People's Republic of Bangladesh
Ministry of Irrigation, Water Development and Flood Control

Flood Plan Coordination Organisation

JAMALPUR PRIORITY PROJECT STUDY

Caisse Francaise de Developpement
and
Commission of the European Communities

FAP 3.1

FINAL FEASIBILITY REPORT

Annex 7 Engineering

January 1993

Consortium

SOGREAH/ HALCROW/ LAHMEYER

in association with
Engineering & Planning Consultants Ltd.
AQUA Consultants and Associates Ltd.
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PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
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GLOSSARY

BADC	Bangladesh Agricultural Research Council
BRDB	Bangladesh Rural Development Board
BWDB	Bangladesh Water Development Board
CCCE	Caisse Centrale de Coopération Economique
DANIDA	Danish International Development Agency
EC	European Community
EIP	Early Implementation Programme
EIRR	Economic Internal Rate of Return
FAP	Flood Action Plan
FEC	Prefeasibility Study for Flood Control in Bangladesh 1989
FCD	Flood Control and Drainage
FCDI	Flood Control Drainage and Irrigation
FFW	Food for Work
FPCO	Flood Plan Coordination Organisation
GO	Government Organisation
GOB	Government of Bangladesh
JPP	Jamalpur Priority Project
JPPS	Jamalpur Priority Project Study
LCS	Labour Contracting Societies
LGEB	Local Government Engineering Bureau
O&M	Operation and Maintenance
PWD	Public Works Datum
MCC	Mennonite Central Committee
N/A	Not applicable
NGO	Non Government Organisation
RESP	Rural Employment Sector Programme
RHD	Roads and Highways Department
RDRS	Rangpur Dinajpur Rural Services
SCI	Service Civil International
SPT	Standard Penetration Test
USCS	United States Classification System

SUMMARY

Physical Features and Present Situation

The general pattern of the topography of the project area is V shaped from east to west with Madardhaw river (or Dadbanga khal) as central, north to south drainage axis. A general gradient from north to south from elevations of 19.8m to 13.7m can be observed. The natural drainage of the area is complex. It was assessed from the study of air photographs and the existing 4" to 1 mile topographical maps, and from site visits. The Madardhaw river, Chatal river and the Jhenai river form the main drainage network of the project area and are fed by numbers of secondary drains which are actually meandering former river beds. At field level, the present drainage pattern is governed by existing bunds around paddy fields and by embankments for roads and flood protection. At field level there are no drainage channels as such and excess water is drained from each paddy field to the next before reach the drains, when base water levels in low-lying areas permit it. The highly uneven topography related to depressions (beels) and former river bank levels adds to the complexity of the present drainage pattern and shows that drainage improvements in the project area will rely more on local structural measures than on structural measures at project level.

Embankments have been constructed in the project area either for providing a dry communication network (roads and railways) or for providing flood protection to agricultural land during the monsoon season.

The main embankments are the railway line from Jamalpur to Bahadurabad, the railway line from Jamalpur to Jagannathganj and the breached flood protection embankment along the Jamuna river from Bahadurabad to Jagannathganj. Other major embankments for roads between eastern and western parts and for internal river flood protection can be found within the project area. In 1988 all embankments were either breached or overtopped, thus highlighting the weakness of the embankment system during major flood events.

Possible Land and Water Development Options

During the progress of the study, four development options were defined and compared.

Option A Flood proofing and drainage improvement for the whole project area.

Option B Controlled flooding and drainage improvements for the mainland project area, and flood proofing for the remaining area outside flood protection embankments.

Option C Controlled flooding for part of the project area (East of Chatal). Flood proofing outside flood protection embankments and drainage improvement for the whole mainland area.

Option D Full scale polderisation and drainage improvements for the whole mainland project area.

Flood proofing intends to provide small scale structural measures with the ultimate objective of reducing flood losses in areas not protected by embankments, mainly the active flood plain area.

Drainage improvements intend to provide structures and channels for an accelerated release of excess water due to river flooding and rainfall with the ultimate objective of increasing cropping periods.

Controlled flooding intends to provide embankments and hydraulic structures with the final objective of admitting controlled flows within the project area, thus preventing excessive rise of water levels during inundations.

Full scale polderisation intends to provide full flood protection of the project area with the final objective of preventing inundation of the area.

At the Interim Planning Report (R2) stage, Option D was discarded on account of the severe disbenefits which would result from the exclusion of all river flood water from the area i.e. prevention of the recruitment of fish and prevention of the necessary river flooding of agricultural land, as required by the farmers.

At Interim Report (R3) stage, the economic comparison showed that option C was unattractive due to a low rate of return resulting from infrastructure provided for the protection of a marginally flood affected area.

Option A and B showed better results and it was therefore agreed that option A and B being the more promising options should be selected for further analysis at feasibility level, treating the flood proofing Project as a separate Project not included in Option B economic analysis (except for the mitigation costs for the confinement of the Jamuna).

Description of Components of the Selected Options

Flood Proofing Measures (Seperate project and Options A)

With the expected rise in river water levels due to existing embankments (right bank, Bhuapur), Jamuna Bridge construction and the future FAP development proposals, the entire population living in island chars, attached chars and set back land would be subject to an increase flood risk.

As a result, mitigation measures have to be provided with the ultimate objective of eliminating incremental damages caused by increased flooding. However, it is not easy to identify the impact of FAP 3.1 development proposal separately from Jamuna Bridge, other FAPs and existing embankment. A tentative figure would be 0.30 m water level increase due to the confinement of the Jamuna during extreme floods. Under FAP 3.1 economic analysis, only half the incremental cost attributed to the Jamuna confinement will be taken into account, the other half being allocated to the Jamuna Right Bank embankment. Nevertheless, the flood proofing programme is proposed for implementation and the corresponding cost is provided.

From a socio-economic point of view, the development to be made under FAP 3.1 would contribute to generating incremental economic and social benefits in the protected land. The living conditions of the Char and Set-back land inhabitants would at best remain the same as before and the equity gap between the population of the unprotected land and of the protected land would further increase.

Therefore, the proposed approach, as established during the Char Study (Annex 9), calls for designing a comprehensive flood proofing programme with the following objectives:

- to save human lives
- to protect houses and households amenities (water supply and sanitation system)
- to protect livestock and poultry
- to protect and develop community infrastructures
- to support the diversification and strengthening of economic livelihood through agriculture production programs and income generation schemes

To meet these objectives, the project has five components:

- Minor Structural Flood Proofing
- Community Infrastructure Development
- NGO Support
- Institutional Support
- Technical Assistance

Detailed Features of Flood Proofing Project Components

i) Minor Structural Flood Proofing

Minor structural flood proofing consists of strategies adopted on individual household basis.

The findings of the study have shown that housing units in Char land are usually temporary facilities because they have to be frequently shifted due to flooding and erosion. The perceptions of Char land people indicate a strong demand for improved and more permanent settlement. This underlines the need for a housing program aiming at:

- providing flood proofed housing facilities to the most vulnerable sections of the population such as the homeless, the landless and the marginal landowners (below 0.1 ha). It is estimated that around 50% of the households (about 35,000) could be eligible under this program. The project will support the construction of "flood free" houses by providing building materials

- providing earth filling to raise houses of the remaining 50% of the population

ii) Community Infrastructure Development

The project would provide financial support to investment in community infrastructure development in the project area. In this respect, 250 micro-projects will be financed throughout the project area (1 micro-project for 250 to 300 households). In order to be eligible under this component an infrastructure micro project should be designed so as to:

- develop the community resource base to provide additional and/or improved livelihood opportunities.

- cost less than Tk 1 million and be completed in less than 1 year

- be implemented through NGOs or relevant government agencies with appropriate technical capabilities

The following activities would be eligible for funding under the micro-project component:

- multi-purposes flood shelters which can also be used as schools, grain stores and community welfare centres.

- refuge areas (elevated earthen platforms)

- drinking water supply and sanitation

- minor scale irrigation/drainage facilities

- development of small roads/dykes

iii) NGO Support

The main objectives of the NGO support, to be provided through experienced NGOs, are:

- to support agriculture production programmes and income generating activities through a credit system.

- to identify, design, and implement minor structural flood proofing components (housing program)

- to participate in the identification, design and implementation of infrastructure micro projects.

- to provide social support services to the population through group formation, community development, education, health and training programmes

iv) Institutional Support

This component will support project implementation and some institutional improvements for the government organization in charge of implementing the project as required to attain sustainable development. Due to the nature of the project programme, no single ministry seems to be appropriate to be in charge of the project implementation. It is recommended that an independent body, the Charland Development Board (CDB), be established. The CDB would act as a coordinating and policy making body and would be responsible for ensuring the enforcement of its decisions by the respective central line ministries.

However, because the establishment of a new authority could take time it is recommended that this project be implemented through the institutional framework to be set up under the FAP 3.1 mainland project. A Deputy Director in charge of the project will be appointed by the Project Management Office (PMO) to be established for the FAP 3.1 main project.

v) Technical Assistance

The main objective of the proposed technical assistance (TA) is to assist in the project implementation and to prepare a comprehensive master plan for the development of Char land. For this purpose, the TA will carry out specific studies and will make a full use of all the information collected by the other FAP studies as well as of the experience gained from the implementation of the first phase of the project.

vi) Project Phasing

Because flood proofing experience is rather limited in scale, and the concerned population is rather large (602 000 people) the project should be implemented in a phased manner. As a result, the project has two different phases, a pilot phase of three years and a main phase of five years or more, depending on the experimental and findings of the pilot phase.

vii) Flood Proofing Costs

The estimated base cost of the flood proofing project, is Tk 1460.6 million excluding physical and price contingencies. The cost of the pilot phase is about Tk 128.0 million while the cost of the main phase is about Tk 1169.1 million. The NGO support, which is also expected to contribute significantly to improving the socio-economic status of the population, accounts for Tk 152.1 million, including 44.6 for the pilot phase. The Technical Assistance which will operate in close cordination with the Mainland Engineering team accounts for Tk 25.5 million including Tk 10.9 million for the pilot phase.

The mitigation cost attributed to the JPP implementation and to be considered for the Mainland project economic analysis is Tk 31.2 million (Option B).

viii) Benefits and Justification

The major benefits of the flood proofing project would be the reduction of livelihood loss due to flood damages for about 114,000 households.

In addition, the population is expected to benefit from the agriculture production programs and income generation activities to be supported by NGOs. Household incomes are likely to rise and the sources of economic livelihood are expected to be more diversified and thereby less subject to flood risk.

Moreover, a wide range of social benefits for the poorest households which are not immediately measurable, are likely to be generated by the project:

- the reduction of flood impact on their livelihood
- the improvement of their nutritional standards and health status
- a raised awareness and self-reliance and an improved level of education of the poorest strata of the population of the project area

Drainage improvement (Options A and B)

Introduction

Waterlogging is a major problem cited by the farmers in the project area requiring accelerated surface water drainage by local measures in the following areas:

- major natural depressions with central beels or group of beels;
- minor natural depressions which remain waterlogged late into the post monsoon season;
- minor water bodies created by man made obstacles (eg roads) with deficient cross drainage.

As regards the main drainage system i.e. Chatal, Jhenai and Madardhaw rivers, it appears that training works are not required. As assessed from site investigations and the operation of the model they are deep enough to convey excess water, and their drainage limitations result from backwater effects caused by high flood water levels in the Jamuna.

The physical requirements for drainage improvement are related to micro-topography and, in the absence of detailed topographical surveys and detailed field enquiries, an estimate of the quantity of work required has been based on:

- analysis of the 4" to 1 mile 1963 maps for the major depressions and individual beels (total number 97);
- reasonable assumptions for minor water bodies not visible on the previous document (total number 300).

Typical arrangements will be as follows:

- for major depressions: channel excavation, gated control structures to regulate minimum water level in beels;
- for minor depressions and other water bodies : channel excavation and culverts.

Provision for the rehabilitation of cross drainage structures on existing main road embankments were considered (90 structures). To address the problems of local participation in the drainage improvement and to refine the design process, it is recommended that a 5000 ha pilot drainage project should be selected and surveyed during the detailed design phase.

The total capital cost for the drainage component is Tk 41.2 million.

Flood Protection Embankments (Option B)

Embankment Alignments

Severe flooding of the Jamalpur area in the recent years indicates a need for flood protection. Option B includes embankments with intake structures for controlled flooding and drainage outlet structures along the boundaries of the Jamalpur area to achieve a sustained development of the regional economy, to prevent loss of life and property, and to reduce damage to railways and roads.

For Option B the following main protection embankments have been considered:

- embankment 1: along the left bank of the Jamuna River at the western boundary of the area between Dewanganj/Bahadurabad in the north and Sarishabari in the south with a length of 73,859 m,

- embankment 2: along the right bank of the Old Brahmaputra at the eastern boundary of the area between Dewanganj in the north and Jamalpur in the south, with a length of 43,170 m,

- embankment 3: on the southern boundary along the railway line between Jamalpur and Sarishabari with a length of 27,239 m,

- embankment 4a: along the left bank of Chatal River from Sarishabari to Jagannathganj Ghat/Dayalpur Fertilizer Factory with a length of 8,240 m

- embankment 4b: along the railway line from Sarishabari to the Dayalpur Fertilizer Factory with a length of 8,240 m.

Alternative heights of embankments were considered in connection with flood protection level i.e. 1 to 100, 1 to 50 and 1 to 20 years return periods. The designation of the alternatives was respectively B5, B4, B3 and B5 was found to be the alternative proving the best return in economic terms.

The selected Option B5 contains embankment 1, embankment 2 and embankment 4a, considering that the area south of JPP (PU2) will be protected against flooding by embankments simultaneously with the protection of JPP. Embankment 4a will connect the Jamuna embankment with any embankment of PU2 area.

If protection embankments of PU2 south of the project area are not constructed in due time then embankments 3 and 4b would have to be considered in order to protect the project area against flooding from the south. In this respect it will be necessary to assess in detail with FINMAP topographic maps, further analysis of flood water levels determined by FAP 25 and further modelling, the exact extent of the embankments required in order to ensure adequate protection for the FAP 3.1 area in the absence of the assumed developments within the PU2 area.

The siting of the flood protection embankments is planned to protect a maximum percentage of the population, agricultural land, villages, railway lines and major access roads from destructive floods. Nevertheless, the alignment will make use of existing embankment alignments at the banks of the rivers, access roads and the railway lines in order to reduce problems related to land acquisition.

The selection of the alignments for the protection embankments was based on an interpretation of the latest spot image satellite maps of the area which show clearly existing embankments and access roads and the actual river channels. The alignments selected by the study of the maps were verified by a detailed field inspection.

The location of the embankment alignments is shown in Figure 7.2.1 and on Drawing 4.

Numerous embankments constructed by various agencies exist on the proposed Old Brahmaputra and Jamuna embankment alignments. These existing embankments were inspected and evaluated in detail to determine their adequacy for incorporation into the proposed embankments. Because of their poor quality and their actual condition the existing embankments are not adequate to be used as an integrated part of the new protection embankments. None of them which are located on the alignment of the proposed protection embankments can be used without reconstruction. Therefore, it is recommended to excavate the existing embankments and to reuse the material in the construction of the new protection embankments. If new embankments (embankments 3 and 4b) along the railway embankment between Jamalpur and Dayalpur are required, the new embankments will be located at the southern toe of the existing railway embankment in order not to interrupt the railway traffic during construction. The railway embankment will provide support to the new embankments.

Embankment Foundation

i) Foundation Conditions

An extensive field and laboratory investigation programme was carried out during the FAP 3.1 study and reported in the Geotechnical Investigation and Topographic Survey Report (R4).

The foundation conditions in the project area are governed by holocene river and flood plain deposits which overlie the pleistocene clay formation of the Madhupur Block. The foundation of the embankment alignments will be predominantly fine grained alluvial soils. The clay formation forms the foundation only at a few isolated areas like the area between Jamalpur and Jhenai River and the area around and north of Bahadurabad.

Considering the ever changing erosion and deposition regime of the river in the area, the alluvial deposits of the flood plain are relatively complex. It is, therefore, difficult to classify foundation materials into distinct and identifiable units. There are some transitional zones but mostly the changes are relatively abrupt representing changes in sediment load of the stream or interruptions in depositional process. The foundation conditions vary from place to place.

ii) Foundation Design Parameters

The geotechnical foundation design parameters of the alluvial material can be summarized as follows: the alluvial soils are poorly graded silty fine sand to sandy silt. There is an indication from the boreholes that in general coarsening of grain sizes appears with depth from silty material (ML to CL) to silty sand (SM) and poorly graded or single sized fine sand (SP).

The distribution of plasticity values for the foundation soils indicates a material of intermediate plasticity.

Standard Penetration Tests and in situ density tests show that the alluvial soils have low in situ density with a relative density far below 85 % (liquefaction potential) down to a depth of about 10 m.

The Madhupur clay is a soft to stiff silty clay with intermediate to high plasticity. There are some lenses of weathered ferruginous fine gravel-sized nodules and mica-rich fine to medium sand.

iii) Groundwater

The groundwater table in the project area is generally shallow, even in the dry season, and is in the range between 1 and 4.5 m below surface. The level depends upon the ground elevation and the level of neighbouring rivers.

The permeability of the foundation soil has been determined in boreholes by constant head tests. The coefficient of permeability is on an average between

10^{-6} to 10^{-7} m/s. The permeability of the sandy soil (SM-SP) increases to 10^{-5} m/s and of clayey soil decreases to less than 10^{-8} m/s.

The groundwater quality in the project area is totally devoid of industrial pollutants, is not critical in the context of embankment construction and is not likely to have any deleterious effects on reinforced concrete used in hydraulic structures or on piled foundations.

Construction Materials

For economic reasons it is envisaged that construction materials for the embankments will be taken from borrow areas which are located close to the embankment alignments. After exploitation of the 2 to 3 m deep borrow areas they will be reclaimed to be used as paddy fields or fish ponds in order not to loose the land for production.

In general, the construction material to be taken from the alluvial deposits in the likely borrow areas is a silty sand to sandy silt (ML to MI material) with relatively constant index properties. Below a depth of about 2 m the construction material changes into sandy material (SP). In areas with Madhuru clay, the construction material is a clayey silt with an average clay content between 6 to 20 %.

Embankment Design

Taking into account the expected properties of the construction materials found close to the embankment as well as the foundation conditions, the embankment design incorporates adequate side slopes and crest width to provide sufficient stability against both normal and extreme loading by high water level on the river and country sides of the embankment, seepage water forces, seismic loading and possible traffic on the crest.

The protection embankments on the different alignments have been designed as homogeneous embankments using sandy to silty sandy alluvial material from nearby borrow areas. According to the predominantly available sandy-silty construction materials, which governs the choice of embankment side slopes, the upstream (river side) slope is to be inclined at a slope 1v:3h and the downstream (country side) at a slope of slope 1v:2h. No special sealing of the embankments will be required since the purpose of the embankments will not be storage of water but protection against flooding over relatively short periods. Therefore homogeneous embankments have been designed.

The design flood level is 1/100 years return period, which is equal to the 1988 flood level plus 0.40 m for the Jamuna embankment and the Sarishabari/Fertilizer Factory embankment. For the Old Brahmaputra embankment, the design flood is 1/50 years return period. A normal, yearly average flood level of about 1.50 m below the 1988 flood level was considered in the design. The design tailwater due to controlled flooding was assumed to be 1 m above foundation level.

The crest level is determined by the freeboard above the maximum design flood level. For the embankments along the Jamuna River with expected large wave run-up due to a large fetch a freeboard of 1.50 m was chosen. For the embankments along the Old Brahmaputra River and along the southern railway line - if needed - a freeboard of 1.10 m was chosen.

The height of the embankments varies from place to place along the alignments in accordance with the foundation elevation, the design flood level and the selected freeboard as described above. The heights of the embankments along the alignments can be seen in the Drawings 16.2 to 16.6 which show the crest level of the embankment, the foundation level, the 88 flood level and the level of existing embankments. The average height of the embankments is substantially less than was assumed in the Interim Report for preliminary costing.

The proposed embankment along the Old Brahmaputra has an average height of 3.50 m with a minimum height of 0.95 m near to Islampur and a maximum height of 6.80 m at the Jhenai River crossing. The average height of the embankment along the Jamuna is 4.90 m with a minimum height of 2.50 m north of Diwanganj and a maximum height of 7.50 m south of Madarganj. The embankment along the southern railway line, if needed, will have an average height of 3.70 m with a minimum height of 2.60 m and a maximum height of 4.85 m.

Two different embankment designs are proposed to be used according to the required height of the embankments:

i) Embankment Alternative 1 (see Drawing 16.8)

Alternative 1 embankments have been designed for situations where the difference between the foundation level and the 100 year flood level is less than 4.00 m. These embankments will therefore have a height of less than 5.10 m where the freeboard is 1.10 m or of less than 5.50 m where the freeboard is 1.50m. Regular yearly inundation during the monsoon season will usually be less than 2 m above the upstream (river side) embankment toe. About 87 % of the embankment length will be constructed according to alternative 1 design.

For the Alternative 1 embankments the upstream (river side) and downstream (country side) slope will be protected only by turfing. Neither a key trench at the upstream toe to extend the seepage path beneath the embankment and to provide protection against scouring nor a drainage layer at the downstream toe will be provided.

ii) Embankment Alternative 2 (see Drawing 16.9/16.10)

Alternative 2 embankments will be constructed where the difference between the foundation level and the design flood level is more than 4.00 m. These embankments will be higher than 5.10 m where the freeboard is 1.10 m and of more than 5.50 m where the freeboard is

1.50 m. It is estimated that only be approximately 13 % of the embankment length will be constructed according to alternative 2 design.

For alternative 2 type embankment only the downstream (country side) slope is turfed. The upstream (river side) slope is to be protected by a 15 cm thick layer of interlocking concrete blocks. The blocks will be placed on top of a filter layer in order to prevent erosion and scouring beneath the blocks and to avoid washing out of embankment fill material during the draw down of flood water on the upstream (river side) face of the embankment. Because of the lack of natural filter material in the vicinity of the embankment alignments, a geotextile filter is to be installed. The geotextile will be anchored into the embankment fill.

At the upstream (river side) embankment toe a key trench with a depth of half the embankment height is to be excavated and backfilled with compacted fill material. The purpose of the key trench is to provide a protection against scouring at the toe and to extend the seepage path beneath the embankment. The key trench material will be surrounded by a geotextile anchored into the embankment. The geotextile will prevent erosion of the key trench fill material in case of scouring at the embankment toe. In case of scouring beneath the key trench the sausage like key trench fill with geotextile would be displaced as a whole into the scoured hole and would help reduce further scouring.

A drainage layer under the downstream (country side) toe of the embankment will be installed in order to guarantee controlled drainage when seepage through the embankment occurs in the yearly flood season. Missing granular drainage material has been substituted by a geodrain (highly permeable geogrid with geotextile filter on both sides). A horizontal length of the geodrain of at least half of the embankment height is required in accordance with stability calculations. To allow free drainage of the geodrain, it is covered by a brick layer with openings (weep holes).

For the Jamuna and Sarishabari/Fertilizer Factory embankments, the crest of both embankment alternatives will have standard width of 7 m. A 3.5 m wide sand-gravel maintenance track is foreseen and considered in the cost estimates. For the Old Brahmaputra embankment, the crest width is 4.5 m with a 3.5 m sand-gravel maintenance track. Any further upgrading to public road is not included in the cost estimates.

A detailed quantity estimate was done based on the actual ground levels along the alignments and the resulting individual embankment heights. The total fill volume was estimated to be about 9 million m^3 for recommended Option. The total costs for this option are estimated to be about Tk 472.7 million, based on individual unit prices (1991 price level) for the different construction materials within the embankment and crest track.

Hydraulic Structures (Option B)

Two types of hydraulic structures have to be constructed under the project.

- Major hydraulic structures to control large discharges on main rivers at the boundaries of the project area

- Minor hydraulic structures along the embankments to maintain and control the present flood pattern and drainage pattern at the boundaries of the project area. 55 flushing structures, with 2 m^3/sec nominal discharge have been proposed.

Major hydraulic structures are as follows:

- S1 Islampur Inlet (1 vent) .... 15 m^3/sec
- S2 Jhenai Inlet (7 vents) .... 115 m^3/sec
- S3 Bausi Bridge outlet (3 Vents) .... 50 m^3/sec
- S4 Jhenai/Chatal outlet (25 vents) .... 400 m^3/sec
- S5 Chatal Inlet (8 vents) .... 130 m^3/sec

The quoted nominal discharges under 0.25 m head, actual discharges depending on actual operating heads.

The sizes of the inlet structures have been fixed in order to match the bed capacity of the channels located downstream these structures. The sizes were then checked with the hydraulic model and the operating conditons during May/June.

Bausi bridge discharge has been fixed in order to be consistant with the NCR study findings and recommendations.

The size of the Jhenai/Chatal outlet has been justified through model simulations and the evaluation of the maximum head loss at the structure location and subsequent flooding of the area within the embankment (See Annex 4 on Modelling)

The Jhenai/Chatal outlet will include a navigation lock.

Foundation conditions at the sites of the hydraulic structures were assessed on the basis of the Geotechnical survey. All major hydraulic structures are proposed to be founded on friction piles 15m deep. All major hydraulic structures are located on straight channels reaches to reduce scour problems. Siltation may require regular dredging of these channels once the project is operational.

The total costs for the major hydraulic structures of the recommended Option, without the S3 structure, will be about Tk 292.4 million. The minor flushing structures will cost a further Tk 34.7 million, approximately.

Recommendations for Detailed Design for Embankments

The geotechnical investigations already completed for the assessment of the foundation conditions and construction material borrow areas along the proposed embankment alignments and at the locations of the hydraulic structures are considered adequate to produce the detailed design. Therefore, supplementary geotechnical investigations for the detailed design can be limited to boreholes, in situ testing and laboratory soil testing on samples from the boreholes for embankments 3 and 4b parallel to the railway Jamalpur to Sarishabari, if these embankments are required. In case of special foundation methods for the hydraulic structures additional geotechnical investigations may become necessary.

If during the detailed design phase a relocation of embankment alignments and/or hydraulic structures is required, additional borings and soil testing will become necessary at the new locations. In this case also new topographic survey would also be required for these locations.

The detailed design of the embankments will require detailed cross-sections of the embankment with reassessment of slope protection, key trench and drainage layer requirements for the various locations along the alignments, especially at river crossings and in connection with hydraulic structures.

A detailed quantity and cost estimate will be necessary based on the finally adopted detailed design of the embankments.

Recommendations for Detailed Design for structures

The sizing of the Jhenai/Chatal outlet will have to be refined with the hydraulic model. The JPPS model should be extended in order to incorporate the Jhenai river downstream the Bausi bridge outlet and the restricted discharge of 50 m^3/s at Bausi Bridge should be confirmed under the feasibility study of PU 2 of the NCR study. One finding of the JPP feasibility study is that the size of Bausi Bridge should be maximized in order to achieve maximal drainage conditions for the project area within the embankments.

Compartmentalisation

The basic concept of compartmentalisation, in engineering terms, is to delineate areas, called compartments, which are bounded by physical features, such as roads, embankments or other physical barriers. Hydraulic structures are provided to control water entering and draining from each compartment. Compartments may be considered as water management units.

The concept has yet to be developed and tested and a special pilot project (FAP 20) has been initiated to this end. FAP 20 was supposed to provide guidelines to FAP 3.1. They were not available at the time of preparation of this feasibility study.

The consideration of the compartmentalisation concept in FAP 3.1 has concentrated on application in the project area. At present, the paddy field is the basic compartment which is the basic water management unit being used by farmers. Water management at paddy field level aims at controlling flows admitted to the fields and passed to the drain (or other fields) in order to maintain the water level required for a given development stage of the crop.

Considering a group of paddy fields, limited by road or other embankments, a new level of compartmentalisation could be obtained. Peripheral control of flows could be achieved at existing culverts and bridges where control structures could be constructed.

The water management procedures for such a compartment should take into account basic aspects and objectives:

- To integrate the management of the volume of water admitted to the compartment from river and the volume of water from unforeseeable rainstorms;

- To increase the water depth in the compartment so that the flooding process from compartment to compartment can be attenuated;

- To satisfy farmer's basic requirements with respect to water levels in their fields and with respect to accelerated drainage;

- To integrate the operation of numbers of control structure in an orderly and centralised manner.

Based on the above considerations and in view of the concern expressed by FPCO in their comments on the previous reports about the possible divergence of approach to compartmentalisation between FAP 3.1 and FAP 20 and the statement therein that "compartmentalisation should not be considered as essential", the strategy for JPPS must be very carefully considered indeed.

FAP 20's production of "tentative guidelines" is expected for the end of 1992 but this is too late for FAP 3.1 to carry out a detailed feasibility study of compartmentalisation of the area before the completion date for JPPS.

It is pointed out in the FAP 20 Inception Report that the "bottom-up" approach, fundamental to compartmentalisation, needs to be flexible and requires a long time for development.

The above observations point very strongly to the adoption of a staged introduction of compartmentalisation to the FAP 3.1 area. At this stage consideration could be given to providing minor water control structures, improving road and other embankments and cross-drainage structures along the existing main compartment boundaries.

Compartmentalisation measures to be considered under this Study are therefore:

- improved drainage; with due consideration of fishing activities in beel areas
- improved compartment boundaries;
- improved cross-drainage structures at compartment boundaries;
- retention of water in the river beds to increase fish production.

The next stage would follow if it is established that improved water management at a wider scale is technically feasible and economically viable and when definitive guidelines became available from FAP 20.

Operation and Maintenance (O&M)

O&M of the FCDI project under the Flood Action Plan is covered by FAP 13, which provides guidance to all new projects under the Flood Action Plan.

BWDB has the ownership of all FCDI projects and is responsible of their O&M. There is an old plan to transfer O&M activities to LGEB, but it has not been implemented so far. Projects examined under FAP 13 have major O&M problems.

It appears that the main FCDI O&M problems result from conflicting interests among the concerned population (some people gain and others lose) and this is hardly taken into account in project planning, design and implementation. The main conflicts are related to decisions about the operation of control structures, to the difficult integration of the needs of farmers and fisherman and to the change of established flow patterns inside and outside project areas, after the construction of the infrastructure (with resulting "public cuts").

Institutional performance is poor due to a lack of any effective organisations which would be in a position to arbitrate between conflicting interests with public participation and due to a lack of skilled personnel. Lack of funds is a major constraint on O&M activities. In effect, with the exception of irrigation charges, BWDB is not entitled to raise revenue directly.

To achieve the long term sustainability of the project, the infrastructure need to be operated and maintained in a way which will maximise the benefits for all the social groups concerned, which requires the combined efforts of local officials, NGO's and the local population.

As a result of this assessment the GOB should determine the overall policy to be applied. The O&M phase of a project presents three contrasting major alternative possibilities for organisational institutions:

- the present practice with BWDB assuming all major O&M responsibility and expenditure.

- the creation of a specific "Project Authority" which will assume a multidisciplinary role in the O&M of the project.

- the passing of the O&M responsibilities to local Authorities and Users Associations.

Under present policies, it is recommended that BWDB should assume responsibility for O&M with specific arrangements to mitigate the outlined short-comings which are due to the fact that BWDB's main skills are in engineering. To introduce a suitable multidisciplinary role of the Project O/M organisation, taking into account the existing organisation of the Government sectors, it is necessary that all relevant Ministries - Ministry of Fisheries and Livestock, Ministry of Agriculture - depute to the Project O&M (under BWDB and hence the Ministry of Irrigation, Water Development and Flood Control) organisation the staff required for an integrated multidisciplinary O&M organisation. Administratively and financially, these deputed staff would remain under the direct responsibility of their own Ministries.

To introduce the local participation into the O&M process, - participation of Local Authorities and of the beneficiaries - the public participation proposed at design stage should be further built into the operation and maintenance stage. Structure committees and embankment committees should be set up and should bear responsibilities for O&M activities under the supervision of the Project O&M organisation.

A tentative annual budget for O&M has been worked out. It represents about 4% of the total project capital cost.

Implementation

General

The recommended development for JPP is very complex and, because these recommendations have been made in advance of the preparation of positive guidelines by the other relevant FAP studies, the implementation programme must take into account the necessity of proving some of these solutions and of getting them accepted by the people most concerned. For this reason a phased development with pilot projects implemented as early as possible in the programme, is strongly recommended.

Programme

With the detailed design phase due to start in 1993, the first year of project implementation would be 1994, although it should be possible to start work on flood proofing project and Fisheries project at the end of the 1993 monsoon, since extensive design work is not required.

Two development phases are recommended possibly overlapping to a certain degree:

i) Phase 1

In the first year of Phase 1, i.e. January 1994, construction would start on the section of the Jamuna embankment from Bahadurabad to the Chatal inlet and the embankments to protect Dewanganj, Islampur and Jamalpur. The drainage pilot project should be completed during 1994, and the pilot flood proofing project and the fisheries project should be initiated.

Immediately after the 1994 monsoon, the full programme of drainage improvements would start based on the initial findings of the drainage pilot area, divided into contracts for beel drainage, improvement of drainage channels and construction of drainage structures. Construction of the Jamuna embankment between the Chatal inlet and Madarganj would commence, also the construction of flushing sluices in completed sections of embankments, and all inlet and outlet structures. The flood proofing pilot project and the fisheries project should proceed beyond the end of 1994.

ii) Phase 2

This phase would involve the construction of the old Brahmaputra embankment from Dewanganj to Jamalpur and the embankment from Sarishabari to the Fertilizer factory. The southern part of the Old Brahmaputra embankment and the enclosure of the Jhenai inlet should be completed by the time that the Jamuna embankment is completed so that the main inflows into the project area are controlled.

An outline programme for these works is given in Figure 7.7.1.

Institutional Arrangements (See Figures 7.4.1 & 7.4.2)

It is consultants opinion in the context of Bangladesh and following discussions with FPCO and other bodies, that the future of projects for the time being will have to be through traditional implementation agencies such as the BWDB.

As a result the only changes should be made for FAP 3.1 should be improvements of the present system rather than the introduction of major new implementation bodies which would compete with the existing ones for scarce, suitably qualified, human resources.

However, it is recommended that an element of the "Project Authority" idea should be adopted within the existing framework of the BWDB so as to introduce the multidisciplinary factors into the project. To this end it is recommended that a Project Steering Committee should be formed to sit quarterly to review and monitor the project progress and to take decisions on policy and financial matters.

For the actual implementation of the project a Project Management Organisation should be formed under a Project Management Officer drawn from BWDB. This organisation should be supported and assisted by a consultancy which would be responsible for the technical design, research and construction supervision.

Summary of Cost Estimates

The Summary of Cost Estimates for the recommended developments is given in Table 7.S.1.

Table 7.S.1 Summary of Cost Estimates Recommended Developments Expressed in 1991 Taka (Financial)

	Mainland Option B5	Char and Setback Land Pilot Phase	Total Initial Investment	Char and Setback Land Main Phase	Overall Investment
Drainage Improvements	41,223,000	-	41,223,000	-	41,223,000
Flood Proofing					
Community Infrastructure	-	25,000,000	25,000,000	175,000,000	200,000,000
Minor Structural Flood Proofing	-	47,500,000	47,500,000	1,035,500,000	1,083,000,000
Sub-total	-	72,500,000	72,500,000	1,210,500,000	1,283,000,000
Embankments (Base Case)	472,756,000	-	472,756,000	-	472,756,000
Hydraulic Structures	327,053,000	-	327,053,000	-	327,053,000
Fisheries Programme	59,000,000	-	59,000,000	-	59,000,000
Land Acquisition	114,660,000	-	114,660,000	-	114,660,000
Total Capital Costs	1,014,692,000	72,500,000	1,087,192,000	1,332,625,000	2,419,817,000
Less loans	-	(7,500,000)	(7,500,000)	(163,500,000)	(171,000,000)
Net Capital Costs	1,014,692,000	65,000,000	1,079,692,000	1,169,125,000	2,248,817,000)
Physical Contingencies @15%	152,204,000	incl above	152,204,000	incl above	152,204,000
Engineering & Tech. Assistan	219,000,000	10,875,000	229,875,000	14,625,000	244,500,000
NGO Support Programmes	10,191,000	44,570,000	54,761,000	107,500,000	162,261,000
Estimated Grand Total (including loans)	1,396,087,000	127,945,000	1,524,032,000	1,454,750,000	2,978,782,000

The summary of cost estimates for option A and B5 are given in table 7.S.2 below. For the economic analysis of option B5, mitigation costs on account of increased water level in the Jamuna river have to be added to B5 costs, i.e. Tk 31.2 million

Table 7.S.2 Summary of Cost Estimates Development Options A and B5 Expressed in 1991 Taka (Financial)

	Option A	Option B5
Drainage Improvements		
Earthworks	6,239,000	6,239,000
New Structures	24,984,000	24,984,000
Rehabilitation of Structures	10,000,000	10,000,000
Sub-total	41,223,000	41,223,000
Flood Proofing		
House improvements for 28,800 H/H	273,600,000	-
Less loans repaid on 30% materials	(43,200,000)	-
Community Infrastructure Micro-Projects, 100 No.	50,000,000	-
Sub-total	280,400,000	-
Embankments (Base Case)		
Jamuna	-	365,326,000
Old Brahmaputra (incl. town protection)	-	86,519,000
Jamalpur - Sarishabari Rlwy	-	-
Sarishabari - Fert. Factory *	-	20,911,000
Sub-total	-	472,756,000
Hydraulic Structures		
Islampur Inlet	-	22,157,000
Jhenai Inlet	-	54,597,000
Chatal Inlet	-	51,335,000
Jhenai/Chatal Outlet	-	164,314,000
Flushing Sluices, 55No.	-	34,650,000
Sub-total	-	327,053,000
Fisheries Programme - Capital works		
Rehabilitation of Jamalpur FSMF	-	8,000,000
Check Structures	-	20,000,000
Fisheries Programme - NGO support		
Establishment costs	-	1,500,000
Staff Costs	-	13,600,000
Running costs for 7 years	-	15,900,000
Sub-total	-	59,000,000
Land Acquisition	31,948,000	114,660,000
Total Capital Costs	**396,771,000**	**1,014,692,000**
Less loans	(43,200,000)	-
Net Capital Costs	353,571,000	1,014,692,000
Physical Contingencies @ 15%	59,516,000	152,204,000
Engineering and Technical Assistan	42,300,000	219,000,000
NGO Support for Public Participation	10,191,000	10,191,000
Estimated Grand Total (including loans)	**508,778,000**	**1,396,087,000**

Cost estimates are based on BWDB rates adjusted to 1991 level, as per GPA.

It has been assessed thats rates for construction works for FCD project contracted according to local bidding procedures are in line with the rates derived from the application of the GPA.

Nevertheless, based on recent experience of construction works contracted in 1992 according to international bidding procedures, it is possible that construction costs will be higher than those derived from the application of the GPA.

An analysis of 1992 rates of recent international tenders shows that a global variation of the project capital cost could be +28%.

1 EXISTING SITUATION AND CONSTRAINTS

1.1 Introduction

As far as the engineering aspects are concerned, the description of the existing situation given in this chapter deals with:

- existing embankments, which may be flood protection embankments or communication embankments (roads and railways);
- the existing natural drainage system;
- the present on-farm development.

Specific constraints which derive from the present situation are also underlined. They will be taken into account at the detailed design stage, in conjunction with other design criteria.

1.2 Embankments

1.2.1 Role of Existing Embankments in the Project Area

Embankments have been constructed in the Jamalpur Project area with two distinct objectives:

i) Embankments which have been constructed with the sole aim of protecting agricultural land against river floods. The main project embankments in this category are as follows:

- the embankment along the left bank of the Jamuna from Bahadurabad to Jagannathganj including the embankment at the intake of the Chatal;
- the embankment along the left bank of the Chatal;
- the embankment along the middle and lower sections of the Jhenai;
- the embankment protecting the area located west of the Jhenai/Chatal junction;
- the various sections of embankments located along the Old Brahmaputra river from Dewanganj to Jamalpur.

ii) Embankments which were constructed with the primary objective of providing a dry road network during the monsoon season and uninterrupted rail travel. Depending on their location, these embankments provide for partial flood protection to agricultural land. Major communication embankments, providing a certain level of flood protection along the project area boundaries are as follows:

- the railway line from Jamalpur to Bahadurabad;
- the road from Jamalpur to Dewanganj;
- the railway from Jamalpur to Jagannathganj.

Numbers of drainage culverts have been constructed along the embankment alignments, to allow water to flow freely from one side of the embankment to the other, thus limiting the flood protection obtained for adjacent agricultural land.

Within the project area a fairly dense secondary road network providing links between villages and access to isolated farms or groups of farms plays a limited role for flood protection, due to the cross drainage structures constructed under the embankments and discontinuous alignments.

1.2.2 Description of Existing Embankments

The general arrangement of existing embankments for flood protection and main construction embankments is shown on Figure 7.1.1.

A detailed inventory and description of existing embankments within the alignment of the proposed protection embankments is presented in the Geotechnical Investigations and Topographic Survey Report (R4) of FAP 3.1 in Section 3.6: Existing Embankment Investigations.

From Bahadurabad to Jagannathganj Ghat, 58 km of flood protection embankments have been constructed by different local authorities on the left bank of the Jamuna River with varying standards of design and construction. The construction materials are sandy to clayey soils. The crest width varies from 1.80 to 2.40 m. (6' to 8'). The overall design of the embankments is not adequate to provide flood protection and there is no straight and/or continuous alignment. Near Bahadurabad and Madarganj the embankments have been eroded severely or have been damaged, mainly during the 1988 flood.

There are minor flood protection embankments on the right bank of the Old Brahmaputra. The most efficient flood protection embankment, constructed to protect the town of Dewanganj from the Old Brahmaputra flooding and erosion, was severely damaged by the 1988 flood.

The main obstacle against floods from the Old Brahmaputra is provided by the railway embankment which runs more or less parallel to the river. However, it is susceptible to overtopping by major floods in the Old

Brahmaputra such as the 1988 flood which damaged it severely between Dewanganj and Bahadurabad. The number of cross-drainage structures between Jamalpur and Dewanganj Bazar is 34. The largest crossing is at the Jhenai bridge with 4 spans.

On the southern side of the project area the elevated railway embankment was severely overtopped south of Bausi Bridge in 1988, with serious breaches between Baira (KM 428) and Jagannathganj Ghat (KM 437) A total of 30 breaches have been recorded by the Railway Authorities. This was caused by flood water flowing out of the project area from NW to SE.

Several embankments for roads, either large or minor have been built. The Jamalpur-Madarganj road is fairly wide. A large number of culverts have been engineered.

Three bridges were destroyed during the 1988 flood and it is understood that the failure came from scour developed at the foot of the abutments. These bridges are presently being reconstructed.

The Jamalpur-Islampur-Dewanganj road is built on embankment-like levees. After Islampur, many secondary roads delineate cells, apparently hydraulically tight. The same features can be observed along the reach Islampur-Jamalpur except in the vicinity of the Jhenai bridge where the landscape appears rather open. In the same area, some road bridges (at least two) are being rebuilt after their failure in 1988. They help crossing rivers of significant width.

Many other secondary roads can be seen all over the area with varying frequencies of culverts.

Some of the embankments supporting the roads might be made with rather sandy material. Some of the culverts of small bridges failed in the past, essentially because of scour developed at the foot of the abutments either by direct or return current. Apparently, some of these structures are being rehabilitated. Culverts concreted along their four faces are implemented. The sloping crest of the sidewalls outside of the riding area definitely appear very steep.

1.2.3 Specific Constraints Related to Embankments

The specific constraints concerning embankments and to be considered for the formulation of development options are as follows:

i) due to the extensive land occupation in the project area, any embankment proposed for improving flood protection of agricultural land should be located on existing embankment alignments, either embankments for flood protection or embankments for roads. Railway embankments should not be raised unless the railway authorities are prepared to carry out this work themselves in conjunction with FAP 3.1. Otherwise where flood protection of railways is required, a separate embankment (either an improved existing or new embankment) will be proposed.

ii) existing natural flow inlets/outlets on the peripheral boundaries of the project area should be taken into account. Locations of major inlet/outlets to be considered in this respect are:

- the Islampur inlet on the Old Brahmaputra river (S1);
- the Jhenai inlet on the Old Brahmaputra river (S2);
- the Chatal outlet at Bausi Bridge (S3);
- the Jhenai outlet in the Jamuna river (S4).
- the Chatal inlet on the Jamuna river (S5);

In the past, major erosion of the Jamuna left bank has occurred. As a result embankments have been breached. For project formulation, it will be necessary to set back the new embankment alignment.

1.3 Natural Drainage System

1.3.1 General Pattern of the Area Topography (see Figure 7.1.2)

The only topographical maps which are available for the study are the 1/50000 Scale maps without contours and the 1/15840 Scale map (4" to a mile) with one contour line every foot.

In order to evaluate the general topography of the area and for a preliminary assessment of the natural drainage pattern in the project area, the 5 foot contours of the 1/15840 scale map were transferred to the 1/50000 Scale maps and then a zoning was established on an A3-sized presentation of the project area. As a result, it appears that the area is V shaped from east to west, with the Madardhaw river (also known as the Dadbanga Khal) as central north-south drainage axis for the area. A general gradient from north to south can be observed, ranging from elevations of 65' (19.8 m) in the north to 45' (13.7m) in the south.

1.3.2 Description of the Existing System

The natural drainage of the area is extremely complex and, in the absence of up-to-date mapping, it is difficult to be sure of the actual flow pattern, which, in any case, varies according to the season and prevailing water levels.

By comparing the existing 4" to 1 mile maps with the recent airphotos, a tentative plan of the existing drainage pattern has been drawn up, which is shown on Drawing No 3 (3 sheets), and a schematic diagram is given in Figure 7.1.3. It must be emphasised that this is a preliminary assessment and will have to be adjusted in the detailed design stage when the FINMAP mapping is available.

Apart from the Jhenai and the Chatal, the main drainage channel is the Madardhaw River (JHM2), which virtually bisects the area as it flows from west of Islampur to its junction with the Jhenai just upstream of the latter's junction with the Chatal. The northern part of the area drains first into an apparent distributary of the Old Brahmaputra, offtaking from near Islampur (JHM3), though there is a strong indication that this channel flows back into the Old Brahmaputra at times of low flows. It joins another channel from the west of the area approximately 10 km west of Islampur to form the Madardhaw.

As the Madardhaw flows south it picks up various drainage channels mainly from the east, the principal of which are the Nujang (JHM2S3) and Jhora (JHM2S1) Khals. Drainage channels from the west are relatively minor since that area drains mainly to the Chatal.

There is another relatively important channel (CHS1) which drains the western part of the project area north of the location of the bunded off Chatal inlet and joins the Chatal just downstream of this point. South of here there are only two defined drainage channels from the west, most of the drainage appearing to go direct to the Chatal.

1.3.3 Specific Constraints Relevant to the Drainage System

The specific constraints concerning the improvements of the drainage system in the project area are as follows:

i) During the monsoon season, improved drainage to control water depth in the paddy fields can be considered for highland areas, where downstream water level conditions do not hamper free drainage by gravity. The flow model gives valuable data for the evaluation of the Jamuna water levels which control tailwater levels in the southern part of the project area.

- During the post monsoon season, accelerated drainage will be a major issue for the improvement of agricultural conditions in the project area, which are at present constrained by inadequate outlets from the beels and the conflicting need to conserve the beels for fish production.

1.4 On Farm Development

1.4.1 Description of Existing System

Existing on-farm development in the project area results from the conjunction of two factors:

- intense population pressure on scarce land which has led to the organisation of the entire area for paddy cultivation with an extremely dense network of bunds and minor embankments.

- highly uneven original microtopography with depressions and former river bank levees scattered all over the area (depressions with central beels being more common in the eastern part of the area).

The control of the water circulating through the paddy fields from highland to low land areas, and then to natural drains, is a field to field water level management for which successive farmers of adjacent fields try to maintain the water level required for their crop, excess water being released to the immediate downstream fields. During the monsoon period and post monsoon period, this field to field water level management is restricted to those areas which can be drained i.e. areas which are not inundated.

This concept of the management of field water levels will be of considerable significance in the discussion of the compartmentalisation concept (see Section 3.6). If we make a comparison with Irrigation water management, the above description would be an upstream water control in which water released in the upper part of a scheme (rain water and flood water in our case) must be discharged to drains if not used by the successive farmers located along the distribution system.

The control of water levels in fields located in low-lying areas such as the natural depressions of the beels, and depressions created by manmade obstacles (road embankments with deficient cross drainage) cannot be considered on the same basis as the drainage of low-lying areas which are subject to protracted flooding because of their location in the low alluvial plain of the rivers i.e.:

- For depressions, the control of water levels will result from the provision/improvements of drainage facilities and natural drains.

- For the low-lying areas, the control of water levels will result from the construction/improvement of flood protection embankments to reduce flood inflows from the main river.

1.4.2 Specific Constraints Relevant to On-farm Development

The specific constraints concerning on farm development works and to be considered for the formulation of development options are as follows:

i) The present situation regarding the land surface is the result of a long process undertaken by the farmers. They have reached a high ability to monitor their field water levels through a very complicated arrangement of successive horizontal paddy fields, bordered by bunds and minor embankments. The design of new infrastructure will have to take into account the existing on-farm development situation.

ii) Low-lying areas have been developed under the same field to field organisation with downstream water level limitations due to the original micro topography (depressions), various manmade obstacles (road embankments) or due to their location in the flood plain of the rivers.

The existing 1/50000 scale map and the future 1/20000 FINMAP maps (Restitution of aerial photographs at the same scale) will not provide the suitable accuracy for the study of detailed arrangements at field level. At feasibility level only outline arrangements have been worked out for planning purposes and cost evaluation.

2 POSSIBLE LAND AND WATER DEVELOPMENT OPTIONS

2.1 Background and General Presentation

The terms of reference call for the confirmation of the NCRS reconnaissance mission proposed development options which are as follows:

Scenario I

Physical components would be restricted to the improvement of the surface drainage conditions. Drains would be re-excavated as may be necessary.

Scenario II

Physical components would provide for the full flood protection of the project area. They would include river embankments with a setback to "guarantee" a life time of 20 years, inner embankments to form compartments and re-excavation of drains to improve surface drainage conditions. Hydraulic structures would include safety weirs to protect river embankments and regulators to manage flows entering into and draining out of the project area.

Scenario III

This Scenario would be similar to Scenario II. The main difference would concern the hydraulic structures which would allow flood flows into the system through openings, sills or regulating structures.

At the start of the Study it was found more relevant to differentiate development options in connection with the compartmentalisation concept which has never been implemented in Bangladesh and for which the technical objectives and the technical feasibility have still to be explained and studied.

The specific pilot project (FAP 20) has been felt necessary by FPCO and this is evidence of the need for a careful approach to the compartmentalisation concept.

Therefore, it was proposed to consider land and water development options with and without compartmentalisation so that within the context of this feasibility study the validity of this important issue can be analyzed and quantified as far as is possible at this stage.

2.2 Possible Development Options for the Study Area

2.2.1 Introduction

The land and water development options, considered at the Interim Report stage, were as follows:

Option A: Flood proofing and drainage improvements (NCRS Scenario I).

Option B: Controlled flooding for the whole areas; intakes on major streams crossing the boundary; full boundary embankments; drainage improvements and flood proofing on char land within the project area (NCRS Scenario III).

Option C: Project divided by extended Chatal left embankment; north and east to have controlled flooding; control structures on the Jhenai; flood proofing for the remaining area and drainage improvement (NCRS Scenarios II/III).

Option D: Full scale polder with flushing sluices and drainage regulators only; Jamuna embankment of geotextile and other protection; improved drainage (NCRS Scenario II).

Options B and C may also include some form of compartmentalisation.

2.2.2 Option A (See Figure 7.2.1)

i) Objectives

The objectives which are in line with the initial findings of FAP 23 are:

- to define modifications which may be made to project designs, such as embankments, to provide refuge areas during extreme floods;
- to define small scale structural measures that can be undertaken by local people, with the ultimate objective of reducing flood losses in the project area,
- to improve drainage conditions so that water level in the paddy fields can be controlled efficiently (removal of excess water due to river flooding and rainfall) taking into account the specific requirements of fisheries activities.

ii) Components

The components for Flood Proofing are:

- refuge areas providing safe places and basic life support during extreme floods, and community infrastructure to improve the population's living conditions,
- flood proofing of households which will be raised above extreme flood levels taking into account the impacts of the Jamuna confinement and other projects which will modify the natural water depth in the river,

The components for Drainage Improvement are:

- improved channels for the drainage of depressions and waterlogged areas;
- excavated channels and new control structures to achieve an accelerated release of excess water and the control of water levels when water should be retained and water bodies preserved

2.2.3 Option B (See figure 7.2.2 and 7.2.3)

i) Objectives

The objectives of Option B are as follows:

- to admit only controlled flows to the project area thus preventing early floods, peak floods and subsequent excessive rise of water levels during inundation;
- to protect railways and towns against floods;
- to improve drainage conditions so that water levels in paddy fields can be controlled efficiently (removal of excess water due to rainfall and when inundation recedes);
- to mitigate, as much as possible, by water management the adverse impact on fisheries.

ii) Components

The components of this Option are the following:

- flood proofing as in Option A for land outside the embankments
- an embankment along the Jamuna river (embankment 1);

- an embankment along the old Brahmaputra river on the eastern side of the railway (embankment 2);

- an embankment along the east bank of the Chatal river on the western side of the railway, downstream of Bausi Bridge (embankment 4a);

- two control structures to admit floods on the Old Brahmaputra river, a major one at Jamalpur for the Jhenai intake (S2) and a smaller structure at Islampur (S1);

- a major control structure at the Chatal inlet from the Jamuna (S5);

- a major control structures to release water from the project area; at Sarishabari (Jhenai/Chatal outlet - S4)

- minor control structures (flushing sluices) in relation to local topography in order to admit controlled floods and to drain excess water;

- channel and drainage improvements as per Option A.

2.2.4 Option C

i) Objectives

The objectives for Option C are the following:

- for the western part of the area, objectives are similar to those of Option A,

- for the eastern part of the area, objectives are similar to those of Option B.

