



COMPARTMENTALIZATION PILOT PROJECT

FAP-20

TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY

FAP-20

VOL-I: WATER RESOURCES AND ENVIRONMENTAL MANAGEMENT

FINAL REPORT

OCTOBER 1994

Resource Planning and Management Consultants
in association with
Sheltech Consultants (Pvt) Limited

TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY

Sheltech-RPMC Consortium
2/4 Lalmatia, Block-C, Dhaka-1207

Tel: 880-2-812591, 325713
Fax: 880-2-812591

Ref: RPMC/TTS/133/94

Date : 2 November, 1994

Mr Hans Visser
Team Leader
Compartmentalization Pilot Project
B B Girls High School Road
Akur Takur Para
Tangail

Subject: **Submission of Final Report**

Dear Sir,

Pleased to submit herewith the subject report as per the Terms of Reference of the study.

Thanking you.

Yours faithfully,

Salma A. Shafi

Salma A Shafi
Team Leader

VOLUME I
WATER RESOURCES AND ENVIRONMENTAL MANAGEMENT

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF MAPS AND FIGURES

* Presented in a separate folder

9

VOLUME II

PHYSICAL, SOCIAL AND INSTITUTIONAL DEVELOPMENT

TABLE OF CONTENTS

CHAPTER	CONTENTS		PAGE

CHAPTER	CONTENTS		PAGE

LIST OF APPENDICES

LIST OF TABLES

26

LIST OF MAPS AND FIGURES

* Presented in a separate folder

ABBREVIATIONS

ADB	Asian Development Bank
BADC	Bangladesh Agricultural Development Corporation
BGS	Bangladesh Geological Survey
BLE	Bhahmaputra Left Embankment
BRDB	Bangladesh Rural Development Board
BRE	Bhahmaputra Right Embankment
BSCIC	Bangladesh Small and Cottage Industries Corporation
BURO	Bangladesh Unemployed Rehabilitation Organization
BWDB	Bangladesh Water Development Board
CARE	Copperative American Relief for Everywhere
CBO	Community Based Organization
CC	Cement Concrete
CH	Chainage
CM	Centimetre
CPP	Compartmentalization Pilot Project
CUS	Cetre for Urban Studies
CWFP	Concerned Women for Family Planning
DC	Deputy Commissioner
DCC	District Coordination Committee
DFO	Divisional Forest Officer
DMP	Dhaleswari Mitigation Plan
DPHE	Directorate of Public Health Engineering
DTW	Deep Tubewell
DU	Dwelling Unit
EPI	Expanded Programme for Immunization
FAO	Food and Agriculture Organization
FFW	Food for Work
GOB	Government of Bangladesh
GL	Ground Level
GLD	Guided Land Development
GWT	Groundwater Table
HBB	Herringbone Bond
HBFE	House Building Finance Corporation
HES	Household Environmental Sanitation
HH	Household
HIG	Higher Income Group
HQ	Headquaters
HSD	Housing and Settlement Directorate
HTW	Hand Tubewell
IDP	Infrastructure Development Programme
Km	Kilometre
LGED	Local Government Engineering Department
LIG	Lower Income Group
m	Metre
MIG	Middle Income Group
MM	Millimetre
MP	Member of Parliament
MPO	Master Plan Organization
NGO	Non-government Organization

O&M	Operation and Maintenance
ORS	Oral Rehydration Saline
PDB	Power Development Board
PTW	Production Tubewell
PWD	Public Works Department
RCC	Reinforced Concrete Cement
REB	Rural Electrification Board
RHD	Roads and Highways Department
RMP	Rural Maintenance Programme
RUA	Rapid Urban Appraisal
SC	Sub-Compartment
SDS	Social Development Sangsad
SSS	Society for Social Service
STIDP II	Secondary Towns Infrastructure Development Project -II
STW	Shallow Tubewell
T&T	Telephone and Telegraph
TCCA	Thana Central Cooperative Association
UCEP	Underprivileged Children's Education Programme
UD	Urban Development
UIPT	Urban Immovable Property Tax
UNICEF	United Nations Children's Emergency Fund
UNDP	United Nations Development Programme
UP	Union Parishad
WARPO	Water Resource Planning Organization
WBM	Water Bound Macadam
WID	Women in Development
WL	Water Level
XEN	Executive Engineer

VOLUME I

CHAPTER 1

FOREWORD

1.1 General

The Tangail Town Integrated Water Management and Development Study was initiated to develop the urban infrastructure and other services to keep up with rural development, a prerequisite for the integrated development of the Tangail Compartmentalization Pilot Project area. The study commenced on March 12, 1994. The final findings of the study relating to flooding and drainage management, geohydrology of the town and surroundings, and environmental management are incorporated in this Volume of the report.

1.2 Flooding and Drainage Management

Chapter 2 of this volume deals with flooding and drainage management. Topographic survey data of the urban area were not available. As such a topographic survey in the scale 1:2000 with 0.25 m contour was carried out for the area. Long and cross section of the main drainage channel of the town from Lohajang river near Tangail Eidgah to Darun Beel through the town and then onward to Lohajang river at Nagar Jalfai was surveyed to a scale 1:500 h and 1:100 v. Similarly long and cross section of the proposed flood embankment/wall was surveyed around the periphery of the urban area to a scale 1:2000 h and 1:100 v. In addition, the proposed site for flushing regulator on the main drainage channel at Eidgah was surveyed to a scale 1:1000. All these maps and drawings excepting the flood embankment map, are furnished in a separate folder.

The recommendations for flooding and drainage management include (1) re-excavation of the main drain and constructing 2m wide masonry drain for a length of 1.7 km from Eidgah to Biswas Betka and then 1.3 km long open channel with a bed width of 4m upto Darun Beel and 3.7 km long open channel with 10m bed width from Darun Beel to Nagar Jalfai; (2) constructing 23.17 km long masonry drains covering the urban area to drain into the main drainage channel at different points and through five drainage outlet structures into the river Lohajang; and (3) construction of an one-vent flushing inlet structure at the Eidgah end of the main drainage channel.

1.3 Geohydrology

Chapter 3 of this volume deals with Geohydrology of the town and surroundings. This component of the study is concerned with availability of groundwater resources keeping in view the partial control of flood by implementation of Tangail CPP. Flood control protection are expected to reduce recharge and without extensive investigations and analysis the relationship can only be defined indicatively. The Tangail CPP area forms an extensive floodplain between the Jamuna river and the slightly elevated terraces of Madhupur tract. It is set up in undulating tracts of rise and fall with wary pattern. The Jamuna-Dhaleswari river system drains most of the area.

The present volume of groundwater abstraction by DPHE production wells and number of hand tubewells is approximately about 12,000 m^3/day. By the year 2000, the population of the town will be about 200,000 who will need about 20,089 m^3 of water a day. Though the aquifer is sustainable to the large withdrawal of groundwater, it should be kept in mind that Tangail town is surrounded by groundwater-irrigated agricultural land. There is always a risk of groundwater mining and hand tubewells are susceptible to it.

UNICEP/DPHE recently conducted a study on declining water level throughout Bangladesh. Their study suggests that by the year 1995 the suction-mode hand tubewells will eventually give way to Tara tubewell technology. Implementation of flood control, diversion and closure of river may further lower down the groundwater table.

1.4 Environmental Management

Chapter 4 of this volume deals with environmental issues of Tangail town such as drainage congestion and waterlogging, drinking and domestic water, groundwater availability, surface and groundwater quality, solid waste, sanitation, health and nutrition.

The main drain of the town has totally lost its capacity due to gradual landfilling with town solid waste, unauthorized encroachment by growing settlement and blockade by embankment at the mouth of the khal. Waterlogging begins with the onset of pre-monsoon rainfall and during monsoon the lowlying areas are often inundated upto 30-60 cm depth. This results in severe damages to road and other infrastructures, and poses environmental health risks as well.

Data from the Sub-consultants socio-economic household survey shows that 51% of the households have access to privately owned hand and shallow tubewells. ADB has made a detailed survey on the existing water supply arrangement of Tangail Pourashava and has designed a plan for water supply considering projected population upto the year 2015. The plan is scheduled for implemention during 1994 through 1999.

Data on groundwater show maximum iron contamination in the water of almost all tubewells. Water quality in the medium deep aquifer appears to be better in terms of iron content compared to that at shallow aquifer.

Tangail town produces at present approximately 5 tons of solid wastes per day. About 62% of this is collected in roadside bins and then carried to the landfill area about 1 km away from the town. All these wastes are dumped without any treatment. About 30% of the solid wastes is disposed off directly into nearby ditches, drains and khals by the household people and the remaining 10% remains scattered beside the streets causing environmental pollution.

According to the socio-economic household survey, about 9% of the households have no latrine and use open spaces for defecation. Another 23% use kutcha latrines. Keeping in view the total number of 20,520 households in Tangail town, additional 10,749 water seal latrines, 6,715 septic tanks and 54 community latrines will be required to provide modern sanitation facilities to cover all the town dwellers.

Findings from the household survey also indicate that diarrhoea, cholera, dysentery and hepatitis together account for about 50%, followed by 17% of sufferings from skin diseases. Health care facilities are inadequate. There are only one government-managed General Hospital, 2 out-patient government clinics and 5 private clinics.

In view of the above findings, the major measures recommended for prioritized action include the follow-up of the implementation of Tangail Town Water Supply Plan made under ADB Second Water Supply and Sanitation Project. This is to be followed by determination of the total volume of groundwater abstraction by number and type of tubewells, and estimated volume of recharge. On health and sanitation considerations the improvement of sanitation facilities by providing approximately 10,8000 low-cost water seal latrines will be required along with the introduction of health education programme and upgrading of the General Hospital and improvement of private sector medical facilities in the town.

CHAPTER 2

FLOODING AND DRAINAGE MANAGEMENT

2.1 General

The Tangail Compartmentalization Pilot Project (CPP) area is located on the left bank of Dhaleswari and Elanjani rivers in the Northeast region of Bangladesh. The area is bounded by a peripheral embankment along the Dhaleswari, Elanjani, Lohajang rivers, Gala Khal and Pungli river connected by an earthen road between Silimpur and Karatia in the south (Map-1). The compartment is divided into 16 sub-compartments. The Tangail town is located in sub-compartment-16 situated at the centre of the compartment on the eastern bank of Lohajang river. The Tangail Pourashava comprising 3226 ha is divided into 6 wards (Map-2). The urban area, however, is 425 ha and inhabited by about 40% of the total population of the compartment.

The main water-related problems of the urban area have been created by the erosion of Lohajang river, insufficiency of the surface drainage system, especially in the central part of the town and the occasional river flooding.

2.2 Background of the Project

People of Bengal delta were used to integrated water management by constructing embankments, closing khals, irrigating their fields by gravity diversion since long. Interference with the nature was minimal and the farmer reaped the benefit by preventing early floods but allowing flooding after the harvest of Aus paddy. The rivers and khals brought fish fry to the fields and positive influence of flooding by increasing fertility of land was exploited by them. The environment was least disturbed. Following disastrous floods of 1954 and 1955 attention was diverted to flood control and a new concept of empoldering areas was introduced. Isolated polders gave solution for enclosed areas but often created problems in the surrounding areas, causing higher water levels. Gradually the water courses outside the polders were silted up and created drainage congestion in the empoldered area.

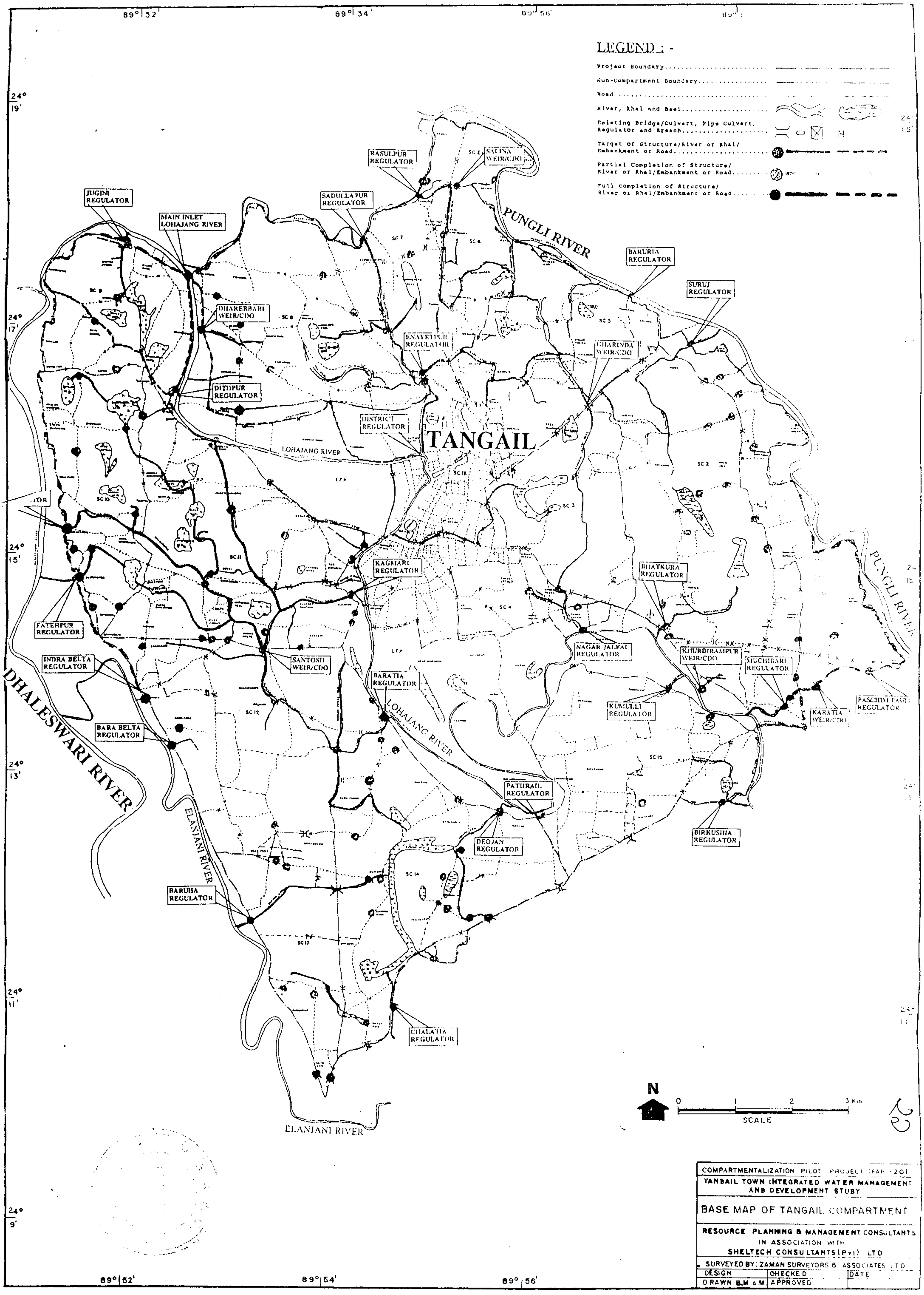
The floods with greater intensity was repeated during 1987 and 1988 leading to several studies to investigate how to protect the country better against devastating floods. With the assistance of international community, the Government of Bangladesh in 1989 undertook a number of studies under Flood Action Plan. Regional Water Resource Development Planning studies have been undertaken to identify alternative water resource management strategies for different regions. These have been followed by feasibility studies for priority investment projects.

The concept of compartmentalization was introduced in the GOB/UNDP Bangladesh Flood Policy Study. According to the Flood Action Plan the areas at the right and left banks of the Brahmaputra would be divided into compartments.

2.3 The Project Rationale

The Flood Action Plan has eleven main components and fifteen supporting activities, which are expected to lead to water resource management and related projects. The FAP-20 is one such projects, aiming at covering the management of flooding on the right and left embankments of the Brahmaputra river. Tangail compartment on the left bank (pending possible future construction of BLE) and Sirajganj compartment on the right bank were selected because of direct protection by a main embankment, the existing BRE. In order to manage the water much more effectively Tangail compartment has been divided into several sub-compartments. A compartment is a protected area or part thereof in which effective water management through semi-controlled flooding and controlled drainage is made possible through structures and associated institutional arrangements. The flood water is expected to flow into the compartment and spread over the area in a controlled way by means of regulating structures.

MAP - I



LEGEND :-
Project Boundary
Sub-Compartment Boundary
Road
River, Khal and Beel
Existing Bridge/Culvert, Pipe Culvert, Regulator and Breach
Target of Structure/River or Khal/Embankment or Road
Partial Completion of Structure/River or Khal/Embankment or Road
Full completion of Structure/River or Khal/Embankment or Road
TANGAIL
PUNGLI RIVER
DHALESWARI RIVER
LOHAJANG RIVER
ELANJANI RIVER
JUGINI REGULATOR
MAIN INLET LOHAJANG RIVER
RASULPUR REGULATOR
SALINA WEIR/CDO
SADULLAPUR REGULATOR
BARURIA REGULATOR
SURUJ REGULATOR
DHARERBARI WEIR/CDO
ENAYETPUR REGULATOR
GHARINDA WEIR/CDO
DITHPUR REGULATOR
DISTRICT REGULATOR
KAGMARI REGULATOR
BHATKURA REGULATOR
FATEHPUR REGULATOR
INDRA BELTA REGULATOR
SANTOSH WEIR/CDO
NAGAR JALFAI REGULATOR
KHURDIRAMPUR WEIR/CDO
MUCHIBARI REGULATOR
BARATIA REGULATOR
KUMULLI REGULATOR
KARATIA WEIR/CDO
PASCHIM PARA REGULATOR
BARA BELTA REGULATOR
PATURAIL REGULATOR
DEOJAN REGULATOR
BIRKUSHIA REGULATOR
BARUHA REGULATOR
CHALATIA REGULATOR
SC 1
SC 2
SC 3
SC 4
SC 5
SC 6
SC 7
SC 8
SC 9
SC 10
SC 11
SC 12
SC 13
SC 14
SC 15
LFP
89° 32'
89° 34'
89° 56'
89° 52'
89° 54'
24° 19'
24° 17'
24° 15'
24° 13'
24° 11'
24° 9'
N
0 1 2 3 Km
SCALE
COMPARTMENTALIZATION PILOT PROJECT (FAP - 20)
TANBAIL TOWN INTEGRATED WATER MANAGEMENT ANB DEVELOPMENT STUBY
BASE MAP OF TANGAIL COMPARTMENT
RESOURCE PLANNING & MANAGEMENT CONSULTANTS
IN ASSOCIATION WITH
SHELTECH CONSULTANTS (Pvt) LTD
SURVEYED BY: ZAMAN SURVEYORS & ASSOCIATES LTD
DESIGN
CHECKED
DATE
DRAWN B.M.A.M.
APPROVED

MAP—2


DISTRICT SADAR
WARD NO-3
DIGULIA
WARD NO-4
BETKA
WARD NO-2
CENTRAL
WARD NO-1
SANTOSH
WARD NO-5
KAZIPUR
WARD NO-6
SCALE - 1:17800
LEGEND
STUDY BOUNDARY
WARD BOUNDARY
MOUZA BOUNDARY
RIVER / KHAL
ROAD
BUS STAND
MARKET
BRIDGE
O.H.W. TANK
SLUM
COMPARTMENTALIZATION PILOT PROJECT (FAP-20)
TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY
MAP OF TANGAIL POURASHAVA
RESOURCE PLANNING & MANAGEMENT CONSULTANTS IN ASSOCIATION WITH SHELTECH CONSULTANTS (PVT) LTD.
DESIGN
CHECKED
DATE
DRAWN B.M.A.M.
APPROVED
DRG. NO

Due to improved situation in flood control and irrigation in the compartments and increase in economic activities, presence of non-agricultural activities are likely to increase in the already strained urban infrastructure facilities of Tangail town.

Tangail, a sub-divisional headquarters, was raised to a district headquarters in 1969. But the town continued to grow up in an unplanned manner. The area covering the town is lowlying and subject to frequent flooding and drainage congestion. The existing infrastructures require immediate improvement to accommodate the present as well as future needs of the town. The project package under consideration is expected to comprise, inter alia, a comprehensive integrated water management and development plan complementary to the ongoing BWDB and CPP programmes in order to improve the flooding and drainage situation of Tangail town.

2.4 Topographic Survey

All topographic data of CPP Tangail area are based on 8 inches to a mile map prepared in 1964 complemented by 1:50000 spot maps and 1:20,000 aerial photographs prepared of FINMAP recently. All these maps, however, do not cover the urban area. As such topographic survey with 0.25 m contour has been carried out in 1:2000 scale for the urban area. The maps are in 12 sheets and shows the roads, buildings, drains, ponds and relevant other information (presented in a separate folder).

Long and cross section of the main drainage channel from Lohajang river to Darun Beel through the town and then onward to Nagar Jalfai has been surveyed in a scale of 1:500 h and 1:100 v (presented in a separated folder).

Similarly long and cross sections of the proposed flood wall have been surveyed around the periphery of the urban area in a scale 1:2000 h and 1:100 v. In addition, proposed site for flushing regulator of the end of Eidgah Road has been surveyed in a scale of 1:1000.

2.5 Hydrological Study

Data available with CPP Tangail have been used for planning the drainage network and flood wall.

