Government of the People's Republic of Bangladesh

Ministry of Irrigation, Water Development and Flood Control
Flood Plan Coordination Organization

BANGLADESH ACTION PLAN FOR FLOOD CONTROL

COMPARTMENTALIZATION PILOT PROJECT (FAP 20)

SIRAJGANJ CPP INTERIM REPORT

ANNEX 2 : MATHEMATICAL MODELLING

(FINAL DRAFT)

June 1993

Euroconsult/Lahmeyer International/Bangladesh Engineering & Technological Services/House of Consultants

under assignment to

DIRECTORAAT GENERAAL INTERNATIONALE SAMENWERKING
Government of the Netherlands
and
KREDITANSTALT FÜR WIEDERAUFBAU
Federal Republic of Germany

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SIRAJGANJ CPP INTERIM REPORT

ANNEX 2: MATHEMATICAL MODELLING

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

1. Introduction

The objective of the Compartmentalization Pilot Project (CPP) FAP 20 is "*...to establish appropriate water management systems for the development of protected areas so that criteria and principles for design, implementation and operation can be made available for the Action Plan*. The integrated water management is the controlled quantitative and qualitative usage of water, including early, late and deep flooding, rainfall and ground water in agriculture, fisheries, transport, sanitation and for domestic and industrial purposes. Through controlled flooding and controlled drainage, the compartmentalization concept can be realised.

Controlled flooding and drainage, meaning that, while some of the area will be protected against undue flooding by means of embankments, facilities will be created to control the flow water entering into or flowing out of the area, in accordance with requirement of the local or regional water management policies.

Compartmentalization, meaning that some of the area or region is sub-divided into smaller water management units, each having own policies and facilities for water management.

In order to test the concept, FAP 20 selected three different areas namely Tangail, Sirajganj and Jamalpur. Mathematical models are, now a days used as planning tool and for that purpose a model of the Sirajganj Compartment has been developed in order to assess the impact of controlled flooding and drainage on the compartment area.

1.1 MIKE11 Model

MIKE11, a commercially available software package which contains a number of process modules developed by the Danish Hydraulic Institute (DHI) is used by the Surface Water Modelling Centre of the Water Resources Planning Organization (WARPO) and is taken as standard software for unsteady flow simulation in Bangladesh.

MIKE11 hydrodynamic moudlues is an implicit, finite difference model for the computation of unsteady flows in rivers and estuaries.

MIKE11 hydro-dynamic module applied with dynamic wave description solves vertically integrated equations of conservation of continuity and momentum (Saint Venant eqautions) based on the following assumptions:-

* water is incompressible
* bottom slope is small
* wave lengths are large compared to water depth.
* flow is sub-critical

Model can be applied to assess engineering interventaion. The accuracy mainly depends upon quality of data. In this stage, maximum deviation can be +- 15 cm.

2. Related Modelling Activities

In North West Region the following modelling activities have been identified:

North West Regional Study (FAP-2) model

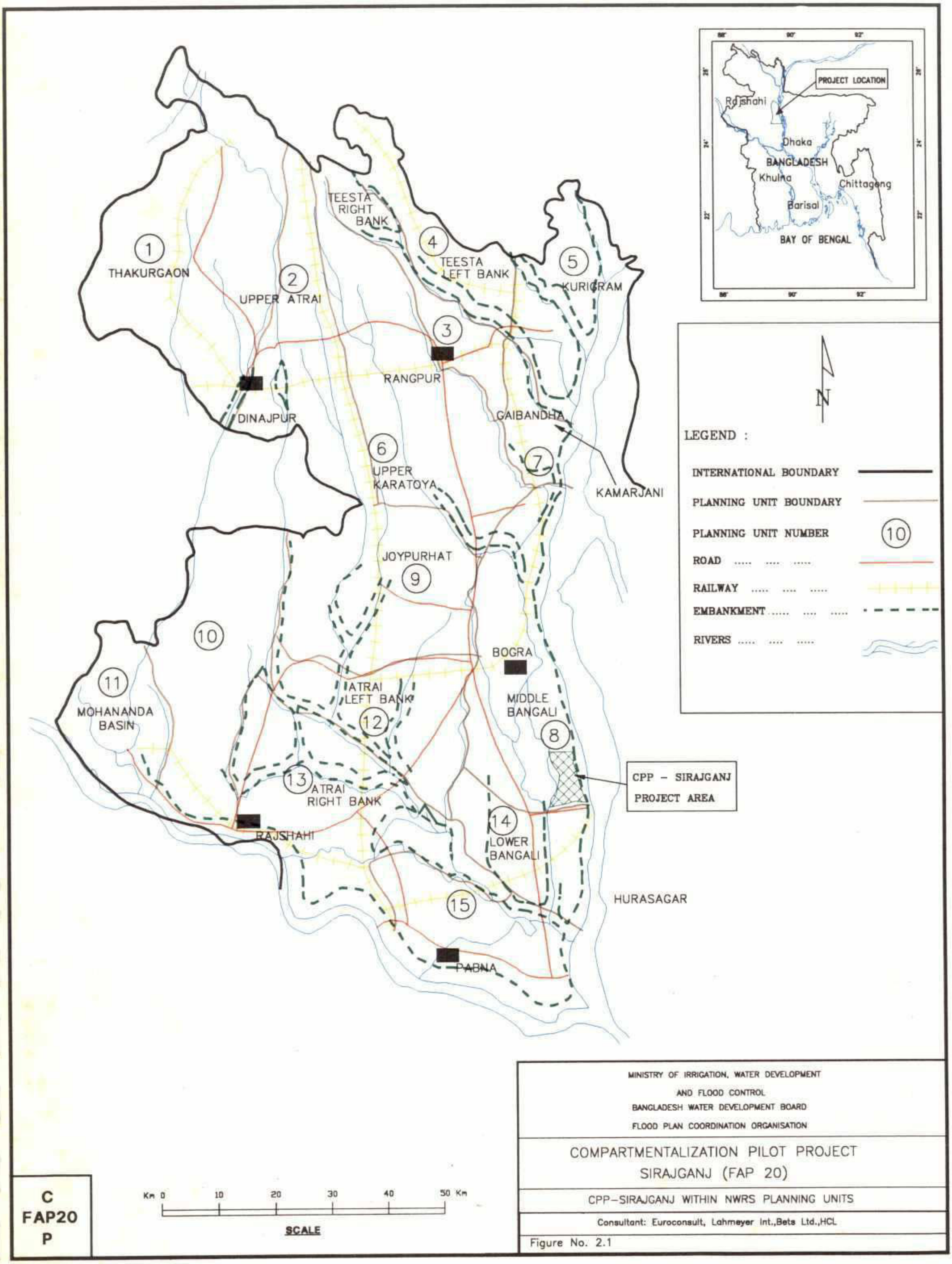
FAP-2 has completed the modelling study for the whole North West Region. The CPP Sirajganj compartment falls within their planning unit no 8. Fig. 2.1 shows the North West Regional Study planning units. The NWR Model includes the Ichamati, Bangali, BRE Breach and Karotoya rivers. The BRE breach information and the relevent part of the Ichamati river cross-sections data were collected from the NWRS model and have been used in the Sirajganj model.

Flood Management Modelling FAP 25

The Flood Management Modelling started from October 1992. In their study, the MIKE11 model will be
integrated with a Digital Elevation Model (DEM) in order to assess and display the flooding depth, duration and spreading. FAP 25 selected Tangail as their pilot project.

Surface Water Modelling Centre (SWMC)

In the SWMC, four regional studies are complete. The North West Regional Model includes the Sirajganj area. Although it is a regional model but in terms of BRE breach impact analysis and regional developement, relevent information is received from SWMC.



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COMPARTMENTALIZATION PILOT PROJECT SIRAJGANJ (FAP 20)

CPP-SIRAJGANJ WITHIN NWRS PLANNING UNITS

Consultant: Euroconsult, Lahmeyer Int.,Bets Ltd.,HCL

Figure No. 2.1

3.0 Concept of the Project

The compartmentalization concept can be achieved through controlled flooding and controlled drainage. The Fig. 3.1 shows the concept of compartmentalization.

3.1 Controlled Flooding and Drainage

The principles of controlled flooding is to allow natural flooding of floodplain land to occur without causing damage to crops, fisheries, infrastructure and urban land. Within flood protection compartments, intake regulators and drainage sluices will manage the control of the timing, depth and duration of the flooding on the land during the rainy season within limits that ensure secure growing conditions for the major agriculture and fisheries. Controlled flooding will be effected by opening and closing of the regulators and sluices in embankements at critical periods of the agricultural and fisheries calenders.

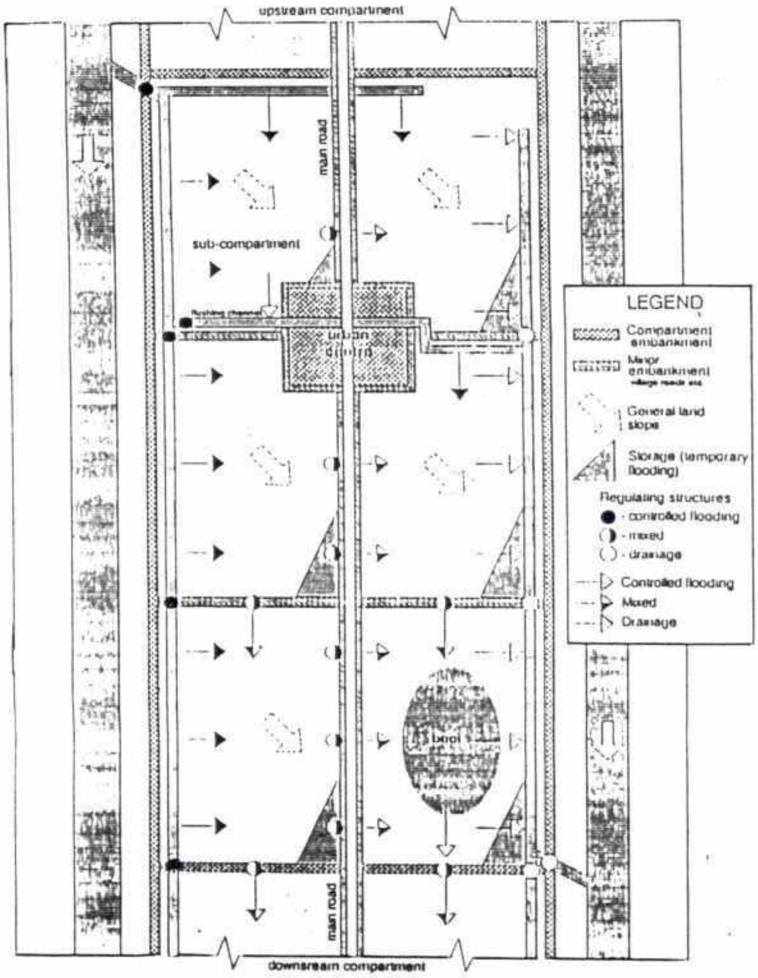


Fig 3.1 Schematic Arrangement of Controlled flooding and Drainage at compartment level

When excessive monsoon rainfall over a compartment coincides with high river stages, it is not possible to evacuate excess floodwater through embankment drainage sluices for a number of days or even weeks. Extensive damage might be caused to the crops. Gradual release of these excess water from one compartment or sub-compartment to another is termed as controlled drainage.

3.2 Compartmentalization

The concept of the compartmentalization concept as defined in the Inception report

> *A compartment is an area in which effective water management particularly through semi-controlled flooding and controlled drainage, is made possible through structural and institutional arrangement. Comaprtmentalization is linked to area development with sound water management as the main agent. A compartment will be sub-divided into sub-compartments and operational water management units.*

The BRE is supposed to give flood protection from Brahmaputra river flooding but in some years it breachs and causes severe damage to crops and infra-structures. Along the Ichamati river, a proposed embankment can prevent flooding from Ichamati river. The peripheral structures will be used to control the floods and drainage. The watermanagement will be developed taking manageable unit.

4.0 Description of Sirajganj Compartment

The Sirajganj area is located in the north west region of Bangladesh and situated on the right bank of the Brahmaputra river. The compartment has a total area of 12057 ha. Its location and its principal features and extent are shown in Fig. 4.1.

The compartment is bordered in the east by the worlds great river the Brahmaputra but project boundaries follows Brahmaputra Right Embankemnet (BRE) between Banglabazar in the north and Sirajganj town in the south. The southern boundaries follows new Bogra road. The Ichamati river forms the western boundary. The northern boundary follows part of the southern bank of Ichamati khal and from Bagbati ghat, the boundaries follow the Ichamati branch.

Table 4.1 Sub-compartment area (based on areal photos and recent GPS Survey and the Area computed by GIS).