This Option derives from the following facts:

- the set back for the flood protection embankment along the Jamuna river, although located in accordance with the 20 year criterion of FAP 3, would not be completely safe in the long term;

- fishing in the area west of the Chatal embankment would be virtually unaffected.

ii) Components

The components for this Option are the following:

- an embankment along the left bank of the Chatal river with extension parallel to the Jamuna to Bahadurabad and to Bausi bridge to the south, dividing the Chatal from the Jhenai;
- a new channel for Chatal at loop approximately 8km upstream of Bausi Bridge;
- an embankment along the old Brahmaputra river on the eastern side of the railway;
- an embankment along the Jhenai river on the western side of the railway downstream of Bausi bridge;
- improvement of embankments around two higher areas west of the Chatal, one around Madarganj and the other to the south east;
- two control structures on the old Brahmaputra river to admit floods, a major one at the Jhenai intake and a smaller structure at Islampur;
- two major structures to release water from the project area, one at Bausi bridge, one on the Jhenai;
- minor control structures (flushing sluices) in relation to local topography in order to admit controlled floods and to drain excess water;
- channel and drainage improvements as per Option A;
- flood proofing measures as per Option A except in the protected area.

2.2.5 Option D

i) Objectives

The objective for Option D is:

- Full flood protection of the project area.

ii) Components

The components of this Option are the following:

- flood embankments as in Option B;
- improved channels and drainage as in Option A;
- major gated inlet structures on the Chatal and Jhenai and a smaller gated structure at Islampur;
- major outlet structures on the Jhenai/Chatal; a simple weir at Bausi Bridge and a controlled structure near Sarishabari;
- controlled minor cross-drainage structures where necessary along boundary embankments;
- flushing sluices where necessary;
- flood proofing measures as in Option B.

2.3 Selection of Options for the Feasibility Study Proper

At the Interim Report (R3) stage, the option for the full flood protection of the area, Option D, was discarded from further discussion on account of the severe disbenefits which would be created by the exclusion of all river flood water from the project area. The main negative impacts which led to this decision were:

- the complete stop to the recruitment of fish species from the rivers and subsequent impact on the nutrition of landless people;
- the impossibility of taking into account the population's wishes regarding the need for controlled flooding of agricultural land;

At the Interim Report (R3) stage, the other three options, A, B and C, were considered for economic comparison and for the evaluation of their respective expected impacts.

The economic comparison has shown that Option C, partial flood control, for the eastern part of the project area was unattractive due to a low EIRR. The main reason for this result is that Option C provides for infrastructure to protect land which, under the "without project situation" is only marginally affected by the floods in comparison to the rest of the project area, with investment costs per ha of embanked area about 30% higher than investment costs per ha of embanked area for Option B.

Option A and B showed a good results.

In terms of impacts and in terms of benefits, the findings concerning these two options were not fully conclusive. The main preliminary result of the Interim Report (R3) study on Options A and B were as follows:

i) Option A: flood proofing and drainage improvement

- it tackles the issues of immediate loss of human life and assets from flooding and allows quick post flood response to economic disruption;
- it provides for a certain increase in agricultural production through drainage improvement;
- it does not affect fish production, the livelihood and an important nutritional source of the landless and the poor;
- it fails to protect the existing cultivated area and therefore does not respond to the expectation of most of the local population;
- it does not provide any economic confidence to the farmers who are reluctant to face the future following major flood events.

ii) Option B: flood control and drainage improvement

- it secures a continuous increase in agricultural production;
- it allows a phased approach to implementation, with the possibility of pilot trials, allowing the assessment of impacts over small areas to be used for further expansion, especially for flood proofing and fisheries;
- it responds to the population expectation, provided that it is implemented on the basis of a "bottom-up" approach.

It was therefore accepted by FPCO and the donors that, Options A and B, being the more promising options in economical, sociological, environmental and technical terms, should be selected for further analysis at feasibility level, treating the flood proofing programme as a separate Project not included in Option B economic analysis (except for the mitigation costs due to confinement of the Jamuna).

2.4 Water Management

2.4.1 Objectives

In the present situation within the Project area, flows from the Jamuna and Old Brahmaputra are made use of for a wide varieties of uses. These include supplementary irrigation (mainly confined to extreme dry years), sustenance of riverine and plain fisheries, waterborne transport and cleansing of the area through flushing action. Current estimates indicate that groundwater recharge is adequately provided by direct rainfall. Larger inflows, and particular ones involving over-bank flow, will contribute to all of the above as well as bringing silts and sedimentions beneficial to agriculture.

As discussed above, in considering the options for development of the area, the choice of full flood protection has been ruled out primarily on the grounds that it will prevent the uses of water as described above, particularly having a major impact upon fisheries. The alternative option of controlled flooding is recommended instead whereby lower beneficial flows are admitted to the area but higher damaging flows are excluded. The size of the boundary rivers for this project are such that the admission or exclusion of flows into the area has negligible effect on the levels of the confined boundary rivers and, in contrast to objectives that may be applied in other parts of the world, controlled flooding for Jamalpur has no bearing on flood attenuation in the boundary rivers.

The objectives of controlled flooding are therefore to enable the current practices of water management within the area to continue as before with minimum disruption whilst at the same time enabling protection of the area against higher damaging flows. To achieve this requires an appreation of the timing of current practices and in relation to this, of future procedures.

2.4.2 Flooding Sequence

Timing is an important factor in the flood control process. During the monsoon, three stages should be considered for the formulation of a flood control project and subsequent water management policy.

- During early monsoon, from April to June, when the external river water levels rise, excessive flood levels from quick floods should be avoided in order to allow farmers to complete cropping activities. At the same time, fish fries should migrate into the internal project rivers. At the end of this period, the inundation of the flood plain is required for both agricultural and fisheries requirements.

  Regarding the future regime of the internal rivers, gated inlet structures sized in connection with these river natural capacities, make possible the admission of discharge which can be adjusted at the gates, according to the flooding level in the internal rivers an on the flood plain.

- The actual levels in the embanked area are the result of the combined occurrence of the discharges admitted at the inlet structures and rainwater. The water management policy is a day to day adjustment of the admitted discharges at inlet structures taking into account flood depths within the project area and the respective requirements stated above. In a normal year the gates will be left fully open until the end of June or at such time as rainfall has commenced in sufficient quantities to provide adequate discharges and water levels. If earlier closures are required careful consideration must be given to not disrupting the episodic migration of fish fries.

- During main monsoon period, from June to September, as assessed with the MIKE 11 model, flooding conditions are mainly governed by rainwater. Inlet structures should be closed most of the time, but under particular circumstances when there is a deficit of rainfall or any specific requirement there remains the opportunity to operate the gates for additional water supplies to the project area. Excessive floods are prevented by the embankments. Drainage is a main objective to be pursued toward the end of this period. Drainage within the area will be by gravity causing accumulation in the lowest areas, mainly in south of the Project. The main outlet structures and flushing sluices will be opened whenever water levels within the embankment exceed external levels, and closed when the reverse is true. In normal years, significant drainage to the outside of the area can occur. Passage of fish back to the rivers will be either through the drainage outlets of via fish passes set in the inlet structures.

- During late monsoon, the whole flood control process is a drainage process during which outlet structures and flushing structures are left wide open for the removal of accumulated water and rainwater from the embanked area. Inlet structures are definitely closed at this stage of the monsoon season.

2.4.3 Water Management and Structure Control

For feasibility study purposes the inlet structres have been sized to dimensions which enable approximetly 80% of average year discharges to pass into the area during the period April to June. This is a critical period for fish fries migration made especially so as at the beginning of the period the flows at two of the three inlets is zero. In general terms this appears to be a reasonable criterion, but one that for which it is clearly desirable that a review is made at detailed design. Such a review should take detailed account of water management practices within the area as a whole and within the vicinity of the structure in particular, which will be greatly facilitated by up to date and detailed mapping. The possibility exists that depending upon actual practices a lower inlet capacity may be possible which would result in cost savings both at the inlet structures and possible at te outlet. Lower discharges may have to be accompanied by longer durations of gate openings, which could offset any savings at the outlet structure.

Control rules for the structures wll have to be developed taking account of the final designs. It may be anticipated however that the followings will apply:

	Inlets	Outlets
Pre-monsoon until end of June	Kept open unless unusually high early floods occurs, in which case full or partial closure to prevent premature flooding (dictated by d/s levels)	Kept open or partially closed to maintain pondage within upstream river and/or to prevent inflow of early floods
Main monsoon June-September	Kept closed unless specific downstream demands arise due principally to unusually rainy conditions	Opened whenever the opportunity to drain exists. Closed whenever needed to prevent inflows from main rivers.
Post-monsoon until end of October	Kept closed	Kept open to drain the area subject only to maintaining necessary pondage upstream for fisheries requirements.

From the above it is apparent that the inlet structures will be operated using downstream levels whereas control of the outlet structures will have to take into account of both upstream and downstream water levels.

3 DETAILED DESCRIPTION OF THE SELECTED OPTIONS

3.1 Introduction

As discussed above, the land and water development options considered for the feasibility study proper were as follows:-

Option A: Flood proofing and drainage improvements.

Option B: Controlled flooding for the whole mainland area; intakes on major streams crossing the boundary; full boundary embankments; drainage improvements and flood proofing on Char land within the project area.

The flood proofing project has been treated as a seperate project, as it does not bear any direct influence on agricultural development of the main land project area, but to be executed in a coordinated manner with the other project components

Only the incremental mitigation cost to compensate for the increased water level in the Jamuna river confinement has been taken into account for the Main land project economic analysis.

The principal components of these options are described in more detail below.

3.2 Flood Proofing

3.2.1 General Approach: From Mitigation to Development

The 1988 floods were the most severe in the living memory of inhabitants of Bangladesh and more than 90% of the housing units in the project area were damaged. In 1991, which was a year of normal flooding, the extend of flood damages affected 30% of housing units.

With the expected rise in river water levels due to existing embankments (right bank, Bhuapur), Jamuna Bridge construction and the future FAP development proposals, the entire population living in island chars, attached chars and set back land would be subject to an increase flood risk.

As a result, mitigation measures have to be provided with the ultimate objective of eliminating incremental damages caused by increased flooding. However, it seems that such a mitigatory approach calls for the following specific comments:

- It is not possible to identify the impact of FAP 3.1 development proposal separately from the impact of the construction of Jamuna Bridge, implementation of the other FAPs and the existing embankment. This means that interventions in Char land and Set-back land cannot be envisaged as mitigation measures of FAP 3.1 alone but should rather aimed to generate socio-economic benefits to the population.

- The development to be made under FAP 3.1 would contribute to generating incremental economic and social benefits in the protected land. The living conditions of the Char and Set-back land inhabitants would at best remain the same as before and the equity gap between the population of the unprotected land and of the protected land would further increase.

The likelihood of an increased equity gap and of the possible resulting conflict situations could be minimized if a comprehensive approach designed to improve the living conditions of the Char land population, and not only to mitigate the negative impacts of all FAP projects, is followed.

This approach calls for designing a comprehensive flood proofing program which will include the following objectives:

- to save human lives
- to protect houses and households amenities (water supply and sanitation system)
- to protect livestock and poultry
- to protect and develop community infrastructure
- to support the diversification and strengthening of economic livelihood through agriculture production programmes and income generation schemes

3.2.2 Project Area

The project area includes 223,000 households and 1,233,000 people spread as follows:

- Island Chars, (118,000 people, 19,000 households)
- Attached Chars and Set Back Land (Left Bank) (309,000 people, 53,000 households)
- Attached Chars and Set Back Land (Right Bank) (175,000 people, 28,000 households)

- Mainland, subject to flood proofing under Option A but protect by embankments under Option B, (631,000 people, 123,000 households)

3.2.3 Project Design

The project is designed to support flood proofing objectives so as:

- to reduce the impacts of flood on the livelihood of Char dwellers
- to flood proof and develop community infrastructure
- to increase incomes and diversify sources of livelihood, particularly of the landless households, through agriculture production programmes and income generation activities

To meet these objectives, the project has five components:

- Minor Structural Flood Proofing
- Community Infrastructure Development
- NGO Support
- Institutional Support
- Technical Assistance

3.2.4 Detailed Features of Project Components

i) Minor Structural Flood Proofing

Minor structural flood proofing is a strategy adopted on an individual household basis or on a small scale collective basis by a "willing group" of clustered households.

The household based flood proofing measures would:

- save human lives
- livestock and poultry
- minimize damages to dwelling units and to household amenities and belongings
- protect people's food reserves stored in their flood proofed houses and hence reduce the need for large scale relief operations during floods

- protect household property against theft because the people would not be displaced by floods

- avoid costs incurred by the household with respect to evacuation of the flood victims and shifting of household amenities

For each household or "willing-group" of households, a flood proofing package will be prepared, the packages will include:

- housing programme

- construction of small-scale earthen platforms for livestock

- raising of tube wells, wells, latrines

The findings of the study have shown that housing units in Char land are usually temporary facilities because they have to be frequently shifted due to flooding and erosion. The perceptions of Char land people indicate a strong demand for improved and more permanent settlement. This underlines the need for a housing program aiming at:

- providing flood proofed housing facilities to the most vulnerable sections of the population such as the homeless, the landless and the marginal landowners (below 0.1 ha). It is estimated that around 50% of the households could be eligible under this program. The project will support the construction of "flood free" houses (1 room, 17 feet * 10 feet) by providing the following building materials:

    - 14 corrugated tin sheets of 9 feet long
    - 12 cubic feet of sized wood
    - 8 RCC pillars of 11 feet long
    - 2 windows and 1 door
    - bamboo fences

    The cost of the building materials for one house is estimated at Tk 10,000. The project will subsidize 70% while the remaining 30% will be loaned to the beneficiaries. This loan will be "interest free" and will be paid back on a monthly instalment basis over a 2 years period.

    In addition, the cost of earth filling to raise one household will be supported by the project i.e. Tk 3,000.

    As a whole, the average project contribution per household is Tk 13,000, Tk 10,000 as subsidies and Tk 3,000 as a loan.

- Providing earth filling to raise houses of the remaining 50% of the population i.e. 6,000 Tk per household (households being larger than those treated above.

The project implementation unit (PIU), to be set up under the government agency in charge of project implementation will be responsible for the procurement of the materials required to implement the flood proofing packages with the support of experienced NGOs.

ii) Community Infrastructure Development

The project would provide financial support to invest in community infrastructure development in the project area. In this respect, 400 micro-projects will be financed throughout the project area (1 for 250 to 300 households). In order to be eligible under this component an infrastructure micro project should be designed so as to:

- develop the community resource base to provide additional and/or improved livelihood opportunities.
- cost less than Tk 1 million and be completed in less than 1 year
- be implemented through NGOs or relevant government agencies with appropriate technical capabilities

The following activities would be eligible for funding under the micro-project component:

- multi-purposes flood shelters which can also be used as schools, grain stores and community welfare centres.
- refuge areas (elevated earth platforms)
- drinking water supply and sanitation
- minor scale irrigation/drainage facilities
- development of small roads/dykes

The micro-projects would be identified by the technical department of the Thana administration, by the union parishad members, by local leaders/representatives, and by the staff of the NGOs working in the area. In identifying micro-projects, a "needs led" approach, would be followed, based on the people's perceptions of the importance of each problem affecting the daily life of the community

After approval from the committee and set up under the project management office, a contract will be signed between the project management office and the local implementing agencies (thanas, LGEB, NGOs) and funds will be disbursed according to an agreed schedule.

iii) NGO Support

The main objectives of the support to be provided to experienced NGOs, are:

- to support agriculture production programmes and income generating activities through a credit system.
- to identify, design, and implement the minor structural flood proofing component (housing programme)
- to participate in the identification, design and implementation of the infrastructure micro projects.
- to provide social support services to the population through group formation, community development, education, health and training programmes

iv) Credit Support

Due to the nature of the Char land and the amount of risk involved, formal credit support through the institutional banking system (NCBs, private banks) is unlikely and should rather be provided through NGOs which have much experience in strengthening population economic livelihood.

In this respect, the project will allocate to each NGO involved in the programme a specific amount of money to support credit activities. The NGO will use this interest free fund allocation on a revolving basis.

v) Social Support Services

In addition to the main activities of the NGOs linked with the support to the minor flood proofing component and with the support to agriculture and income generating activities, NGOs would provide services including health, education, training and awareness. Vocational training would help unemployed or under-employed people to acquire new professional skills and thus to find alternative sources of incomes when farm work is not available.

vi) Contractual links of NGOs

Each NGO will be bound to the project authorities, either directly or through the foreign consultant, by a contract clearly spelling out the scope of work, the staffing and the budget allocation.

vii) Phasing of NGO Support

During the pilot phase of the project, five NGOs will be involved in five different parts of the project area including both island Chars, attached Chars and set back land. In the main phase, these NGOs will increase their area of intervention so that the entire project area will be covered.

In the pilot phase, the field staff of one NGO should comprise 1 coordinator, 2 field supervisors and 15 field workers. Each field worker, who will be in charge of 200-250 households, will be assisted by 5 local link workers. Each NGO should establish 2 flood proofed community houses in their respective areas. These premises would also be used as office space by the field supervisors and field coordinator. Transportation facilities will include 3 engine boats, 3 motorbikes for the field coordinator and the field supervisors.

During the main phase, these facilities would be increased to enable the NGOs to extend their coverage of the project area.

viii) Institutional arrangement

Specific institutional arrangements for the government organization in charge of implementing the project are required to attain sustainable development. Due to the nature of the project programme, no ministry alone seems to be appropriate to be in charge of the project implementation. It is recommended that an independent body, the Charland Development Board (CDB), be established. The CDB could act as a coordinating and policy making body and would be responsible for ensuring the enforcement of its decisions by the respective central line ministries.

However, because the establishment of a new authority could take time it is recommended that this project be implemented through the institutional framework to be set up under the FAP 3.1 main land project. A Deputy Director in charge of the project will be appointed by the Project Management Office (PMO) to be established for the FAP 3.1 main project.

The Deputy Director Office will be responsible for:

- Project Management, including :
    - administration of NGOs contracts
    - approval of households based minor flood proofing packages

- disbursement of project contribution for minor flood proofing to beneficiaries
- approval of micro-projects, preparation of contracts with the relevant organizations for implementation, disbursement of funds, supervision.
- preparation of progress and policy advisory reports for the PMO

- Monitoring and Evaluation:
  - procurement of Technical Assistance, of NGOs and of project equipment and vehicles
  - administration and finance

Under the PMO, a project implementation unit (PIU) will be in charge of the following activities in close cooperation with the thana representatives and NGOs:

- preparation of minor flood proofing packages for households (technical and engineering aspects)

- identification and design of infrastructure micro-projects

- supervision of the implementation of the minor flood proofing packages and infrastructure micro projects

- technical assistance and training (agriculture, fisheries, forestry, women's affairs)

- data collection for the monitoring and evaluation programme of the project

Another major institutional improvement to be supported by the project, would be the design and formulation of a comprehensive multi-purpose master plan for development of the Char land. In this regard, a set of supporting studies would be implemented under the Technical Assistance component of the Project with respect to land allocation procedures, resettlement of erosion victims, agriculture development, fisheries development, poverty alleviation, education, health and women's issues.

ix) Technical Assistance

The main objective of the technical assistance (TA) under the mainland project is to assist in the project implementation and to prepare a comprehensive master plan for the development of Char land. For this purpose, the TA consultant will carry out specific studies and will make a full use of all the information collected by the other FAP studies as well as of the experience gained from the implementation of the first phase of the project.

3.2.5 Flood Proofing Project Phasing

The flood proofing projects concerns a large area both in terms of surface area (about 1,140,000 ha) and during in terms of population (602,000 people). Because the flood proofing experiences are rather limited in scale and because the nature of the project implies a bottom-up design approach, it is proposed to implement it in two phases.

- A pilot phase of three years, during which the proposed solutions will be tested and duing which the methodological approach for full implementation will be worked out. This pilot phase will represent about 5% of the total Flood proofing programme.
- A main phase which last 5 years, or more depending on the initial findings of the pilot phase, during which the identified full programme will be implemented.

3.2.6 Project Cost

Cost estimates for the flood proofing project have been detailed in tables 7.3.1 to 7.3.10

The estimated base cost as shown in Table 7.3.10 is Tk 1,460.6 million excluding physical and price contingencies. The cost of the pilot phase is about Tk 128.0 million while the cost of the main phase is about Tk 1,332.6 million. The NGO support, which is also expected to contribute significantly to improving the socio-economic status of the population, accounts for 34% of the pilot project base cost. The Technical Assistance accounts for 9% of the pilot project base cost.

For the main phase project, once the approach and the methodology are fixed, the NGO support and the Technical Assistance will account for 8% and 1% respectively.

The mitigation cost attributed to the JPPS implementation and to be considered for the Mainland project economic analysis is Tk 31.2 million.

3.2.7 Benefits and Justification

The major benefits of the flood proofing project would be the reduction of livelihood loss due to flood damages for the concerned households.

In addition, the population is expected to benefit from the agriculture production programs and income generation activities to be supported by NGOs. Household incomes are likely to rise and the sources of economic livelihood are expected to be more diversified and thereby less subject to flood risk.

Moreover, a wide range of social benefits for the poorest households which are not immediately measurable, are likely to be generated by the project:

- the reduction of flood impact on the livelihood of the poorest households combined with the expected rise in incomes would contribute to raising self-reliance, thereby minimizing socio-economic dependency on the rural elite,

- the rise in incomes will contribute to improving the nutritional standards of the poorest families, thus contributing to improving the overall health status of the population in general and of the children in particular,

- the social development programmes of the NGOs will raise the awareness, the self-reliance and the level of education of the poorest strata of the population of the project area, thus increasing their socio-economic status,

Although the contribution of the flood proofing project to economic development is rather limited, the socio-economic benefits are tremendous and are sufficient to justify the project on social grounds alone.

3.3 Drainage Improvement

3.3.1 General

Waterlogging has been cited as a major problem within the Project area during the sociological investigations and the main drainage improvements consist of accelerating the surface drainage process in waterlogged areas, which can be classified in three categories:

- major natural depressions with a central beel or group of beels;

- minor natural depressions which remain waterlogged late into the post-monsoon season;

- minor artificial water bodies created by man-made obstacles (mainly roads) with deficient cross-drainage structures.

There are 47 individual beels identifiable from the 4" to 1 mile maps in the 13 groups of beels discussed in Section 3.3.2 below. From these maps it was also possible to identify a further 42 individual smaller beels. Consequently for drainage cost estimation, the figure of 47 for the grouped beels has been taken and a figure of 50 for individual beels to allow for possible omissions.

No accurate assessment of the minor natural depressions and other minor water bodies actually related to the microtopography, is possible until detailed topographical surveys and detailed field enquiries are carried out at the detailed design stage. At this stage, for cost evaluation purposes, a tentative "reasonable" figure of 300 cases of the waterlogging situation has been assumed.

Typical physical arrangements for drainage improvements will be as follows:

Major natural depressions:

- excavate the natural channel outlets to facilitate drainage: three standard channel sections have been used discharging 0.5 m3/sec, 1.25 m^3/sec and 3.5 m^3/sec depending on the catchment area of the beel or group of beels. Lengths of channels have been estimated from the 4" to 1 mile maps;

- construct gated control structures to regulate minimum water levels in beels and allow quick drainage when necessary. Here, three types of structure with 24", 36" and 60" pipes have been used to match the above channels.

Minor depressions and other water bodies:

- excavate outlet channels: 0.2 km of excavation each;

- construct culverts: for 50% of the total number.

Rehabilitation of the principal cross-drainage structures throughout the area must also be taken into consideration. The total number involved is approximately 90, some of which may not require attention.

As far as the field drainage conditions within the project area are concerned, it should be underlined that due to its basic characteristics, the river model cannot provide detailed information. As a matter of fact, the area elevation curves used for the model construction do not reflect the local variations in microtopography. Over a given area as a whole, the proportion of the land in each range of elevations is determined and used to synthesise an area elevation curve. This gives a schematic representation of the ground which is assumed by the model to have a continuous slope from the top part of the area to the bottom part of the area.

As regards the main drainage system i.e. the Chatal, Jhenai and Madardhaw rivers; from site investigations and the operation of the model, it appears that training works are not required. The rivers are deep enough to convey excess water, and drainage limitation depend on the tailwater conditions imposed by Jamuna water levels and any restriction of flows through Bausi Bridge.

3.3.2 Drainage Design

i) Design Criteria of Drainage System

Three drainage periods can be distinguished:

- pre-monsoon period, from April to June, during which gravity drainage is usually possible until river levels start rising at the end of June,

- monsoon period, from July to September, during which high river levels impede gravity drainage and gated outlets should remain closed,

- post-monsoon period, from October to November during which gravity drainage can be achieved as soon as receding water levels permit.

Design criteria for the drainage system have to be considered for both the internal drainage network conveying runoff water to the gated structures, and for the gated structures themselves. Specific consideration for the gated structures is required so that they provide satisfactory post-monsoon drainage conditions. For planning purposes, and in order to assess the volume of works, the proposed design criteria are derived from the "Third Flood Control and Drainage Project" design manual based on BWDB practices and approved by BWDB.

For the design of the drainage system, it is recommended that a 10 days rainfall with a 1 in 10 years return period is taken into account.

For the project area full rainfall analysis is given in Table 7.3.11. The calculations of the drainage modulus is based on the following formula:

$$d = \frac{I + R - T(E + S) - F}{T}$$

Where	I	=	Pre-storage, assumed as 50 mm.
	R	=	Cumulative design rainfall for 10 days in mm.
	T	=	Period considered in this case 10 days
	E	=	Evapotranspiration in mm/day assumed as half the average potential rate for the period.
	S	=	Deep percolation, assumed as 2 mm/day.
	F	=	Long term flood depth assumed as 150 mm.

Hence:

$$d = \frac{R - 10E - 120}{10}$$

As a result, a drainage modulus "d" of 33 mm/days or 3.8 1/s/ha will be considered for the project area.

ii) Sample Area

A sample area was first looked at using the above criteria and a tentative layout indicated on Figure 7.3.2. The dimensions of channels and discharges for each of the areas is given in Table 7.3.12.

On the basis of the analysis of the 4' to a mile map, this has now been extended to the complete area and local catchments measured for all beels or groups of beels in excess of 100 ha. The channels which drain these catchments have been identified and their discharges calculated.

Thirteen beels or groups of beels with local catchments in excess of 100 ha have been identified. In some cases, where channels flow through the beels, it has been necessary to consider an extended catchment to obtain the true discharge. Approximately 50% of the beels in the area are included in these thirteen groups, but two other smaller groups exist, and it is estimated that a further 50 no. isolated small beels exist. Other non-permanent beels and waterlogged areas are tentatively estimated at 300.

Three standard drain sections have been selected which will pass the required discharge due to rainfall for the range of areas involved. Their details are shown on Figure 7.3.3. The smallest section (Type A) has been used for the 300 non-permanent beels.

Similarly, three types of standard gated culverts have been used for regulation of drainage flows and where it might be necessary to maintain the water level in a beel for a period. Their details are given on Drawing No 5.

As a result, quantities for drainage improvement are as follows:

Natural depressions:	Improved drains	Type A	37.6	km
		Type B	8.4	km
		Type C	2.5	km
	New Structures	Type A	55	no
		Type B	13	no
		Type C	2	no
Minor water bodies:	Improved drains	Type A	60	km
		Type B	150	no
Rehabilitation of structures:			50	no
Land acquisition:			163	ha

3.3.3 Internal Rivers

From the long and cross-sections obtained, and the model simulations these channels have been found to have sufficient capacity to cater for the discharges calculated in the controlled flooding situation. Therefore no major work on them is envisaged.

3.3.4 Pilot Project

i) General

To address the problems of local liaison and participation in the drainage improvements, to refine the design process and to monitor the benefits, it is recommended that a pilot drainage project should be selected for the detailed design phase.

ii) Location

CCCE have suggested an area of between 5000 and 10000 ha for the pilot project. The area bounded by the Jamalpur-Madarganj road on the South, the Chatal embankment on the west, the Melandaha to the west and the road from Melandaha south to the Jamalpur-Madarganj road amounts to some 5000 ha. It is representative, having the main drainage channel, the Marardhaw, passing along its western boundary, an average number of beels and also has a high intensity of irrigation. With the added advantage of good road access from the north and south, this is recommended as being a suitable area for the pilot project.

3.4 Flood Protection Embankments

3.4.1 General Concept

Severe flooding of the Jamalpur area in recent years requires flood protection measures together with drainage measures to achieve a sustained development of the regional economy, to prevent loss of life and property, and to reduce the susceptibility to damage of the two railway lines (Jamalpur-Diwanganj and Jamalpur-Sarishabari) and the main and feeder roads in the area.

Flood protection can be achieved by embankment dykes with intake structures for controlled irrigation flooding and drainage outlet structures along the boundaries of the Jamalpur area.

The Jamalpur Priority Project Area within the North Central Region has the shape of more or less a triangle with approximate side length of 74 km along the Jamuna River in the west, 43 km along the Old Brahmaputra in the east and 35 km along the railway line Jamalpur-Jagannathganj Ghat (Bayalpur) in the south. The ground elevation varies between 14 and 18 m +PWD.

The main protection dykes which have been considered are:

- embankment 1: along the left bank of the Jamuna River at the western boundary of the area between Diwanganj/Bahadurabad in the north and Sarishabari in the south with a length of 73,859 m,
- embankment 2: along the right bank of the Old Brahmaputra at the eastern boundary of the area between Diwanganj in the north and Jamalpur in the south, with a length of 43,170 m,
- embankment 3: on the southern boundary along the railway line between Jamalpur and Sarishabari with a length of 27,239 m,
- embankment 4a: along the left bank of Chatal River from Sarishabari to Jagannathganj Ghat/Dayalpur Fertilizer Factory with a length of 8,240 m
- embankment 4b: along the railway line from Sarishabari to the Dayalpur Fertilizer Factory with a length of 8,240 m.

The selected Option B5 contains embankment 1, embankment 2 and embankment 4a, considering that the area south of JPP (PU2) will be protected against flooding by embankments simultaneously with the protection of JPP. Embankment 4a will connect the Jamuna embankment with any embankment of PU2 area.

If protection embankments south of the project area are not constructed in due time then embankments 3 and 4b would have to be constructed in order to protect the project area against flooding from the south. In this respect it will be necessary to assess in detail with FINMAP topographic maps, further analysis of flood water levels determined by FAP 25 and further modelling, the exact extent of the embankments required in order to ensure adequate protection for the FAP 3.1 area in the absence of the assumed developments within the PU2 area.

As regards to the Old Brahmaputra embankment, it is required in order to meet the four following objectives:

- to protect the major towns of the Project area, Dewanganj, Islampur and Jamalpur,
- to protect the elongated strip of agricultural land at the east of the highland area from Dewanganj to Jamalpur,
- to control the major natural openings connecting the Old Brahmaputra river to the central part of the Project area (Islampur inlet, Jhenai inlet) and the low laying area between Melandaha and Jhenai inlet.

3.4.2 Alignment of Embankments

The siting of the flood protection embankments is planned, subject to technical and economic viability, to protect a maximum percentage of the population, agricultural land, villages, railway lines and major access roads from destructive floods.

Therefore, it seems to make sense to locate the embankments next to the banks of the two rivers Jamuna and Old Brahmaputra (see Drawing 4). However, the placing of the embankments near to the Jamuna River and the Old Brahmaputra is limited by the risk of bank erosion due to the shifting of major flow channels and creation of new channels. In recent years severe bank erosion has occurred at Bahadurabad, Madarganj, Shoknagari and Jagannathganj by the Jamuna River and at Dewanganj by the Old Brahmaputra. These natural phenomena are not restricted to major flood events but are constant action which occur often during pre-monsoon, monsoon and especially during post monsoon periods. Therefore the embankments need to be sufficiently set back from the river to avoid additional river training works. The set back has been assessed in accordance with the recommendations of FAP 3 for a 20 year "guaranteed life" before river bank erosion is likely to threaten the embankments.

The second main principal of siting the alignment of any embankment dyke shall be, as far as possible, the use of existing embankment alignments at the banks of the rivers, access roads and the railway lines in order to reduce problems related to land acquisition.

It is not a precondition to locate the embankment alignment on top of the highest topographic points, since the differences in elevation in the area of concern are minimal and do not justify economically the siting of the embankments on an alignment passing through the highest topographical points.

The availability of construction material for the embankment is not a limiting factor in selecting the alignments. The embankment design can be adapted to the available material. The site investigations do not indicate any occurrence of unsuitable foundation conditions of the embankments along the alignment which would require diversion of the alignment.

Along the Jamuna River several flood protection embankment dykes have been constructed by different local authorities. The existing embankments are of varying standards of design and construction quality and have generally been built on a piecemeal basis. However, at many locations along the bank of the Jamuna River embankments are missing, are washed away or are in bad condition. At other locations, the existing embankments do not provide a straight alignment which is essential to reduce construction costs of new embankments. Access roads along the Jamuna River bank follow preferably the existing embankments. The alignment of the new protection dykes along the Jamuna River will follow more or less the existing dykes as long as they are in a straight economical line and the new embankments are not endangered by the vicinity of the river. A setting back of the alignment in areas where the Jamuna River erodes the left bank at the time being (mainly between Bahadurabad and the Chatal River) has been implemented. At Bahadurabad the location of the embankment will be in accordance with the river training and protection of the village as proposed by FAP 21/22.

Along the Old Brahmaputra the alignment of the protection dykes is near to the river bank and is not parallel to the straight railway line Jamalpur-Diwanganj, as initially considered, in order to protect as much land as possible. The alignment of the proposed embankment will neither use the embankment of the railway line nor the existing main road from Jamalpur to Diwanganj about 20% of which is newly constructed. Existing protection embankments are seldom found along the Old Brahmaputra right bank in the alignment of the proposed embankment. Therefore the alignment of the protection dyke will have to follow mainly elevated existing local roads and tracks to reduce problems of land acquisition.

At the southern boundary of the project area, the embankment alignment will run south of Jamalpur in order to protect Jamalpur and will join the railway line Jamalpur-Sarishabari west of Jamalpur. A topographic survey along the railway line indicated that the railway embankment is not high enough to avoid overtopping in case of a flooding of the area south of the railway by floods of more than a one in twenty return period. The alignment is to be constructed at the southern slope of the railway embankment to protect the railway and the project area north of it against flooding from the south. However, as mentioned in Section 3.4.1, it has been assumed that flood protection of the area south of the railway line will be constructed in the near future before the completion of the protection embankments of the project area. Therefore the embankment along the railway will not be necessary. Only the embankment between the southern end of the Jamuna embankment at Sarishabari and the Fertilizer Factory at Dayalpur west of the railway (Jamuna river side) will be required to link the Jamuna embankment with the new embankment south of the project area to be built by others.

The selection of the alignments for the protection embankments was based on an interpretation of the latest spot image satellite maps of the area which show clearly existing embankments and access roads and the actual river channels. The alignments selected by the study of the maps were verified by detailed field inspection.

The locations of the embankment alignments are shown on Drawing 4 and Figure 7.3.1.

3.4.3 Geotechnical Conditions

i) Regional Geology

Bangladesh has four distinct physiographic units and these are the Hilly Regions in the east, the Table Land in the centre, the Flood Plains in the centre and the Delta in the south (see Figure 7.3.4). The project area lies within the Madhupur Block of the Table Land in the flood plains of the Jamuna River and Old Brahmaputra River which cut through the rolling topography of the Table Land region. The Madhupur Block is located downstream of the Shilong basement block.

The Brahmaputra River rises in Tibet from the Chemayung-dung Glacier. It crosses Tibet and Assam along Pleistocene faults which separate Shillong and Dinajpur shields before entering the pleistocene Table Land of Bangladesh, which is considered to be part of the Dinajpur shield.

The floodplain was created after severe tectonic activities in 1767. In a period of about 50 years after this event the original Brahmaputra River was shifted from the area of the Old Brahmaputra towards the west to the existing Jamuna River bed, forming the flood plain on top of the Madhupur Block.

The clay formation of the Madhupur Block belongs to the Pleistocene Epoch and is the oldest exposed stratigraphic unit in the project area. The cohesive soils of this formation represent stable and relatively high land in the project area. Its boundary is clearly visible on SPOT Imagery. Madhupur Clay Formation has a maximum thickness of about 32 m and overlies with a discordance the Dupi Tila sandstone of Mio-Pliocene Age.

The river and flood plain alluvia of the Holocene Epoch are in the form of sandy silts, fine sands and silty clay lenses. These have largely replaced Madhupur Clay within the river channels and overlie it to varying degrees elsewhere in the flood plain areas.

The Madhupur Block is limited by the SW-NE striking Hinge Fault and the Meghna Fault, by SE-NW striking Karatoya/Banar Fault and Madhupur Fault. Faults parallel to these faults cross the project area. Also W-E striking faults parallel to the Main Boundary Thrust cross the area (see Figure 7.3.5).

A number of pleistocene faults, assumed to be still active, have been recorded in the vicinity of the project area.

ii) Geomorphology and Drainage

The project area is mainly a very flat flood plain dissected by rivers and secondary channels in the north and low rolling topography characteristic of Table Land in the southern part. Numerous silted up old river channels and natural depressions exist in the form of Beels in the area. The flood plain characteristic topography is extensively interrupted and to some extent dominated by man-made flood protection, roads and railway embankments. The natural ground elevation varies between 14 and 18 m + PWD.

The Brahmaputra River, divided into the Old Brahmaputra and the Jamuna River north of Diwanganj, is the main river draining the area. After passing the Shilong Block the Brahmaputra turns from an E-W flow direction to a more or less N-S direction (see Figure 7.3.4).

The main drainage channels within the project area are generally geo-structurally implemented with secondary channels appearing to be superimposed and may have their origins before the 1862 and 1882 tectonic uplift of Bangladesh. Of these, most important are Jhenai and Chatal channels which are now largely redundant with some flow occurring during monsoon and high floods. The presence of beels create micro-drainage systems which largely operate in relative isolation except those which are recharged by low flood waters. Within the project area, flood protection embankments and compartmentalisation largely obscures the natural drainage.

iii) Seismic Risk and Liquefaction Potential Assessment

Bangladesh is located on the northern edge of the Indian Plate which is characterised by subduction that has contributed to the oogenesis of the Himalayan Belt. The displacement rate caused by the Indian Plate underthrusting the largely stable Asian Plate is relatively high and as such is a potential source of catastrophic energy release through earthquakes.

The seismic activity in the project area may also be expected from tectonic source related to the subduction and from subsidence of the Bengal basin. The basin is subsiding between 1.5 mm to 21 mm per year due to a combination of physical and tectonic phenomena. The physical phenomena include consolidation of alluvial sediments under their own weight. The subsidence causes minor earthquakes with low energy release.

Several strong earthquakes have been recorded around the project area (see Figure 7.3.5) including the Shillong Earthquake of 1897 which caused wide spread destruction and liquefaction of alluvial deposits over a large area.

An earthquake in 1885, the epicentre of which was probably associated with the crossing of the Atrai and Hinge Fault, reaching 7 on Richter scale, is perhaps the most severe earthquake to have its epicentre within this country. Most of the recorded earthquake epicentres are located within Shillong Plateau.

A 30 to 50 year return period for an earthquake with magnitude of 7 has been considered for the study.

The estimated ground acceleration for Jamalpur area (see Figure 7.3.6) is 0.2 g for short return periods and 0.3 g for long return periods as reported by FEC (Prefeasibility Study for Flood Control in Bangladesh, 1989). The corresponding response accelerations of an earthfill dam compacted to 85% relative density are about 0.05 and 0.1 g, respectively.

Recent investigations on liquefaction of delta deposits has confirmed that earthquakes with a magnitude of 5 and over of sufficient duration can induce liquefaction in case the relative density is below 85%.

Earthquakes of this magnitude are a real possibility during the life time of the protection embankments. Therefore, it has to be taken into account that there is a potential of liquefaction of foundation soils in an event of a severe earthquake. However, considering the height of protection embankments as proposed with their relatively low bearing pressure, the risk of a failure of the embankments due to liquefaction of the foundation soil is low. No economic means of reducing this risk further is available.

Due to the high relative density of the proposed mechanically compacted protection embankments it can be concluded that slumping or sliding of embankment due to seismically induced liquefaction of the embankment fill materials is unlikely to occur.

3.4.4 Design Criteria

i) Foundation Conditions

The foundation conditions along the proposed embankment alignment have been investigated by 49 boreholes with a regular spacing of 2.5 km of 10 m depth with continuous sampling, SPTs, and permeability testing. Laboratory tests on disturbed and undisturbed samples were executed to obtain design parameters. The borehole locations are presented in the topographic map, Drawing 16.1, the simplified boreholes logs in the longitudinal sections along the embankment alignments, Drawings 16.2 to 16.7. The full detail of investigation is subject of a separate report entitled "Geotechnical Investigations and Topographic Survey Report" (R4). The results obtained from this report have been used as the basis for embankment and hydraulic structure foundation design.

The foundation along the Jamuna River is predominantly formed by fine grained alluvial soils. Considering the ever changing erosion and deposition regime of the river in the area, the alluvial deposits of the flood plain are relatively complex. It is, therefore, difficult to classify foundation materials into distinct and identifiable units. There are some transitional zones but mostly the changes are relatively abrupt representing changes in sediment load of the stream or interruption in depositional process. The foundation conditions vary from place to place. Therefore, only general foundation design criteria can be given. The definite foundation design mainly for foundation excavation will have to be adapted from case to case in accordance with the local conditions during construction.

Madhupur clay will form the foundation of the Jamuna embankment from the northern turning point of the embankment alignment from E-W to N-S direction through Bahadurabad to Belgachha, forming the relatively stable shore of the Jamuna River, and at some isolated areas further downstream.

The foundation along the Old Brahmaputra between the Jhenai River mouth and the area north of Diwanganj is formed by alluvial deposits with the same changes in the materials as along the Jamuna River, which does not allow a classification in distinct and identifiable units.

In the area between Jamalpur and the Jhenai River and other isolated locations along the alignment the foundation of the embankment is formed by Madhupur clay.

The foundation conditions at the hydraulic structures, which are described in detail in the Section 3.4 of the Geotechnical Investigations and Topographic Survey Report (R4), are similar to those of the embankments and are governed by alluvial deposits.

The geotechnical design parameters of the alluvial foundation material can be summarized as follows: the alluvial soils are poorly graded silty fine sand to sandy silt. There is an indication from the boreholes that in general coarsening of grain sizes appears with depth from silty material (ML to CL) to silty sand (SM) and poorly graded or single sized fine sand (SP).

The distribution of plasticity values for the foundation soils at Old Brahmaputra and Jamuna River is shown in Figure 7.3.7.

Within the alluvial deposits, frequent concentrations of fine to medium (maximum 3 mm length) mica flakes occur. These mica zones in places are 5-10 cm thick. The presence of mica is likely to increase deformable character of the foundation material.

From SPTs and in situ density tests it is proved that the alluvial soil is of low in situ density with a relative density far below 85 % (liquefaction potential).

The shear strength of the fine sandy-silty material is determined to be on the average of 27.5 degrees with a cohesion of 15 kN/m^2.

The Madhupur clay is a soft to stiff silty clay with intermediate to high plasticity. Occasional lenses of weathered ferruginous fine gravel-sized nodules and mica-rich fine to medium sand can be found. The average shear strength was determined to be in the range of 18 degrees friction angle with 25kN/m^2 cohesion for intermediately plastic clay and 15 degrees and 50kN/m^2 cohesion for highly plastic clay.

The foundation design parameters for the four following distinct areas along the embankment alignments are presented in Table 7.3.14:

Section 1: Ch.	0.00	-	10.00 km	Jamalpur to Jhenai River intake
Section 2: Ch.	10.00	-	32.50 km	Jhenai River to Islampur
Section 3: Ch.	32.50	-	72.50 km	Islampur to Chatal intak e
Section 4: Ch.	72.50	-	121.00 km	Chatal to Bayalpur.

The groundwater table in the project area is generally shallow, even in the dry season, and is in the range between 1 and 4.5 m below surface. The level depends upon to ground elevation and the level of neighbouring rivers. Tube wells in the vicinity of groundwater piezometers in recent boreholes may have influenced the water table. However, a relatively stable groundwater table was observed during the investigations.

A summary of the levels of the groundwater table in the boreholes along the embankment alignments is presented in Figure 7.3.8. These levels were measured during the dry season and may represent the lowest groundwater table. During the monsoon season the groundwater table will rise to the ground surface.

The permeability of the foundation soil has been determined in boreholes by constant head tests. The coefficient of permeability is on an average 10^{-6} to 10^{-7} m/s. The permeability of sandy soil (SM-SP) increases to 10^{-5} m/s and of clayey soil decreases to less than 10^{-8}m/s. A summary of permeability values from boreholes along the embankment alignment is presented in Figure 7.3.9.

The groundwater quality was chemically analysed using water samples collected from boreholes on each proposed hydraulic structure site. A summary of test results is given in Table 7.3.15.

The groundwater quality in the project area is totally devoid of industrial pollutants, is not critical in the context of embankment construction and is not likely to have any deleterious effects on reinforced concrete used in hydraulic structures or on piled foundations.

ii) Construction Material

For economic reasons it is envisaged that embankment construction materials will be taken from borrow areas which are located along the embankment alignments.

To obtain an embankment with some sealing characteristics it is recommendable to use as far as possible more silty to clayey material. From the boreholes it is known that silty material is predominant in the upper 2 m of the soil profile. Therefore the material in the borrow areas should be excavated to a depth of about 2 m.

The exploited borrow areas will not be lost for agricultural production. Shallow borrow areas can easily be reclaimed for rice paddies since the excavated level will be, in most cases, above the groundwater table. Cleared topsoil can be placed on top of the exploited area. In case of a higher groundwater level than the exploited depth of the borrow area, the borrow pit can be used for fish farming. Artificially flooding of borrow areas could also provide ponds for fish farming.

The type of re-use of exploited borrow areas can be decided during the detailed design phase or during construction through public participation.

The construction materials in the borrow areas in the alluvial deposits seldom vary in general terms as to their properties.

For the embankments along the Old Brahmaputra and the Jamuna River four zones of borrow areas can be identified:

Borrow 1:	Ch. 0.00	-	10.00 km	Jamalpur to Jhenai River intake
Borrow 2:	Ch. 10.00	-	32.50 km	Jhenai River to Islampur
Borrow 3:	Ch. 32.50	-	72.50 km	Islampur to Chatal intake
Borrow 4:	Ch. 72.50	-	121.00 km	Chatal intake to Bayalpur

A summary of the average soil design parameters of the above 4 borrow areas is given in Table 7.3.16.

In general, the construction material of the alluvial deposits are silty sand to sandy silt (ML to MI material). Below a depth of about 2 m the construction material changes into sandy material (SP).

In areas with Madhupur clay, the construction material is a clayey silt with an average clay content between 6 to 20 %.

The average grain size distribution of the construction material in the 5 borrow areas is presented in Figure 7.3.10.

The average plasticity values of the construction material are shown in Figure 7.3.11.

The maximum dry density (Proctor density) of the alluvial construction material is in the range of 14.6 to 16.5 kN/m^3. The optimum moisture content is slightly below the natural moisture content of 15 to 23 % (see Figure 7.3.12).

Consolidated drained triaxial tests carried out on intermediate plasticity silty clays yielded the following results:

Cohesion: 24 kN/m^2
Friction: 18°

For high plasticity clays (CH) the results are:-

Cohesion: 48 kN/m^2
Friction : 10°

For cohesive material average values of cohesion 25 kN/m^2 and of friction angle 15° is considered.

For silty-sandy construction material the friction angle is assumed to be 27.5 degrees and the cohesion 20 kN/m^2 based on relevant test results.

The coefficient of permeability determined from the constant head tests are generally about 10^{-6} to 10^{-7} m/s for silty sand to sandy silt. The permeability of soils occasionally increases to 10^{-5} for SM-SP soils. For clayey material it decreases to values below 10^{-8} m/s. Similar or slightly lower permeability must be expected from reworked and compacted fill material.

iii) Use of Existing Embankments

Numerous embankments constructed by various agencies exist on the proposed Old Brahmaputra and Jamuna embankment alignments. These were inspected and evaluated in detail to determine their adequacy for incorporation into the proposed embankments. Actual construction methods were also observed to determine the adequacy of manual compaction and placement methods.

A detailed inventory and assessment of the existing embankments is given in the Geotechnical Investigation and Topographic Survey Report (R4). In-situ density testing was also carried out to determine relative compaction of the existing embankment materials. The average properties of the existing embankments are summarized in Table 7.3.17.

The compaction of these embankments in places is extremely poor due to manual fill placement methods which do not involve any compaction except pedestrian traffic. With a few exceptions the relative density of the fill material of the existing embankments is below 85 %. The placement of the fill material is also not done in horizontal layers but in inclined layers on the embankment slopes. It is a kind of battering of fill pile, shaping and raising it as the work progresses. The fill material, because of the mode of placement of material, is frequently sheared leaving preferential seepage paths and low density zones.

The in-situ density and Proctor tests carried out on the existing embankments indicated that the relative density is in general less than 85%, the relative density which is required to avoid liquefaction during seismic events when saturated. It may be noted that the embankment sections currently under construction at various locations may have significantly lower density than those which have undergone consolidation due to dissipation of pre-pressures and consolidation under self weight.

Because of their poor quality and their actual condition the existing embankments are not adequate to be used as an integrated part of the new protection embankments. None which are located on the alignment of the proposed protection embankments can be used without reconstruction. The existing embankments are in an extremely bad condition due to various reasons including:

- overtopping of the dyke due to insufficient height of the embankment and following erosion of the unprotected dyke slopes,
- erosion and undercutting of the embankment dyke by flood water with considerable high flow velocity, by scouring or by wave action, due to insufficient protection of the dyke upstream slope and toe,
- insufficient stability of the embankment slopes and regressive erosion by seepage at high hydraulic gradient through and beneath the dyke due to inadequate design of the embankments and poor construction,
- weakening of the embankments by human action like cutting of the embankments to allow drainage of inundated land, to provide irrigation water, to allow passage of boats and fish or to use the embankment material for other purposes.

The embankments are undercut by erosion of the rivers or by human action (increase of rice paddy or use of construction material). They are flattened or totally removed by erosion, instability or human action. The remaining embankment sections have in most cases slopes with inclinations of 1:1 to 1:1.5 which keeps the embankment slopes in a sensitive equilibrium without any safety against sliding in case of loading by flood water and seepage forces. The volume of the existing embankments in the proposed embankment alignment is less than 10 % of the volume of the proposed embankments. The height of the existing embankments is in general below the level of a 100 year flood or even below a 50 year flood. The condition of the existing embankments and their height in relation to the required height of protection embankments can be seen from Drawing 16.1 to 16.7.

Strengthening and upgrading of the existing embankments to be incorporated in the new protection embankments is considered to be technically unfeasible because of the poor existing quality and to be more costly than their removal and the construction of totally new embankments. Therefore, the excavation of the existing embankments and the re-use of the material in the construction of the new protection embankments is recommended. In the case of the new embankment to be built along the railway embankment between Jamalpur and Dayalpur, the protection embankment should be located at the southern toe of the railway embankment in order not to interrupt the railway traffic during construction. The railway embankment would be used as a support for the new embankment.

iv) Embankment Design Principals

A proper and adequate design is the first and principal approach for stable protection embankments. However, the application of relevant and effective construction methods as well as proper preventive and periodic maintenance of the embankments are of equal or greater importance.

Taking into account the nature of the construction material available nearby as well as the foundation conditions, the embankments are designed with adequate crest width and side slopes to provide stability against loading caused by: normal and extreme loading by high water level on the upstream (river) and downstream (country) sides of the embankment, seepage water forces, seismic events and possible traffic on the crest.

Special sealing of the embankments will not be required since the purpose of the embankments will not be long term storage of water but protection against flooding during a relatively short period. Therefore homogeneous embankments have been designed.

For economic reasons no upstream slope protection is to be provided for most of the embankments (Design Alternative 1). Only those embankments which will undergo regular yearly inundation during the monsoon season with a maximum average yearly flood level of more than about 2.00 m above the upstream embankment toe should be protected against erosion and scouring because of increased risk of wave attack and seepage through and beneath the embankment. These embankments should also be provided with a drainage layer at the downstream toe for controlled drainage of the embankment (Design Alternative 2).

v) Embankment Slopes

In accordance with the BWDB standards the embankment slopes will have inclinations of 1v:3h on the upstream (river) side and 1v:2h on the downstream (county) side.

vi) Design Flood Levels

Long term gauging of both the Jamuna and the Old Brahmaputra River does not exist. Therefore the estimation of flood levels for the design of the embankments is based on the recorded level of the 1988 flood. It is considered that this flood represents a flood with a return period of 50 to 60 years. The 100 year flood level is about 0.40 m above the 1988 flood level. The 20 year flood level is assumed to be 0.25 m below the 1988 flood level.

With the Jamuna left embankment as proposed under Option B5, with the proposed Jamuna bridge in place and all FAP embankments implemented it has been predicted by FAP 25 that the water level of the 50 years flood (1988) will rise by 0.74 m at Dayalpur and by 0.07 m at Bahadurabad.

Figure 7.3.13 gives the 1988 flood levels at various locations of the project area as was used in the preparation of quantity estimates for the embankments. Subsequently, at the end of September 1992, updated flood water levels had been received from FAP 25 after completion of the quantity and cost estimate. It is estimated that the new FAP 25 levels will result in an increase in the costs of the Jamuna embankment of about 7.5%, and in the total Option B5 costs of about 3.5%. This cost increase has not been incorporated in the cost estimates or economic analysis prepared for this report. However it may be noted that a physical contingency allowance of 10% has been made.

As a matter of urgency, uniform instructions were issued by FPCO to all FAPs regarding design water levels for flood embankments. The instructions require a 100 year return period design water level for all embankments on external rivers and a 50 year standard for all internal rivers. These are acceptable design criteria which have been applied.

From records since 1964 mean annual maximum flood levels were elaborated for some locations of the project areas and are shown in Table 7.3.18.

vii) Design Tailwater

It has to be considered in the embankment design that the land on the downstream side of the embankments is flooded by monsoon rain water and controlled flooding from the two rivers Jamuna and Old Brahmaputra for the purpose of irrigation and fish farming in the beels. Therefore a tailwater on the country side of the embankments has to be taken into account in the design.

Without compartmentalisation of the project area it is assumed that the tailwater will have a level of:

- 00 to 30 cm above ground surface in high elevated land
- 30 to 90 cm above ground surface for medium elevated land
- 90 to 180 cm above ground surface for low elevated land.