2.6 Proposed Drainage System

The CPP Tangail includes areas of Tangail Pourashava. The core area of the Pourashava is located in sub-compartment-16. The non-urban area included in the Pourashava pertains to a part of sub-compartments 3 to 8, 11, 12, 14 and Lohajang Flood Plan. The urban area suffers from water congestion both from rain and river water. The overall drainage is away from Dhaleswari and Pungli rivers towards lowlaying land in the south-east. Overall land elevation is flat with contours varying between + 12.5 m and + 7.5 m PWD. However, in detail, the relief comprises a complex network of ridges, depressions and channels. Flooding of depression normally begins with the onset of the pre-monsoon rainfall due to lack of proper drains. With the rise of river water during flood season surface flood water enters the area through open channels and in high flood through overland flow.

The major problem of the town residents is the lack of proper drainage facilities, which affects most houses and roads through inundation during early flood and monsoon season.

It is observed that 92% of the population do not have any access to drainage facilities, with about 6.6% having access to kutcha drains and only 1.8% to pucca drains. About 80% of the households are affected by heavy flood/rainfall and 45% of them experience waterlogging. Most of the residents expressed dissatisfaction with the present drainage system during the Sub-consultants socio-economic study.

For easy and smooth drainage facilities, the urban area may be divided into few zones as given below and arrange the drainage channel in such a way that the rain/storm and waste water run easily upto its outlet points (map-3).

2.6.1 Zone A

Zone A is the district headquarters area. All the rain and waste water may be accumulated by a link open drain and disposed in the river Lohajang near Housing Estate through a gated pipe regulator. Rain water of the area around the District Lake may be allowed to run into the lake and excess water during rainy season may be taken out through the same disposal point upto a certain height. The pipe/box regulator controlled by gate will resist the entry of river water. It is proposed to construct 5.25 km of roadside pucca drains in this zone.

2.6.2 Zone B

Zone B consists of Sabalia and Kodalia areas which are thinly populated. All the rain and waste water in this zone may be drained through the existing canal located at the eastside of hospital area which runs into the lowlying area of the zone. The outlet of the drain on Mymensingh Road in this area is located near the bridge of Mymensingh Road and water deposits in a big ditch adjacent to road. Arrangement will have to be made to discharge this water during heavy rainfall by excavating small canal along Sabalia road (near southern boundary of the hospital) upto the canal located at the south-east side of the hospital. It is proposed to construct 3.1 km of roadside pucca drains in this zone.

2.6.3 Zone C

Zone C covers the total area of Akur Takur Mouza. This is a perennial drainage congested area where waterlogging occurs even during normal rain. During heavy rainfall some portion of this area is inundated by about 30 to 60 cm in depth. Roads are always submerged during rainfall in this lowlying zone. All rain water may be drained by constructing proper drainage channels and two outlets for this area. Present drains in this area are inadequate as these are not properly constructed and are small in size to drain the area. The slopes are improper and flow is blocked. Proposed outlet points will be provided with flap gates so that river flood water from outside cannot enter into the drain. It is proposed to construct 3.53 km of pucca drains in this zone.

2.6.4 Zone D

This zone includes the Housing Estate and few portions of Kagmari village. Rain/storm water and waste water may easily be disposed of into the river. At present there is no problem from the rain and waste water in the area. During flood, the area gets submerged. Housing Estate is presently vacant and the adjoining village area is free from waterlogging, and the zone needs no immediate improvement.

2.6.5 Zone E

This is the core area of Tangail town. The main canal, passing through this area since long, used to be the main drainage channel of the town even five years back. Now this canal is not functioning as the canal mouth has been blocked by embankment and used for fish cultivation. This canal should be re-excavated. The outlet points of all the roadside drains falling into this canal are closed or blocked by solid waste in its mouth or the existing drains have collapsed or the slope of drain is not maintained well. Embankment across the canal at the beginning should be removed to open for normal discharge during dry season and a flushing regulator should be constructed for regulating the flow during monsoon i.e. flood. It is proposed to construct 4.66 km of pucca drains in this zone.

2a

2.6.6 **Zone F**

This area is actually lowlying and at present there is no drain to serve the area. A canal near the boundary of Kumudini College has been closed by the road- side residents. A small length of 200 m canal should be re-excavated for discharging the storm water accumulated from the Tangail-Mymensingh roadside drain. If this canal is re-excavated, large volume of water will be discharged into Darun Beel which ultimately drains into Lohajang river through Jalfai Khal. About 1.68 km of pucca drains are proposed in this zone.

2.6.7 **Zone G**

The area is situated in between Dighulia and Kagmari Road. The Lohajang river is in the westside. All the rain and waste water may be collected in one point by link drain and disposed of into the river through a regulator. Flap valve should be provided in its outlet so that the river water cannot enter the area. About 2.76 km of pucca drains are proposed in this zone. ?

2.6.8 **Zone H**

This is the south-west part of the Tangail town. At present there is no problem from rain and waste water. Few drains should be provided along the roadside and outlet points be connected to the lowlying area. All the accumulated water in the lowlying area may discharge naturally into the Bera Bochna Khal and this Khal should be cleared from the illegal occupants so that the water may run easily upto the Kazipur Beel. About 0.48 km of pucca drain is proposed for the zone.

2.6.9 **Zone I**

This area is situated at the south-east corner of Tangail town. About 1.71 km of pucca drain may be built at present. Few drains may be constructed inside the 'hat' (rural market) area for easy running of rain and storm water, and all accumulated water may be discharged into lowlying areas surrounding the 'hat'.

2.7 **Future Flood Protection**

The Brahmaputra Left Embankment (BLE) is expected to give full flood protection to the Tangail area. But its implementation is yet to be finalized and for the present it is considered uncertain. The construction of Brahmaputra Right Embankment (BRE) has given mixed benefit. BRE has given protection from flood but has considerably deteriorated the soil condition. Growth of pests, especially termites, has increased and entry of fish fry to the large protected area has stopped resulting in a serious environmental problem. The embankment is also not free from river erosion and breaches due to rat-holes causing major disaster in some years. Keeping these in view, the Compartmentalization Pilot Project has proposed that normal controlled flooding will continue through peripheral embankment and structures there, which will regulate flow and will be fish-friendly as well as navigable.

Tangail Comparmentalization Pilot Project (Tangail CPP) aims at normal controlled flooding. This will be achieved by peripheral flood control embankment and gated as well as ungated inlets/regulators.

The existing regulators are at (1) Binnafair, (2) Fatehpur, (3) Indra Belta and (4) Belta Sarai/Bara Belta. It is proposed to construct the main inlet structure at Jugini and several medium regulators at Khorda Jugini, Sadullapur, Rasulpur, Baruria, Suruj, Enayetpur, Dhitpur, Tangail (district HQ), Kagmari, Baratia, Nagar Jalfai, Bhatkura, Kumulli, Munshibari, Paschim Pauli, Deojan, Pathrail, Birpushia, Baruha and Chalatia. About 46 controlled drainage outlets are also being built. It is planned to maintain a level of water of +11m PWD within the compartment.

The interim report proposes prevention of flooding in Tangail town with a frequency upto 1:20 years by operating the main inlet at Jugini (12.15 m). The top level of the main regulator is 13.47 m which corresponds to flood frequency of 1:50 years. The 1988 record flood was, however, 13.43 m at Jugini.

The peripheral embankment about 46 km in length is in fact a combination of several embankments/roads built under local initiative under the Food-for-Works Programme. Very often it followed existing village paths with sharp turns and do not have regular geometric shape. In some areas it passes through village dwellings. The designed top level of embankment is +13.73 PWD at Ramdevpur and +12.90 PWD at Silimpur at the south-west corner and +12.83 PWD at Nathkhola at the south-east corner of the CPP area. This will take care of any severe flood similar to that experienced in 1988. This corresponds to 1:7 years return period with 0.90 m free board and 1:100 year return period without free board. The 1:100 years flood level at Jugini is +13.70 m PWD and 1:50 years flood level is +13.47 m PWD.

The regulators are proposed to be kept open upto mid-July. Thereafter when river level rises the gates will be operated to allow flood water to enter the compartment upto +11 m PWD. Flooding of Tangail town will not occur with a water level in Lohajang river below +11.75 m PWD. If it exceeds, the town will be flooded as it happened in 1991 when river level rose to +12.07 m PWD and the central part of the town was flooded to a depth of about 0.7 m.

When flood level exceeds 1:50 years flood, the main inlet regulator at Jugini will not be able to keep flood water away from the compartment and as a result Tangail town will be flooded unless some extra flood protection works are carried out for Tangail town.

Tangail Municipality is considering a plan to construct a road along the bank of Lohajang river. If this road is built as a flood embankment with a top level of +13.5 PWD it may give protection to the town above recorded flood observed in 1988. In case Municipality's plan does not materialise, a concrete flood wall may be considered as an alternative measure. This will, however, cut off link between the strip of land left on the riverside from the rest of the town. This may not be liked by the people and would perhaps require consultations with them.

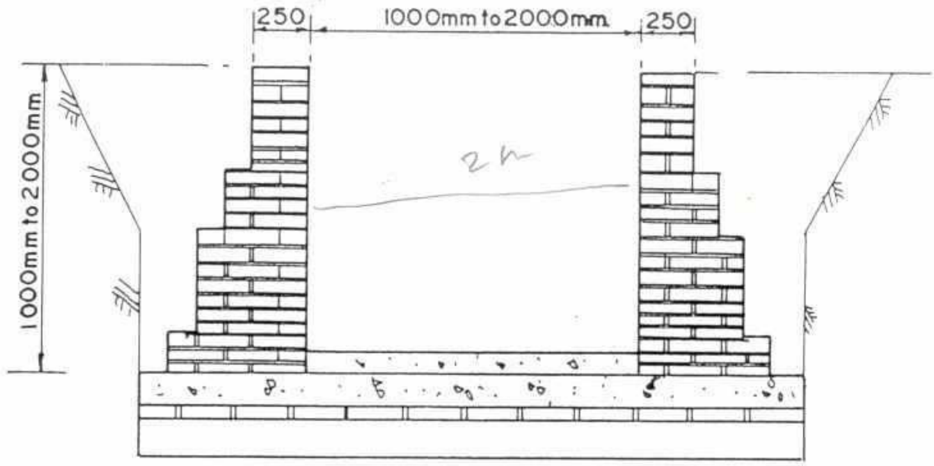
2.8 Recommendations

Tangail town suffers from water congestion both from rain and river water. Flooding of depression normally begins with the onset of premonsoon rainfall due to lack of proper drains. The existing drains are mostly closed or blocked by solid wastes. In places drains have collapsed and the slope is not properly maintained up to the outfall.

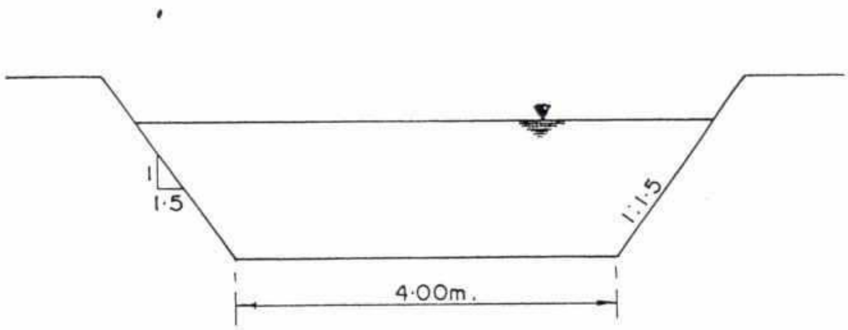
It is recommended to re-excavate the main drain and construct a masonry drain 2m wide from food godown near Eidgah to food godown at Biswas Betka about 1.7 km in length and then 1.3 km long open channel northward from this point to Darun Beel. This drain will be able to carry 5 cumecs of flow (Figure 2.1).

For easy and smooth drainage facility the urban area has been divided in nine zones and 23.17 km long internal drainage system has been planned connecting the main drain or river or low areas outside the urban area (Figure 2.2). Five outlet structures (Figure 2.3) are proposed to drain the water to Lohajang river which will prevent flood water from entering the town. An inlet structure (Figure 2.4) is recommended at the Eidgah end of the main drain to flush the channel during flood season.

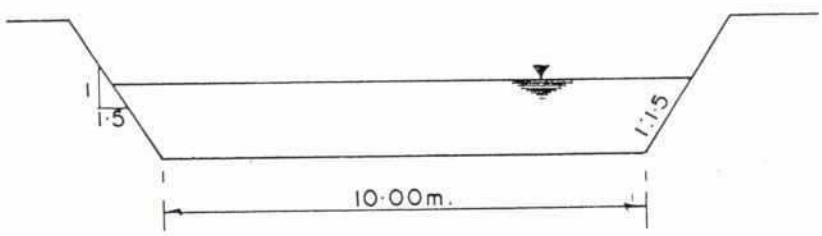
With the improvement of drainage facilities it is expected that many of the problems faced in developing the town will be removed. General sanitation will improve, risk of contaminating surface water sources will be lessened, houses will have longer life span, maintenance cost of houses will reduce and the floors of the houses will be considerably free from dampness, maintenance of roads will be less expensive. In general the health condition will improve, and there will be lesser incidence of water-borne diseases.



CH 0·00km to CH 1·70km

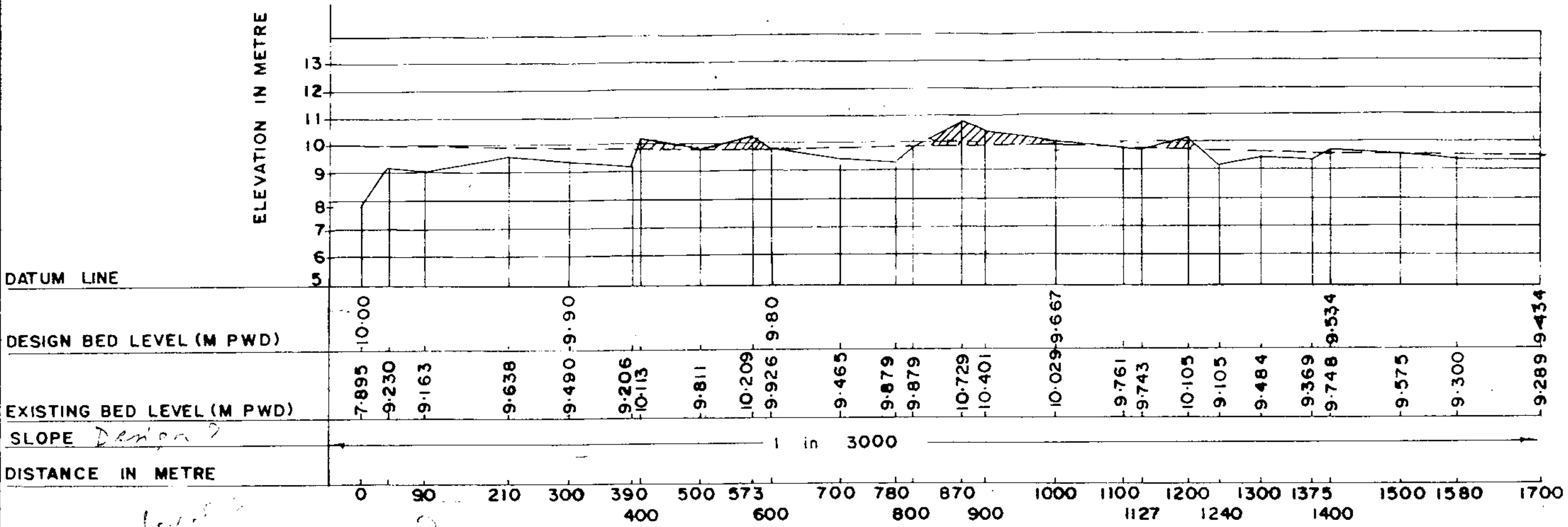


CH 1·70km to CH 3·00km



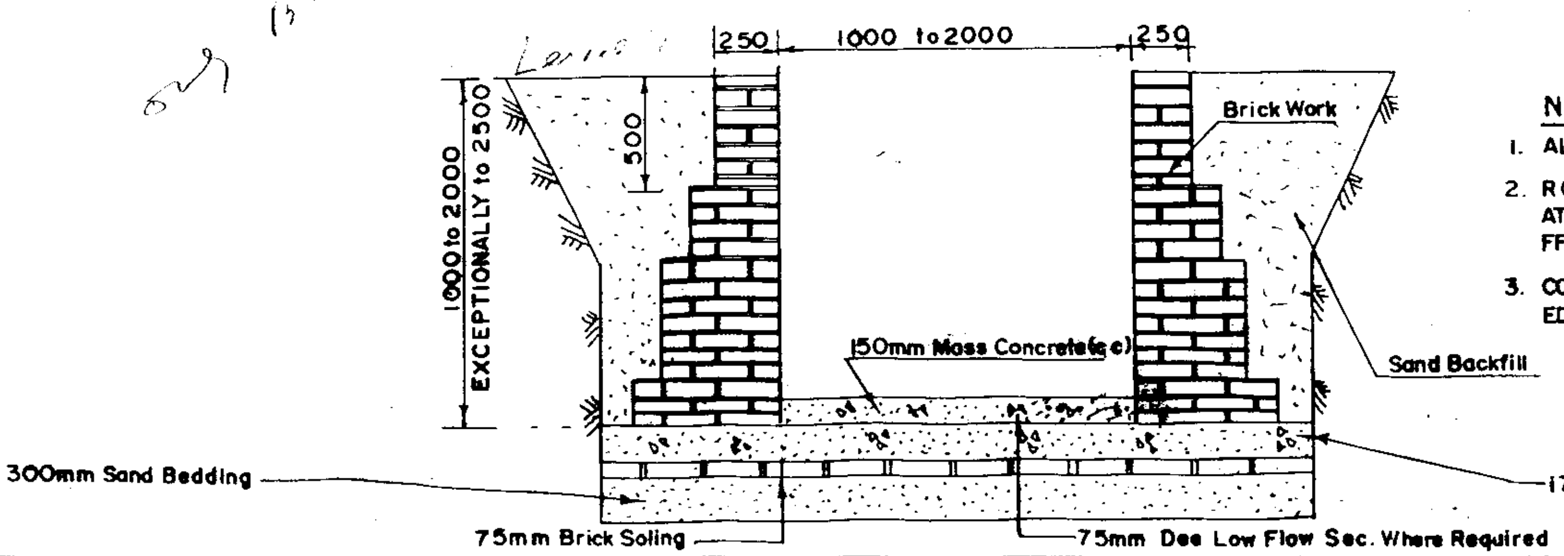
CH 3·00km to CH 6·78km

COMPARTMENTALIZATION PILOT PROJECT (FAP-20)		
TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY		
CROSS SECTION OF DRAINAGE CHANNEL		
RESOURCE PLANNING & MANAGEMENT CONSULTANTS IN ASSOCIATION WITH SHELTECH CONSULTANTS (Pvt) LTD.		
SURVEYED BY: ZAMAN SURVEYORS & ASSOCIATES LTD		
DESIGN	CHECKED	DATE
DRAWN B.M.A.M.	APPROVED	FIGURE-2.1



CH0·00km TO CH 1·70km

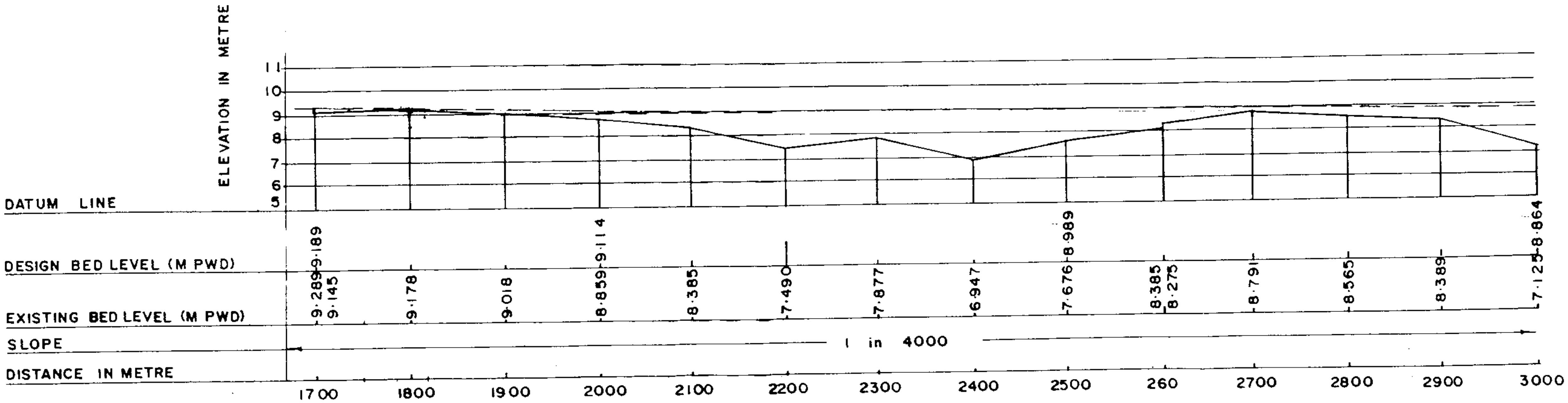
Scale
HOR. 1:150
VER. 1:200



Note

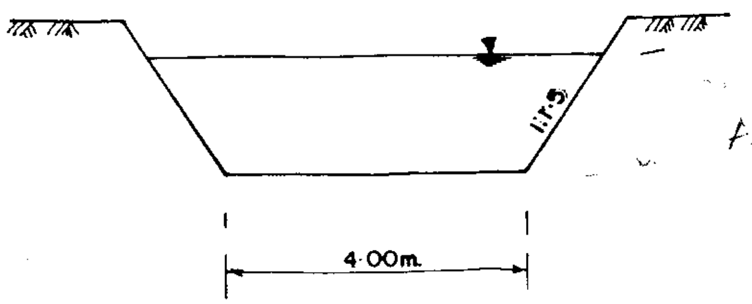
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. RC. STRUTS (150x150mm) TO BE PROVIDED AT THE TOP OF THE DRAIN ON HIGH TRAFFIC ROUTES.
3. COVER SLAB PROVIDED WHERE REQUIRED (75mm THICK ON DRAINS).