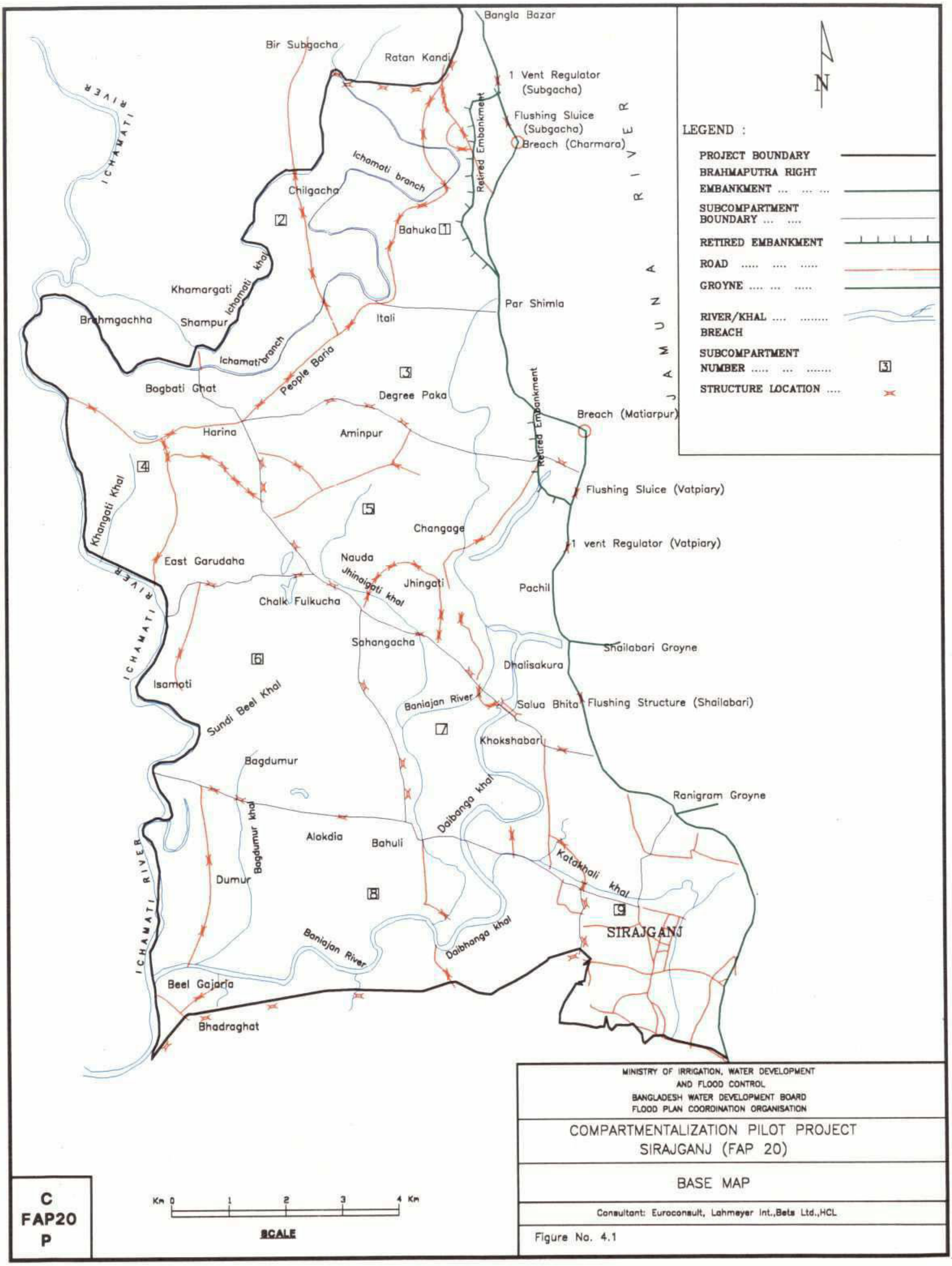
Sub-Compartment No (1)	Gross Area (ha.) (2)	Net Cultivable Area (ha) (3)	Homestead (ha) (4)	Water bodies (ha) (5)
1	873	750	101	22
2	797	709	83	5
3	1061	893	160	8
4	1371	1132	223	16
5	2012	1656	294	62
6	1455	1196	238	21
7	1283	1071	169	43
8	2319	1981	259	79
9	886	191	685	10
Total	12057	9579	2212	266
% of Total		79.5	18.3	2.2

Column 3 = Column 2 - Homestead - Waterbodies

4.1 Topography and Soils

The area slopes from north-east towards south-west. The land levels vary between 10.9 m to 14.5 m PWD. The low lying area is observed in the mid of the compartment connecting Par Simla to Pangashi. The characteristic topographical feature of the area is its flatness. As a consequences of the low gradients, the rivers and drainage channels within the project area are generally heavily meandered and braided.

Based on the findings of a 1976 report (DSS, 1976 (revised)) five soils associations are found in the project area. Soils are mainly silty loam to silty clay loam along the Brahmaputra but soils inside the compartments are fine sandy loam, silt loam and silty clay are found.



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COMPARTMENTALIZATION PILOT PROJECT
SIRAJGANJ (FAP 20)

BASE MAP

Consultant: Euroconsult, Lahmeyer Int., Bets Ltd., HCL

Figure No. 4.1

C
FAP20
P

4.2 Climate

There are two main seasons, separated by transition season. The monsoon starts from July/August until September and show typical monsoon chracteristics of heavy rain and very high humidity. The post monsoon season (October - November) is sunny and relative cool, with only occasional scattered showers.

4.3 River System

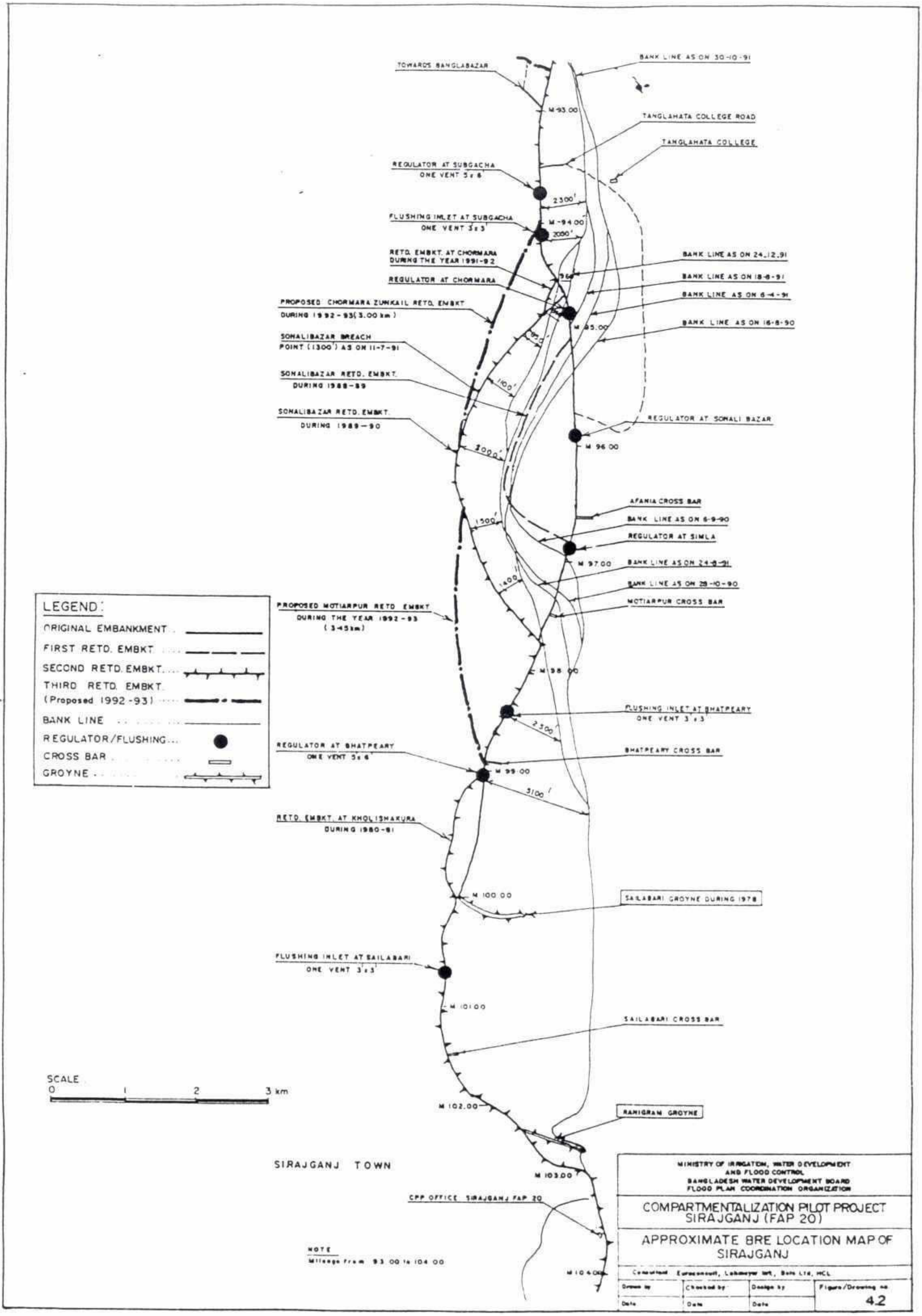
The project area is bounded, and effectively defined, by the Jamuna (Brahmaputra) embankment to the east and the western boundary is bounded by the Ichamati river. The major channels observed in the project area are Baniajan khal, Doibhanga khal, Bagdumur khal and Jhinaigati khal. Most of these channels lost their conveyance due to construction of the BRE which closes most of the channel mouth.

4.4 Floodplain flow

Floodplain plays an important role in terms of tranport of weater. Most of the floodplain flow occurs during the BRE breach. As most of the channels lost their conveyance, spilling took place and the floodplain act as an channel to carry water. But in case of normal flooding i.e. the rainfall-runoff flow, water logging take place. The detailed flow pattern shows in the Fig. 5.1.

4.5 BRE Breach

The BRE is one of first FCD projects in Bangladesh. The Brahmaputra originates from the northern slopes of the Himalyas in Tibet. The BRE has been orginally built at a length of approx. 200 km from Hurasagar to Kamarjani between 1957 and 1968. The progressive retirement of the BRE demonstrates by the severity of the natural bank erosion of the Brahmaputra river. It is clearly shown that the most serious flooding problems occur along the Brahmaputra due to breaches in the BRE. Along the entire BRE, the Kazipur reach is one of the most unstable sections. It is reported that there are frequent breaches and embankemnt retirements in this section and because the land slopes away from the embankment, the breaches cause severe damage. The BRE breach either from the north or inside the project influences hydraulic regimes tremendously. The Fig. 4.2 shows the location of the BRE Breach and embankment retirement within the Sirajganj compartment.



TOWARDS BANGLABAZAR
BANK LINE AS ON 30-10-91
M-93.00
TANGLAHATA COLLEGE ROAD
TANGLAHATA COLLEGE
REGULATOR AT SUBGACHA
ONE VENT 5x6'
2300'
FLUSHING INLET AT SUBGACHA
ONE VENT 3x3'
M-94.00
2000'
RETD. EMBKT. AT CHORMARA
DURING THE YEAR 1991-92
BANK LINE AS ON 24.12.91
REGULATOR AT CHORMARA
BANK LINE AS ON 18-8-91
BANK LINE AS ON 6-4-91
PROPOSED CHORMARA ZUNKAIL RETD. EMBKT
DURING 1992-93(3.00 km)
M 95.00
BANK LINE AS ON 16-8-90
SONALIBAZAR BREACH
POINT (1300') AS ON 11-7-91
1100'
SONALIBAZAR RETD. EMBKT.
DURING 1988-89
SONALIBAZAR RETD. EMBKT.
DURING 1989-90
REGULATOR AT SONALI BAZAR
M 96.00
2000'
AFANIA CROSS BAR
BANK LINE AS ON 6-9-90
1500'
REGULATOR AT SIMLA
M 97.00
BANK LINE AS ON 24-8-91
1400'
BANK LINE AS ON 28-10-90
MOTIARPUR CROSS BAR
PROPOSED MOTIARPUR RETD EMBKT
DURING THE YEAR 1992-93
(3.45km)
LEGEND:
ORIGINAL EMBANKMENT
FIRST RETD. EMBKT.
SECOND RETD. EMBKT.
THIRD RETD. EMBKT.
(Proposed 1992-93)
BANK LINE
REGULATOR/FLUSHING
CROSS BAR
GROYNE
M 98.00
FLUSHING INLET AT BHATPEARY
ONE VENT 3'x3'
2300'
REGULATOR AT BHATPEARY
ONE VENT 5x6'
BHATPEARY CROSS BAR
M 99.00
3100'
RETD. EMBKT. AT KHOLISHAKURA
DURING 1980-81
M 100.00
SAILABARI GROYNE DURING 1978
FLUSHING INLET AT SAILABARI
ONE VENT 3'x3'
M 101.00
SAILABARI CROSS BAR
SCALE
0 1 2 3 km
M 102.00
RANIGRAM GROYNE
SIRAJGANJ TOWN
M 103.00
CPP OFFICE SIRAJGANJ FAP 20
NOTE
Mileage from 93.00 to 104.00
M 104.00
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APPROXIMATE BRE LOCATION MAP OF
SIRAJGANJ
Consultant Euroconsult, Lahmeyer Int, Bele Ltd, HCL
Drawn by
Checked by
Design by
Figure/Drawing no
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Date
Date

5. Sirajganj Compartment Model Development

5.1 Schematization of the Hydraulic System

The development of the CPP Sirajganj compartment Model has the primary objectives:

i) to test the compartmentalization concept, controlled flooding and controlled drainage.

ii) to assess the effectiveness of drainage and flood control measures; and

iii) to develope the water management system.

