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PEOPLE'S REPUBLIC OF BANGLADESH

Ministry of Irrigation, Water Development and Flood Control

Bangladesh Water Development Board

CYCLONE PROTECTION PROJECT II - FAP 7
FEASIBILITY AND DESIGN STUDIES

FINAL PROJECT PREPARATION REPORT
APPENDIX I - FEASIBILITY STUDY ON PATENGA PROJECT

May 1992

Joint Venture of
KAMPSAX INTERNATIONAL A/S,
BCEOM
DANISH HYDRAULIC INSTITUTE
in association with
DEVELOPMENT DESIGN CONSULTANTS LTD

Financed by European Community - Project No. ALA/87/05

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PREFACE

The present report describes a technical and economic analysis of embankment proposals for Polder 62, Patenga performed by the Consultants in October 1991.

REPORT VOLUMES

The present Report Volume is part of the

CYCLONE PROTECTION PROJECT II - FAP 7
FEASIBILITY AND DESIGN STUDIES
BWDB COMPONENT
FINAL PROJECT PREPARATION REPORT

Consisting of the following Volumes :

Volume 1	-	Main Report
Volume 2	-	Annexes I - XI, XIII
Volume 3	-	Annex XII - Polder Data
Appendix A	-	Hydraulic Studies
Appendix B	-	Field Surveys and Soil Investigations
Appendix C	-	Embankment Design
Appendix D	-	Agriculture
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1. INTRODUCTION

The present paper presents proposals for rehabilitation and strengthening of the embankment in Polder 62, Patenga. Recommendations as to the optimum solution are given on basis of a technical and economical analysis.

The paper is an outline of the feasibility study under preparation as part of Cyclone Protection Project II (CPP II).

2. EMBANKMENT HISTORY

A plan of Polder 62 is shown in Drawing 1.

In 1963 a continuous embankment (CEP embankment) was constructed over a distance of 15 km extending northwards from the Karnaphuli River. The crest level was 6.7 m and seaward slope was 1:5.

Since 1980 this embankment has been extended northward by some 3.5 km to chainage 18.5 km.

The embankment has been damaged on numerous occasions by high tide monsoon waves and cyclonic storms. Due to coastal erosion the most severe damage occurs at south Patenga and the embankment in this area has been damaged and retired several times since its initial construction in 1963.

The flash flood in 1984 and the 1985 cyclone left open a 1.9 km long gap in the embankment from chainage 3.6 km to 5.5 km. Works on an armoured embankment to close this gap was on-going when the 1991 cyclone struck and caused extensive flooding and damage in Chittagong. The design of the new embankment was with seaward slope of 1:4 and protection by placed concrete blocks to crest level 7.3 m.

This design is very similar to that of the armoured embankment between chainage 2.8 km and 3.5 km, constructed after 1986, although this has proven to be inadequate to sustain even normal high tide monsoon waves The armour of the existing embankment was totally damaged and the embankment severely damaged during the April 1991 cyclone.

Several futile attempts have been made in the past to protect the embankment against wave erosion including, stone armour, steel slag, brickwork and placed concrete blocks of various thickness.

3. PRESENT STATUS OF THE EMBANKMENT

The present highest elevation along the alignment of the embankment is shown in the figures in Annex 1.

The status of the embankment as per October 1991 is as follows (chainages - see Drawing 1):

3.1 Chainage 0.0 km to 1.4 km

From chainage 0.0 km to 1.4 km the main embankment runs parallel to the Kharnaphuli River at a distance approximately 200 m from the riverside. The river embankment itself serves as and is protected by a vertical masonry wall with a rubble revetment. Hence, the main embankment is only exposed to wave action during severe cyclonic storms. The road pavement and the sea wall has been partly damaged during the April 1991 cyclone and the main embankment crest has been eroded to levels between 5.5 m and 6.7m.

3.2 Chainage 1.4 km to 1.9 km

From chainage 1.4 km to 1.9 km the embankment runs at the country side of the Naval Academy and is therefore not exposed to wave action even during severe cyclonic storms. The embankment has been scoured at its foot on the country side by water flowing out after the inundation caused by the April 1991 cyclone.

3.3 Chainage 1.9 km to 2.5 km

From chainage 1.9 km to 2.5 km the embankment runs in the same alignment as the original CEP embankment. However, coastal erosion has moved the coastline in front of this embankment up to 1,200 m landward in the period 1938 to 1986. Earlier mangrove afforestation in this area has been cut down in order to provide a free sight from the Naval Academy towards to sea. After construction of a training wall (raised in 1955) along the northern side at the mouth of Karnaphuli river some accretion has taken place in front of the Naval Academy. This part of the embankment was heavily damaged during the April 1991 cyclone and a wide breach has formed immediately north of the Naval Academy (chainage 2.3 km). Where the embankment apparently has been cut earlier to let in sea water to a shrimp pond.

3.4 Chainage 2.5 km to 3.6 km

From chainage 2.5 km to 3.6 km the embankment runs in an alignment which is retired up to 500 m relative to the original CEP embankment. The design Crest level is approximately 7 m and the seaward slope 1:4 protected by placed concrete blocks from chainage 2.7 to 3.6 km. The coastline has moved 800 m landward in the period 1938 to 1986 and is now situated at the foot of the embankment. Before the cyclone the embankment armour has been severely damaged at several locations by high tide wave action and the armour was totally damaged during the April 1991 cyclone. The embankment itself suffered severe damage and a major breach has formed at chainage 2.8 km by water flowing out after the

inundation caused by the cyclonic storm surge. The crest level is now between 2.2 and 6.5 m.

3.5 Chainage 3.6 to 5.5 km

From chainage 3.6 km to 5.5 km there is no embankment. The former embankment was breached during flash floods in 1984 and was further damaged during the cyclone in 1985 and high tide monsoon waves. From December 1990 works on a new embankment protected by concrete blocks to crest level 7.3 m has been ongoing until the recent cyclone hit the area. Work has since been terminated. The ground level along the embankment alignment varies between 1.0 and 3.0 m.

3.6 Chainage 5.5 to 18.7 km

From chainage 5.5 to 18.7 km there is an earth embankment with design crest level 6.7 m and seaward slope 1:5. The width of the foreshore is 500 to 800 m and the coastline appears to be stable. Mangrove afforestation is present at certain stretches, whereas it has been cut in other areas to provide space for shrimp cultivation. The Export Processing Zone (EPZ) is situated immediately behind the embankment from chainage 7.5 km to 10.5 km. The embankment was partly damaged during the April 1991 cyclone and crest levels now vary between 5.5 and 6.7m. After the cyclone Repair works has been carried out under Food For Work programme and a dwarf embankment has been constructed to close the breaches.

4. COASTAL EROSION

During the monsoon period the wind direction is mainly SSW. The wave breaking together with the incoming tide sets up a longshore north-going current resulting in a littoral drift of same direction.

In the dry season the northly winds sets up a south-going littoral drift. However, due to higher waves and more consistent direction during the monsoon period, the net littoral transport is north-going.

The accretion in front of the Naval Academy results from the south-going transport stopped by the river training wall acting as a groin.

The north-going sediment transport along the coast **south** of the Karnaphuli River is disrupted by the river.

The Karnaphuli River discharges a certain amount of sediment, transported as suspended load. Due to the longshore current, these sediments will not be settled immediately north of the river mouth but transported further north and settled in more calm waters on the mangrove covered foreshore from chainage 6 km and north hereof.

With a net north-going sediment transport and no supply from south due to the Karnaphuli River, there will be a net loss of sediments on the coast

from chainage 2.5 to 5.6 km, resulting in the continuous erosion in this area.

Based on examination of maps from 1938 and 1986 the average rate of coastline regression can be estimated to be in the range 15 to 25 m/year.

5. OBJECTIVES FOR EMBANKMENTS AND COASTAL PROTECTION IN POLDER 62

The general objectives for the sea facing embankments included in CPP II are

- to **protect** the polder against inundation by saline water due to high tide and wave overtopping during monsoon conditions and
- to **minimize** saline water inundation and water flow velocities in the polder during severe cyclonic storm conditions

Due to the high concentration of industrial investments and infrastructure in Polder 62, the consequences of inundation by saline water here are much wider than in any other polder included in CPP II.

The objectives for the sea facing embankment in this polder should therefore be

- to **protect** the polder against inundation by saline water due to high tide and wave overtopping during monsoon conditions
- to **protect** the EPZ area, adjoining EPZ development area and other major industrial areas against inundation by saline water due to storm surge and wave overtopping during severe cyclonic storms
- to **minimize** saline water inundation and water flow velocities during severe cyclonic storm conditions in the polder area north of the EPZ area and its development area

Furthermore, the coastal erosion at chainage 1.9 to 5.5 km causes a continuous loss of land which in the long term is threatening the infrastructure in the area (i.e. roads and Chittagong Airport). For this stretch the embankment,in combination with appropriate coastal protection measures, should meet the following objective :

- to **reduce** the coastal erosion to a minimum

6. PROPOSALS FOR EMBANKMENT REHABILITATION AND STRENGTHENING

To meet the objectives listed in section 4, three alternative proposals have been prepared for a embankment of Polder 62.

The three proposals include identical works for the following reaches:

- Chainage 0.0 to 1.30 km (existing embankment parallel to Karnaphuli River)
- Chainage 5.55 to 11 km (existing embankment in front of industrial areas and potential industrial development areas)
- Chainage 11 to 18.7 km (existing embankment)
- Chainage 18.7 to 22.2 km (new embankment)

For chainage 1.98 to 5.55 km three alternatives have been analysed:

- Alternative 1 is a retired embankment with afforestation on the foreland.
- Alternative 2 is an embankment in the present alignment protected by a new foreland created by pumping in dredged sand in front of the embankment.
- Alternative 3 is an embankment in the present alignment protected by a revetment at the foot of a 25 m wide berm.

A summary of the cost estimates for the proposals is given in the table below. It should be noted that the embankment behind Naval Academy, which only require some very minor maintenance work, is not included in the estimate.

A further description of the proposals is given in section 6.1 to 6.5 and a break down of the estimates is given in Annex 1.

CHAINAGE (km)	LENGTH (m)	ALT. (No.)	TOTAL COST (million Taka)		
			Embankment.	Struc-tures	Total
0.0 - 1.30	1,300		6		
1.98 - 5.55	3,565	1	199		
		2	275		
		3	300		
5.55 - 11.0	5,450		79		
11.0 - 22.2	11,200		72		
TOTAL, Proposal 1	21,515		356.0	40	396.0
TOTAL, Proposal 2	21,515		432.0	40	472.0
TOTAL, Proposal 3	21,515		457.0	40	497.0

Table 6.1 : Investment Costs

Maintenance of the embankment and the appurtenant structures and works will include the following:

- Maintenance of slopes and crests damaged by wave erosion and human activities
- Maintenance of afforestation on the foreland
- Maintenance of artificial beaches created by sand nourishment and eroded by wave action
- Maintenance of revetments scoured and damaged by wave action
- Maintenance of structures damaged by waves and currents

The cost estimate for maintenance of embankments, beaches and revetments are described in section 6.2 to 6.5. For structures the yearly maintenance cost is estimated to 1.5 % of the investment.