COMPARTMENTALIZATION PILOT PROJECT (FAP — 20)		
TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY		
LONGITUDINAL SECTION OF DRAINAGE CHANNEL (00·00km. to 1·70km)		
RESOURCE PLANNING & MANAGEMENT CONSULTANTS In association with SHELTECH CONSULTANTS(Pvt)LIMITED		
Surveyed by ZAMAN SURVEYORS AND ASSOCIATES LIMITED		
DESIGN	CHECKED	DATE
DRAWN	APPROVED	FIGURE - 2·1 - A



CH 1·70km TO CH 3·00km.

SCALE
HOR. 1: 50
VER. 1: 200



CROSS SECTION

COMPARTMENTALIZATION PILOT PROJECT (FAP – 20)

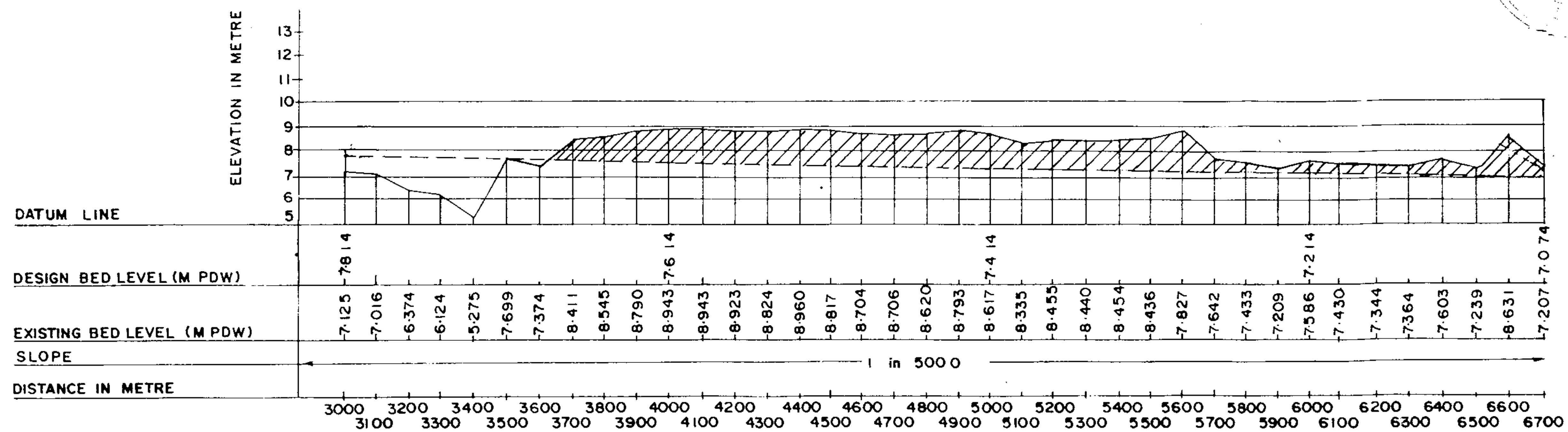
TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY

LONGITUDINAL SECTION OF DRAINAGE CHANNEL (1·7km. to 3·00km)

RESOURCE PLANNING & MANAGEMENT CONSULTANTS
in association with
SHELTECH CONSULTANTS(Pvt) LIMITED

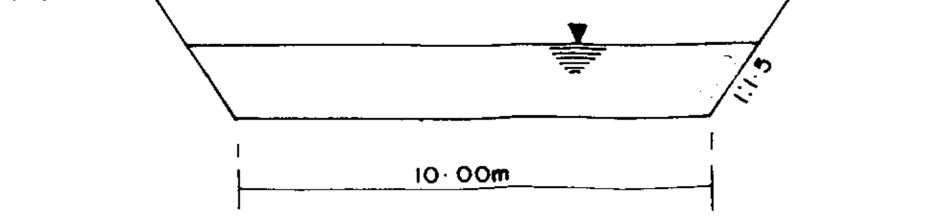
Surveyed by ZAMAN SURVEYORS AND ASSOCIATES LIMITED

DESIGN	CHECKED	DATE
DRAWN	APPROVED	FIGURE - 2·1 - B



CH 3·00km TO CH 6·70km

SCALE
HOR. 1:150
VER. 1:200

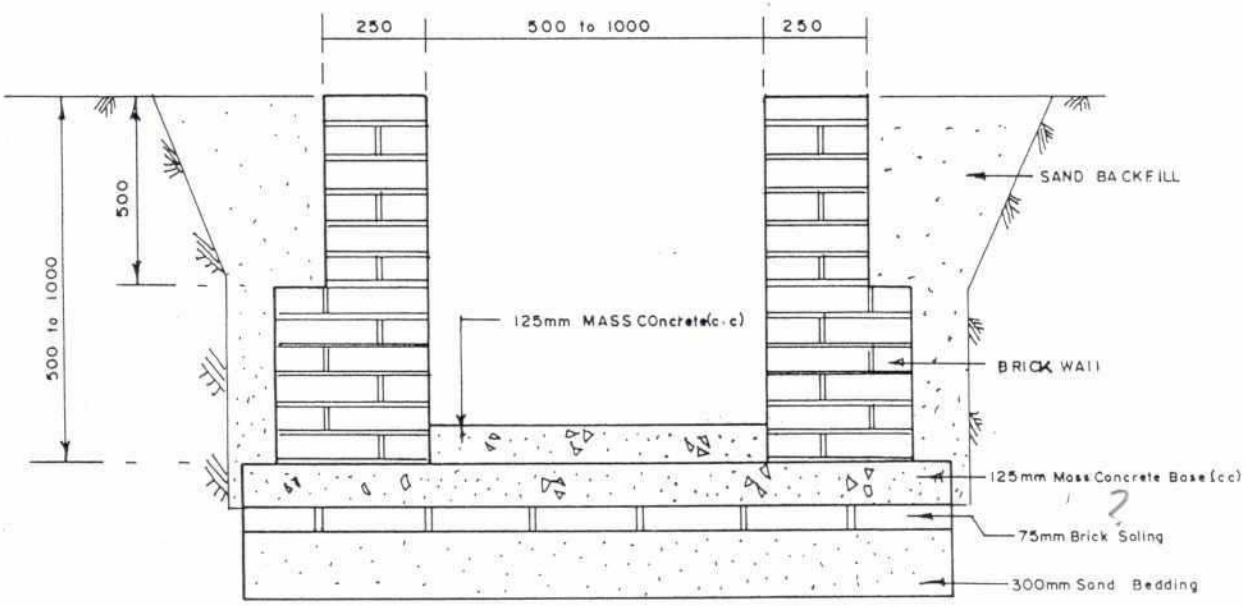


CROSS SECTION

COMPARTMENTALIZATION PILOT PROJECT (FAP—20)
TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY
LONGITUDINAL SECTION OF DRAINAGE CHANNEL (3·00km to 6·70km)
RESOURCE PLANNING & MANAGEMENT CONSULTANTS in association with SHELTECH CONSULTANTS(Pvt)LIMITED
Surveyed by ZAMAN SURVEYORS AND ASSOCIATES LIMITED

DESIGN	CHECKED	DATE
DRAWN	APPROVED	FIGURE - 2·1-C

INTERNAL PUCCA DRAIN

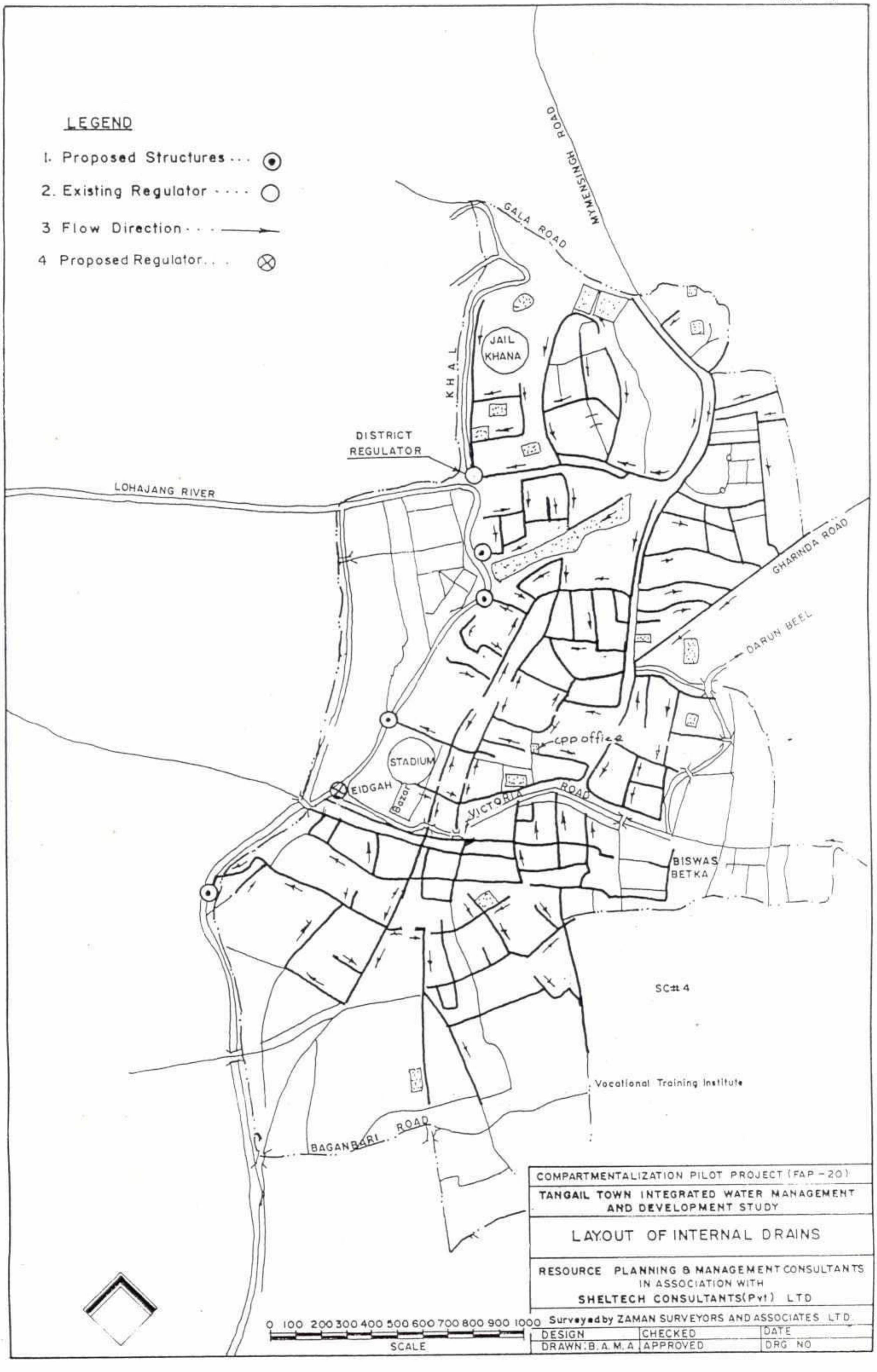


Note

ALL DIMENSIONS ARE IN MILLIMETERS.

COMPARTMENTALIZATION PILOT PROJECT (FAP-20)		
TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY		
CROSS SECTION OF INTERNAL DRAIN		
RESOURCE PLANNING & MANAGEMENT CONSULTANTS IN ASSOCIATION WITH SHELTECH CONSULTANTS (Pvt) LTD.		
Surveyed by ZAMAN SURVEYORS AND ASSOCIATES LTD		
DESIGN	CHECKED	DATE
DRAWN	APPROVED	FIGURE- 2.2

MAP - 4



COMPARTMENTALIZATION PILOT PROJECT (FAP - 20)

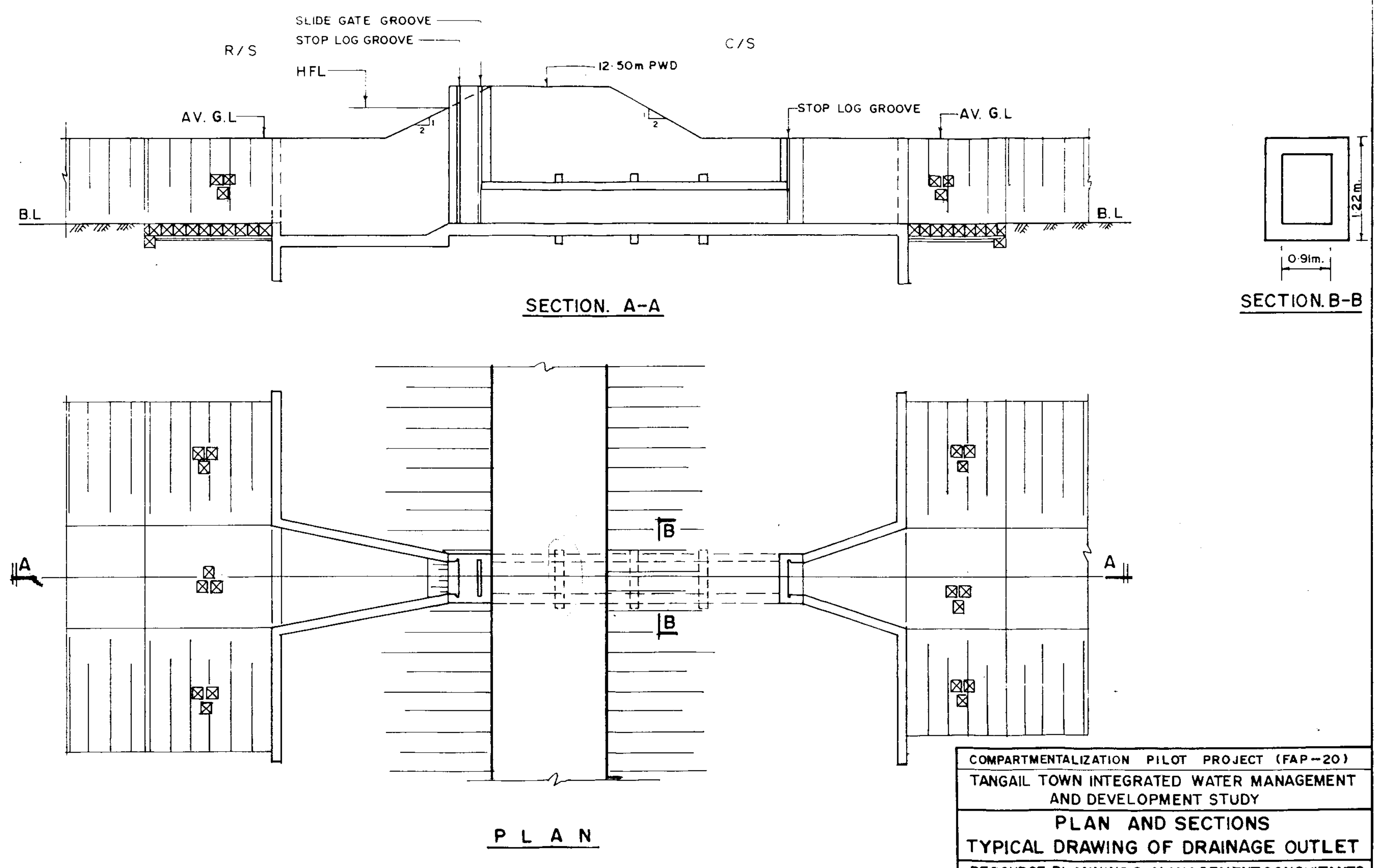
TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY

LAYOUT OF INTERNAL DRAINS

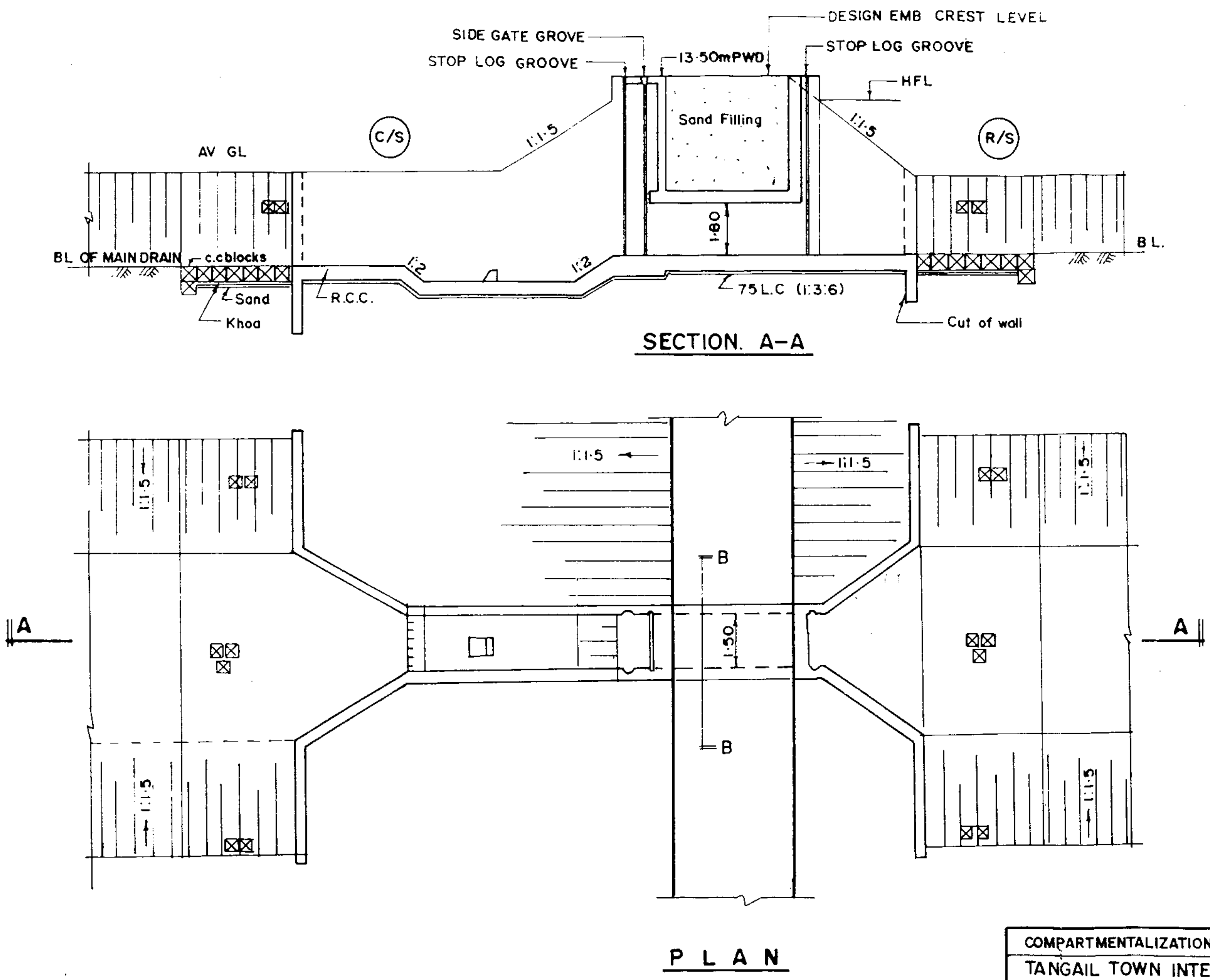
RESOURCE PLANNING & MANAGEMENT CONSULTANTS IN ASSOCIATION WITH SHELTECH CONSULTANTS (Pvt) LTD

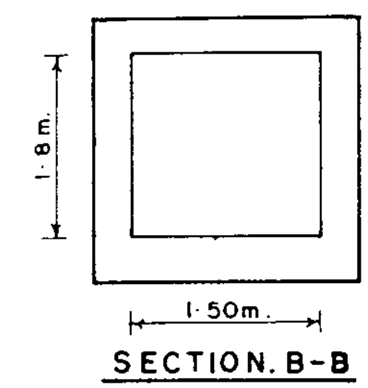
Surveyed by ZAMAN SURVEYORS AND ASSOCIATES LTD.

DESIGN	CHECKED	DATE
DRAWN: B. A. M. A	APPROVED	DRG NO



COMPARTMENTALIZATION PILOT PROJECT (FAP-20)		
TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY		
PLAN AND SECTIONS TYPICAL DRAWING OF DRAINAGE OUTLET		
RESOURCE PLANNING & MANAGEMENT CONSULTANTS In association with SHELTECH CONSULTANTS (Pvt) LTD.		
Surveyed by ZAMAN SURVEYORS AND ASSOCIATES LTD.		
DESIGN	CHECKED	DATE
DRAWN	APPROVED	FIGURE - 2·3





COMPARTMENTALIZATION PILOT PROJECT (FAP – 20)		
TANGAIL TOWN INTEGRATED WATER MANAGEMENT AND DEVELOPMENT STUDY		
TYPICAL DRAWING OF FLUSHING REGULATOR		
RESOURCE PLANNING & MANAGEMENT CONSULTANTS in association with SHELTECH CONSULTANTS (Pvt) LTD.		
Surveyed by ZAMAN SURVEYORS AND ASSOCIATES LTD.		
DESIGN	CHECKED	DATE
DRAWN: B.M.A.M.	APPROVED	FIGURE - 2·4

The CPP Tangail envisages a peripherial embankment to protect the area from flooding. The design top level of the embankment is +13.73 PWD at Ramdevpur/Jugini. This will take care of the recorded highest flood of +13.43 observed in 1988.