In terms of the model schematization, the last objective basically differs from first two. In water management project, the flow follows distinct routes through a canal system. Flow can therefore be described very well in a one-dimensional flow. Moreover, the importance of channel follows from the irrigation demands and supplies. However, these same channels may be relatively irrelevant in studing flood control problems. During the monsoon, when most of the area is inundated by half a meter depth in an average year, the channels contribute relatively little to the exchange of water masses between two ares. Most of the flow takes place as over land flow through the paddy fields at very low velocities. Since compartmentalization mainly aims at to flood water management, the present schematization is sufficient upto the second objective and could be used for providing the boundary data for sub-compartment level model.

Also another important diffrence between i), ii), and iii) is the structural interventations which influences a wider area during the flood season than the dry period. So the schematization included an area larger than the project area to avoid the structural influence on the boundaries.

The schematization addresses the distinct features of the compartmentalization concept i.e combination of channel and the floodplain flow and retention. So the channel flow and floodplain flow are based on the actual linkage and interaction between channel and floodplain. The flooding and draining pattern are shown in Fig. 5.1. Considering the above points, two different types of model schematization are used depending on whether it is predominantly a spilling or a drainage area. In spilling areas, natural levees are formed along the rivers by sedimentation due to the sudden reduction in the flow velocity of the entering water. In predominant drainage areas, these levees are not present. The principle difference between the two situations is shown in Fig. 5.2. In a typical drainage area, it is reasonable to assume that the water level is the same in the river and on the floodplain.

Drainage Spilling

Fig. 5.2 Classification for Floodplain and River based on Drainage and Spilling

Hence floodplain storage can thus directly be included in the modelled river cross-section, and only one model h-point is required to describe the water level over the whole area. In a typical spilling area, the water levels in river and floodplain might differ due to the presence of a levee. In case of only over land flow, a channel is introduced to represent the flow. The schematization is shown in Fig. 5.3.

The existing structures (bridges and culverts) are taken into schematization if significantly contribute to the general flow pattern.

The same schematization is used to raise the 'with project' situation with some modification. The BRE breach is taken into account by introducing a channel. The cross-section and boundary condition is collected from NWRS.

5.2 Selection of Channels in the Schematization

A schematization of the model is shown in Figure 5.3. The Sirajganj model schematization is comprised of 25 channels connected at 26 nodes (a node is the meeting point of two or more channels). These channels form the basis of the hydraulic connections. The selection of the channels mainly

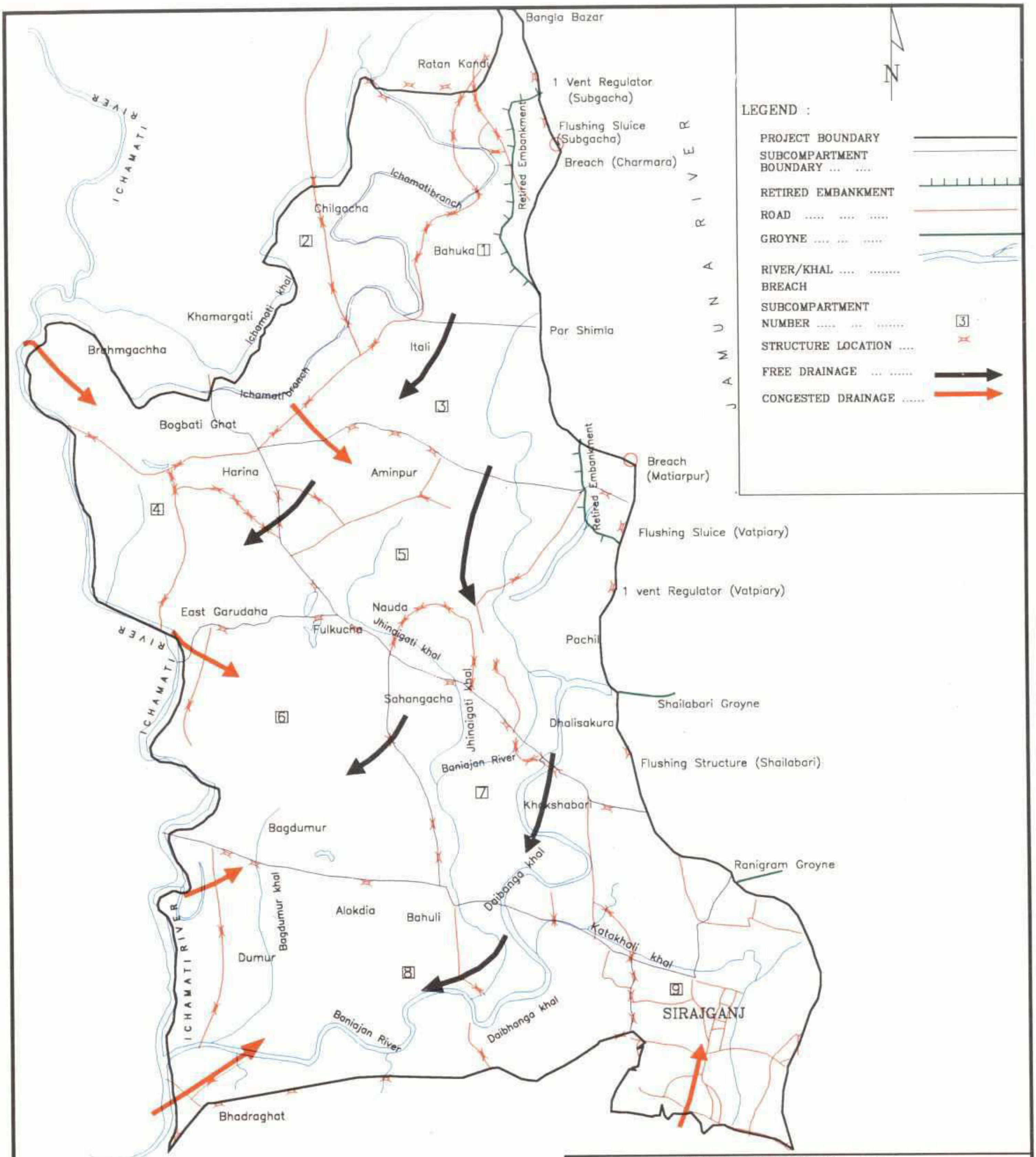
depends on the following criteria :

- the importance of the channel in terms of flooding.

- the importance of the channel in terms of drainage.

The most important channels that have been included are : Baniajan, Doibhanga, Jhinaigati, Bagdumur, Katakhali khal. Apart from the Ichamati river, Khal and Branch, there are number of floodplain flow channels connecting the rivers. The floodplain channels are named by **Ch**. The rivers included in the model are shown in Table 5.1.

Structures are schematized with H-points immediately upstream and downstream of the structure, and a Q-point at the location of the structure. Four existing regulators have been included in the model.



C
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Km 0 1 2 3 4 Km

SCALE

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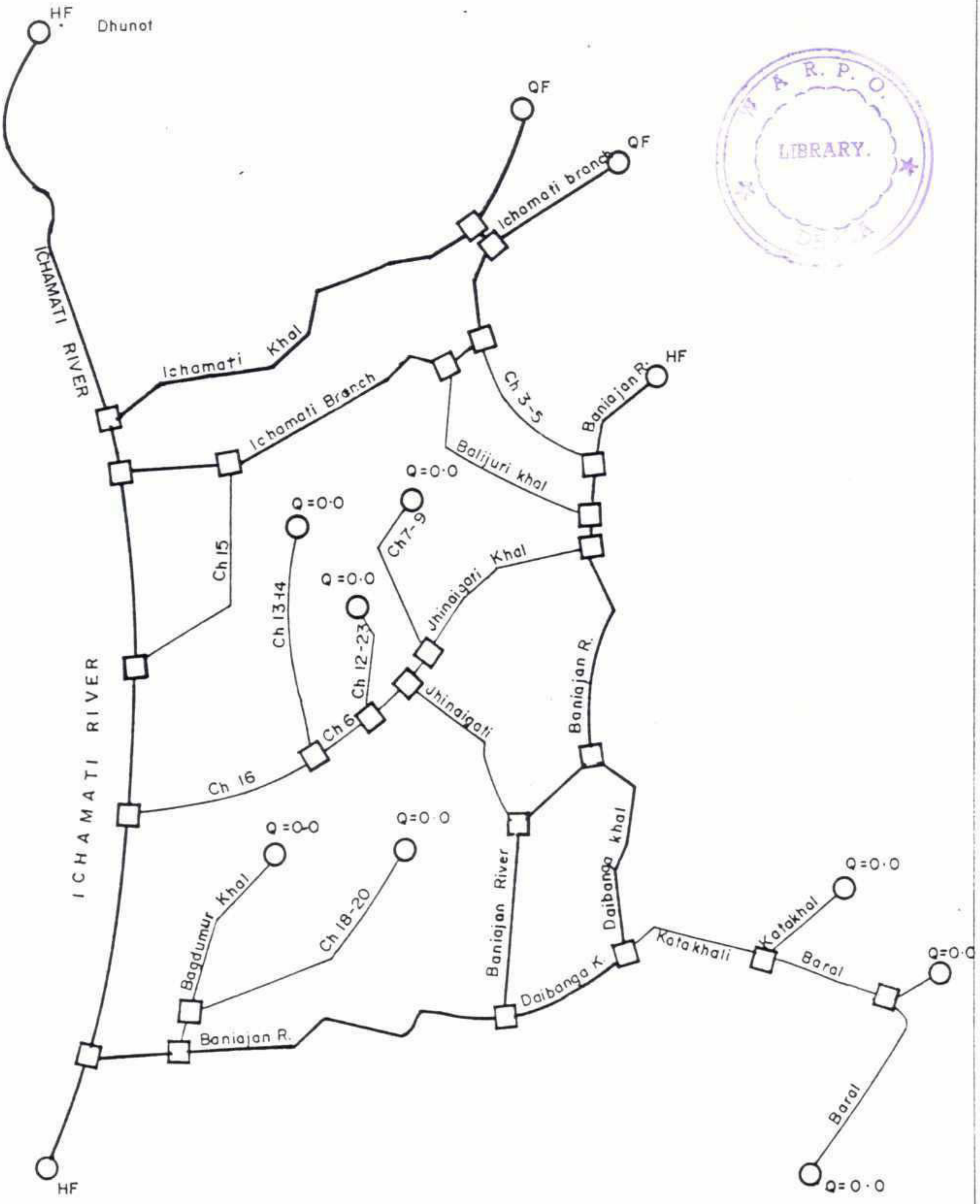
ACTUAL SITUATION
FREE DRAINAGE
CONGESTED DRAINAGE

Consultant: Euroconsult, Lahmeyer Int.,Bets Ltd.,HCL

Figure No. 5.1



LEGEND:-

○ BOUNDARY

□ NODE

Ch15 FLOODPLAIN CHANEEL

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SCHEMATIZATION MAP OF SIRAJGANJ

Consultant: Euroconsult, Lahmeyer Int, Bets Ltd, HCL

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Date:	Date:	Date:	5.3

Table 5.1 Channels included in the model

Channel Name	Length	Start at	End at
Ichamati river	21.375	Boundary	Boundary
Ichamati khal	11.0	Boundary	Ichamati River
Ichamati Branch	19.0	Boundary	Ichamati River
Baniajan	20.75	Boundary	Ichamati River
Doibhanga	9.90	Baniajan	Baniajan
Jhinaigati	8.0	Baniajan	Baniajan
Bagdumur	4.5	Boundary	Baniajan
Katakhali	2.4	Boundary	Baniajan
Baral	5.0	Baniajan	Boundary
Ch15	2.8	Boundary	Ichamati River
Ch16	4.05	Jhinaigati	Ichamati River
Ch18-20	5.756	Boundary	Bagdumur
Ch7-9	3.037	Boundary	Jhinaigati
Ch3-5	2.878	Ichamati Branch	Baniajan
Ch1	0.8	Boundary	Ichamati Branch
Ch12-23	2.7180	Boundary	Ch16

5.3 Model Boundaries

The Sirajganj model boundary is based on the following criteria :-

- the model should be able to predict the impact of the external areas;

- preferably, discharge boundaries should be applied upstream and water level boundaries downstream.