The following table shows a summary of the cost estimates for the total yearly maintenance during a project life time of 25 years:

Year after Construction	Proposal 1 (million Taka/year)	Proposal 2 (million Taka/year)	Proposal 3 (million Taka/year)
0-4	4.4	4.5	7.4
5	4.4	89.5	7.4
6-9	4.4	4.5	7.4
10	4.4	89.5	7.4
11-14	4.4	4.5	7.4
15	169.5	89.5	7.4
16-19	4.4	4.5	7.4
20	89.5	89.5	7.4

Table 6.2 : Yearly Maintenance Costs

6.1 Chainage 0.0 to 1.3 km

Cross-section in the embankment is shown on Drawing 6. The existing embankment with average crest level 5.8 m will be resectioned and raised to level 7.0 m. The present slopes 1:5 and 1:2 will be maintained.

This embankment is running parallel to the Karnaphuli River and will be exposed during severe cyclonic storms only. The wave attack will be reduced by the road embankment which has crest level 6.0 m.

The cost estimate for resectioning totals **6 million Taka**

Maintenance costs are estimated to 1.5 % of the investment in earthworks.

6.2 Chainage 1.44A to 2.82A, Naval Academy

Plan of the Naval Academy area is shown on Drawing 5.

The area reclaimed for the Naval Academy outside the main embankment is protected by a masonry retaining wall with crest level between 5.5 and 6.0 m. The sea wall is protected against scour by a stone revetment and the access road to the premises runs along the sea wall along Karnaphuli river.

Repair of the sea wall and the access road is envisaged to be carried out under the emergency programme for polder 62 provided sufficient funds for financing are available. The justification for inclusion of these works, which are not directly beneficial to polder 62, is that the reclaimed area for the Naval Academy provides protection of the main protective embankment from chainage 1.30 to 1.98 km.

Soil investigations are on-going in order to establish a basis for preliminary engineering for strengthening/reconstruction of the masonry sea wall from chainage. The proposal for works and cost estimate awaits the outcome of these investigations.

The total costs are at present assessed at **70 million Taka.** These capital costs have not been considered in the detailed cost/benefit analyses for the proposed protective embankments for polder 62.

6.3 Chainage 1.98 to 5.55 km

The Consultant has analyzed three different concepts for flood protection and coastal protection in this area. The alignments are shown on Drawings 2 - 4 and cross-sections are shown on Drawings 7 - 8 :

Alternative 1:

Construction of an embankment in a retired alignment and minimizing the erosion of the obtained foreland through afforestation by mangrove, babla and other suitable tree species. Ground level of the foreland is approximately 3.0 m.

Beach nourishment immediately after the construction of the embankment will widen the foreland by some 200 m and thereby protect the afforestation during its initial growth period.

The embankment will be an earth embankment protected by a well compacted clay layer, turfing and afforestation, crest level 8.5 m. Seaward slope 1:7 and country side slope 1:3. The embankment will be designed for cyclonic conditions (water level 6.4 m, significant wave height 2.1 m, wave period 9 sec.).

The investment cost is estimated to **199 million Taka**

A break down of the estimate is included in Annex 2.

It is a condition that afforestation of the foreshore is established, therefore the cost for acquisition of the land on the sea side of the embankment has been included in the cost estimate.

The damaged embankment will have to be cleared by repositioning the concrete blocks to the foot of the existing embankment. This will reduce the coastal erosion for a period.

The maintenance costs for the embankment itself is estimated to 1.5 % of the capital investment in earthworks.

The maintenance of the foreshore will depend very strongly on the rate of erosion of the created beach and the afforestated foreland.
This rate of erosion can be estimated very roughly on basis of the erosion observed in the past and an evaluation of the reduction of the wave energy in storm situations - caused by the afforestation (approximately 30 % reduction). Since no credit is given to the sand- and silt retaining effect of the afforestation in more moderate wave situations, this approach will lead to a somewhat conservative estimate of the erosion.

With a rate of erosion reduced (by afforestation) from 15-25 m/year to 10-18 m/year, the life time of the foreshore will be 11-20 years.

The most probable life time is estimated to 15 years. In order to save the embankment from wave erosion it will be necessary to create a new foreshore by beach nourishment in year 15 after construction and maintain the foreshore by repeated nourishment throughout the entire life time of the embankment.

The amount of sand to be nourished in year 15 is estimated to 2,000,000 m3 and the maintenance is estimated to 1,000,000 m3 each 5 years hereafter.

This maintenance of the beach is similar to the maintenance expected for Alternative 2, but here started in year 0 (see below).

Alternative 2:

Construction of an embankment in the present alignment and establishing of a new coast line by building up and maintaining a new foreshore seaward hereof. As the foreshore will consist of sand, afforestation will not be possible.

The embankment will be an earth embankment a in alternative 1 with crest level 8.5 m. Seaward slope 1:7 and country side slope 1:3. The embankment will be designed for cyclonic conditions (water level 6.2 m, wave height 2.1 m and wave period 9 sec.)

The investment cost is estimated to **275 million Taka**

A break down of the estimate is included in Annex 2.

The maintenance costs for the embankment itself is estimated to 1.5 % of the capital investment in earthworks.

The maintenance of the foreshore will depend very strongly on the rate of erosion of the created beach. This rate will depend on the quality (coarseness) of the sand available for the nourishment.

Based on analysis of sand used for reclamation of the EPZ area it is estimated that the rate of erosion of the beach may be as high as 40 m year, which implies a maintenance of 200,000 m3 per year or 1,000,000 m3 each 5 years.

Alternative 3:

Construction of an embankment in the present alignment and protection of the foot of the embankment by a stone revetment.

The embankment will consist of an earth embankment as in alternative 1 with crest level 8.5 m. The seaward front will include a 25 m wide berm at elevation 4.5 m. Above this berm the slope will be 1:7.

The seaward front of the berm will be protected by a revetment with slope 1:2 consisting of stone- or concrete block armour in random placement.

This revetment will be designed for monsoon conditions with return period 20 years (water level 4.5 m, significant wave height 2.4 m, wave period 9 sec.). This relatively big wave height (compared to Alternative 1 and 2) is due to the low ground level in front of the revetment. In the calculations this ground level is set to 0.5 m (3.0 m in Alternative 1 and 2). In some sections the present ground level is higher, but erosion to level 0.5 can be expected.

The concrete blocks from the existing embankment will be re-used as toe- and berm protection of the revetment.

The earth embankment will be designed for cyclonic conditions (water level 6.4 m, wave height 3.4 m, wave period 9 sec.). The berm will create wave breaking and thus reduce the wave attack and the run-up on the slope.

The investment cost is estimated to **300 million Taka**.

A break down of the estimate is included in Annex 2.

The maintenance costs for the embankment itself is estimated to 1.5 % of the capital investment in earthworks.The maintenance of the revetment will consist in repair of the toe of damages due to scouring and repair of the armour layer in cases where the design conditions are exceeded. The damage caused by exceedance of design conditions in monsoon period is estimated to 5 % of the capital investment in revetment material. The damage caused during the design cyclonic storm is expected to be 10 %.

Estimating the repair of scour damages to 0.75% per year and exceedance of monsoon- as well as cyclonic design conditions 1 time per 20 year result in yearly maintenance amounting to 1.5 % of the investment in revetment material.

6.4 Chainage 5.6 to 11 km

The cross section for this embankment is shown on Drawing 9. The present embankment with average (post cyclone) crest level 6.7 m will be raised to level + 8.5 m to provide 'no overtopping or nearly no overtopping conditions during severe cyclonic storms. The seaward slope will be 1:7.

The cost estimate shows a total of **79 million Taka**.

Maintenance costs are estimated to 1.5 % of the investment in earthworks.

6.5 Chainage 11 to 18.7 km and 18.7 to 22.2 km

The cross-section for chainage 11 to 18,7 is shown on Drawing 10. The present embankment with average (post cyclone) crest level 6.2 m will be raised to level 7.0 m.

Cross section for chainage 18.7 to 22.2 km is shown on Drawing 10.

This portion of the embankment is new and will be constructed to level 7.0 m in order to enclose the polder towards the highway, which has crest level 8.4 to 9.1 m in this area.

The cost estimate for embankment from 11 to 22.2 shows a total of **72 million Taka**.

Maintenance costs are estimated to 1.5 % of the investment in earthworks.

7. BENEFITS FROM AN IMPROVED EMBANKMENT

7.1 General

The characteristics of polder 62 Patenga are different from the others polders covered by CPP II. The main reasons for this are:

- Patenga has two very important industrial estates in Bangladesh:
  - o The Patenga Industrial Area with the highest concentration of industrial production in Bangladesh and
  - o The Industrial Export Processing Zone of Bangladesh
- The most important ocean port of Bangladesh, Chittagong, is located in the area.
- The Chittagong Airport is located in the polder.
- The agricultural sector is of minor importance because of a very small cultivated area and the dominating industrial activities.

In view of the above it is clear that the agricultural aspect should be given limited considerations when looking at the present project from the development point of view. Consequently, launching of preventive measures against inundation should primarily be constructed with the aim of protecting industrial production.

To assess the damages caused by cyclonic surges the consultant has collected information from four sources of information: official statistics, damages reports from the April 1991 cyclone and talks with authorities and senior management staff in the project area.

7.2 Major industrial activities

Chittagong has always been the principal port of Bangladesh. Therefore the major industrial activities have been located in this area.

Among the major industries should be mentioned Chittagong Steel Mill, General Electrical Manufacturing, Eastern Cable, Chittagong Cement Factory, Eastern Refinery and the Triple Super Phosphate Complex.

The annual turnover and value added for the major industries have been computed by a CIDA funded study in 1985 (1) . The study found that the annual turn over amounted to 10,835 million Taka and the value added to 3,600 million Taka, including the industries in EPZ. It is assumed that only minor changes in industrial production outside the EPZ have taken place since 1985.

7.3 The Bangladesh Export Processing Zone (EPZ)

The Export Processing Zone was established in 1983. The aim is to attract foreign investment and to create employment opportunities.

The Zone has been established in accordance with international well known principles such as tax holidays for 10 years, exemption of income taxes on borrowed capital, duty free import of machinery, duty free export of goods etc.

The export processing zone is competing with similar zones in other countries on conditions regarding local labour costs, stability etc.

The zone covers an area of 412 acres(167 ha) which is divided into plots of ½ an acre. The land is developed and the zone authority is leasing the land to the industries on a 30 years term with possibility for extension.

The industries are covering 3 different groups:

- Category A With 100% foreign investment,
- Category B Joint ventures and
- Category C 100% national owned.

As of October 1991 74 industries have been approved, out of which 39 are in operation in October 1991. The remaining ones are expected to commence production within half a year. There are presently employed 9,600 in the factories.

Due to the low labour cost industrial production of garments is a dominating activity. But other production which requires a relatively high labour input are also established in the Export Processing Zone.

The consultant has been informed that when all the aforesaid industries are established the total value of the investment is expected to reach 473 million USD.

7.4 Estimation of benefits for the industry

The benefits to be taken into account can basically be divided into 3 groups regarding industrial production:

- saved damages to industrial buildings
- saved damages to production equipment, raw material and products
- saved losses in value added in connection with down-time periods after have been flooding.

The above benefits have estimated on basis of the losses incurred by the April 1991 cyclone.

7.5 Losses due to April 1991 cyclone

During the cyclone saline water inundated the Export Processing Zone and nearly all the factories had saline water in 1-1.5 meter height above the ground floor.

The Export Processing Zone Authority has estimated the loss after the April 1991 cyclone to **1600 million Taka**.

This amount covers only the direct losses while losses of value added during the down time after the cyclone have not been included in the estimate.