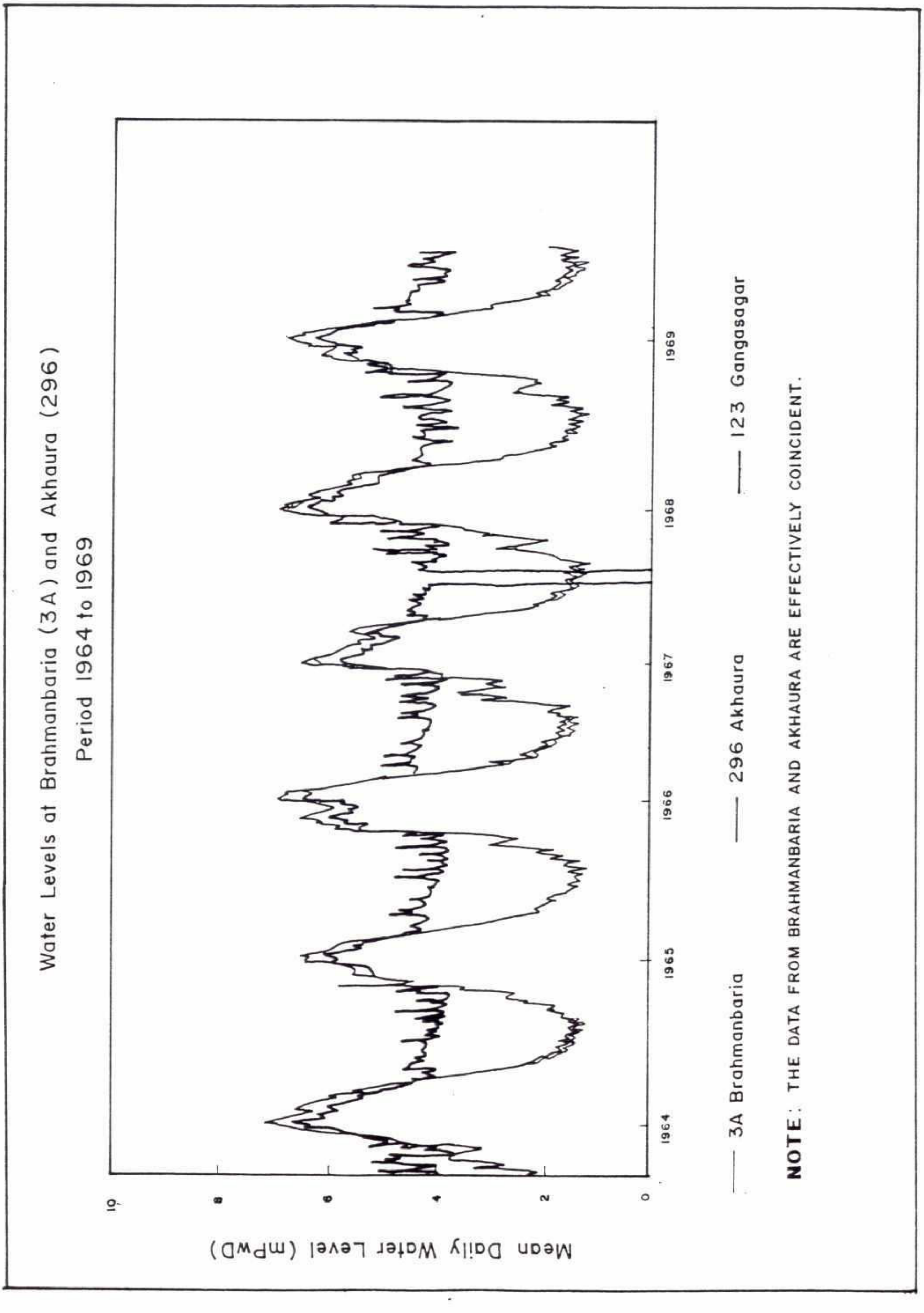
The urban area is not likely to be flooded before river water level rises above +11.75 PWD which corresponds to +12.15 PWD at Jugini. In 1991 when water level rose to +12.07 PWD the central part of the town was flooded to a depth of 0.7 m.

Flooding of Tangail town can be prevented by operating the main inlet at Jugini for all flood events with frequency of 1:20 years. Protection above that level can be provided by constructing an embankment or a flood wall along Lohajang river with a top level of +13.5 PWD which is about 2 m above average bank level. This will cut off link between the strip of land left on the river-side from the rest of the town which is disliked by the people. As such it is not recommended.

The estimated cost of various interventions are Tk. 81.94 million/86.70 million. O&M cost will be approximately 3% of the capital cost i.e. Tk. 2.5 - 2.6 million per annum.

Figure B.3.4

Water Levels between 1964 and 1968



09

CHAPTER 3

GEOHYDROLOGY OF THE TOWN AND SURROUNDINGS

3.1 General

This component of the project is concerned with study of the groundwater resource leading to an assessment of the available potentiality due to the partial control of flood water by implementation of CPP under FAP - 20.

There has been several previous studies and reports on groundwater resources of the Tangail region by a number of executing agencies and consultants, for specific purposes. More recent and particularly relevant studies on groundwater has been conducted by MPO (presently WARPO) in 1986-1991. No specific study showed the relationship between groundwater and flood control. Increases in flood control protection are expected to reduce recharge and without extensive sight-specific investigations and analyses the relationship can only be defined indicatively.

3.2 Topography and Physiography

The Tangail town with an area of 32.26 sq. km. is bounded to the north-east by Madhupur Tract and by the river systems of Jamuna and Dhaleswari in the south-west. The town is elongated north-south with tapering towards north and with its base in the south. The Tangail town is located in Sub-compartment 16 situated at the centre of the compartment on the eastern bank of the Lohajang river. Though the area forms an extensive flood plain between the Jamuna river and the slightly elevated terraces of Madhupur tract, but the topography is not very much pronounced as monotonous alluvial plain rather it is set up in diversified undulating tracts of wavy pattern. The general relief of the area is in between 9 to 10 m above mean sea level.

The physiographic configuration is transition between the Madhupur and Jamuna floodplains and extensively the area occupies the Jamuna floodplan physiographic unit (FAO report). This unit is characterized by ridges and basins with silts on the ridges and clays in the basins. The surface is broken by small cutoff and meanders of subsidiary streams and distributaries of the Jamuna. Now they rarely receive alluvium from major rivers unless immediately adjacent to it, due to the degree of stream incision. Within the irregular flat topography however there is significant land diversity. The concept of a 'homestead level' exists which is locally the highest land and therefore least vulnerable to flooding. The homestead level may be several metres higher than the surrounding agricultural land.

This local variation is important hydrogeologically because it is related to the depth and duration of flooding during the wet season, and hence has a bearing on recharge. MPO (1987) produced a land classification for the whole of Bangladesh based on depth of flooding, which relates to recharge concept. The classification system is shown in Table 3.1.

Table 3.1: **Land Classification of Bangladesh Based on Flood Depth**

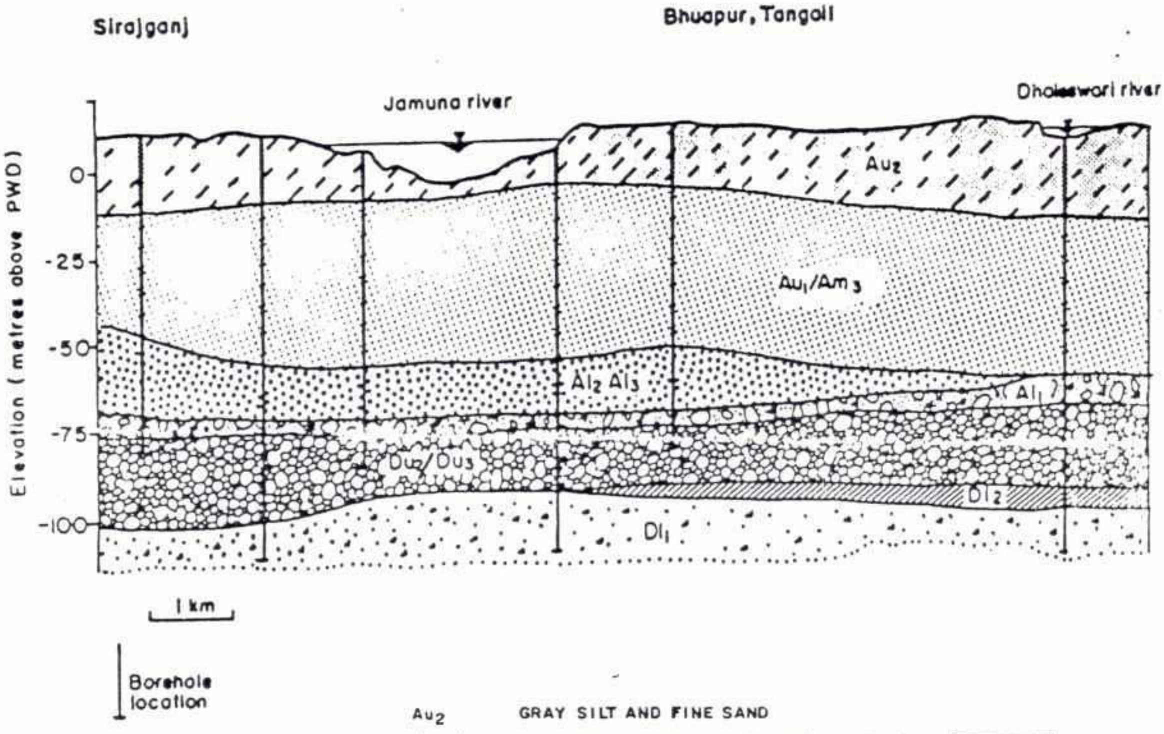
Land Type	Description	Flood Depth (cm)	Nature of Flooding
FO	Highland	0 - 30	Intermittent
F1	Medium - High	30 - 90	Seasonal
F2	Medium - Low	90 - 180	Seasonal
F3	Lowland	Over 180	Seasonal
F4	Low - Very Low	Over 180	Seasonal/ Perennial

Source: MPO 1987

FIGURE - 3·1

A Schematic Hydrogeological Sections Through Rivers

Jamuna and Dhaleswari Rivers



Au_2	GRAY SILT AND FINE SAND	
Au_1/Am_3	GRAY MICACOOUS FINE TO MEDIUM SAND	SCREENABLE UNIT
Al_2/Al_3	GRAY MICACOOUS NED TO COARSE SAND AND GRAVEL	
Al_1	GRAY SAND AND GRAVEL WITH BOULDERS	
Du_2/Du_3	BROWN COARSE SAND WITH GRAVEL AND SILT	
Dl_2	GREENISH GRAY SILT CLAY	
Dl_1	GRAVELY SAND	

SOURCE: JICA, 1976

3.3 Geology of the Study Area

The geology of the Tangail region has been extensively described in previous studies and reports (Consultants of ADB and MPO Phase 1.) The entire area is covered by weakly consolidated alluvial sediments of the Jamuna and Dhaleswari river systems which are broadly similar in origin and characteristics to surrounding areas. The typical pattern seen in borehole logs, shows progressively coarser sediments with depth and consists of three main lithological divisions:

Top	:	Upper clay and silty clay thickness 0-12 m
Middle	:	Intermediate aquifer fine to medium sands, with thickness of 15-30 m (permeability in range of 20 ± 10 m/day).
Lower	:	Main aquifer with medium to coarse sand and gravel with thickness over 60-50 m (permeability in range of 80 ± 40 m/day).

The upper clay layer in the Tangail region is relatively thin compared with the surrounding areas. Deep tubewells in the region are usually screened in the medium and coarse sands, while hand and shallow tubewells often tap the finer grained intermediate layers. Geological conditions across the region are fairly uniform.

3.4 Aquifer System

Tectonical setting with major geologic activities has defined the development of major drainage system and sedimentation pattern of surface and sub-surface lithology in the study area. The sediments were laid down by the Jamuna-Dhaleswari river system and its distributaries and tributaries like Dhaleswari, Lohajang, Elanjani, Pungli, etc.

The lithological assessment is based on the number of bore logs from the DPHE, private wells and BADC wells which are located in and around the study area. The assessment depicts the analogy to the Jamuna Aquifer unit.

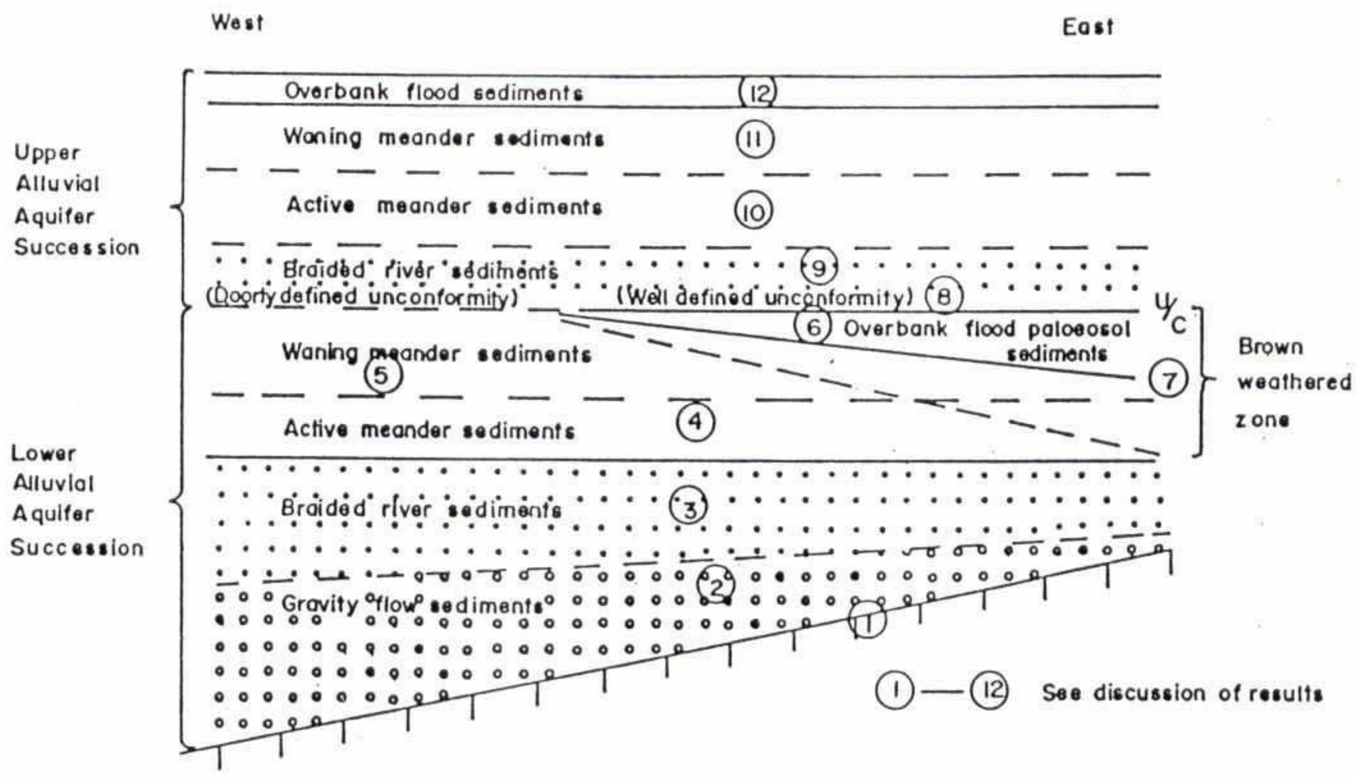
This unit includes the physiographic units of Jamuna floodplain. There are two distinct fining up sequences, separated by middle clays which vary from 3 to 10 m in thickness. The middle clay is missing in places and replaced by fine sands. The lower aquifer is relatively uniform with coarse sands and gravels at the base fining up to the dividing clay. The upper aquifer is less uniform with considerable variation in this grain size. The upper clay can locally be semi-confined in the upper aquifer, but on dewatering it is likely to become unconfined. The upper clay varies in thickness from 3 to 9 m, and is often underlain by silts up to 14 m. This unit is bounded by faults and forms a scour channel of a former course of the river Jamuna. This accounts for the variations in the upper aquifer and gives rise to the distinctive **semi-confined to unconfined aquifer characteristics.**

3.4.1 Hydraulic Properties of Aquifer

The hydraulic properties of the Jamuna Aquifer unit were studied in detail under the BGS Study by Barker et al (1989) by a combination of conventional pumping test analysis, laboratory testing and computer modelling. These are probably the most accurate data available, and agree well with the average permeabilities derived from the commissioning tests of DPHE/BADC wells. The laboratory tests on disturbed, but representative aquifer samples (Davies and Herbert, 1990) are shown in Figure 3.3 and almost perfectly match the grey sand, permeabilities parameters.

FIGURE - 3·2

Schematic Cross Section Through the Jamuna Alluvial Sequences



Source : Davies (1989)

80

Table 3.2: **Permeabilities of the Jamuna Aquifer Unit**

Parameter	Upper Aquifer		Lower Sequence	
m/d	Av.		Av.	
Horizontal Permeability (m/d)	22.1	15.5	66.8	14.9
Vertical Permeability (m/d)	11.7	4.7	37.7	23.6
Anisotropy (k_h/k_v)	1.61		2.54	

Source : Barker et al (1989)

Determination of the vertical permeability of the aquitards is more difficult than the permeability of the aquifers, although it is at least as important since it is one of the primary determinants of potential recharge. In Jamuna aquifer unit the principal aquifer overlying the main aquifer is continuous with the soil zone. This is more explained by properties of aquifer as obtained from BWDB pumping test.

The pumping test result of BWDB on one of the BADC wells near Tangail town area (village Kasba Atia of Kotwali) depicts the hydraulic properties like Transmissivity, Storativity and specific capacity in these aquifers. The transmissivity is 2100 m^2/day, storage is 1 x 10^{-3} while the specific capacity 20.57 l/s/m. (BWDB Paper No. 502). These results suggest that a large amount of groundwater could be withdrawn by using different pumping technologies in the Tangail town.

The present volume of groundwater abstraction by DPHE production wells and hand tubewells is approximately about 12,000 m^3/day.

The present requirement based on the existing population of 152,000 is about 21,280m^3 per day (0.14m^3/person/day). The excess volume of water about 10,000m^3/day is probably met from other sources like private hand tubewells, shallow tubewells, ring well etc. By the year 2000 the population of the urban area will be about 200,000 and about 20,089 m^3/day water will be required. So, exploitation of these aquifers could be safely done as indicated by ADB report that if an additional volume of 12,320m^3 water is withdrawn the decline in groundwater level will be negligible.

Though the aquifer is sustainable to the large withdrawal of groundwater but Tangail town is surrounded by groundwater-irrigated agriculture land. Hence there is always a risk of groundwater mining and HTW are susceptible to it.

3.4.2 Rivers and Groundwater

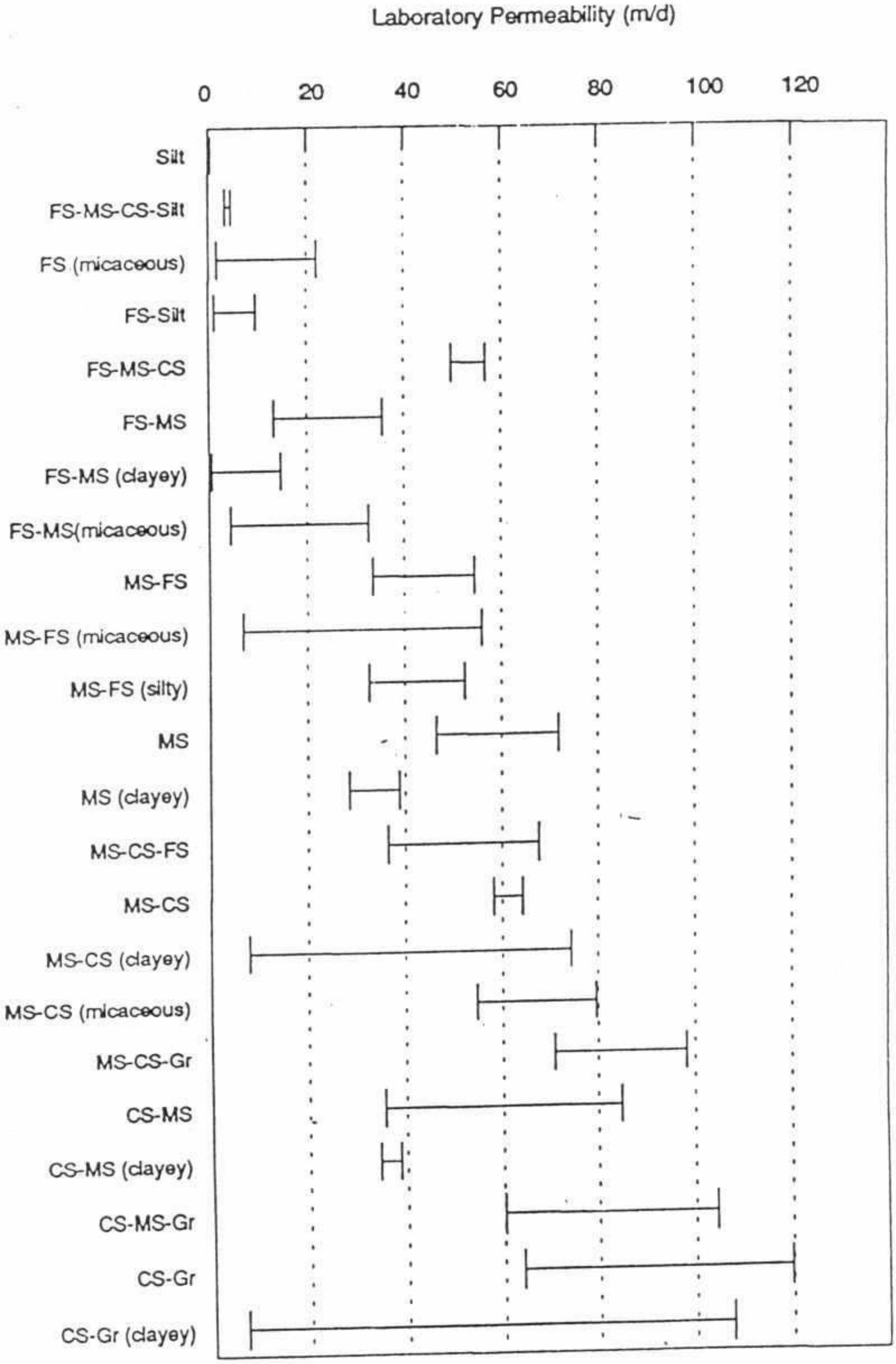
a) Flooding

Flooding is a natural recurring phenomenon in Bangladesh. The main causes of flooding are overbank spill on rivers and accumulation of rainwater in the areas of low land. Flooding in the lowlying areas is caused by the land to drain due to high levels in the natural drainage channels.