- The boundaries should be selected at locations where the hydraulic conditions are not affected by the future project condition.

The upstream boundary of the model in Ichamati river is extended upto the Dhunot. Because discharge data are not available a time dependent water level is used. A sensitivity analysis is carried out in this respect. The downstream boundaries are taken in the Ichamati river at Nalkasengati. The upstream boundaries of the Ichamati khal and Ichamati Branch is based on the runoff generated up of this boundary points.

Table 5.2 Boundary Locations and Type

River	Upstream Boundary		Downstream Boundary	
	Type	Name of Station	Type	Name of Station
Ichamati river	Water level	Dhunot	Water level	Nalkasengati
Ichamati Branch	Discharge	Upper Catchment		
Baniajan	Discharge	Q=0.0		
Bagdumur	Discharge	Q=0.0		
Ichamati khal	Discharge	Upper Catchment		
Katakhali Khal	Discharge	Q=0.0		
Ch18_20	Discharge	Q=0.0		
Ch13_14	Discharge	Q=0.0		
Ch7_5	Discharge	Q=0.0		

There are number of internal boundaries which are either generated by the rainfall-runoff model or assign Q=0.0. The boundaries and the type of boundary used are shown in Table 5.2.

To simulate the BRE breach, another boundary is introduced in Jamuna (Kazipur).

5.4 Data Requirement for the Hydrodynamic Model

The following data are required for the model set-up:

- Surface water level data
- Topographic data

Surface Water

In order to have a comprehensive picture of the flooding and drainage pattern of Sirajganj Compartment, 19 water level measuring stations were installed in May 1992. All the gauges were connected with a fixed reference level (PWD bench mark). The 1992 year is a dry year and hence no floodplain flow occur but only the reflection of rainfall-runoff are observed.

In 1993, the same number of water level gauges were installed to obtain hydrographs in both floodplain and river. Fig. 5.4 shows the location of the measuring water level stations of 1992 respectively.

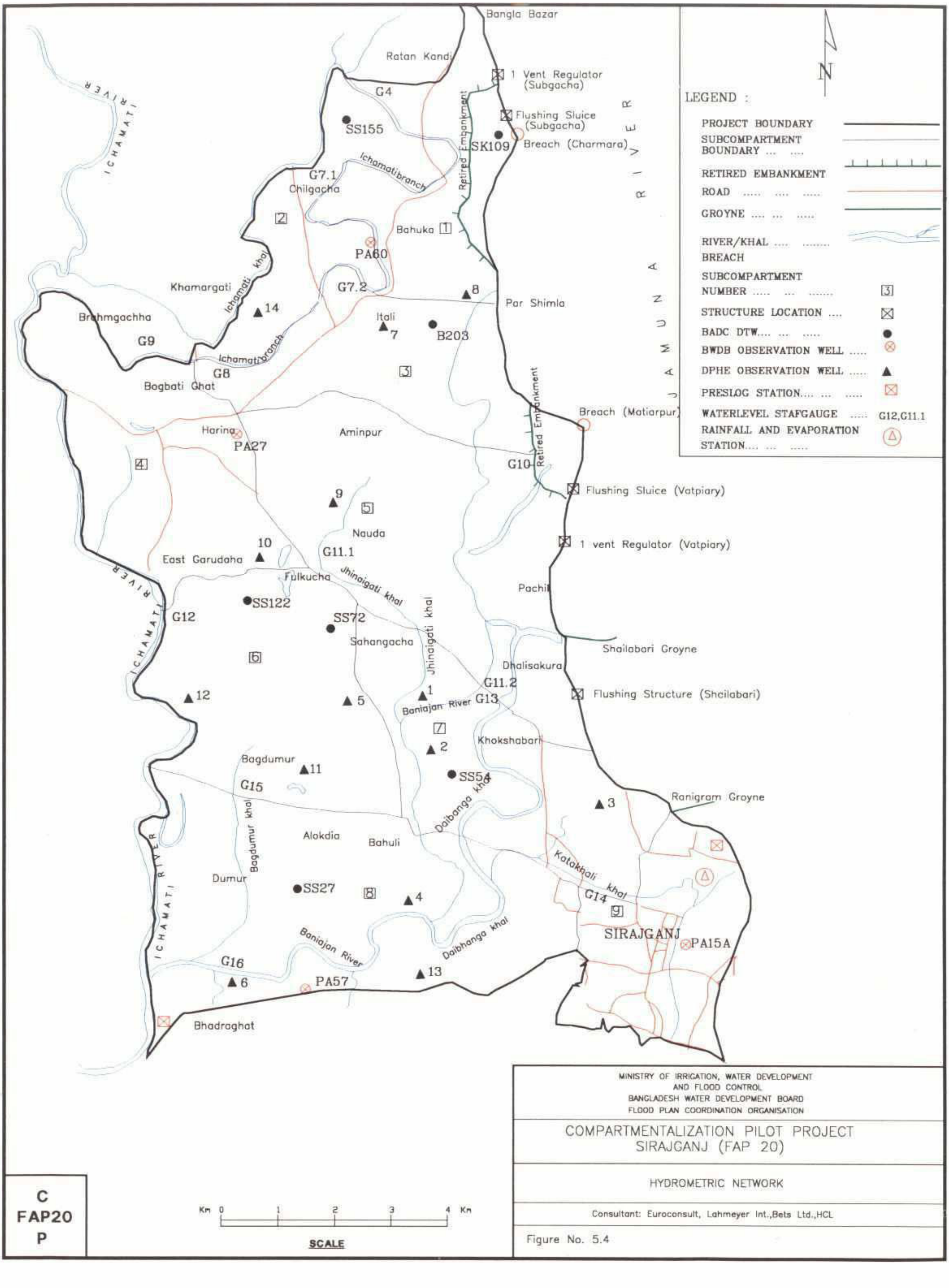
Topography

The prominent channels within the compartment were surveyed from November 1992 onwards and subsequently used in the model. The relevant cross-sections of Ichamati river (northern portion) and BRE breach cross-section have been collected from Surface Water Modelling Center (SWMC) and North West Regional Study (FAP 2). The number of cross-sections used in different channels are shown in Table 5.3.

The inclusion of the floodplain and its proper description is important since it act both as storage and transport (flow). The floodplains are mostly included in the model either as extensions of channel cross-sections or given as cross-section to simulate both the storage and transport function depending on the flow type (Section). The floodplain data are taken from the water development map from 1964 (scale: 8 inch to a mile; contour interval 0.3 m). From the data, area-elevation curves for every sub-compartment and catchment are prepared.

Table 5.3 Number of cross-sections used in the model

Name of the River	No of cross-sections	Total Length
Ichamati river	10	21.835
Ichamati Branch	13	19.302
Ichamati Khal	12	11.480
Baniajan	24	20.850
Doibhanga	11	9.90
Jhinaigati	9	8.314
Bagdumur	6	4.50
Ch1	13	2.0
Ch15 (Kagati Khal)	3	2.80
Ch12_23	6	2.718
Ch16 (Fulkocha Khal)	5	4.05
Ch18-20 (Gazaria khal)	7	5.756
Ch7_9	4	3.037
Ch3_5	11	2.878
Katakhali Khal	5	2.40
Baral	3	5.0



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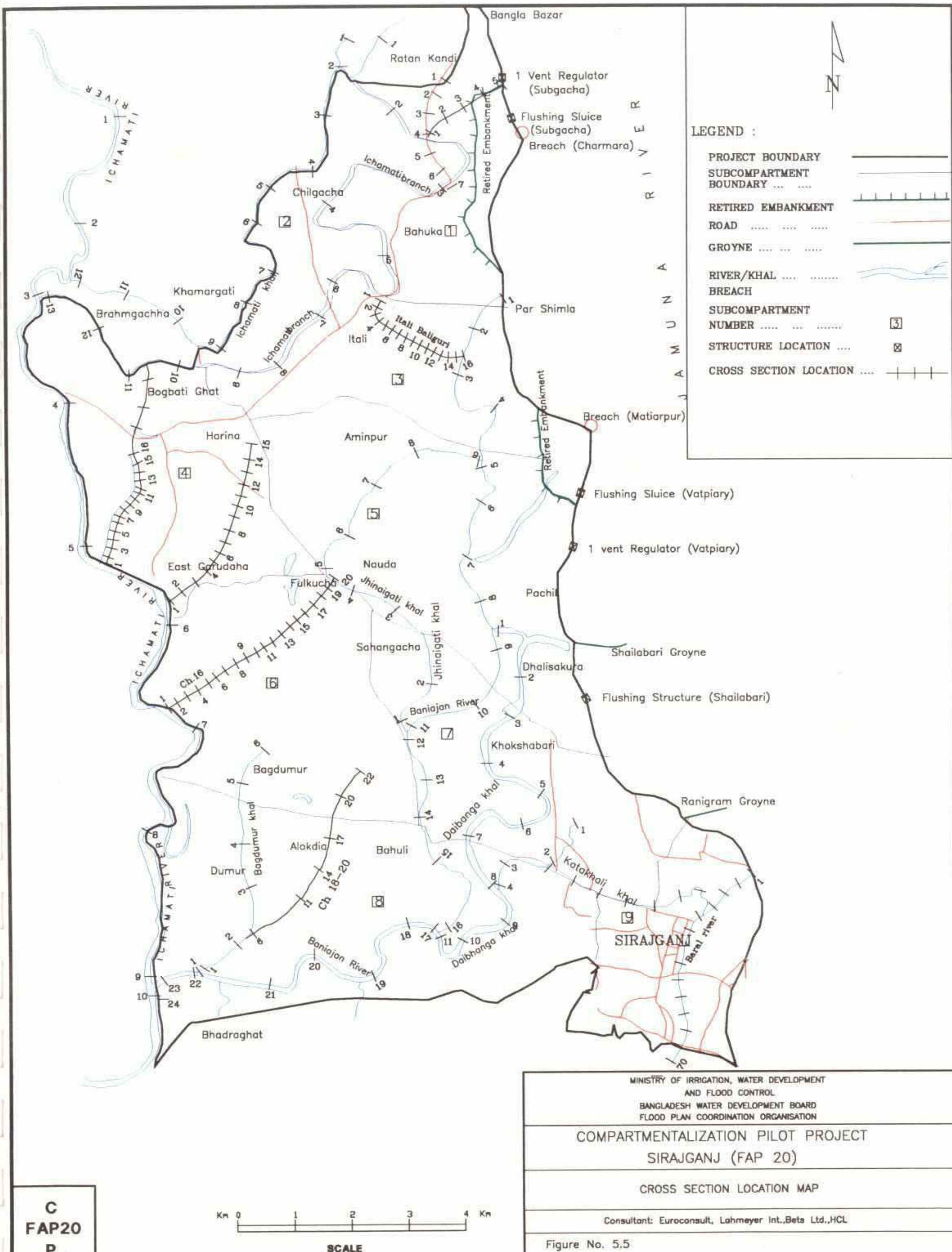
SIRAJGANJ (FAP 20)

HYDROMETRIC NETWORK

Consultant: Euroconsult, Lahmeyer Int.,Bets Ltd.,HCL

Figure No. 5.4

28



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SIRAJGANJ (FAP 20)

CROSS SECTION LOCATION MAP

Consultant: Euroconsult, Lahmeyer Int., Bets Ltd., HCL

Figure No. 5.5

C
FAP20
P

6. Calibration of the Hydrodynamic Model

Calibration is the process of adjusting the model parameters in such a way that the model simulates the river stage and discharge realistically. The CPP Sirajganj model is calibrated against the 1992 condition starting from May upto November.

The calibration in general shows agreement with the observed hydrographs. In Baniajan khal, the comparison with G-16 shows similar pattern. The average peak remains around 9.5 mPWD. From August, the water levels remains high upto end of October. It indicates the influence of 'backwater' effect in Ichamati river. In G-8, Ichamati branch, the computed and measured water level shows good agreement. In October, there is sudden rise in water level because of the retention structure. In Ichamati river, G-12 near Garudah, the observed and computed shows good agrement. The calibration in the Bagdumur khal, which originates from the floodplain, does not shows good ageerment. This is partly due to that 1992 is a very dry year and/or gauge shift is not properly done. It is quite obvious that in floodplain, the flow gets more obstruction in the flow than in the river due to the presence of vegetation and so in floodplain flow calibration, roughness coefficient is an important parameter to adjust. In the model, therefor varing Chezy's roughness coefficient is used in channel and floodplain.

As there is no discharge measuring stations in or near the project area, actual and simulated discharges cannot be compared. The discharge hydrographs shows the variation in discharges. The maximum discharges found from model in the Ichamati river, Baniajan khal, Ichamati branch, Ichamati khal are 700, 40, 10 and 10 m3/sec respectively.

The results are shown in Appendix 4.1.