The down time after the cyclone was generally between 1 to 2 months for some of the factories a bit longer. The general picture was that full scale production was not reached before 3 months. On basis of the information provided by EPZ Authority an average down time period of 1.5 month has been used although it is considered to be on the low side.

On the basis of information provided by the Exporting Processing Zone Authority (EPZ) regarding number of industries, turnover, value added and area occupied, the total production value and the value added have been calculated.

In the Chittagong Industrial Area the impact by intrusion of saline water was much bigger than in the EPZ.

The down time for some of the factories was also considerably longer than in the Exporting Processing Zone. The main reasons for this seems to be the fact that the ground level in the industrial area is approximately 1 meter lower than in EPZ. For several of the industries the machinery were located under the floor level.

For the Steel Mill it appears that 90% of the machinery was placed under the floor level and one of the six mills is still out of operation.

The minor industrial activities also named the cottage industry has also been facing losses. These losses have been estimated on basis of official statistics regarding production value, employment etc for the district in question.

The amount of the destruction is estimated at approximately **54 million Taka** which is insignificant compared to the magnitude of losses incurred by the big industries.

The total industrial losses incurred by the April 1991 cyclone can on basis of the above be estimated to:

Direct losses	**3200 million Taka**
Down time	**620 million Taka**
Total	**3820 million Taka**

In Annex 3 is shown a break down on the component: direct losses and down time.

7.6 Benefits from protection of properties and infrastructure

After the April 1991 cyclone several official damage reports have been prepared by the respective ministries.

The direct impact of the wind should not be underestimated when assessing the damages to homes (houses and cottages). The total number of homes damaged have been estimated to 12,000. As a rough estimate it is anticipated that half of the damages to homes have been caused by the wind and not by the intrusion of water.

The Airport of Chittagong is also located in the polder. In the airport area the water rose to two meter above ground level soon after the intrusion. The devastation to the property and equipment have been estimated by the Civil Aviation Authority to **150 million Taka**. According to officials from the Civil Aviation Authority nearly all of the damage should be ascribed to intrusion of water. Losses due to down time has not been taken into account.

7.7 Agricultural Benefits

The agricultural benefitted area is estimated to 890 ha. For this area has been calculated the farm budget in the with and with out project situation. It has been assumed that in the with out project situation the yield will decrease with 4 percent per year until it reaches a total decrease of 20 %. The total agricultural benefits per year after full impact by the embankment amounts only to **2.7 million Taka** per year.

7.8 Frequency of Flooding

On the basis of brief interviews with senior management in the project area it is concluded that during the 1970 and 1985 cyclone there had not been any or insignificant intrusion of saline water in the industrial area. Last time the Patenga industrial area was flooded was in 1966.

The previous study on Patenga prepared for CIDA, dated February 1987, has carefully analysed the relationship between water levels and damages to the area. In addition a high water level return period curve had been

estimated. It should however, be born in mind that these estimates have been made on basis of very few reliable data.

The surge heights and frequencies estimated correspond fairly well with the consultant's findings. On the basis of the CIDA study and other records the consultant has assessed that the surge water level during the April 1991 cyclone represents a 1 in 40 years event.

Table 7.1 shows the relationship between damages caused by different surge levels, their estimated return period, frequency and annual accumulated benefits with the project under above assumption.

Still water surge level (m PWD)	Return period (year)	Estimated damage without project (million Taka)	Frequency (non-exceedance)	Annual cost & frequency differential (million Taka)	Estimated Degree of protection with project	Annual Cumulated benefits with project (million Taka)
4.60	5.00	0	0.80		100%	
				40.1		40.1
5.20	10.00	802	0.90		100%	
				60.15		100.25
5.80	20.00	1,604	0.95		100%	
				70.17		170.43
6.40	40.00	4,010	0.975		100%	
				75.18		245.62
7.02	100.00	6,015	0.990		100%	
				31.08		276.70
7.65	200.00	8,020	0.995		80%	

Table 7.1 Estimated annual cumulated benefits with project

Calculation of the yearly benefits has been carried out on the basis of the information in the table 7.1. This is in accordance with the Guidelines for Project Assessment prepared by the Flood Plan Coordination Organization. The value in table 7.1 are financial. In the economic analysis a conversion factor of 0.82 has been applied.

The Net Present Value (NPV) and the Economic Internal Rate of Return (EIRR) have further been calculated with the assumptions that the April 1991 cyclone surge represents a 1 in 20 years and 1 in 100 years event, refer Annex 4 and section 8.2.

8. ECONOMIC ANALYSIS OF THE THREE PROPOSALS

8.1 Assumptions

The main assumptions for the economic analysis are as follows:

a. **Investment Cost**. Only cost directly associated with the project are considered . The cost cover land acquisition, earthworks and construction of structures.

b. **Operation and Maintenance.** Maintenance cost are estimated to 1.5% of construction cost of structures and earthworks.

c. **Prices of Earthworks.** The unit price per cubic m. has been estimated on basis of ICB tenders received 1990 for Patenga and rates for similar works carried out under contracts with Bangladesh Water Development Board.

d. **Frequency of extreme water level.**The base case has been calculated on the assumption of a return period of 40 years for the water level in connection with the April 1991 cyclone.

e. **The value of benefits** has been escalated by an annual increase of 3%.

f. **Standard Conversion Factor.** For all non agricultural costs and values a SCF of 0.82 have been applied in accordance with the Guidelines for Project assessment issued by FPCO. For agricultural prices a detailed productwise assessment based on import prices have been undertaken.

8.2 The three proposals for the embankment are considered as providing equally good protection against floods. Consequently, the analysis should be limited to find the least cost solution.

Under the assumption of a 20 years project period the EIRR and NPV are shown in table 8.1 for the base case, where the water level of 6.4 meter during the April 1991 cyclone corresponds to 40 years return period.

Table 8.2 and 8.3 show the result of calculations under the assumption that the 6.4 meter corresponds to 20 and 100 years return periods respectively.

	TOTAL COST million Taka	EIRR %	NPV million Taka
Proposal 1	396	59.3	1411
Proposal 2	472	50.7	1319
Proposal 3	497	49.1	1353

Table 8.1: April 1991 cyclone surge taken as 1 in 40 year event; base case

	TOTAL COST million Taka	EIRR %	NPV million Taka
Proposal 1	396	114.4	3600
Proposal 2	472	100.1	3507
Proposal 3	497	96.3	3542

Table 8.2: April 1991 cyclone surge taken as 1 in 20 year event.

	TOTAL COST million Taka	EIRR %	NPV million Taka
Proposal 1	396	33.8	583
Proposal 2	472	27.9	491
Proposal 3	497	27.8	525

Table 8.3: April 1991 cyclone surge taken as a 1 in 100 year event;

As shown in the tables, all three proposals will yield an extremely high rate of return. A result which is not surprising in view of the substantial industrial capital investment in polder 62.

8.3 Net Present Value and Sensitivity test

The Net Present Value (NPV) for all three proposals has been calculated on basis of a 20 years project period.

As it will appear proposal 1 has the highest NPV while the NPV for proposal 2 and 3 are more or less the same.

However, when comparing the two latest proposals it should be noted that the reason for a higher NPV for proposal 2 despite a lower initial investment is the requirement of regular maintenance every 5 years. A requirement

which not only from an economic point of view but also when the aspects of maintenance, organisational and funding are taken into account make proposal 2 less recommendable than the two others.

To test the EIRR to possible changes in the key variables a serious of test have been executed.

Below is shown for the base case with what percentage the key economic parameters can be changed before the EIRR reach 12 %.

	Prop. 1	Prop. 2	Prop 3
Increase in investment and O & M cost	+ 443%	+321%	+359%
Reduction in benefits	86%	81%	83%

9. CONCLUSIONS AND RECOMMENDATIONS

The economic analysis shows that Proposal 1 from a strictly economic point of view is the most attrctive investment.

The internal rate of return is for 59.3% for Proposal 1, which is 8.6% higher than that of Proposal 2 and 9.8% higher than of Proposal 3.

Proposal 2 yields the lowest rate of return and in addition has a demanding maintenance profile consequently the consultant finds that this proposal can not be recemmended.

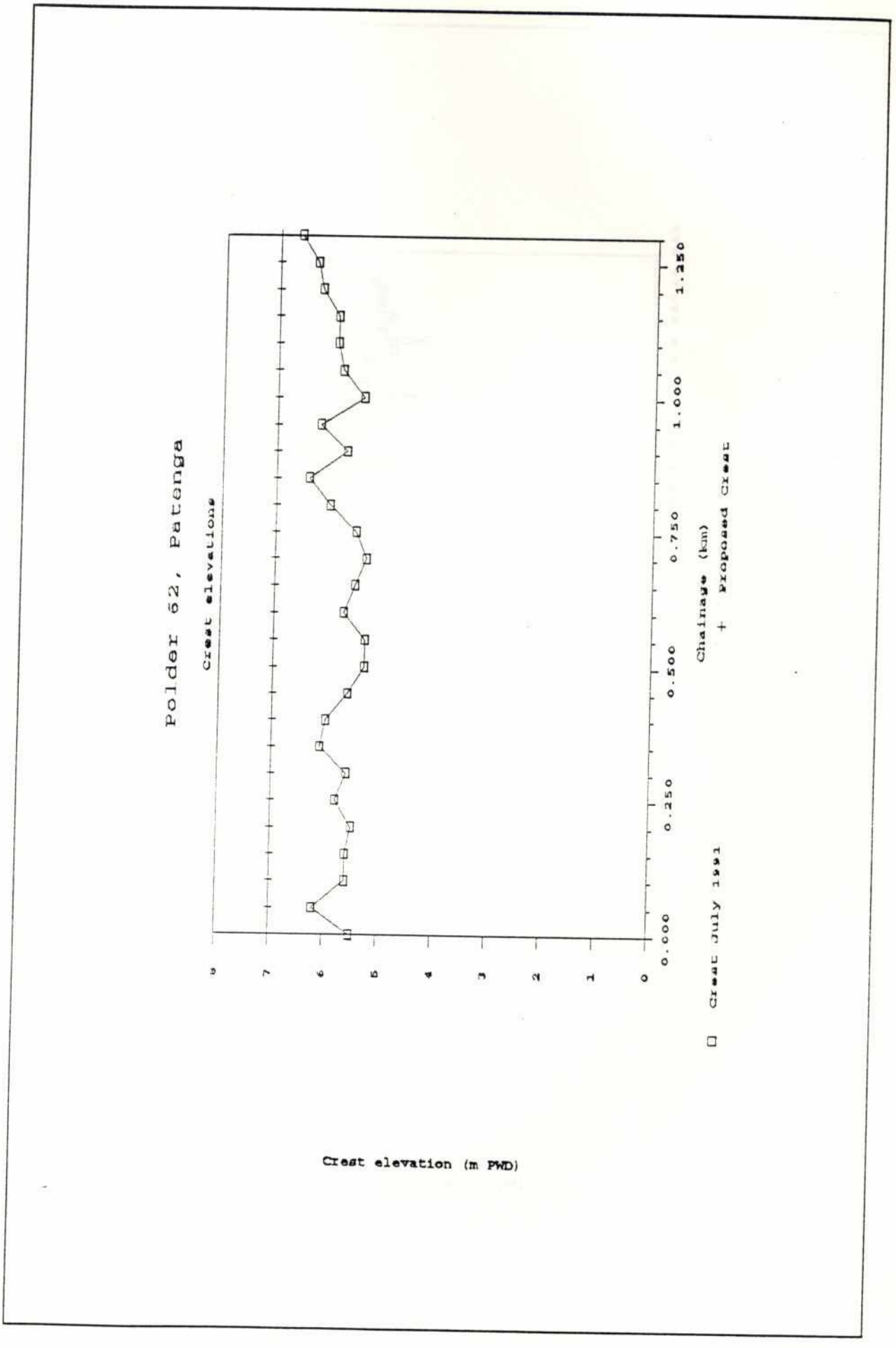
A condition for a succesfull performance of solution 1 or 3 is that funding for maintenance is secured for the entire life time of the project.