There is an extensive network of river meander throughout the whole of the project area. Their interrelationship with the aquifer system has, however, never been well defined in quantitative terms. Various studies have all concluded that some degree of hydraulic continuity exists. Their conclusions were mainly based on analysis of river stage and groundwater level fluctuations.

FIGURE - 3.3

Permeabilities of the Jamuna Aquifer Unit



Source : Davies and Herbert (1990)

Data from the major rivers on river stage fluctuation (Table 3.3) and their cross-sections (Figure 3.4) show the interactions between the river and the aquifer. There is also a probability of interaction of smaller rivers and drainage channel with aquifer system but this can be defined as drainage function within the system. Rivers that coincide with boundaries of the study area are the Jamuna and Dhaleswari river systems with their numbers of distributaries, tributaries and off-shoots. The following two parameters have significant importance to the groundwater study:

- the inter and intra annual variation in river levels; and
- the hydraulic connection of the river with the aquifer system.

Table 3.3: **River Stage-Annual Fluctuation**

River	Stage	
	Min.	Max.
Jamuna	1.8	7.5
Dhaleswari	3.5	8.3
Bangshi	1.6	5.8

It has been revealed from previous studies that there in an influence on river levels with groundwater levels and which is noticeable upto a distance of about 3 to 5 km from rivers (MMP 1982 North-west Region Groundwater Study).

The significance of the connection between rivers and aquifers generally become apparent only when large-scale groundwater abstraction near a river takes place. To analyse the degree of connection it is essential that piezometric levels in the aquifer are observed at both sides of the river. The hydraulic connection of the Dhaleswari and Lohajang with the aquifers underlying Tangail town cannot be adequately assessed without knowledge of piezometric conditions on the side of the river opposite the main abstraction area.

The degree of hydraulic continuity depends on the degree of penetration of the river into the aquifer. Comparing river base levels with the base of the upper aquitard is shown in Table 3.4 Typical cross-sections are shown in Figure 3.4. A flow mechanism can be established between the river and the aquifer by simulation of these data.

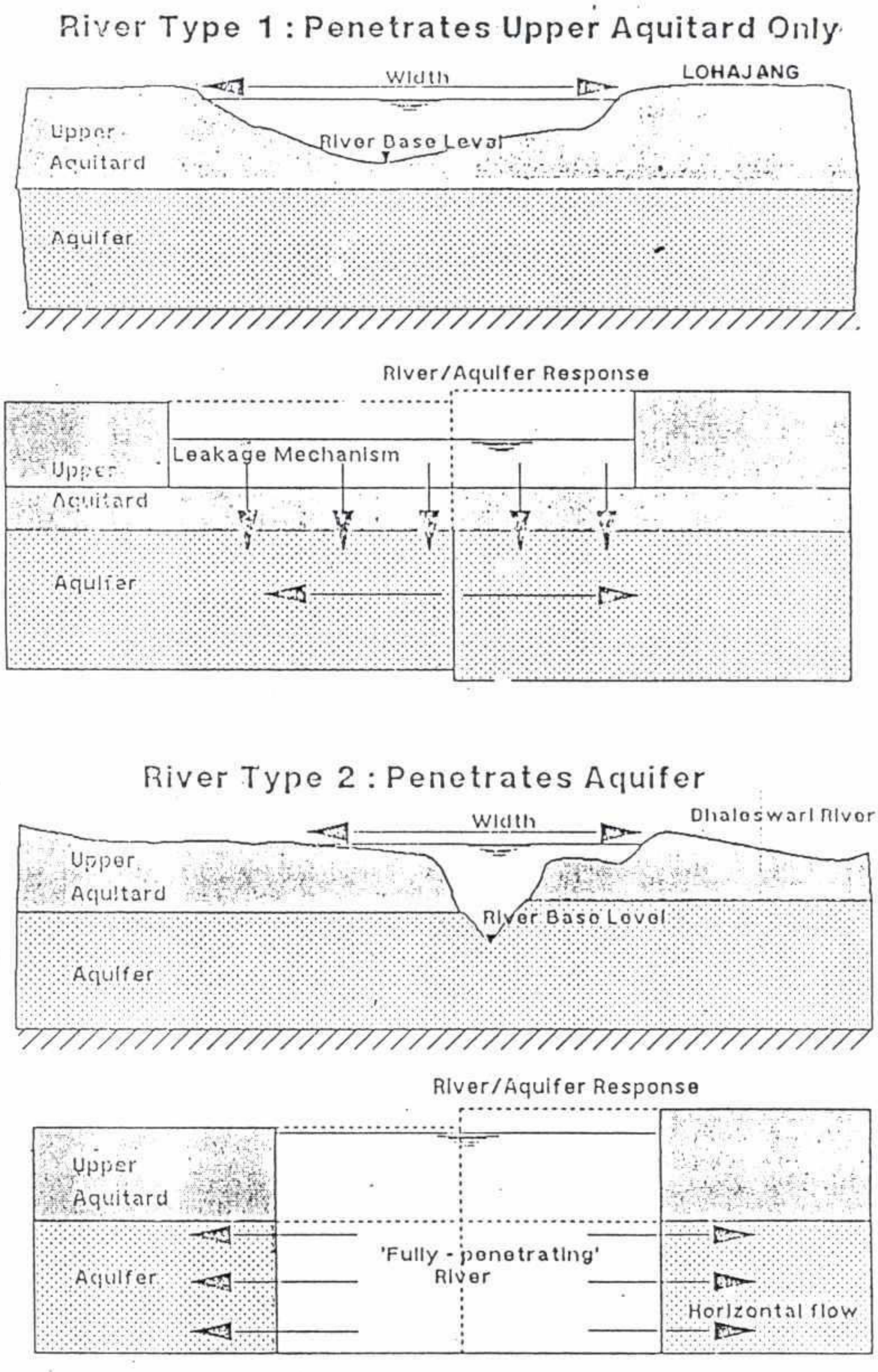
Table 3.4: **Average River Cross Section Details**

River	Base level (PWD)	Base of Upper Aquitard (m PWD)	Penetration of Upper Aquifer	Wet Season Width (m)	Dry Season Width (m)
Jamuna	10.5 to 20.5	-4.0 to -30.0	Yes	7000	5000
Dhaleswari	2.5 to -10.5	0.0 to -2.5	Yes	600	400
Bangshi	2.7 to -7.8	-0.0 to -2.0	Yes	220	150

Source: MMI/EPC (1991)

FIGURE - 3.4

River / Aquifer System



89

b) **Recharge**

Natural recharge to the aquifer system is mainly from two sources, direct infiltration of rainwater, and deep percolation of water accumulated at the land surface. The latter includes water contained within field and flood water (Figure 3.5).

MPO has conducted extensive studies on the assessment of natural recharge to the aquifer system. Potential recharge was defined as the amount of water that may percolate downward past the base of the root zone of crops. This definition implies that the table is at great depth and that the formations underlying the base of the root zone do not constrain the downward percolation. Actual recharge is normally much less than potential recharge because of rejection of water from the aquifer system during the monsoon season. Water tables rise to or near the ground surface and create so called 'aquifer full' conditions. Any rain or flood water that might potentially infiltrate into the system is rejected under such conditions. It becomes obvious that when additional subsurface storage capacity is developed by abstraction of groundwater that more recharge can enter the aquifer system before rejection starts. The potential recharge to the area is about 800 mm, while only 600 mm is the available recharge.

3.5 Groundwater Resources Evaluation

The entire area is underlain by the upper clay silt varying from 0 to 12 m and subsequent sand layers upto a depth of 150 metres. From the previous studies the parameters of the groundwater resources as determined of different factors are as follows:

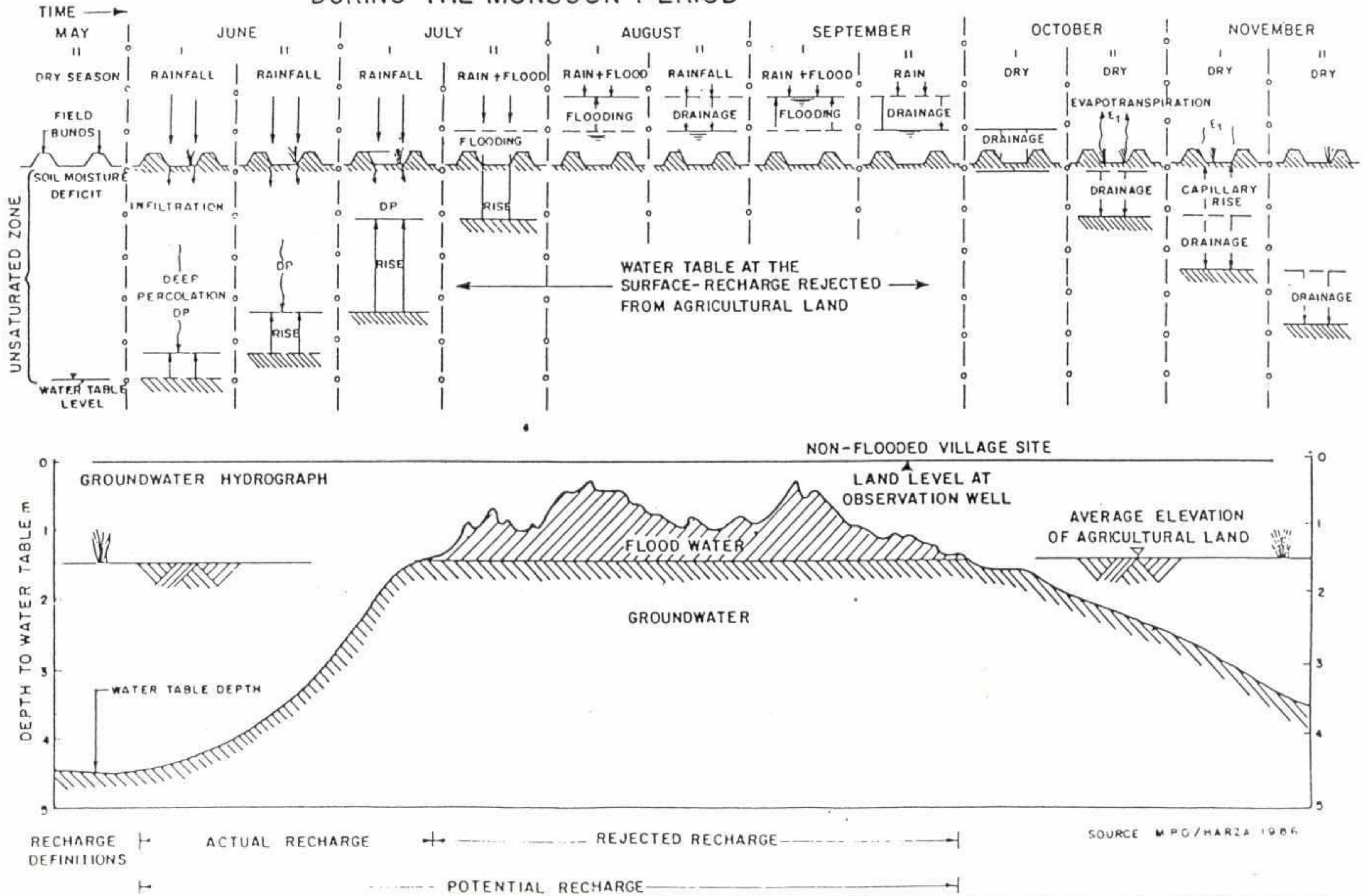
Aquifer Conditions

a)	Thickness upper clay & silt	0-12 m
b)	Depth to top of main aquifer	0-35 m
c)	Thickness of main aquifer	20-75 m
d)	Percentage of coarse material in aquifer	50-75%
e)	Specific yield from borelogs	0.043
f)	Maximum depth of water table from land surface	5-7 m
g)	Water table fluctuation	3-4 m

Resources available in aquifer

a)	Potential recharge (upto depth 8 m from L.S)	158.80 Mm^3
b)	Actual recharge- on existing development and losses from fluctuation	94.53 Mm^3
c)	Available recharge for further development	64.27 Mm^3

RECHARGE CONCEPTS
LAND, WATER AND GROUNDWATER ENVIRONMENT
DURING THE MONSOON PERIOD



Aquifer Properties

a)	Transmissivity	1800 - 2500 m²/day
b)	Storage co-efficient	0.001 - 0.007
c)	Permeability	41 m/day

Chemical Quality

a)	TDS	100 - 250 mg/l
b)	pH	6.5 - 7.00
c)	Iron	2.5-12 mg/l
d)	Total Hardness	38 - 200 mg/l

The parameters suggest that except the iron content, no other constraints prevail to exploit the groundwater resources which is without any flood protection or of any river channel closure or diversion in and around the project area.

3.5.1 Water Levels

Information on groundwater levels in study area is obtained from the network of observation wells of BWDB, water level monitoring of DPHE and nearby BADC wells. Water level data collected, compiled and Hydrographs were drawn for the 3 observation wells located in and around the study area.

Hydrographs (Figure 3.6) show a similar pattern indicating that existing groundwater pumping is still well within recharge limits and that groundwater level continues to recover on each monsoon season.

DPHE monitoring data depict that maximum 6.78 m of drop in water level recorded in 1993, but in same well (well No. 7) the water level is 6.00 m only 1994. Data from other tubewell show similar trend of fluctuations. Hydrographs show that the drop in water level is recovered during monsoon and flood phase. It can be interpreted that if over-abstraction continues a bigger drop in water level is predicted.

UNICEF/DPHE recently conducted a study on declining water level throughout Bangladesh by group of Consultants. Consultants modelled the area and resources potential, and predicted the water level at full development either on area or on resource. The predicted water level for Tangail Thana from report of UNICEF/DPHE **(Study to Forecast Water Level)** is shown in Table 3.5.

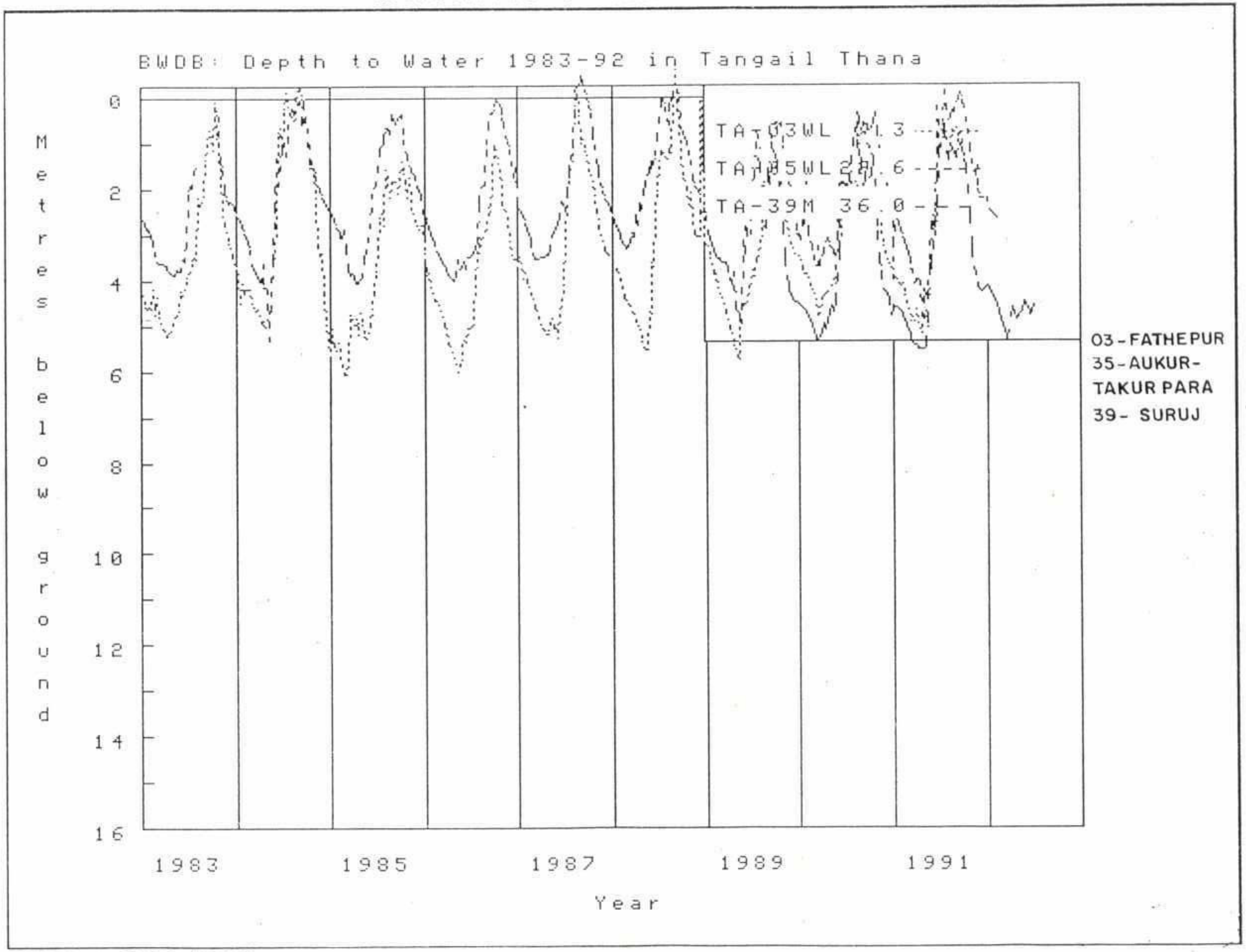
Table 3.5: **Predicted Water Level**

Actual	Predicted			
Deepest in 1991	1995	2000	2010	At full development
5.5	6.2	7.00	8.2	8.2

These data suggest that by the year 1995 the suction mode hand tubwell will eventually transfer to Mini-Tara and Tara tubewell technology and by the year 2010 full development of resource will take place. Nevertheless, it may be predicted that water level may further lower down and resource may be constrainted upon the implementation of flood control protection, diversion and closure on rivers.

FIGURE-3·6

HYDROGRAPHS OF OBSERVATION WELLS



SOURCE : BWDB (GWC)

8D

Natural Discharge

There is little quantitative information available on the natural discharge of groundwater. The principal mechanisms must be baseflow to rivers and evapotranspiration in lowlying areas, but their relative importance is not known. Nevertheless, there is no doubt that baseflow plays an important role in maintaining the dry season flows of the minor rivers. This is immediately apparent for perennial streams on the highland areas of the Madhupur Tract, and less obviously so on the Jamuna floodplain, where the off-takes of numerous left bank distributaries of the Jamuna are dry for around three to five months of the year, and must therefore be maintained by baseflow. In areas such a elevated terraced topography, extension of Madhupur Tract with large topographic differences and a thick upper aquitard, groundwater flow probably helps to maintain levels in ponds and channels, beels and rivers. Base-flow losses have been estimated by MPO on a catchment basis from water balance simulation modelling. The regional character of the groundwater resource does not allow for inclusion of all the local variations in parameters that control the natural drainage from the aquifer system. The natural losses, relates to the average depth to the water table. Hence to include local variations of parameters detailed study is required for water table hydrographs in relation to drainage and discharge function.

3.5.3 Impact on Resources for Dhaleswari Closure

Invariably the discharge of Dhaleswari river will reduce significantly because of the closure of north off-take channel of the Dhaleswari due to construction of the Jamuna Bridge. This reduction in discharge will affect the potential recharge of the region. In Tangail potential recharge is 800 mm but it will reduce to 500 mm i.e. 41% reduction in the potential recharge (DMP Report 1991). An estimate of this effect follows.

3.5.4 Effects

MPO (1986) showed that a strong linear correlation exists between the potential recharge and the annual rainfall with flood. Actual recharge is potential recharge less rejected recharge. The latter is defined as the fraction of water available at the surface which cannot infiltrate and percolate because the water table is at the surface. Rejected recharge becomes surface runoff.

Lower water and inundation levels in the Dhaleswari basin as a result of the closure of the N-intake channel would naturally lead to a decrease of potential recharge, However, the decrease and its effect on the actual recharge depends on many factors and cannot be quantified without detailed studies.

From the MPO groundwater studies, a very preliminary indication of the quantified effects can be obtained.