7.0 Rainfall-Runoff Model (NAM)

The rainfall-runoff model (NAM) is a set of mathematical expressions that describe the behaviour of the land phase of the hydrological cycle. The complex hydrological processes are simplified to a few key elements; runoff, interflow from the surface storage zone to the upper groundwater zone and baseflow from the upper to the lower groundwater zone. The numerical values of the parameters which determine the runoff rates are adjusted during the calibration over one or more hydrological years. Moreover, the parameter selections are based on the previous modelling experience in this area (the model of the North West Regional Study and Surafce Water Modelling Center).

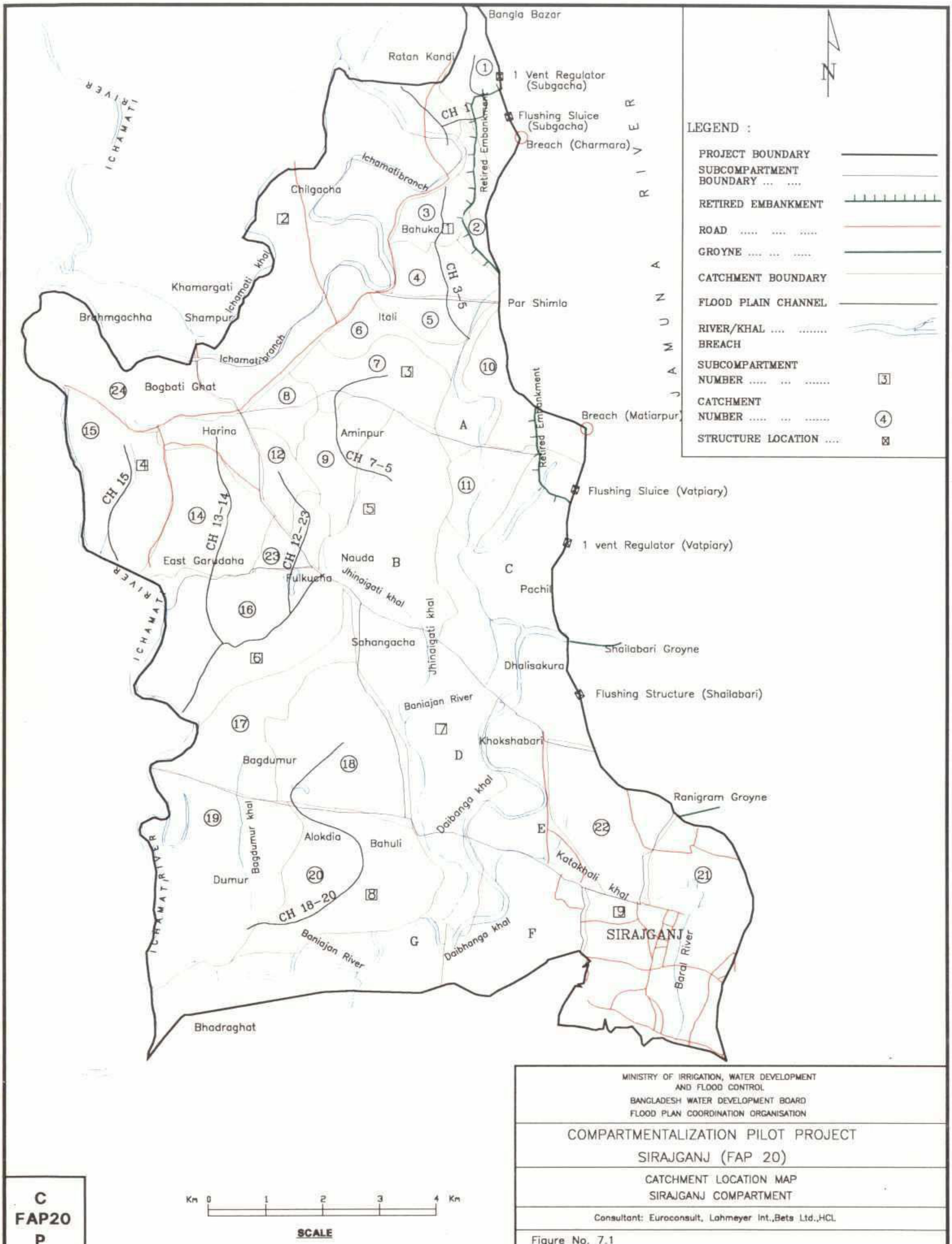
The NAM catchments are defined in combination with the channel schematization.

7.1 Catchment Description and Delineation

For the purpose of the NAM modelling the Sirajganj Compartment was divided into 24 catchments; the locations and identifiers for these catchments are shown in Fig. 7.1. The criteria for fixing the catchment boundaries are as follows:

* existing roads;
* watershed line;
* flow pattern and linkage

For catchment boundaries delineation, the recent areal photographs were used in conjunction with 1964 BWDB contour maps.



MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD
FLOOD PLAN COORDINATION ORGANISATION

COMPARTMENTALIZATION PILOT PROJECT
SIRAJGANJ (FAP 20)

CATCHMENT LOCATION MAP
SIRAJGANJ COMPARTMENT

Consultant: Euroconsult, Lohmeyer Int.,Bets Ltd.,HCL

Figure No. 7.1

C
FAP20
P

Table 7.1 NAM Catchment and its Area

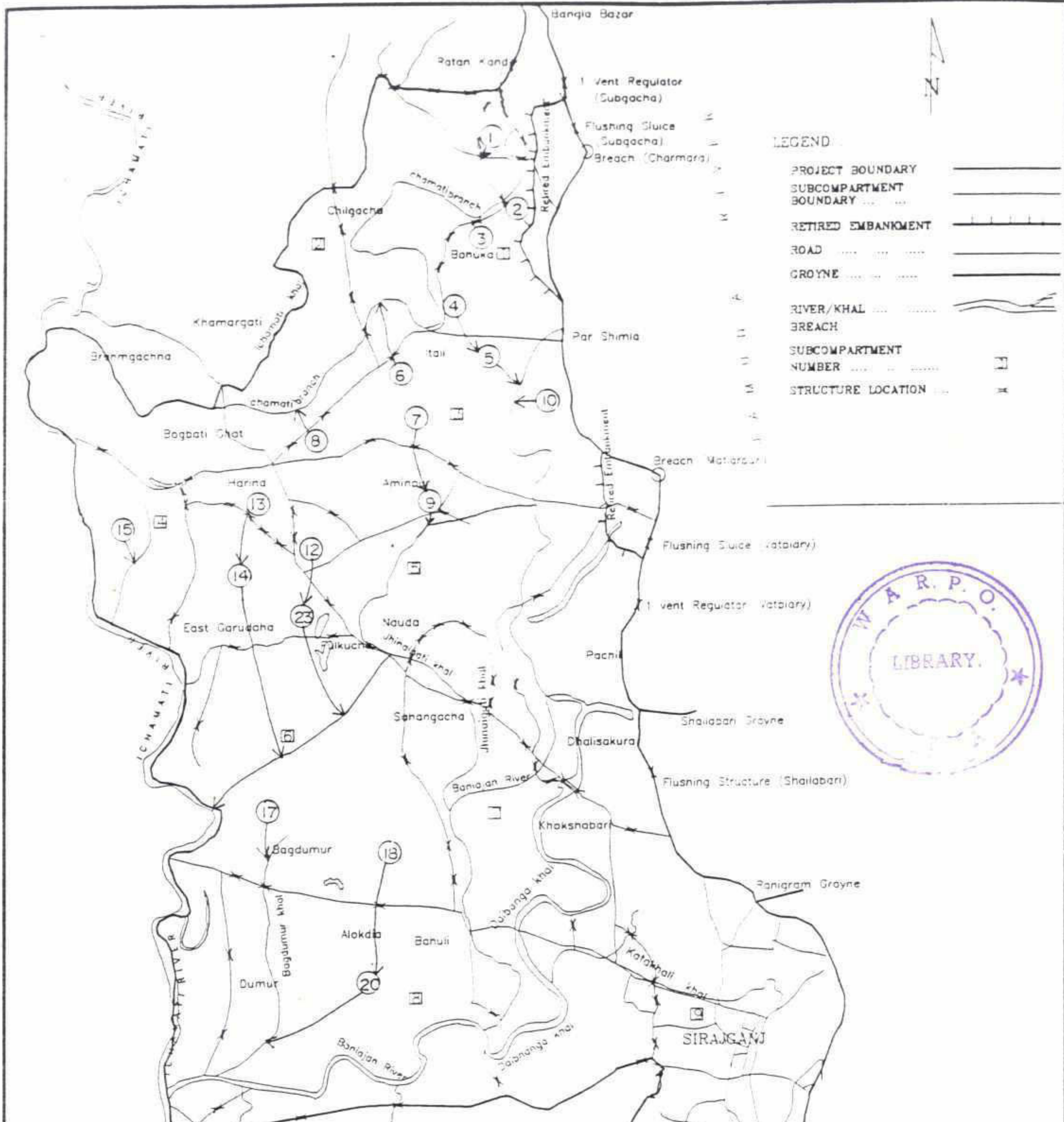
Catchment No.	Area in Ha.	Catchment No.	Area in Ha.
1	195.69	13	130.11
2	99.09	14	341.54
3	114.27	15	387.51
4	152.98	16	639.71
5	119.86	17	333.34
6	120.30	18	507.21
7	261.57	19	683.60
8	100.50	20	555.50
9	202.33	21	862.08
10	227.87	22	378.62
11	168.98	23	113.59
12	99.39	24	411.98

Extensive field visits were performed to confirm the catchment delineation. Apart from these flow pattern i.e. flooding and drainage is also guide catchment delination. The Table 7.1 shows the catchment area. The Fig. 7.2 shows the catchment and its draining point.

The river catchments are kept separate in the analysis. In order to estimate the parameters for the NAM model of Sirajganj compartment, catchment number 13 is selected.

7.2 Data Collection for NAM model

The input data to the model are : precipitation and potential evapotranspiration. On this basis, it produces, as its main results, mean daily values of streamflow as well as information about other elements of the land phase of the hydrological cycle, such as the temporal variation of the soil moisture content and the groundwater recharge.



MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD
FLOOD PLAN COORDINATION ORGANISATION

COMPARTMENTALIZATION PILOT PROJECT
SIRAJGANJ (FAP 20)

CATCHMENTS AND THEIR DRAINAGE POINTS

Consultant: Euroconsult, Lohmeyer Int., Bets Ltd., HCL

Figure/Drawing No. 7.2

C
FAP20
P

7.2.1 Rainfall

Daily rainfall data are required for the rainfall-runoff model. For the study purpose, Sirajganj (R-34), daily rainfall data is collected and used in the model.

The Table 7.2 shows the mean monthly and annual precipitation in Sirajganj and Dhunot.

Table 7.2. Mean Monthly and mean Annual of Sirajganj and Dhunot rainfall

Month	Sirajganj (mm)	Dhunot (mm)
Jan	11.7	12.9
Feb	17.4	10.6
Mar	34.5	24.7
Apr	86.3	88.7
May	207.7	180.9
Jun	318.3	367.7
Jul	318.8	392.1
Aug	318.2	334.2
Sep	245.8	262.8
Oct	142.1	137.8
Nov	16.1	23.4
Dec	2.3	6.4
Annual	1719.2	1841.9

Table 7.3 shows the median seasonal and annual rainfall at Sirajganj.

Table 7.3 Median seasonal and Annual rainfall at Sirajganj

Nov-Feb	Mar-May	Jun-Oct	Annual
15.4	301.1	1225.6	1542.1

7.2.2 Groundwater level data

For the calibration purpose, a number of groundwater stations were collected from BWDB's hydrology section. The stations are

Station Number	Period collected
PA15	1985-1991
PA27	1985-1991
PA59	1985-1991
PA60	1985-1991

These stations are shown in Fig 5.4.

7.2.3 Discharge

There are no discharge measuring stations are available within the CPP Sirajganj.

7.2.4 Temperature

CPP Sirajganj is situated in moderate zone in terms of temperature. The maximum and minimum temperature are 42.8 and 5.0 C respectively. Table 7.4 shows the monthly extreme values of temperature at Sirajganj.

Table 7.4 Extreme monthly maximum and minimum temperature (C) at Sirajganj meteorological station

Month	Max	Min.
Jan	30.6	5.0
Feb	35.0	7.2
Mar	40.6	11.1
Apr	42.8	13.3
May	42.8	17.8
Jun	37.9	20.6
Jul	40.0	21.7
Aug	39.4	23.3
Sep	38.3	21.7
Oct	37.2	17.2
Nov	33.9	10.6
Dec	31.7	7.2

7.2.5 Potential Evapotranspiration

The potential evapotranspiration value is taken from the Sirajganj station. The values are shown in the Table 7.5.