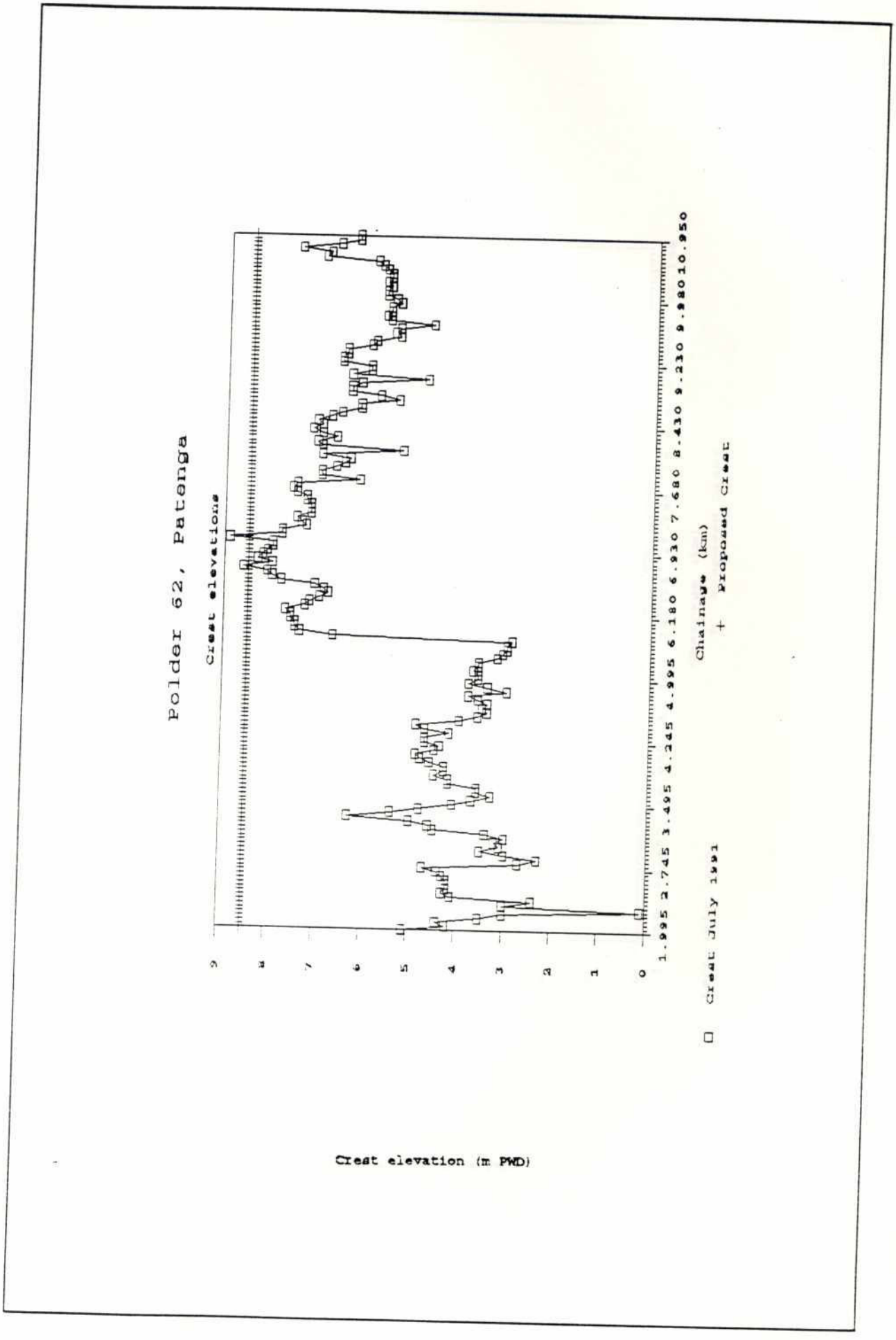
For proposal 1 the maintenance issue is a bit complicated as it requires maintenance in specific years of the project in order to meet an accepteble life time. There are good reasons to assume that these extraordinary maintenance cost will only be funded if financial sources from abroad will be secured.

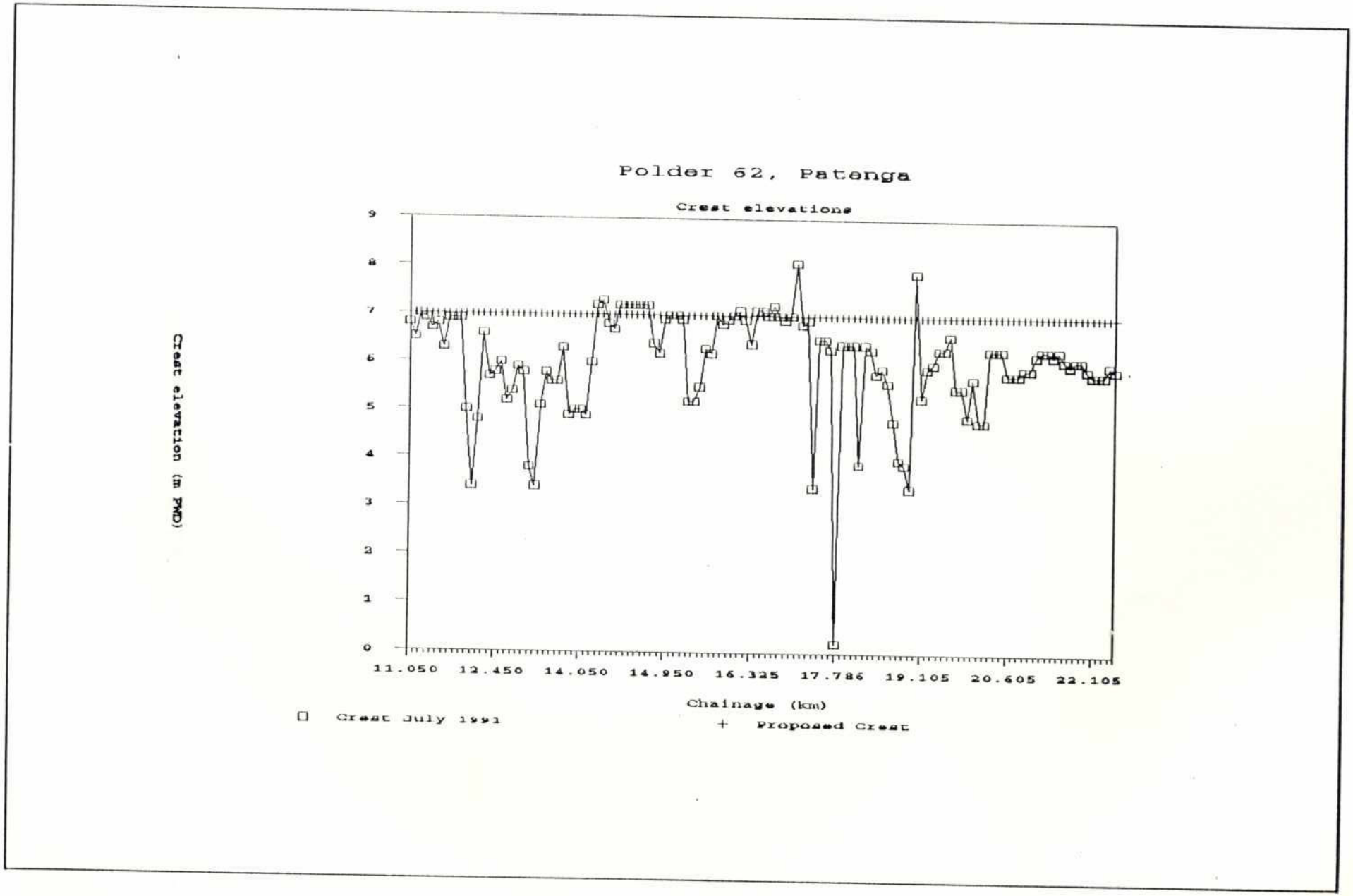
In view of the above the consultant can only recommend Proposal 1 provided that the foreign funding of the project also includes an allocation for future periodic maintenance.

The maintenance involved in Proposal 3 is of a more controlled nature and might be covered by national funds on a regular basis.

ANNEX 1 : CREST LEVELS AS SURVEYED JULY 1991


Polder 62, Patenga
Crest elevations
Crest elevation (m PWD)
Chainage (km)
0.000
0.250
0.500
0.750
1.000
1.250
0
1
2
3
4
5
6
7
8
Crest July 1991
+ Proposed Crest


Polder 62, Patenga
Crest elevations
Crest elevation (m PWD)
Chainage (km)
1.995 2.745 3.495 4.245 4.995 6.180 6.930 7.680 8.430 9.230 9.980 10.950
0 1 2 3 4 5 6 7 8 9
Crest July 1991
Proposed Crest


Polder 62, Patenga
Crest elevations
Crest elevation (m PWD)
9
8
7
6
5
4
3
2
1
0
11.050
12.450
14.050
14.950
16.325
17.786
19.105
20.605
22.105
Chainage (km)
Crest July 1991
Proposed Crest

ANNEX 2 : BREAK DOWN OF COST ESTIMATES

CYCLONE PROTECTION PROJECT II					29/10/91
CAPITAL COST ESTIMATE - Price Level Forecast January 1992,					
POLDER 62, PATENGA. RETIRED EMBANKMENT, ALT. 1				CHAINAGE 1.980 km to 5.545 km	
				Length (m):	3,565
Item No.	Description	Unit	Quantity	Rate TAKA	TOTAL 1000 TAKA
1.	CONSTRUCTION				165,780
1.1	General Costs (5%)				9,000
1.2	Earth Works				71,780
1.2.1	Site Clearance	l.s.			5,000
1.2.2	Stripping	m²	214000	10	2,140
1.2.3	Embankment fill	m³	625000	100	62,500
1.2.4	Turfing	m²	214000	10	2,140
1.2.5	Armour Blocks	m³		1500	0
1.2.6	Toe and berm blocks	m³		750	0
1.2.7	Bedding Layer	m³		1100	0
1.2.8	Geotextile	m²		100	0
1.3	Beach Nourishment				85,000
1.3.1	Mobilization and demob.	l.s.			5000
1.3.2	Dredged Fill	m³	1000000	80	80,000
1.4	Structures	l.s.			0
2.	LAND AQUISITION				15,000
2.1	Embankment	m²	600000	25	15,000
3.	CONTINGENCIES				18,000
3.1	10 % of Subtotal				18000
4.	TOTAL COSTS				198,780
	COST PER M EMBANKM.				56