For the upper Dhaleswari basin Tangail Town the recharge estimates are as follows:

Mean annual potential recharge :	600-700 mm
Actual recharge without groundwater development :	200-300 mm
Present consumption as percentage of available recharge :	40- 60%

The **available recharge** is the usable recharge (75% of mean potential recharge) less natural losses before it can be used (base flow, capillarity flux and evapotranspiration) and after reduction for planning constraints.

Assuming a 10% lower potential recharge, the future available recharge would be as follows:

Present situation

Natural losses and constraints:	0.75 x 650 - 400 = 90 mm
Actual consumption :	0.5 x 400 = 200 mm

3.5.5 Future Situation

Available recharge:	0.9 (0.75 x 650) - 90 = 350 mm

As the future available recharge (350 mm) remains much greater than present consumption (200 mm), it must be concluded that the present groundwater use in the upper Dhaleswari basin Tangail will not be affected by a 10% reduction of mean potential recharge. Only if the present consumption would be about 80% of the available recharge, the reduced flooding would have an adverse impact on the groundwater use.

It should, however, be stressed that the future groundwater development potential will be reduced from 200 to 150 mm or by 25%. Increases in flood protection are expected to reduce recharge, but without extensive site-specific investigation and analysis the relationship can only be defined indicatively.

3.6 Conclusions and Recommendations

a) A hydrogeological system is recognisable in the study regions which is similar to many other areas of Bangladesh. If an extension of groundwater development is planned after flood protection a study should be made using the MPO model to see what effect it is likely to have on recharge.

b) If additional groundwater development for irrigation looks to be advantageous in areas where over-abstraction currently appears to be taking place, the MPO recharge estimates could be re-examined to see if they are over-conservative. The bases for the examination would be monitoring data on groundwater abstraction and observed water level change.

c) In existing or proposed areas of high groundwater utilization for monitoring the effects of fertilizer (nitrate) and pesticide application should be investigated. If necessary, some sensible and appropriate codes of good agricultural practice with respect to fertilizer and pesticide application should be devised, and incorporated into development proposals, so that groundwater drinking standards are not hampered.

d) There is no other known natural groundwater problem though the situation on groundwater contamination by fertilizer and pesticides is unknown but the excess iron content is the only chemical constraint at present.

e) The MPO recharge model is applicable to the project area and provides values of potential and usable recharge. These values can be constrained to provide data on available recharge. Small constraints are applicable for baseflow losses.

f) Implementation of flood protection schemes has the effect of reducing potential recharge. However, the most significant effects are experienced on areas of deep, prolonged flooding, i.e. F3/F4 land types, which occupy a large part of the study area.

g) Because mixed-mode tubewell development exists, local well-field planning is vital and development should not proceed without detailed hydrogeological assessment at thana level. It is obvious that groundwater level will go down to maximum level of 8 m, as predicted by other consultants.

h) **For a close follow-up of the study area's development this report calls primarily for the extension of the groundwater observation network as an efficient groundwater management tool and a revised mathematical groundwater model to be run on the basis of the additional data collected from improved piezometers network (with duration of 18 to 24 months) for a higher accuracy on regional variations with updated information on hydrogeology, soils, agriculture, meteorology, flood phase and depth, domestic and industrial water consumption, and with the trend of population growth and development.**

92

CHAPTER 4

ENVIRONMENTAL MANAGEMENT

4.1 General

This chapter deals with some of the important environmental issues of Tangail town such as drainage congestion and waterlogging, drinking and domestic water, groundwater availability, surface water and groundwater quality, solid waste, sanitation, health and nutrition, etc. Issues like landuse distribution, and some others are not covered here and those are included in other chapters of this report. This chapter also gives a preliminary idea about the type of impact on the important environmental issues of Tangail Pourashava due to the proposed development activities.

4.2 Drainage Congestion and Waterlogging

The Lohajang river is the main drainage channel of Tangail Pourashava area and flows across the town from north towards south-west direction. The second drainage channel is Tangail Khal and this starts from the Lohajang river near Eidgah in ward 2 and then passing through the middle of the town ends near eastern Biswas Betka in the same ward of Tangail Pourashava. Tangail Khal once served as the only drainage passage of the main town and its adjacent areas. But now it has totally lost its capacity due to gradual land-filling with town solid waste, unauthorized encroachment by growing settlements, and blockade by embankment at the mouth of the khal. Tangail town has approximately 9 km of pucca and 6 km of kutcha internal drains constructed by Pourashava and outlet points of all these drains are connected to these two main drainage channels. But the present situation is such that none of these drains are in workable condition either due to poor design in slope maintenance during construction or congestion by solid garbages. All these facts, in addition to the overall flat topography and lowlying nature of Tangail town area, have created serious drainage congestion leading to waterlogging problems within the whole Pourashava area.

The major waterlogged areas of Tangail town are shown in Figure 4.1. Adi Tangail and Paradise Para in Ward 1, western and eastern part of Biswas Betka and Ashekpur in Ward 2, part of Enayetpur, Deola, Kodalia, Sabalia and Akur Takur Para in Ward 3, part of Akur Takur Para, Kagmari and Beradoma in Ward 4, Lohajang river adjacent areas of Santosh and Kagmari in Ward 5, and Char Patuali, Bera Bochna, Kazipur, Bajitpur and Bhalukkandi in Ward 6 are the most affected water congested areas. Rain water, flood water and urban effluents are the main causes of water congestion. Waterlogging in Ward 1 and in Ward 5 is due to rain water and flood water, respectively, while in rest of the wards both these sources cause congestion problem. Insufficient drainage provision has been identified during field investigations as the major reason for waterlogging in Wards 1,2,3,4 and 6. Congestion of existing drains has also been found to exacerbate the situation in Wards 2 and 4. But in the whole portion of Ward 5 and Akur Takur Para in Ward 3 waterlogging is mainly due to lowlying nature of the lands. Rain water logging usually begins with the onset of pre-monsoon rainfall, and during post-monsoon the lowlying areas of Tangail town are often inundated upto a depth of 30 - 60 cm. The rise of Lohajang river water during flood season sometimes causes flood water congestion by overland flow for few days. These results in severe damages to road and other infrastructures, and poses environmental health risks in the affected areas.

The Sub-consultants socio-economic household survey for Tangail town found that about 92% of the total population of Tangail Pourashava do not have any access to drainage facilities and about 80% of the households are directly affected by monsoon rains and heavy floods.

To allow easy and smooth drainage of rain and flood water, and to solve the problems associated with waterlogging of Tangail town the following engineering measures have been proposed dividing the whole Pourashava area into nine zones. For details see Chapter 2 of this volume.

Zone A (District Headquarters area) - Construction of a pipe regulator controlled by flap gate and 5.25 km roadside pucca drain.

Zone B (Part of Sabalia and Kodalia area) - Excavation of a small canal along Sabalia road and construction of 3.1 km roadside pucca drain.

Zone C (Total Akur Takur Mauza) - Construction of 3.53 km pucca drain with two outlet points provided with flap gates.

Zone D (Housing Estate area & part of Kagmari) - No immediate measure is needed.

Zone E (Core area of Tangail town) - Re-excavation of the main drain i.e., Tangail Khal, construction of a flushing regulator at the mouth of Tangail Khal and 4.66 km pucca drain.

Zone F (Areas in between Kumudini College and Darun Beel) - Re-excavation of approximately 200 m long canal along the road adjacent to Kumudini College boundary wall and construction of 1.68 km pucca drain.

Zone G (Areas in between Dighulia and Kagmari road) - Construction of a pipe regulator fitted with flap valve and 2.76 km of pucca drain.

Zone H (West-south part of Tangail town) - Construction of 0.48 km roadside pucca drain.

Zone I (South-east corner of Tangail town) - Construction of 1.71 km pucca drain and few drains inside the hat area.

4.3 Drinking and Domestic Water

Tangail town has an estimated population of 1,52,000 at present. Based on this figure, the present requirement of drinking and domestic water for the Tangail Pourashava is calculated as 24,320 m^3 per day (@ 0.16m^3/person/day). Source from Tangail Pourashava has reported that the Pourashava authority provides water supply facilities to the town dwellers by 4 DPHE-installed pump tubewells (PTW) and 523 Pourashava-provided hand tubewells (HTW). These two sources supply an estimated volume of 11,911 m^3 water per day. Detailed information about water requirement and supply, and the relavent calculations are presented in Table 4.1. Water abstracted by the pump tubewells are supplied to the consumer via 22 km long water supply pipelines after passing through a treatment plant of 225 m^3/h capacity. There are at present 1,933 water supply connections out of which 1,778 are domestic, 10 public and the remaining 145 commercial.

Table 1 : Drinking and domestic water requirement and supply in the Tangail town.

Volume of water requirement at present[1] (@ 0.16 m^3/person/day)
: 24,320 m^3/day

Volume of water supplied at present : 11,911 m^3/day
Piped water = 5,049 m^3/day
HTW water = 6,862 m^3/day

Sources of water supply :

Well specification	No.of wells	Av.capacity,m^3/h	Av.daily operation,h	Abstracted volume m^3/d
DPHE PTW	4	57.38	22	5,049
Pourashava provided HTWs	523	1.64	8	6,862

Arrangement for water supply :
- Treatment plant = 1 No. x 225 m^3/h capacity x 24hrs. operation per day
- Total length of existing water supply pipelines = 22 km (approx.)
- Total number of present water supply connections = 1933
  (Domestic 1778 + Public 10 + Commercial 145)

Additional volume of water requirement at present : 12,409 m^3/day

Average demand for additional water supply connections : 60/year

Estimated additional volume of water supply will require
after 5 years[2] : 20,089 m^3/day

Next 5 years plan for water supply arrangements :
- Rehabilitation of the existing 1 PTW + 1 OHT + 1 treatment plant
- Sinking of new 7 PTWs
- Construction of new 2 OHTs.+ 2 treatment plants
- Construction of new 38 km long piped water supply network

Source : Tangail Pourashava and DPHE, Tangail

Based on the estimated volume of present water requirement and supply, it is calculated that an additional volume of 12,409 m^3 water is needed per day to cover the whole community. This additional volume of requirement is probably met from sources other than Pourashava such as private-owned hand tubewells, shallow tubewells, dug wells, ring wells, ponds, lakes, etc. Reliable data on the number of privately owned tubewells and estimated volume of water supplied from those sources are not available. However, data from socio-economic household survey showed that about 51% of the households have access to privately-owned sources comprising hand tubewells and shallow tubewells.

---

[1] Assuming the present population of 152,000

[2] Assuming the projected population of 200,000 by the year 2000.

Tangail Pourashava has a projected population of 2,00,000 by the year 2000. So, it is calculated that an additional volume of 20,089 m^3 water will be required per day after 5 years. ADB has made a detailed survey on the existing water supply arrangement of Tangail Pourashava and has designed a plan for the town's water supply system considering the projected population upto the year 2015. This plan is a part of the Second Water Supply and Sanitation Project, Bangladesh and mainly consists of rehabilitation of all the existing pumps, motors, overhead tank, treatment plant, transmission and distribution lines, etc., and sinking of 7 new PTWs, construction of 3 new treatment plants, 3 overhead tanks, 38 km. of piped water supply network, etc. The total project cost is estimated at Taka 130.75 millions and the implementation will take place in between 1994 and 1999. If implemented as scheduled, the project will fulfil the estimated future demand for water supply for the Tangail Pourashava.

4.4 Groundwater Availability

The sub-surface of the Tangail town area consists of an upper clay layer varying from 2 to 12 m and a subsequent sand layer upto a depth of 154.22 m with fine to medium to coarse sand. This sand layer constitutes the aquifer system and acts as the main source of groundwater in this area. Hand tubewells usually abstract water from the shallow aquifer whereas deep tubewells abstract water from both shallow and medium deep aquifer. More discussions on groundwater may be found in Chapter 3 of this volume.

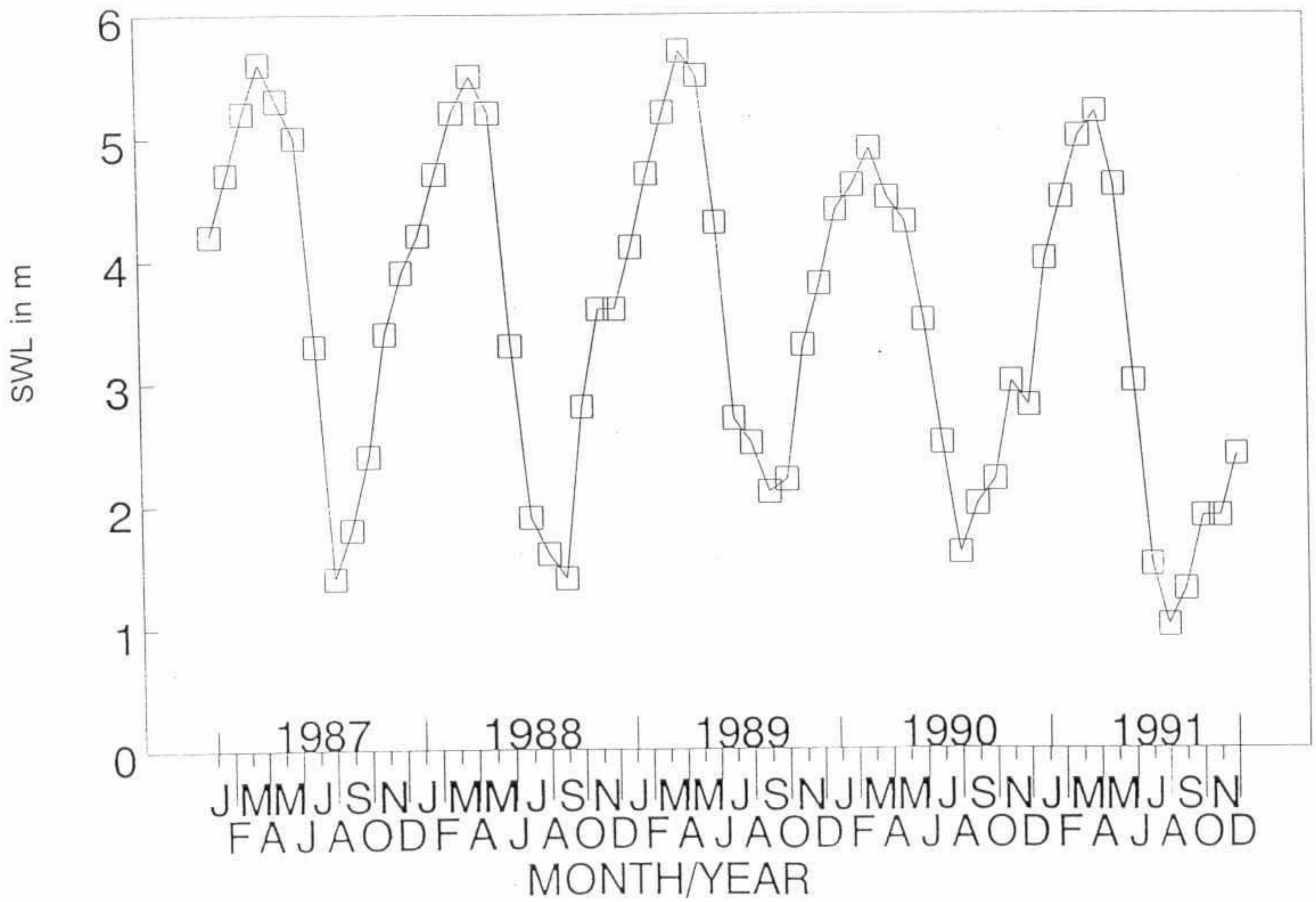
Specific data on ground water abstraction in the Tangail Pourashava is not available at present. However, sources from DPHE Tangail and Tangail Pourashava give the following estimate of groundwater abstraction.

Abstraction Source	Present capacity, m^3/h	Abstracted Volume, m^3/d
DPHE Production Well # 3	41.33	909
# 4	82.00	1,804
# 7	34.50	759
# 8	71.68	1,577
Pourashava provided Hand Tubewells = 523	1.64	6,862
	Total Volume	11,911 m^3/d

An ADB report[1/] in 1993 indicated that groundwater abstraction upto 12,320 m^3/d would not cause any substantial decline in groundwater level in the Tangail Pourashava. This estimation agrees well with the estimated abstraction volume of 11,911 m^3/d and with the groundwater level data as presented in the appendix (Table 4.2 and Table 4.3). Data for static groundwater level during the dry season (April) for the past five years (1990-1994) in the DPHE production tubewells at Tangail (Table 2 in the appendix) indicate the maximum recorded drop of 6.78 m in 1993 for DTW # 7. Water level in the same well in 1994 was measured as 6 m below surface level showing a slight increase of 0.78 m. Data for other tubewells also show similar trend of fluctuation in water levels. Groundwater level data and the hydrographs for BWDB well # TA-09 from 1987 to 1991 as presented in Table 4.3 and Figure 4.2 respectively show slight draw-down in the water table in the dry season and again rise in the monsoon. None of these data indicate any definite trend of continuous lowering of groundwater level in that well. These facts gave clear idea about maximum recharge either by infiltration of rain water or by inundation of flood water during the monsoon. The trend in temporary declining of groundwater table in the peak dry season is due to huge abstraction for irrigation purposes during that period. However, the total

[1/] Second Water Supply and Sanitation Project, Bangladesh, Final Report. Vol. 3 Tangail. ADB 1993.

Fig 4.2: Groundwater Hydrograph for BWDB Well # TA-09
Lat.(N) 24.13.12 Long(E) 89.56.08 in Tangail Pourashava



84

volume of groundwater abstraction taking into consideration the private-owned hand tubewells, STWs, and DTWs used for domestic and irrigation in the Tangail Pourashava need to be estimated properly and in that case some modification in the recharge calculation may be required, and only after that any meaningful conclusion about groundwater availability can be made.

4.5 Surface Water and Groundwater Quality

Some data on surface water and groundwater quality in the Tangail Pourashava are available from different sources and these are presented in Table 4.4. Data for surface water quality show that Tangail Khal water near Park Bazar in Ward 2 of Tangail Pourashava suffers problem due to higher concentration of ammonia, iron, oxygen demanding materials and faecal coliform bacteria. But the surface water from the other two sources namely Alowa Khal and Santosh Dighi in Ward 5 do not show any major problem, except bacterial contamination, in terms of deteriorated water quality. Data on groundwater show maximum iron contamination in almost all tubewell waters. According to an ADB report (ADB, 1993), iron content in the groundwater in the shallow aquifer at Tangail Pourashava varies from 0.8 mg/L to more than 10 mg/L and that water quality in the medium deep aquifer appears to be better in terms of iron content compared to the shallow aquifer. Source from DPHE mentioned that all the pump tubewell screens get clogged very often due to high mineral content in groundwater causing decrease in specific capacity of the pumps. Regeneration is being done every year but the expected yields are only for few months and again the screens get clogged. Another source from Tangail Pourashava reported that, groundwater from DTW # 7 at Ansar Camp showed a wide variation in water quality between the months of January and March in 1986. In January, the water was totally free from coliform bacteria but in March presence of coliform bacteria upto 7 numbers per 100 ml. of water made it completely unsatisfactory for human consumption.

Socio-economic survey for Tangail Town Development Study found that about 73% of the total population of Tangail Pourashava are not aware of any harmful effect of using contaminated water.

4.6 Solid Waste

According to Pourashava, Tangail town produces at present approximately 5 tons of solid waste per day and about 60 % of the total solid waste generated are collected in roadside bins and then carried in garbage vans into the landfill site (behind Rotary Pally) near Kagmari bridge, about 1 km away from the town. All the wastes are dumped there without any treatment. The remaining 30% of the solid waste are disposed off directly into nearby ditches, drains, and khals by the local people whereas the other 10% remains scattered in the streets causing environmental pollution. Findings from the socio-economic survey indicated that 64% of the urban people dispose off their wastes in open areas, 22.6% use open ditches, 2.6% use drains and only 1.3% use dustbins. However, there is no doubt that the present solid waste collection and disposal system is yet to be modified by increasing the number of dustbins, garbage vans and cleaning staff of the Pourashava. At the same time a plan is to be developed for the projected solid waste generation of 10 tons per day by the year 2000. The plan for Tangail Pourashava Environmental Services prepared in the ADB Second Water Supply and Sanitation Project, Bangladesh can be followed in this regard.

Table 4.2: **Static Groundwater Level During the Dry Season (April) in Some DPHE Production Tubewells at Tangail**

Production tubewell #	Water Depth (Metre)				
	1990	1991	1992	1993	1994
3	4.25	5.57	5.90	5.25	-
4	4.40	5.67	5.04	5.27	4.80
7	6.06	6.42	-	6.78	6.00
8	4.96	5.32	5.62	5.58	5.00

Source : DPHE, Tangail

Table 4.3: **Groundwater Level Data in BWDB Well # TA - 09 (Latitude : 24°13′12″ : Longitude : 89°56′08″) in Tangail Pourashava**

Year	Water Depth Below Measuring Point (Meter)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987	4.2	4.7	5.2	5.6	5.3	5.0	3.3	1.4	1.8	2.4	3.4	3.9
1988	4.2	4.7	5.2	5.5	5.2	3.3	1.9	1.6	1.4	2.8	3.6	3.6
1989	4.1	4.7	5.2	5.7	5.5	4.3	2.7	2.5	2.1	2.2	3.3	3.8
1990	4.4	4.6	4.9	4.5	4.3	3.5	2.5	1.6	2.0	2.2	3.0	2.8
1991	4.0	4.5	5.0	5.2	4.6	3.0	1.5	1.0	1.3	1.9	1.9	2.4

Source : Groundwater Circle II, BWDB, Dhaka

4.7 **Sanitation**

Tangail Pourashava has a total holding number of 20,520. It has been gathered from DPHE that the total number of presently working latrines in the Pourashava area are some 6,952. Out of these, 950 are septic tank, 2,050 are water seal, 2 are community, 700 are bucket and 3,250 are pit latrines. The latter two types of latrines are now-a-days not included in modern sanitation system. So, in true sense Tangail town residents avail facilities only with those 3,002 numbers of septic tank, water seal and community latrines. In other words, only about 15% of the total households enjoy modern sanitation facilities.