Table 7.5 Potential Evapotranspiration

Month	Potential Evapotranspiration
Jan	94.5
Feb	126.0
Mar	171.0
Apr	181.7
May	122.1
Jun	73.7
Jul	51.8
Aug	64.7
Sep	70.9
Oct	87.8
Nov	95.6
Dec	97.3

7.3 Model Parameters

Following are the model parameters, a total of 13 parameters must be adjusted in the calibration phase:

1. U_{max} 2) L_{max} 3. CSmelt 4. CQ_{OF} 5. CQ_{IF} 6. CL_{OF} 7. CL_{IF}

8. CL_{G} 9. CBFL 10. CK_{1} 11. CK_{2} 12. CK_{BFU} 13. CK_{BFL}

Mositure intercepted on the vegetation, as well as water trapped in the depresions and in the uppermost cultivated part of the ground is representated as surface storage. U_{max} denotes the upper limit to the amount of water in surface storage.

The soil moisture in the root zone, a soil layer below the surface fronm which the vegetation can draw water for transpiration, is represented as lower zone storage. L_{max} denotes as uppeer limit to the amount of water in this storage.

Rain is the subject, first, to the functions of the surface storage. The amount of water, U, in surface storage is continuously diminished by evaporative consumption as well as by horizontal leakage (interflow). When there is maximum surface storage, some of the excess water will enter the stream as overland flow, whereas the remainder is diverted as infiltration into lower zone and groundwater storages.

Moisture in the lower zone storage is subject to consumptive loss from transpiration, while the moisture content controls the amount of the infiltrating water which enters the groundwater storages.

The groundwater recharge is generally divided into two groundwater storages, upper and lower, having different time constants. The groundwater storages act as linear reservoirs continuously draining to the stream as baseflow.

The overland flow and the interflow are routed through one linear reservoir before all of the streamflow components are added androuted throgh a final linaer reservopir; thus a continous streamflow hydrograph is obtained.

7.4 Model Calibration

During model calibration, the model parameters are adjusted to create a good fit between the simulated and the observed hydrographs.

Calibration of rainfall-runoff models can be performed either by trial and error or by using a numerical optimisation method. Previous experince using a numerical algorithm for the NAM model, supported by experience of local institutions during recent years, has shown that numerical parameter estimation methods often lead to unrealistic parameter values. Futhermore, the trial and error method is the only possible approach allowing a distinction between calibration objectives, such as giving priority to accurate prediction of low flows for water supply planning purposes or to peak flows for flood control. For these reasons, trial and error calibration method is used in this studies.

The year 1992 is selected to calibrate the NAM rainfall runoff model parameters. The selected parameters are shown in Table 7.6.

Table 7.6 Selected NAM model parameters

NAM Model Parameters	Parameter Value	Remarks
Area of the Catchment	1.3	estimated
Surface storage capacity	20	recomended
Maxm water content in root zone storage	100	calibrated
Time Constant for routing interflow Time Constant for routing overland flow	48 48	calibrated
Time constant for interflow	400	calibrated
Time constant for baseflow	800	calibrated
Rootzone threshold value for ground water recharge	0.7	calibrated
Specific yield	0.05	calibrated
Minm. gorundwater depth	0.0	calibrated
Maxm. groundwater depth causing base flow	6.0	calibrated
Groundwater depth for unit capillary flux	1.5	calibrated
Infiltration factor	6.5mm/day	calibrated

Fig. 7.3 shows the runoff, rainfall intensity and comparison of measured and computed groundwater depth for catchment number 13 of 1992. The same model run from 1986 to 1992 are shown in Fig. 7.4.

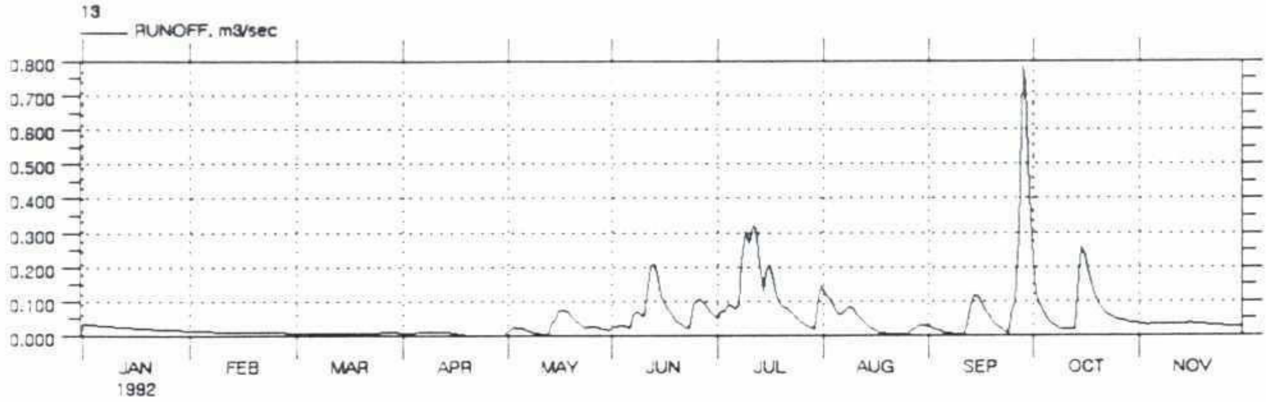
Table 7.7 Monthly relative seasonal variation of groundwater outlet depth

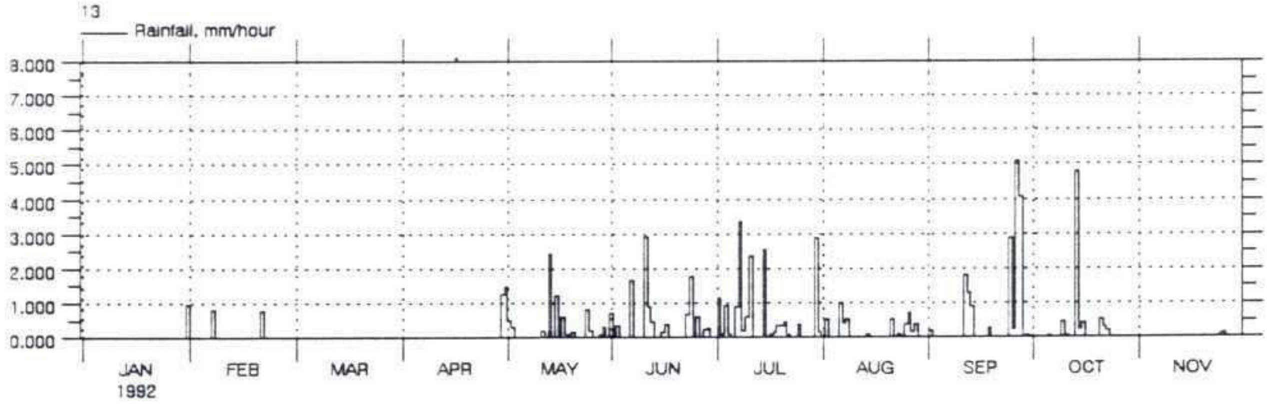
Month	Relative variation
January	0.82
February	0.85
March	0.90
April	1.00
May	0.60
June	0.30
July	0.00
August	0.00
September	0.10
October	0.40
November	0.75
December	0.80

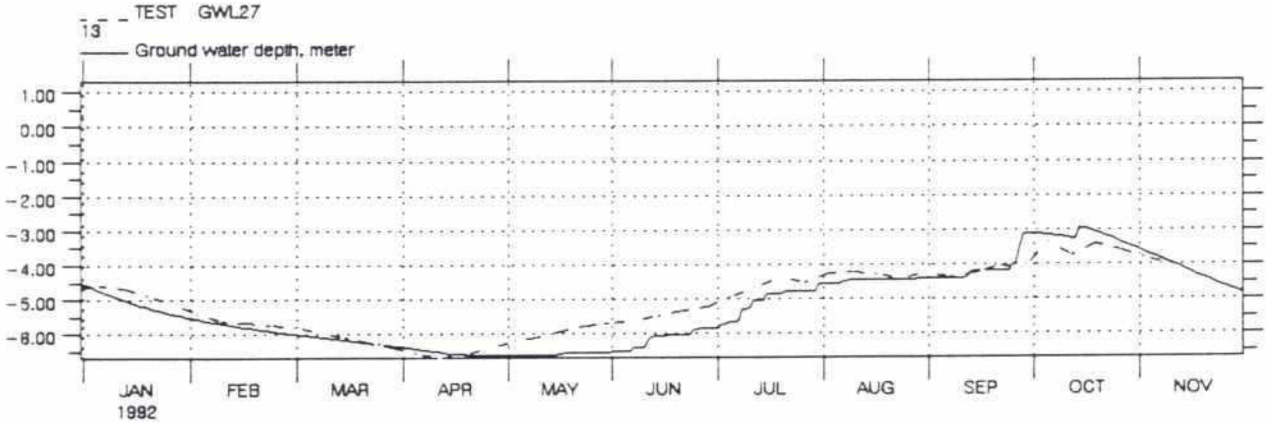
Monthly relative seasonal variarion of groundwater outlet depth between maximum 6.0 m. and minimum 1.6 m. established in Table 7.7.

7.5 Verification of the Model

Using the calibrated parameters presented in Table 7.6, the model is verified from April, 1986 to March, 1992. The results of the computed groundwater depth is compared with the measured values and shown in Fig. 7.4. The hydrograph shows in 1986 there is high rainfall but its effect is not reflected in the measured groundwater depth.

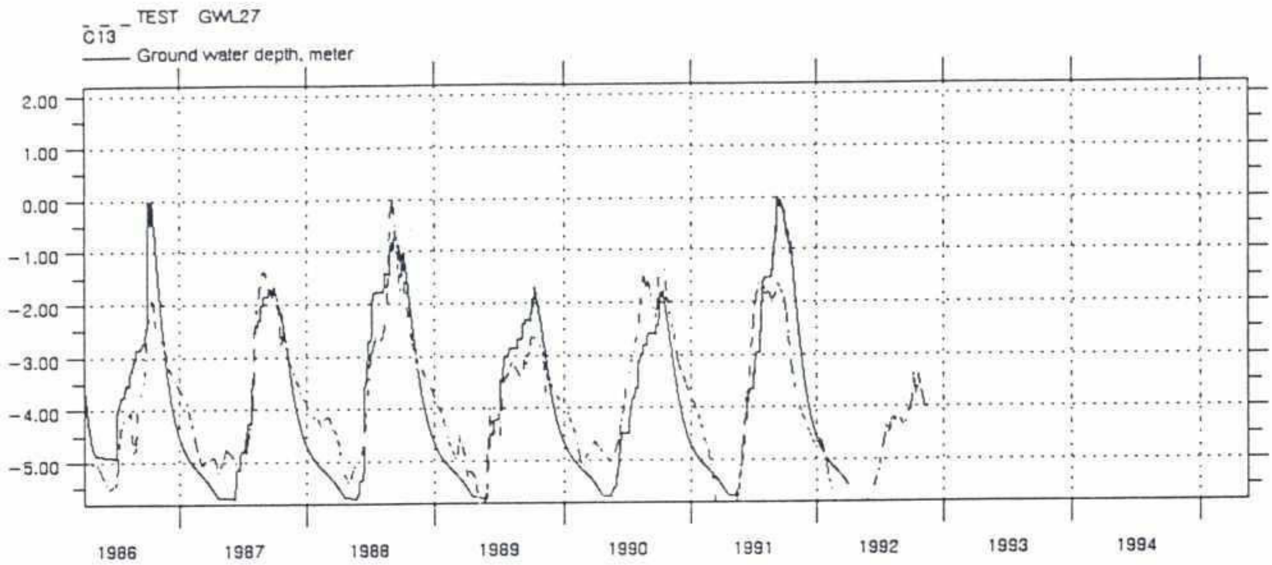






	Compartmentalization Pilot Project, Sirajganj Compartment Catchement 13 Comapared and measured groundwater depth, 1992

DATA FILE : SGRRPAR.NSF RESULT FILE : SGRR92.NOF	BOUNDARY FILE : SGRRSET.BSF CALCULATED : 17 – APR – 1993, 14:33	**N A M** Dwg no.: 7.3



	Compartmentalization Pilot Project Sirajganj Compartment Comapared and measured groundwater level

DATA FILE : TEST2.NSF RESULT FILE : TEST1.NOF	BOUNDARY FILE : TEST1.BSF CALCULATED : 13 – MAR – 1993, 10:57	NAM Dwg no.: 7.4

8. Selection of Simulation Years

The selection of the simulation year is specially important as the modelling will not be performed for a statistical range of years (for example a model run for 25 years). The assessment of the most relevant years for the modelling is based on the probability of damage resulting from hydrological events. Damage in this situation are of two types i.e. infra-structural and agricultural damage.

- Infrastructural damage; it is predominately determined by the level of the flood and only slightly by the duration, the timing, the speed of rise and the sediment load of the flood. The yearly maximum event is a typical indicator for the potential damage.

- Agricultural damage; 5 qualities are equally important for the potential agricultural damage as follows.

  - Flood level
  - Timing of the flood
  - Speed of rise of a flood
  - Flood duration
  - Sediment load of a flood

The yearly maximum flood level is not the only indicator for the potential damage.

