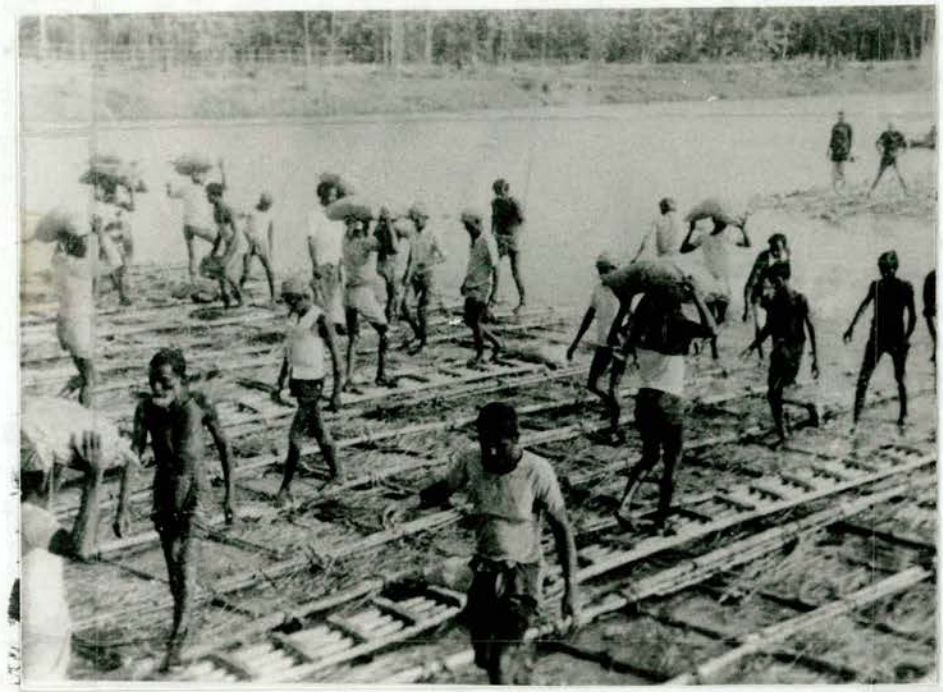
Marking middle layer of goalpata leaves

Filling mattress with reed and goalpata

Carrying reed roll to sill mattress

Sill mattress almost ready

Positioning of mattress on sink location



Ballasting of mattress

Ballasting of mattress

Ballasting of sill mattress

Ballasting by head load almost ready

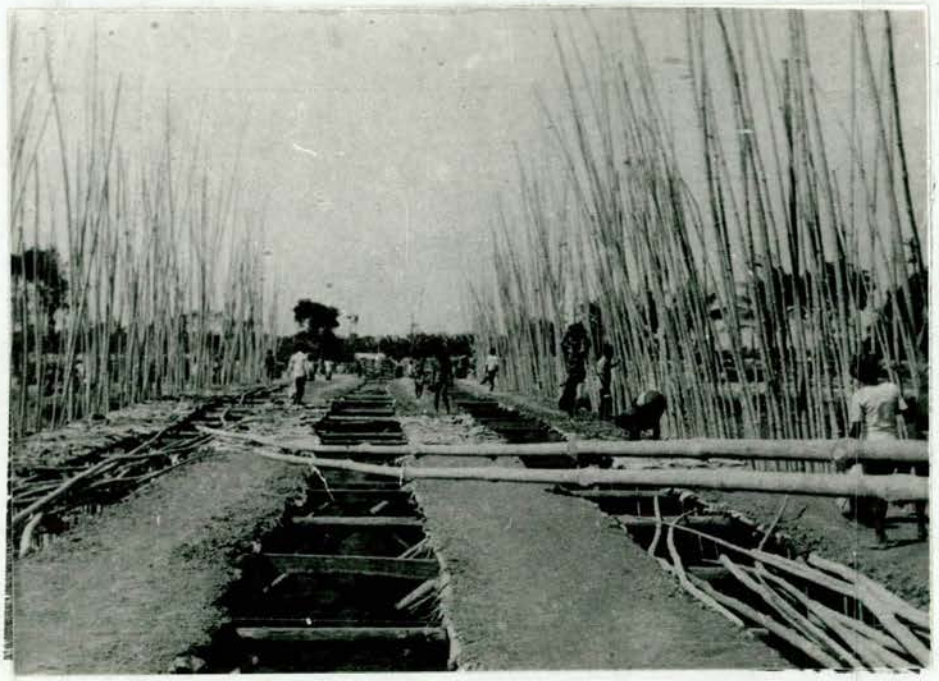
Sinking and continued ballasting

Mattress just sunk

Pile driving for cofferdambridge

Finishing walkpaths and bamboo screen piling

In_coming tide



Finishing walkpaths and bamboo screen piling

Start final closure operation, dumping gunny bags from walkpaths

Dumping gunny bags over four walkpaths by 1600 labourers

Actual closure in progress

The final closure gap

Amtali Khal closed

Gunny bag dam upto PWD + 8 ft. middle walkpaths already removed

Earthwork in progress