According to the findings of the socio-economic household survey, about 9% of the households have no latrine and they use open spaces for defecation. Another 23% use kutcha latrines. Sanitary sewerage from these two sources runs off straight to the nearby ditches, khals or ponds and eventually leads to bacterial pollution in the surface water system. Pit latrines, which are used by 21% of the households, are also subject to occasional overflow due to heavy rainfall or flush flood causing same pollution problem during monsoon. Survey on the knowledge of harmful effect of open sanitary sewerage showed that about 33% of the households are aware of health risks, another 33% know only about environmental pollution while the rest have no knowledge about it.

Keeping in view the total number of 20,520 households in the Tangail town, it is estimated that 17,518 numbers of additional latrines (water seal 10,749 + septic tank 6,715 + community 54) will be required to provide modern sanitation facilities for all the town dwellers and a health education programme is to be initiated among the general people to make them more aware about environmental hazards and risks.

4.8 Health and Nutrition

The most common health related problem of the Tangail Pourashava is water-borne diseases like diarrhoea, cholera, dysentry, jaundice, etc. Vector borne diseases like malaria, kalazar, filariasis, etc., internal worm infection, respiratory infection, skin diseases and others are also there. But the prevalence of the latter is low compared to water-borne diseases. Correct disease profile for the Tangail town is not available. However, findings from household survey indicated that diarrhoea, cholera, dysentry and hepatitis account about 50% followed by 17% of skin diseases. Health care facilities are inadequate in Tangail town. There are only 1 Government General Hospital, 2 out-patients Government Clinics and 5 private clinics.

Information regarding nutritional status among various social group people, major nutrient deficiency diseases and percentage of people suffering from malnutrition are not available with the Department of Health, Tangail.

4.9 Environmental Impact of Recommended Project Activities

This report on Tangail Town Integrated Water Management and Development Study proposes a number of activities for the development of Tangail Pourashava (See Chapter 2 of this Volume and Chapters 2 and 3 of Volume II for details). These include the following and some other activities.

I - Re-excavation of the main drain i.e., Tangail Khal and another one small canal along the road adjacent to Kumudini College boundary wall.

II - Excavation of a small canal along the Sabalia road

III - Construction of a 2 m wide and 1.7 km long drain from food godown near Eidgah to food godown at Biswas Betka, and then 1.3 km long open channel towards Darun Beel.

IV - Construction of 23.4 km roadside pucca drains having outlet points to the main drain, Lohajang river, and low lying areas outside the Pourashava.

V - Construction of four outlet structures connecting the internal drain network with the Lohajang river.

VI - Construction of one inlet structure at the Eidgah end of Tangail Khal to allow seasonal flushing.

VII - Construction of a flood wall along the bank of Lohajang river with a top level of 13.5 + PWD.

VIII - Development of Bajitpur Hat and some other important market places.

IX - Rehabilitation of the existing road system and construction of new roads in Tangail town.

X - Improvement of slum areas.

All the proposed activities may have both positive and negative impacts on the town environment. For example, activities from I-V will accelerate quick drainage and will have positive impact on the waterlogging situation and related problems. Activity VI will allow seasonal flushing of Tangail Khal and this will improve water quality in the surface water channels and reduce urban water pollution related health risks, specially the prevalence of water borne diseases. Activity VII, which is proposed to protect the Tangail town for a flood frequency of 1:50 years, may have negative impact on groundwater recharge by surface water flow or flood water innundation. Activities VIII-X will, no doubt, improve the overall socio-economic condition of the Pourashava people. However, considering all the positive and negetive points in relation to the individual activity it is apparent that the overall trend of environmental impact will be positive. Activities those were considered to have negative impact and those having no direct impact on the important environmental issues of Tangail town the following measures and initiatives are recommended.

- Follow up the implementation of Tangail Town Water Supply Plan made under ABD Second Water Supply and Sanitation Project, Bangladesh.

- Determination of the total volume of groundwater abstraction by number and type of tubewells, and estimated volume of recharge.

- Regular monitoring of groundwater table in the observation wells of Tangail Pourashava area.

- Modification of the present solid waste collection and disposal system, and follow up the implementation of the ADB plan in this respect.

- Improvement of sanitation facilities by providing approximately 10,800 low-cost water seal latrines, and introduction of health education programme.

- Upgrading of the government General Hospital and improvement of private sector medical facilities.

Table 4.4: Surface Water and Groundwater Quality in the Tangail Pourashava

Sample source	Water Quality Parameters											
	Temp °C	p^H	EC μS/cm	DO mg/L	Ammonia mg/L	T.H. mg/L	Ca.H mg/L	Chloride mg/L	Iron mg/L	Manga-nese mg/L	BOD mg/L	T.Coliform n/100 ml.	F.Coliform n/100 ml.
Tangail khal	22.3	7.4	417	8.0	4.5	-	-	-	4.0	0.05	35.4	25,000	20,000
Aloa Khal	19.3	7.5	170	10.7	0.7	-	-	-	0.9	0.02	12.4	1,200	1,000
Santosh Dighi	23.6	7.5	65	9.6	0.6	-	-	-	0.6	0.02	8.0	40	35
PTW # 3	-	6.8	421	-	-	256	153	-	2.2	0.2	-	-	-
PTW # 4	-	7.1	490	-	-	48.1	48.1	40	6.5	0.4	-	-	-
PTW # 7	-	7.1	600	-	-	46.2	36.5	20	4.3	0.4	-	-	-
PTW # 8	-	6.8	445	-	-	45	34	14	5.0	1.2	-	-	-
Shallow Aquifer, Tangail Pourashava	26-27	6.5-7.0	310-455	-	-	38-200	36-100	32-45	0.8->10	-	-	-	-

Source: CPP Environmental Pollution Survey. 1994 and ADB Survey Report, 1993

APPENDICES

d 2

APPENDICES
(To Chapter 2)

In the appendices the design of different structural works recommended in this report has been described. The design, drawings and cost estimates are of feasibility level.

The recommended structural works are main drain from Eidgah Tangail to River Lohajang at Nagar Jalfai, internal drains, drainage out-let structures and an inlet structure of the main drain.

ac

APPENDIX I
(To Chapter 2)

DESIGN OF MAIN DRAIN TANGAIL KHAL FROM FOOD GODOWN AT EIDGAH IN TANGAIL TOWN TO LOHAJANG RIVER AT NAGAR JALFAI

Existing Bed Level:

ch 0.00 : 7.895 m PWD.
ch 45 : 11.990 m PWD Embk.
ch 95 : 12.092 m PWD Embk.
ch 369 : 11.533 m PWD Embk.
ch 400 : 10.113 m PWD Culvert, invert : 10.113, W=4.40, H=3.15, L=5.35
ch 573 : 10.209 m PWD Culvert, invert : 10.209, W=7.00, H=3.51, L=5.15
ch 1000 : 10.029 m PWD
ch 1127 : 9.743 m PWD Culvert, W=4.00, H=3.00, L=5.30m
ch 1240 : 9.105 m PWD Culvert, W=6.10, H=3.42, L=5.30m
ch 1375 : 9.369 m PWD Culvert, W=5.00, H=2.45, L=2.00m
ch 1700 : 9.145 m PWD Culvert, W=7.40, H=4.40, L=9.60m
ch 1948 : 9.193 m PWD Culvert, W=3.90, H=3.83, L=5.20
ch 2000 : 8.895 m PWD
ch 2080 : 8.901 m PWD Pipe Culvert, Q=.88m, Top=9.80, L=5.90m
ch 2433 : 8.567 m PWD Culvert, W=3.20, H=3.28, L=6.80m
ch 2595 : 8.385 m PWD Culvert, W=3.80, H=3.80, L=5.65
ch 3000 : 7.125 m PWD
ch 3400 : 5.275 m PWD
ch 3500 : 7.699 m PWD
ch 4000 : 8.790 m PWD Paddy land
ch 5000 : 8.617 m PWD Paddy land
ch 5925 : 8.761 m PWD Bridge, W=4.00, H=7.10, L=8.00
ch 6000 : 7.566 m PWD
ch 6718 : 7.431 m PWD Bridge, W=2.75, H=4.55, L=7.70
ch 6780 : 6.881 m PWD

Invert levels and other information on bridges and culverts are shown in Map-6.

C-8

Drainage Area: 2 sq mile

The proposed discharge from rainfall runoff

a) During Pre-monsoon:

$$\frac{2x27*}{35.28}m^3/sec=1.53m^3/sec\approx 2m^3/sec$$

Dr. co-eff = 1"

b) During Monsoon:

$$\frac{2x79*}{35.28}m^3/sec=4.48m^3/sec\approx 5m^3/sec$$

From the existing long section of the channel it is observed that there are 10 culverts in between ch 0.00 to ch 3000 (i.e. urban area) and paddy land in between ch 3000 to ch 6.881 (end).

The tail reach area is under sub-compartment 4.

Given

SC No.	Required WL in m PWD	
	Pre-monsoon	Monsoon
4	8.70 m	9.55 m

Observed max^{m} water level in the month of August at
Lohajang : 10.00 m PWD
Outfall bed level of Lohajang : 6.84 m PWD.

There will be a drainage regulator at the outfall of channel to regulate the flow of water from the channel to Lohajang river and vice versa. Water will be drained from the sub-compartments in case of high local rainfall and low river stage. Water may be allowed to enter into the sub-compartment during early flood situation in the river for fish migration and the gates may be closed at river stage higher than the sub-compartment WL.

* Reference: Construction programme FY 1994-95
Design Criteria Cluster-III, CPP Tangail, May 1994

From Chainage 0 to Chainage 1700

In the urban area, pucca brick drain has been proposed. From ch 00.00 (Eidgah-Lohajang River) to ch 1700 (Figure 2.1).

$Q = 5\ m^3/sec.$
$n = 0.015$
$S = 1$ in 3000

$$\therefore S = \frac{1}{3000} = 0.00033$$

$$S1'2 = \sqrt[2]{.00033} = 0.0182$$

Considering b = 2.00 m. d = 1.5 m
Area = 2x1.5 = 3 m^2
Perimeter = 2+2x1.5 = 5 m

$$R = \frac{3}{5} = 0.6$$

$$R2'3 = 0.711$$

$$V = \frac{R2'3 . s1'2}{n} = \frac{0.711x0.0182}{0.015}$$

$$= 0.86 m/sec.$$

$$\therefore Q = AV = 3x0.86 = 2.59 m^3/sec$$ $< 5.0\ m^3/sec.$ O.K.

From ch 1700 to ch 3000

Earthen drain of trapezoidal section will be provided.

Assumed $Q = 5\ m^3/sec.$

$n = 0.035$

$S = 1$ in 4000

$$S = \frac{1}{4000} = 0.00025$$

$$S^{1/2} = \sqrt[2]{.00025} = 0.0158$$

Area = 5.875x1.25 = 7.34 m^2

P = 4+2x1.8x1.25 = 8.5 m

$$R = \frac{7.34}{8.5} = 0.863$$

$$R^{2/3} = (0.863)^{2/3} = 0.907$$

$$\therefore V = \frac{R^{2/3} \cdot S^{1/2}}{n} = \frac{0.907 x 0.0158}{0.035}$$

= 0.4, m/sec. > 0.3 m/sec

< 0.7 m/sec

$\therefore$ Q = 7.34x0.41 = 3.00 m^3/sec <5.0 m^3/sec. O.K.

Proposed Section

b = 4.00 m

d = 1.25 m

Side Slopes : 1.5 (H) : 1.00 (V)

From ch 3000 to ch 6760

The water will be discharged through Gharinda-Jalfai Khal to Lohajang river.

Discharge Calculation:

External discharge from Sadullapur - Gharinda Khal
= 9 m^3/sec
Catchment Area : 1438 ha *.

Discharge from 1438 ha (Pre-monsoon) :

$$\frac{1438x27x2.47}{640x35.28}=4.25m^3/sec$$

Discharge from 1438 ha (Monsoon) :

$$\frac{1438x79x2.47}{640x35.28}=12.50m^3/sec.$$

∴ Max^m discharge through Khal (Pre-monsoon): 9+4.25+5
= 18.25 m^3/sec

Max^m discharge through Khal (Monsoon) : 12.50+9+5
= 26.50 ≈ 25 m^3/sec.

There will be a outfall drainage regulator at Nagar Jalfai. The max^m allowable W. L. at the u/s of the proposed drainage regulator is 9.60 m PWD during pre-monsoon and optimum WL to be maintained at u/s is between 10.25 ~ 9.50 m PWD.

Q = 25 m^3/sec
n = 0.035
S = 1 in 5000

$$S=\frac{1}{5000}=0.0002$$

$$S1/2=\sqrt[2]{.0002}=0.0141$$

Area = 13.75x2.50 = 34.375 m^2
P = 10+2x1.8x2.50 = 19 m

$$R=\frac{34.375}{19}=1.809$$

* Reference: Construction programme FY 1994-95
Design Criteria Cluster-III, CPP Tangail, May 1994 (Jalfai Regulator SC-4).

$$R^{2/3} = 1.485$$

$$\therefore V = \frac{R^{2/3} . S^{1/2}}{n} = \frac{1.485 x 0.0141}{0.035}$$

= 0.60 m/sec. > .3 m/sec.

< .7 m/sec.

∴ Q = 34.375x.6 = 20.56 m^3/sec. < 25 m^3/sec. O.K.

∴ Proposed section

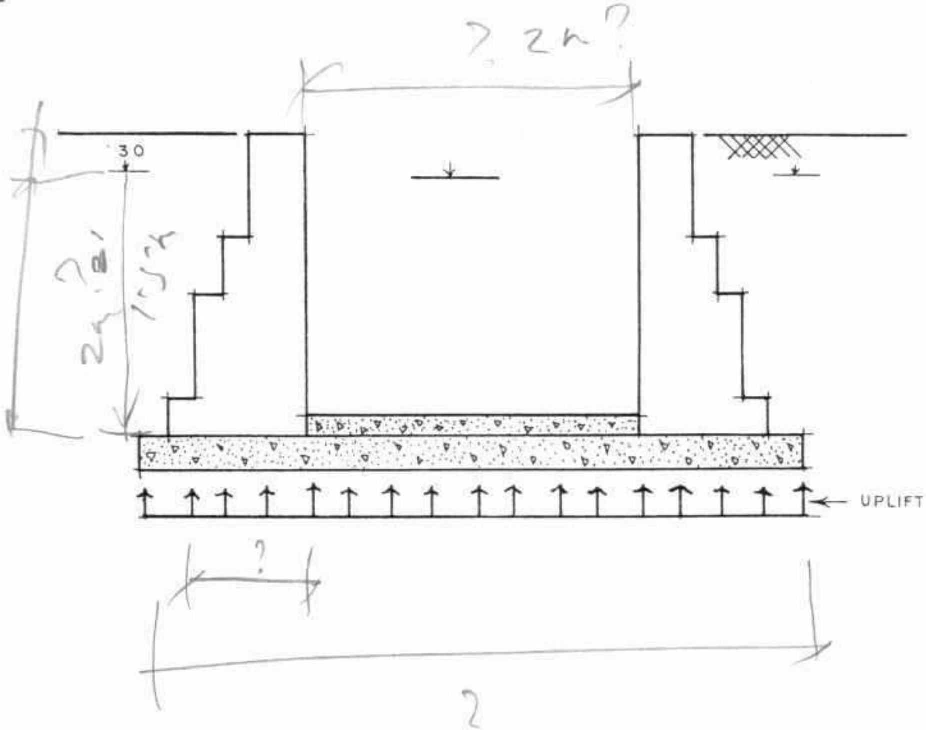
b = 10 m

d = 2.50 m

Side slopes 1.5 (H) : 1.00 (V).

STABILITY ANALYSIS OF THE PROPOSED MASONRY DRAIN

i) **Against Uplift**



a) **Detail Loads and pressures:**

i) **Brickwork, concrete and earthload**

Brickwork:	0.25 x 0.5 =	0.125	
	0.375 x 0.5 =	0.188	
	0.50 x 0.5 =	0.250	
	0.625 x 0.5 =	0.313	
		0.876 x 2 x 1920 =	3364 Kg

Mass Concrete:			
	2 x 0.15 =	0.300	
	3.75 x 0.175=	0.656	
		0.956 x 2306 =	2205 Kg

Earthwork: 2 x 0.437 x 2.0 x 1840 = 3216 Kg
(Backfill)

90

ii) **Water load**

Inside drain: 2 x 1.50 x 1000 = 3,000 Kg

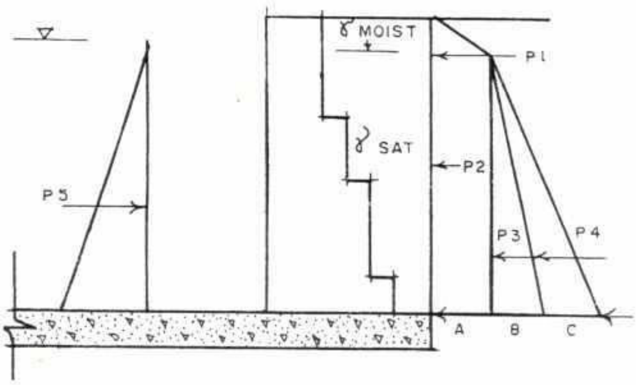
11,785 Kg

iii) Uplift: (2.175 - .3) x 3.75 x 1000 = 7,031 Kg

$\therefore$ Factor of safety against uplift = $\frac{11785}{7031}$ = 1.68>1.10

Against Horizontal Force

Case-I



- G.W.T is 0.3m below G1. Backfill is submerged & the drain is full. ?

i) Earth pressure

Angle of Internal friction of

backfill soil, Ø = 30° Sand ?

$$Ca=\frac{1-.50}{1+.50}=0.333$$

Total Shear:

P_1 = 0.50x.333x1840x0.3x0.3 = 27 kg

P_2 = .333x1840x0.3x1.70 = 313 kg

P_3 = 0.50x.333x920x1.70x1.70 = 443 kg

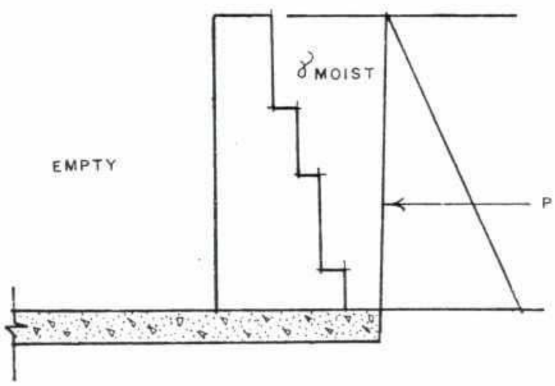
P_4 = 0.50x1000x1.70x1.70 = 1445 kg

2228 kg

P_5 = 0.50x1000x1.50x1.50 = 1125 kg

∴ Net Horizontal Force = (2228-1125)kg = 1103 kg

Case-II



- Backfill is not submerged i.e. GWT below bed level of drain and drain is empty.

Earth pressure

P = 0.5x.333x1840x2.0x2.0 = 1225 kg>1103 kg
As such case II is critical.

Horizontal Load:

Weight of brickwork = 3364/2 = 1682 kg

Weight of soil = 0.187x1840x1.5 = 516 kg

2198 kg

Total vertical force is about 1.80 times more than total horizonal force. There is also a co-efficient of resistance below concrete and brickwork.

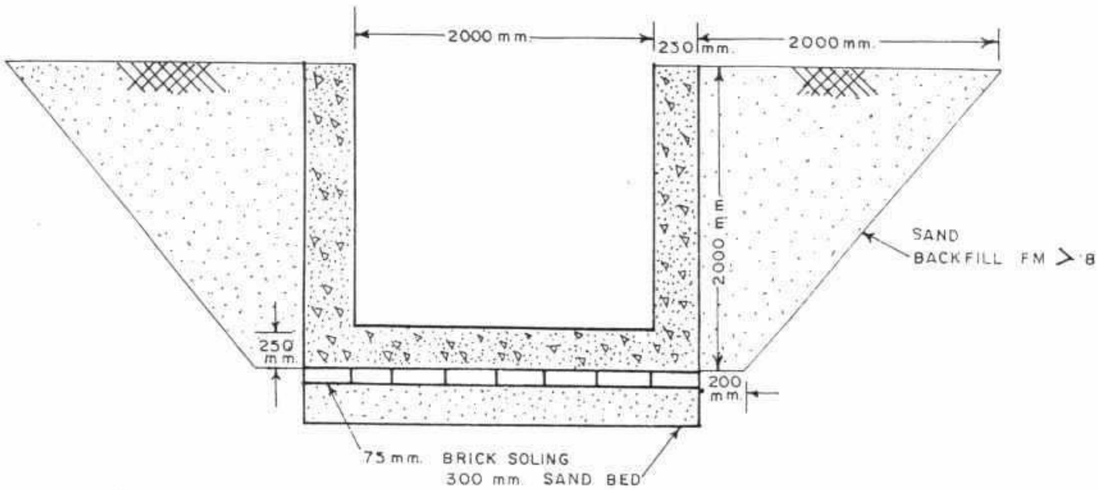
Hence OK

iii) Stress developed at the base of brick work

Considering the vertical load:

Horizontal force (1225-0.57x2198) kg = -27
no stress is developed

Design of R.C.C. Drain



96

Stability Analysis

Against Uplift

a) Detail load & Pressure

Concrete:	2 x 0.25	=	.50
	2 x 0.25	=	.50
	2.5 x 0.25	=	.625

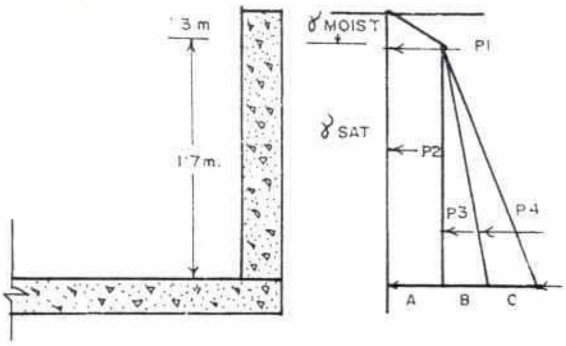
	1.625 x 2400	=	3900 kg
Water Load:	2 x 1.50 x 1000	=	3000 kg

			6900 kg
Uplift:	(2.25 - 0.3) x 2.50 x 1000	=	4875 kg

∴ Factor of safety against uplift = $\frac{6900}{4875} = 1.415 > 1.10$

OK

Wing Wall Design



The critical loading condition for wing wall design is when the backfill is partially saturated.