However, in order to take account of possible future compartmentalisation a tailwater level of 1 m above the ground surface has been used in the designs.

viii) Embankment Height and Freeboard

The safety of an embankment dyke is governed to a great extent by the embankment height and the freeboard above the design flood level. Only full height embankments have been considered in the design so that they will not need to withstand overtopping. Embankments cannot be designed safely for overtopping using the available fine grained construction material. Embankment overtopping would result in frequent erosion damage with high annual levels of repair and maintenance costs, which could easily be as much as 30 % of the capital cost.

The crest levels for flood protection embankments have been determined on the basis of the computed design flood level for the selected frequency of occurrence with the addition of the requisite freeboard. The frequency of occurrence of floods is selected to be 1 in 100 years for Jamuna and the southern limit embankment, and 1 in 50 years for Old Brahmaputra embankment. Sensitivity investigations have also been made on 50 year and 20 years levels (see Section 3.4.7).

A rational determination of the freeboard may be based on the height and run-up of waves. Considering the relatively large flooded area of the Jamuna river bed with a fetch of at least 10 km and a westerly wind with an average velocity during monsoon periods of 14.8 km/h (8 knots) and maximum wind velocities up to 320 km/h which occur normally at the end of the dry season when floods are unlikely to occur, a freeboard of 3 m would be required according to a calculation using the formula given in BWDB-embankment standard.

Considering a flooded area of 3 km on the landside (downstream) side of the Old Brahmaputra embankment and a westerly wind with an average velocity of 14.8 km/h (8 knots) a freeboard of 2.46 m would be required.

However, freeboards of this height are excessive taking into consideration the relatively low height of the embankments. Where wind and fetch data are not available, the BWBD standard recommends to apply freeboards recommended by USBR which will be a freeboard of minimum 2.00 m for the Jamuna embankment and about 1.40 m for the Old Brahmaputra embankment. Since the average wind velocity of the project side is less than the one considered for the application of USBR's recommended freeboards, a freeboard of 1.50 m above the 100 year flood level has been applied for the protection embankments along the Jamuna from Diwanganj to Sarishabari. This is considered to provide sufficient safety against damage to the embankment crest in case of overtopping taking into account also the wide embankment crest (see below).

A freeboard of 1.10 m above the 1/50 years flood level is considered sufficient for the protection embankments along the Old Brahmaputra between Jamalpur and Diwanganj, which are less exposed.

To prevent flood water from the flooded areas north or south of the railway between Jamalpur and Sharishabari from overtopping the

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embankment, a freeboard of 1.10 m above the 1/50 years flood level, is recommended.

As regards to the protection embankment between Sharishabari and the Fertilizer factory, it should be underlined that it will be part of the Jamuna left bank embankment to be constructed under FAP 3.1 and FAP 3.2.(PU 2 of the NCR) Therefore, as a matter of consistancy, this embankment has been designed with a freeboard of 1.50 m above the 1/100 years flood level, on the same basis as the criteria be used for the design of Jamuna embankment.

The USBR recommends that the freeboard should, under no circumstances, be less than 3 ft (91 cm) for a full flood protected embankment. This recommendation has been conformed with as described above.

ix) Bank Top Roads and Crest Width

For maintenance purposes it is advisable that year round access is possible along the major embankments. For this provision has been made in the cost estimates for a 3.5 m sand-gravel track along each alignment. This should be considered a minimum requirement and represents the standard adopted in the base case of the economic analysis. Notwithstanding this, higher standards of road to permit public vehicles access may be considered as beneficial additional investments. If the road is to be used local feeder road with only light traffic or even as an main access road the crest road can be constructed as a sand-gravel paved road. For a highway with frequent traffic of motorcars and trucks a bituminous paved road is preferable (see Drawings 16.8 and 16.9). In accordance with Bangladesh standards, which are acceptable to the consultant in both cases, a firm base and sub-base layer of a mixture of sand and khoa has to be provided. For a bituminous pavement the base and sub-base layer would be stabilized by a 0.25 m thick brick layer on both sides. However no bituminous paved roads have been allowed for in the alternative cost estimates. Both types of road have a standard width of 5.00 m. This width is required to allow passing of two trucks. It is in the range of BWDB standard, which requires a width between 4.25 and 5.50 m. The shoulders of the crest are formed by a sand-khoa mix with turfing.

It is recommended that consideration of the type and size of crest roads be given during detailed design on the basis of investments which are justifiable with respect to the transport benefits generated. It may be appropriate to then recommend a phased construction of the roads involving initial construction of a maintenance tract with subsequent upgrading to higher standards at a later date as traffic increses. Such justifications would require an appreciation of current and future numbers and types of vehicles, axle loads etc, the study if which is beyond the current TOR.

Along the Jamuna, it is proposed and considered in the feasibility to provide a crest width of 7 m with a 3.5 m sand-gravel paved road. This standard is consistant with the standard applied to the existing right bank embankment along the Jamuna and is considered appropriate to a structure of this magnitude and importance.

Along the Old Brahmaputra it is proposed, and considered in the feasibility, to provide crest width of 4.5 m with a 3.5 m sand-gravel pared track.

Between Jamalpur and Sarishabari, if required in this location, it will be sufficient to construct a protection embankment, if required in this location, with a crest width of 4.50 m. The crest width of 4.50 m will allow a 3.5 m wide sand-gravel paved road for maintenance.

x) Seepage

Seepage through and beneath the embankments has to be expected when the upstream (river side) slope is inundated during floods.

The seepage line through the embankments has been calculated for stability analysis in accordance with the method of Kozeny-Casagrande.

The critical seepage beneath the embankment is calculated for a weighted creep ratio of about C_w = 7 to 8 after Lane for silt to fine sand.

xi) Seismic Factor

For the embankment design seismic factors of k_h=0.10 and k_v=0.07 have been considered according to the probable ground acceleration of the project area..

3.4.5 Embankment Design

The embankment design follows the design criteria as given above. The standard designs for the various alternative embankment sections and roads are presented in Drawings 16.8 to 16.10.

The protection embankments on the different alignments have been designed as homogeneous embankments using sandy to silty sandy alluvial material from nearby borrow areas. According to the predominantly available sandy-silty construction materials, which governs the choice of embankment side slopes, the upstream (river side) slope is to be inclined at a slope 1v:3h and the downstream (country side) at a slope of slope 1v:2h. In a few locations, where only clayey construction material is available, the downstream (country) side slopes will be flattened to the same slope of 1v:3h as the upstream (river) side slope. This is necessary because of the relatively low shear strength of the clayey fill material.

The embankments have been checked for stability against slipping by calculations on the basis of results from laboratory tests on the construction materials using a computerised Modified Bishop Method (see below).

The height of the embankments varies from place to place along the alignments in accordance with the foundation elevation, the design flood levels and the selected freeboards as described above. The height of the embankments along the alignments can be seen in Drawings 16.1 to 16.7 which show the crest level of the embankment, the foundation level, the 88 flood level and the level of the existing embankments .

The proposed embankment along the Old Brahmaputra will have a minimum height above ground level of 0.55 m near to Islampur and a maximum height of 6.40 m at the Jhenai River crossing. The average height will be 3.08 m. The proposed embankment along the Jamuna will have a minimum height of 2.50 m north of Diwanganj and a maximum height of 7.50 m south of Madarganj. The average height will be 4.92 m. The embankment along the southern railway line has a height between 2.60 m and 4.85 m with an average height of 3.61 m for the section Jamalpur-Sarishabari and 3.85 m between Sarishabari and the Fertilizer Factory.

Two different embankment designs have been used as follows:

- Embankment Alternative 1 (see Drawing 16.8)

  Alternative 1 embankments have been designed for situations where the difference between the foundation level and the design flood level is less than 4.00 m. These embankments will therefore have a height of less than 5.10 m where the freeboard is 1.10 m or of less than 5.50 m where the freeboard is 1.50m. Regular yearly inundation during the monsoon season will usually be less than 2 m above the upstream (river side) embankment toe. About 85 % of the embankment length will be constructed according to alternative 1 design.

  Alternative 1 has two variants according to the required crest width. Alternative 1a is for embankments with a crest width of 7.00 m. Alternative 1b is for embankment with a crest width of 4.50 m.

- Embankment Alternative 2 (see Drawing 16.9/16.10)

  Alternative 2 embankments will be constructed where the difference between the foundation level and the design flood level is more than 4.00 m. These embankments will be higher than 5.10 m where the freeboard is 1.10 m and of more than 5.50 m where the freeboard is 1.50 m. It is estimated that only be approximately 15 % of the embankment length will be constructed according to alternative 2 design.

Alternative 2 has two variants according to the required crest width. Alternative 2a (Drawing 16.9) is for embankments with a crest width of 7.00 m. Alternative 2b (Drawing 16.10) is for embankment with a crest width of 4.50 m.

For the Alternative 1 embankments the upstream (river side) and downstream (country side) slope will be protected only by turfing. The use of Vetivar grass rather than local turf may be considered at the detailed design stage. Neither a key trench at the upstream toe to extend the seepage path beneath the embankment and to provide protection against scouring nor a drainage layer at the downstream toe will be provided.

For alternative 2 type embankment, only the downstream (country side) slope is turfed. As in the case of the alternative 1 embankments, Vetivar grass may be considered in place of local turf at the detailed design stage. The upstream (river side) slope is to be protected by a 15 cm thick layer of interlocking concrete blocks. The blocks will be placed on top of a filter layer in order to prevent erosion and scouring beneath the blocks and to avoid washing out of embankment fill material during the draw down of flood water on the upstream (river side) face of the embankment. Because of the lack of natural filter material in the vicinity of the embankment alignments, a geotextile filter (300 to 400 g/m^2) is to be installed. The geotextile will be anchored into the embankment fill. The geotextile will then prevent erosion of the key trench fill material in case of scouring at the embankment toe. In case of scouring beneath the key trench the sausage like key trench fill with geotextile will be displaced as a whole into the scored hole and would reduce further scouring. The purpose of the key trench is to provide a protection against scouring at the toe due to annual floods but also to extend the seepage path beneath the embankment. A trench with a depth of half the embankment height is adequate to meet the requirements of the weighted creep ratio according to Lane.

Since flood water will inundate the upstream (river side) embankment slope, seepage through the embankment has to be considered. Therefore a drainage layer in the downstream (country side) embankment toe has been designed for alternative 2 embankments only. In the absence of local sources of suitable granular drainage material a geodrain (highly permeable geogrid with a geotextile filter on both sides) has been allowed for. The horizontal length of the geodrain of at least half of the embankment height is required in accordance with stability calculations (see below). The geodrain is to be installed just above the tailwater level to allow free drainage also during controlled flooding of the project area. The geodrain extends down the country side slope to the embankment toe. To protect the geodrain and allow free drainage, it should be covered by a brick layer with openings.

3.4.6 Embankment Stability Analysis

Stability calculations have been executed to confirm the safety of the embankments.

The following loading cases have been considered:

i) Downstream (country side) slope

- case 00: no flooding, no tailwater
- case 01: high flood level, seepage through the embankment, no tailwater, no downstream drainage;
- case 02: high flood level, seepage through the embankment, no tailwater, downstream drainage;
- case 03: high flood level, seepage through the embankment, tailwater at 1 m, no downstream drainage;
- case 04: high flood level, seepage through the embankment, tailwater at 1 m, downstream drainage;
- case 05: yearly flood level, seepage through the embankment, no tailwater, no downstream drainage;
- case 06: yearly flood level, seepage through the embankment, no tailwater, downstream drainage;
- case 07: yearly flood level, seepage through the embankment, tailwater at 1 m, no downstream drainage;
- case 08: yearly flood level, seepage through the embankment, tailwater at 1 m, downstream drainage;
- case 09: no flooding, no tailwater, seismic loading, $k_h=0.1/k_v=0.07$;

- case 10: yearly flood level, seepage through the embankment, no tailwater, no downstream drainage, seismic loading, $k_h=0.1/k_v=0.07$;

- case 11: yearly flood level, seepage through the embankment, tailwater at 1 m, downstream drainage, seismic loading, $k_h=0.1/k_v=0.07$;

ii) Upstream (country side) slope

- case 20: no flood,

- case 21: high flood level, seepage through the embankment;

- case 22: yearly flood level, seepage through the embankment;

- case 23: yearly flood level, seepage through the embankment, slope protection and key trench

- case 24: no flood, seismic loading $k_h=0.1/k_v=0.07$;

- case 25 high flood level, seepage through the embankment, seismic loading $k_h=0.1/k_v=0.07$;

- case 26: yearly flood level, seepage through the embankment, seismic loading $k_h=0.1/k_v=0.07$;

- case 27: yearly flood level, seepage through the embankment, seismic loading $k_h=0.1/k_v=0.07$, slope protection and key trench.

The calculations were performed using a tested computer programme which applies the modified Bishop method (slip circle method).

The critical slip circles and the corresponding safety factors "ETA" are presented in Figure 7.3.14.

In Table 7.3.19 the results of the stability calculations are summarized. The calculated safety factor of stability against slipping are compared with those recommended. The safety factors do not give any indication for stability against erosion attack by flood water.

The required safety factors are based on the probability of occurrence of the load case. High flood as well as seismic loading have a small probability and therefore a smaller required safety factor.

For all calculated load cases for the upstream (river side) embankment slope the recommended safety factors are fulfilled by the calculated ones. For the downstream (country side) slope the required safety factors are achieved for all the critical load cases. It will be noted that the low safety factors calculated for cases 03 and 07 demonstrate the need for the downstream drainage included in the alternative 2 design. In case 08 there is small shortfall compared to the recommended safety factor, but this is considered acceptable at this stage. In case of seismic loading, the recommended safety against slipping is achieved.

All the stability analysis discussed above relates to an embankment height of 6 metres. Further analysis using a range of actual embankment heights will be required at the detailed design stage.

3.4.7 Quantity and Cost Estimate

i) Quantity Estimate

Detailed quantity estimates were performed for the flood protection embankments. The quantity estimates were done for the following embankment sections:

Embankment 1	along the Jamuna left bank between Diwanganj (Ch.43,170), Bahadurabad (Ch.53.900) and Sarishabari (Ch.117,029),
Embankment 2	along the Old Brahmaputra right bank between Jamalpur (Ch.0) and Diwanganj (Ch.43,170),
Embankment 3	along the Railway between Sarishabari (Ch. 117,029) and Jamalpur (Ch. 144,268),
Embankment 4a	along the left bank of Chatal River between Sarishabari (Ch.0) and Dayalpur Fertilizer Factory (Ch, 8,240),
Embankment 4b	along the Railway Dayalpur F.F. (Ch. 8,240) and Sarishabari (Ch. 16.480).

The quantity estimates are based on a detailed topographic section along the embankment alignments. The alignments were split into about 170 individual sections with more or less similar foundation levels for the detailed quantity estimates.

The embankment volume per running meter was obtained using the cross-section with 1v:3h upstream slope and 1v:2h downstream slope, a crest width of 7 m or 4.50 m as may be the case, and the height of the embankment. The height is composed of the height between the foundation level and the flood level and of the freeboard. For cost comparison the following embankment heights were considered:

1988 flood level + 40 cm (100 years flood) + freeboard
1988 flood level (50 years flood) + freeboard
1988 flood level - 25 cm (20 years flood) + freeboard.
1988 flood level - 45 cm (10 years flood) + freeboard.

The freeboard is 1.5 m along the Jamuna river and 1.1 m along internal rivers.

The quantities of the following individual construction items were determined separately:

- embankment fill material,

- crest gravel paved road,
- key trench excavation,
- key trench backfill,
- geotextile for filter layer beneath concrete block of u/s slope protection,
- geodrain in the d/s embankment toe,
- geotextile for reinforcing the key trench at the u/s embankment toe,
- concrete block of u/s slope protection,
- turfing

Key trench excavation and backfill, u/s slope protection and downstream drainage layer (geodrain) were only considered in the quantity estimate for the alternative 2 embankments. Alternative 2 embankments are required for about 5% of the length of the Old Brahmaputra embankment and for about 19% of the Jamuna embankment, which represents 13% of the total length of embankments 1, 2 and 4a.

The embankments will follow more or less the alignments of existing river protection embankments and road embankments. These existing embankments have to be removed because of their weakness. Therefore, additional stripping and excavation of the embankment foundation will not be necessary. The cost for the excavation of the material of the existing embankments is deemed to be equal to the saving in new fill resulting from the re-use of the material.

ii) Cost Estimate

The cost estimate is based on the elaborated detailed quantities and individual unit prices for the different construction materials and embankment zones. The basis of the unit rates are:

- Schedule of Rates for Mymensingh O&M Circle by BWDB. Prices are of 1989. For 1991 prices the unit rates have been multiplied by 1.15 i.e. 15% inflation increase in two years.

- Schedule of Rates for Road Works by Roads and Highway Department (RHD), Dhaka Zone (incl.Jamalpur). The prices have also been multiplied by 1.15 to account for inflation.

- Unit Prices for Geotextile etc. obtained from Suppliers and/or contract prices including shipping and placing.

The increase of the 1989 BWDB prices by 15% in two years is based on a joint assessment and proposal of FAP 3.0 and FAP 3.1 which was prepared on May 7th in reply of an request of FPCO for general use.

The unit prices (price level 1991) are shown in Table 7.3.20.

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A detailed analysis of unit rates from recently awarded contracts has been carried out (see para 3.7) as a result, a possible cost increase of capital cost during tendering period has been assessed and taken into account for economic sensitivity analysis (see annex 8 on Economics)

For the base case involving a sand-gravel paved maintenance track, a global unit price of Tk 485 per running meter of embankment was applied. For the gravel-paved road with base and sub-base layer a global unit price of Tk 1,477.55 per running meter of embankment was calculated, based on the individual unit costs as given in Table 7.3.20.

A detailed study was carried out to determine the effect of the possible embankment heights on the project profitability (see the results in annex 8 on economics). The Tables 7.3.21 to 7.3.24 were established for this specific purpose, they recapitulate costs based on detailed quantity estimates, excluding land acquisition, contingencies and engineering costs.

The selected individual embankment sections used for comparison of possible alternatives are as follows:

Emb 1	-	embankment along Jamuna river
Emb 2	-	embankment along Old Brahmaputra river
Emb 3	-	embankment along Jamalpur/Sarishabari railway

The costs for the recommended alternative Options B used for the determination ofthe optimum embankment height are summarised in Table 7.3.25.

In Table 7.3.26 the quantities and costs are summarised for the recommended embankment heights Alternative B5, for the following individual embankment sections:

embankment 1: embankment along Jamuna River with 1.50 m freeboard above 100 year flood level, total length 73,859 m

embankment 2: embankment along Old Brahmaputra with 1.10 m freeboard above 50 year flood level, total length 43,170 m

embankment 4a: embankment along left bank of Chatal River between Sarishabari and Bayalpur Fertilizer Factory, with 1.50 m freeboard above 100 year flood level, total length 8,240 m.

3.4.8 Recommendations for Detailed Design of Embankments

The geotechnical investigations already completed for the assessment of the foundation conditions and construction material borrow areas along the proposed embankment alignments and at the locations of hydraulic structures are considered adequate to produce the detailed design.

Due to a very comprehensive geotechnical investigation programme during the Feasibility Study stage, additional geotechnical investigations required for the Detailed Design stage will only be required if the recommended Option B, alternative 5 is revised. For example, the following investigations may become necessary:

- 10 m deep boreholes with SPTs, permeability tests (constant head) and sampling with a spacing of 2.5 km along the proposed embankment alignment from Jamalpur to Bayalpur along the railway line.

- execution of laboratory testing on disturbed and undisturbed samples from above boreholes to determine soil parameters like: grain size distribution, Atterberg limits, in-situ density, Proctor values, triaxial and shear box shear-strength values;

- additional borings and laboratory testing similar to the above if special foundation methods for the hydraulic structures are found to be necessary;

- additional borings and laboratory testing similar to the above in case of a relocation of the proposed alignment of the embankments and of the hydraulic structures during the detailed design.

The embankment alignments and the location of the hydraulic structures have been fixed on maps and in the field, topographic survey has been executed for them and the alignment is marked by concrete blocks in the field. However, some minor changes of the alignments at locations of the hydraulic structures may be required as a result of the detailed design. These would result in the need for further limited topographic survey.

The detailed design of the embankments will require detailed cross-sections of the embankments with reassessment of slope protection, key trench and drainage layer for various locations along the alignments, especially at river crossings and in connection with hydraulic structures. As indicated earlier, studies should be made of expected traffic along the embankments and appropriate designs for bank top roads should be finalised.

A detailed quantity and cost estimate is necessary based on the finally adopted detailed design of the embankments and the finally elaborated flood levels.

Technical specifications for the construction of the embankments has to be prepared, including a bill of quantities.

3.5 Hydraulic Structures

3.5.1 Introduction

Two types of hydraulic structures have to be constructed:

- major hydraulic structures comprising inlet and outlet structures which will provide for fairly large discharges. Five structures of this type are envisaged.

- minor hydraulic structures (flushing sluices) constructed along the embankments at specific locations for the management of flood water. These would be required in areas where water from the rivers previously flooded the project area along the Jamuna and the Old Brahmaputra, to prevent farmers breaching the embankment during periods of water shortage. They may also be used as drainage outlets to relieve flooding within the project area if river levels permit. From the embankment long sections, 46 such locations have been identified and an additional nine, making a total of 55, have been included in the cost estimates.

Discharges of the major hydraulic structures, as justified in the following paragraphs are as follows:

Islampur inlet	15 m^3/sec	under 0.2 m head
Chatal inlet	130 m^3/sec	under 0.25 m head
Jhenai inlet	115 m^3/sec	under 0.25 m head
Jhenai/Chatal outlet	400 m^3/sec	under 0.25 m head
Bausi Bridge outlet	50 m^3/sec	(not included in the project components as part of FAP 3 programme)

Discharges at flushing sluices will be between 1 and 2 m^3/sec at for head difference between 0.25 m and 1 m.

During the study, the consultant was asked to check, if it was possible to avoid the Jhenai/Chatal outlet thanks to an alternative arrangement with low return embankments along the Chatal river. As suggested by the flat natural topography along the river and as felt by the consultant, this alternative is obviously more costly than the proposed option and without taking into account the drainage structures that would be needed at numbers of locations. This alternative was rapidly discarded.

3.5.2 Sizing of Inlet Structures

The design philosophy of option B is that of controlled flooding which acknowledges the need for inlet structures within the protection embankment to permit inflow of water from the boundary rivers. The purposes of allowing such inflows include:

- enabling current field practices reliant on river flows to continue as before
- maintenance of navigation within the internal river system
- partial mitigation of impacts upon riverine and (to a lesser extent) flood plain capture fishery
- maintenance of stable channels for drainage purposes
- minimisation of reductions in groundwaters recharge resulting from reduction in annual flooding
- partial mitigation of reduction of silt and sediment entering the fields

In the JPPS area none of these requirements are easily quantifiable in meaningful manner, although they are recognised collectively as being important and necessitating provision of inlet structures. Thus, in order to establish a basis for hydraulic design of these structures it has been considered that they should be set at a size consistent with maintaining bank full conditions in the downstream channels with a low afflux (0.25 m) with the structure operating under drowned condition. A low value for afflux was taken to velocities within reasonable limits given the requirements above.

As a matter of reference, BWDB design afflux for sluice structures is of the same order and even less (0.5 feet).

At preliminary design level, it is therefore necessary to consider the river capacities downstream the 3 major inlet structures.

On the basis of the longitudinal profiles and cross sections obtained from the NCRS for the Jhenai and Chatal river, and on the basis of the topographic surveys carried out during the JPPS, the river capacities have been calculated, section by section for the average slope of the river. As a result, the following minimal and maximal normal specific capacities have been found:

- Patharkata river - from the Old Brahmaputra river to the junction with the Madardhaw river: theoritical capacities of individual sections vary from 15m^3/s to 25m^3/s.

- Chatal river - from the Jamuna river to the junction with the Jhenai river: theoritical capacities of individual sections vary from 70m^3/s to 190m^3/s

- Jhenai river - from the railway bridge to the junction with the Chatal river: theoritical capacities of individual sections vary from 100m^3/s to 300m^3/s

Discharges conveyed by the internal river system during monsoon result from the following sources

- water from the major inlet structures. When the gates are fully open, the maximum discharge depends on the available head given by U/S and D/S water level conditions at the structures.

- water from the flushing structures located along the embankment (55 structures with an average of 2m^3/s each).

- water from the rainfalls which is drained from highest paddy fields to the river system.

Therefore the maximum capacity of the inlet should not necessarily match the maximum river bed capacities. The flushing structures represent a total discharge of 110m^3/s admitted within the project area. The average rainfall in June which is about 300mm represent an additional discharge of 75m^3/s within the project area.

At preliminary design stage, and for planning purpose, the following sizes were proposed and checked with the model operation:

Inlet	Number of vents	Nominal * discharge for 0.25m head	Maximum discharge as per model (1977)	Channel capacity m³/s min	max
Islampur	1	15	12	15	25
Chatal	8	130	150	70	190
Jhenai	7	115	210	100	300

* to calculate number of vents.

There is therefore consistency between the required discharges and the proposed structure sizes.

3.5.3 Operating Conditions of Inlet Structures

Water levels in the rivers, at the location of the inlet structures, have been calculated for 3 return periods (1:1.25, 1:2, 1:5) and per decads. These levels were plotted versus time with the representation of the invert level and bank level of the channel downstream the inlets (See Appendix A)

Further analyses were undertaken on the major inlet structures on the Jhenai and Chatal rivers to investigate their performance under average conditions during May and June when the main rivers are rising. Using simplified relationships to describe downstream levels which assume normal flow within the rivers, comparisons were made of the discharges under increasing head to the selected ventages and alternative sizes of these structure, both larger and smaller. The results are shown graphically in Appendix A and are summarised below for the end of June just before gate closure would be expected to happen:

	No of Vents	Reduction of existing discharge	Variation on Base Cost	Remark
Jhenai Inlet	9	12.1%	125%	
	7	17.4%	100%	Selected size
	5	26.4%	75%	
	3	42.6%	50%	
Chatal Inlet	10	19.5%	122%	
	8	25.6%	100%	Selected size
	6	34.5%	78%	
	4	47.7%	56%	

If 20% reduction n discharge is considered acceptable then the above would indicate a marginal increase in the Jhenai and a marginal decrease in the Chatal inlets could be possible. However, given the approximations used in the analyses such refinements could be considered when detailed analyses are possible with the availability of better mapping (FINMAP) and other relevant data, including additional cross sections in the channels downstream the intakes. It is recommended that during detailed design more detailed surveys are undertaken to establish in the field water level and discharge requirements based on current agricultural practices. Additionally the further work on fish fry and fish migrations patterns should be taken account of in so far as they will constrain periods of gate operation and flow velocities through the structures.

3.5.4 Sizing of Outlet Structures

The size of the Bausi Bridge outlet has been fixed in order to be consistent with the NCR study findings and requirements i.e. 50 m^3/s.

The size of the Jhenai/Chatal outlet has been justified through model simulations and the evaluation of the maximum head loss at the structure location during operation (See Annex 4 on Modelling)

3.5.5 General Description of the Major Hydraulic Structures

S-1 Islampur Inlet Q = 15 m^3/S, 1 vent, 3.35 m width

The Islampur intake will be fitted with a single vertical lift (fixed-wheel) hydraulic gate. The structure has the following functions:

- Regulation of the inflow from the Old Brahmaputra River into the protected area to the west. This regulation is necessary in order to provide the controlled flooding required by the farmers. There are also fisheries interests for which water must be provided.
- Exclusion of major floods in the Old Brahmaputra from the protected area.
- Discharge of drainage flows, from rainfall falling over the protected area, out of this area into the Old Brahmaputra system when water levels in the Old Brahmaputra are low enough.
- Provision for gate operation to allow fish migration through structure except when the sliding gate is closed at times of extreme flood.
- A navigation lock is not required.

S-2 Jhenai Inlet Q = 115 m^3/S, 7 vents, 27.45 m width

The Jhenai inlet will have 7 No vertical lift (fixed - wheel) hydraulic gates. The structure has the following functions:

- Regulation of flows from the Old Brahmaputra River through into the Jhenai River and thence into the protected area. This regulation is necessary in order to provide the controlled flooding required by the farmers. There are also fisheries interests for which water must be provided.

- Exclusion of major floods in the Old Brahmaputra from the protected area.

- This structure is not likely to be needed to take drainage flows, from rainfall falling over the protected area, out through the embankment into the Old Brahmaputra.

- No need to make special provision for fish migration through structure when sliding gates closed at times of high flood, although this could be considered as an option.

- No special need to provide navigation lock.

S-3 Bausi Bridge Outlet Q = 50 m^3/S, 3 vents, 34.95 m width.

The Bausi bridge outlet, if required, will have 3 vertical lift (fixed - wheel) hydraulic gates. The functions of the structure are as follows:

- Regulation of outflows, to the east and south towards the Bangsi River area. Farmers and fishermen apparently need water supplies in area to be maintained in a similar way to that at present, but limited to 50 m^3/S so as not to inundated Bangsi area. However, it is of interest to note that once in twenty year flows of around 500 m $^3/S$ presently pass into the Bangsi River area through the Bausi Bridge.

- Exclusion of flood water from entering the protected area from the east, although this is not considered to be a major risk as the Old Brahmaputra River is about 20 kms distant. There is a possible indirect flood problem caused by backing-up in Bangsi River system, itself backing-up from link back to Lower Jhenai River and ultimately from the Jamuna.

- Drainage of flows resulting from rainfall falling over the protected area, out through the embankment to east and south but <u>not</u> vice-versa.

- Provision for gate operation to allow fish migration through structure except when the sliding gate is closed at times of extreme flood.

- A navigation lock is not required.

S-4 Jhenai/Chatal Outlet Q = 400 m^3/S, 25 vents, 99.75 m width.

The Jhenai/Chatal outlet will have 25 vertical lift (fixed wheel) hydraulic gates to be provided in structure. The functions of the structure are as follows:

- Regulation of flow discharge out of area towards the south through the lower Jhenai River which passes ultimately to the Jamuna.

- Exclusion of flood water from entering protected area from the south (ultimately from the Jamuna River).

- Drainage of excess flood water out of the protected area, so that water levels in protected area do not exceed those necessary in order to provide the controlled flooding required by the farmers and fishermen, so far as this is possible.

- Provision for gate operation to allow fish migration through structure except when the sliding gate is closed at times of extreme flood.

- Special need for a single width navigation lock to be provided so as to allow boats to pass up the Jhenai River system. If possible the lock should be operated to assist with fish migration.

S - 5 Chatal Inlet Q = 130 m^3/5, 8 vent, 31.60 m width.

The Chatal inlet will have 8 hydraulic gates. Special double vertical lift gates should be seriously considered as an option in the structure so as to allow fish migration at high and low flow stages. The functions of the structure are as follows:

- Regulation of inflows from the Jamuna River into the protected area to the east. This regulation is necessary in order to provide the controlled flooding required by the farmers and fisheries interests.

- Exclusion of major floods coming from the Jamuna River, out of the protected area.

- This structure is not likely to be needed to take drainage, from rainfall falling over the protected area, out through the embankment into the Jamuna River.

- There is a serious need for special provision to be made for fish migration through structure at both high and low flows. It is not practical however to allow for this migration at the very highest flood levels in Jamuna River.

- No special need to provide navigation lock.

3.5.6 Foundation Conditions

A detailed assessment of the foundation conditions of the main hydraulic structures are given in the Geotechnical Investigation and Topographic Survey Report (R4). Each proposed structure site was investigated by drilling 20 m deep boreholes, except for the Islampur inlet/outlet structure where the boreholes were 15 m deep. Continuous sampling, SPTs and permeability testing was carried out.

From the findings of the soil investigation programme, the provision of friction piles, 15 m deep, is recommended for all the structures. At a depth of 10 m on an average the density of the soil will be sufficient to provide adequate friction and not be susceptible to liquefaction.

Chemical analysis of water samples indicates the water to be non-aggressive and therefore ordinary Portland cement can be used for concrete works.

3.5.7 Sedimentation at Structure Locations

Sedimentation should not normally be an operational constraint at the flushing structures located on the embankments at flood plain level. In fact, in the vicinity of these structures, the water velocity will be slowed by existing bunds and other levees and deposition of sediment is likely to take place before the water reaches the flushing structure headworks.

The major control structures to be constructed as inlets on existing rivers are intended for the control of the amount of river flows admitted to the area. Under the conditions when the gates of the structure are closed, sedimentation will definitely take place in front of the structures unless they are diversion structures located on the outside bend of the river concerned.

Under the Project, all major control structures are located on straight connecting channels and dredging of these channels may be necessary on a regular basis once the project is implemented.

3.5.8 Hydraulic Structure Costs

The cost of the hydraulic structures included in the recommended Option B, alternative 5 are shown in Table 7.3.27 (2 sheets). i.e. Tk 392.4 million for the major hydraulic structures and Tk 34.6 million for the flushing structures.

3.6 Compartmentalisation - Basic Concept to be Applied

3.6.1 Objectives and Main Constraints

Compartmentalisation is an old concept, which worked in less crowded times in the region but which has yet to be developed and tested in the modern context.

The basic concept of compartmentalisation, in engineering terms, is to delineate areas, called compartments, which are bounded by physical features, such as roads, embankments or other physical barriers. Hydraulic structures are provided to control water entering and draining from each compartment. Compartments may be considered as water management units.

The application of the concept will therefore require a clear understanding of water management in the "without compartment" situation and clear proposals for water management in the "with compartment" situation. The farmers should play a major part in this and help decide what proposals and structures are needed. Water management considerations should apply to:

- internal water management of a given compartment;
- interrelated water management of adjacent compartments.

This would require a tiered organisation of farmer-led committees.

3.6.2 FAP 20 Findings

Input from FAP 20 on basic compartmentalisation design criteria and design guidelines was supposed to be made available for the Jamalpur Priority Project Study. Due to a delay of about 16 months in the start of FAP 20, the JPPS has to be carried out with only the FAP 20 Inception and draft Issues Reports available up to August 1992.

The FAP 20 Inception Report deals with general issues about the way the Compartmentalisation Pilot Project has to be implemented. The latest general ideas about the concept of compartmentalisation are also given:

"A compartment is an area in which effective water management, particularly through controlled flooding and controlled drainage, is made possible through structural and institutional arrangements. A compartment can be subdivided into sub-compartments:

- on a regional level, compartments may buffer the excess water from local rainfall and the river system;
- on the compartment level, the main purpose is related to the satisfaction of local objectives e.g. by controlled flooding and drainage or even retention."

As regards water management, it is stated :

"Water management is the controlled usage of: water, including early, late and deep flooding; surface and groundwater quantity; water use in agriculture, fisheries, transport, sanitation and for domestic and industrial purposes."

FAP 20 intends to implement a "bottom-up" methodology in which priority is given to the involvement of local people who will define the problems, the solutions and implement the programme using their own resources.

3.6.3 Development of the Concept with Respect to Present On-Farm Water Management.

At present, the paddy field is the most obvious water management unit (or compartment) which fully meets the previous objective.

At paddy field level, water management by the farmer is to control flows admitted to the field and passed to the drain in order to maintain the water level required for a given development stage of the paddy.

It is important to relate the concept of control of flows to the concept of control of water levels in developing the compartmentalisation concept.

Considering a group of paddy fields, limited by existing embankments, these will irrigate and drain on a field to field basis across the area. Under compartmentalisation, the upstream fields would be assumed to maintain a higher water level than normal, for a limited period, to reduce the accumulation of water in the lower fields and ultimately in lower compartments. The peripheral control of the flows could be obtained at all existing culverts and bridges where control structures could be constructed.

It should be underlined that at this compartmentalisation level, it is possible to control flows at the embankments and therefore the storage of the water in the compartment; providing this does not conflict with the required water levels, particularly in the lower paddy fields. This group of paddy fields will form the next level of compartmentalisation.

The control of the water levels in a compartment formed by a group of paddy fields is the first difficulty to be solved in the application of the compartmentalisation concept.

A second difficulty to be solved is the modification of the functions of existing culverts and bridges located in the embankments which are currently controlled by the farmers on either side according to their local needs, without consideration for the effect on others at a lower level. Farmers may want to either release or retain water, depending whether they have too much or too little at a particular time and this, almost invariably, will clash with the interests of those immediately downstream.

The operation of numbers of structures controlling flows at the periphery of a compartment implies an integrated water management which should take into account not only the internal requirements of a given compartment but also the requirements of adjacent compartments. Such integrated water management may involve the coordinated operation of many control structures.

It appears that the application of the compartmentalisation concept to groups of paddy fields implies an extensive involvement of the beneficiaries at the design stage in order to evaluate their specific requirements and avoid the construction of facilities they may not want or accept.

The third level of compartmentalisation would involve a number of groups of paddy fields. Once again, the problems underlined above would have to be considered on a larger scale, with the more complicated water management constraints involving a large number of small and larger structures. This level of water management would also be getting above farmer level and, therefore, an upper limit to the size of compartment may have to be decided on practical grounds.

Based on the above considerations, the application by FAP 3.1 of the compartmentalisation concept at field level will concern local drainage improvements for groups of paddy fields, with extensive participation of the concerned beneficiaries.

3.6.4 Development of the Concept with Respect to Flood Control

The compartmentalisation concept applied to flood control only can provide the flood control processes described in this Section. Control structures on the peripheral embankments would be operated in order to admit a limited volume of flood to provide controlled flooding within the project area. This water would be shared between compartments, through a limited number of control structures located on the compartment embankments. This would, ideally, have the effect of attenuating the flood and preventing rapid flooding of the lower areas.

Subsequent water management procedures for such a system would have to deal with the following specific aspects:

- to integrate the management of the volume of water admitted to the compartments from the rivers and the volume from unforeseeable rainstorms;

- to reconcile farmers' basic requirements with respect to water levels in their fields and the consequences of constraining discharges at compartment boundaries.

For FAP 3.1, the application of the compartmentalisation concept for flood control will concern the operation of the main hydraulic structures on the project boundaries.

3.6.5 Development of the Concept With Respect to Fisheries

As detailed in Annex 2 on Fisheries, it would be possible to control the water levels in river beds in order to maintain water bodies during the dry season for the development of fish farming activities. This concept can be applied to the Chatal/Jhenai river beds which could retain water in the end of monsoon as long as they are not converted into paddy fields. As regards the minor river beds which are cultivated once they have dried out, the application of the concept may create conflicting situations between farming activities and fishing activities. The local participation of water users is absolutely necessary for this specific application of the compartmentalisation concept with respect to fisheries.

3.6.6 Conclusions

Based on the above considerations and in view of the concern expressed by FPCO in their comments on the previous reports about the possible divergence of approach to compartmentalisation between FAP 3.1 and FAP 20 and the statement therein that "compartmentalisation should not be considered as essential", the strategy for JPPS must be very carefully considered indeed.

It is pointed out in the FAP 20 Inception Report that the "bottom-up" approach, fundamental to compartmentalisation, needs to be flexible and requires a longer time for development. Until definitive guidelines are available, it will be extremely difficult to explain the concept of compartmentalisation to farmers and convince them of its objectives.

The above observations point very strongly to the adoption of a phased introduction of compartmentalisation to FAP 3.1. At this stage consideration could be given to improving local drainage conditions taking the fisheries requirements into account. Improvement to cross-drainage structures along the possible main compartment boundaries will be considered at the detailed design stage where this is not already being done by LGEB or RHD. This last component would have an immediate direct benefit to the Project in the form of improved communication even if compartmentalisation went no further.

Compartmentalisation measures considered under this Study are therefore:

- improved drainage; with due consideration of fishing activities in beel areas.

- improved compartment boundaries formed by existing roads;

- improved cross-drainage structures at compartment boundaries.

- retention of water in river beds to increase fish production.

All proposed measures are local measures which will imply the operation of individual water control structures. The public participation for the physical implementation of these measures i/e location of structures, maximum water level etc. will be required. The structures will be operated by local committees of water users.

The next stage would follow if it is established that improved integrated water management is technically feasible and economically viable and when definitive guidelines became available from FAP 20. A considerable input must be envisaged in discussing the concept with the farmers and fishermen concerned. This would involve several teams comprising sociologists, agro-economists and drainage engineers with inputs from environmentalists, institution specialists and fisheries experts.

Assuming the public had accepted the idea and agreed to participate, the optimum arrangement of sub-compartments would be discussed with them including size and location, embankment levels, types of structures etc.

Also to be discussed will be construction methods and public participation in construction or the employment of the landless for earthworks in particular. Local contribution to the costs would probably best take the form of the provision of labour. FAP 20 should have made recommendations on the best technical and institutional arrangements by the time decisions on this matter are required, but these will have to be presented locally and possibly adapted to suit particular local needs.

An extension and training programme should be introduced for the public and operating personnel, with field demonstrations, and a pilot compartment might be considered. This might possibly be linked with the Agriculture Sector Support Project, one of whose objectives is the improvement of water management through the improvement of the extension and training services.

3.7 Land Aquisition

Land aquisition for the construction of the various project components has been assessed as follows:

- Embankment option B5, 408 ha for the construction of about 125 km of embankment

- Drainage improvement, 163 ha for the construction of about 110 km drains and 220 structures

- Major hydraulic structures, 14 ha for the construction of 4 structures

The cost of land aquisition has been calculated at the rate of Tk 196,000.

Total cost for land aquisition: Tk 114,660,000.

3.8 Variation of Unit Rates

Cost estimates of JPPS are based of BWDB rates adjusted to 1991 level as per GPA.

In the opinion of the consultant and based on recent experience, if construction works are contracted according to international bidding procedures, it is possible that construction costs will be higher than those derived from the application of the recommendations of the GPA.

In order to assess this likely increase, unit rates of the JPPS were compared to the 1992 rates of successful tenders on the coastal embankment rehabilitation programme, on the road embankment rehabilitation programmes in Rajshahi and Argarahat areas. Furthermore, the 1992 rates for the Thakurakona FCD Project, awarded by BWDB on a local competitive bidding basis have been compared to JPPS rates.

The results of this comparison are given in Tables 7.3.28. to 7.3.34.

The rates of Thakurakona FCD project, located in Mymensingh area, and JPPS rates are consistent. This conclusion reflects the fact that Thakurakona Project is carried out according to local bidding procedures which involve less constraints on quality control during work execution when compared to international procedures.

For the other tenders, which are based on international procedures, rates are higher than those used for the JPPS. The rates for road embankment indicate that, compared to the lowest tender, the rate for embankment fill could be 100% higher than those determined by GPA.

A further analysis has been carried out on the following basis.

- BWDB latest schedule of rates for Mymensingh Circle, valid for 1992-1993.

- FAP 21/22 has been approached. This FAP having conducted a similar rate analysis for works to be implemented by the end of 1993.

- The comparison of the breakdowns of rates supplied by the tenderers of the Coastal Rehabilitation Programme. (See Tables 7.3.32 and 7.3.33)

As a result, various conclusions were reached, they provide a good basis for the evaluation of the rates that could apply to the JPP project at implementation stage.

<u>BWDB rates (1992 - 1993)</u>

- For earthwork for embankment, 4 m height, the 1993 rate is built up as follows (in Tk/1000 cft):

Labour for excavation/placing:	335.31
Labour for manual compaction :	78.75
royalties (200 000 Tk/ha) :	250.52
Subtotal:	664.58
Profit (12.5%):	83.07
Total:	747.65 Tk/1000 cft

i.e. 26.4 Tk/m^3, including 11.10 Tk/m^3 for excavation/placing and 3.52 Tk/m^3 for manual compaction.

- For Concrete 1/2/4, the 1993 rate is built up as follows (in Tk/m^3):

Cement:	1481.98
Sand:	157.66
Gravel:	766.43
Subtotal:	2406.07
Profit (10%):	240.60
Subtotal:	2646.67

Labour:	327.30
Profit (12.5%):	40.91
Subtotal:	268.21
Total:	2914.88

BWDB rates are inclusive of all costs for mobilisation, rent, taxes, temporary works, insurances etc. but they call for the following comments:

- In general, labour requirements are underestimated. For embankment, the assumed output is 3 m^3 per working day. This is a strict assumption which could be questioned.

- Costs for material are slightly underestimated. For example cement accounts for 4000 Tk per ton when the present market price is 4200 Tk per ton.

- Costs for labour range from 35 Tk/day for unskilled labour to 65 Tk/day for skilled labour. The average labour rate for concrete is 45 Tk/day. According to the information collected by FAP 21/22, contractors have difficulties in finding good labour at less than 50 to 60 Tk/day.

Overall, on all items, BWDB rates seem to be on the low side.

FAP 21/22 Rates (1992)

FAP 21/22 has calculated rates which are as follows:

- For earthwork: manual excavation and placing, mechanical compaction with AT 2000 (grasshopper) 39 Tk/m^3, 10 Tk/m^3 being for compaction

- For earthwork executed with machinery for excavation, placing and compaction, the calculated rate is 51 Tk/m^3

- For concrete: 3420 Tk/m^3, without overhead and with formwork (90 Tk/m^3) for the fabrication concrete blocks 0.5x0.5x0.5 m. If we adjust without formwork and with 5% overhead, this rate becomes 3496 Tk/m^3. For similar work, FAP 21/22 collected site information in July 1992 and rates were upto 3200 Tk/m^3.

Coastal rehabilitation programme (1992)

The coastal rehabilitation programme cannot be directly compared to a FCD project in Jamalpur area for the following reasons:

- The works are executed under high ground water conditions. The specification regarding the drying of the material shows that the adjustment of the material moisture content before compaction is a significant constraint for the contractor.

- In the coastal area, the cost of the labour can be double the cost of the labour in other areas in Bangladesh.

- The proposed embankments have 2 cores with a more strict specification for the inner core (compaction 90 instead of 80 for the outer part of the embankment). The designer may have assumed that this arrangement would lower the cost of the works. This may have had an opposite effect. Coastal embankments are small when compared to an earthdam and the works may have been quoted at a higher price by contractors who may have found less difficulties in constructing homogeneous embankments, especially if these contractors have no experience for such a design.

Despite the above remarks, the analysis of the rates given in tables 7.3.32 and 7.3.33 can be made as follows.

- Earthworks - Core I

  It is interesting to note that the variation of the unit rates have no relation with the amount of works involved.

  Contract No. 3 can be discarded for the analysis. The cost of the labour (118 Tk) cannot be explained and it differs completely from the other quotations ranging from 36 Tk to 57 Tk. Contract 3 unit rate is double the rates of contracts 5, 6 and 7.

  Contract No. 2 and 4 are high due to the Items "temporary works" for 2 and "transport" for 4. This may reflect specific working conditions which are not known to FAP 3.1. If it is the case, the rates for those two contracts are not relevant for our analysis in connection with JPP.

  Contracts No. 5, 6 and 7 have similar rates with the cost of equipment and overhead/Taxes/Insurance Profit on the high side for 5 and 6. This is compensated by an higher cost of labour and an higher cost of the earth for 7.

  Royalties (earth) is quoted in 3 contracts out of the 6. This would mean that this cost is covered by other Items when it is not quoted.

- Concrete Class B

  Contract No. 2 has a breakdown which is not relevant. It includes 600 Tk for formwork and 750 Tk for cement, which is obviously about half the actual price.

  Contract No. 3 has quoted all items higher than those of the other contracts. This may reflect specific works or a lack of competition at tender stage.

  Contracts No. 5, 7 and 8 have consistent quotations for the concrete materials and it appears that they are about 25% higher than BWDB figure. Items for concrete fabrication (machinery, labour etc) are also consistent, but BWDB figure is higher. This could be explained if BWDB quotes under labour part of the cost for the fabrication of the aggregates. In return, quotation for overhead, taxes, insurance and profit are on the high side when compared to BWDB figure.

Consultant's recommendations

Based on the above considerations, rates that could be experienced for the JPP are detailed hereafter. It should be clear that the actual future rates will depend on many factors that cannot be assessed at present i/e market forces and amount of works available in Bangladesh at the time of tender, size of the contracts, recommendations for labour intensive or mechanical methods of execution and ultimately magnitude of the quality control system set up for the work supervision.

Compacted fill (Tk/m^3)

royalties (earth)	9.00
equipment	4.00
consumable	4.00
labour	20.00
other	4.00
Subtotal	41.00
overhead 5%	2.25
taxes/insurances 5%	2.25
profit 10%	4.00
Subtotal	8.20
Total general	49.20 Tk/m^3
Say 50 Tk/m^3	

Assumptions: Labour at 60 Tk/m^3 , 3m^3/day/worker
Compaction 8 Tk/m^3, equipment and consumable.

Concrete (Tk/m³)

Coarse aggregate	1200
fine aggregate	200
cement	1480
Subtotal	2880
labour/machinery	220
Subtotal	3100
overhead 5%	155
taxes/insurances 5%	155
profit 10%	310
Subtotal	620
Total general	3720 Tk/m³

The earthwork rate above is consstant with FAP 21/22 estimates and somethat higher (6%) than their estimate for concrete.

Based on this assessment it is proposed that for the economic analysis the variation in capital cost is calculated according to the following variation of JPPS rates.

- for embankment: rate for compacted fill 50 Tk/m³ instead of 30 Tk/m³ other rates increased by 20%;

- for hydraulic structures and other structures: total cost increased by 20%;

As a result of the above assumptions a sensitivity analysis should be made for a global variation of the project capital cost of + 28% vs base case, as calculated in table 7.3.34.

4 INSTITUTIONAL APPROACH

4.1 Implementing Agency

The institutional approach for the implementation of a FAP project including: detailed design, construction, operation and management has not yet been defined. While different types of project may require different approaches there are certain basic decisions which have to be taken by the GOB.

There would appear to be three ways of implementing projects

- Through traditional project implementation agencies such as BWDB

- Through autonomous country wide institutions set up specifically for the type of projects envisaged

- Through project specific semi autonomous authorities created for the projects

Whilst the formation of an independent authority is possibly the most efficient means of implementing large project and FAP 3 have suggested a regional authority, it is the consultants opinion in the context of Bangladesh and following discussions with FPCO and other bodies, that the future of projects for the time being will have to be through traditional implementation agencies such as the BWDB.

This being said there is a history of shortfall in realising the full potential of projects in the past which has been highlighted by FAP 12 and is being further studied by FAP 13. This means that some changes are needed. It is recommended that for FAP 3.1 the only changes should be made by improving the present system rather than by introducing large new implementation bodies which would only rival the existing ones for scarce, suitably qualified, human resources.

It is not recommended that FPCO or any other body should take over the implementation of this project, rather that it should be transferred to the BWDB, being primarily a water development project, for the design and implementation phase. If in the future the GOB adopts a different country wide policy for project implementation then this recommendation could be modified but it is not seen to be in the terms of reference for this project to consider such a wide issue.

However it is recommended that an element of the project authority idea should be adopted within the existing framework of the BWDB so as to introduce the multidisciplinary factors into the project. To this end it is recommended that a Project Steering Committee should be formed to sit quarterly to review and monitor the project progress and to take decisions on policy and financial matters. Sub committees would be floated as required for the monitoring of specific matters such as technical changes or financial problems.

For the actual implementation of the project a Project Management Organisation should be formed under a Project Management Officer drawn from BWDB. This organisation should be supported and assisted by a consultancy which would be responsible for the technical design, research and construction supervision. Terms of Reference for the Consultancy have been included in Appendix to the Main Report but these will have to be modified by the FPCO in order to fit with funding agency and GOB requirements and decisions on the actual contents of the future project package.

4.2 Implementation Organisation

The main structure of the proposed organisation is suggested in the Organogramme shown in Figure 7.7.1. This organisation is only for the implementation period and will have to be redesigned by the PMO for the Operation and Maintenance organisation. This will be dependant on the Government Policy for the O&M of the whole FAP programme and may be a continuation of existing organisations or may involve new specific organisations as outlined above. FPCO need to obtain this policy decision from the work now being undertaken by FAP 26 and advise the various FAP projects accordingly.

Figure 7.7.2 shows the foreseen steps in the implementation process.

The organogramme of fig 7.7.1 shows how the Steering Committee and the Project Management Organisation can be set up and linked to the consultants for technical in put. This organisation is designed primarily for the detailed design phase.

At the head of the project would be the steering committee which would be chaired by the BWDB and have permanent members drawn from FPCO, Agriculture, Fisheries, Local Government, NGO s, Finance, Transport, Environment. It should meet at least quarterly and the Project Manager should be its secretary.

The actual project management should be part of the BWDB project implementation sector and should be headed by a Project Manager. On the permanent staff would be officers seconded from agriculture, fisheries, finance and local government. The PMO would administer and monitor the implementation phase of the project assisted by a consultant.

The consultant, will be responsible for the technical element of the detailed design phase and part of the responsibility will be to ensure the technical transfer of knowledge to the PMO.

A significant element of the consultancy input should be the establishment and running of a Quality Assurance programme which will monitor the whole of the project work and ensure that Terms of Reference and Guidelines are observed and met. Whilst this increases the consultants input, it is now internationally accepted as an important element in project implementation.

4.3 Peoples Participation

4.3.1. Design Stage

Peoples Participation in a major project of this type is difficult at the planning stage. Throughout the feasibility study the peoples opinions and views have been sought through questionnaires, consultations with local bodies and individuals and public discussions. These are detailed in the various sections of the report particularly the Social, Environmental and Char land Annexes and the results of the data collection have been taken account in the formulation of a Land and Water Development Plan for both the Mainland and Char land areas. At the present stage this is considered to be the best way of involving the "People".

At the design stage the role of Peoples Participation will need to be heightened, but it must be done carefully. It is counterproductive to test implementation ideas on the general public unless there is a possibility of the public influencing, and being seen to influence, the outcome of the idea. Thus ideas should not be published until there is the availability of funds and organisation to execute the idea but before there is a final commitment to do so. This ensures that the feed back is in time to influence any activity if the response is negative, but equally the activity will be seen to go ahead if the response is positive.

In view of the above, Peoples Participation should be sought throughout the implementation. This work will need to be ongoing into the Operational Stage of the project and should continue indefinitely with a suggested initial funding period of 8 years.

Peoples Participation is also very relevant for the main construction project, but less appropriate in the design and siting of the major construction units which are primarily technical problems. The questionnaires and consultations have already tested general opinion on the conceptual phase of the project with a massive majority being in favour of an embankment project. It may be noted that the Sociologists suggest that the Landless people may not fully appreciate the full implications and project interventions, even though these have been explained, but the fact remains that they strongly perceive advantages in the construction of embankments. This includes provision of refuge on highland during floods; opportunities for wage paid work during the construction period and also afterwards due to higher agricultural activities. Disbenefits would seem to be realised but given a lower importance being too far in the future.