Since FAP 20 has to test the concept of compartmentalization in its broadest sense it is considered most suitable to do the selection of the simulation years for the model on the basis of the potential agricultural damage and to complement this by an assessment of the annual peak water level as an indicator for the possible infrastructural damage.

The selection of the design year is based on the North West Regional Study (FAP 2) recommendation. FAP 2 divided the whole region into 15 planning units and for each planning unit a 25 year model run was analysed to select years whose severity approximated to that of the required design periods of 2, 5, 10 and 20 years. Sirajganj compartment belongs in the planning unit number 8. In selecting design years, most weight was given to the results for the 10-day duration, because this was considered most generally, significant for agricultural considerations.

For selecting appropriate cropping patterns and other agricultural consideration, the date at which certain flood levels could be expected is of critical importance. The average 3-day mean waterlevel per decade has been assessed and return periods for time series of 10-day mean levels. The selected design years for planning unit number 8 as recommended by FAP 2 are summerised below :

1-in-2	1-in-5	1-in-10	1-in-20
1985	1970	1973	1988

The selected design years as shown in the table deserve additional comments. The year 1988 is marked as 1 in 20 year because 1988 was the worst year by no more than a few centimeters, so a very small change (well within the margin of error of the model) could bring the estimated return period down to close to 20 years. Also Fig 8.1 shows diffrence in water level at Brahmaputra and water level in the Ichamati river (Sirajganj at Jamuna and Nalkasengati at Ichamati river). The planning unit number 8, due to its north-south location, the severe levels varied substantially across the area and no one year represents condition as severe as 1 in 20 across the unit as whole.

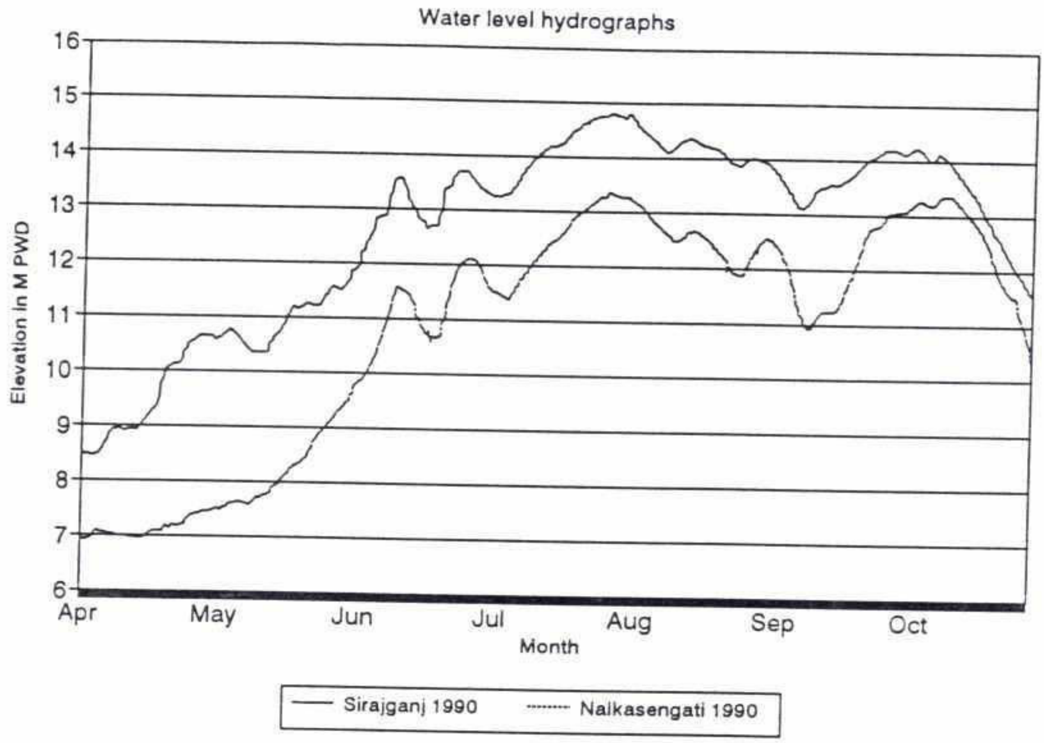


Fig. 8.1 Water level at Sirajganj (Jamuna) and Nalkasengati (Ichamati).

For the modelling the following years have been analyzed on the basis of Dhunot water level station (Table 8.1) and shows below the characteristics of the year selected :

- 1970.
  - Pre-monsoon (from May till end of June): waterlevel rises sharply from last

decade of June form 11.90 to 12.98 m PWD; normal rainfall (255.1 mm up to 30/6); **dry**.
- Monsoon (from July till September): maximum waterlevel +14.72 m in first decade of August; normal rainfall (912.5 mm from 1/7 to 30/9); **wet**.
- Post-monsoon (October-November): water level dropped from 13.08 m to 11.75 ; 273.6 mm rainfall; **normal**.

- 1985.
  - Pre-monsoon: waterlevel rises in second decade of May from 11.29 to 12.06 m PWD (0.77 m rise) ; normal rainfall (655.3 mm up to 30/6); **wet**.
  - Monsoon: waterlevel around 14.5 m; normal rainfall (805.8 mm from 1/7 to 30/9); **normal**.
  - Post-monsoon: water level recedes from 13.23 m to 11.56 m; not significant rainfall (87.4 mm after 1/10); **dry**.

- 1973.
  - Pre-monsoon: sharp rise in last decade of June from 14.56 m. to 13.01 m ; abundant rainfall (830.9 mm up to 30/6); **potentially harmful**.
  - Monsoon: waterlevel rises in first decade of September from 12.82 m to 14.80 m; abundant rainfall (859.9 mm from 1/7 up to 30/9); **wet**.
  - Post-monsoon: sudden drop in water level in first decade of October from 14.97 m to 13.75 ; significant rainfall (204 mm after 1/10); **dry**.

- 1988.
  - Pre-monsoon: level +12.31 m with max rise of 1.07, 0.72 m/3days during first and second decade of June; abundant rainfall (935 mm up to 30/6); **potentially harmful**.
  - Monsoon: waterlevel around 14.5 m. Abrupt rise in water level from 13.87 m to 16.87 m (3 m./3days rise); abundant rainfall (828.3 mm from 1/7 up to 30/9); **wet**.
  - Post-monsoon: water level dropped from 13.82 m to 11.60 m.; significant rainfall (297.6 mm after 1/10); **dry**.

The years 1973, 1970, 1985 and 1988 have been selected as design years and out these years only 1970 and 1973 is used for model simulation. A summary is shown in Table 8.2.

Table 8.2 Summary of the Selected years for simulation.

Year	Pre-Monsoon	Monsoon	Post-Monsoon	Peak level Return Period
1970	dry	wet	normal	1:5
1973	potentially harmful	wet	normal	1:10
1985	wet	wet	dry	1:2

Table 8.1 MAXIMUM 3-DAY MEAN WATER LEVEL AT DHUNOT (1964–91)

Year	April			May			June			July			August			September		
1964	10.98	11.00	10.98	12.11	11.98	11.28	12.58	13.87	14.81	15.04	15.27	15.70	16.04	15.58	14.84	14.80	14.96	14.87
1965	10.89	10.89	10.86	10.90	12.00	12.01	13.76	13.80	14.04	14.31	14.43	14.59	14.78	15.67	15.37	14.93	14.80	14.79
1967	11.32	11.38	11.39	11.82	11.73	11.48	11.53	11.95	12.22	12.40	13.38	13.35	12.63	12.41	12.26	11.96	12.15	12.67
1968	11.13	11.11	11.09	11.03	11.28	11.34	11.32	12.00	12.66	13.44	13.75	13.74	13.83	13.53	12.90	12.98	12.50	13.08
1969	11.24	11.36	11.36	11.30	11.46	11.85	12.18	12.48	12.72	12.98	13.67	13.89	13.74	13.64	13.88	13.89	13.62	13.62
1970	11.07	11.09	11.09	11.08	11.22	11.25	11.60	11.90	12.98	13.09	13.40	14.38	14.72	14.69	14.27	13.08	12.41	12.71
1972	11.30	11.29	11.27	11.28	11.28	11.32	11.42	12.06	12.55	12.43	12.04	13.46	13.89	13.89	12.69	12.83	12.85	12.31
1973	10.88	10.71	11.01	11.20	12.13	12.37	11.94	13.01	14.56	14.76	14.75	13.63	14.25	14.59	14.36	12.82	14.80	15.24
1974	11.19	11.21	11.14	11.33	12.15	12.56	12.21	12.35	13.43	13.84	14.52	14.83	14.80	14.65	14.19	14.13	13.81	13.64
1975	10.64	10.73	10.85	10.70	10.90	11.66	11.71	11.50	11.78	12.27	12.83	13.37	13.37	12.78	12.65	12.51	13.30	13.29
1976	10.79	10.42	10.78	10.91	10.98	11.15	12.00	12.71	12.45	13.27	14.00	14.21	13.95	14.04	14.01	13.83	12.88	12.67
1977	10.93	10.96	10.96	11.23	11.24	11.93	12.83	13.47	14.20	14.03	13.46	14.02	14.09	13.56	13.51	14.30	13.82	13.13
1978	10.87	10.95	11.00	11.23	11.32	11.92	13.06	13.29	13.49	13.37	12.96	13.44	13.59	13.40	12.57	12.19	13.09	13.11
1979	10.78	10.93	10.91	10.85	10.81	10.85	10.92	11.08	11.11	11.08	12.08	13.46	13.49	12.88	13.55	3.81	13.95	13.91
1980	10.78	10.69	10.71	11.36	12.33	12.25	12.78	12.38	12.47	12.01	13.18	13.53	13.17	13.41	13.90	13.76	13.06	13.32
1981	10.94	11.45	11.40	11.41	12.24	12.81	13.17	12.50	11.86	13.18	13.42	13.99	14.03	13.91	13.78	14.02	14.00	13.92
1982	10.88	10.81	10.79	10.76	10.85	10.88	11.28	12.54	12.69	12.84	13.31	13.48	13.53	13.52	12.79	12.69	13.14	13.29
1983	10.65	10.56	10.82	10.92	11.20	11.90	11.71	11.61	12.01	12.58	12.74	12.98	13.55	13.34	13.11	13.12	13.56	13.79
1984	10.93	10.91	10.77	11.06	11.92	12.66	13.58	14.25	14.47	14.56	15.60	15.84	15.82	15.06	13.73	14.68	16.28	16.26
1985	10.93	10.76	10.79	10.79	11.29	12.06	12.26	12.20	12.03	12.76	13.27	14.07	14.31	14.23	13.17	13.30	13.58	13.46
1986	10.77	10.70	10.79	10.85	11.29	11.55	11.31	11.23	12.34	13.47	13.49	13.01	13.35	13.34	12.72	13.03	13.49	14.45
1987	11.05	10.97	11.34	11.42	11.37	11.33	11.29	11.53	12.53	13.82	14.10	15.50	15.94	15.80	15.59	14.78	14.86	14.25
1988	10.91	10.85	10.93	10.99	11.03	12.03	12.31	13.38	14.10	14.27	14.50	14.34	13.69	13.87	16.87	16.85	15.85	14.71
1989	11.09	11.06	11.01	10.96	10.91	12.71	12.81	12.87	12.97	13.79	14.18	14.18	13.99	12.84	12.41	13.08	13.43	13.38
1990	11.03	11.02	11.02	11.03	11.36	12.14	12.92	13.66	14.36	14.06	14.86	15.24	15.19	14.72	14.70	14.70	14.39	15.04
1991	11.00	10.94	10.97	10.98	11.69	13.05	13.03	14.00	14.64	14.92	15.83	15.42	15.10	15.26	15.20	15.19	15.32	15.27
Num	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
2	10.93	10.92	10.97	11.08	11.38	11.76	12.08	12.46	12.89	13.28	13.66	13.99	14.04	13.87	13.61	13.56	13.67	13.69
5	11.11	11.18	11.14	11.34	11.80	12.36	12.83	13.34	13.90	14.39	14.65	14.71	14.84	14.77	14.60	14.57	14.63	14.57
10	11.23	11.36	11.26	11.51	12.07	12.75	13.33	13.93	14.58	15.13	15.30	15.19	15.37	15.36	15.25	15.24	15.27	15.16
20	11.34	11.53	11.38	11.68	12.34	13.13	13.80	14.49	15.22	15.84	15.92	15.64	15.88	15.93	15.87	15.88	15.88	15.72
25	11.38	11.58	11.41	11.73	12.42	13.25	13.95	14.67	15.42	16.06	16.12	15.79	16.04	16.11	16.07	16.08	16.08	15.89