CYCLONE PROTECTION PROJECT II					29/10/91
CAPITAL COST ESTIMATE - Price Level Forecast January 1992,					
POLDER 62, PATENGA. EMBANKMENT + Nourishment, ALT. 2				CHAINAGE 1.980 km to 5.545 km	
				Length (m):	3,565
Item No.	Description	Unit	Quantity	Rate TAKA	TOTAL 1000 TAKA
1.	CONSTRUCTION				248,780
1.1	General Costs (5%)				12,000
1.2	Earth Works				71,780
1.2.1	Site Clearance	l.s.			5,000
1.2.2	Stripping	m^2	214000	10	2,140
1.2.3	Embankment fill	m^3	625000	100	62,500
1.2.4	Turfing	m^2	214000	10	2,140
1.2.5	Armour Blocks	m^3		1500	0
1.2.6	Toe and berm blocks	m^3		750	0
1.2.7	Bedding Layer	m^3		1100	0
1.2.8	Geotextile	m^2		100	0
1.3	Beach Nourishment				165,000
1.3.1	Mobilization and demob.	l.s.			5000
1.3.2	Dredged Fill	m^3	2000000	80	160,000
1.4	Structures	l.s.			0
2.	LAND AQUISITION				3,250
2.1	Embankment	m^2	130000	25	3,250
3.	CONTINGENCIES				23,000
3.1	10 % of Subtotal				23000
4.	TOTAL COSTS				275,030
	COST PER M EMBANKM.				77

CYCLONE PROTECTION PROJECT II					29/10/91
CAPITAL COST ESTIMATE - Price Level Forecast January 1992,					
POLDER 62, PATENGA. REVETMENT + EMBANKMENT WITH BERM, ALT.3				CHAINAGE 1.980 km to 5.545 km	
				Length (m):	3,565
Item No.	Description	Unit	Quantity	Rate TAKA	TOTAL 1000 TAKA
1.	CONSTRUCTION				268,285
1.1	General Costs (5%)				14,000
1.2	Earth Works				254,285
1.2.1	Site Clearance	l.s.			0
1.2.2	Stripping	m^2	228000	10	2,280
1.2.3	Embankment fill	m^3	725000	100	72,500
1.2.4	Turfing	m^2	228000	10	2,280
1.2.5	Armour Blocks	m^3	61000	1500	91,500
1.2.6	Toe and berm blocks	m^3	47500	750	35,625
1.2.7	Bedding Layer	m^3	39000	1100	42,900
1.2.8	Geotextile	m^2	72000	100	7,200
1.3	Beach Nourishment				0
1.3.1	Dredged Fill	m^3			0
1.4	Structures	l.s.			0
2.	LAND AQUISITION				3,250
2.1	Embankment	m^2	130000	25	3,250
3.	CONTINGENCIES				28,000
3.1	10 % of Subtotal				28000
4.	TOTAL COSTS				299,535
	COST PER M EMBANKM.				84

CYCLONE PROTECTION PROJECT II					29/10/91
CAPITAL COST ESTIMATE - Price Level Forecast January 1992,					
POLDER 62, PATENGA. RESECTIONING TO +7.0 m				CHAINAGE 0.0 to 1.30 km	
				Length (m):	1,300
Item No.	Description	Unit	Quantity	Rate TAKA	TOTAL 1000 TAKA
1.	CONSTRUCTION				5,507
1.1	General Costs (5%)				200
1.2	Earth Works				5,307
1.2.1	Site Clearance	l.s.			
1.2.2	Stripping	m²	13000	10	130
1.2.3	Embankment fill	m³	40000	120	4,800
1.2.4	Turfing	m²	37700	10	377
1.2.5	Armour Blocks	m³		1500	0
1.2.6	Toe and berm blocks	m³		750	0
1.2.7	Bedding Layer	m³		1100	0
1.2.8	Geotextile	m²		100	0
1.3	Beach Nourishment				0
1.3.1	Mobilization and demob.	l.s.			
1.3.2	Dredged Fill	m³		80	0
1.4	Structures	l.s.			0
2.	LAND AQUISITION				0
2.1	Embankment	m²		25	0
3.	CONTINGENCIES				500
3.1	10 % of Subtotal				500
4.	TOTAL COSTS				6,007
	COST PER M EMBANKM.				5

CYCLONE PROTECTION PROJECT II					29/10/91
CAPITAL COST ESTIMATE - Price Level Forecast January 1992,					
POLDER 62, PATENGA. RESECTIONING TO +8.5 m				CHAINAGE 5.55 to 11.0 km	
				Length (m):	5,450
Item No.	Description	Unit	Quantity	Rate TAKA	TOTAL 1000 TAKA
1.	CONSTRUCTION				71,090
1.1	General Costs (5%)				3,600
1.2	Earth Works				67,490
1.2.1	Site Clearance	l.s.			
1.2.2	Stripping	m^2	175000	10	1,750
1.2.3	Embankment fill	m^3	625000	100	62,500
1.2.4	Turfing	m^2	324000	10	3,240
1.2.5	Armour Blocks	m^3		1500	0
1.2.6	Toe and berm blocks	m^3		750	0
1.2.7	Bedding Layer	m^3		1100	0
1.2.8	Geotextile	m^2		100	0
1.3	Beach Nourishment				0
1.3.1	Mobilization and demob.	l.s.			
1.3.2	Dredged Fill	m^3		80	0
1.4	Structures	l.s.			0
2.	LAND AQUISITION				0
2.1	Embankment	m^2		25	0
3.	CONTINGENCIES				7,500
3.1	10 % of Subtotal				7,500
4.	TOTAL COSTS				78,590
	COST PER M EMBANKM.				14

CYCLONE PROTECTION PROJECT II					29/10/91
CAPITAL COST ESTIMATE - Price Level Forecast January 1992,					
POLDER 62, PATENGA. RESECTIONING TO + 7.0 m				CHAINAGE 11.0 to 22.2 km	
				Length (m):	11,200
Item No.	Description	Unit	Quantity	Rate TAKA	TOTAL 1000 TAKA
1.	CONSTRUCTION				65,700
1.1	General Costs (5%)				3,200
1.2	Earth Works				62,500
1.2.1	Site Clearance	l.s.			
1.2.2	Stripping	m²	250000	10	2,500
1.2.3	Embankment fill	m³	550000	100	55,000
1.2.4	Turfing	m²	500000	10	5,000
1.2.5	Armour Blocks	m³		1500	0
1.2.6	Toe and berm blocks	m³		750	0
1.2.7	Bedding Layer	m³		1100	0
1.2.8	Geotextile	m²		100	0
1.3	Beach Nourishment				0
1.3.1	Mobilization and demob.	l.s.			
1.3.2	Dredged Fill	m³		80	0
1.4	Structures	l.s.			0
2.	LAND AQUISITION				0
2.1	Embankment	m²		25	0
3.	CONTINGENCIES				6,300
3.1	10 % of Subtotal				6,300
4.	TOTAL COSTS				72,000
	COST PER M EMBANKM.				6

ANNEX 3 : BREAK DOWN OF ESTIMATED LOSSES AND BENEFITS

INDUSTRIAL LOSSES:

Direct losses:

	million Taka
Export Processing Zone (EPZ)	1600
Chittagong Industrial Area	1580
Cottage industry	20
Total	3200

Lost value added:

Annual value added:

Export Processing Zone	1152
expected increase(1)	770
Chittagong Industrial Area	3000
Cottage industry	34
Total	4956
Losses during 1½ month down time:	620

Export Processing Zone. Based on information from the EPZ Authorities it is estimated that the yearly turnover for the 78 approved industries will be 160 million us dollars (USD) equal to 5,760 million Tk , when in full operation. The average value added for the industries is 20%.
These industries covers 247 plots. Assuming the same average annual turn over for the developed but unleased plots (166) as for the existing ones contribute to an increase of 107 million USD or 3852 million Taka.

Chittagong Industrial Area. The CIDA funded study had estimated the yearly turnover value added to for all indistries in the water exposed area to 3600 million Tk. This estimate included alos 12 industries in EPZ. Deduction an estimate for the EPZ industries leaves 3000 million Tk for the industrial area. Based on information provided during a

visit in the project area there are good reasons to anticipate that these figures have not changed very much since 1985. For some of the industries it seems to be decreasing a bit.

Cottage industry. On the basis of official statistics covering the area number of employed and turnover has the yearly turnover been estimated to 85-90 million Tk. Assuming a value added of 40% gives
a yearly value added of 34 million Tk.

OTHER LOSSES:

Houses:

According to damages report and other sources the number of totally damaged houses(cottage and houses) should be 12,000. Assuming that half of the houses have been destroyed due to the wind and an average price of 15,000 Tk. This price reflects that the poorest constructions are more likely to be damaged. The total value of lost house is estimated to 90 million TK.

The Chittagong Airport:

Based on information provided by the Civil Aviation Authority the total losses for to the airport amounts to 130 to 170 million Tk. The replacement value which also may include better equipment is estimated to over 300 million Tk. According the source just mentioned it was the intrusion of saline water which has caused the major part of the damages. As a conservative estimate it is assumed that at least 100 million Tk can be ascribed to intrusion of water. The total assets is about 30,000 million Tk.

Infrastructure:

Apart from the airport it has been difficult to obtain an estimate of the losses in value of infrastructure. Consequently, damage to roads and bridges have not been counted.

Standard Conversion Factor. For all the above indicated values a SCF of 0.82 has been applied.

ANNEX 4 : ANNUAL CUMULATED BENEFITS WITH PROJECT FOR RETURN PERIODS 20-AND 100 YEARS OF APRIL 1991 CYCLONE CONDITIONS.

Still water surge level (m PWD)	Return period (year)	Estimated damage without project (million Taka)	Frequency (non-exceedance)	Annual cost & frequency differential (million Taka)	Estimated Degree of protection with project	Annual Cumulated benefits with project (million Taka)
4.60	2.00	0	0.50		100%	
				120.3		120.3
5.20	5.00	802	0.80		100%	
				120.3		240.6
5.80	10.00	1,604	0.90		100%	
				140.4		381.0
6.40	20.00	4,010	0.95		100%	
				125.3		506.3
7.02	40.00	6,015	0.975		100%	
				93.2		599.5
7.65	100.00	8,020	0.990		80%	

20 year return period.