The major benefit of a strong Peoples Participation element in the design stage of the project is likely to be in the handling of land acquisition for construction. The estimated project costs include the expected appropriate land compensation at the present GOB rates. Despite strenuous efforts to minimise these requirements, the construction of the main embankments are expected to displace people who will have to be temporarily accommodated elsewhere, and those land owners who will either have to be allocated equivalent replacement land (which is unlikely due to the scarcity of this) or given a cash compensation for their loss. The design of the main embankment should incorporate a philosophy of multipurpose use with provision of berms on the protected side for permanent settlement and temporary refuge where appropriate.

4.3.2 Construction

The construction of major engineering works is well known to BWDB and the TOR for bidding form a separate part of this report. The mechanics of this would be handled through the existing GOB/BWDB contract bidding procedure and would be open to international type tendering procedures even if confined to Bangladeshi contractors.

Peoples Participation must continue through the construction phase into operation & maintenance. A particular point where this will be particularly necessary for the success of the project, is the location of minor works.

In the proposed project there are planned some 55 plus Flushing Structures. These are to be introduced in order to prevent/dissuade the local population from cutting embankments. At this stage they have been sited by engineers selecting apparently optimum sites from topographical data. This exercise should be further refined during the design stage with field testing and consultation. However, it is strongly recommended that even with such consultation during the design phase, the construction contract should be written to allow final positioning of the flushing structures to be decided at the time of construction. This is because people do not normally fully appreciate the problems until they see the implementation actually starting. From past experience it is a fact of life that the positions of such structures will have to be adjusted at that time and appropriate provision in the contract can save much delay and extra expense and claims.

Similar action should be taken with minor drainage channels and flood proofing constructions. Where possible, self help, force account, or NGO construction should be utilised for all minor works providing a flexibility of approach that involves the ultimate user in the implementation.

4.3.3 Operation and Maintenance

The above concepts must be further built into the operation of the project. Structure committees will need to be established for the control of minor works such as the flushing structures and the drainage control structures. These committee should be formulated during the detailed design phase so that they may interact with the ultimate operational organisation of the project in order to draw up and maintain a project wide Flood Control regime. They should be responsible within this framework for the day to day operation of their section of works. It is suggested that these committees should also participate to the maintenance of their related structures.

5 OPERATION AND MAINTENANCE

5.1 General

The study of Operation and Maintenance (O&M) of FCD and FCDI projects under the Flood Action Plan is covered by FAP 13. It has the following three aims:

(1) identification of constraints on effective operation and maintenance of FCD and FCDI Projects, in Bangladesh;

(2) preparation of guidelines for ways of overcoming these constraints both for existing and new projects;

(3) recommendations on ways of maximizing participation of beneficiaries.

The particular focus of FAP 13 is to provide guidance for the O&M of any new FAP projects. The main findings of FAP 13 are given in the following paragraphs.

5.2 Institutional Context

5.2.1 BWDB

The Bangladesh Water Development Board (BWDB), placed under the control of the Ministry of Irrigation, is responsible for the planning, execution and O&M of FCDI projects and has the ownership of all FCDI project.

Regional offices of BWDB zones are responsible for the O&M of projects. Zonal Chief Engineers are responsible to the O&M member of the BWDB Board. BWDB has a hierarchy of O&M officers and engineers who are in charge of the supervision of the work of employees assigned to hydraulic structures and to specific lengths of embankments (although much of the infrastructure is without assigned personnel).

The basic unit under the Zonal Chief Engineers is the O&M Division headed by an Executive Engineer. Each Division contains the Subdivisional Engineers and Section Officers and then the employees assigned to structures and embankments (Khalachis).

5.2.2 LGEB

The Local Government Engineering Bureau (LGEB) was created in 1984 to provide technical assistance at District and Thana level for planning, design, construction, operation and maintenance of local civil infrastructure. In 1984 it was decided that LGEB would take responsibility for the O&M of small schemes constructed by BWDB. The transfer of the schemes from BWDB to LGEB has not been implemented yet.

5.2.3 Jamalpur Institutional Context

The BWDB in the project area is represented by a Subdivisional Engineer heading three Section Officers. BWDB does not have a community mobilisation structure which might be used to organise the local maintenance system. The principal maintenance activity channelled through BWDB is the improvement of roads, canals and embankments under Food for Work programmes (known as CARE and FFW earth moving projects).

In the Jamalpur area, agricultural extension services are available through an agriculture office which includes a Deputy Director (Extension), a training officer, a crop specialist, a field specialist and a crop preservation and irrigation specialist, with 112 block officers. The main activities are related to agriculture with no involvement in O&M activities. Other organisations, similarly, have only agriculture as a field of activity such as BARC (Bangladesh Agricultural Research Council) and BRDB (Bangladesh Rural Development Board).

Detailed information on the Jamalpur institutional context is available in Annex 6.

5.3 O&M Performance and Constraints

Operation relates to operation of water control structures. In most of the project area, drainage is the main objective pursued.

All projects examined under FAP 13 have operating problems which can be classified as follows:

- problems arising from drainage facilities which are not adequate;
- problems arising from a lack of clear definition of responsibilities for operation. Operation committees have been set up on projects, but there is a lack of institutional and technical support;
- problems arising from conflicting interests of farmers for the opening and the closing of control structures. Conflicts are related to the required drainage levels on high and low land areas;
- problems arising from conflicting interests of farmers and fishermen.

In practice FCDI projects mean that some people gain and others lose. In project planning, different interest groups are not involved and conflicts are often the consequence of the basic project concepts.

Maintenance concerns embankments, drains, canals, and structures.

Embankments are generally in a poor condition. The main maintenance problems are as follows:

- breaches due to overtopping by a flood water level higher than expected at design stage;
- breaches related to poor construction;
- breaches on hastily constructed retired embankments when the protection provided is not up to the previous standard;
- cuts made by people outside the projects in case of negative impacts outside project area e.g. higher water levels during floods or impeded drainage;
- cuts made by people inside the project, in order to facilitate drainage, irrigation or fishing activities.

The poor condition of embankments results from a general lack of public consultation at planning, design and implementation stages. Sometimes details of project designs are not adequate and cause operation problems e.g. the use of fall boards in water control structures, which may be removed by people having specific operating objectives.

5.4 Institutional Performance

On many projects, the institutional performance is poor and the main shortcomings are as follows:

- there are no project committees with formal status for project operation. Attempts to form structure (sluice) committees have been made but generally they are not effective;
- operation of structures is often dominated by interested groups without the participation of all concerned;
- field staff members of BWDB have no training and sometimes assign responsibilities to local influential persons;
- field staff members of BWDB receive little guidance and proper monitoring from superior officers. They are not in a position to arbitrate between conflicting interests;

- the O&M Division of BWDB are more engaged in administration than in field level technical matters. Theoretical programmes of works cannot be carried out due to shortage of time and funds.

5.5 Funding

Lack of funds is a major constraint on O&M activities. There is a lack of funds for routine maintenance and, with the exception of irrigation charges, BWDB is not entitled to raise revenue directly.

Available funds tend to be allocated to running costs rather than maintenance.

5.6 Lessons Learnt for Future O&M

- the technical involvement of BWDB until physical completion of projects should be maintained in the long run for project operation, taking into account human aspects of management;
- projects which result from local demand and which have not been imposed from outside are likely to benefit from local interest in O&M;
- O&M problems stem from the lack of local consultation and participation in the planning process and the implementation process;
- consultation during the planning process of a project and proper studies should permit assessment of off-site implications;
- O&M problems may arise from poor design, implementation and construction;
- the failure of the Khalashi system could be avoided through granting ownership rights to user groups or private individuals;
- for complex projects, sluice committees are not the answer to project management. Coordinated operation is required and a higher level of "System management" should be organised;
- "System management" would provide the opportunity for a continuous assessment of project performance and the adjustment of the project to changing needs and circumstances;
- the setting up of user groups is essential to overcome local problems in water management, for example users both upstream and downstream of a particular structure should be involved, to avoid disputes and unnecessary deliberate breaches in the embankments;

- fee recovery is very poor when infrastructure is provided free and when the intended service is not provided;

- creating exclusive rights for the use of embankments as shelters, temporary or permanent, would be likely to secure their maintenance by the beneficiaries. The ideal would be to have the interests of direct users coincident with those of passive beneficiaries of the same infrastructure.

5.7 Conclusions

In order to secure efficient O&M activities on the physical completion of FCD and FCDI projects, two main issues should be considered and treated carefully:

- project formulation and implementation should be carried out in consultation with the future beneficiaries and other concerned population in areas adjacent to the project;

- institutional arrangements for O&M for a project should aim at ensuring the beneficiaries involvement through direct participation at all project stages;

5.8 Recommendations

The successful completion of the project demands continuous attention to:

- keep the infrastructure in a useful condition;

- fulfil the objectives of the scheme i.e ensure the increased production planned. To ensure that the structures are operational and properly maintained will require establishment and coordination at a high level of a "Project Management Organisation" including:

    - Structure committees to ensure proper operation and maintenance of the structures;

    - A coordination body including: funding agency representatives, Government officials, local representatives, NGOs and beneficiaries;

    - technical input to appraise the overall management;

    - Funding agency;

    - NGOs which will boost the economic condition of beneficiaries and non direct beneficiaries.

To achieve the long term sustainability of the project, the structures need to be maintained to provide the planned service, and the benefits expected have to be framed in a way which will maximize the outputs for all sections of people in the area. The identification of the social groups developed in the Socio-economic Annex 6 shows that a considerable gap exists between the extremes. Consequently it is a priority to avoid widening of the gap and this requires the combined efforts of local officials, the NGOs and all the local people in the following schemes:

- Structure committees for operation and maintenance to be set up with representation of the beneficiaries, parishad member, official technical officer, NGO representatives, village leader and administrative representative from the Thana or District.

  These committees will draw up plans for the operation of the gates, will adjust the plans during unfavourable weather conditions, will settle any conflicts, will look after the structures, etc. The committees will be trained to understand the complexity of the scheme and all the tasks to be performed. To conduct the training in a participatory way it should be carried out by a technical official assisted by an NGO worker.

- Embankment maintenance schemes are necessary from the beginning. The method to be adopted may vary because the approach differs between the organisations which have developed experience in kacha structure maintenance e.g. DANIDA in Noakhali, RESP in Faridpur, NGOs like RDRS in Rangpur and CARE in a major part of Bangladesh. The CARE system demands local financial participation. Maintenance on rural roads is done at Union level. The Union Parishad must financially contribute 10% of the allocation before approval of the scheme. The work is done by women on a food-for-work basis.

- The approach to maintenance of embankments will need to be broadened and thus open avenues for innovative types of employment. Embankments represent a big area which can be used for afforestation. The NGOs like SCI, RDRS, etc. have successfully carried out programmes of afforestation along both minor and important road embankments. The organisation of such a programme will require proper agreement for land use, a funding agency and training and organisation of the beneficiaries.

- The flood control measures will permit a more intensive use of land which will bring more irrigation facilities and therefore scope for an organisation around the water distribution. The experience of selling water by a group of landless organised by Prosika (NGO) has developed an approach which reduces the patronising influence of the land owners.

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- The construction of flood proofing will require attention and the committee created during the planning stage should extend the use of the infrastructure for educational purpose (Pucca structure) and afforestation and fishery purpose (Kacha). The MCC experience in the South of the project has been proved successful. They coordinated the people participation and officials.

5.9 Evaluation of O/M cost

5.9.1 O/M Requirements and Methods

The main operational activities to be undertaken can be summarised as follows:

- operation of major hydraulic structures (S1, S2, S4, S5)
- operation of the navigation lock (S4)
- operation of the flushing structures (55 nos)
- operation of the drainage structures
- operation of the structures for the fisheries programme

The operation of the major hydraulic structures and the navigation lock at Jhenai/Chatal outlet should be under the direct responsibility of the "Project Management Organisation".

As long as the proper operation of the flushing structures and drainage structures directly benefits the farmers and fishermen, structure committees should be formed with the participation of representatives of all beneficiaries concerned, and under the supervision of the "Project Management Organisation". The gate operators should be designated in agreement with the committees.

The main maintenance activities to be undertaken can be summarised as follows:

- maintenance of hydraulic structures
- maintenance of embankments

The maintenance of the hydraulic structures involves routine inspection and maintenance, and periodical inspection and maintenance.

Routine maintenance should be carried out annually. On the basis of this annual inspection, the programme for the required maintenance will be drawn up by the Section staff and will be executed by gangs engaged on a daily basis or by contract during the dry season.

Periodical inspection and maintenance would require the drying out of the structures. This work should be executed by contractors.

The maintenance of the embankments involves annual maintenance and periodical re-sectioning.

For the annual maintenance, every kilometre of embankment should be inspected at Section level at the end of the monsoon and proposals for maintenance made to the O&M office. Public cuts, slides and erosions should be identified and located. After checking the proposed programme and after the approval of O&M authorities, the Section staff will issue work orders for maintenance during the dry season.

The work has to be carried out by gangs employed as a seasonal basis, and should be supervised by the Section staff with the assistance of embankment committees, which should be involved in this process as the main beneficiaries of proper maintenance.

For periodical re-sectioning, on average every 7 years, it is necessary to undertake the survey of the embankments in order to compare the actual situation with the "as built" situation.Based on this comparison, the quantities for works to be executed by contractor or by gangs employed on a seasonal basis can be estimated.

5.9.2 Staffing, Administration and Support Services

Project operation and management requires adequate staff, facilities, equipment and funds. At present, in the project area, BWDB has set up 1 Subdivision and 3 Sections. With the implementation of the JPP, 3 Subdivisions and 9 Sections will be required for the operation and the maintenance of the new infrastructures. This is in accordance with standard BWDB practice for a scheme of the size of the JPP.

On this basis, and using BWDB standards for planning staffing resources, the following staff will be required:

Type of Personnel	No.	Scale of pay per MNNPS	Annual Remuneration (Tk.'000) *
A. Managerial (Local)			
Superintending Eng	1(p.t)	4200-5250/-	32
Executive Engineer	1	2800-4425/-	100
Asst.Eng/Sub-Divn Eng	3	2400-3600/-	250
Assistant Director	1	1650-3220/-	75
Sub-total A	5(full), 1 (part time)		457
B. Skilled			
SAE (Section)	9	1000-2280/-	560
Divisional Accountant	1	1000-2280/-	60
Head Clerk	1	850-1700/-	50
Steno-typist	1	900-2075/-	55
Senior Accounts Asst.	2	900-2075/-	102
Accounts Clerk	5	800-1630/-	240
Lower Division Asst.	3	800-1630/-	140
Subdivisional Clerk	3	800-1630/-	140
Typist	4	750-1550/-	150
Draughtsman	1	850-1700/-	50
Tracer	1	700-1415/-	35
Surveyor	9	750-1550/-	340
Sub-total B :	40		19 220
C. Unskilled			
Store Keeper	2	750-1550/-	70
Camp Supervisor	1	700-1415/-	35
Driver	4	750-1550/-	140
Gestetner Operator	1	650-1280/-	35
Record Supplier	1	700-1415/-	35
Sweeper	3	500-860/-	75
Cook	1	600-1110/-	34
Work Assistant	6	700-1415/-	210
Cook helper	2	500-860/-	50
Gardener	1	500-860/-	25
Guard	6	550-965/-	165
Sluice khalashi	50	500-860/-	1 250
MLSS	10	500-860/-	250
Embankment khalashi	12	500-860/-	280
Sub-total C :	108		2 654

* including allowances and bonus.

In coordination with the organisation set up for the O&M of the flood control infrastructure, separate arrangements for agriculture support and fisheries support should be set up, taking into account the existing relevant institutions :

- for agriculture, the existing staffing is sufficient and does not required to be strengthen. At present 240 block officers and 25 officers are operating in the project area.

  Operating conditions are far from being satisfactory, and it is advised that the existing organisation should be provided with the following support: allowances, means of transport and a training programme.

  A budget of Tk 4 million per year for 5 years has been estimated, but it has not been considered as a cost to the project.

- for fisheries, the existing staffing of the DOF should be kept at present level. The implementation of the Fisheries programme will rely on NGO's. The corresponds cost has been assessed in the Annex 2 on Fisheries i.e. Tk 31 million.

5.9.3 Cost Summary

A rough tentative cost estimate of annual O/M costs could be as follows:

i) Cost of management and supervision staff in Tk. per year

O&M proper of infrastructures	
• Managerial level	457 000
• Skilled level	1 922 000
• Unskilled level	2 654 000
Sub total (i)	5 033 000

ii) Supplies and consumable in Tk/year

Maintenance of buildings and compounds	500 000
Running cost of offices	300 000
Running cost of vehicles(10)	3 500 000
Purchase of transport (every 4 years)	5 000 000
Miscellaneous purchases	2 200 000
Sub total (ii)	11 500 000

iii) Contracted works

- Maintenance of flood embankment

annual maintenance	
125 km @ Tk 100000km/year	12 500 000
periodical re-sectioning, raise 0.5m	
over 18km/year:	
80 000 m^3/year @ 30 Tk/m^3	2 400 000
emergency works	2 000 000
Sub total	16 900 000

- Maintenance of hydraulic structures

painting & greasing	500 000
replacing seals	200 000
repairing u/s-d/s protections	1 000 000
repair to structures	500 000
miscellaneous	500 000
emergency works	1 000 000
Sub total	3 700 000

- Maintenance of drainage system

cleaning of drains	
110km x Tk 15000/km	1 650 000
excavate silted sections	
110km x Tk50000km(1/5 years)	1 100 000
Sub total	2 750 000

- Maintenance of Fisheries facilities

fisheries compound and structures	600 000
Sub total	600 000

Sub total (iii)		23 950 000
Total (i), (ii) & (iii), per year		Tk 40 483 000
percentage of total capital cost	4.0 %	

6 IMPLEMENTATION PROGRAMME - PHYSICAL, ENGINEERING AND T.A

6.1 General

The recommended development within the JPP study area includes the parallel development of controlled flooding and drainage measures on the mainland and flood proofing on the setback and char land areas.Linkages between the two programmes exist from the point of view that construction of the embankment will impact upon water levels in the setback and char lands and that the design of refuge areas for the flood proofing should be taken account of during embankment design and construction.It may also be noted that it may be considered desireable from a public relations standpoint to advance both programmes together in a coordinated manner.

It is proposed that in order to proceed with the flood proofing programme it is necessary to commence with some pilot schemes as part of the initial detailed planning phase.These pilot schemes would represent approximately 5% of the overall programme as identified.To facilitate this,it is recommended the that pilot flood proofing programme is undertaken under one financing package together with the mainland project.In this way the necessary coordination between the two can be best achieved.

In summary therefore it is recommened that the following should be treated as one overall package of works:

Implementation Package:

Stage 1

- Detailed design of embankments and hydraulic structures
- Design and implementation of pilot drainage works
- Design and implementation of pilot flood proofing programme
- Design and implementation of the fisheries programme
- Technical assistance and NGO support programmes to facilitate the above

Stage 2

- Implementation of embankments and hydraulic structures in a phased development programme
- Review of pilot drainage scheme,design and

implementation of remaining drainage works

- Continuation of pilot flood proofing works incorporating reviews leading to detailed definition of the overall programme

It is recommended that implementation of the overall flood proofing programme be subject to review of the detailed planning undertaken above and that these works and programmes should be subject to a separate financing package to be agreed at that time.

The following discussions and recommendations are confined to the Stage 1 and 2 implementation programme as described above.

6.2 Programme

With the detailed design phase due to start early in 1993, the first year of project implementation would be 1994, though it should be possible to start work on pilot flood proofing project and fisheries project at the end of the 1993 monsoon, since extensive design work is not required.

The proposed implementation programme has been worked out taking into account the following constraints:

- The studies are due to finish by the end of 1993, therefore the first construction works will start late in the dry season of 1993/94, only 3 to 4 months before the 1994 monsoon. During this period construction works for embankments, for the drainage pilot area could start. However, it would be more realistic to start construction of the main hydraulic structures after the 1994 monsoon, so that a full dry season is made available for works in river beds exposed to floods.

- As far as flood protection embankments are concerned, the priority should be given to components which are the most urgently needed, such as town protection and the upper flood protection along the Jamuna river.

- As far as technically possible with regards to the objectives of the project, a staged approach with packages is required.

- As far as possible, the investment rate should be evenly spread over the whole construction period. For a given components, contracts that could be undertaken by local contractors will be delineated during the detailed design phase.

Two development phases are recommended, possibly overlapping. Phase 1 is a priority phase. Phase 2 could be delayed without involving major adverse effects for the overall project objectives during normal flood events provided that the southern part of the Old Brahmaputra embankment and the closure of the Jhenai inlet is completed when the Jamuna embankment is completed.

It is necessary to complete the Jhenai intake (S2) before completing the southern part of the Jamuna embankment in order to avoid uncontrolled inflows from the Jhenai, which would be unable to escape, from causing flooding in the southern part of the project area. Both these activities are in Phase 1 of the project and are due to be completed in 1997. Coordination between them will be necessary.

Phase 1

A year in advance of Phase I proper, the pilot project for flood proofing would have started. It has been considered that a phased implementation would continue throughout both phases of the Project, although only the pilot project has been included as project component.

In the first year of Phase 1, i.e. the end of January 1994 at the earliest, construction would start on the section of the Jamuna embankment from Bahadurabad to the Chatal inlet, the embankments to protect Dewanganj, Islampur and Jamalpur, the drainage pilot project, while the pilot flood proofing project are being completed.

Immediately after the 1994 monsoon, the full programme of drainage improvements would start based on the initial findings of the drainage pilot area, divided into contracts for beel drainage, improvement of drainage channels and construction of drainage structures. The construction of the Jamuna embankment between the Chatal inlet and Madarganj would commence, also the construction of flushing sluices in completed sections of embankments, and all inlet/outlet structures.

Phase 2

This phase would involve the construction of the Old Brahmaputra embankment from Dewanganj to Jamalpur and the embankment from Sarishabari to the fertilizer factory.

An outline programme for these works are given in Figure 7.6.1.

6.3 Project Implementation and Build Up of Protected Area.

The proposed implementation programme has been designed to achieve a progressive build up of the area protected under the project. This allows some of the project benefits to be realised early in the implementation programme.This factor has been taken into account in the economic analysis.

In quantitative terms, the following build up of project benefits can be expected:

End of 1995.	Jamuna embankment completed between Bahadurabad and Chatal inlet: 20% (estimate) of the area will be ready for production as per "with project" [W] situation.
End of 1995.	Jamuna embankment completed between Bahadurabad and Madarganj: 30% to 35% (from hydraulic model) of the area will be ready for production as per [W].
End of 1997.	Jamuna embankment completed, as well as the closure of Jhenai inlet: 90% (estimate) of the area will be ready for production as per [W].
End of 2000.	All project components completed and 100% of the area will be ready for production as per [W].

6.4 Implementation of Drainage Improvements

It is not possible at feasibility stage to produce anything other than outline designs for minor drainage, since extensive topographic detail is first required. It is recommended that the actual detailed designs are done during the construction phase, based on guidelines produced during the Detailed Design phase and from the findings on the Drainage Pilot Area and the Supporting Studies. This in fact follows normal BWDB procedures for works at field level where liaison with landowners and village leaders is essential on the routing of channels, the type of structures and land acquisition. The ground for this will have been laid during the Supporting Studies.

If it is found practicable to continue with the detailed topographical surveys used on the Pilot Drainage Area, designs can be based on the 1:5000 mapping thus produced. However, should this prove too expensive or time consuming, a reduced survey input based on Mouza maps and enlarged topographic maps may be possible.

A way to do this is to obtain the 16" to 1 mile Mouza maps which show all land boundaries accurately. Contours for the area must then be produced at the same scale. This was relatively easy in the past when 4" to 1 mile maps were simply enlarged 4 times and overlays produced. The new mapping will however be at a scale of 1:20 000, or 1:10 000 if maps of this scale have been specially ordered for the project. These could be converted very laboriously to 16" to 1 mile scale, but it would be far better and of considerable value for the future to obtain a Large Format (max size A0) Plain Paper Complete Variable Scale (enlarge and reduce) Multiple Copy Plan Printer. This will also take plastic film so that overlays can be produced directly.

Tentative layouts of channels and structure locations could then be produced on the overlay taking account of both land divisions and contours and the result set out by the surveyors in the field, discussed with those concerned locally, adjusted where necessary and the final result drawn up properly.

This alternative approach will be tested during the study of the Pilot Drainage Area.

6.5 Implementation of Fisheries Project

The Fisheries Project will be implemented in two phases :-

- A first phase will include the rehabilitation of Jamalpur fish hatchery. During this phase, the institutional strengthening of the fisheries sector in the project area will be initiated and NGO's will be mobilized.

- A second phase, which will be more operational for the development of the fisheries sector which will include the construction of minor control check structures on minor river beds for the creation of static water bodies and the development of fish farming. Extension services will be provided in order to promote the various fish farming activities to be developed.

6.6 Engineering and Technical Assistance

The project implementation programme includes three categories of components, each category requiring specific provisions in terms of engineering input and technical assistance. The description of the three categories of components are as follows:

- Detailed design and preparation of tender documents for physical works:

  This will concern the main infrastructure, embankments and hydraulic structures, as well as the pilot drainage project, the flood proofing pilot project and the pilot fisheries project. An integrated team of national and foreign consulting firms will undertake the tasks to be carried out under this heading.

- Works execution of the main infrastructure, embankments and hydraulic structures, as well as drainage improvement works:

  National contractors will be engaged under competitive bidding for this work. Contract sizes will vary depending the nature of the works to be undertaken. An integrated team of national and foreign consulting firms will undertake work supervision and will act as "the Engineer" according to FIDIC rules.

The team will include the necessary staff for the back up of the supervision team and the issue of working drawings and other drawings, as may be necessary during the progress of the works.

The team will also include the experts required for the monitoring and the evaluation of the execution of the flood proofing and fisheries programmes.

- Works execution for the Flood Proofing/Fisheries programmes:

  The execution of the programmes will rely on NGO's that will be responsible for their implementation. In order to monitor and to evaluate these programmes, a technical assistance and institutional support will be provided within the framework set up for the supervision of the major infrastructure works (See above).

In quantitative terms, a total of 100 man-months of foreign experts, and 220 man-months of national experts will be required for the preparation of detail designs and tender documents. The fields of expertise will be: Civil Engineering, Drainage, Irrigation, Hydrology/Modelling, Geotechnics, Hydromechanics, Sociology, Institution, Agro-economy, Fisheries, Environment.

The services will be provided during 1993.

During works execution, the fields of expertise for works supervision proper will be: Civil Engineering, Mechanics, Quality Assurance and Quantity Survey. A design office should be set up for the whole construction period. The team will include part time T.A experts in the field of sociology, institutions, fisheries, ecology, nutrition and health. Considering that during monsoon most of the activities will be stopped, a total of 120 man-months of foreign experts and 500 man-months of national experts will be required. The services will be provided over 7 years, from 1994 to 2000.

As far as surveys are concerned, the following will be required:

1993	topographic survey for the drainage pilot project. Additional topographic survey for final location of embankments and structures, and geotechnical survey at major structure locations may be required as discussed in Section 3.4.8 above.

1994-2000 topographic survey for the drainage improvement project.

Sociological surveys and other surveys in connection with population are included in the man-months inputs stated here above.

The cost estimate for Engineering costs, technical assistance and surveys is as follows:

	cost in Tk (millions)	
	1993	1994-2000
Foreign expertise/international experts	64	77
National expertise	11	20
Local expenses	15	25
Surveys	5	2
Total	95	124

Total general: Tk 219 million

As detailed in Annex 6 on Social Impact Assessment, an additional Tk 11.0 million have been provided for the public participation process through NGO's.

This process will be an integral component of the detailed design phase and the first two years of the construction phase.

Regarding the flood proofing project, Engineering and TA have been costed seperately in the relevent chapter of this Annex. A provision of Tk 10.9 million has been proposed for the pilot flood proofing project.

7 Quantities and estimated cost

7.1 Flood proofing

Estimated quantities and costs for flood proofing have been detailed in tables 7.3.1 to 7.3.10.

(i) Estimated quantities and costs of physical components are given as follows

- Cost of House Improvement and Raising: Table 7.3.1.
- Costs of Microprojects (3 samples): Tables 7.3.2 to 7.3.4.
- Weighted Cost of Microproject: Table 7.3.5

(ii) Estimated cost of Technical Assisstance

- Proposed Allocation of expertise (man-months): Table 7.3.6.
- Cost of Technical Assisstance Table: 7.3.7.

(iii) Estimated cost of NGO

- Manpower requirement for NGO support: Table 7.3.8
- Cost of NGO support: Table 7.3.9

(iv) Summary of flood proofing cost estimates: Table 7.3.10

7.2 Drainage Improvement

Estimated costs for drainage improvement have been detailed in table 7.3.13

7.3 Embankment construction

- Estimated cost of individual embankments: table 7.3.21 to 7.3.24.
- Summary for Height Alternatives: table 7.3.25
- Main quantities and Estimated costs for the recommended option B5: Table 7.3.26.

7.4 Hydraulic Structures: table 7.3.27

7.5 Other Costs

- Engineering and Technical Assistance: Annex 7 para 6.6

- Land acquisition: Annex 7 para 3.7
- Fisheries Project: Annex 2 para 5.5
- NGO support programme: Annex 6 para 4.4.4

7.6 Summary of Cost Estimates

- Recommended Developments: Table 7.3.35
- Development options A and B5: Table 7.3.36

Table 7.3.1 Estimated Costs for Flood Proofing

Material	Item	Unit	Quantity	Rate (Tk)	Amount (Tk)	Attb to Mitgn	Net Amnt (Tk)
Wood	Wall Plates	m^3	0.0345	12,360.0	426.4	0%	0.0
	Tie Beams	m^3	0.09	12,360.0	1,112.4	0%	0.0
	Rafters	m^3	0.04	12,360.0	494.4	0%	0.0
	Purlins	m^3	0.0375	12,360.0	463.5	0%	0.0
G. Steel	Roofing	m^2	19.32	182.0	3,516.2	0%	0.0
	Ridge	no.	3	100.0	300.0	0%	0.0
Concrete	Pillars	m^3	0.198	3,205.0	634.6	0%	0.0
MS Bars	Pillars	kg	8.08	24.4	197.2	0%	0.0
MS Plate	Pillars	no.	8.00	6.0	48.0	0%	0.0
	Screws	gross	1.00	50.0	50.0	0%	0.0
	Nails	gross	1.00	50.0	50.0	0%	0.0
Bamboo	Walling	m^2	15.00	50.0	750.0	0%	0.0
Miscellaneous and contingencies		-	-	20%	1,608.5	-	
				Total	9,651.30		0.0
				Say	10,000.00		0.0
Earth filling to raise hoses:							
Household < 0.1ha		m^3	201.0	16.35	3,300.0	10%	330.0
Household > 0.1ha		m^3	349.6	16.35	5,700.0	10%	570.0

Legend: Attb = Attribute, Mitgn = Mitigation, Amnt = Amount.

Table 7.3.2 Estimated Costs for Flood Proofing
Micro Project 1 : Clustered refuge, 50x80m
Expressed in 1991 Taka

Item	Unit	Qantity	Rate (Tk)	Amount (Tk)	Attribute to Mit'gn	Net Amount (Tk)
Raised earth platform, 50x80x3m	m^3	12,000	16.35	196,200	10%	19,620
Tubewells, sinking and platform	no.	2	10,000	20,000	5%	1,000
Latrines and plinths	no.	2	2,200	4,400	0%	0
Community centre cum school, 7x4	no.	1	45,400	45,000	0%	0
Community centre cum health center	no.	1	45,000	45,000	0%	0
Afforestation	LS.	1	5,000	5,000	0%	0
			Total:	315,600		20,620

Table 7.3.3 Estimated Costs for Flood Proofing
Micro Project 2 : Clustered Refuge 60x30m + livestock (5,000x5m)
Expressed in 1991 Taka

Item	Unit	Qantity	Rate (Tk)	Amount (Tk)	Attribute to mit'gn	Net Amount (Tk)
Raised re-excavation with raised bank for livestock shelter (5m long)	km	5	52,210	261,050	10%	26,105
Raised earth platform, 60x30x3m	m^3	5,400	16.35	88,290	10%	8,829
Tubewells, sinking and platform	no.	2	10,000	20,000	5%	1,000
Latrines and plinths	no.	2	2,200	4,400	0%	0
Community centre cum school, 7x4	no.	1	45,000	45,000	0%	0
Community centre cum health centre	no.	1	45,000	45,000	0%	0
Afforestation	LS.	1	5,000	5,000	0%	0
			Total:	468,740		35,934

Table 7.3.4 Estimated Costs for Flood Proofing
Micro Project 3 : Road/Embankment/Refuge
Expressed in 1991 Taka

Item	Unit	Qantity	Rate (Tk)	Amount (Tk)	Attribute to mit'gn	Net Amount (Tk)
Road cum embankment connecting	km	5	22,000	110,000	10%	11,000
Catkin plantation, 100 acres	lab-day	1,500	40	60,000	0%	0
Tubewells, sinking and platform	no.	12	10,000	120,000	5%	6,000
Ferry boat	no.	1	60,000	60,000	0%	0
Raising School, Madrasha or Mosque	no.	1	100,000	100,000	10%	10,000
Excavate fishpond	LS.	1	110,000	110,000	0%	0
			Total:	560,000		27,000

**Table 7.3.5 Estimated Costs for Flood Proofing
Weighted Cost of Micro Projects for Community Infrastructure
Expressed in 1991 Taka**

	Estimated Cost (Tk)	Weight	Net Cost (Tk)	Mitigation Cost (Tk)	Net Mitigation (Tk)
Micro Project 1: Clustered refuge, 50x80m	315,600	18%	56,808	20,620	3,712
Micro Project 2: Clustered Refuge 60x30m + livestock	468,740	18%	84,373	35,934	6,468
Micro Project 3: Road/Embankment/Refuge	560,000	64%	358,400	27,000	17,280
	Totals	100%	499,581		27,460
	Say		500,000		27,500

**Table 7.3.6 Proposed Allocation of Expertise
Under the TA Component**

(in man-months)

TA inputs	Pilot Phase			Main Phase			All Project		
	Local	For.	**Total**	Local	For.	**Total**	Local	For.	**Total**
Rural Development	30	66	**96**	50	30	**80**	80	96	**176**
Rural Engineering	30	-	**30**	50	18	**68**	80	18	**98**
Agriculturist	12	-	**12**	12	-	**12**	24	-	**24**
Land/Legal Spec.	6	-	**6**	-	-	-	6	-	**6**
Women Development Specialist	30	-	**30**	50	24	**74**	80	24	**104**
Total	**108**	**66**	**174**	**162**	**72**	**234**	**270**	**138**	**408**

Table 7.3.7 Estimated Costs for Flood Proofing Technical Assistance Expressed in 1991 Taka

	Rate (Tk)	Pilot Phase		Main Phase		Total Progarmme	
		Amount (mm)	Cost (MTK)	Amount (mm)	Cost (MTK)	Amount (mm)	Cost (MTK)
Local man-months	50,000	108	5.40	162	8.10	270	13.50
Foreign man-months	640,000	66	3.30	72	3.60	138	6.90
Local Expenses	20%	-	1.74	-	2.34	-	4.08
Surveys	5%	-	0.44	-	0.59	-	1.02
	Total	174	10.88	234	14.63	408	25.50

Table 7.3.8 Manpower Requirement for NGO support

Staffing Plan for 5 NGOs	Pilot Phase (3 years)		Main Phase (5 years)		Project (8 years)
	No Staff	Man-Months	No Staff	Man-Months	Man-Months
Coordinators	1*5	180	1*5	300	480
Field Supervisors	2*5	360	4*5	1,200	1,560
Field Workers	15*5	2,700	40*5	12,000	14,700
Total NGOs Staff		**3,240**		**13,500**	**16,740**

Table 7.3.9 Cost of NGO Support

Unit Cost in '000 Tk
Total Cost in 'million Tk

NGO SUPPORT (5 NGOS)		Pilot Phase (3 years)		Main Phase (5 years)		Project (8 years)
PROJECT BASE COST	Unit Cost	No	**Total**	No	**Total**	**Total**
1. Investment Costs						
A. Motorbikes	100	15	1.50	20	2.00	3.50
B. Engine Boats	100	15	1.50	15	1.50	3.00
D. Computer	150	5	0.75	-	0.00	0.75
E. Credit Funds	2000	5	10.00		0.00	10.00
F. Community Houses	200	10	2.00	25	5.00	7.00
Total Investment			**15.75**		**8.50**	**24.25**
2. Recurrent Costs						
A. Staff (man-months)	5	3240	16.20	13500	67.50	83.70
B. Health/Education/ Training Programs	.5	10000 (HH)	5.00	25000 (HH)	12.50	17.50
C. Consumable	1000		5.00		10.00	15.00
D. Administration		10%	2.62	10%	9.00	11.62
Total Recurrent			**28.82**		**99.00**	**127.82**
Total Base Cost			**44.57**		**107.50**	**152.07**

Table 7.3.10 Estimated Costs for Flood Proofing Summary of Flood Proofing Cost Estimates Expressed in 1991 Taka

	Unit Rate (Tk)	Total No. of HH	Total Cost (MTK)	Mitigation Rate (Tk)	Mitigation Cost (MTK)	Pilot Scheme	
						No. of HH	Cost (MTK)
Minor Structural Flood Proofing							
Vulnerable Housing							
- Building materials	10,000	57,000	570.0	0	0.0	2,500	25.0
- Earth filling	3,300	57,000	188.1	330	18.8	2,500	8.3
Other Housing							
- Earth filling	5,700	57,000	324.9	570	32.5	2,500	14.3
Total		114,000	1083.0		51.3	5,000	47.5
Loans for building materials at	30%		171.0	0.0%	0.0	30.0%	7.5
Net Project Payment			912.0		51.3		40.0
Total			1,083.0		51.3		47.5
Community Infrastructure							
Weighted Cost of Micro Projects	500,000	400.0	200.0	27,500	11.0	50	25.0
NGO Support			152.1	0.0%	0.0		44.6
Technical Assistance			25.5	0.0%	0.0		10.9
Grand Total			1,460.6		62.3		128.0
Less loans			(171.0)		0.0		(7.5)
Net Total			1,289.6		62.3		120.5
Attribute share to Jamilpur Project (FAP 3.1)				50.0%	31.2		

Table 7.3.11 Rainfall Depth-Duration Frequency Period : May-June

Station Name	Return Period (Year)	1 Day mm	2 Day mm	3 Day mm	4 Day mm	5 Day mm	6 Day mm	7 Day mm	8 Day mm	9 Day mm	10 Day mm
DEWANGANJ (R062)	2	143	204	224	240	254	264	275	282	291	300
	5	238	317	337	354	365	374	384	395	402	411
	10	310	404	424	441	449	458	467	480	487	495
	20	380	486	507	524	530	538	547	563	568	576
	25	402	512	533	551	555	563	572	589	594	602
JAMALPUR (R067)	2	120	168	195	216	227	241	250	271	280	292
	5	207	275	310	334	340	357	368	405	416	427
	10	274	357	398	424	427	445	459	507	521	530
	20	338	436	483	510	511	530	546	605	621	629
	25	358	560	509	537	537	557	573	636	652	660
SARISHABARI (R032)	2	141	190	225	259	275	291	305	323	333	348
	5	230	308	388	444	476	491	508	526	540	556
	10	298	397	511	585	629	643	662	682	698	715
	20	363	483	630	720	776	790	810	831	849	868
	25	383	510	667	762	822	836	856	878	897	916

Table 7.3.12 Sample Area Drainage Parameters

Catchment Area	Discharge	Design Section			Velocity
ha	m^3/sec	Bed Width m	Depth m	Bed Slope cm/km	m/sec
A:1206	4.812	5.41	1.8	10	0.33
B:1083	4.136	5.11	1.7	10	0.32
C:388	1.482	3.12	1.04	18	0.32
D:352	1.345	2.98	0.99	19	0.30
F:230	0.878	2.41	0.80	25	0.30

Table 7.3.13 Cost of Drainage Improvements

Designation	Cost (Tk)
i) Natural depressions	
• drain improvements	
Type A 37.6 Km @ Tk 52,210	1,963,096
Type B 8.4 Km @ Tk 74,480	625,632
Type C 2.5 Km @ Tk 206,900	517,250
• control structures	
Type A 55 no @ Tk 109,400	6,017,000
Type B 13 no @ Tk 161,120	2,094,560
Type C 2 no @ Tk 231,220	462,440
ii) Minor water bodies	
• improvement of drains	
Type A 60 Km @ Tk 52,210	3,132,600
• culverts	
Type A 150 no @ Tk 109,400	16,410,000
iii) Rehabilitation of structures	
50 no @ Tk 200,000	10,000,000
Grand-total	41,222,578
Say	41,223,000

Table 7.3.14 Average and Range of Properties of Foundation Materials

Parameter	Units	Borrow 1	Borrow 2	Borrow 3	Borrow 4
U S C S Classification	-	MI,CI SM,CI	ML,MI SM,CI	MI,CI SM,CI	ML,MI SM,CI
Sand Content	%	10-40	10-97	5-100	0-70
Silt Content	%	60-75	3-77	3-83	30-100
Clay Content	%	0-15	0-13	0-12	0-15
Nat. Moist. Content	%	18-26	15-40	14-30	14-42
Opt. Moist. Content	%	15-23	12-24	16-20	14-23
Max. Dry Density	KN/m^3	16-17	14-18	15-17	15-18
Cohesion (effective)	KN/m^3	25	20	20	20
Friction Angle (effective)	Degree	15.0	27.5	27.5	27.5
Estimated Permeability	m/s	10^{-8} - 10^{-9}	10^{-6} - 10^{-7}	10^{-7} - 10^{-8}	10^{-7} - 10^{-8}

Table 7.3.15 Water Samples Chemical Analysis

Sample No.	pH	Soluble Salt Content (ppm)	Conductivity (mmhos/cm)	Hardness of $CaCo_3$ (mg/l)	Sodium Chloride (ppm)	Sulphate (ppm)
JHEN-S-2	7.9	256	0.40	Mod.Hard	15	32
CHAT-S-2	7.2	204	0.32	Mod.Hard	91	21
CHAT-S-3	7.1	230	0.36	Mod.Hard	85	21
BAUS-S-1	7.1	204	0.32	Mod.Hard	80	19
BAUS-S-2	7.1	236	0.37	Mod.Hard	121	24
JH-U-S-1	6.9	179	0.28	Mod.Hard	65	16
JH-D-S-1	7.1	214	0.30	Mod.Hard	52	21

Notes:
- Water samples collected upon completion of borehole drilling.
- Total Hardness based on USGS (1988)

Table 7.3.16 Average and Ranges of Potential Embankment Construction Material

Parameter	Units	Borrow 1	Borrow 2	Borrow 3	Borrow 4
USCS Classification	-	MI,CI SM,CI	ML,MI SM,CI	ML,MI SM,CI	ML,MI SM,CI
Sand Content	%	10-40	10-97	5-100	0-70
Silt content	%	60-75	3-77	3-83	30-100
Clay Content	%	0-15	0-13	0-12	0-15
Nat. Moist. Content	%	18-26	15-40	14-30	14-42
Opt. Moist. Content	%	15-23	12-24	16-20	14-23
Max. Dry Density	kN/m^3	16-17	14-18	15-17	15-18
Cohesion (effective)	kN/m^2	25	20	20	20
Friction Angle (Effective)	degree	15.0	27.5	27.5	27.5
Estimated Permeability	m/s	10^{-8}-10^{-9}	10^{-6}-10^{-7}	10^{-7}-10^{-8}	10^{-7}-10^{-8}

Notes:
- Average shear strength (cohesion and friction angle) values are average values based on laboratory results.
- Percentage of particle content range is based on composite grading envelope (see Figure 7.3.10)
- Permeability estimate based on Hazen's Formula.

Table 7.3.17 Existing Embankment Fill Material Parameters

Parameter	Units	Existing Embankment Old Brahmaputra	Existing Embankment Jamuna
USCS Classification	-	SP,ML,MI,CI	SM,ML,MI,CI
Sand Content	%	14-94	5-52
Silt content	%	6-71	29-79
Clay Content	%	0-15	2-16
Nat. Moist. Content	%	10.4-21.2	13.4-42.3
In-situ Density	kN/m^3	11.7-15.3	11.0-13.8
Opt. Moist. Content	%	14.7-23.7	11.2-23.2
Max. Dry Density	kg/m^3	14.9-16.8	15.4-16.6
Relative Density	%	78-97	70-90

Table 7.3.18 Mean Annual Maximum Flood Water Levels since 1964

Location	Mean Water level (m PWD)	Standard Deviation (m)
Jamalpur	17.00	0.40
Jhenai Intake	17.53	0.49
Bahadurabad	19.80	0.30
Jagannathganj	15.13	0.38
Bausi Bridge	15.80	0.38

Table 7.3.20 **Unit Prices (1991)**

Item	Unit	Rate (Tk)
Clearing + excavation	m^3	16.35
Alluvial Fill, placing and with mechanical compaction including local material - up to 4 m embankment - up to 6 m embankment - up to 8 m embankment	 m^3 m^3 m^3	 29.20 30.35 31.50
Extra over for carriage of material up to a distance of 15km.	m^3	44.85
Geotextile 300 g/m^2 Material & Transport & Placing	m^2	95.65
Geodrain Material & Transport & Placing	m^2	173.90
Crest Road Layers of Sand and Khoa, including delivery, placing & compaction of 1/2 Sand & 1/2 Khoa for sub-base	m^3	493.00
Placing & Compaction of 1/3 Sand & 2/3 Khoa for base	m^3	607.00
Placing & compaction of 1/4 Sand & 3/4 Khoa for pavement	m^3	664.00
Turfing	m^2	2.90
Brick Slope Protection	m^2	129.00

Table 7.3.21 Embankment Construction Costs
Embankment 1
JAMUNA (73.880 km)
Crest width 7.0m, 3.5m maintenance track

Design Case	B5	B4	B3
Water level return period (yrs)	100	50	20
Freeboard (m)	1.50	1.50	1.50
Embankment fill	214,558,305	190,148,333	161,776,962
Protection, drain etc.	77,481,672	72,802,513	65,770,539
Key trench	37,454,337	34,722,294	30,078,275
Road	35,831,800	35,831,800	35,831,800
Total (Taka)	365,326,114	333,504,940	293,457,576

Table 7.3.22 Embankment Construction Costs
Embankment 2
OLD BRAHMAPUTRA (43.170 km)
Crest width 4.5m, 3.5m maintenance track

Design Case	-	B5 & 4	B3
Water level return period (yrs)	100	50	20
Freeboard (m)	1.10	1.10	1.10
Embankment fill	n/a	49,521,575	43,551,654
Protection, drain etc.	n/a	10,978,942	9,885,310
Key trench	n/a	5,080,671	4,334,229
Road	n/a	20,937,450	20,937,450
Total (Taka)	n/a	86,518,638	78,708,643

Table 7.3.23 Summary of Embankment Construction Costs
Embankment 3
JAMALPUR - SARISHABARI RAILWAY (27.239 km)
Crest width 4.5m, 3.5m maintenance track

Design Case	-	B5 & 4	B3
Water level return period (yrs)	100	50	20
Freeboard (m)	1.10	1.10	1.10
Embankment fill	n/a	33,298,204	28,621,132
Protection, drain etc.	n/a	-	-
Key trench	n/a	-	-
Road	n/a	13,210,915	13,210,915
Total (Taka)	n/a	46,509,119	41,832,047

Table 7.3.24 Summary of Embankment Construction Costs
Embankment 4a and 4b (Both sides of railway)
SARISHABARI RAILWAY - FERTILISER FACTORY (16.480 km)
Crest width 7.0m, 3.5m maintenance track

Design Case	B5	B4	B3
Water level return period (yrs)	100	50	20
Freeboard (m)	1.50	1.50	1.50
Embankment fill	33,828,298	29,630,331	26,519,146
Protection, drain etc.	-	-	-
Key trench	-	-	-
Road	7,992,800	7,992,800	7,992,800
Total (Taka)	41,821,098	37,623,131	34,511,946

Table 7.3.25 Summary of Embankment Construction Costs
for Design Alternatives
All with 3.5m maintenance track

Design Case	B5		B4		B3	
Water level return period (yrs)	100	50	50	50	20	20
Freeboard (m)	1.50	1.10	1.50	1.10	1.50	1.10
Crest Width (m)	7.0	4.5	7.0	4.5	7.0	4.5
Jamuna	365.3	-	333.5	-	293.5	-
Old Brahmaputra	-	86.5	-	86.5	-	78.7
Jamalpur - Sarishabari Rlwy	-	-	-	-	-	-
Sarishabari - Fert. Factory *	20.9	-	18.8	-	17.3	-
Totals (Million Taka)		472.8		438.8		389.4

**Table 7.3.26 Embankment Construction Costs
Main Quantities and Cost Estimates
for Recommended Option B5
Base Case with 3.5m maintenance track**

Embankment		1 Jamuna	2 Old Brahmaputra	4a Sarishabari Fert. Plant	
Water level return period (yrs)		100	50	100	
Freeboard (m)		1.50	1.10	1.50	
Crest Width (m)		7.00	4.50	7.00	
	Unit	Main Quantities			Totals
Embankment fill	m^3	6,879,709	1,587,414	561,623	9,028,746
Turfing	m^2	2,184,344	829,163	199,326	3,212,833
Geotextile	m^2	488,760	69,382	-	558,142
Geodrain	m^2	94,569	13,897	-	108,466
Concrete blocks	m^2	26,016	3,609	-	29,625
Key Trench excavation	m^3	262,044	32,211	-	294,255
Key Trench fill	m^3	262,044	32,211	-	294,255
	Unit	Main Costs			Totals
Embankment	Taka	329,494,314	65,581,188	16,914,149	411,989,651
Maintenance Track	Taka	35,831,800	20,937,450	3,996,400	60,765,650
Total BASE COST *	**Taka**	**365,326,114**	**86,518,638**	**20,910,549**	**472,755,301**
Incremental cost to increase road standard to feeder road (excluding black top)	Taka	73,329,594	42,848,383	8,178,612	124,356,589
Total upgraded cost	Taka	438,655,708	129,367,021	29,089,161	597,111,890

* Base cost used in economic analysis.