Ø = 30°   Ca = 0.333

Shear & Moment

P_1 =	0.50 x .333 x 1840 x .3 x.3	=	27 kg
P_2 =	0.333 x 1840 x .3 x 1.70	=	313 kg
P_3 =	0.50 x .333 x 920 x 1.70 x 1.70	=	443 kg
P_4 =	0.50 x 1000 x 1.70 x 1.70	=	1445 kg

			2228 kg

Moment	27 x 1.80	=	48.6 kg-m
	313 x $1.70/_2$	=	266.1 "
	443 x $1.70/_3$	=	251.0 "
	1445 x $1.70/_3$	=	818.8 "

			1384.5 kg-m

For coarse agregate Jhama brick chips:

f^1c = 176 kg/cm² (2500 psi)
fs = 1266 kg/cm² (18,000 psi)
fc = 70 kg/cm² (1000 psi)
k = 0.357
J = 0.881
R = 11 kg/cm² (157 psi)

Moment = 1384.5 kg-m

$$dmoment=\sqrt{\frac{1384.5x100}{11x100}}=11.22cm$$

d = 25 - (8+.5) = 16.5 cm

$$As=\frac{1384.5x100}{1266x\cdot 881x16.5}=7.52cm^2$$

use 12mm Ø @ 15 cm c/c

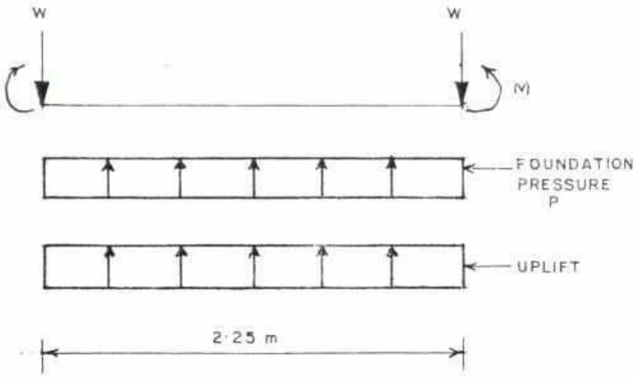
Temp & Distribution Steel

Earth face: .001 x 25 x 100 = 2.5 cm², 10mm Ø @ 30 cm c/c
Exposed face: .002 x 25 x 100 = 5.0 cm², 12mm Ø @ 20 cm c/c

90

Apron Design

Loading condition
Soil behind wingwall
is saturated below
water table & most
above water table



W	=	2 x .25 x 2400	=	1200 kg
Water load	=	1.5 x 2 x 1000	=	3000 kg
Uplift	=	1.95 x 2.50 x 1000	=	4875 kg

$$P = \frac{2x1200 + .25x2.5x2400 + 3000 - 4875}{2.50} = 810 kg/m.$$

Moment from Wing wall:

.50 x .333 x 1840 x.3x.3 x 1.925	=	53 kg-m
.333 x 1840 x .3 x 1.825 x $1.825/_2$	=	306 "
.50 x .333 x 920 x 1.825 x 1.825 x $1.825/_3$	=	310 "
.50 x 1000 x 1.825 x 1.825 x $1.825/_3$	=	1613 "

		1682 kg-m

$$\therefore Moment: C/L: 1682 + 810x2.5x2.5/8 + \frac{4875}{2} x \frac{2.25}{2x2}$$

$$-1200x\frac{2.25}{2} - \frac{3000}{2} x \frac{2.25}{2x2} - \frac{1500}{2} x \frac{2.25}{2x2}$$

= 1681 + 633 + 1371 - 1350 - 844 - 422
= 1069 kg-m (Bottom Tension)

$$As = \frac{1069x100}{1266x \cdot 881x16.5} = 5.81 cm^2$$

$$use. 12mm\phi @ \frac{1.13x100}{5.81} = 19.00 cm. c/c$$

Provide 12mm Ø @ 15 cm c/c as used in wing wall.

Temp & distribution steel - As mentioned above in case of wing wall.

A. COST ESTIMATES OF MASONRY DRAIN FOR 1 KM CONSIDERING W = 2.0 M, H = 2.0 M

Quantity:

a)	Earth work in excavation	:	1000x3.75x0.75 (m) = 2812.5 m^3		
b)	Sand filling	:	1000x3.75x0.30	=	1125
c)	Back filling	:	1000x0.25x2.0x2	=	1000
			1000x.187x1.75x2	=	655
			1000x.5x1x1x2	=	1000

					2655 m^3
d)	75 mm brick soling	:	1000x3.75	=	3750 m^2
e)	Mass concrete	:	1000x3.75xx.175	=	660.63
			1000x2.00x.150	=	300.00

					960.63 m^3
f)	Brick work	:	2x1000x.250x.50	=	250 m^3
			2x1000x.375x.50	=	375 m^3
			2x1000x.50x.50	=	500 m^3
			2x1000x.625x.50	=	625 m^3

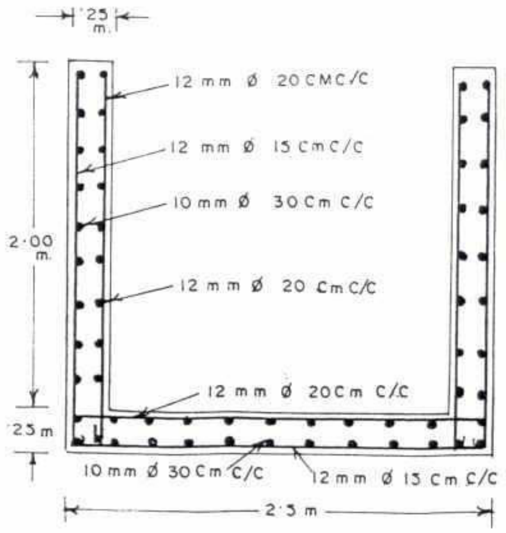
				=	1750 m^3
g)	Plastering	:	1000x2.50x2	=	5000 m^2

Cost:

1)	Earthwork in excavation	:	2813 m^3xTk 29.36	=	Tk. 82,590/=
2)	Sand filling FM>.5	:	2125 m^3x 144.48	=	Tk. 1,62,540/=
3)	Back filling FM>.8	:	2655m^3x181.73	=	Tk. 4,82,493/=
4)	Brick soling 75 mm	:	3750 m^2x 81.76	=	Tk. 3,06,600/=
5)	Mass concrete	:	961 m^3x 2831.21	=	Tk. 27,20,793/=
6)	Brick work	:	1750 m^3x1691.56	=	Tk. 29,60,230/=
7)	Plastering	:	5000 m^2x56.40	=	Tk. 2,82,000/=

					Tk. 69,97,246/=
				Say	Tk. 7 million

Cost Estimates of RCC Main Drain for 1 (one) Km



Section of RCC Darain

Quantity:

a)	Earth work excavation:	1000 x 2.50 x .75	=	1875m³
b)	Sand filling:	1000 x 2.50 x 0.30	=	750m³
	Back filling:	$1000x2x\frac{2+.2}{2}x2$	=	4400m³
c)	75mm brick soling:	1000 x 2.50	=	2500m³
d)	Re-inforced Concrete:	1000 x .25 x 2 x 2	=	1000m³
		1000 x .25 x 2.50	=	625m³

				1625m³

e) Metal works:

0.5% of concrete — .005 x 1625 = 8.125m³

Unit wt. of steel — 7850 kg/m³

∴ Metal works: — 7850 x 8.125 kg = 63781 kg

f) Shuttering:

1000 x 2 x 0.30 =	600m²
1000 x 2 x 2.25 =	4500m²
1000 x 2 x 2.00 =	4000m²
	9100m²

<u>Cost:</u>

1.	Earth work in excavation:	1875 x Tk. 29.36	= Tk. 55,050.00
2.	Sand filling	750 x Tk. 144.48	= Tk. 108,360.00
	Back filling with Sand FM>.8	4400 x Tk. 181.23	= Tk. 799,612.00
3.	Brick soling 75mm	2500 x Tk. 81.76	= Tk. 204,400.00
4.	RCC (1:2:4) 20mm: Pick jhama, sand FM 1.50	1625 x Tk.2918.09	= Tk. 4,741,896.00
5.	Metal works	63781x Tk. 35.25	= Tk. 2,248,280.00
6.	Shuttering 30mm wooden plank with 28 BWG sheet	9100 x Tk. 183.40	= Tk. 1,668,940.00
			Tk. 9,826,538.00

Cost per Km = Tk. 9.827 million
Say Tk. 9.800 million

Total cost for 1.70 Km of RCC drain
1.70 x 98 = Tk. 16.660 million

B. Cost Estimates of Excavation/Re-excavation of Drainage Channel.

Chainage	Ext.L.	D.B.L.	Diff.	Area	Length	Ttl.Volume
Ch 3650:	8.421	8.421	0^m	m^2	$-^m$	m^3
Ch 3700:	8.411	7.774	0.737	8.185	200	1637
Ch 4000:	8.943	7.614	1.329	15.940	350	5579
Ch 4400:	8.960	7.534	1.426	17.310	400	6924
Ch 4800:	8.620	7.454	1.166	13.700	400	5480
Ch 5200:	8.617	7.374	1.243	14.750	400	5900
Ch 5600:	7.827	7.294	0.533	5.756	400	2302
Ch 6000:	7.586	7.214	0.372	3.928	400	1571
Ch 6400:	7.603	7.134	0.469	5.020	300	1506
Ch 6600:	8.631	7.094	1.537	18.914	150	2837
Ch 6700:	7.207	7.074	0.133	1.356	50	68

						33804

Quantity of earth work $\approx$ 34000 m^3

Cost:

Earthwork in excavation and re-excavation of channel

= 34000x16.52 = Tk. 5623601/-
Say 0.6 million

Cost of masonry main drain for 1.7km = Tk. 11.9 million
Cost of RCC main drain for 1.7 km = Tk. 16.6 million

Cost of the earthen drain for 5 km = Tk. 0.6 million

Cost of back filling beyond sand filling shown in Figure 2.1 has not been considered. It is proposed to gradually fill up this area with town garbage/carried earth by the Municipality.

APPENDIX II
(To Chapter 2)

DESIGN OF INTERNAL DRAIN

It is proposed to construct 23.17 km of internal drains. Typical section of the pucca drain is given in Figure 2.2.

Statement of Drains showing length in Km
Summary

Zone	Proposed drain	Existing drain	Combined length
A	5.25	-	5.25
B	3.10	0.34	3.44
C	3.53	0.94	4.47
D	No provision	-	-
E	4.66	1.07	5.73
F	1.68	0.7	2.38
G	2.76	1.05	3.81
H	0.48	-	0.48
I	1.71	0.18	1.89
Total	23.17	4.28	27.45

ঢ২

Length of different internal drains
Zonewise

Zone	Drain	Proposed	Existing
A	A1	0.34	-
	A2	0.20	-
	A3	0.15	-
	A4	0.10	-
	A5	0.17	-
	A6	0.24	-
	A7	0.19	-
	A8	0.62	-
	A9	0.22	-
	A10	0.10	-
	A11	0.12	-
	A12	0.09	-
	A13	0.21	-
	A14	0.22	-
	A15	0.30	-
	A16	0.23	-
	A17	0.74	-
	A18	0.14	-
	A19	0.21	-
	A20	0.29	-
	A21	0.08	-
	A22	0.11	-
	A23	0.06	-
	A24	0.12	-
Total		5.25	-

82

Zone	Drain	Proposed	Existing
B	B1	0.72	0.26
	B2	0.08	-
	B3	0.08	-
	B4	0.08	-
	B5	0.12	-
	B6	0.08	-
	B7	-	0.08
	B8	0.17	-
	B9	0.04	-
	B10	0.16	-
	B11	0.14	-
	B12	0.20	-
	B13	0.13	-
	B14	0.14	-
	B15	0.06	-
	B16	0.24	-
	B17	0.04	-
	B18	0.03	-
	B19	0.06	-
	A20	0.08	-
	B21	0.45	-
Total		3.10	0.34

Zone	Drain	Proposed	Existing
C	C1	0.12	-
	C2	0.08	-
	C3	0.10	-
	C4	0.12	-
	C5	0.28	0.29
	C6	0.10	-
	C7	0.06	-
	C8	0.04	-
	C9	0.15	-
	C10	0.09	-
	C11	0.25	-
	C12	0.41	0.34
	C13	0.15	-
	C14	0.15	-
	C15	0.12	-
	C16	0.13	-
	C17	0.36	0.08
	C18	0.19	0.16
	C19	-	0.04
	C20	-	0.03
	C21	0.16	-
	C22	0.32	-
	C23	0.15	-
Total		3.53	0.94
D	No provision for drain		

Zone	Drain	Proposed	Existing
E	E1	0.06	-
	E2	0.15	-
	E3	0.06	-
	E4	0.08	-
	E5	0.10	-
	E6	0.10	-
	E7	0.14	-
	E8	0.10	-
	E9	0.26	-
	E10	0.27	-
	E11	0.22	-
	E12	0.06	-
	E13	0.08	-
	E14	0.35	-
	E15	0.14	-
	E16	0.13	-
	E17	0.23	-
	E18	0.13	-
	E19	0.13	-
	E20	-	0.12
	E21	-	0.14
	E22	0.10	-
	E23	0.14	-
	E24	0.22	-
	E25	0.07	-
	E26	0.06	-
	E27	0.20	-
	E28	0.09	-
	E29	-	0.06
	E30	0.26	-
	E31	0.19	-
	E32	-	0.12
	E33	-	0.06
	E34	-	0.51
	E35	-	0.06
	E36	0.10	-
	E37	0.08	-
	E38	0.08	-
	E39	0.28	-
Total		4.66	1.07

67

Zone	Drain	Proposed	Existing
F	F1	0.20	0.70
	F2	0.23	-
	F3	0.35	-
	F4	0.45	-
	F5	0.45	-
Total		1.68	0.70

Zone	Drain	Proposed	Existing
G	G1	-	0.29
	G2	0.19	-
	G3	-	0.08
	G4	0.45	-
	G5	1.17	-
	G6	0.08	-
	G7	0.87	-
	G8	-	0.12
	G9	-	0.56
Total		2.76	1.05

Zone	Drain	Proposed	Existing
H	H1	0.48	-
Total		0.48	-

Zone	Drain	Proposed	Existing
I	I1	-	0.03
	I2	0.06	-
	I3	-	0.03
	I4	-	0.04
	I5	0.23	0.08
	I6	0.16	-
	I7	0.11	-
	I8	0.03	-
	I9	0.09	-
	I10	0.09	-
	I11	0.04	-
	I12	0.04	-
	I13	0.09	-
	I14	0.03	-
	I15	0.11	-
	I16	0.09	-
	I17	0.18	-
	I18	0.08	-
	I19	0.07	-
	I20	0.15	-
	I21	0.06	-
Total		1.71	0.18

69

Cost Estimates of Pucca Drain for one kilometre considering
W = 1.00, H = 1.00

Quantity:

a) Earthwork in excavation	:	1000x2.1x.75 (m)	=	1575 m^3
b) Sand filling	:	1000x1.95x0.30	=	585
c) Back filling	:	1000x.250x1.20x2	=	600
	:	1000x.5x.5x2	=	500

				1100 m^3
d) Brick work	:	1000x.25x.50x2	=	250
		1000x.375x.50x2	=	375
				--------
				625 m^3
e) 75 mm Brick soling	:	1000x1.95	=	1950 sq m
f) Mass concrete (1:2:4)	:	1000x1.95x.125	=	243.75
		1000x1.00x.125	=	125.00

				368.75 m^3
g) Plastering	:	1000x1.50x2	=	3000 m^2

<u>Cost</u>:

a)	Earthwork in excavation	:	1575 m^3x29.36	= Tk. 46,242/=
b)	Sand filling FM>.50	:	585 m^3x144.48	= Tk. 84,520/=
c)	Back filling FM >.8	:	1100 m^3x181.23	= Tk. 1,99,353/=
d)	Brick soling 75 mm	:	1950 m^2x81.76	= Tk. 1,59,432/=
e)	Brick work (1:4)	:	625 m^3x1691.56	= Tk. 10,57,225/=
f)	Mass concrete (1:4:8) 25 mm stone chips	:	368.75x2831.21	= Tk. 10,44,009/=
g)	Plastering (1:4)	:	3000 m^2x56.40	= Tk. 1,69,200/=
				Tk. 27,59,981/=
			Say	Tk. 2.76 million

Cost of 23.17 km of Internal Pucca Drain = Tk 64 million

70

APPENDIX III
To Chapter 2)

DESIGN OF DRAINAGE OUTLET STRUCTURE

Five drainage outlet structures have been proposed to drain out the water of zone A (DR1 & DR2), C (DR3 & DR4) and G (DR5) partially or fully to Lohajang river during high local rainfall (Figure 2.3). The main purpose of the outlet structures is to discharge the accumulated water of the drainge channels to Lohajang river. The structures will also prevent the flood water from entering into the channels when the water level of Lohajang river is higher than the channels water level and may start drawing again when the situation reverses. In case of extreme drainage congestion, pumping out excess water to the river with the help of portable pumps may have to be used to ease the situation. The water level of the Lohajang river is mainly controlled by the main Jugini inlet operation rule and by the possible backflow from the area south of the compartment. The approximate cost of each structure will be Tk. 1 million.

The water of zone B, E and F will be drained to the main drainage channel through 5 outlets as shown in the map as 0-1 to 0-5. The sill level of the outlets may be fixed at the bed level of the outfall channel. Part of zone G, zone H and zone I will be drained to the ditches through link drain as shown in the map.

Catchment area of the drainage outlets and outlets to Tangail khal are stated below.

Catchment Area in ha

Drainage Outlet to Lohajang river			Outlet to Tangail khal		
DR-1	=	35.55	0-1	=	29.37
DR-2	=	69.75	0-2	=	19.48
DR-3	=	32.99	0-3	=	31.64
DR-4	=	37.83	0-4	=	79.73
DR-5	=	46.51	0-5	=	95.29
		222.63			203.51

Zone D	=	44.51
Zone H	=	52.98
Zone I	=	105.46
		629.09

Assuming 1 in. (25.4mm) rainfall during pre monsoon period and 3 in. (76.2mm) rainfall during the monsoon period,the runoff of the catchment area has been computed as 2.95×10^{-3} cumec during pre-monsoon and 8.64×10^{-3} cumec during monsoon period. The monsoon period runoff of the different outlets in cumec will be as below:

DR-1	=	0.307	0-1	=	0.254
DR-2	=	0.603	0-2	=	0.168
DR-3	=	0.285	0-3	=	0.273
DR-4	=	0.327	0-4	=	0.240
DR-5	=	0.402	0-5	=	0.823
		1.924 Cumec			1.758 Cumec

APPENDIX IV
(To Chapter 2)

DESIGN OF INLET STRUCTURE

The proposed inlet structure will be located on the left bank of Lohajang river near the food godown adjacent to Eidgah. This structure is provided at the offtake of main drainage channel to flush the drainage channel during flood season. The main drainage channel passes through the town area and discharges the rain water collected through secondary drain to Darun Beel which ultimately drains into Lohajang river through Nagar Jalfai Regulator.

The purpose of proposed inlet regulator is to allow water entering the main channel from Lohajang river for flushing the channel upto desired level. The gate of the structure will be closed when the water level of Lohajang river reaches the urban area flood level ie average +11.00 m PWD, max$^{\underline{m}}$ + 11.75 m PWD. The structure will be a one-vent regulator, the capacity of which is approximately 5 cumec.

A typical drawing of the structure is shown in Figure 2.4. The approximate cost of the structure will be Tk. 3 million.

ঠL

PROPOSED BUDGET FOR VARIOUS INTERVENTIONS

	Items	Quantity (Nos.)	Cost (in million Tk.)
1.	Excavation/Re-excavation of Drainage channel		
	a) Main Drain	1.7 km	11.90/16.60
	b) Earthen Drain	5.0 km	0.64
	c) Masonry Internal Drain	23.17 km	61.40
2.	Drainage Outlets	5 Nos	5.00
3.	Inlet Structure	1 No	3.00
	Total		81.94/86.70

- If main drain is built with RCC the cost will increase by Tk. 4.76 million
- O&M cost will be approximately 3% of the capital cost.