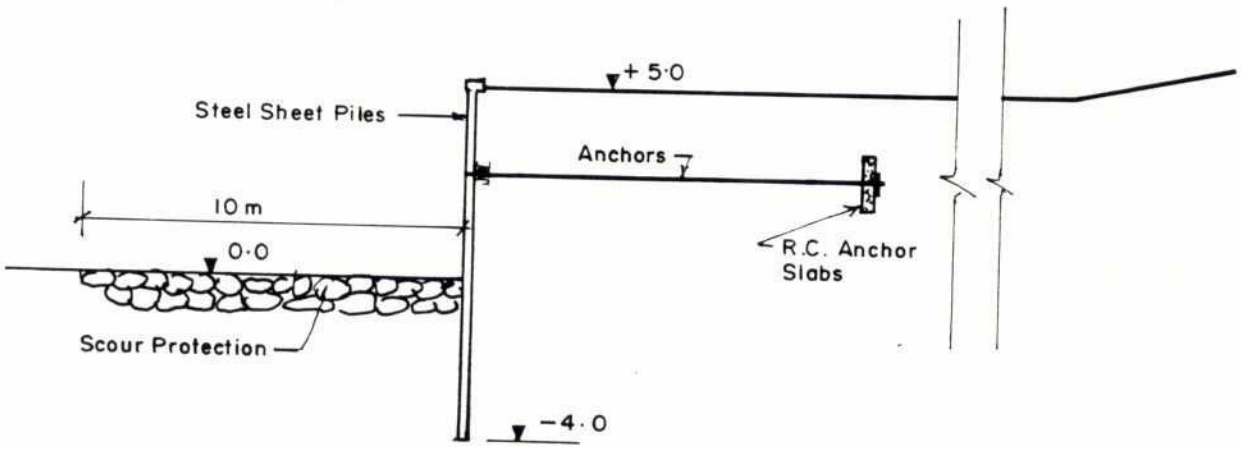
Still water surge level (m PWD)	Return period (year)	Estimated damage without project (million Taka)	Frequency (non-exceedance)	Annual cost & frequency differential (million Taka)	Estimated Degree of protection with project	Annual Cumulated benefits with project (million Taka)
4.60	10.00	0	0.90		100%	
				20.5		20.5
5.20	20.00	802	0.95		100%	
				30.08		50.13
5.80	40.00	1,604	0.975		100%	
				42.11		92.23
6.40	100.00	4,010	0.99		100%	
				25.06		117.29
7.02	200.00	6,015	0.995		100%	
				18.65		135.94
7.65	400.00	8,020	0.998		80%	

100 year return period

ANNEX 5 : **DRAWINGS 1-10**
SKETCH S 1

SKETCH S1

STEEL SHEET WALL AS ALTERNATIVE REVETMENT



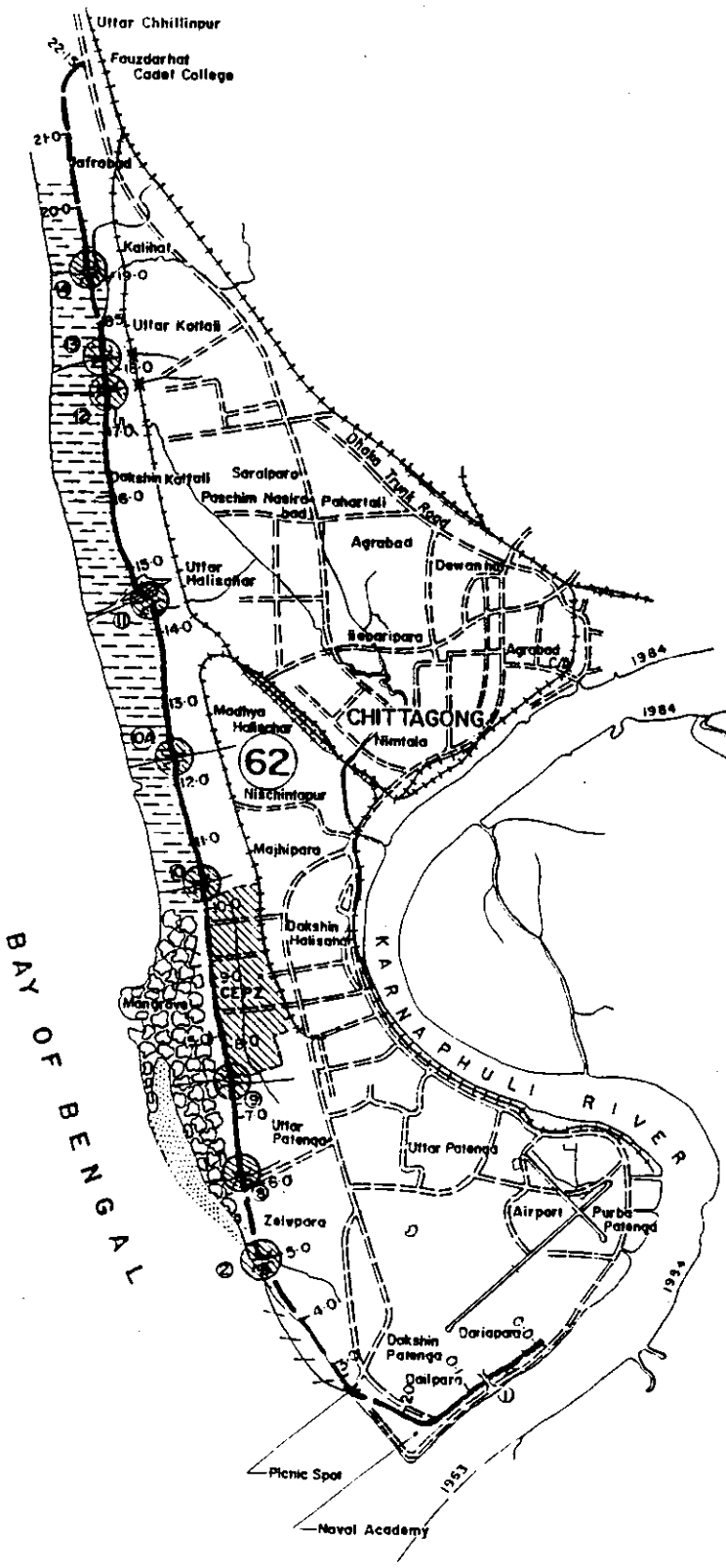
ESTIMATED COST TK. 110,000/m

POLDER NO. 62

62

LEGEND

- River & Khal
- Roads
- Railway Line
- Existing Embankment Chainage in Km 7·0, 8·0 & Miles (5·0)
- Proposed Embankment
- Shore Line 1986
- Shore Line 1963
- Limit of Protected Area
- Original C E P Embankment
- Proposed Sluice
- Existing Sluice



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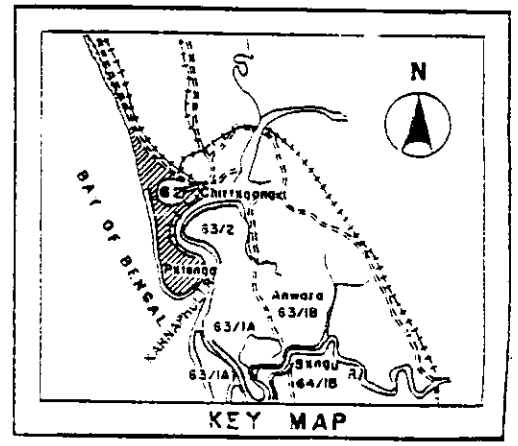
SCALE



PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

EMERGENCY CYCLONE PROTECTION PROJECT

PLAN OF POLDER

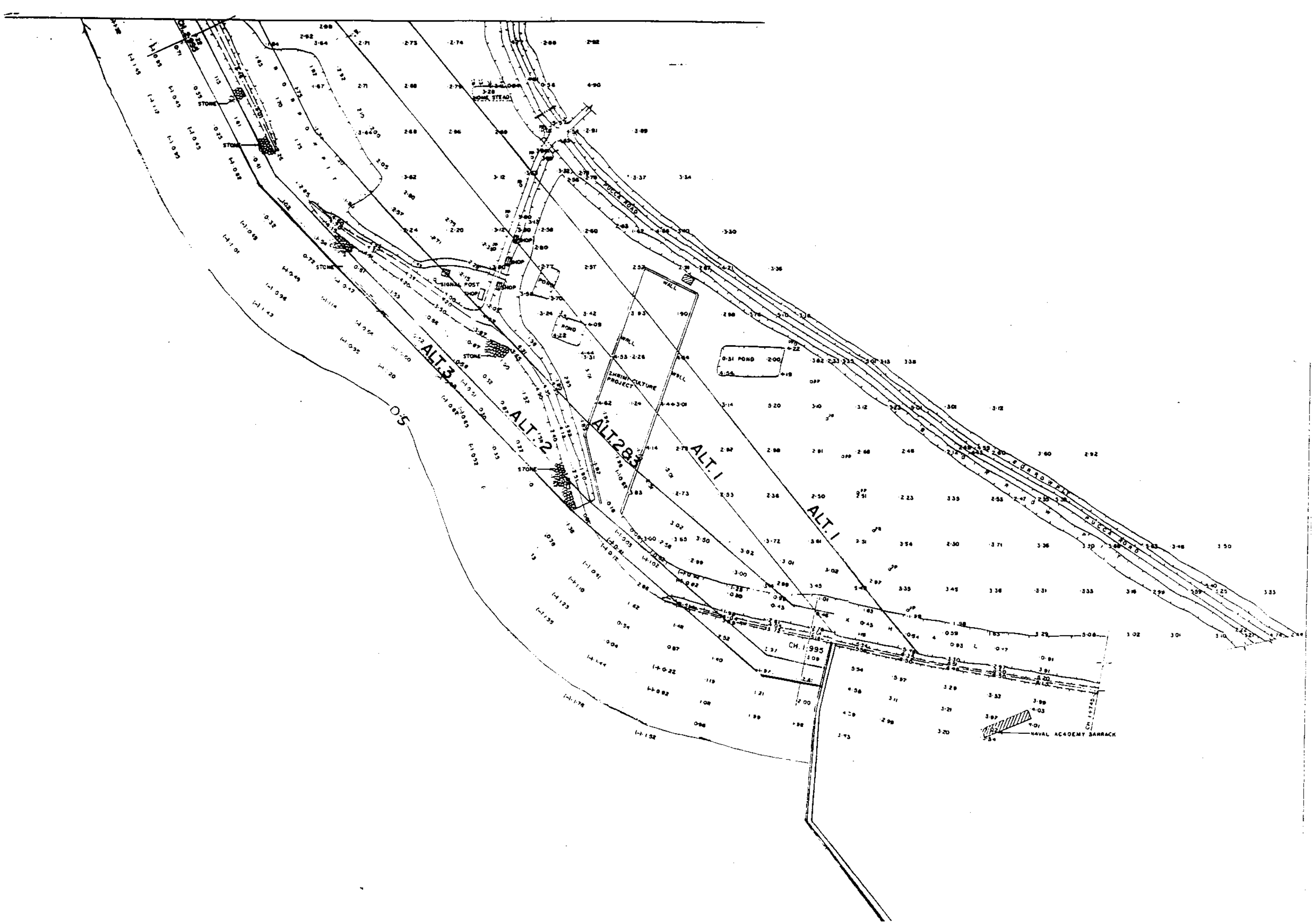
POLDER 62 PATENGA

Design: | Recomm: | Appd.