Table 7.3.27 **Hydraulic Structures** **Estimated Cost (In Taka)**

Description of Work	Unit	Rate (Tk)	Islampur Inlet (S1)		Jhenai Inlet (S2)		Jhenai/Chatal Outlet (S4)		Chatal Inlet (S5)	
			Quantity	Cost (Tk)	Quantity	Cost (Tk)	Quantity	Cost (Tk)	Quantity	Cost (Tk)
Excavation	cu.m	22.40	11384	255,002	36781	823,894	80641	1,806,358	19890	445,536
Filling	cu.m	13.65	7796	106,415	13061	178,283	16604	226,645	9553	130,398
Wellpoint Dewatering	hr/pump/100 WP	207.00	2160	447,120	15120	3,129,840	54000	11,178,000	17200	3,560,400
Bailing Out of Surface Water	cu.m	0.93	14580	13,559	102060	94,916	364500	338,985	116640	108,475
Cement Concrete	cu.m	218.65	60	13,119	134	29,299	347	75,872	142	31,048
R.C.C.	cu.m	2,870.00	1724	4,947,880	4537	13,021,190	13202	37,889,740	3980	11,422,600
R.C.C. Piles (Cast-in-Situ)	MR.	1,020.00	2592	2,643,840	4716	4,810,320	11970	12,209,400	4770	4,865,400
Water Tight Shutter	sq.m	406.65	2077	844,612	5424	2,205,670	14788	6,013,540	4779	1,943,380
M.S. Rod	per Kg.	25.97	168952	4,387,683	444626	11,546,937	1293698	33,597,337	390040	10,129,339
PVC Water Stop	per M.	824.35	54	44,515	180	148,383	608	501,205	175	144,261
Slot for Gate	per Kg.	50.38	3267	164,591	28476	1,434,621	110800	5,582,104	32296	1,627,072
Steel Sheet Pile	per M Drive/Pile	1,923.72	1554	2,989,461	3241	6,234,777	7392	14,220,138	3087	5,938,524
Sand Filling	cu.m	427.90	4854	2,077,027	9050	3,872,495	12522	5,358,164	6375	2,727,863
Contraction Joint	per MR.	157.10	-		62	9,740	255	40,061	58	9,112

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Table 7.3.27 **Hydraulic Structures** **Estimated Cost (In Taka)**

Description of Work	Unit	Rate (Tk)	Islampur Inlet (S1)		Jhenai Inlet (S2)		Jhenai/Chatal Outlet (S4)		Chatal Inlet (S5)	
			Quantity	Cost (Tk)	Quantity	Cost (Tk)	Quantity	Cost (Tk)	Quantity	Cost (Tk)
Steel Sheet Pile Cutting	Each	60.67	151	9,161	312	18,929	707	42,894	297	18,019
Filling of Expansion Joint	sq.m	202.61	55	11,144	108	21,882	279	56,528	105	21,274
Tar Paper	Each set	108.35	4	433	18	1,950	61	6,609	20	2,167
Manual Excavation	cu.m	14.50	95024	1,377,848	159239	2,308,966	497272	7,210,444	196711	2,852,310
Cross Dam	cu.m	31.45	6573	206,721	24077	757,222	43012	1,352,727	21126	664,413
C.C. Block	cu.m	118.84	315	37,435	618	73,443	1322	157,106	571	67,858
Wire Netting	Each	787.72	285	224,500	925	728,641	2938	2,314,321	1078	849,162
Gravel and Sand Filling	cu.m	827.40	223	184,510	684	565,942	2143	1,773,118	801	662,747
Ring Bund	cu.m	14.15	65287	923,811	58938	833,973	191036	2,703,159	83420	1,180,393
Steel Sliding Gate	sq.m	25,432.00	8.82	224,310	61.74	1,570,172	220.5	5,607,756	70.56	1,794,482
Wooden Stop-Log	cu.m	22,277.00	1.0	22,277	7.88	175,543	31.5	701,726	6.24	139,008
Lock Gate Accessories & Tilting Bridge	L.S.	13,350,000.00	-	-	-	-	-	13,350,000	-	-
Totals				22,156,975		54,597,026		164,313,938		51,335,242

Cost of flushing structures : 55 mo x Tk 630,000 total : Tk 34,650,000

Table 7.3.28 Comparison of JPPS Rates and Rates from Recently Awarded Contracts (1992)

Type of work : Road embankment				
	Contract A	Contract B	JPPS	average ratio to lower tender
Embankment fill (TK/m³)	80	60	30	2.00
Pavement (TK/m)	1088	934	1480	0.63
RCC (TK/m³)	3860	3919	2870	1.35
Reinforcement (Tk/ton)	26619	25360	25970	0.98

Source: Tenders for Rajshahi and Argarahat road rehabilitation (EEC)

Table 7.3.29 Type of Work : Hydraulic Structure

	Contract (2)	Contract (3)	Contract (7)	Contract (8)	JPPS	Average ratio to lowest tender
Excavation (Tk/m³)	69	65	25	80	22.5	1.11
Concrete (Tk/m³)	4704	5072	3605	4000	2870	1.26
Reinforcement (Tk/t)	32830	38220	31000	34000	25970	1.20
Geotextile (Tk/m²)	-	-	-	156	95	1.64
Compacted sand fill (Tk/m³)	392	735	300	200	427	0.47
Formwork (Tk/m²)	392	816	200	-	406	0.50
Steel sheet pile (Tk/t)	98000	122500	75000	-		
Earthwork in backfill (Tk/m³)	39.2	55	19	30	14	1.36

Source: Tenders for coastal rehabilitation programme (EEC)

Table 7.3.30 Type of Work: Polder embankment (coastal area)

	Contract (4)	Contract (5)	Contract (6)	Contract (7)	JPPS	Average ratio to lowest tender
Corefill 1 (Tk/m³)	135	85	80	86	30	2.70
Corefill 2 (Tk/m³)	130	95	90	113	-	-
Overall cost (Tk/m³)	220	137	121	109	64	1.90
Geotextile	100	-	-	-	95	1.05

Source: Tenders for coastal rehabilitation programme (EEC)

Table 7.3.31

Type of work: FCD Project - Thakurakona	
Volume of embankment:	331,123 m^3
Contract amount: (including Royalties)	Tk 10,331,911
i.e.	31.2 Tk per m^3
Volume of JPPS embankment	9,000,000 m^3
Cost estimate: (without road/geotextile)	Tk 337,420,000
i.e.	37.5 Tk per m^3

Source: for Thakurakona FCD Project (BWDB) contract

Table 7.3.32 Coastal Embankment. Breakdown of Rate 205 - Core I

Contract No%	2	%	3	%	4	%	5	%	6	%	7	%
Earth	14	10.0			14	10.40					10.6	12.2
Equipment	14	10.0	4.00	2.40	14	10.4	12	14.1	12	15.0	7.5	8.6
Power/Water	-	-	0.20	0.10			1	1.2	1	1.2	-	
Fuel/Oil	2	1.4	1.50	0.90	3	2.2	5	5.9	5	6.2	-	
Temporary work	36	25.7	0.05	0.03	2	1.6	3	3.5	3	3.8	-	
Labour	36	25.7	118.00	70.10	36	26.6	40	47.0	40	50.0	57.3	66.5
Transport	5	3.6	5.00	2.90	36	26.6	1.83	2.2	1.83	2.3	-	
Others	5	3.6	8.50	5.00	3	2.2	8	9.4	3.84	4.8	-	
Subtotal	112		137.25		108		70.83		66.67		74.8	
Overhead	11.2	8.0	6.862	4.20	10.8	8.0	3.54	4.2	3.34	4.2	1.49	1.6
Taxes/Insurances	5.6	4.0	10.294	6.10	5.4	4.0	3.54	4.2	3.33	4.4	2.24	2.5
Profit	11.2	8.0	13.725	8.30	10.8	8.0	7.08	8.3	6.67	8.3	7.48	8.6
Subtotal	28.0		30.881		27.0		14.16		13.34		11.21	
Total(Tk/m^3)	140.0		168.131		135		84.99		80		86.01	
Q(m^3)	1,260,000		825,000		990,000		2,290,000		1,235,000		443,000	
C (Tk)	308,261,675		335,353,594		230,161,150		281,804,000		144,649,120		77,035,982	
EW(Tk)	180,909,960		161,397,000		142,215,000		228,525,000		120,130,000		48,434,000	
EW/Q(Tk/m^3)	143		195		144		100		97		109	

Table 7.3.33 Coastal Embankment Works. Breakdown of Rate 4.10.2.2 - Concrete Class B

Contract No.	2		3		5		7		8		BWDB 1992-93		JPPS 1991	
Coarse aggregate	1200		1290				1215.00		1220		1482			
Fine Aggregate	500	2450	578	3618		3040	292.50	2906.70	195	2990	158	2406	2497	2497
Cement	750		1750				1399.20		1575		766			
Machinery	50		40		30		33.00		50				86	
Power/water	-		20		10		-		10					
Fuel/Oil	10		40		20		-		10					
Formwork	600	960	-	472	-	210	-	228.00		250				336
Temporary works	-		20		-		-							
Labour	300		352		150		195.00		180		327		250	
Transportation	290		30		-		-							
Others	100		20		-		-		60					
Subtotal	3760		4141		3250		3134.70		3300		2733			
Overhead	376		207		162.5		62.69							
Taxes/Insurances	188		310		162.5		94.04		660					
Profit (10%)	376		414		325.0		313.49				281			
Subtotal	940		931		650		470.49		660					
Total general	4700		5072		3900		3605.19		3960		3014			2870

Source : Coastal rehabilitation programme (EEC)

Table 7.3.34 Sensitivity Analysis, Variation of Unit Rates for Work

Designation and increment	basic capital cost MTK	revised capital cost MTK	incremental cost MTK
Fisheries (+20%)	28.0	33.6	5.6
Hyd. Structures (+20%)	327.1	392.5	65.4
Embankment			
• embankment fill (+66%)	279.7	464.3	184.6
• others (+20%)	193.0	231.6	38.6
Total	827.8	1122.0	294.2
Total increment on total basic capital cost for B5 (1045.9 MTK) + 28%			

Notes:1 - Due to the nature of the works, Drainage works and flood proofing works are not expected to be carried out on an international tender basis. Therefore BWDB rate are considered as valid.

Notes:2 - for fisheries, only infrastructure components are taken into account.

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Table 7.3.35 Summary of Cost Estimates Recommended Developments Expressed in 1991 Taka (Financial)

	Mainland Option B5	Char and Setback Land Pilot Phase	Total Initial Investment	Char and Setback Land Main Phase	Overall Investment
Drainage Improvements	41,223,000	-	41,223,000	-	41,223,000
Flood Proofing					
Community Infrastructure	-	25,000,000	25,000,000	175,000,000	200,000,000
Minor Structural Flood Proofing	-	47,500,000	47,500,000	1,035,500,000	1,083,000,000
Sub-total	-	72,500,000	72,500,000	1,210,500,000	1,283,000,000
Embankments (Base Case)	472,756,000	-	472,756,000	-	472,756,000
Hydraulic Structures	327,053,000	-	327,053,000	-	327,053,000
Fisheries Programme	59,000,000	-	59,000,000	-	59,000,000
Land Acquisition	114,660,000	-	114,660,000	-	114,660,000
Total Capital Costs	1,014,692,000	72,500,000	1,087,192,000	1,332,625,000	2,419,817,000
Less loans	-	(7,500,000)	(7,500,000)	(163,500,000)	(171,000,000)
Net Capital Costs	1,014,692,000	65,000,000	1,079,692,000	1,169,125,000	2,248,817,000)
Physical Contingencies @15%	152,204,000	incl above	152,204,000	incl above	152,204,000
Engineering & Tech. Assistan	219,000,000	10,875,000	229,875,000	14,625,000	244,500,000
NGO Support Programmes	10,191,000	44,570,000	54,761,000	107,500,000	162,261,000
Estimated Grand Total (including loans)	1,396,087,000	127,945,000	1,524,032,000	1,454,750,000	2,978,782,000

Table 7.3.36 Summary of Cost Estimates Development Options A and B5 Expressed in 1991 Taka (Financial)

	Option A	Option B5
Drainage Improvements		
Earthworks	6,239,000	6,239,000
New Structures	24,984,000	24,984,000
Rehabilitation of Structures	10,000,000	10,000,000
Sub-total	41,223,000	41,223,000
Flood Proofing		
House improvements for 28,800 H/H	273,600,000	-
Less loans repaid on 30% materials	(43,200,000)	-
Community Infrastructure Micro-Projects, 100 No.	50,000,000	-
Sub-total	280,400,000	-
Embankments (Base Case)		
Jamuna	-	365,326,000
Old Brahmaputra (incl. town protection)	-	86,519,000
Jamalpur - Sarishabari Rlwy	-	-
Sarishabari - Fert. Factory *	-	20,911,000
Sub-total	-	472,756,000
Hydraulic Structures		
Islampur Inlet	-	22,157,000
Jhenai Inlet	-	54,597,000
Chatal Inlet	-	51,335,000
Jhenai/Chatal Outlet	-	164,314,000
Flushing Sluices, 55No.	-	34,650,000
Sub-total	-	327,053,000
Fisheries Programme - Capital works		
Rehabilitation of Jamalpur FSMF	-	8,000,000
Check Structures	-	20,000,000
Fisheries Programme - NGO support		
Establishment costs	-	1,500,000
Staff Costs	-	13,600,000
Running costs for 7 years	-	15,900,000
Sub-total	-	59,000,000
Land Acquisition	31,948,000	114,660,000
Total Capital Costs	**396,771,000**	**1,014,692,000**
Less loans	(43,200,000)	-
Net Capital Costs	353,571,000	1,014,692,000
Physical Contingencies @ 15%	59,516,000	152,204,000
Engineering and Technical Assistan	42,300,000	219,000,000
NGO Support for Public Participation	10,191,000	10,191,000
Estimated Grand Total (including loans)	**508,778,000**	**1,396,087,000**

FIGURES

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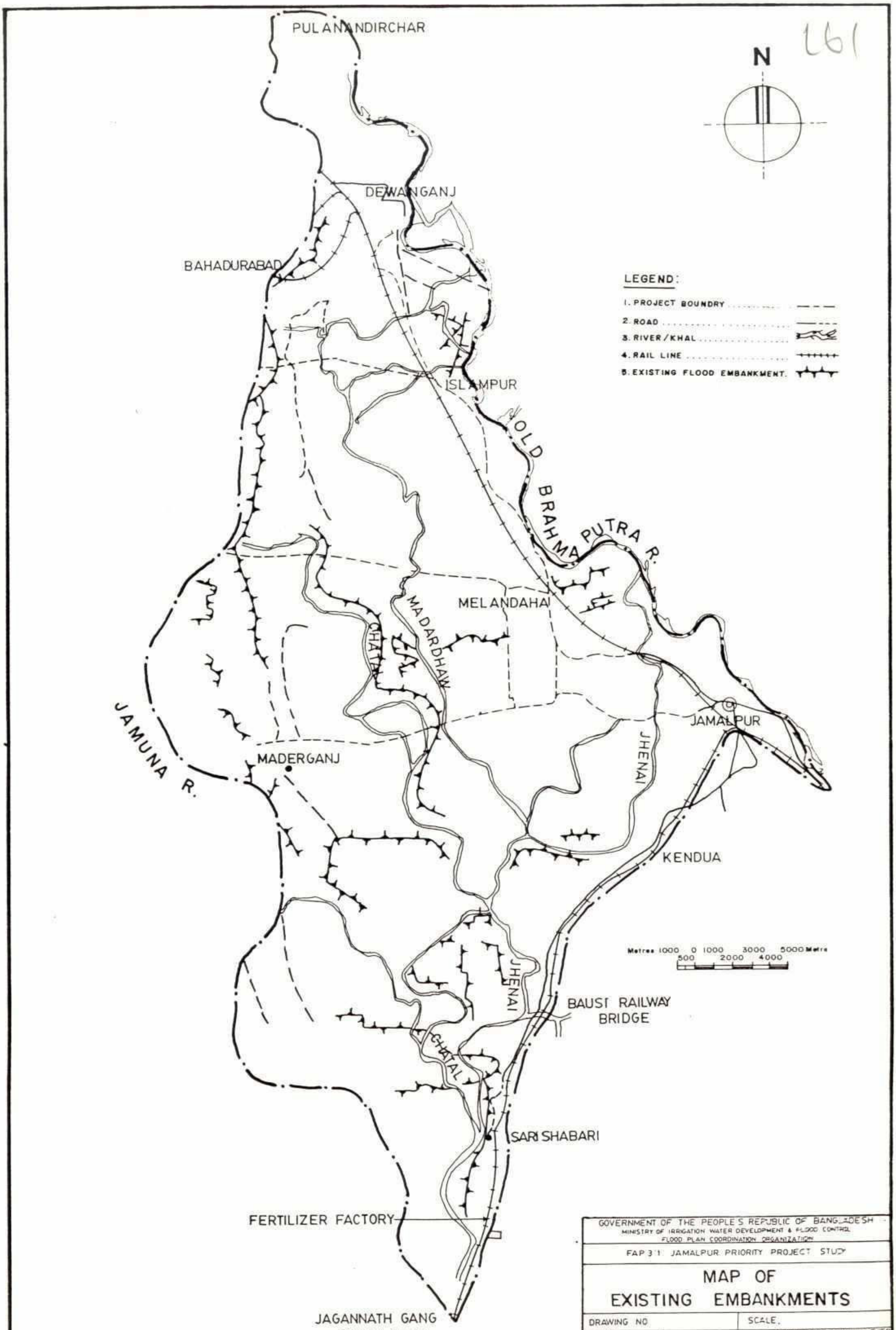
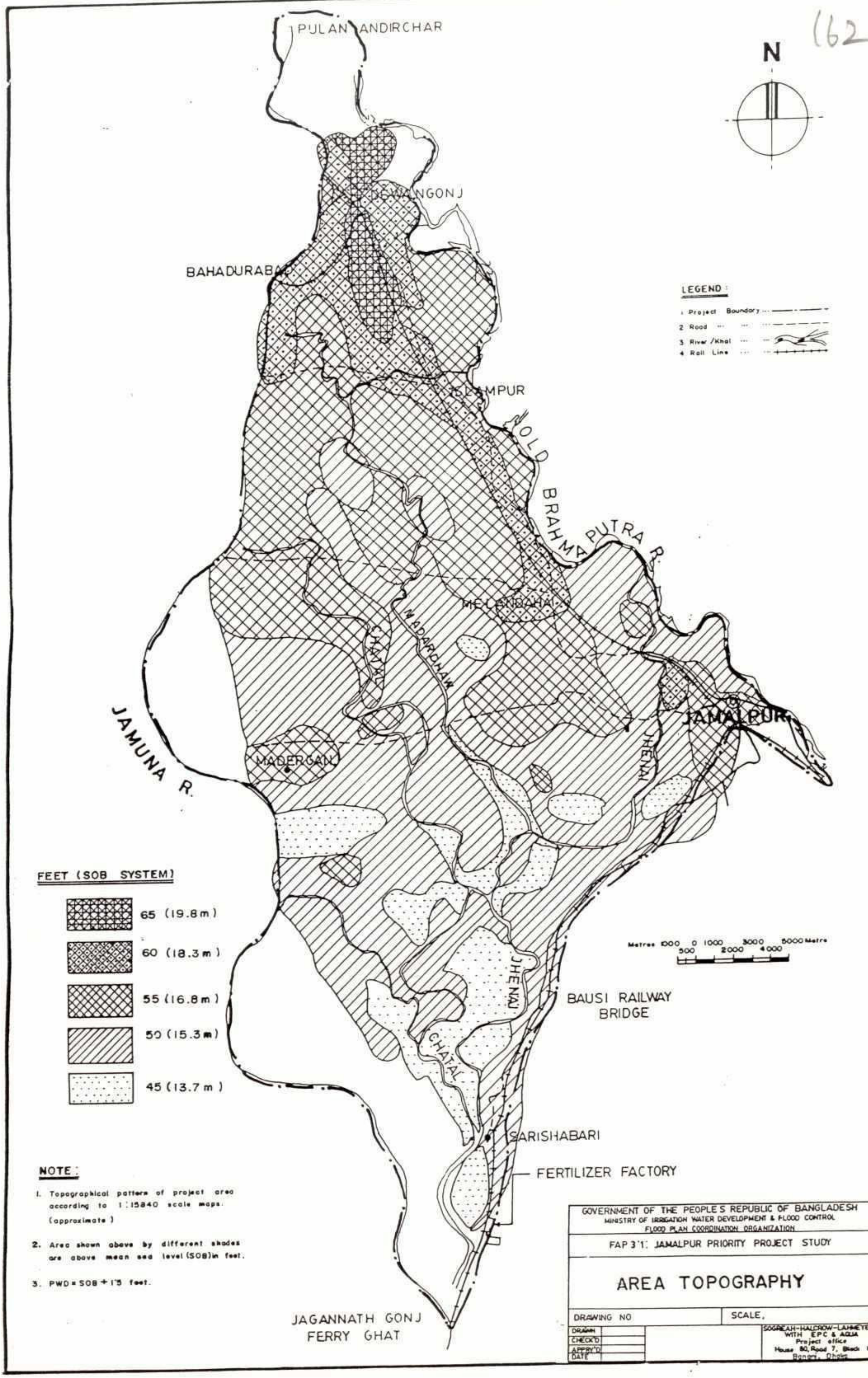

PULANANDIRCHAR
N
DEWANGANJ
BAHADURABAD
LEGEND:
1. PROJECT BOUNDRY
2. ROAD
3. RIVER / KHAL
4. RAIL LINE
5. EXISTING FLOOD EMBANKMENT.
ISLAMPUR
OLD BRAHMA PUTRA R.
MELANDAHA
MADARDHAW
CHATAL
JAMUNA R.
JAMALPUR
MADERGANJ
JHENAI
KENDUA
Metres 1000 0 1000 3000 5000 Metre
500 2000 4000
JHENAI
BAUST RAILWAY
BRIDGE
GHATAL
SARISHABARI
FERTILIZER FACTORY
JAGANNATH GANG
FERRY GHAT
GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN COORDINATION ORGANIZATION
FAP 3.1 JAMALPUR PRIORITY PROJECT STUDY
MAP OF
EXISTING EMBANKMENTS
DRAWING NO
SCALE.
DRAWN
CHECK'D
APPRV'D
DATE
SOGREAH-HALCROW-LAHMEYER
WITH EPC & AQUA
Project office

162


PULAN ANDIRCHAR
N
DEWANGONJ
LEGEND :
1 Project Boundary
2 Road
3 River /Khal
4 Rail Line
OLD BRAHMA PUTRA R.
JAMUNA R.
JAMALPUR
JHENAI
CHATAL
FEET (SOB SYSTEM)
65 (19.8 m)
60 (18.3 m)
55 (16.8 m)
50 (15.3 m)
45 (13.7 m)
Metres 1000 500 0 1000 2000 3000 4000 5000 Metre
BAUSI RAILWAY BRIDGE
SARISHABARI
FERTILIZER FACTORY
NOTE :
1. Topographical pattern of project area according to 1:15840 scale maps. (approximate)
2. Area shown above by different shades are above mean sea level (SOB) in feet.
3. PWD = SOB + 1'5 feet.
JAGANNATH GONJ
FERRY GHAT
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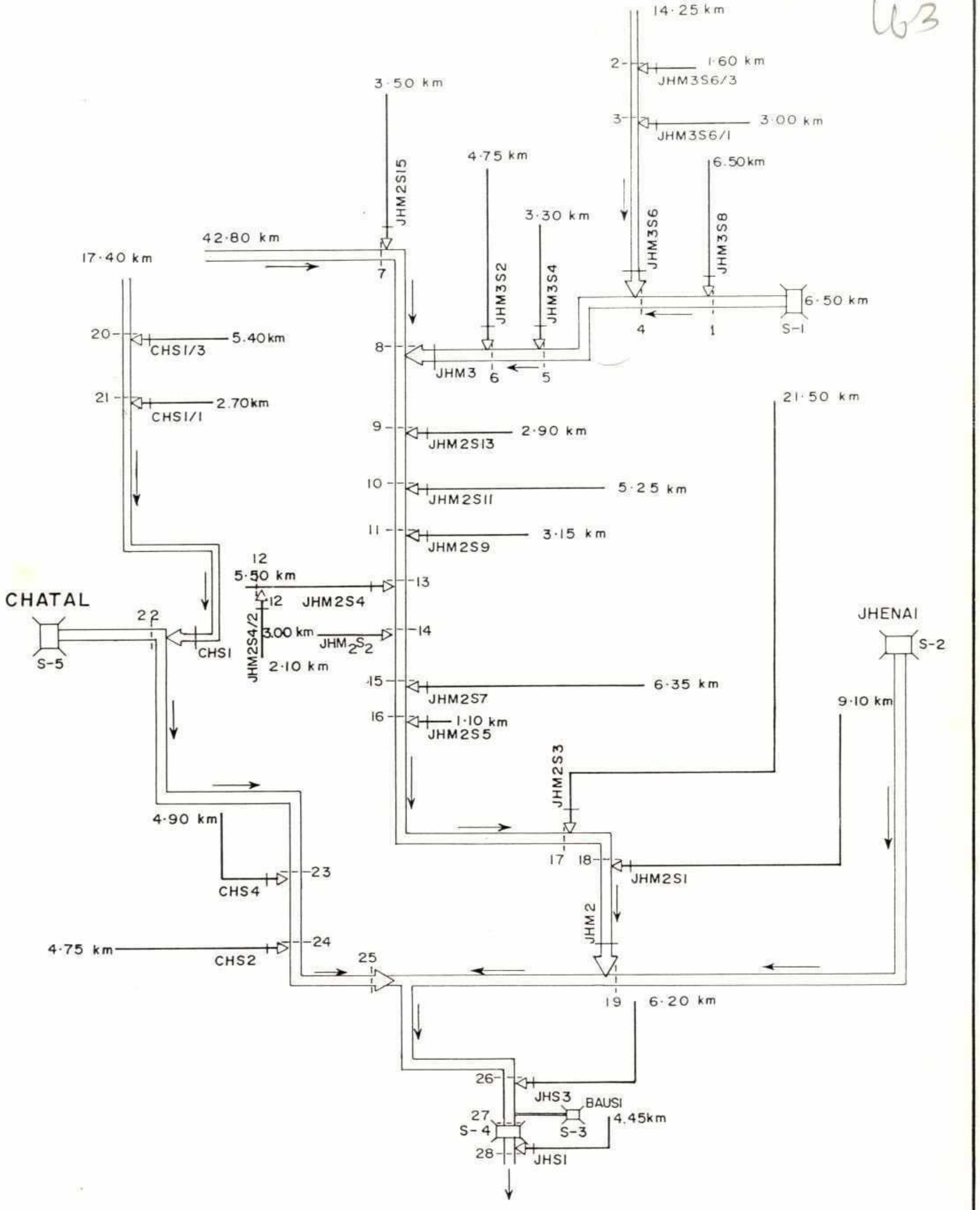
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN COORDINATION ORGANIZATION
FAP 3'1: JAMALPUR PRIORITY PROJECT STUDY
AREA TOPOGRAPHY
DRAWING NO
SCALE,
DRAWN
CHECK'D
APPRV'D
DATE
SOGREAH-HALCROW-LAHMEYER WITH EPC & AQUA
Project office
House 80, Road 7, Block H
Banani, Dhaka



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MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN CO-ORDINATION ORGANIZATION

FAP 3.1 : JAMALPUR PRIORITY PROJECT STUDY

SCHEMATIC DIAGRAM

DRAINAGE NET-WORK

DRAWING NO | SCALE : NOT TO SCALE

DRAWN / CHECK'D / APPRV'D / DATE

SOGREAH-HALCROW-LAHMEYER WITH EPC & AQUA
Project office
House 80, Road 7, Block 'H'
Banani, Dhaka

Figure 7.2.1

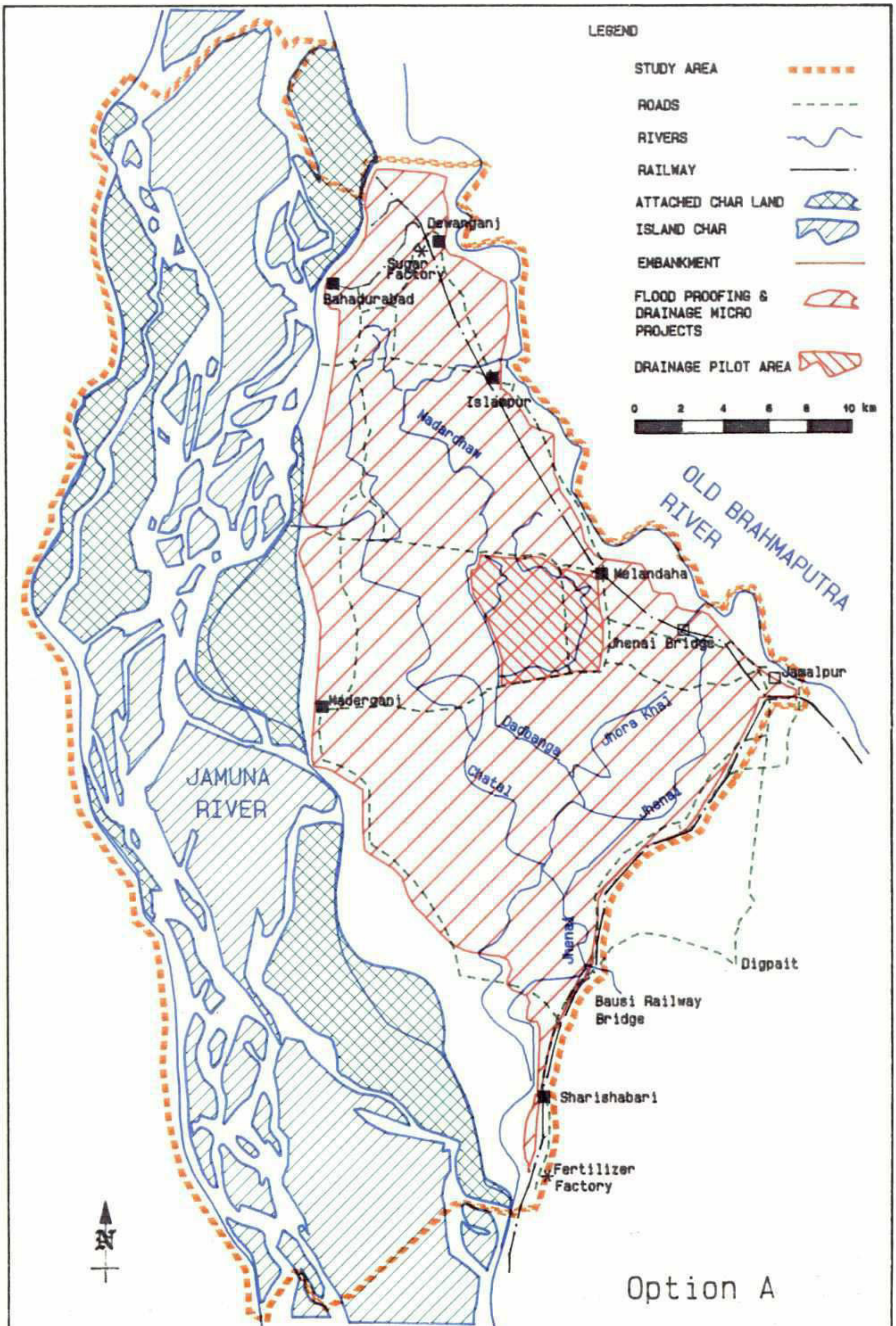

LEGEND
STUDY AREA
ROADS
RIVERS
RAILWAY
ATTACHED CHAR LAND
ISLAND CHAR
EMBANKMENT
FLOOD PROOFING & DRAINAGE MICRO PROJECTS
DRAINAGE PILOT AREA
0 2 4 6 8 10 km
OLD BRAHMAPUTRA RIVER
JAMUNA RIVER
Dewanganj
Sugar Factory
Bahadurabad
Islampur
Madardhaw
Melandaha
Jhenai Bridge
Jamalpur
Madarganj
Dadbanga
Jhora Khal
Chatal
Jhenai
Digpait
Bausi Railway Bridge
Sharishabari
Fertilizer Factory
N
Option A

Figure 7.2.2

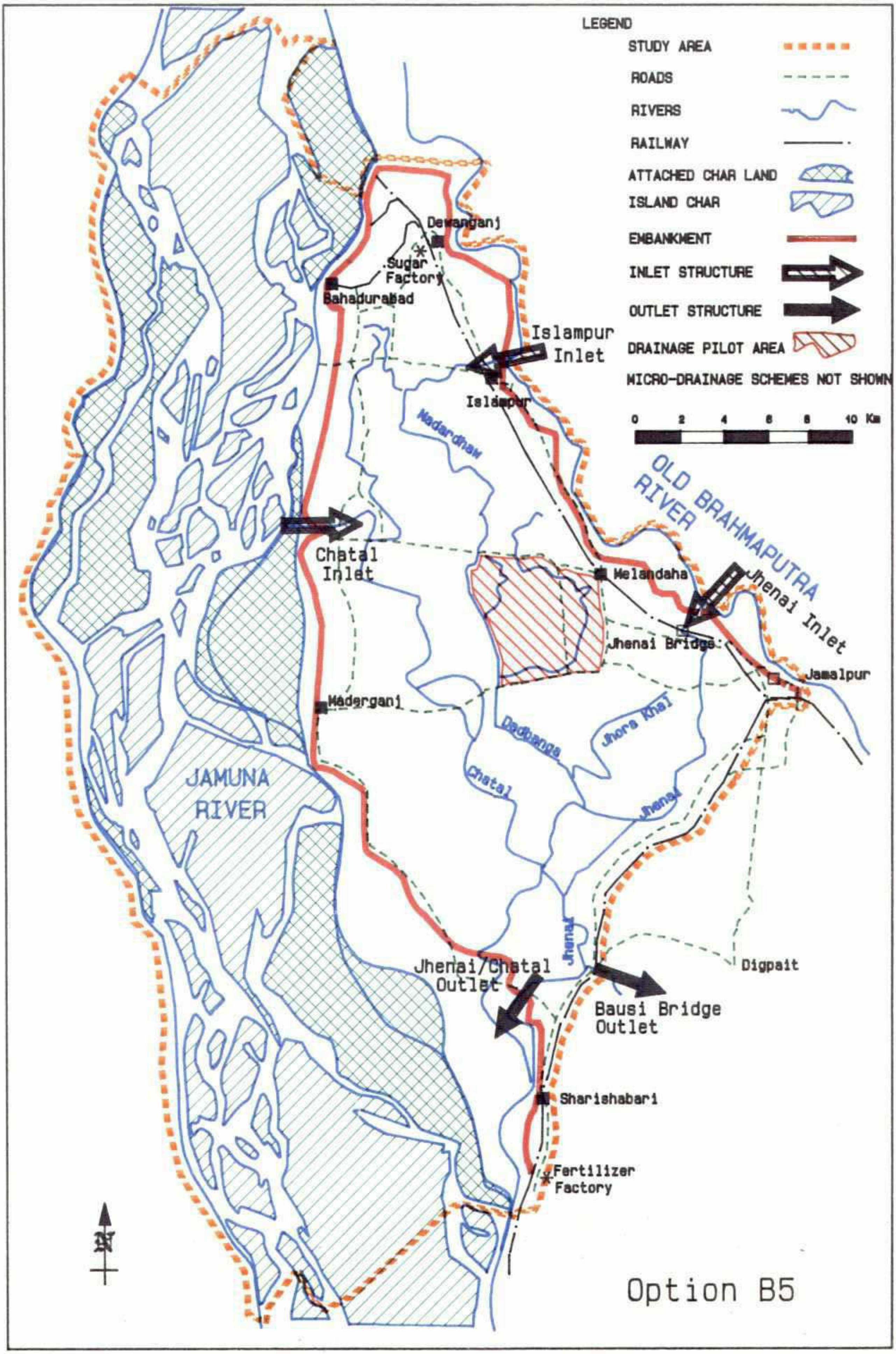
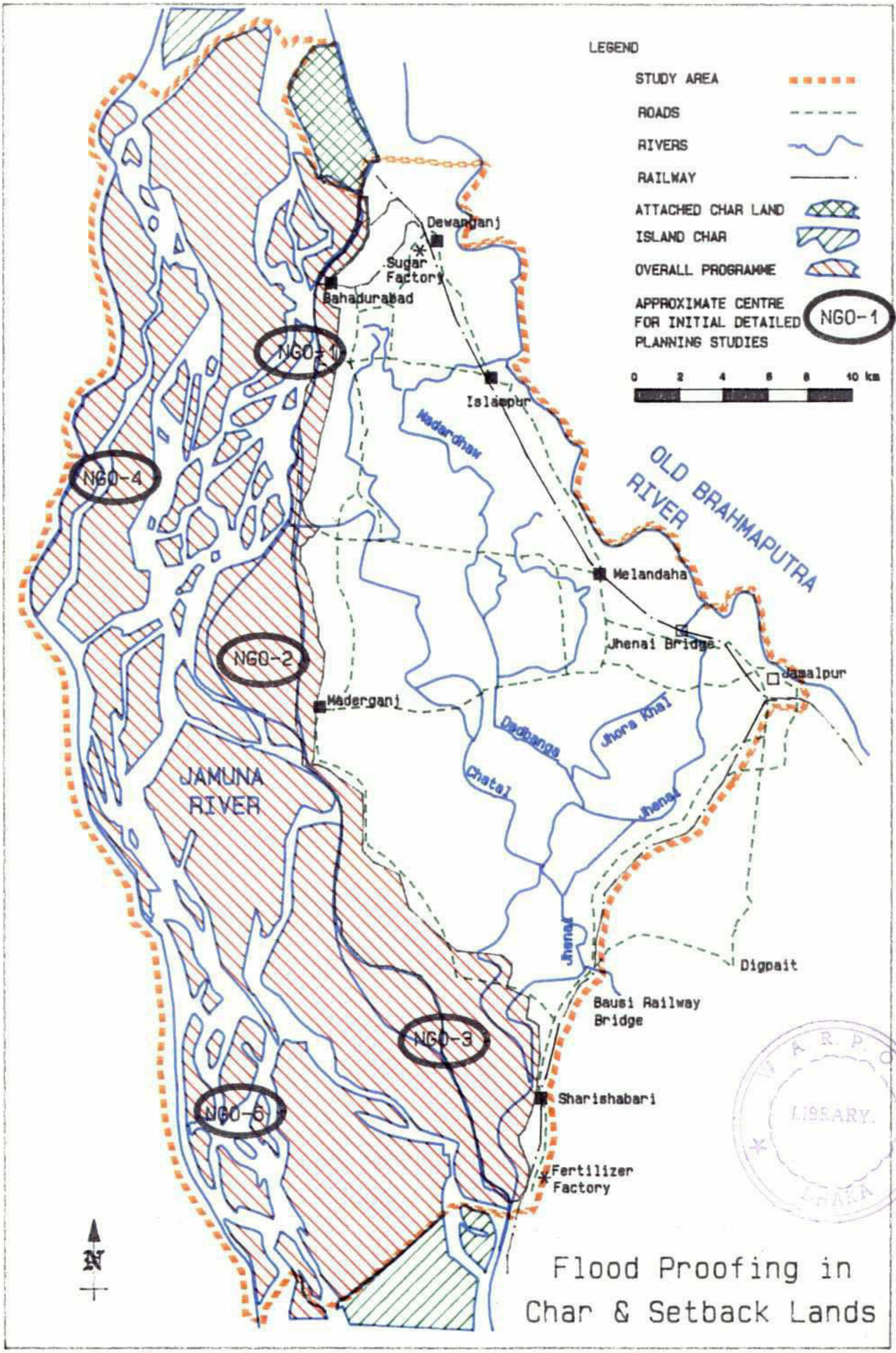
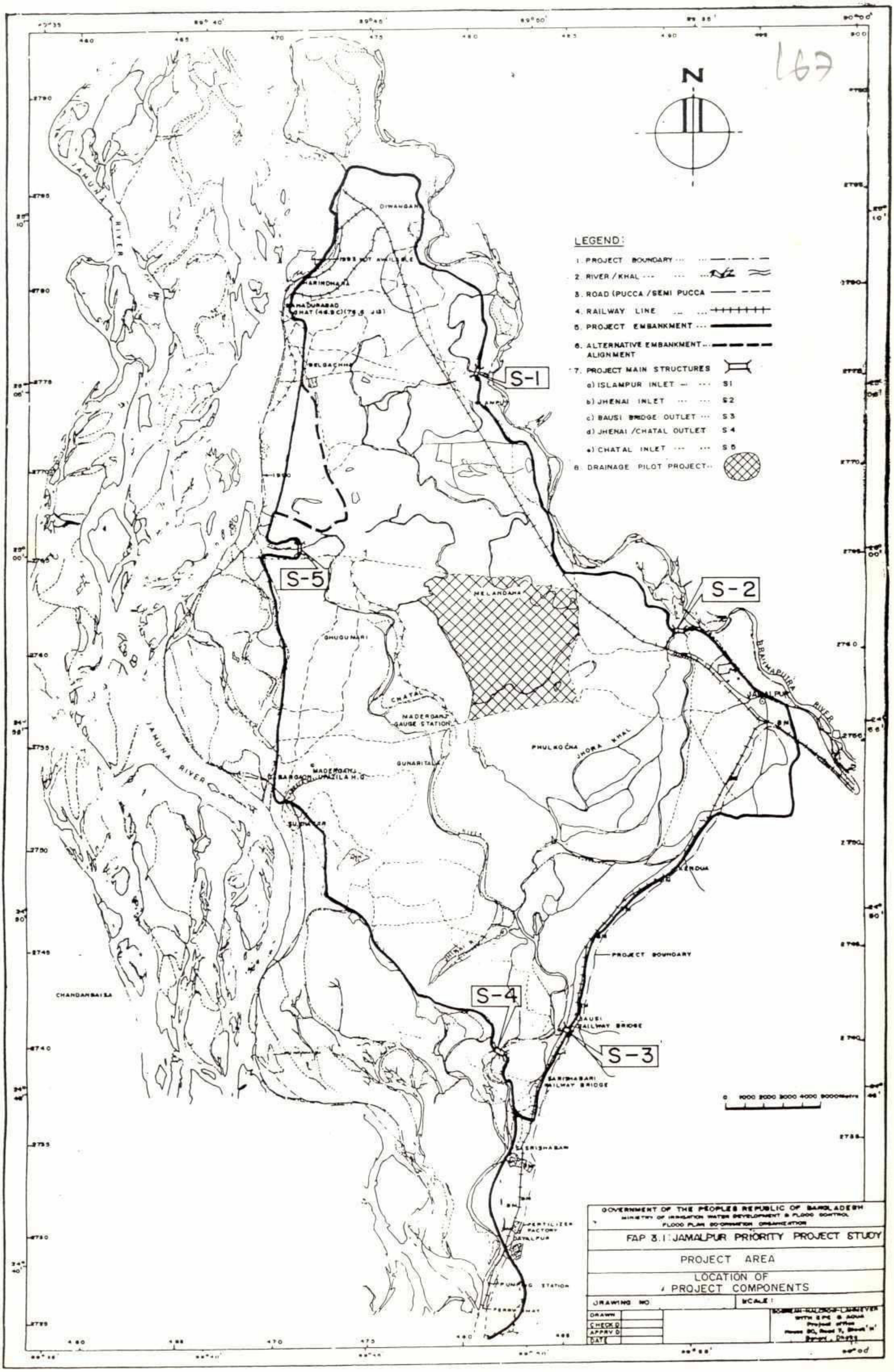

LEGEND
STUDY AREA
ROADS
RIVERS
RAILWAY
ATTACHED CHAR LAND
ISLAND CHAR
EMBANKMENT
INLET STRUCTURE
OUTLET STRUCTURE
DRAINAGE PILOT AREA
MICRO-DRAINAGE SCHEMES NOT SHOWN
0 2 4 6 8 10 Km
Dewanganj
Sugar Factory
Bahadurabad
Islampur Inlet
Islampur
Madardhaw
OLD BRAHMAPUTRA RIVER
Chatal Inlet
Melandaha
Jhenai Inlet
Jhenai Bridge
Jamalpur
Maderganj
Dadbanga
Jhora Khal
Chatal
Jhenai
JAMUNA RIVER
Jhenai/Chatal Outlet
Bausi Bridge Outlet
Digpait
Sharishabari
Fertilizer Factory
N
Option B5

Figure 7.2.3



Flood Proofing in Char & Setback Lands

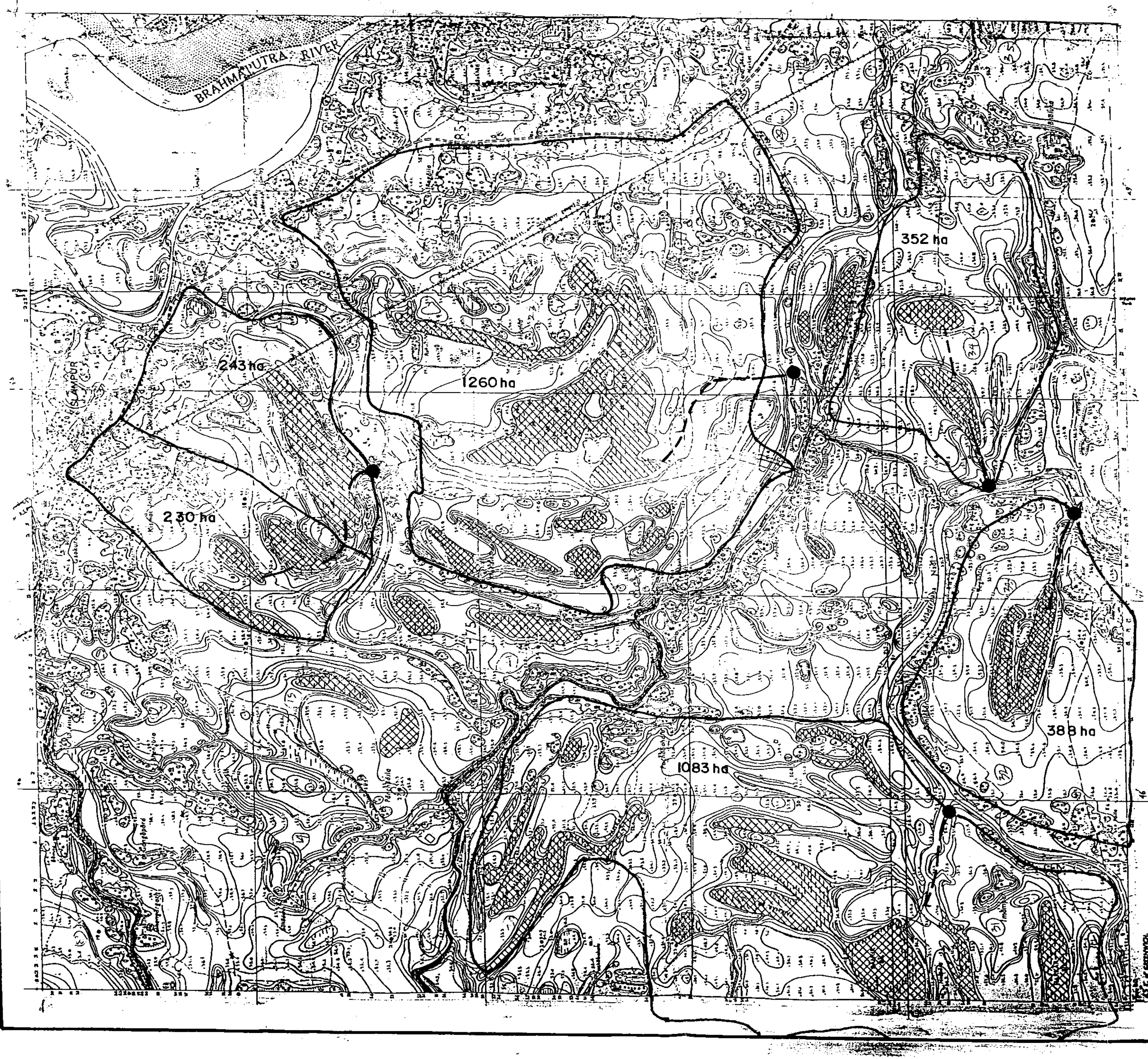
FIGURE 7.3.1



167
N
LEGEND:
1. PROJECT BOUNDARY
2. RIVER / KHAL
3. ROAD (PUCCA / SEMI PUCCA
4. RAILWAY LINE
5. PROJECT EMBANKMENT
6. ALTERNATIVE EMBANKMENT ALIGNMENT
7. PROJECT MAIN STRUCTURES
a) ISLAMPUR INLET S1
b) JHENAI INLET S2
c) BAUSI BRIDGE OUTLET S3
d) JHENAI / CHATAL OUTLET S4
e) CHATAL INLET S5
8. DRAINAGE PILOT PROJECT
S-1
S-2
S-3
S-4
S-5
JAMUNA RIVER
BRAHMAPUTRA RIVER
DIWANGANJ
MELANDAHA
GHUGUMARI
CHATAL
MADERGANJ GAUGE STATION
PHULKOCHA
JHORA KHAL
GUNARITALA
JAMALPUR
KENDUA
PROJECT BOUNDARY
CHANDANBAISA
BAUSI RAILWAY BRIDGE
SARISHABARI RAILWAY BRIDGE
SARISHABARI
FERTILIZER FACTORY
PUMPING STATION
GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN CO-ORDINATION ORGANIZATION
FAP 3.1 : JAMALPUR PRIORITY PROJECT STUDY
PROJECT AREA
LOCATION OF PROJECT COMPONENTS
DRAWING NO
SCALE :
DRAWN
CHECKD
APPRVD
DATE

FIGURE 7.3.2

168



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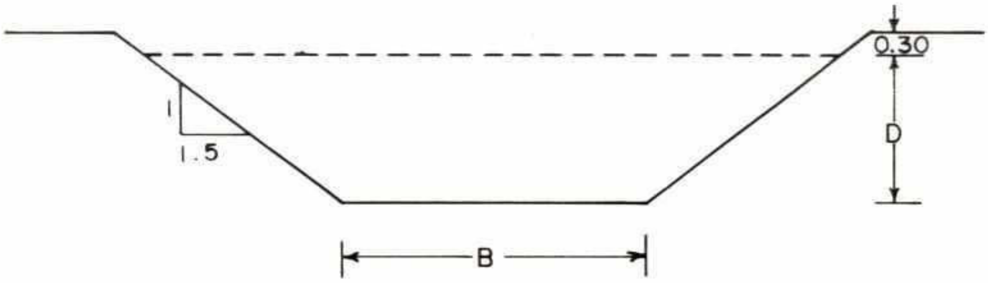
MINISTRY OF IRRIGATION WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN CO-ORDINATION ORGANIZATION

FAP 3.1: JAMALPUR PRIORITY PROJECT STUDY

TYPICAL POSSIBLE DRAINAGE ARRANGEMENT

DRAWING NO.	SCALE:-
DRAWN	SOGREAH-HALCROW-LAHMEYER WITH EPC AQUA Project office House 80, Road 7, Block 'H' Banani, Dhaka
CHECKED	
APPRV'D	
DATE	

(167)



DRAIN TYPE	B (m)	D (m)	DISCHARGE m3/SEC
A	1.83	0.61	0.50
B	2.88	0.96	1.25
C	4.80	1.60	3.50

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FLOOD PLAN CO-ORDINATION ORGANIZATION

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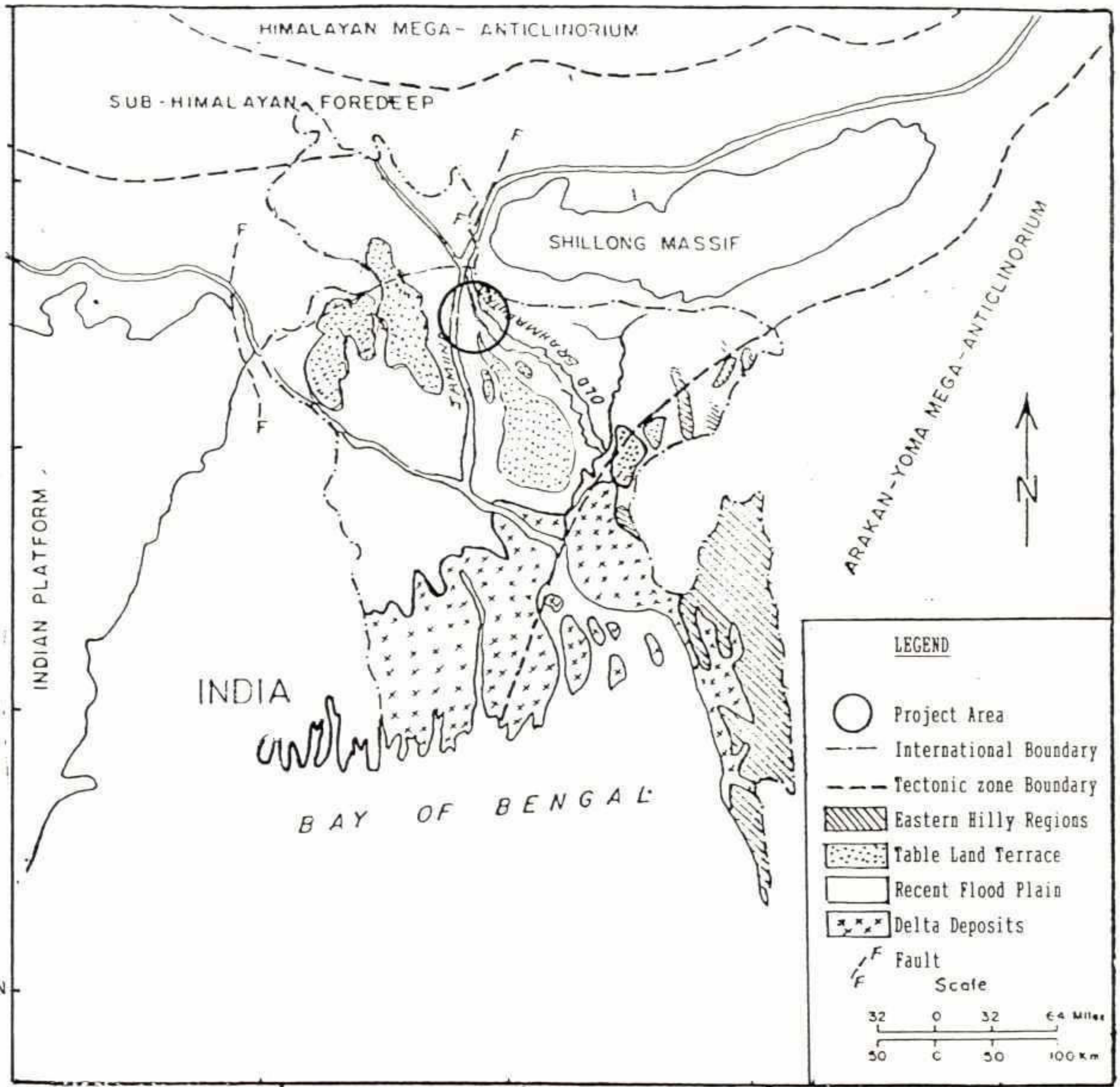
TYPICAL DRAIN CROSS SECTION

DRAWING NO. | SCALE: NOT TO SCALE

DRAWN
CHECK'D
APPRV'D
DATE

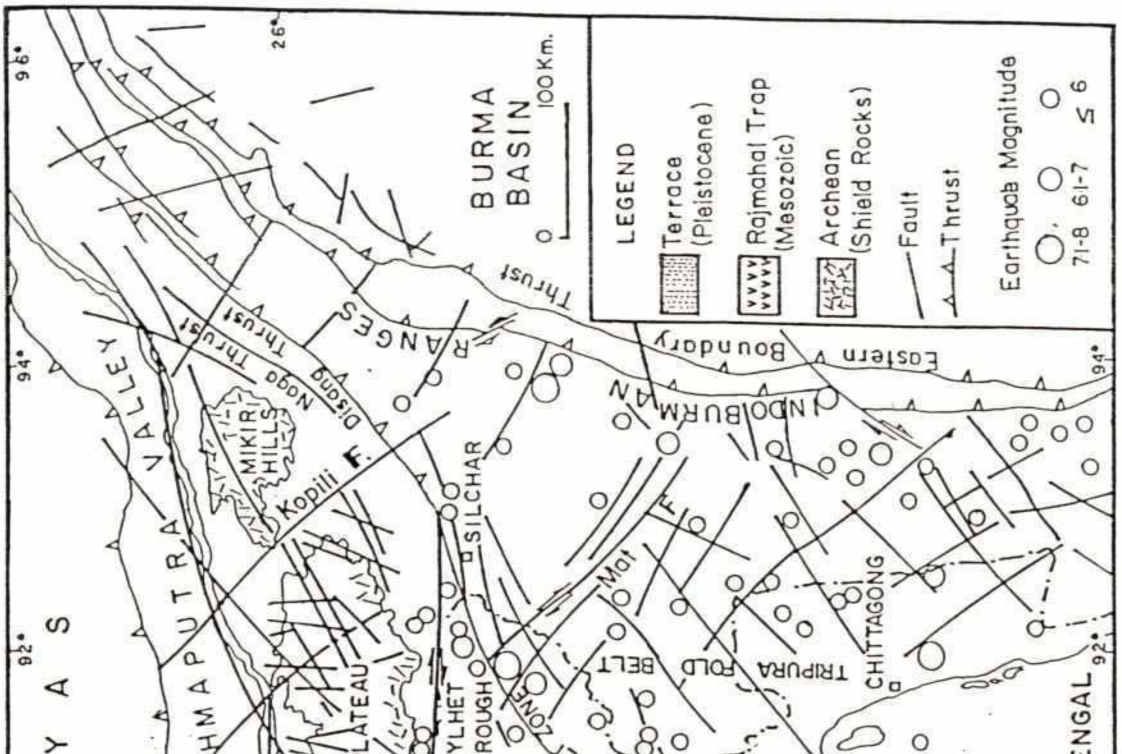
SOGREAH-HALCROW-LAHMEYER WITH EPC & AQUA
Project office
House 80, Road 7, Block 'H'
Banani, Dhaka

FIGURE 7.3-4



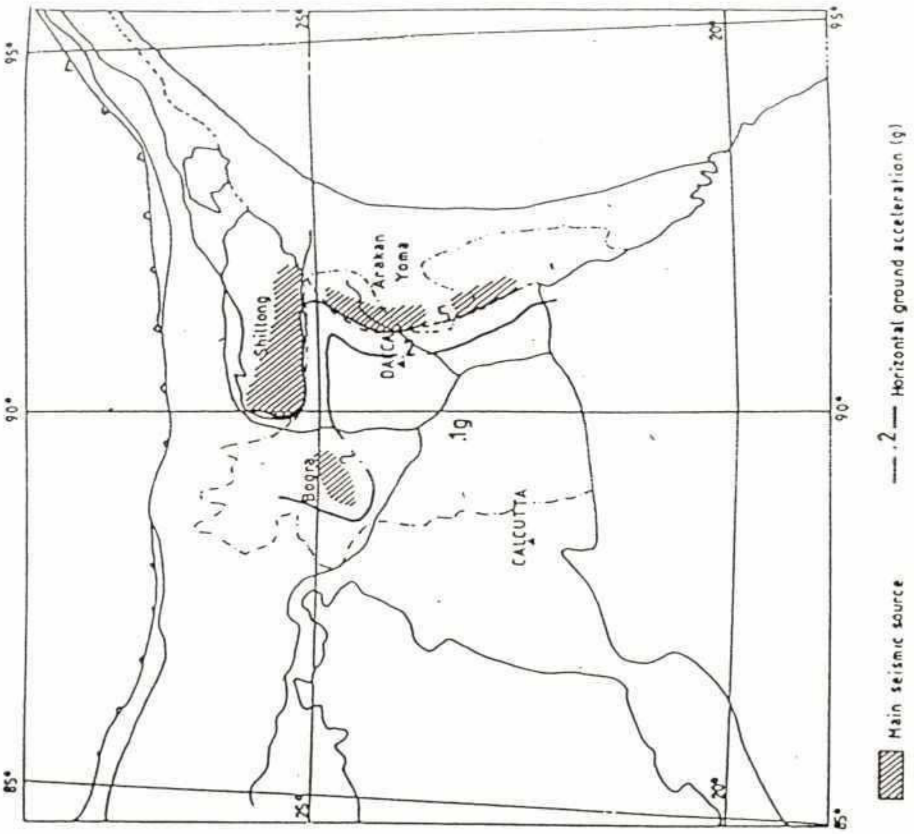
SIMPLIFIED PHYSIOGRAPHIC AND TECTONIC MAP OF BANGLADESH

FIGURE 7.3.5 171

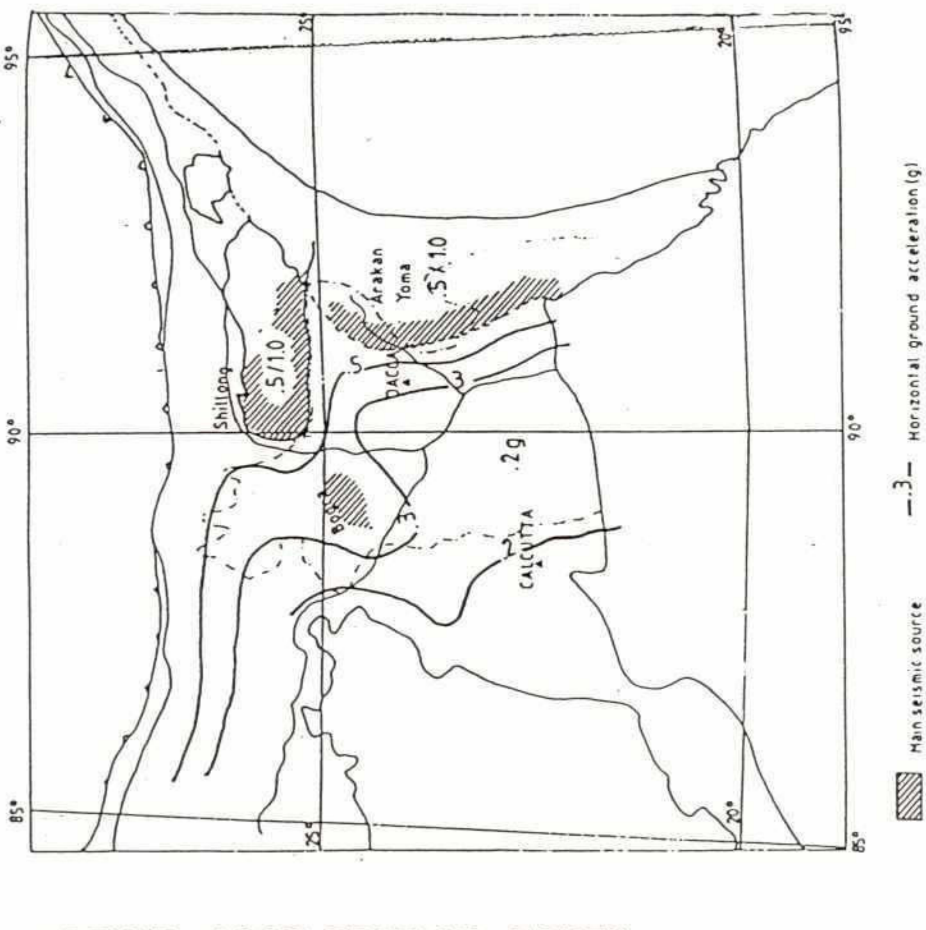


SEISMO-TECTONIC MAP OF BANGLADESH

FIGURE 7.3.6



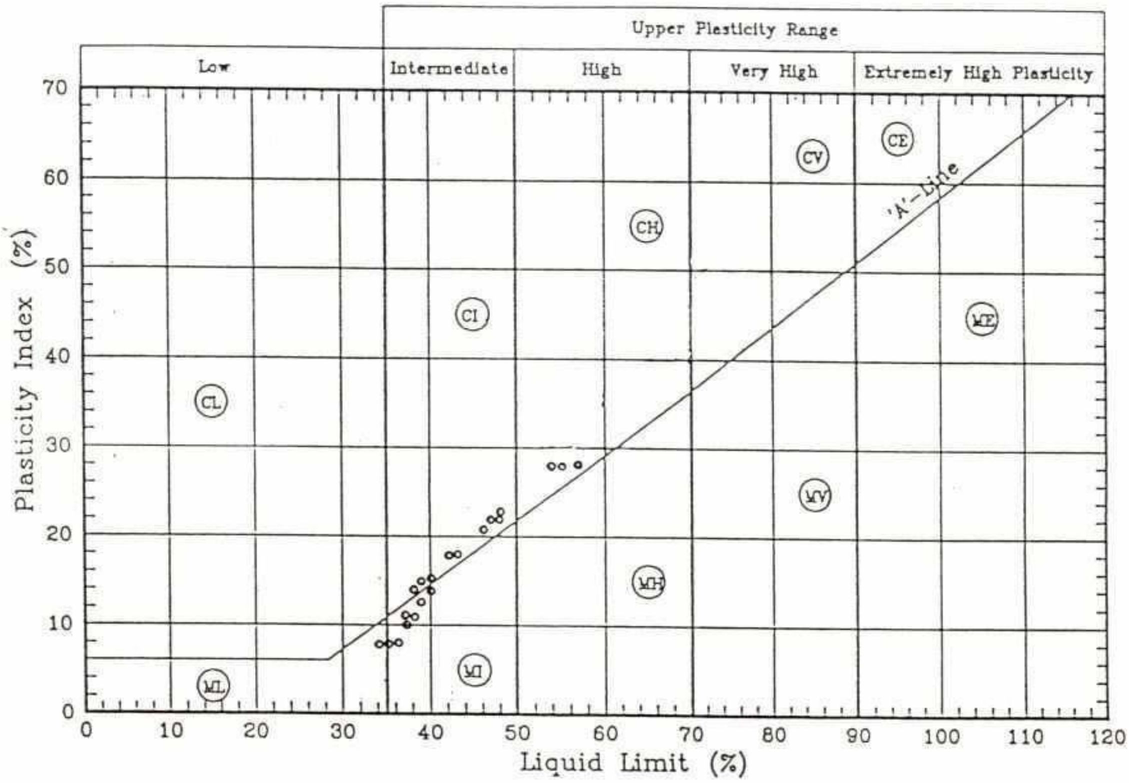
Ground Acceleration Zones For
Long Return Periods



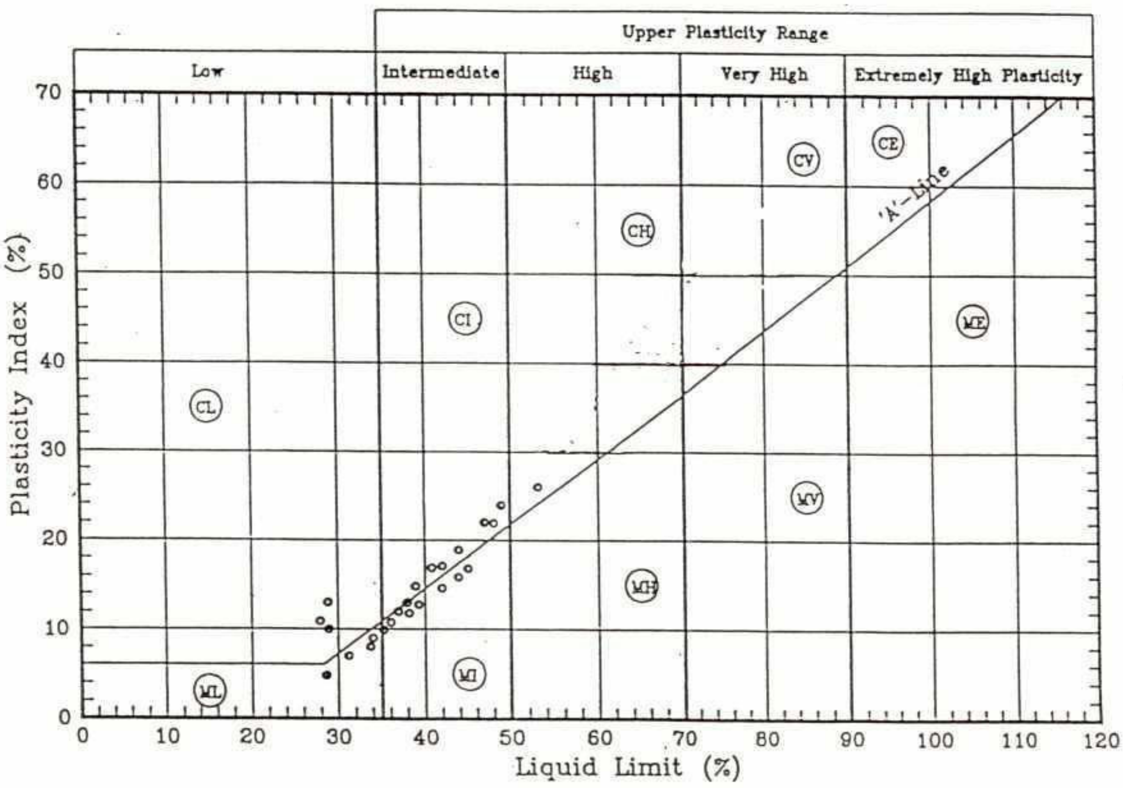
Ground Acceleration Zones For
Short Return Periods

GROUND ACCELERATION ZONES

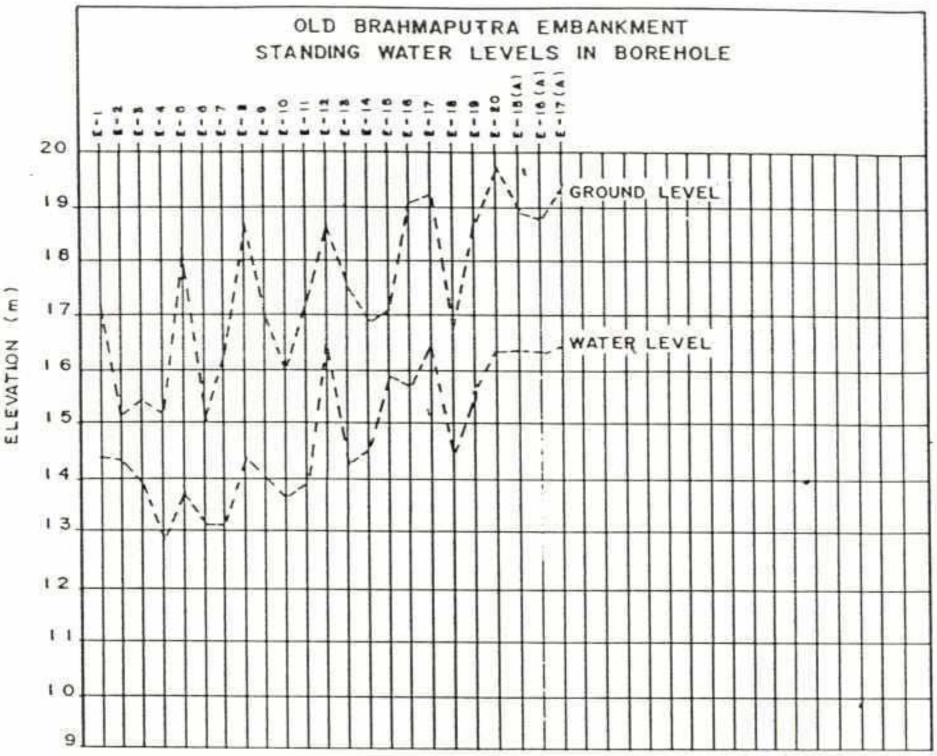
OLD BRAHMAPUTRA EMBANKMENT FOUNDATION
SUMMARY OF PLASTICITY TEST RESULTS

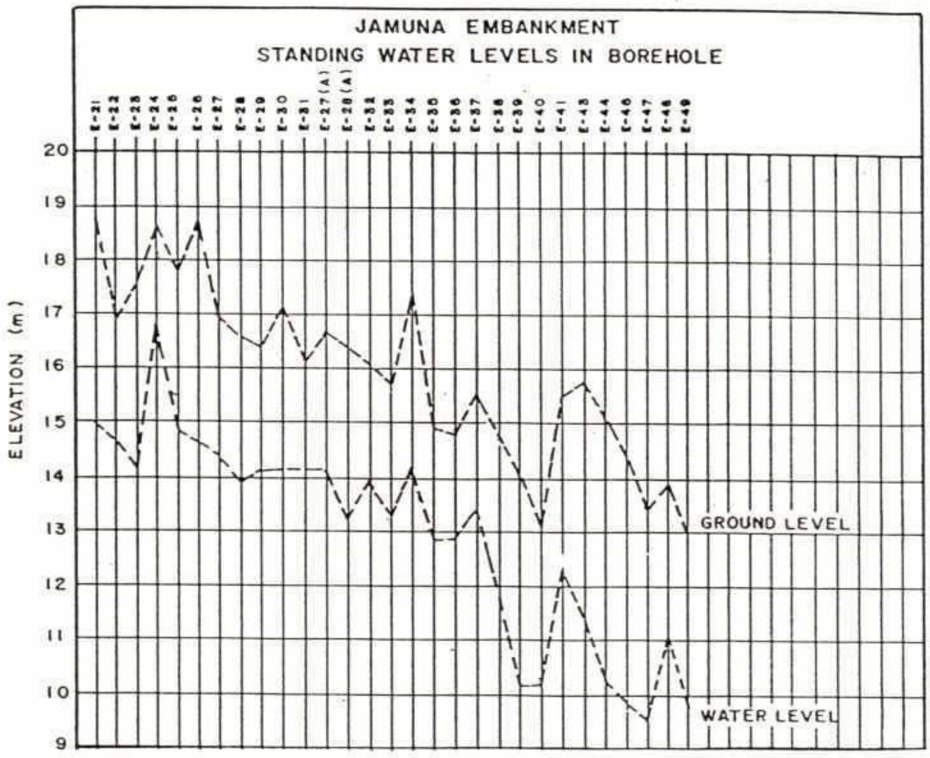


JAMUNA EMBANKMENT FOUNDATION
SUMMARY OF PLASTICITY TEST RESULTS



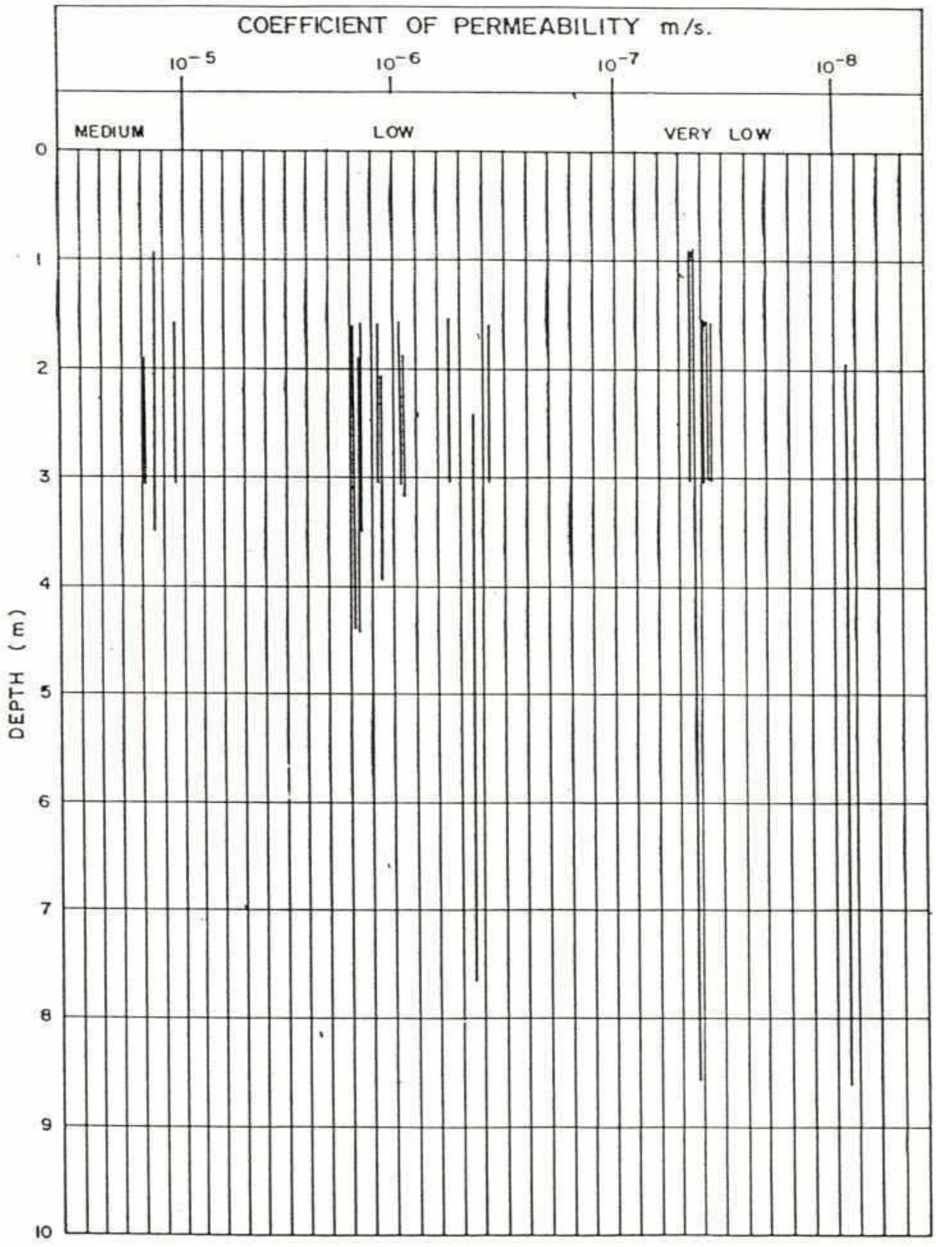
FOUNDATION SOIL SUMMARY OF PLASTICITY TEST RESULTS





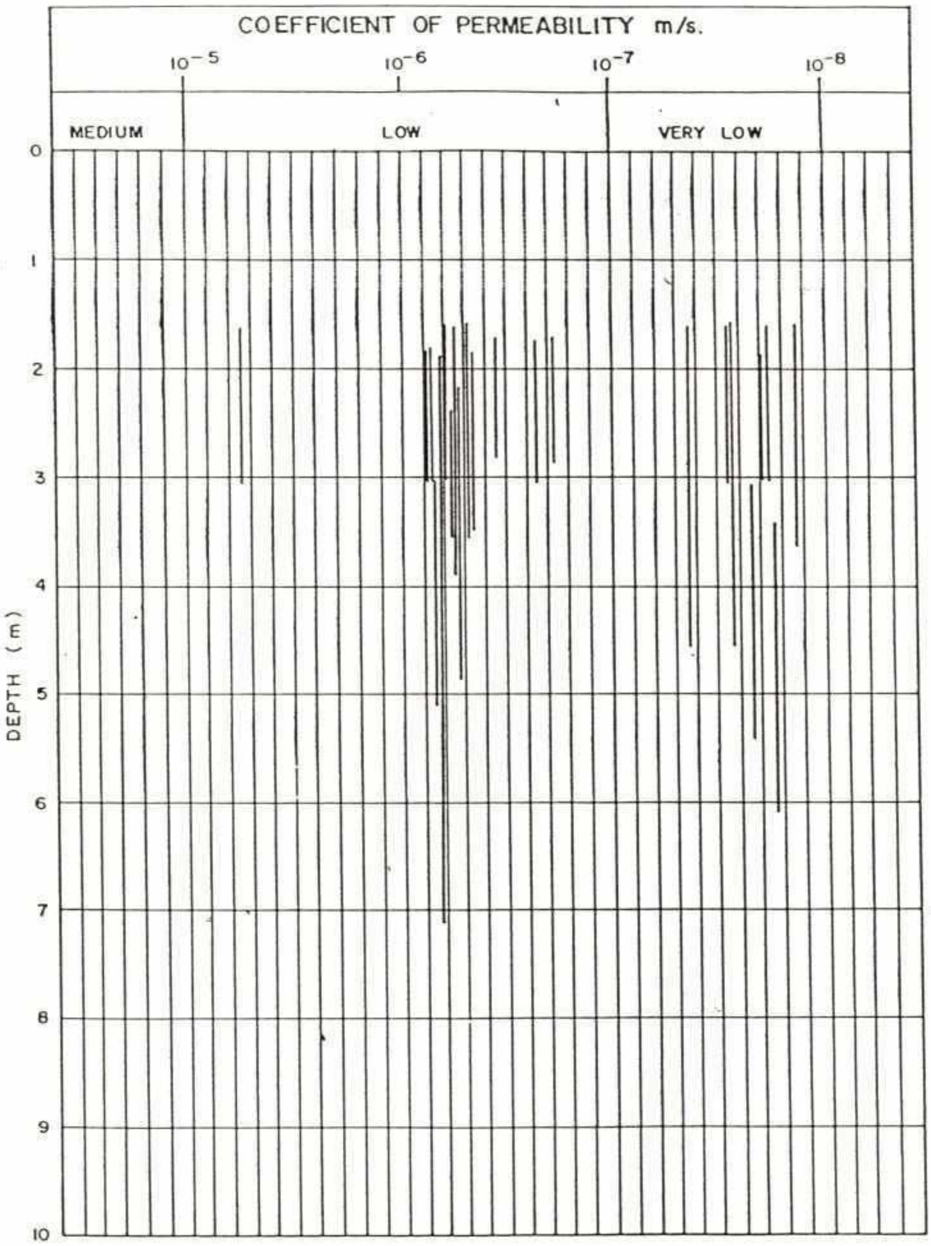
STANDING WATER LEVELS IN BOREHOLES

FIGURE 7. 3. 9A



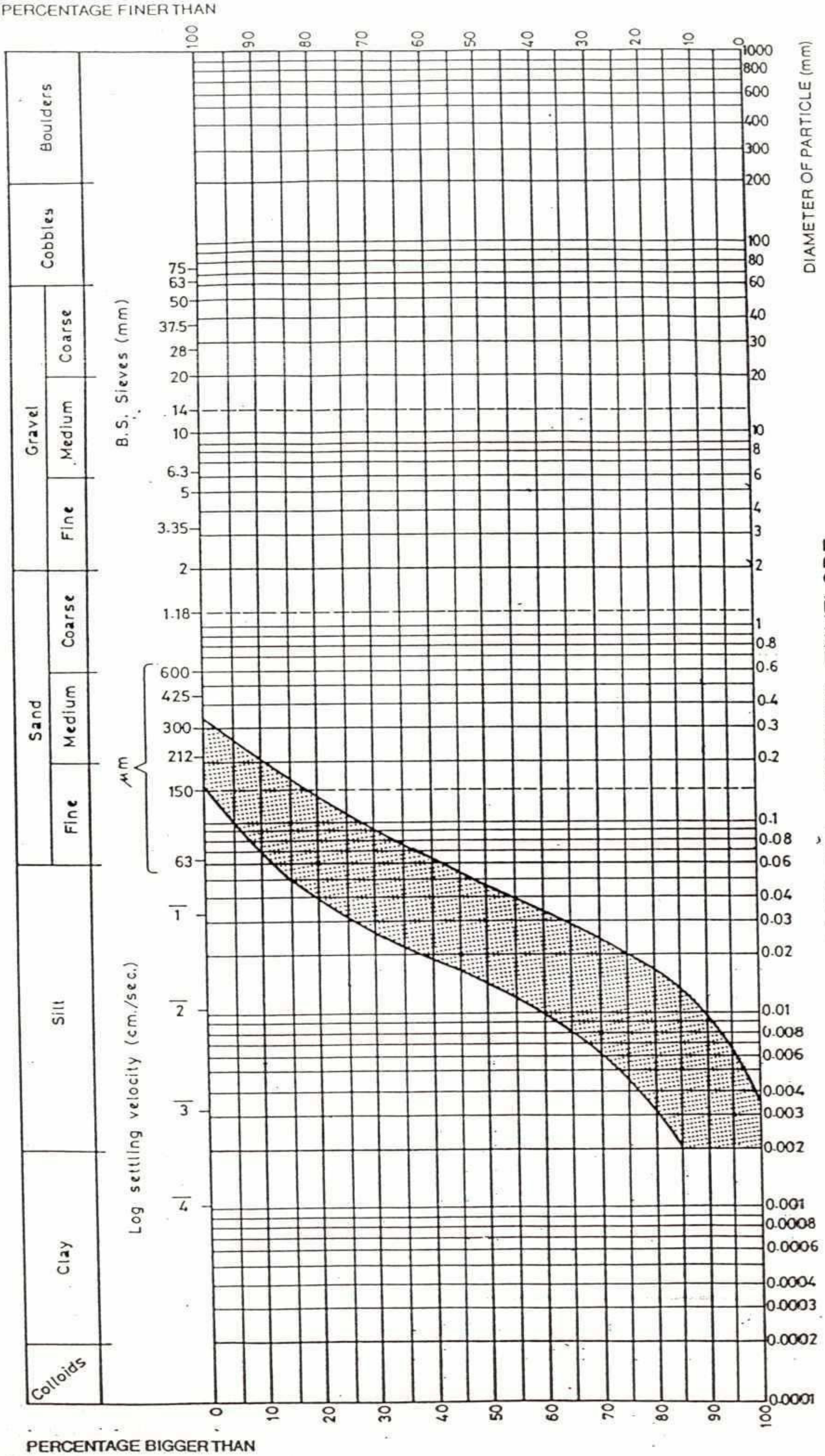
OLD BRAHMAPUTRA EMBANKMENT
SUMMARY OF BOREHOLE PERMEABILITY TESTS

FIGURE 7.3.9B



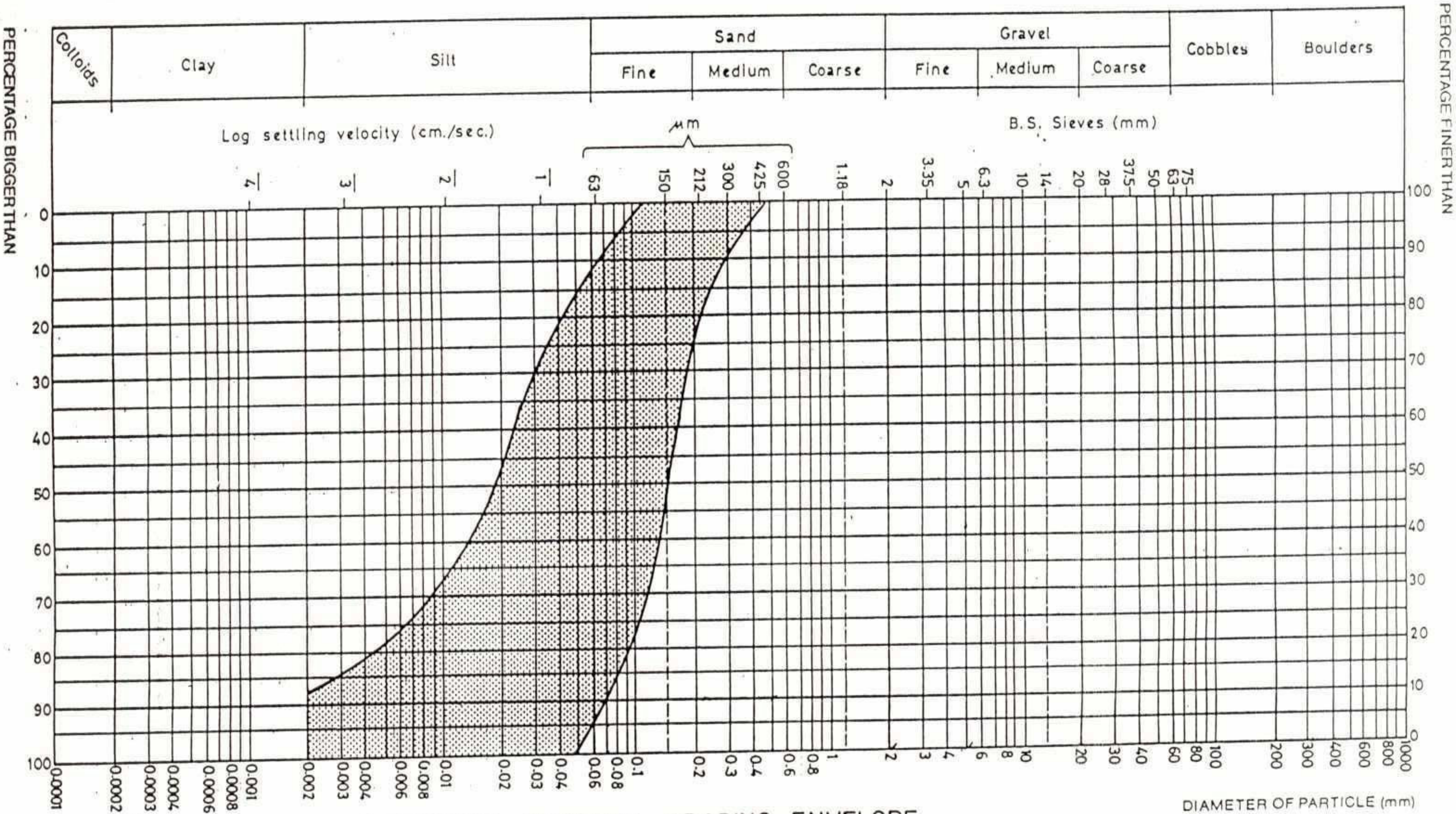
JAMUNA EMBANKMENT
SUMMARY OF BOREHOLE PERMEABILITY TESTS

FIGURE 7.3.10A



CONSTRUCTION MATERIAL GRADING ENVELOPE
DEPTH 0.00–2.00m (NOMINAL)
EMBANKMENT CHAINAGE 0.00–10.00km.

FIGURE 7.3.10B



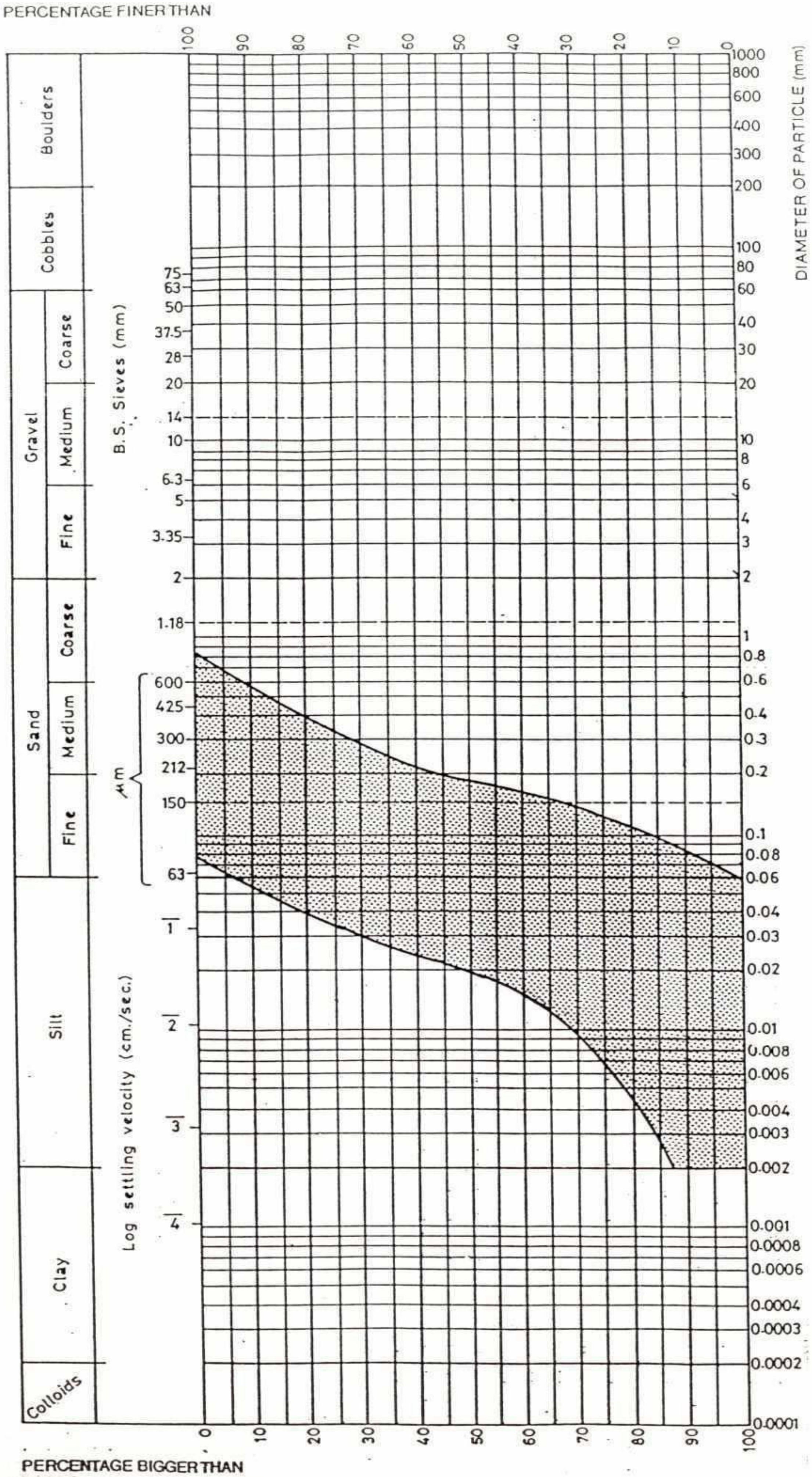
CONSTRUCTION MATERIAL GRADING ENVELOPE

DEPTH 0.00-2.00m (NOMINAL)

EMBANKMENT CHAINAGE 10.00-32.50km.

178

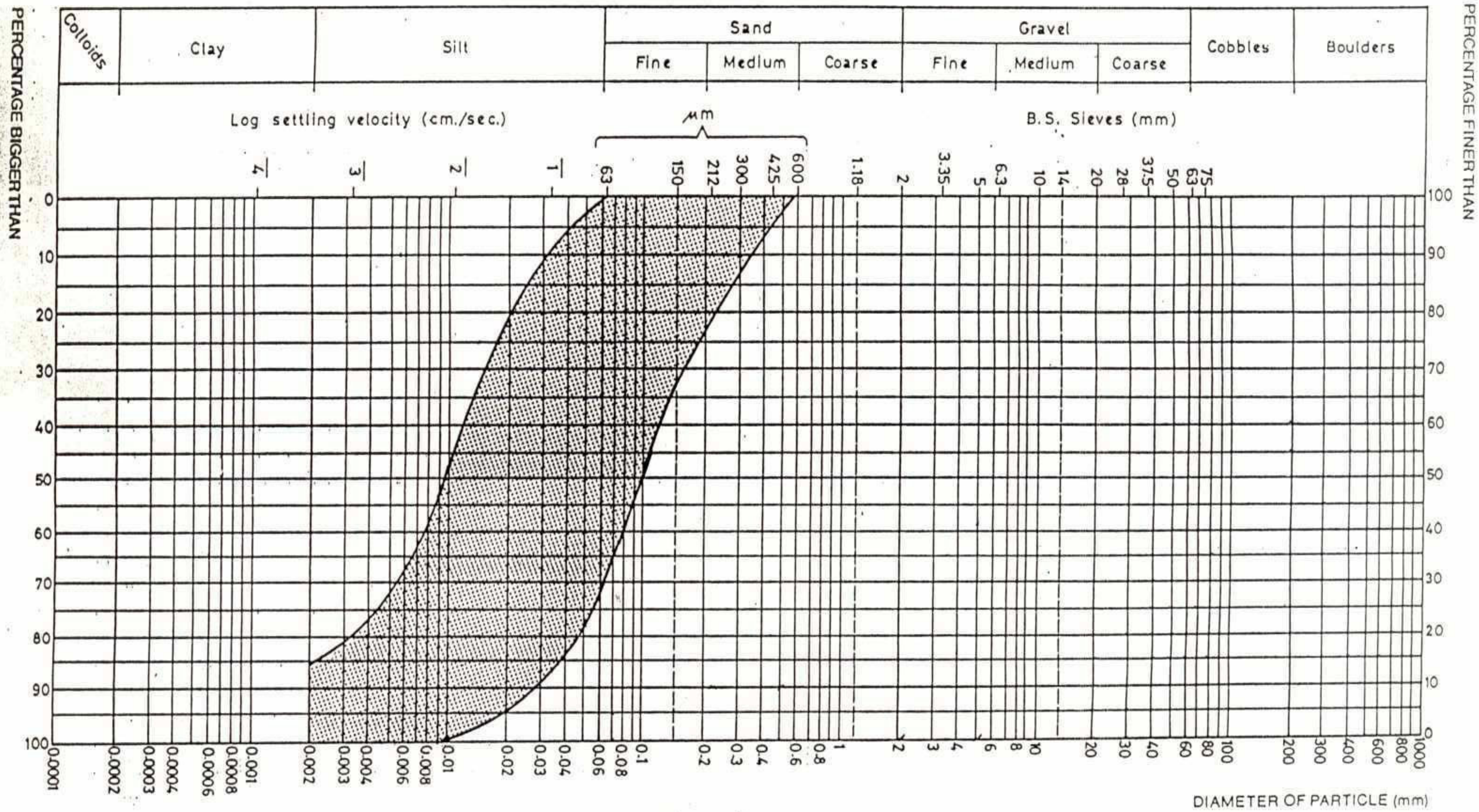
FIGURE 7.3.10C



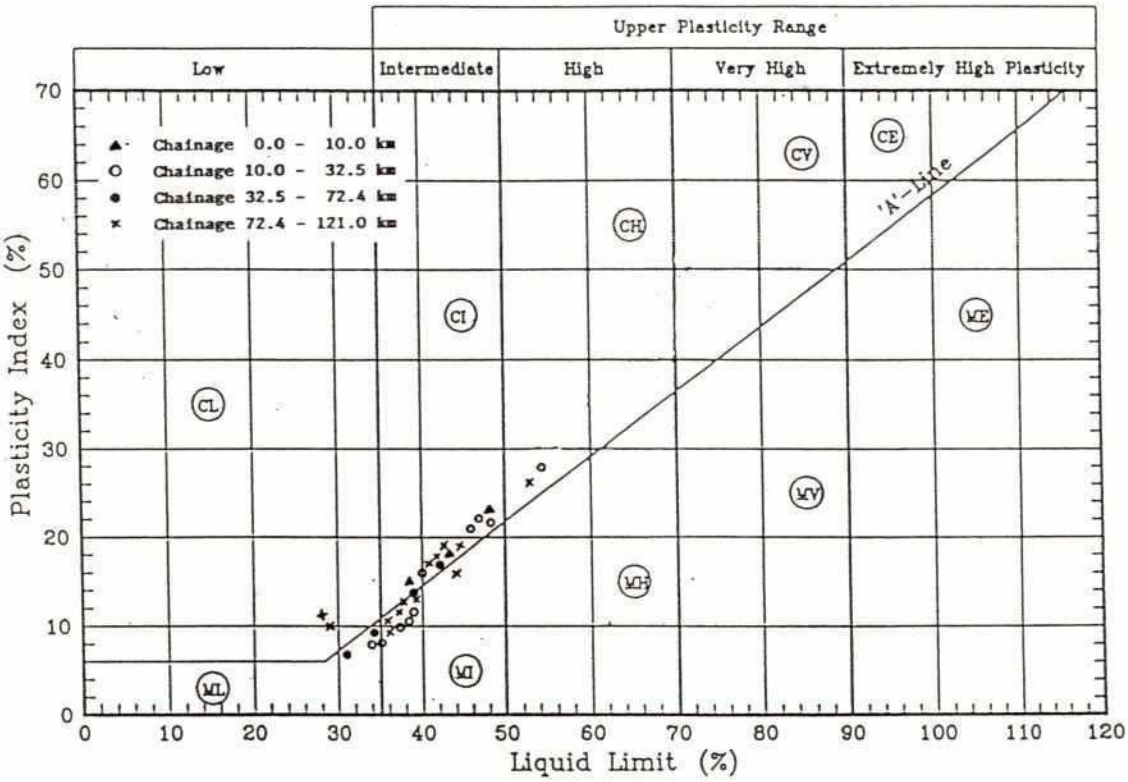
CONSTRUCTION MATERIAL GRADING ENVELOPE

DEPTH 0.00 – 2.00 m (NOMINAL)

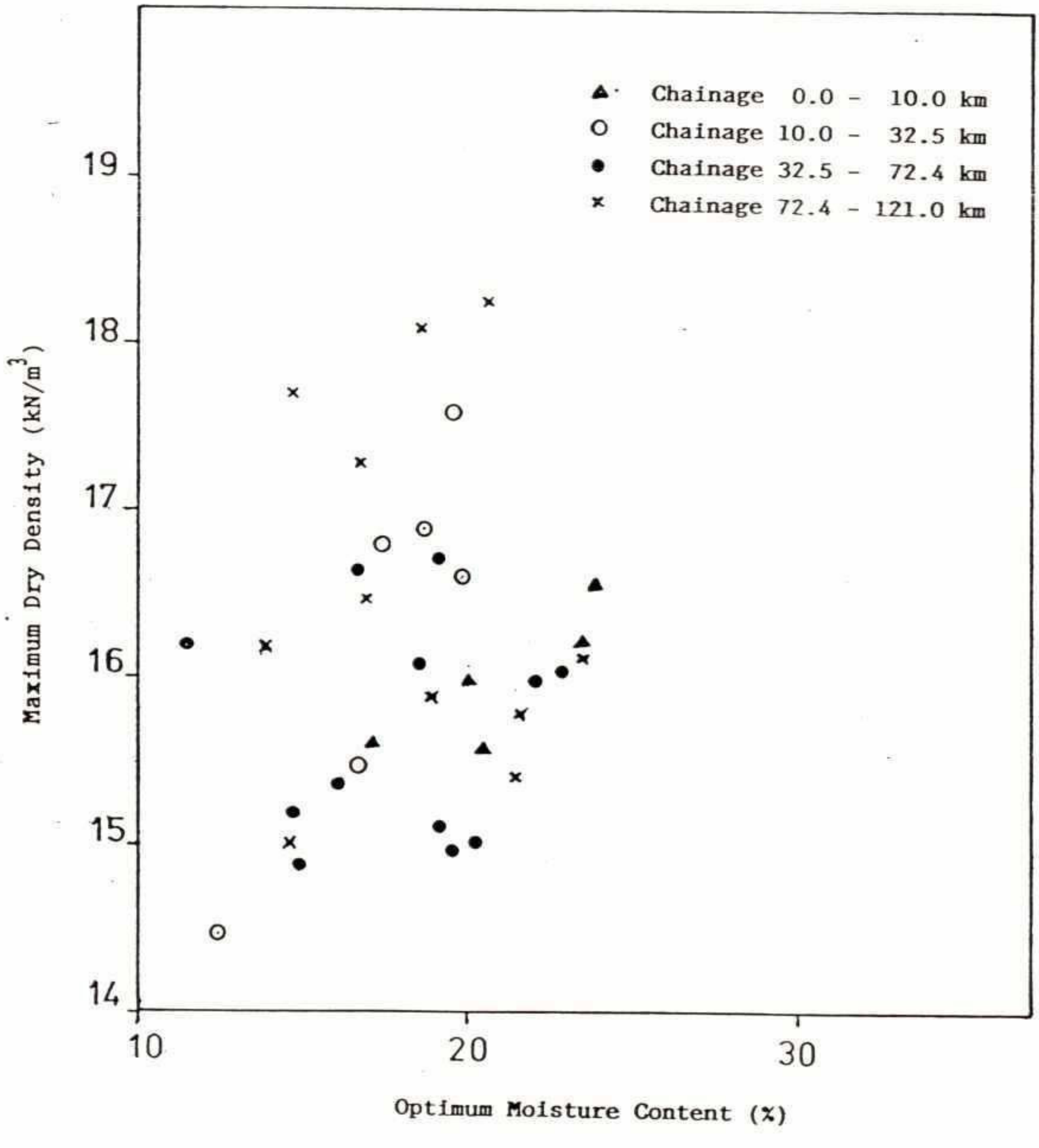
EMBANKMENT CHAINAGE 32.5 – 72.4 km.



CONSTRUCTION MATERIAL GRADING ENVELOPE
DEPTH 0.00-2.00m (NOMINAL)
EMBANKMENT CHAINAGE 72.4-121.0km.

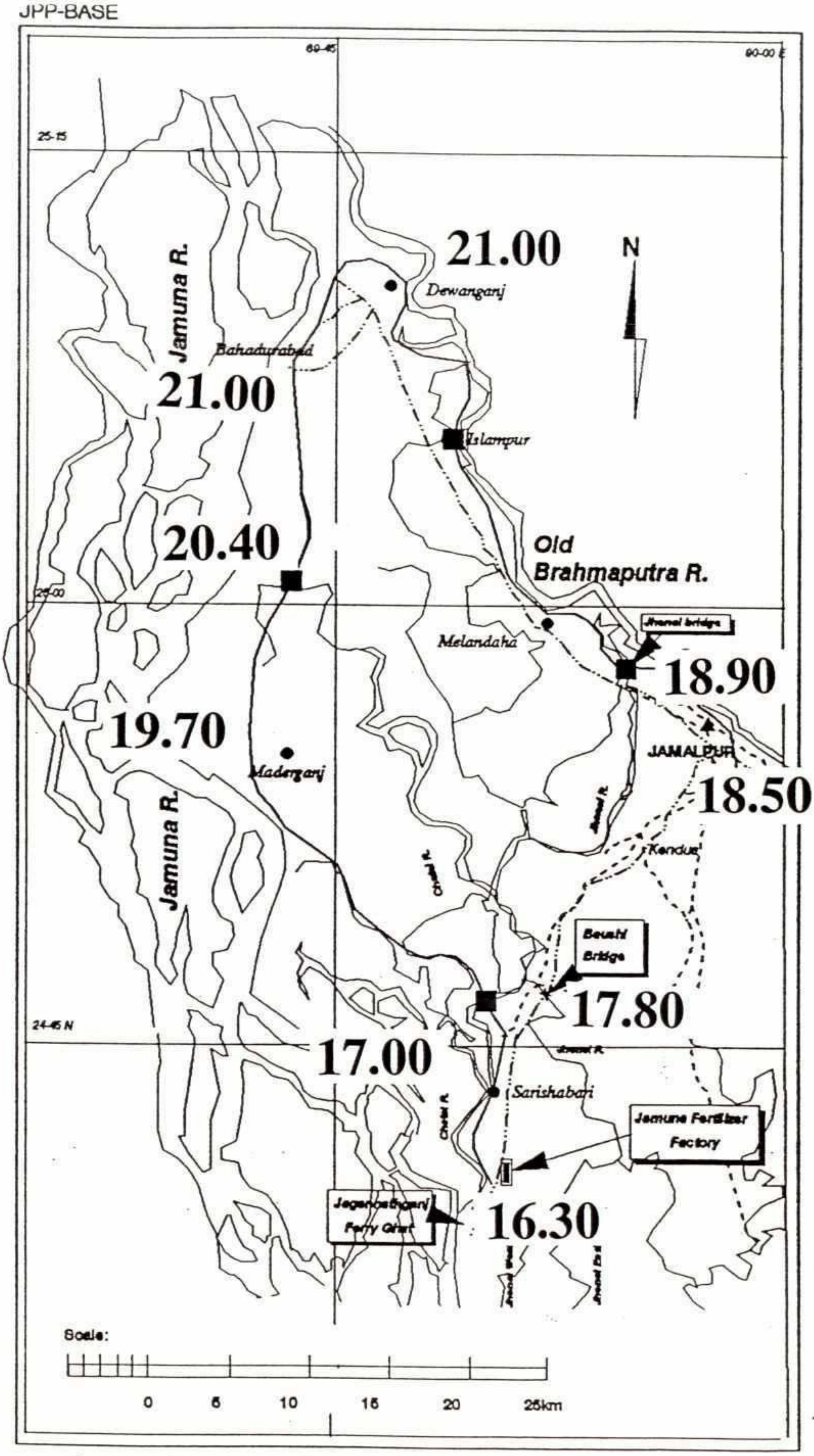


EMBANKMENT CONSTRUCTION MATERIALS
SUMMARY OF PLASTICITY TEST RESULTS



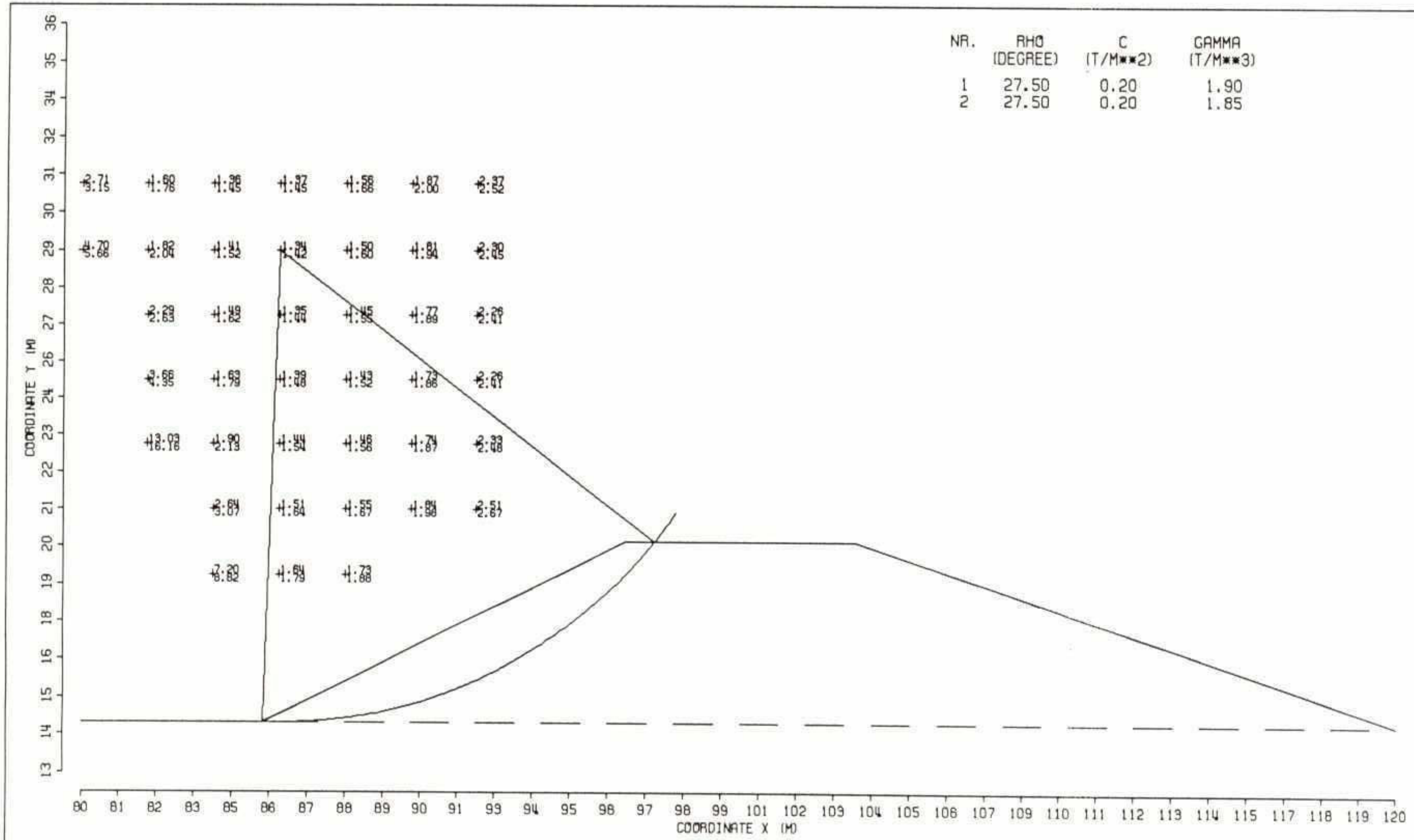
EMBANKMENT CONSTRUCTION MATERIALS
SUMMARY OF STANDARD PROCTOR TEST RESULTS

FIGURE 7. 3.13



1988 FLOOD LEVELS AT PROJECT AREA

EMBANKMENT STABILITY CALCULATION RESULTS
LOAD CASES 00 to 11
AND 20 to 27



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	1.90
2	27.50	0.20	1.85

00 JJPS EMBANKMENT; d/s, no flood, no tailwater

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.42

CENTER:	86.00/29.00
RADIUS:	14.51
ACTIVE MOMENT:	177.09
PASSIVE MOMENT:	237.23

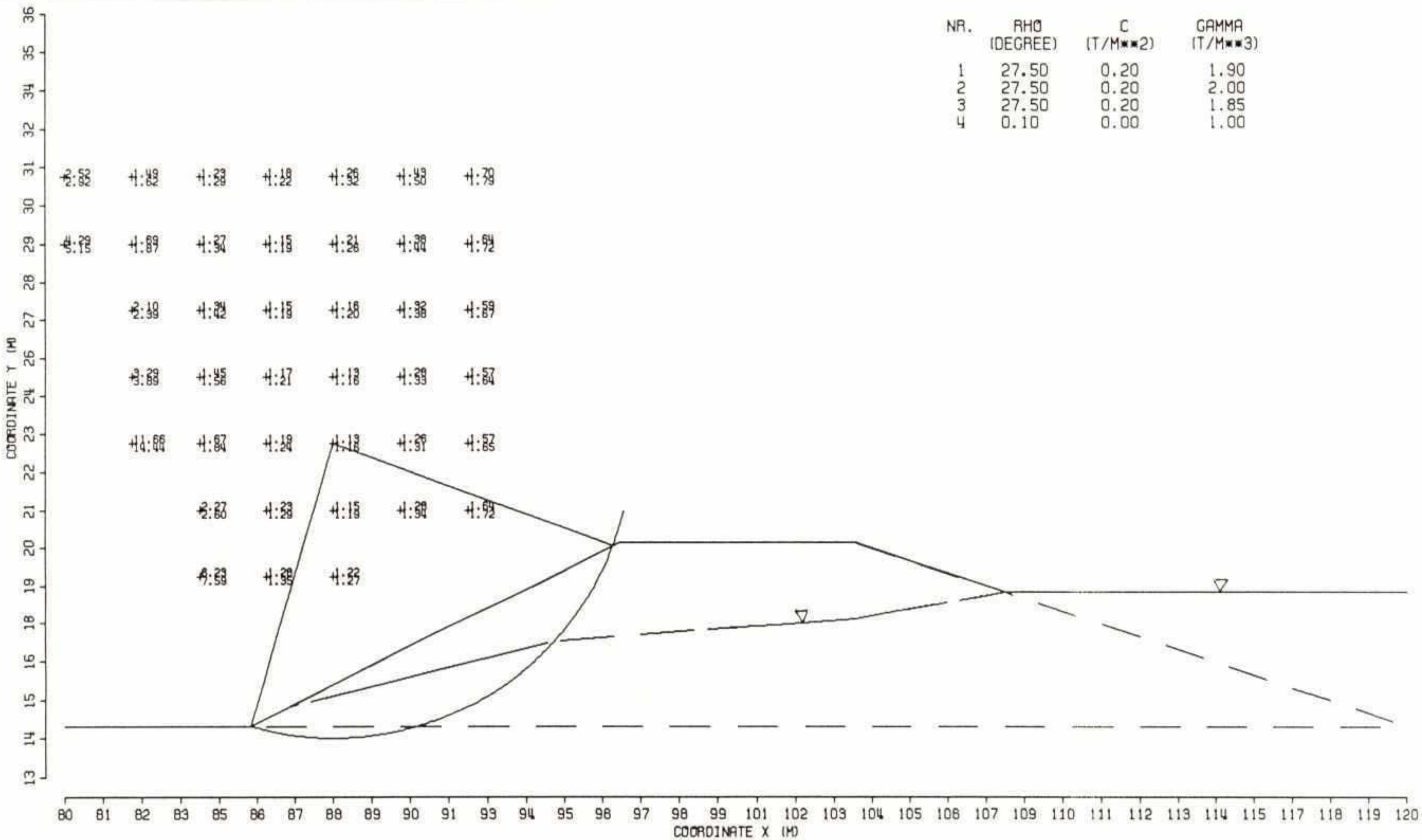
SCALE
|——| = 114 CM

.... ANCHOR
--- STRATUM
--- PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐

185



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	1.90
2	27.50	0.20	2.00
3	27.50	0.20	1.85
4	0.10	0.00	1.00

01 JJPS EMBANKMENT; d/s, high flood, no drainage, no tailwater

LAHMEYER INTERNATIONAL

BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.16

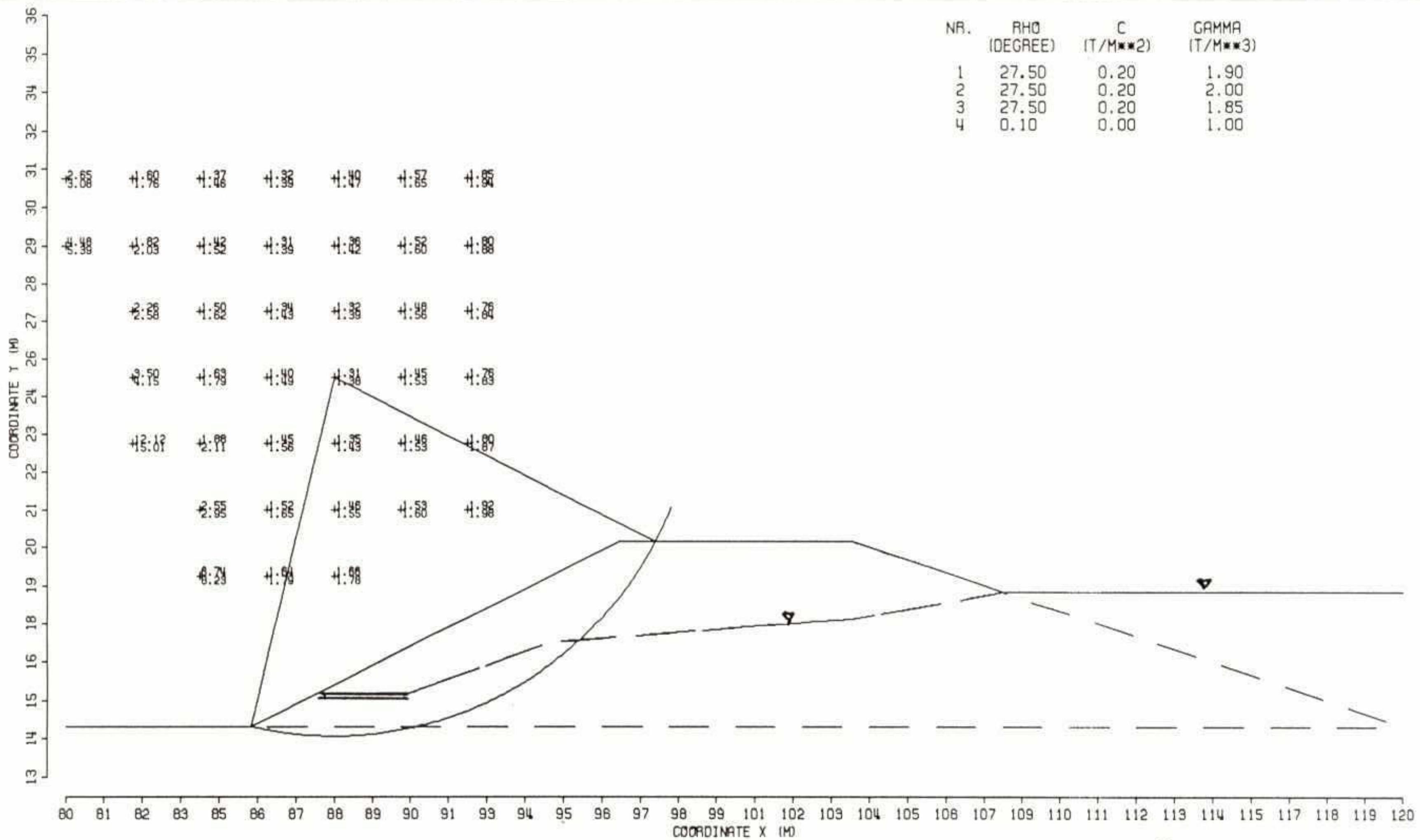
CENTER: 88.00/23.00
RADIUS: 8.86
ACTIVE MOMENT: 124.19
PASSIVE MOMENT: 139.93

SCALE
├─┤ = 114 CM

---- ANCHOR
--- STRATUM
--- PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	1.90
2	27.50	0.20	2.00
3	27.50	0.20	1.85
4	0.10	0.00	1.00

02 JJPS EMBANKMENT; d/s, high flood, drainage, no tailwater

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.38

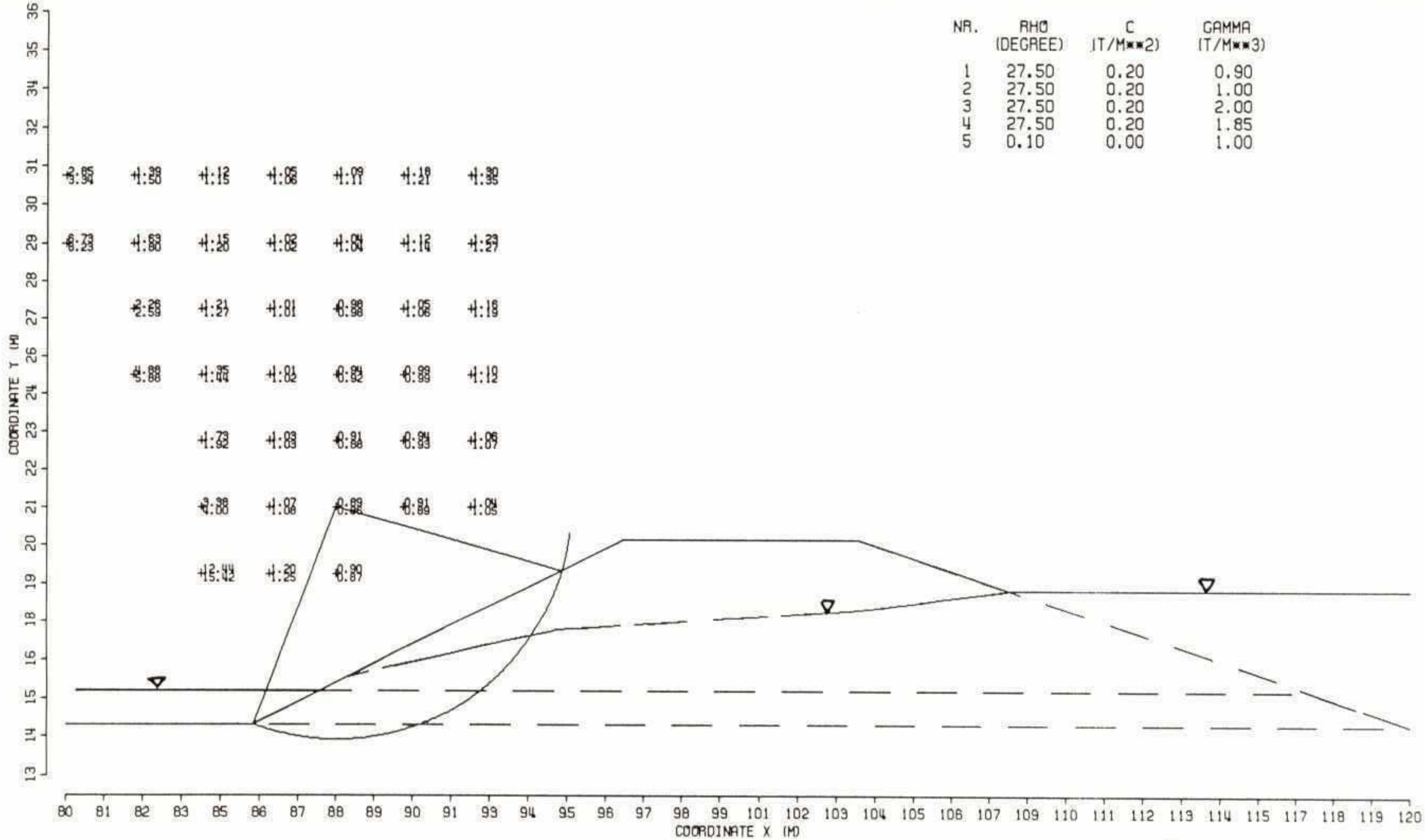
CENTER:	88.00/25.00
RADIUS:	10.79
ACTIVE MOMENT:	180.33
PASSIVE MOMENT:	236.29

SCALE
|—| = 114 CM

---- ANCHOR
--- STRATUM
— — — PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	0.90
2	27.50	0.20	1.00
3	27.50	0.20	2.00
4	27.50	0.20	1.85
5	0.10	0.00	1.00

03 JJPS EMBANKMENT; d/s, high flood, no drainage, tailwater

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 0.86

CENTER:	88.00/21.00
RADIUS:	6.96
ACTIVE MOMENT:	72.99
PASSIVE MOMENT:	65.22

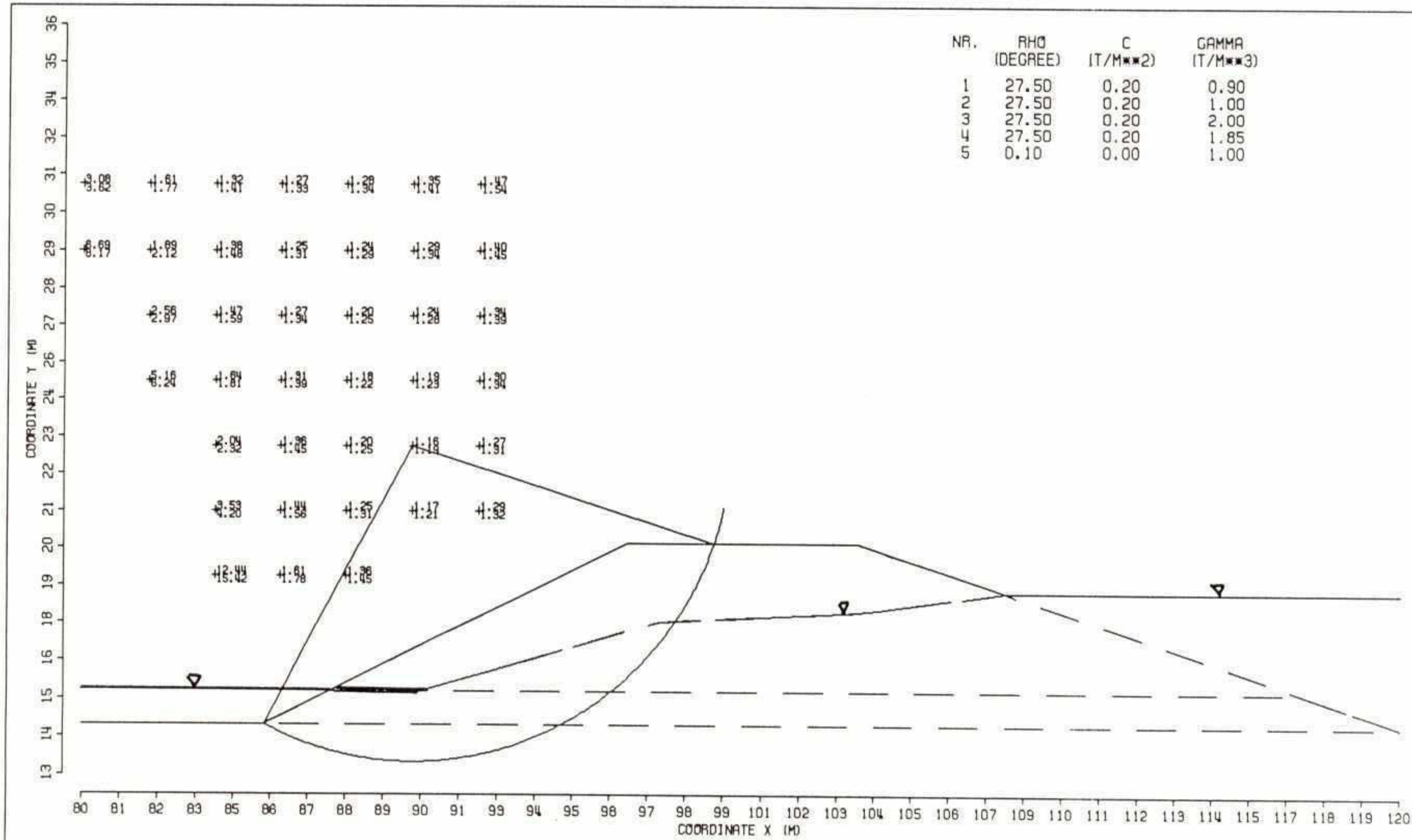
SCALE
|—| = 114 CM

.... ANCHOR
--- STRATUM
--- PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐

188



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	0.90
2	27.50	0.20	1.00
3	27.50	0.20	2.00
4	27.50	0.20	1.85
5	0.10	0.00	1.00

04 JJPS EMBANKMENT; d/s, high flood, drainage, tailwater

LAHMEYER INTERNATIONAL
BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.19

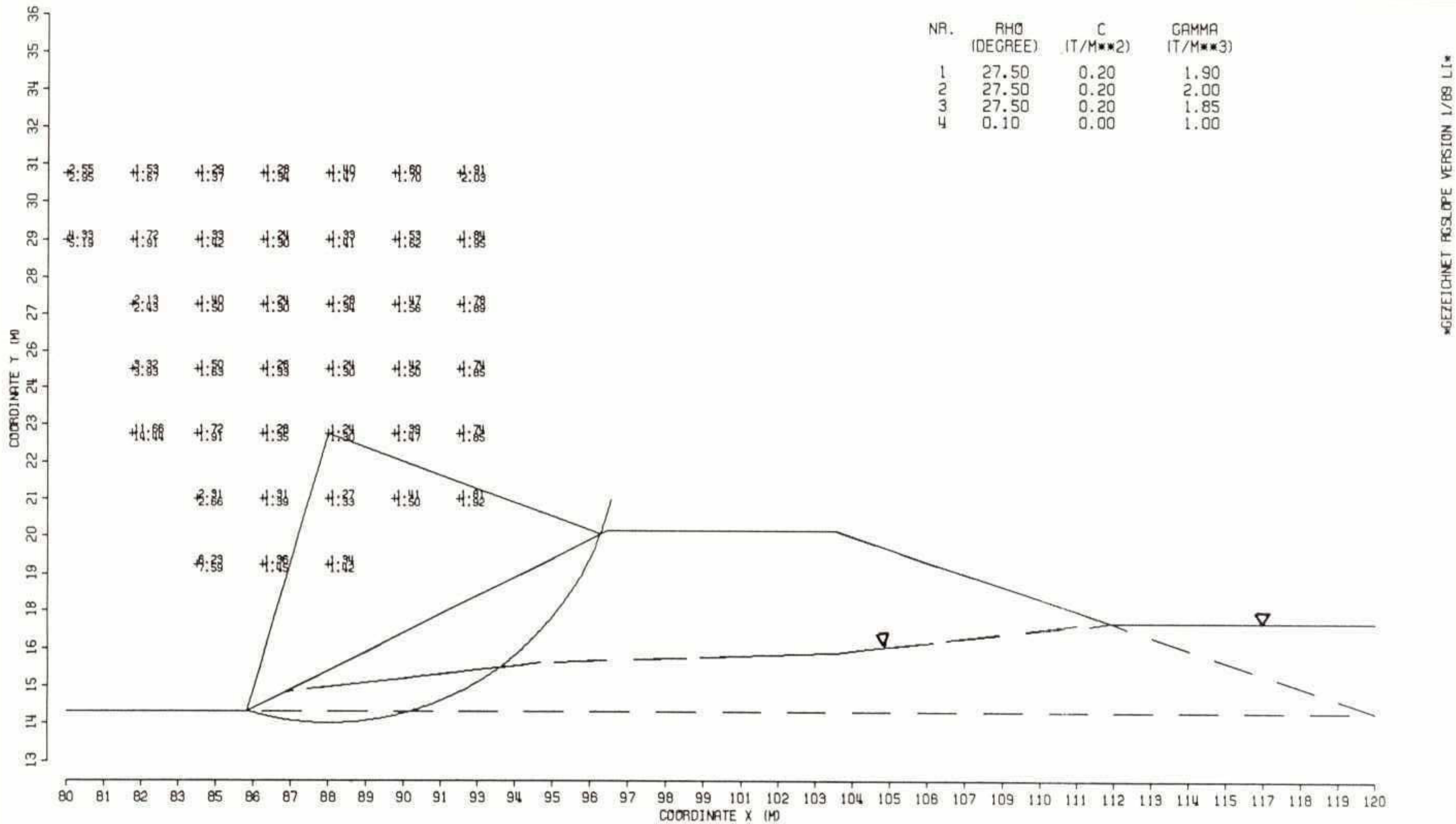
CENTER: 90.00/23.00
RADIUS: 9.62
ACTIVE MOMENT: 231.20
PASSIVE MOMENT: 268.83

SCALE
|—| = 114 CM

.... ANCHOR
--- STRATUM
--- PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ANNEX



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	1.90
2	27.50	0.20	2.00
3	27.50	0.20	1.85
4	0.10	0.00	1.00

05 JJPS EMBANKMENT; d/s, yearly flood, no drainage, no tailwater

LAHMEYER INTERNATIONAL

BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.30

CENTER: 88.00/25.00
RADIUS: 10.79
ACTIVE MOMENT: 178.55
PASSIVE MOMENT: 221.62

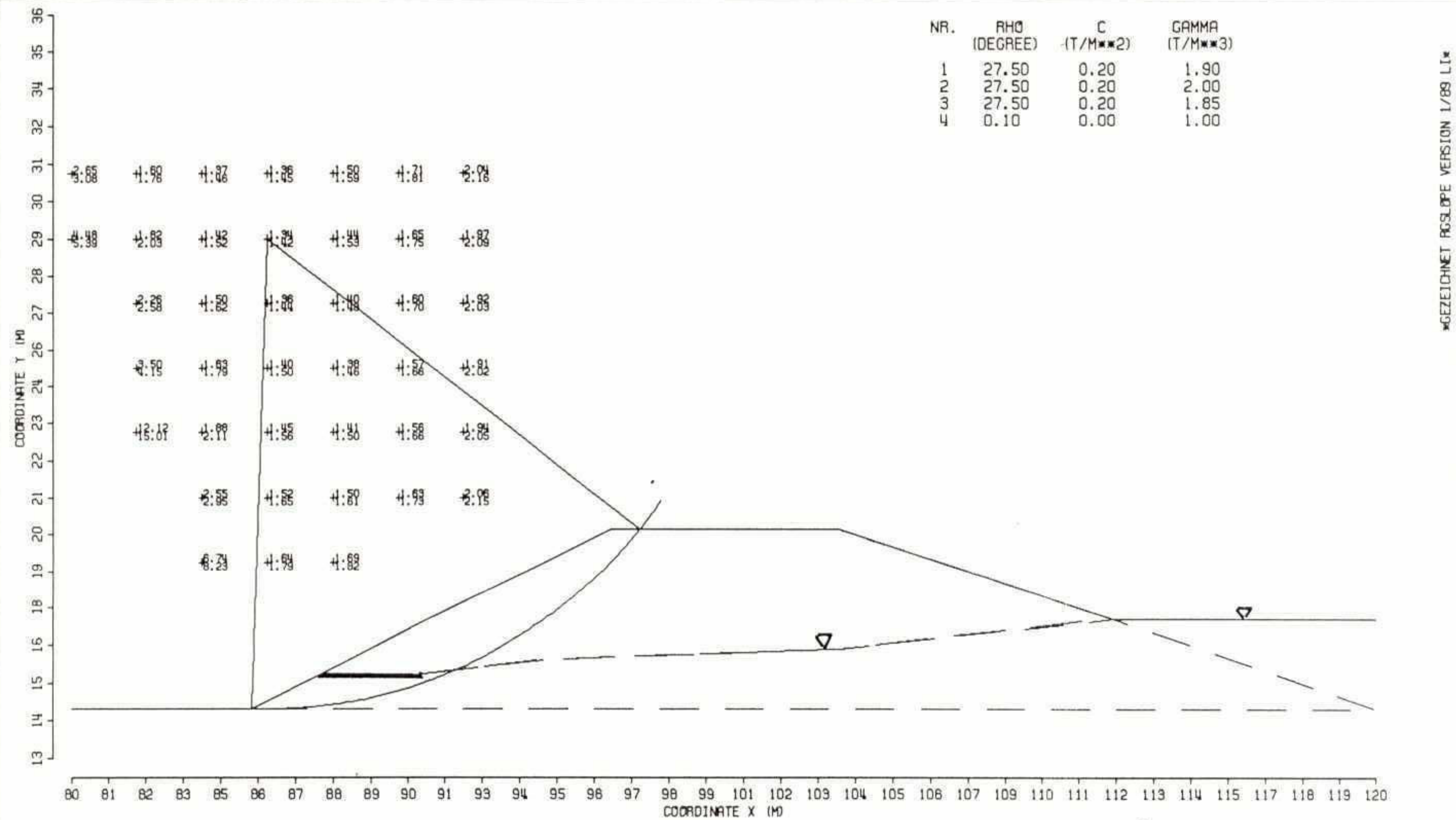
SCALE
|—| = 114 CM

---- ANCHOR
- - - STRATUM
- - - PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ANNEX

190

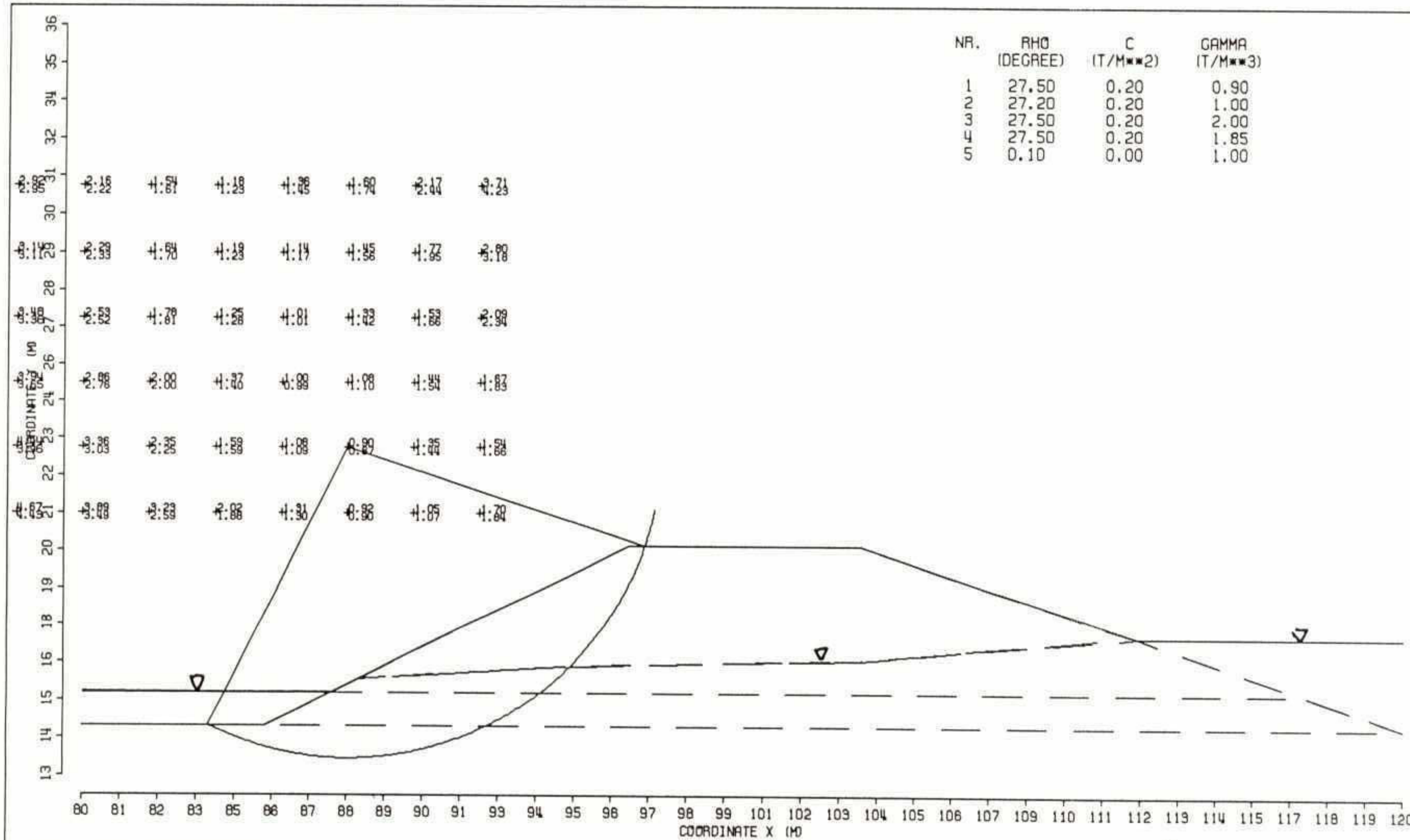


06 JJPS EMBANKMENT; d/s, yearly flood, drainage,no tailwater

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, (MAIN)

ETA (BISHOP) = 1.42	CENTER: 86.00/29.00 RADIUS: 14.51 ACTIVE MOMENT: 178.19 PASSIVE MOMENT: 238.74	SCALE ⊢⊣ = 114 CM ---- ANCHOR --- STRATUM --- PHREATIC SURFACE	STABILITY ANALYSIS ACC. TO BISHOP AND KREY (DIN 4084) FIG. ANNEX

191



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	0.90
2	27.20	0.20	1.00
3	27.50	0.20	2.00
4	27.50	0.20	1.85
5	0.10	0.00	1.00

07 JJPS EMBANKMENT; d/s, yearly flood, no drainage, tailwater

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 0.87

CENTER: 88.00/23.00
RADIUS: 9.49
ACTIVE MOMENT: 172.04
PASSIVE MOMENT: 154.83

SCALE
|—| = 114 CM

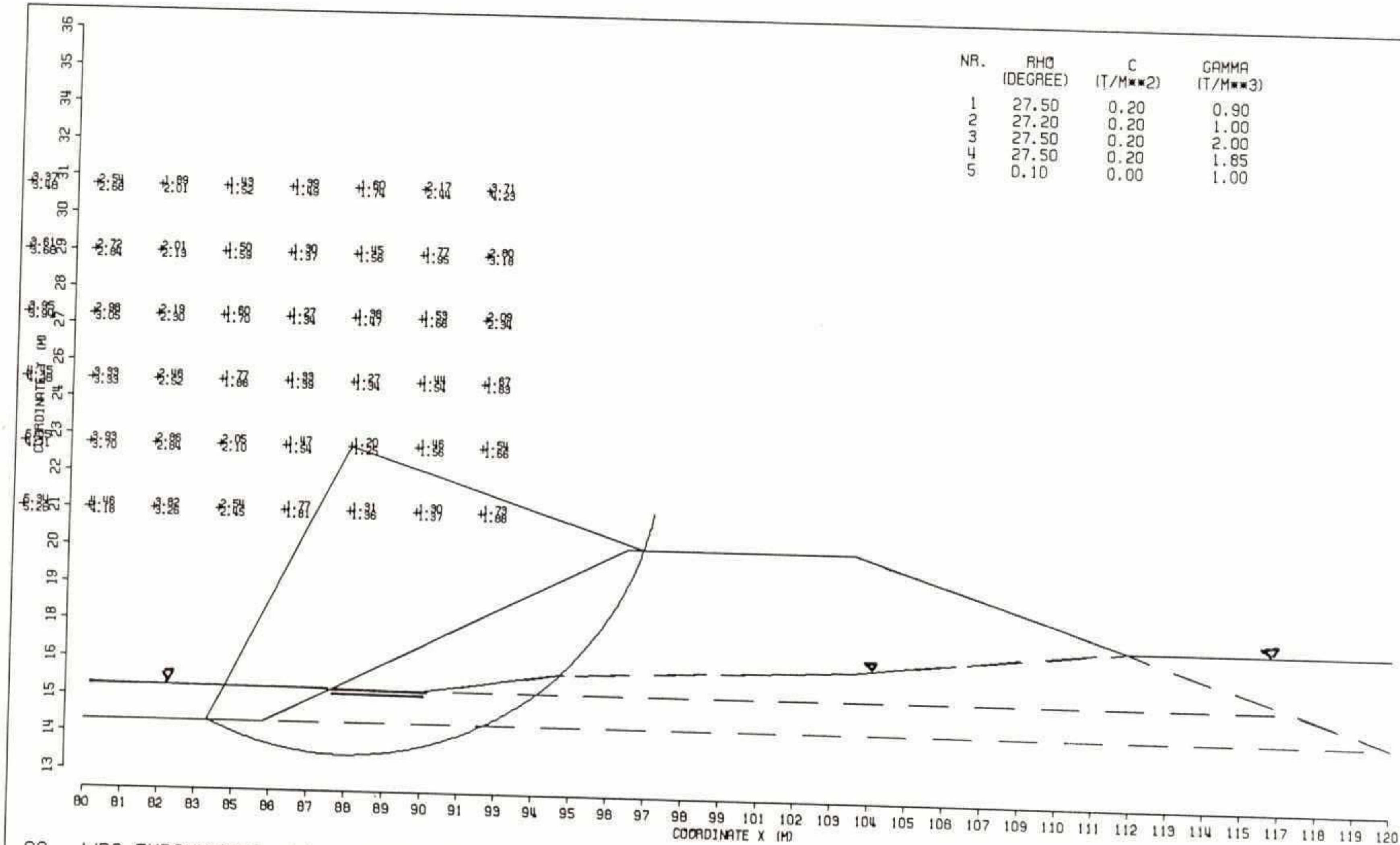
---- ANCHOR
--- STRATUM
--- PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐

192

NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	0.90
2	27.20	0.20	1.00
3	27.50	0.20	2.00
4	27.50	0.20	1.85
5	0.10	0.00	1.00



08 JJPS EMBANKMENT; d/s, yearly flood, drainage, tailwater

ETA (BISHOP) = 1.25

CENTER: 88.00/23.00
RADIUS: 9.49
ACTIVE MOMENT: 170.41
PASSIVE MOMENT: 204.49

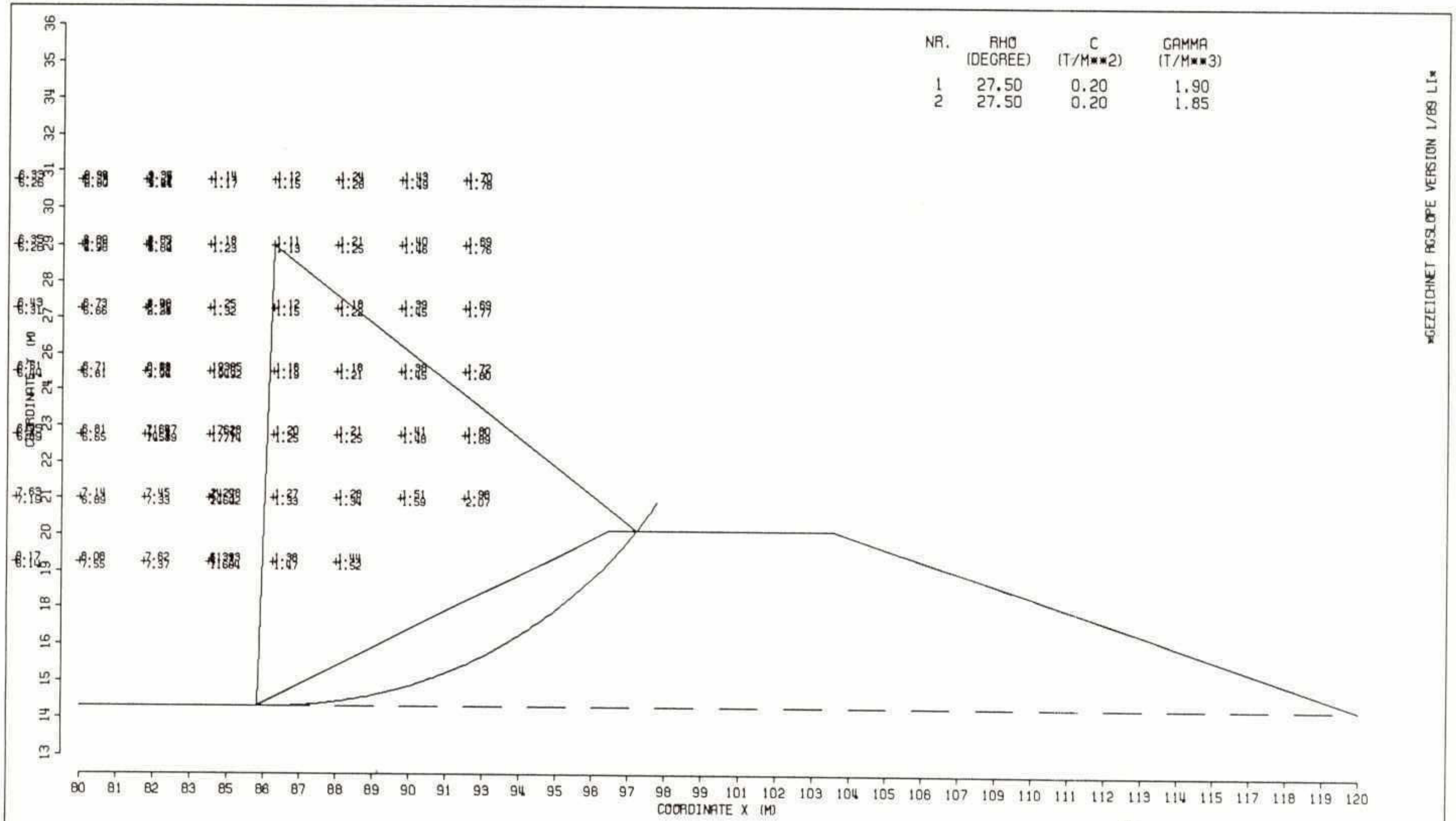
SCALE = 114 CM

ANCHOR
STRATUM
PHREATIC SURFACE

LAHMEYER INTERNATIONAL
BERATENDE INGENIEURE FRANKFURT, MAIN

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ANNEX



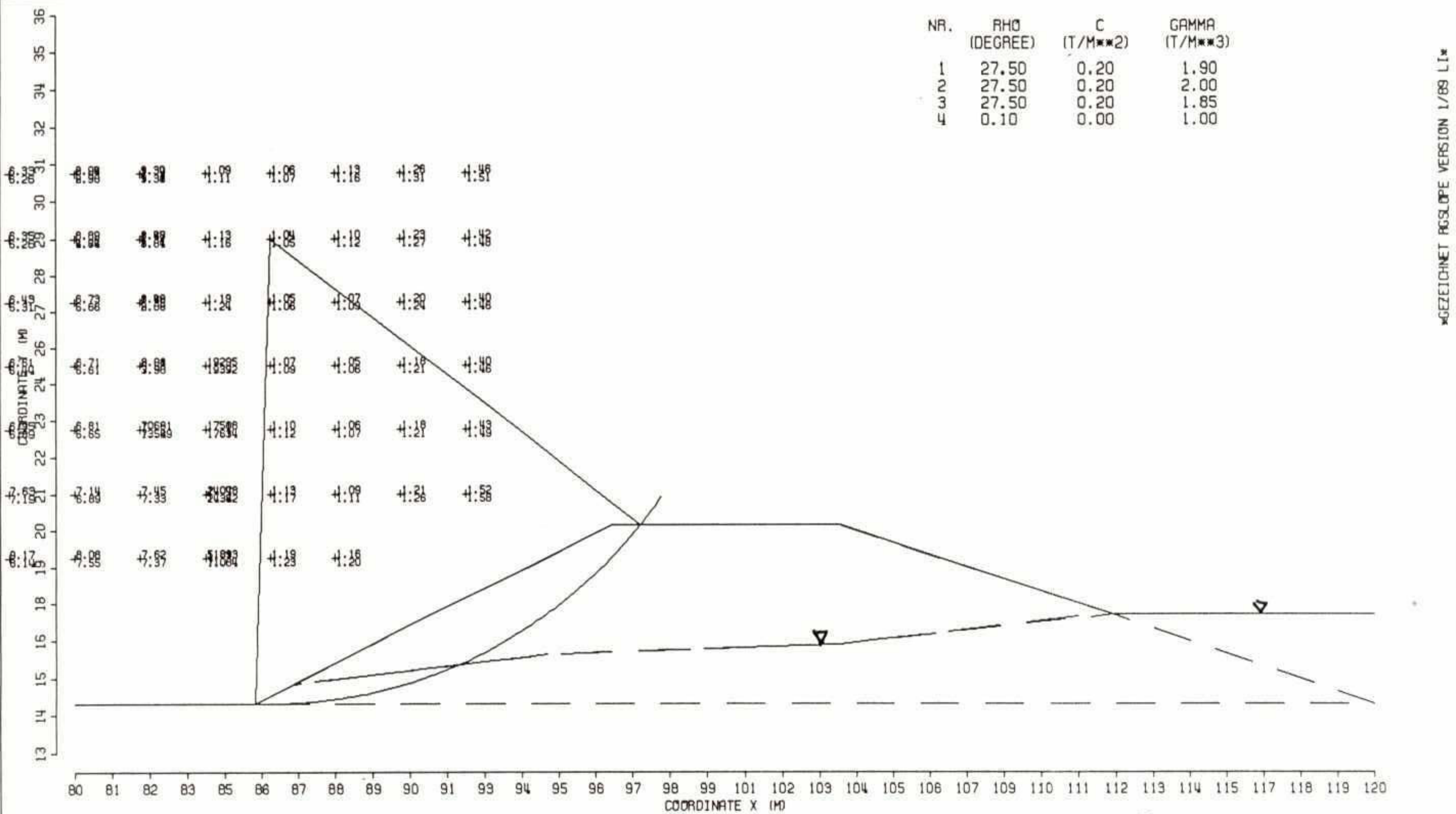
09 JJPS EMBANKMENT; d/s, no flood, no tailwater, seismic loading

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.13	CENTER: 86.00/29.00 RADIUS: 14.51 ACTIVE MOMENT: 200.90 PASSIVE MOMENT: 222.85	SCALE ⊢⊣ = 114 CM ---- ANCHOR --- STRATUM --- PHREATIC SURFACE	STABILITY ANALYSIS ACC. TO BISHOP AND KREY (DIN 4084) FIG. ☐ ANNEX ☐

194

NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	1.90
2	27.50	0.20	2.00
3	27.50	0.20	1.85
4	0.10	0.00	1.00



10 JJPS EMBANKMENT; d/s, yearly flood, no drainage, no tailwater, seismic

LAHMEYER INTERNATIONAL

BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.05

CENTER:	86.00/29.00
RADIUS:	14.51
ACTIVE MOMENT:	199.12
PASSIVE MOMENT:	207.88

SCALE

|—| = 114 CM

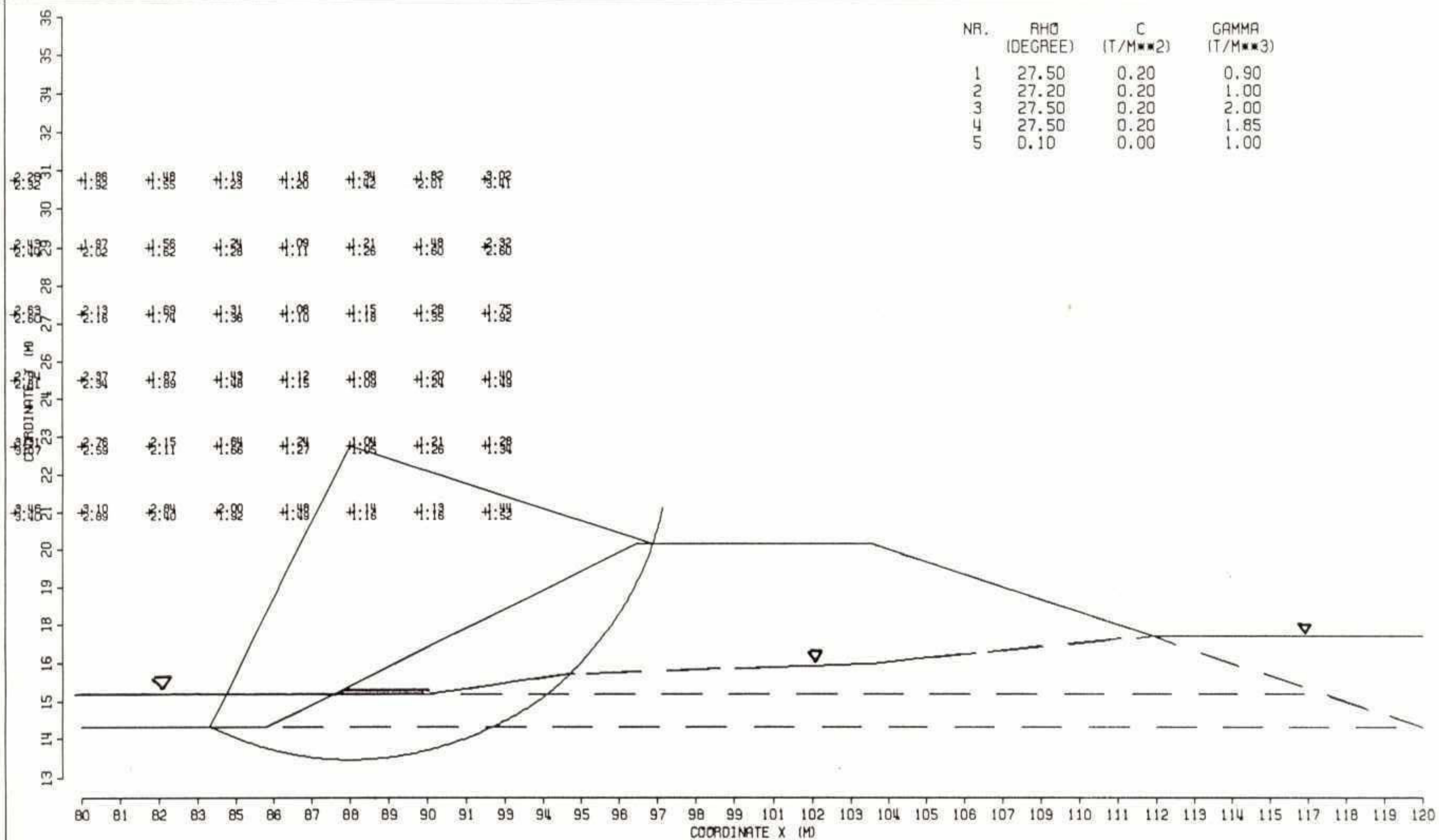
.... ANCHOR
- - - STRATUM
— — PHREATIC SURFACE

STABILITY ANALYSIS

ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ANNEX

196



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	0.90
2	27.20	0.20	1.00
3	27.50	0.20	2.00
4	27.50	0.20	1.85
5	0.10	0.00	1.00

11 JJPS EMBANKMENT; d/s, yearly flood, drainage, tailwater, seismic

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.05

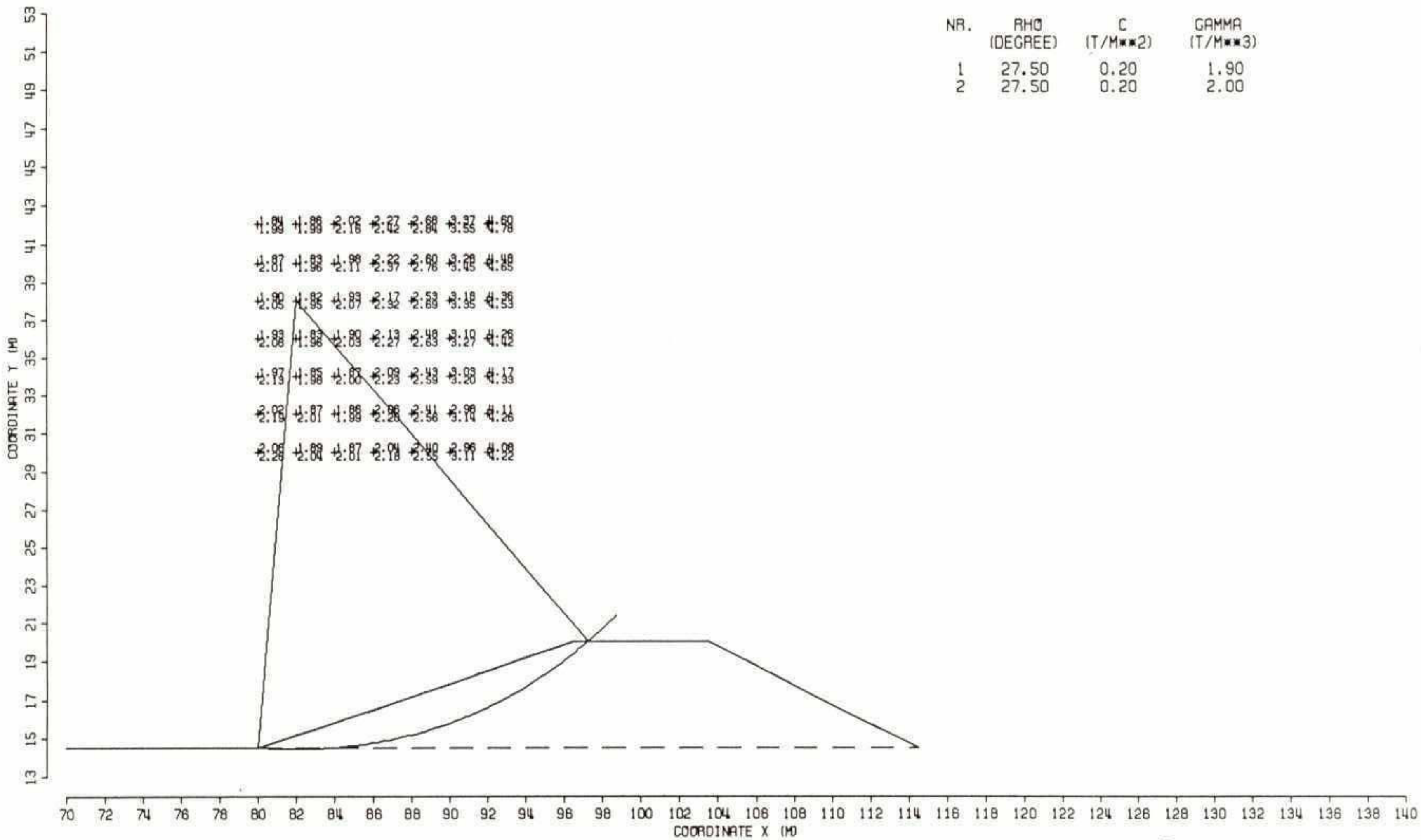
CENTER: 88.00/23.00
RADIUS: 9.49
ACTIVE MOMENT: 184.96
PASSIVE MOMENT: 191.98

SCALE
|—| = 114 CM

.... ANCHOR
--- STRATUM
--- PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	1.90
2	27.50	0.20	2.00

20 JJPS EMBANKMENT; u/s, no flood

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, M/MAIN

ETA (BISHOP) = 1.95

CENTER:	82.00/38.00
RADIUS:	23.58
ACTIVE MOMENT:	337.58
PASSIVE MOMENT:	613.94

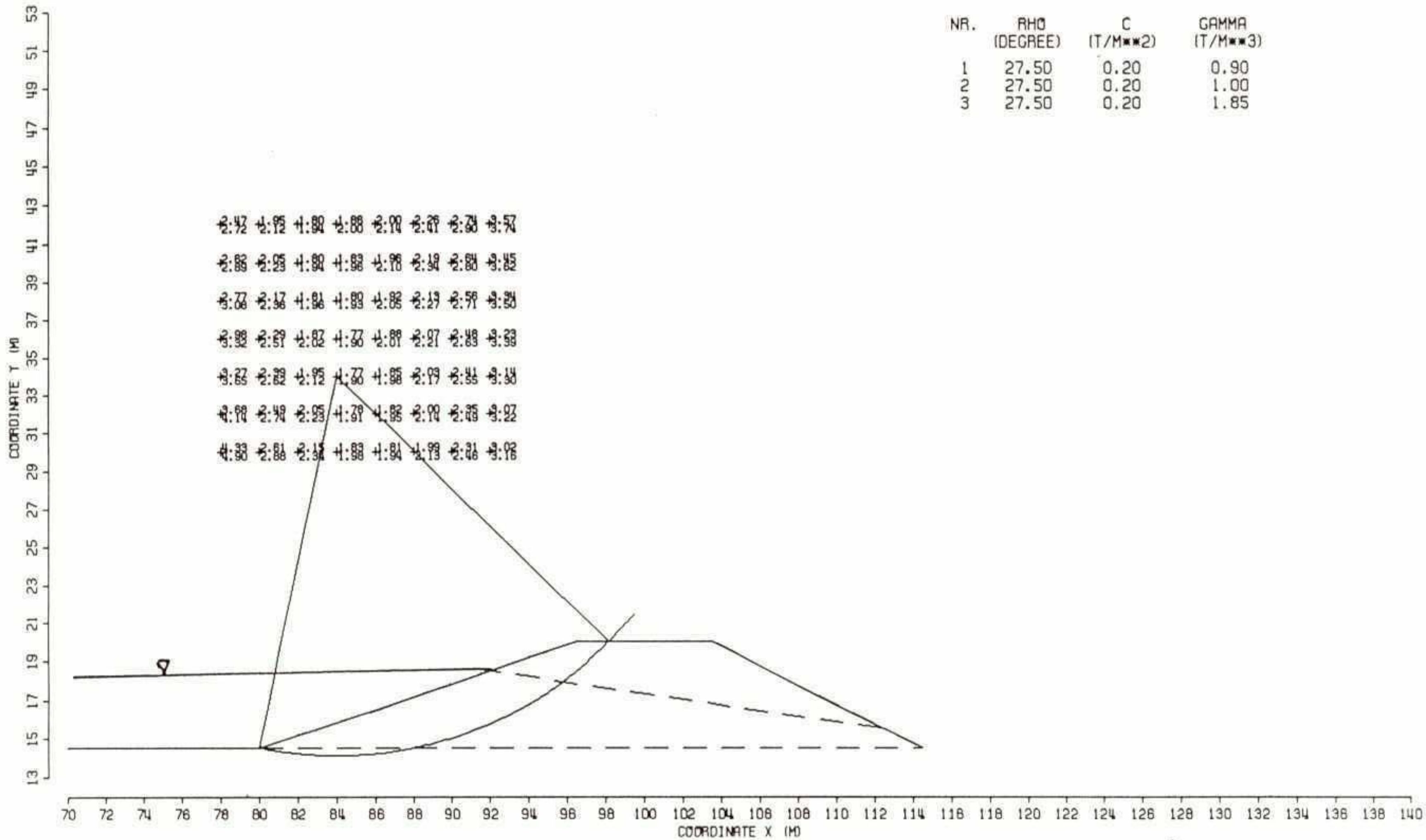
SCALE ⊢⊣ = 200 CM

---- ANCHOR
- - - STRATUM
— — — PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐

197



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	0.90
2	27.50	0.20	1.00
3	27.50	0.20	1.85

GEZEICHNET RGSLOPE VERSION 1/89 LI

21 JJPS EMBANKMENT; u/s, high flood,

LAHMEYER INTERNATIONAL

BERATENDE INGENIEURE FRANKFURT, M(AIN)

ETA (KREY) = 1.77

ETA (BISHOP) = 1.90

CENTER:	84.00/34.00
RADIUS:	19.90
ACTIVE MOMENT:	256.12
PASSIVE MOMENT:	452.19

SCALE

|——| = 200 CM

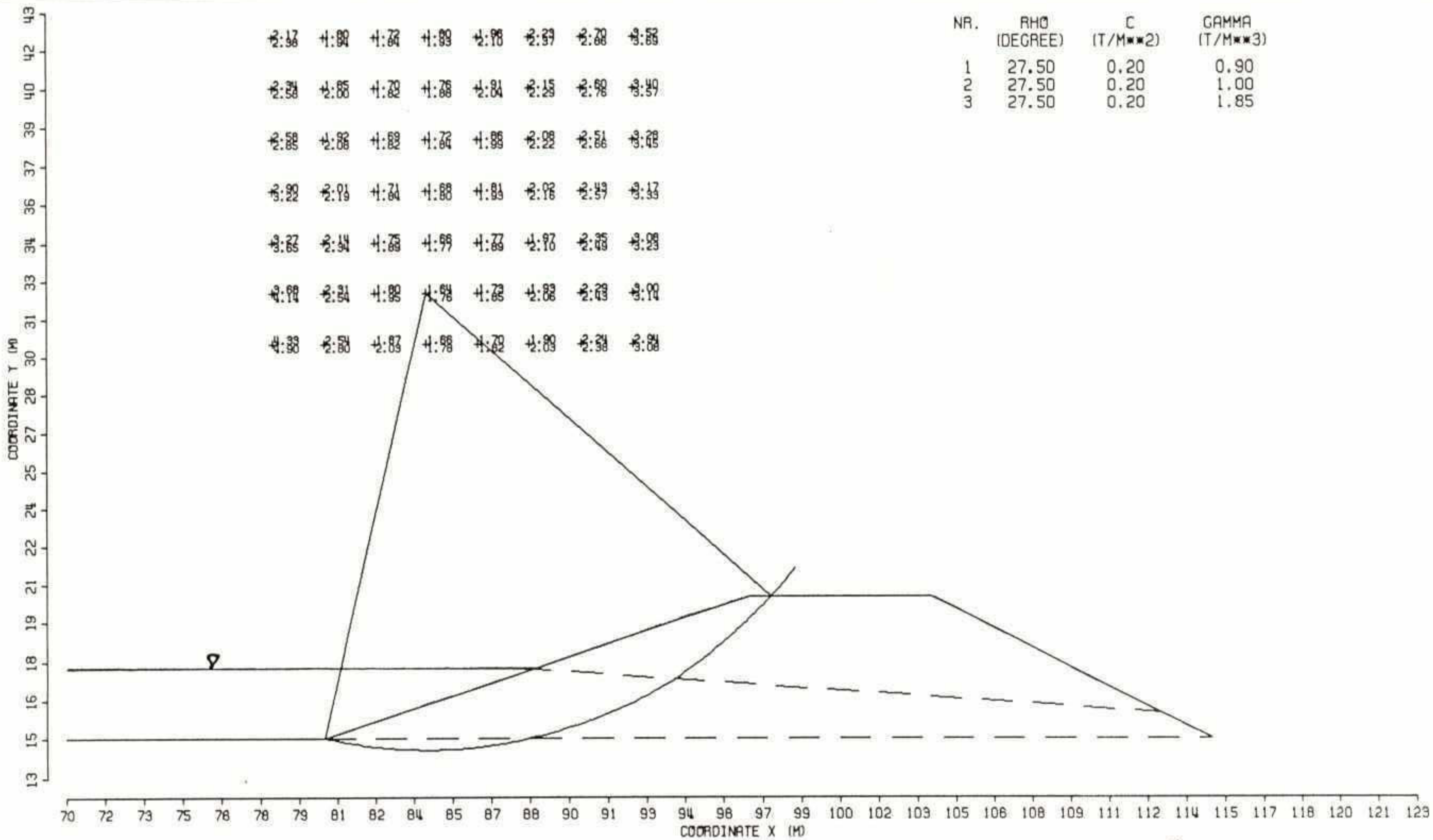
.... ANCHOR
- - - STRATUM
- - - PHREATIC SURFACE

STABILITY ANALYSIS

ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐

198



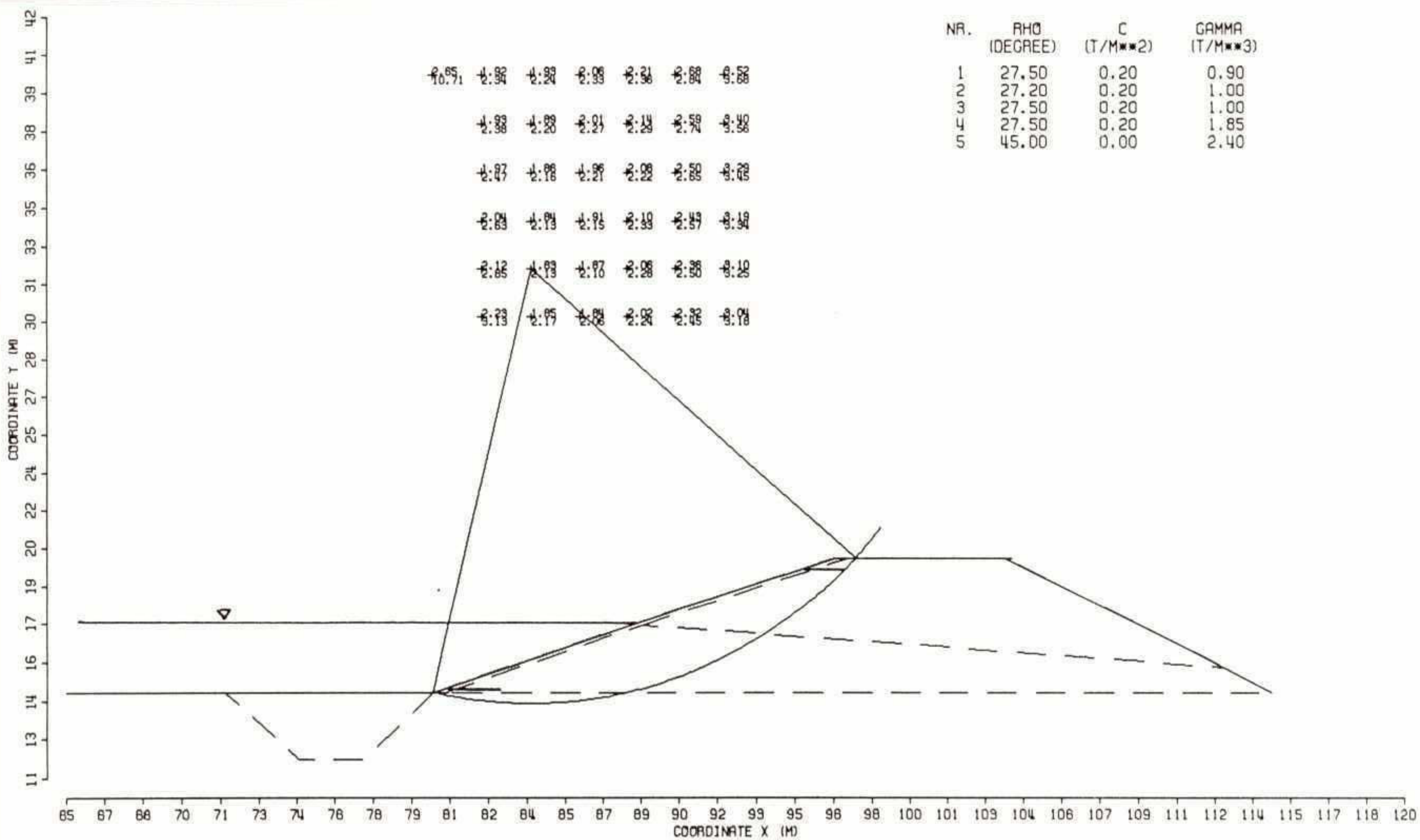
22 JJPS EMBANKMENT; u/s, yearly flood,

LAHMEYER INTERNATIONAL

BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.76	CENTER: 84.00/32.00 RADIUS: 17.95 ACTIVE MOMENT: 256.62 PASSIVE MOMENT: 422.09	SCALE ├─┤ = 150 CM	STABILITY ANALYSIS ACC. TO BISHOP AND KREY (DIN 4084)
		.... ANCHOR - - - STRATUM - - - PHREATIC SURFACE	FIG. ☐ ANNEX ☐

199



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	0.90
2	27.20	0.20	1.00
3	27.50	0.20	1.00
4	27.50	0.20	1.85
5	45.00	0.00	2.40

GEZEICHNET RGSLOPE VERSION 1/89 LI

23 JJPS EMBANKMENT; u/s, yearly flood, key trench+slope protection

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = . 2.06

CENTER:	86.00/30.00
RADIUS:	16.82
ACTIVE MOMENT:	363.86
PASSIVE MOMENT:	669.50

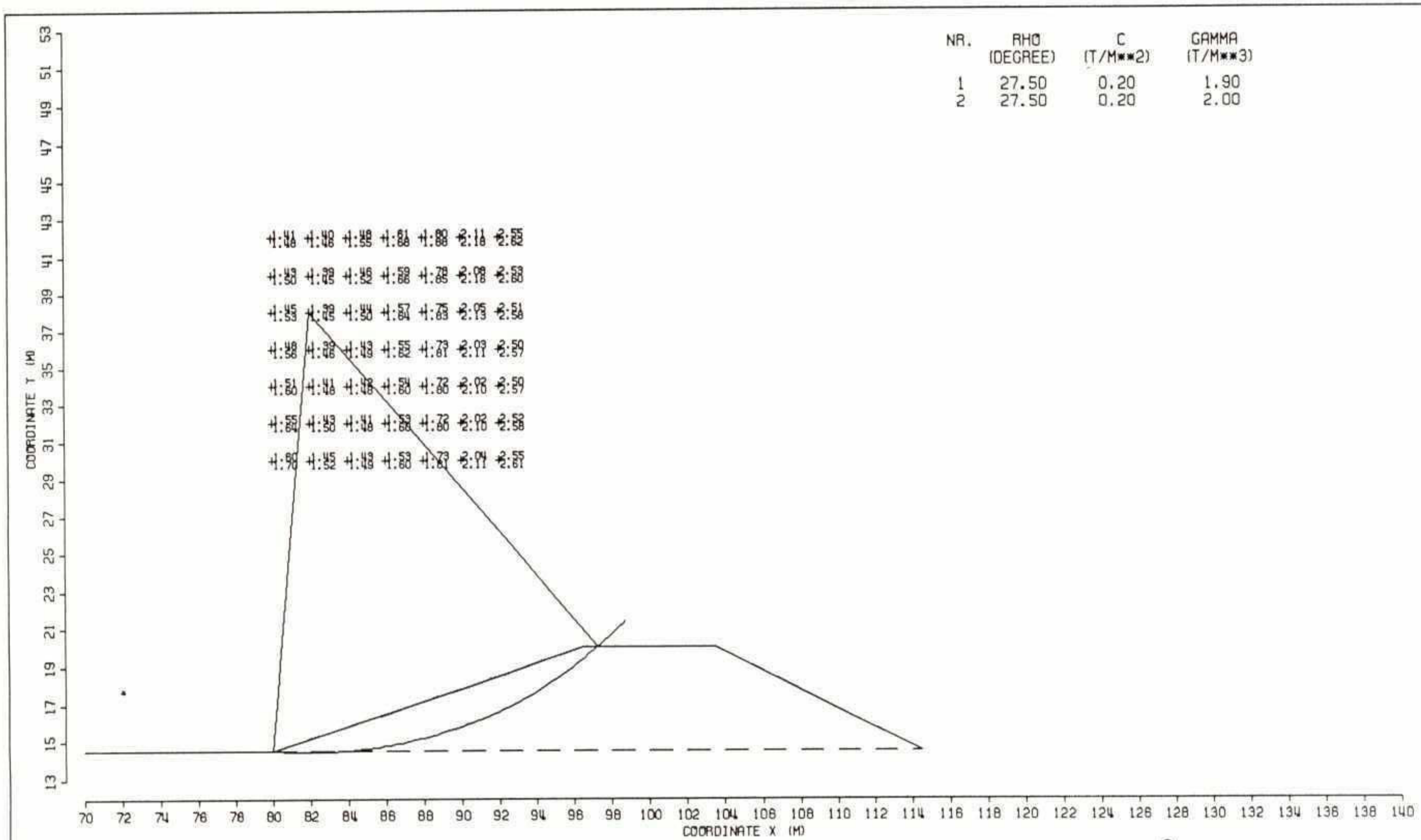
SCALE: |—| = 157 CM

Legend: ANCHOR; STRATUM; PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐

200



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	1.90
2	27.50	0.20	2.00

24 JJPS EMBANKMENT: u/s, no flood, seismic loading

LAHMEYER INTERNATIONAL
BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.45

CENTER:	82.00/38.00
RADIUS:	23.58
ACTIVE MOMENT:	415.99
PASSIVE MOMENT:	576.25

SCALE
= 200 CM

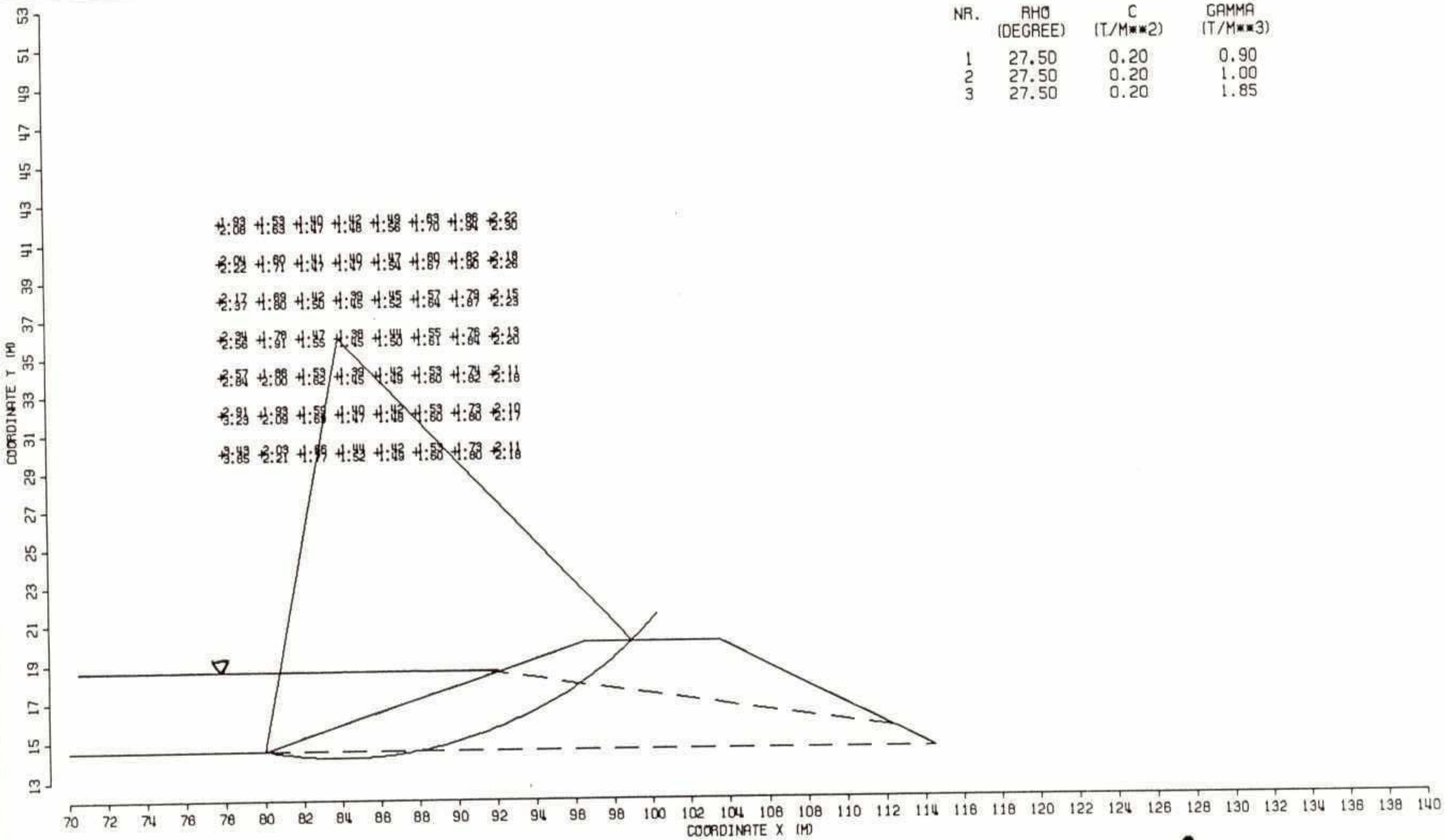
ANCHOR
STRATUM
PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ANNEX

201

NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	0.90
2	27.50	0.20	1.00
3	27.50	0.20	1.85



GEZEICHNET RGSLOPE VERSION 1/89 LI

25 JJPS EMBANKMENT; u/s, high flood, seismic loading

LAHMEYER INTERNATIONAL
BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.45

CENTER: 84.00/36.00
RADIUS: 21.87
ACTIVE MOMENT: 364.30
PASSIVE MOMENT: 504.12

SCALE
|—| = 200 CM

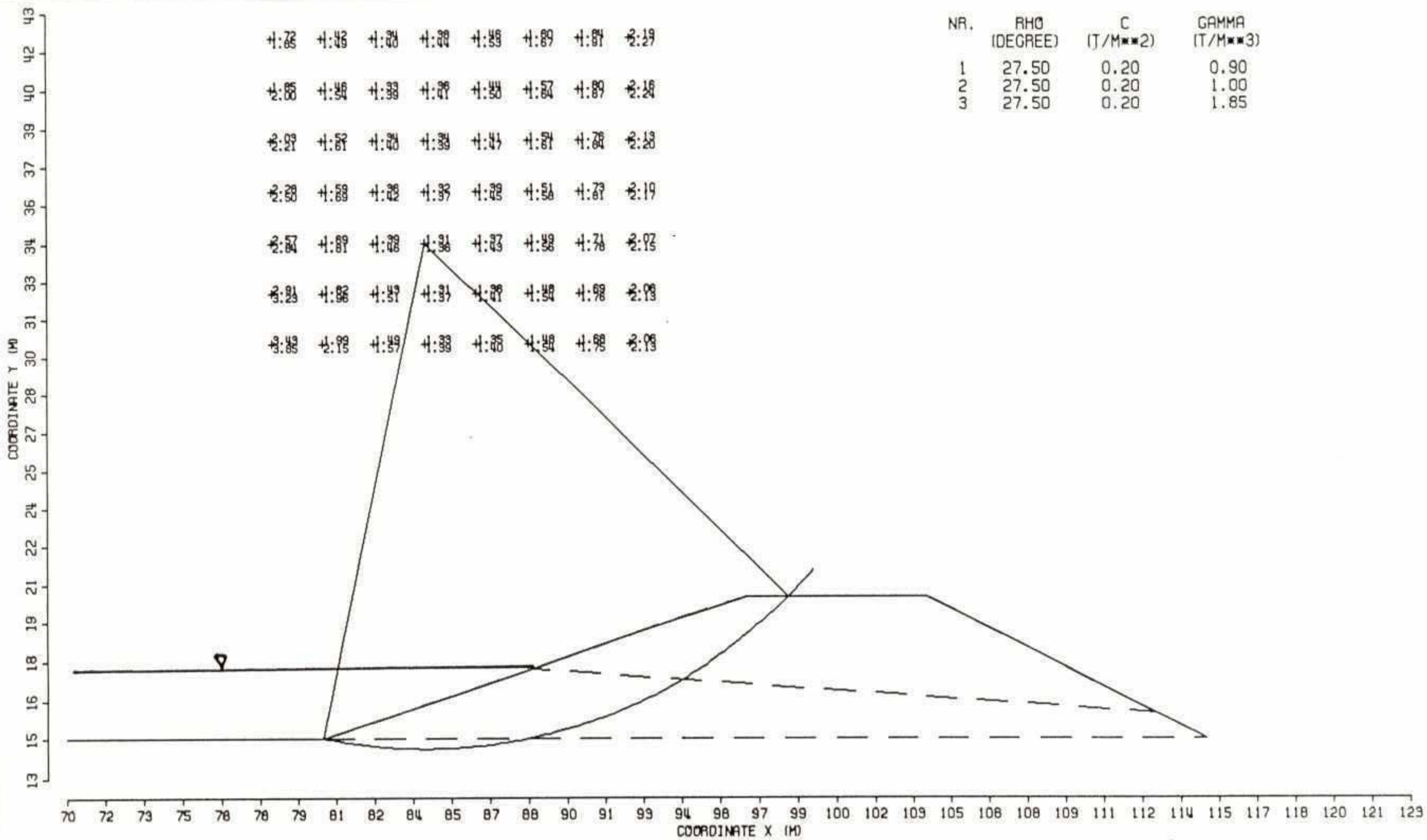
---- ANCHOR
--- STRATUM
--- PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ☐ ANNEX ☐

202

203



NR.	RHO (DEGREE)	C (T/M**2)	GAMMA (T/M**3)
1	27.50	0.20	0.90
2	27.50	0.20	1.00
3	27.50	0.20	1.85

26 JJPS EMBANKMENT; u/s, yearly flood seismic loading,

LAHMEYER INTERNATIONAL

BERATENDE INGENIEURE FRANKFURT, (MAIN)

ETA (BISHOP) = 1.36

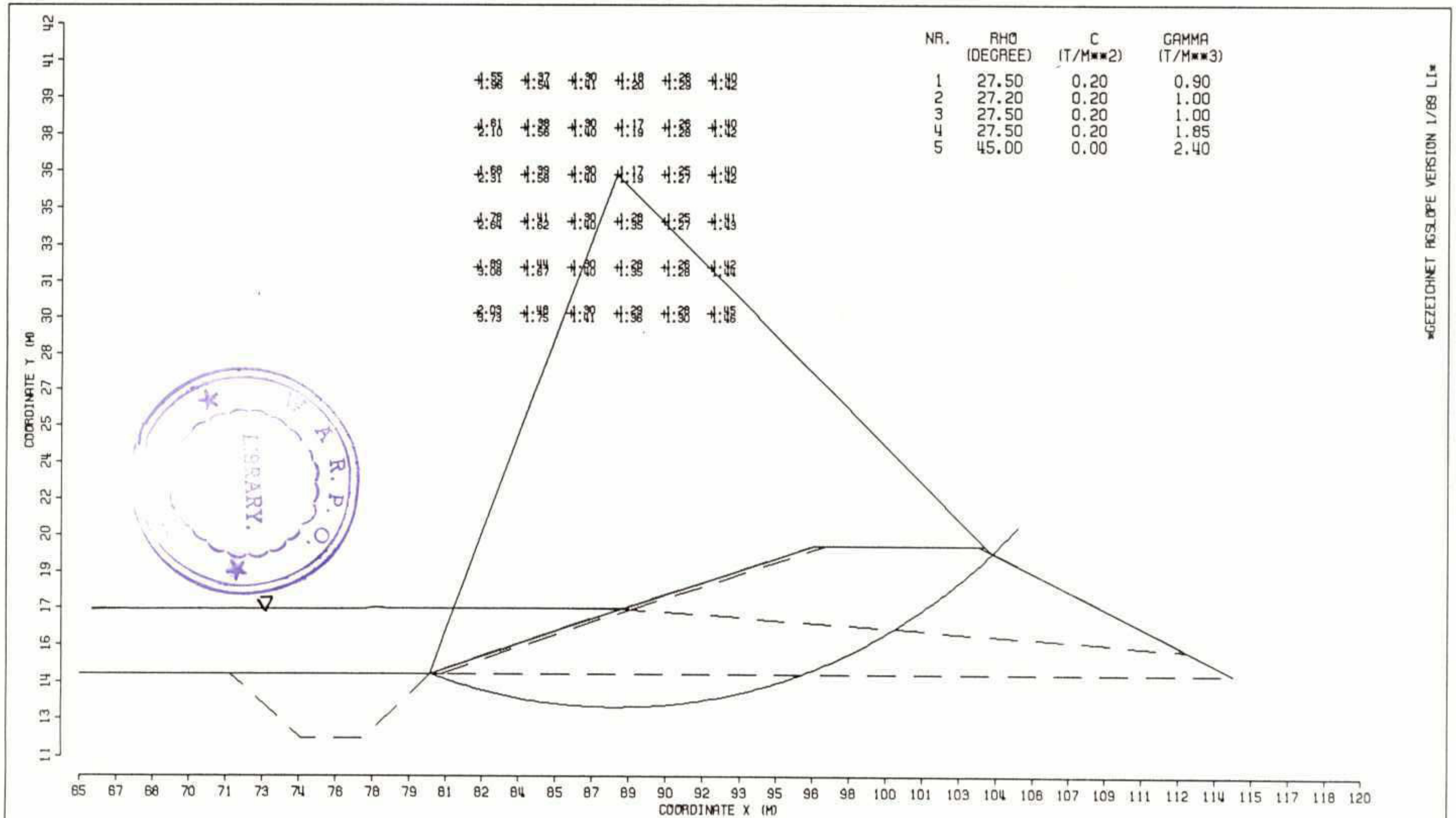
CENTER:	84.00/34.00
RADIUS:	19.90
ACTIVE MOMENT:	365.82
PASSIVE MOMENT:	479.06

SCALE = 150 CM

---- ANCHOR
--- STRATUM
--- PHREATIC SURFACE

STABILITY ANALYSIS
ACC. TO BISHOP AND KREY (DIN 4084)

FIG. ANNEX



27 JJPS EMBANKMENT; u/s, yearly flood,key trench+slope prot.,seissmic

LAHMEYER INTERNATIONAL — BERATENDE INGENIEURE FRANKFURT, MAIN

ETA (BISHOP) = 1.19	CENTER:	88.00/36.00	SCALE ├─┤ = 157 CM	STABILITY ANALYSIS ACC. TO BISHOP AND KREY (DIN 4084)
	RADIUS:	22.94	---- ANCHOR	FIG. ☐ ANNEX ☐
	ACTIVE MOMENT:	425.95	--- STRATUM	
	PASSIVE MOMENT:	498.58	--- PHREATIC SURFACE	

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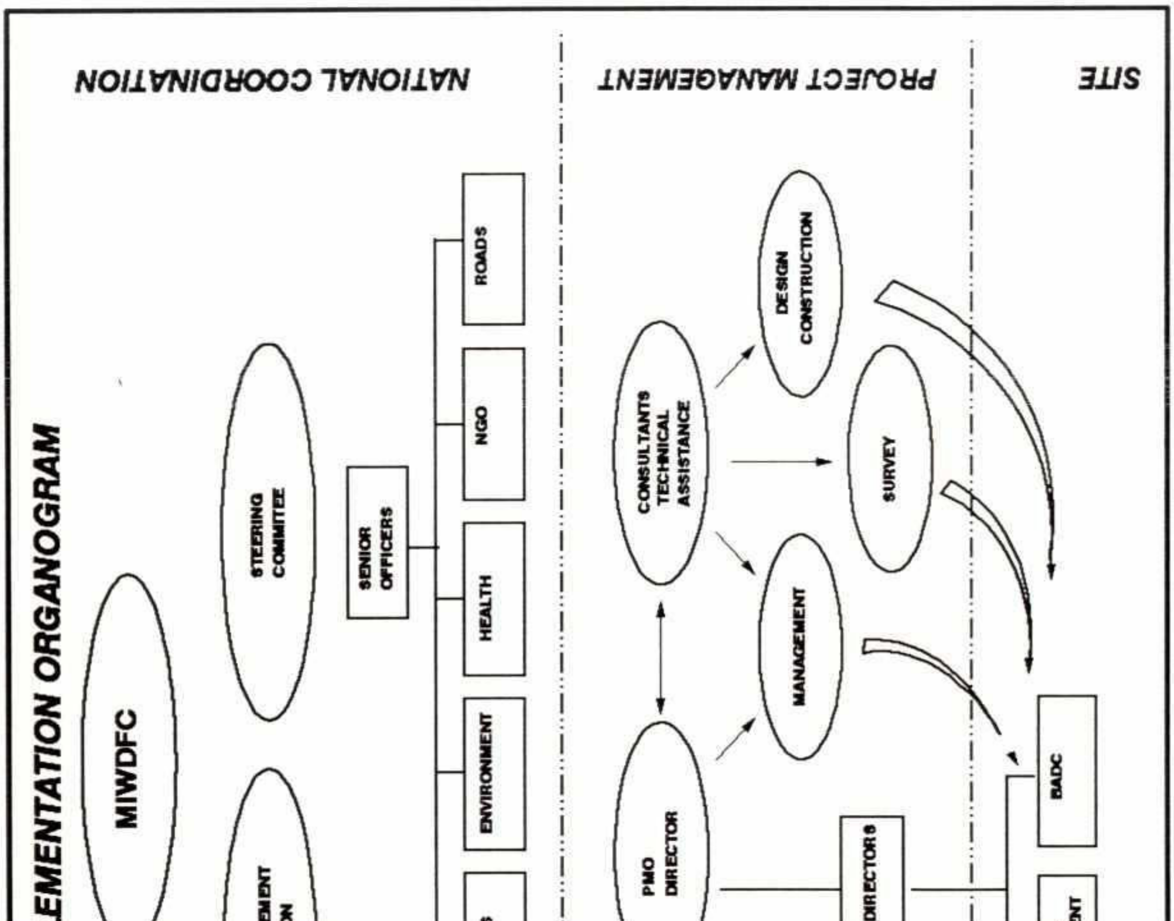

JAMALPUR IMPLEMENTATION ORGANOGRAM
NATIONAL COORDINATION
PROJECT MANAGEMENT
SITE
MIWDFC
FPCO
B.W.D.B. PROJECT MANAGEMENT ORGANISATION
STEERING COMMITEE
SENIOR OFFICERS
BADC
LOCAL GOVERNMENT
FISHERIES
ENVIRONMENT
HEALTH
NGO
ROADS
FAP STUDIES
PMO DIRECTOR
CONSULTANTS TECHNICAL ASSISTANCE
MANAGEMENT
SURVEY
DESIGN CONSTRUCTION
DEP.DIRECTORS
FISHERIES
BWDB X'EN
LOCAL GOVERNMENT
BADC

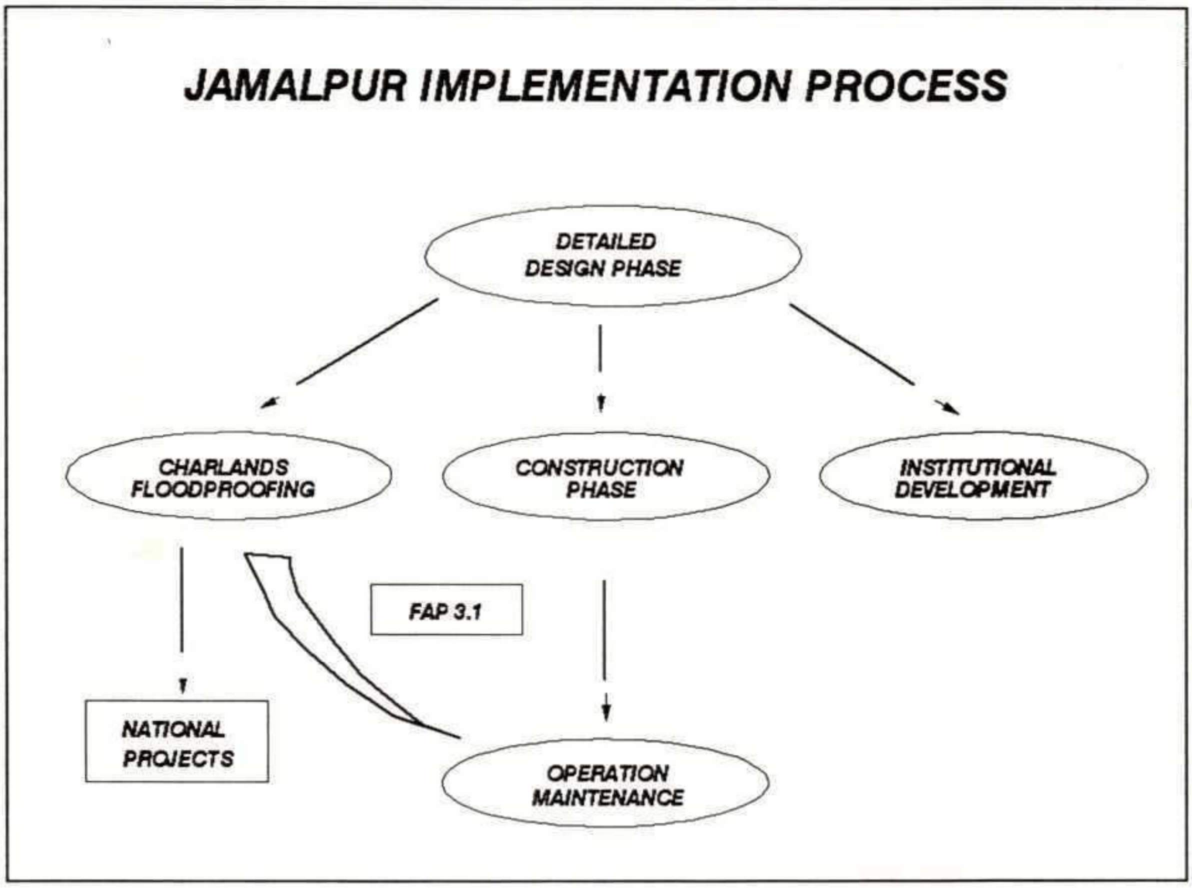
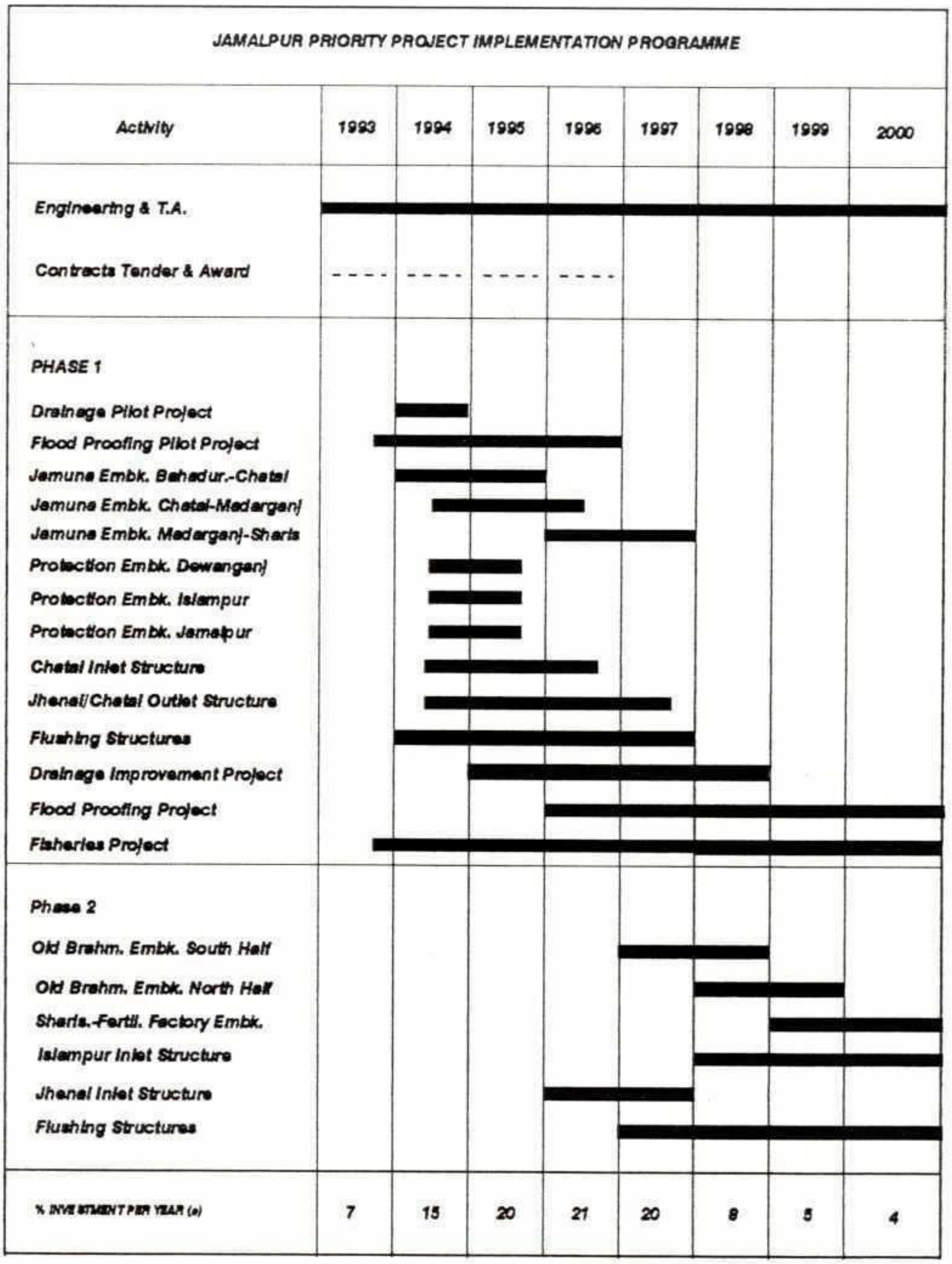

JAMALPUR IMPLEMENTATION PROCESS
DETAILED DESIGN PHASE
CHARLANDS FLOODPROOFING
CONSTRUCTION PHASE
INSTITUTIONAL DEVELOPMENT
FAP 3.1
NATIONAL PROJECTS
OPERATION MAINTENANCE

Figure 7.7.1

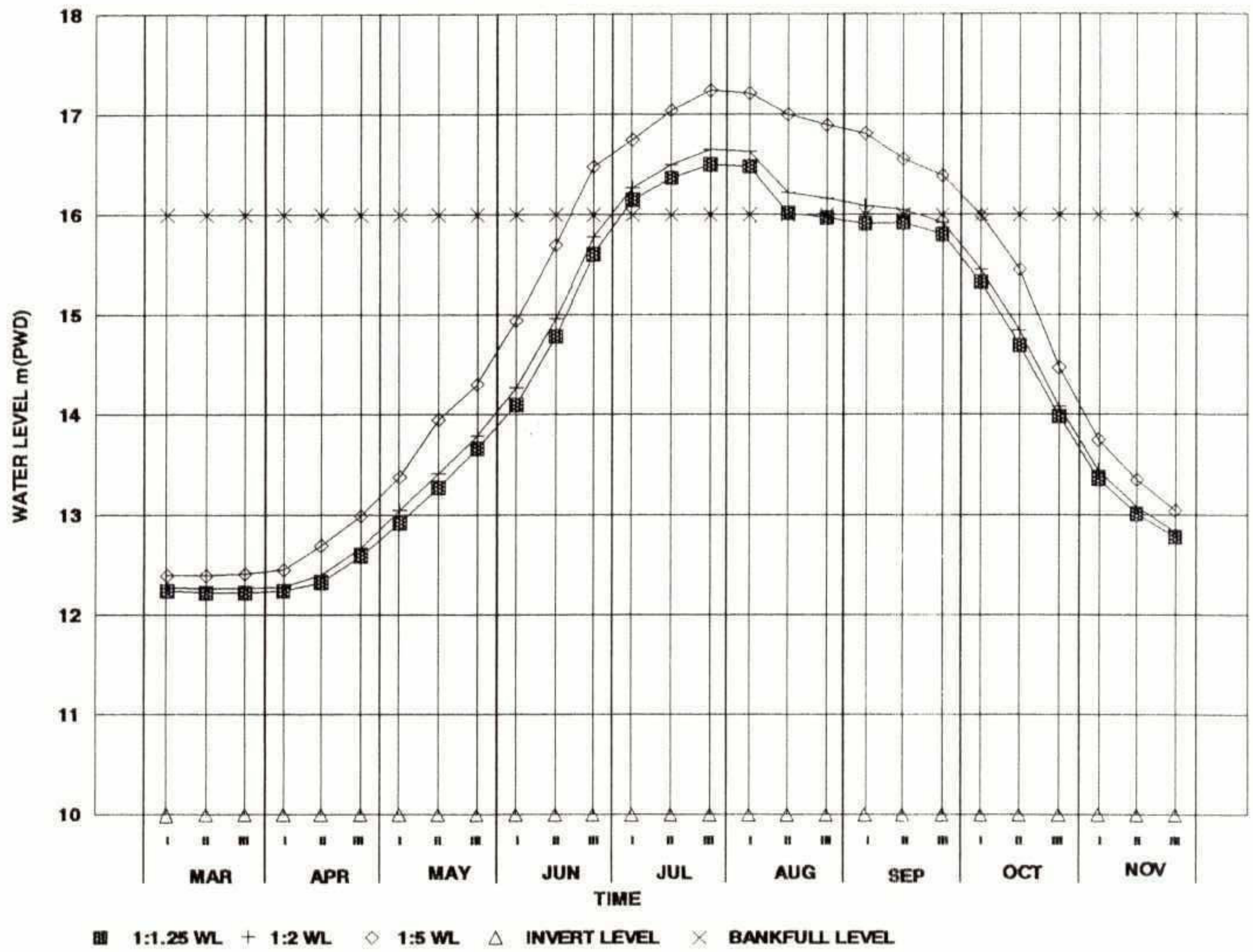

JAMALPUR PRIORITY PROJECT IMPLEMENTATION PROGRAMME
Activity
1993
1994
1995
1996
1997
1998
1999
2000
Engineering & T.A.
Contracts Tender & Award
PHASE 1
Drainage Pilot Project
Flood Proofing Pilot Project
Jamuna Embk. Bahadur.-Chatal
Jamuna Embk. Chatal-Madarganj
Jamuna Embk. Madarganj-Sharis
Protection Embk. Dewanganj
Protection Embk. Islampur
Protection Embk. Jamalpur
Chatal Inlet Structure
Jhenai/Chatal Outlet Structure
Flushing Structures
Drainage Improvement Project
Flood Proofing Project
Fisheries Project
Phase 2
Old Brahm. Embk. South Half
Old Brahm. Embk. North Half
Sharis.-Fertil. Factory Embk.
Islampur Inlet Structure
Jhenai Inlet Structure
Flushing Structures
% INVESTMENT PER YEAR (a)
7
15
20
21
20
8
5
4

APPENDIX

A **AVERAGE RIVER WATER LEVEL AT MAIN INLET STRUCTURES. COMPARISON OF ALTERNATIVE SIZES OF INLET STRUCTURES.**

JAMALPUR PRIORITY PROJECT STUDY

AV.WL JHENAI INLET STRUCTURE



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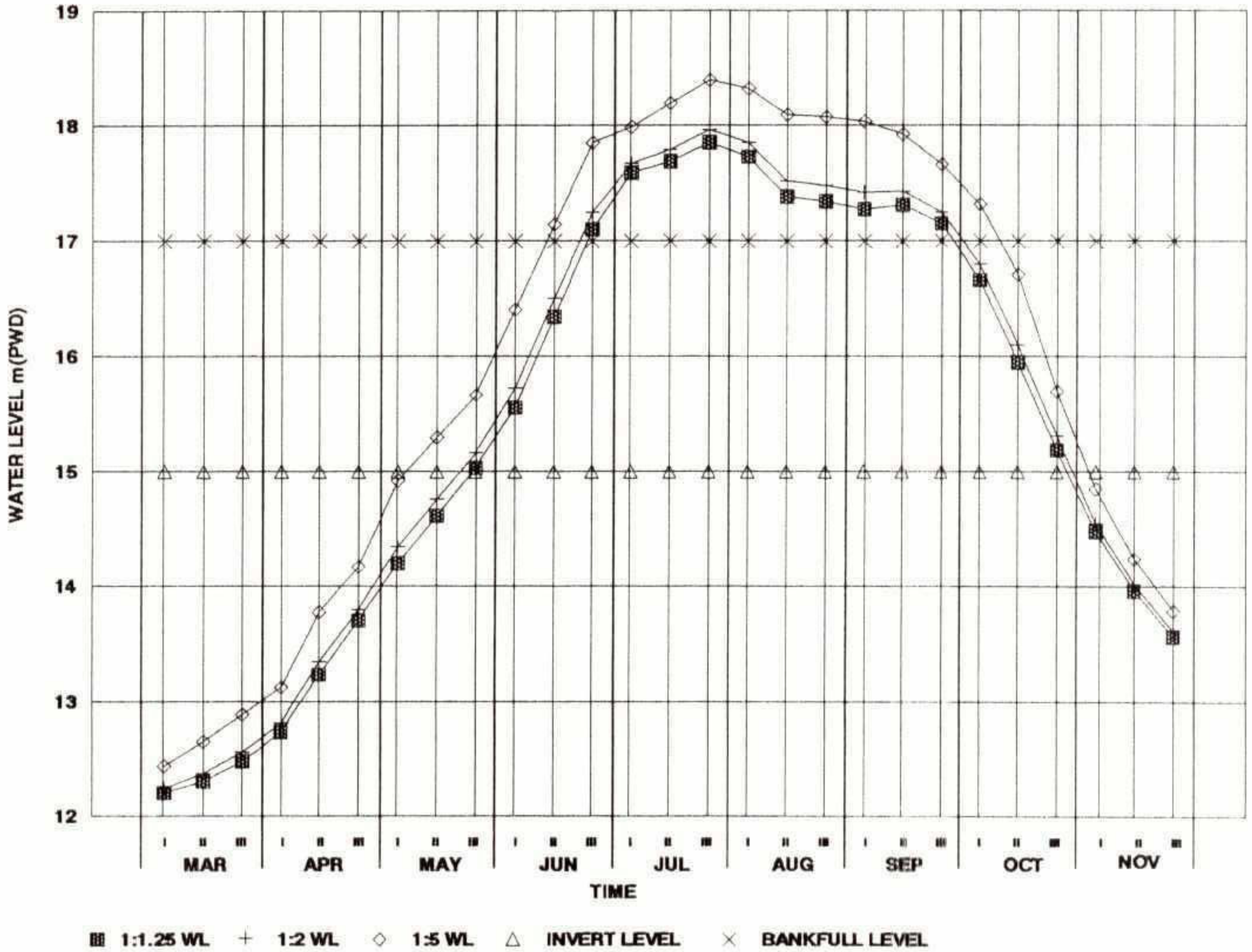
JAMALPUR PRIORITY PROJECT STUDY

AV.WL CHATAL INLET STRUCTURE



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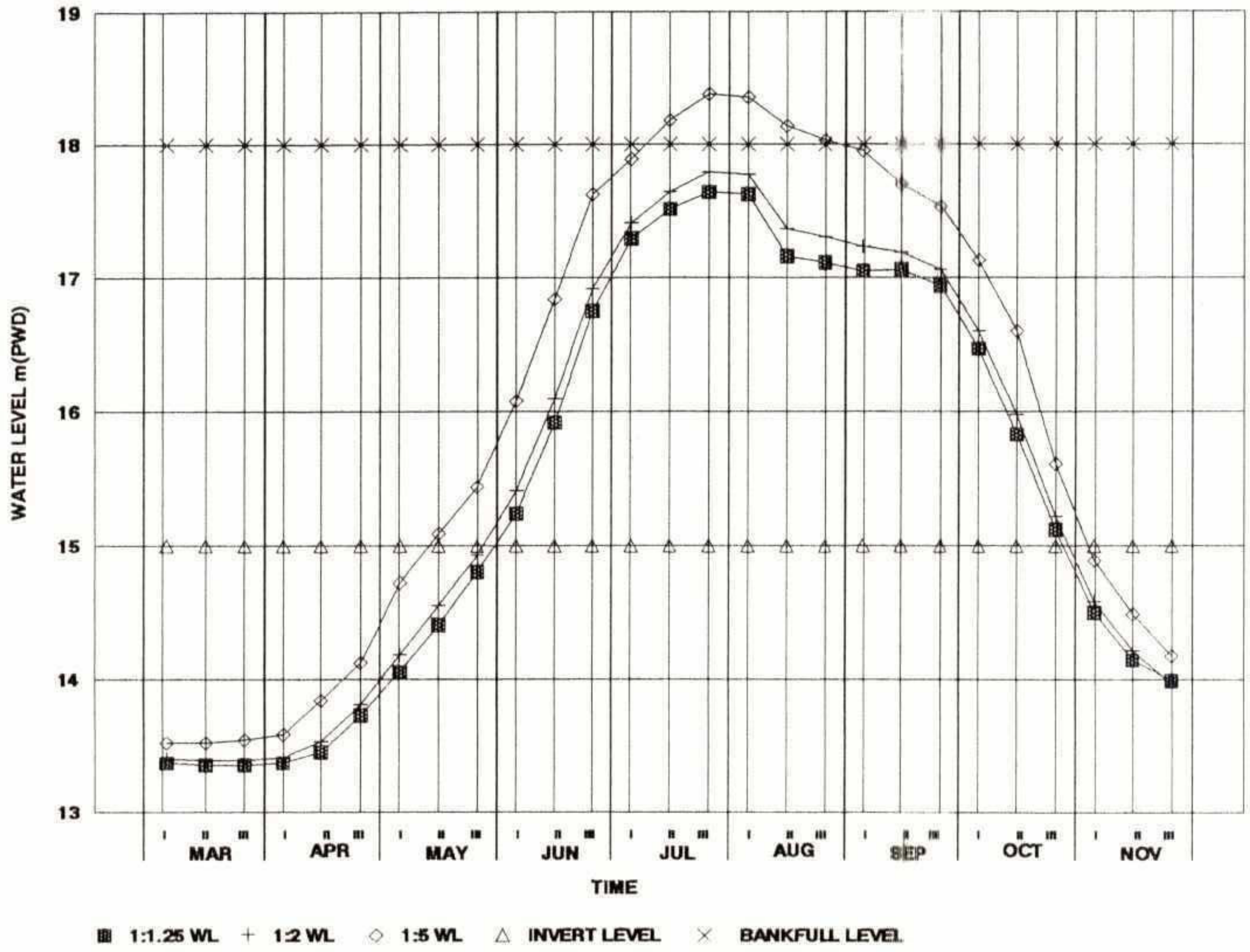
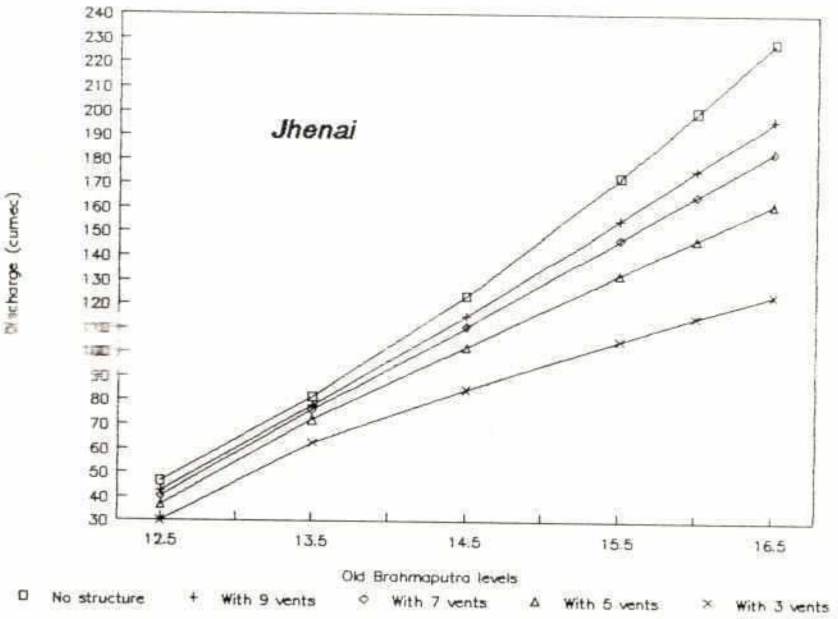
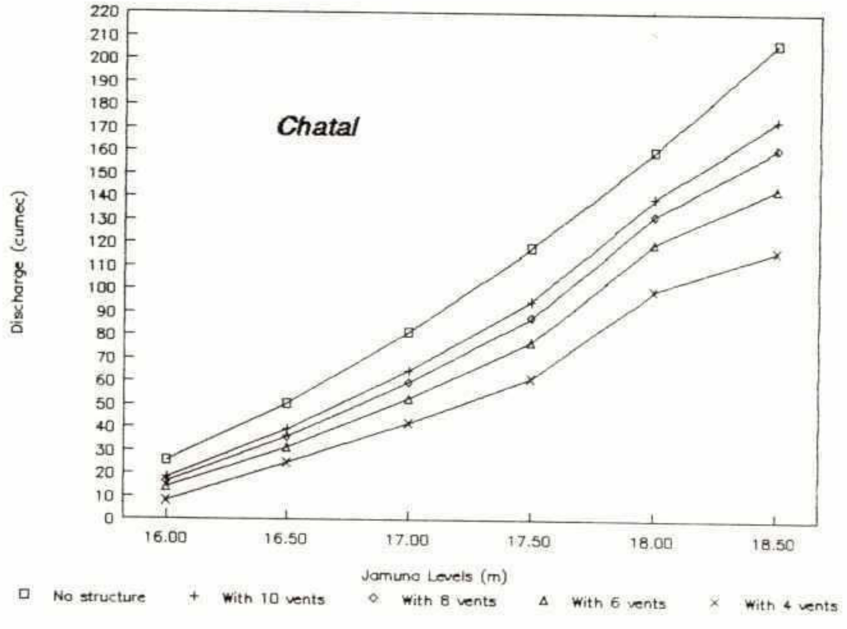
JAMALPUR PRIORITY PROJECT STUDY

AV.WL ISLAMPUR INLET STRUCTURE



211





Flows at Jhenai and Chatal Inlets

Variations with upstream water levels

assuming normal free flow in d/s channel