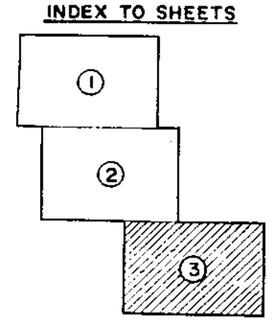
DATE :

SCALE :

DRAWING NO. : 1



INDEX TO SHEETS

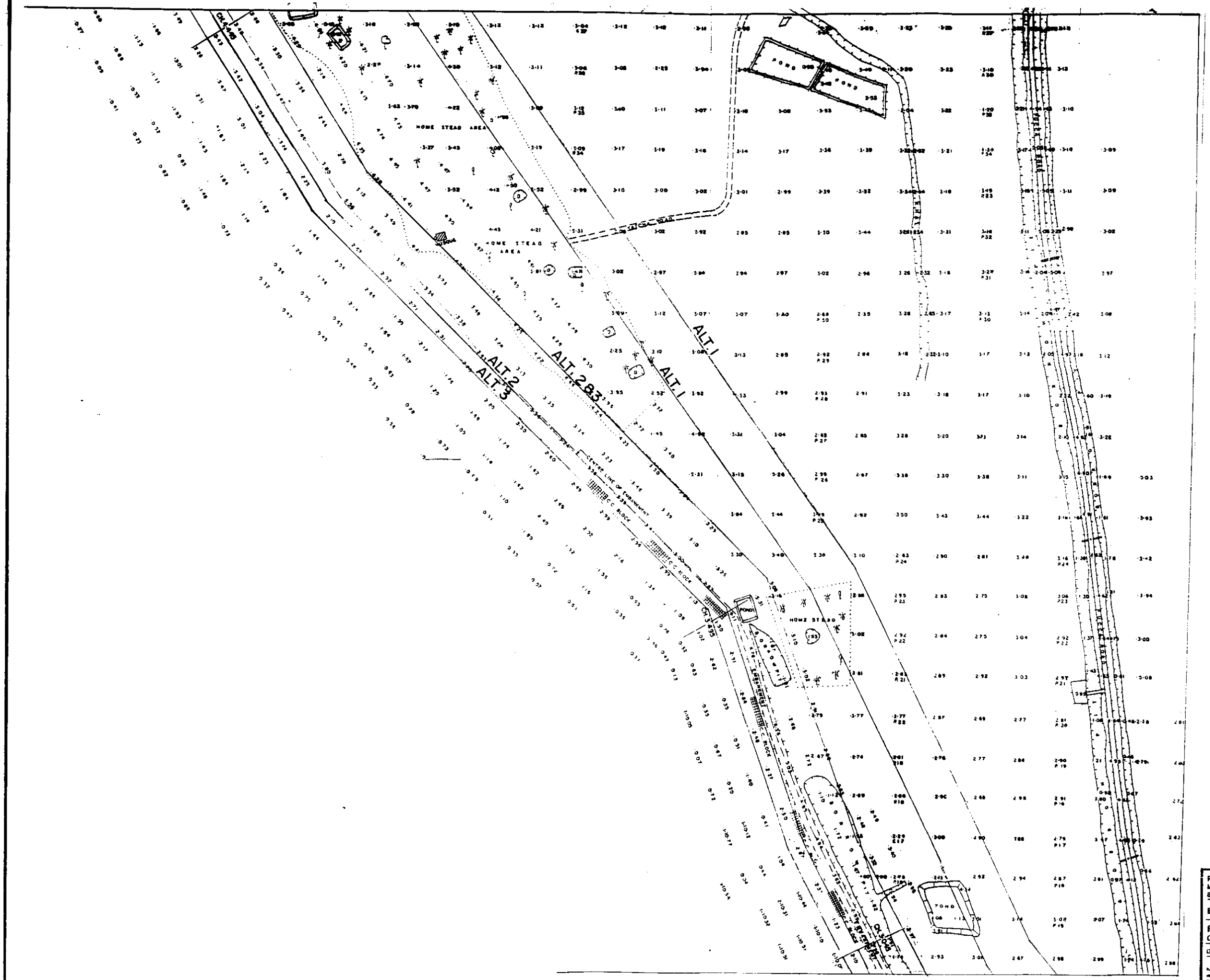


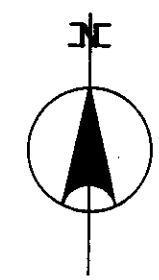
METRE 50 0 50 100 METRE

SCALE

PEOPLE'S REPUBLIC OF BANGLADESH MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL BANGLADESH WATER DEVELOPMENT BOARD			
EMERGENCY CYCLONE PROTECTION PROJECT			
PLAN CHAINAGE 1.75–3.0			POLDER 62 PATENGA
Design:	Recomm.:	Appr.:	DATE : 30-10-1991
KAMPSAX INTERNATIONAL A/S, SOGEOM and DANISH HYDRAULIC INSTITUTE in association with DEVELOPMENT DESIGN CONSULTANTS LTD			SCALE :
			DRAWING NO. : 2

82





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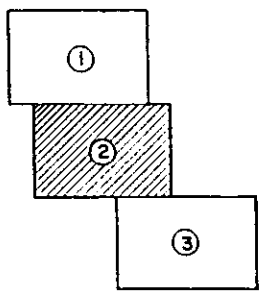


METRE 50 0 50 100 METRE

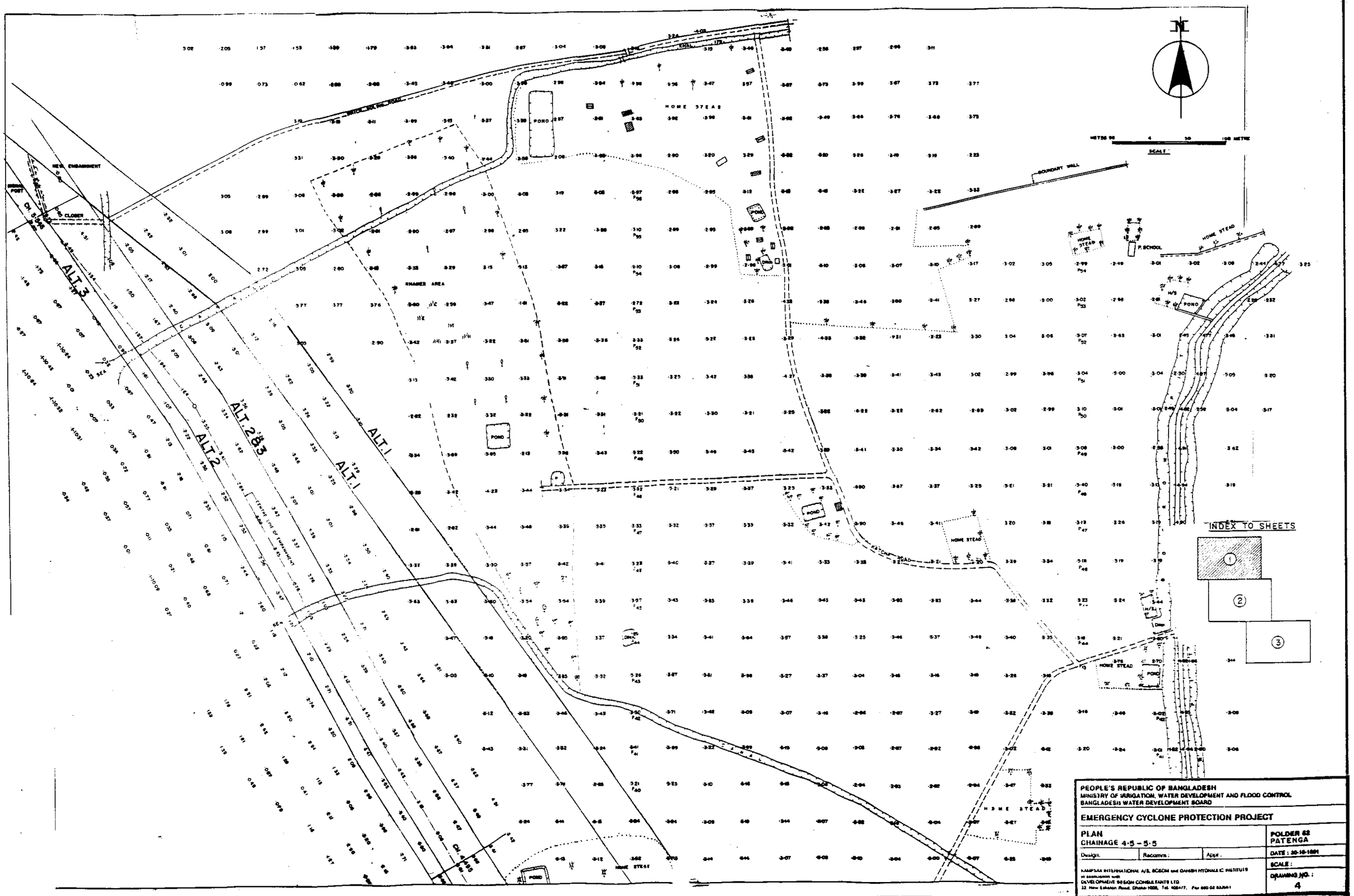
SCALE

PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

EMERGENCY CYCLONE PROTECTION PROJECT

PLAN CHAINAGE 3·0 – 4·5	POLDER 62 PATENGA
Design: Recomm: Appr.	DATE : 30-10-1991
	SCALE :
	DRAWING NO. : 3

HAMPSAR INTERNATIONAL A/S, BCEOM and DANISH HYDRAULIC INSTITUTE
in association with
DEVELOPMENT DESIGN CONSULTANTS LTD
23, New Eskaton Road, Dhaka-1000, Tel. 406477, Fax 880 02 833661



PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

EMERGENCY CYCLONE PROTECTION PROJECT

PLAN
CHAINAGE 4·5 – 5·5

POLDER 62
PATENGA

Design.	Recomm.	Appr.

DATE : 30-10-1991

SCALE :

DRAWING NO. : 4

RAMBØLL INTERNATIONAL A/S, SCECOM and DANISH HYDRAULIC INSTITUTE
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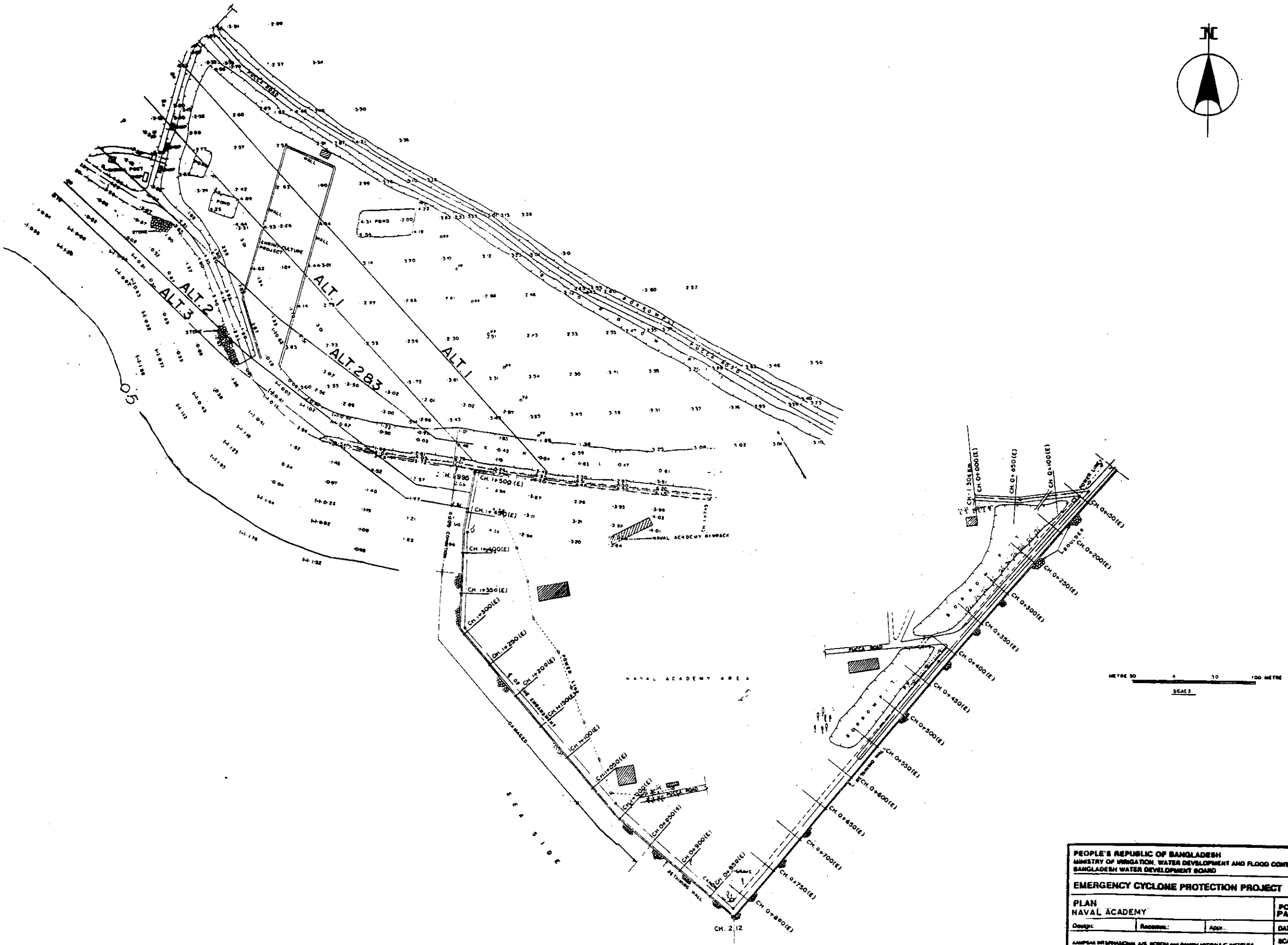
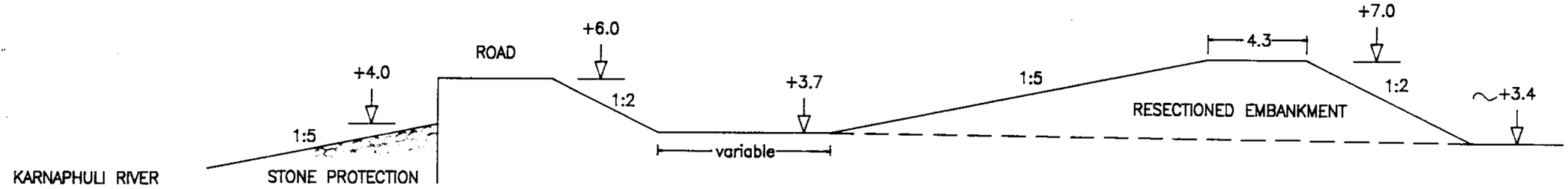
DEVELOPMENT DESIGN CONSULTANTS LTD.
33 New Eskaton Road, Dhaka-1000, Tel. 408477, Fax 880 02 832961



PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

EMERGENCY CYCLONE PROTECTION PROJECT

PLAN NAVAL ACADEMY	POLDER 62 PATENGA
Design: Recomm.: Appr..	DATE : 30-10-1991
KAMPSAX INTERNATIONAL A/S, BCEOM and DANISH HYDRAULIC INSTITUTE in association with DEVELOPMENT DESIGN CONSULTANTS LTD 33 New Eskaton Road, Dhaka-1000. Tel. 408477. Fax 880 02 834441	SCALE : DRAWING NO. : 5



CHAINAGE 0–1.3

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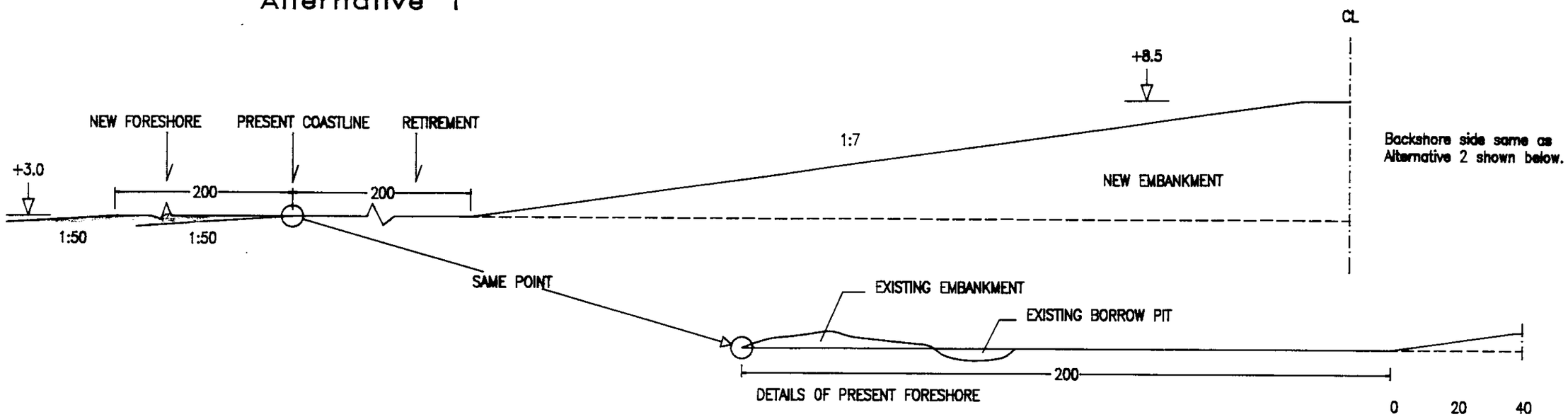
SCALE

Note: All dimensions are in meter.

CYCLONE PROTECTION PROJECT II
POLDER 62, PATENGA
1991–09–10 6

Alternative 1



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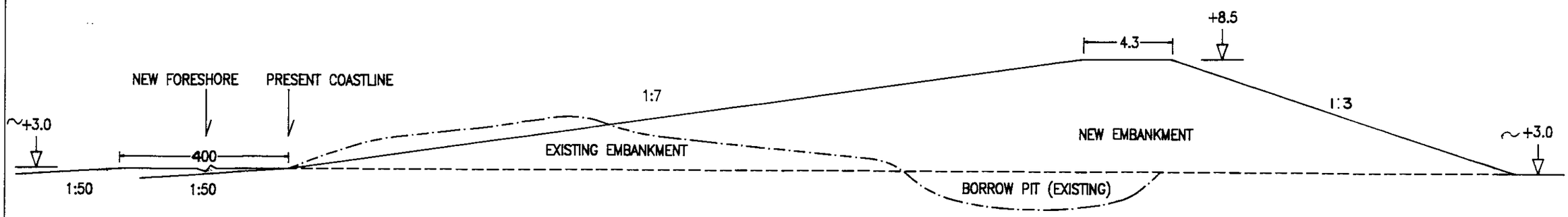
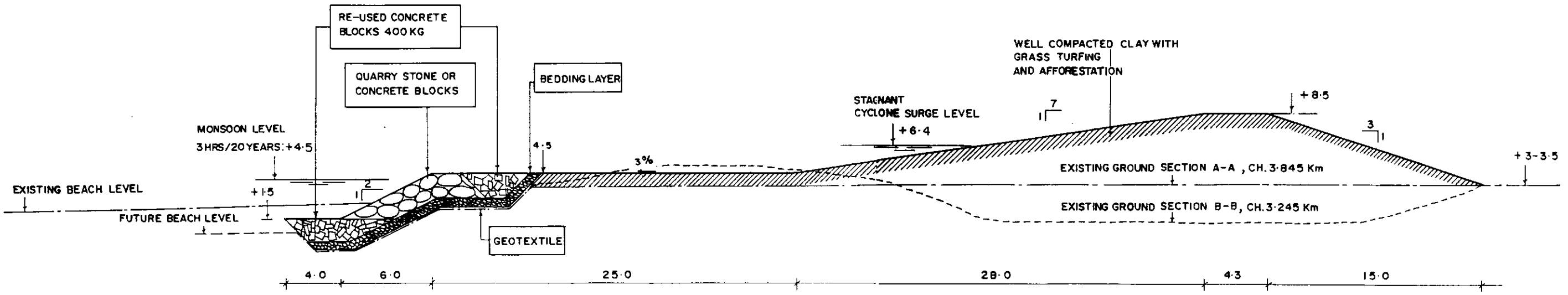


CHAINAGE 1.98-5.5

0 5 10
SCALE

Note: All dimensions are in meter.

CYCLONE PROTECTION PROJECT II
POLDER 62, PATENGA
1991-10-29



PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD

EMERGENCY CYCLONE PROTECTION PROJECT

CROSS-SECTION
CHAINAGE 1.98 - 5.5. ALT 3

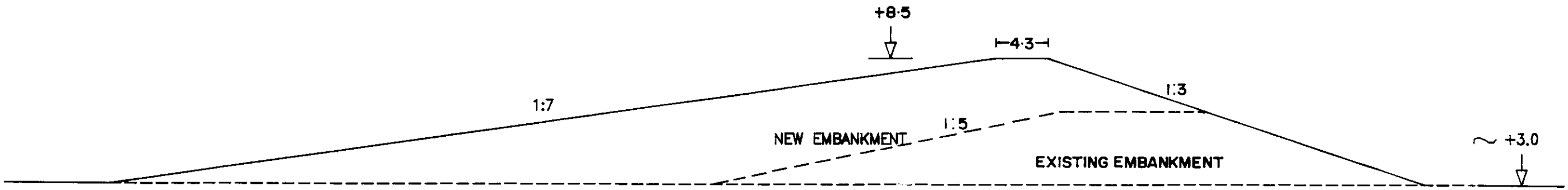
POLDER 62
PATENGA

Design: Recomm.: Appr.: DATE 30-10-1991

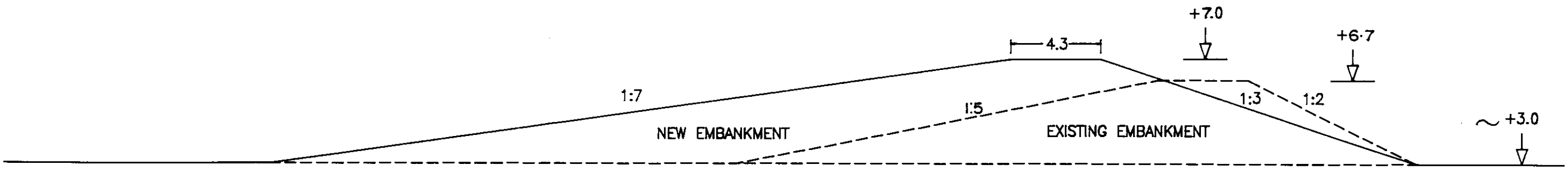
KAMPSAX INTERNATIONAL A/S. BCEOM and DANISH HYDRAULIC INSTITUTE in association with DEVELOPMENT DESIGN CONSULTANTS LTD
22 New Eskaton Road, Dhaka-1000 Tel 408477 Fax 880 02 832951

SCALE

DRAWING NO. 8



CHAINAGE 5.6–11



CHAINAGE 11–18.5

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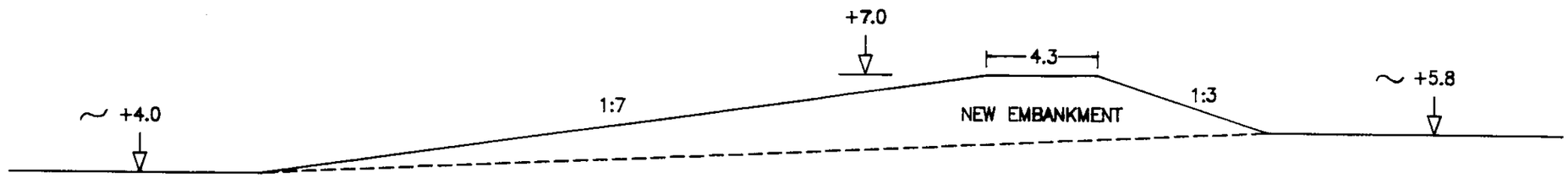
SCALE

All dimensions are in meter.

CYCLONE PROTECTION PROJECT II
POLDER 62, PATENGA
1991–09–10



CHAINAGE 18.7-22.2

0 5 10
SCALE

Note: All dimensions are in meter.

CYCLONE PROTECTION PROJECT II
POLDER 62, PATENGA
1991-10-29 10