Year	October			November			December			January			February			March		
1964	14.45	13.52	12.90	12.25	11.52	10.91	10.60	10.43	11.02	10.98	10.96	10.20	10.90	10.92	10.91	10.91	10.88	10.90
1965	13.95	12.52	11.49	11.25	11.18	11.06	11.03	10.99	10.95	10.95	10.91	10.60	10.96	10.96	10.96	10.95	10.94	(1.00)
1967	12.66	12.78	12.25	11.82	11.65	11.54	11.44	11.39	11.35	11.30	11.25	11.21	11.17	11.16	11.14	11.12	11.12	11.10
1968	13.31	13.44	13.35	12.30	12.08	11.99	11.91	11.83	11.69	11.50	11.44	11.41	11.37	11.30	11.25	11.23	11.23	11.26
1969	13.99	13.95	12.73	12.02	11.88	11.79	11.68	11.58	11.51	11.44	11.39	11.37	11.34	11.27	11.23	11.17	11.14	11.10
1970	13.08	12.96	12.32	12.04	11.82	11.75	11.59	11.53	11.45	11.37	11.37	11.34	11.32	11.30	11.22	11.18	11.17	(1.00)
1972	12.26	12.18	11.95	11.79	11.70	11.59	11.52	11.48	11.44	11.42	11.41	11.40	11.15	11.06	11.12	11.13	11.11	10.88
1973	14.97	13.75	13.39	12.23	12.02	11.76	11.65	11.50	11.41	11.35	11.30	11.34	11.31	11.28	11.19	11.12	11.04	11.14
1974	13.67	13.66	13.26	12.59	12.13	11.87	11.78	11.61	11.55	11.50	11.45	11.40	11.37	11.36	11.30	11.25	11.12	10.82
1975	13.18	12.66	12.31	11.87	11.63	11.45	11.33	11.25	11.19	11.15	11.13	11.12	11.11	11.09	11.04	10.98	10.95	10.90
1976	12.66	12.23	11.79	11.52	11.39	11.32	11.23	11.18	11.13	11.12	11.09	11.09	11.08	11.07	11.04	10.99	10.95	10.94
1977	13.41	13.52	12.60	12.04	11.94	11.81	11.57	11.49	11.41	11.29	11.25	11.18	11.13	11.05	10.98	10.96	10.91	10.89
1978	12.68	12.12	11.76	11.52	11.47	11.43	11.35	11.30	11.28	11.22	11.23	11.21	11.15	11.07	11.03	10.99	10.92	10.89
1979	13.36	13.37	12.65	12.01	11.75	11.57	11.62	11.56	11.50	11.47	11.44	11.36	11.13	11.09	11.05	10.94	10.88	10.86
1980	13.30	13.15	13.48	12.47	11.93	11.75	11.63	11.51	11.45	11.39	11.43	11.40	11.34	11.29	11.05	10.99	10.90	10.88
1981	13.21	12.48	12.07	11.85	11.70	11.58	11.50	11.50	11.45	11.39	11.32	11.25	11.20	11.15	11.08	11.00	11.01	10.98
1982	13.10	12.25	11.94	11.89	11.64	11.56	11.43	11.33	11.27	11.28	11.27	11.23	11.17	11.12	11.03	10.91	10.83	10.76
1983	14.19	14.40	14.18	13.11	12.21	11.90	11.73	11.64	11.74	11.53	11.47	11.42	11.33	11.27	11.21	11.15	11.03	10.98
1984	14.96	13.90	12.85	12.18	11.90	11.63	11.51	11.44	11.38	11.33	11.30	11.27	11.22	11.16	11.12	11.09	11.02	10.95
1985	13.23	12.72	12.99	12.52	11.77	11.56	11.44	11.38	11.31	11.26	11.23	11.20	11.09	11.03	10.91	10.86	10.81	10.74
1986	14.73	14.59	14.26	12.89	12.23	11.94	11.81	11.73	11.65	11.51	11.46	11.42	11.38	11.28	11.19	11.12	11.13	11.13
1987	14.61	13.73	13.10	12.56	12.00	11.85	11.65	11.56	11.48	11.43	11.42	11.37	11.25	11.17	11.14	11.10	11.02	11.02
1988	13.82	13.69	11.88	11.70	11.55	11.60	11.64	11.45	11.41	11.37	11.35	11.33	11.28	11.22	11.16	11.15	11.13	11.11
1989	13.50	13.35	12.20	11.79	11.64	11.54	11.44	11.37	11.31	11.29	11.26	11.21	11.12	11.13	11.12	11.07	11.03	11.02
1990	15.31	15.32	14.61	12.97	12.22	12.00	11.84	11.72	11.64	11.58	11.55	11.51	11.43	11.31	11.26	11.21	11.13	11.09
1991	14.86	13.52	12.87	12.15	11.92	11.77	11.66	11.57	11.64	11.72	11.70	11.52	11.29	11.30	11.28	11.25	11.20	11.13
Num	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	24
2	13.57	13.17	12.60	12.06	11.77	11.61	11.50	11.42	11.38	11.33	11.30	11.27	11.20	11.15	11.10	11.05	11.01	10.96
5	14.37	13.93	13.33	12.51	12.07	11.96	11.91	11.86	11.62	11.54	11.51	11.46	11.36	11.28	11.22	11.17	11.13	11.09
10	14.90	14.44	13.81	12.81	12.27	12.19	12.18	12.15	11.77	11.68	11.65	11.58	11.47	11.37	11.30	11.25	11.21	11.18
20	15.40	14.92	14.28	13.09	12.47	12.41	12.44	12.42	11.92	11.81	11.78	11.70	11.57	11.45	11.38	11.32	11.28	11.26
25	15.56	15.07	14.42	13.18	12.53	12.48	12.52	12.51	11.97	11.85	11.82	11.74	11.60	11.48	11.40	11.34	11.31	11.29

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9. Model Application

The calibrated model is primarily used to simulate the development activities. The options were tested with the following events:-

- 1992 Calibration Year

- without project situation

* BRE breach outside the project area
* BRE braech inside the project area
* 1 in 5 year situation

- with project situation

* BRE breach outside the project area
* BRE braech inside the project area
* 1 in 5 year situation
* rainfall only situation (1987 closed compartment)

The developed options are described in the next section. The model results are compared for the **without** and **With** project situation.

9.1 Development of Options

The planning for Sirajganj compartment is developed to test the compartmentalization concept. More specifically the compartmentalization was developed in line with the following objectives:

* controlled flooding into and within the compartment;
* controlled drainage within compartments and between neighbouring compartments;
* improve agriculture and irrigation;
* improving fisheries;
* improve infra-structure

There are three options developed and each of the options have common features. The common features are described in Section 9.2.

9.2 Option Features

Breach Mitigation

Breach mitigation measures are mainly aims at to mitigate the breach impact which are occurring as a result from the erosive power of the Jamuna river. Breaches observed in the eastern boundary and north of the CPP Sirajganj project area. The direct impact of the

BRE breach are i) damage of infra-structure ii) damage of crops. The velocity developed of the incoming water are so high that the existing bridges and culverts cannot cope up with this velocity. The breach mitigation mechanism is shown in the Fig 9.1. If the breach mitigation taks place within the project boundary, the sub-compartmnet concern will hold the incoming breach water and then release the water gradually into the neighbouring sub-compartment through the improved drain. In physical terms this means that the actual impact of a breach occurrence can be mitigated through the upgradation of the existing roads (or other structural elements) which can serve as embankments and development of the existing structures so that breach water can be regulated in such a way that these excess water can gradually be release from one sub-compartment to another without damaging the crop and infra-structures.

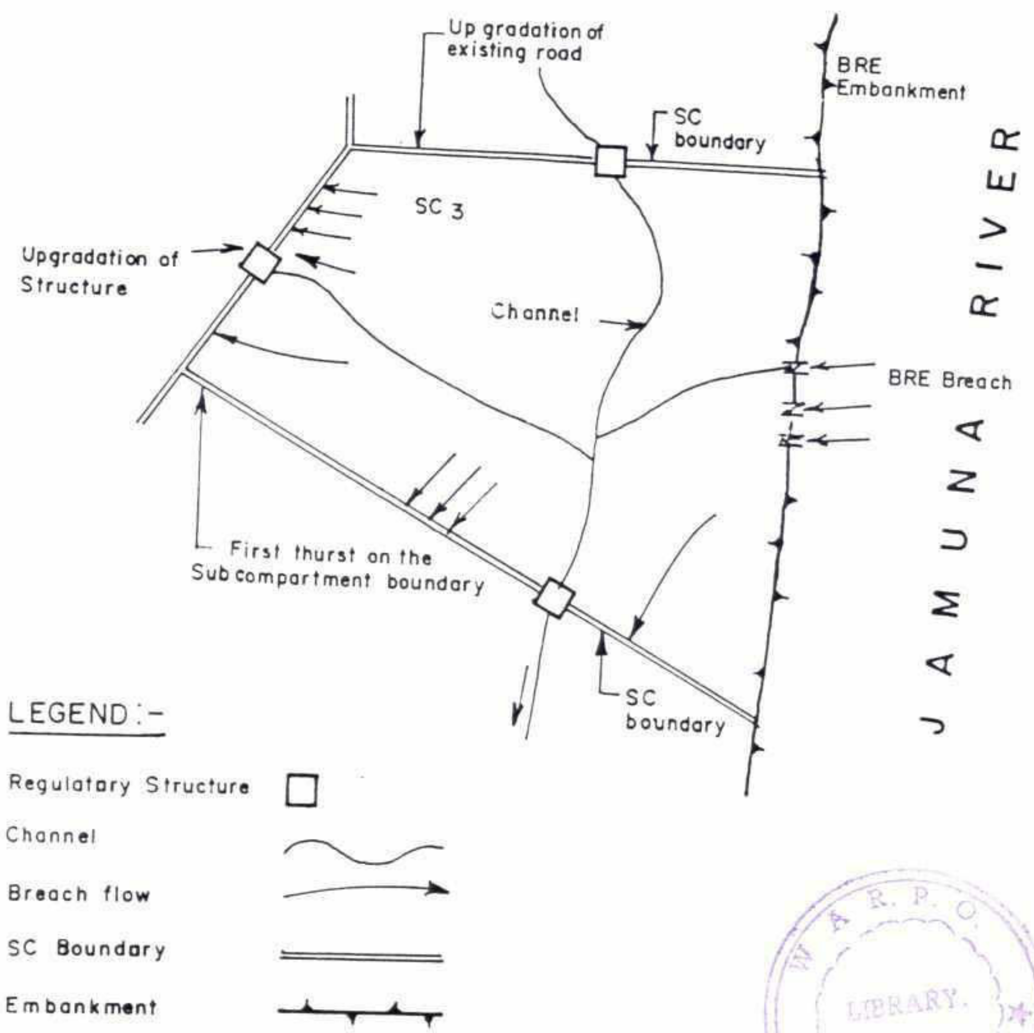


Fig. 9.1 Breach Mitigation Mechanism

Drainage Improvement

The drains will be improved by considering the critical peirod both for agriculture and fisheries. Improving menas increase the carrying capacity of the channel.

Flood Protection:

In order to protect the area from river flooding, embankment are necessary. The flood protection measures are taken regarding floods which originates from waterlevel raising from the secondary river system beyond a certain probability level.
Flooding is caused by:

1) a local BRE breach on the boundaries of the Sirajganj compartment;
2) major runoff as a result of local rainfall upstream of the CPP Sirajganj project area;
3) backwater (or backflow) effect from the Karatoya river back into the Ichamati river;
4) any combination of the above three.

Water Retention:

Water retention is one of the important element of compartmentalization. The objective of the retention is to retain rainfall or flood water in a specific area and gradully release it into the next sub-compartment.

Sub-compartment Management:

The flood water will flow into the compartment and spread over the area in a controlled way by means of regulating structures in the primary embankments along this river and the gated or ungated openings in the secondary embankments between the compartments. The structural and non-structural measures to achieve this can be called the macro (main) system.

The way the flood, as well as the drainage of excess rainfall, has to be controlled will be determined by the demands from inside the compartment. The required structural and non-structural measures for water management within the compartments can be called the micro system.

It is obvious that a compartment can be a large area and that hydrology, topography, existing infrastructure, landuse and administrative boundaries are important factors to consider. In analogy with an irrigation system, it is possible to make a distinction between the macro (main) system and the micro (minor) system. Clearly, to make the participation of the beneficiaries in Project planning, design, construction, operation, maintenance, monitoring and evaluation successful, it will be necessary to subdivide the compartment into rather small units.

Watermanagement

Whatever the options selected for compartment development, watermanagement will be carried out in each sub-compartment accordingly. The water requirement for each SC will be the basis for water management. As indicated earlier, the boundaries as defined are preliminary boundaries. In due course these subcompartmental boundaries may need to be changed as a result of agronomic, hydrologic, economic or other reasons. For that reason,homogeneous unit have to be developed The components for watermanagement are as follows:-

- retention structure
- developments of internal channels
- developments of internal roads

The following options for development are discussed:

OPTION 1 :	**COMPARTMENT DEVELOPMENT SITUATION WITHOUT THE ICHAMATI EMBANKMENT**
OPTION 2A :	**COMPARTMENT DEVELOPMENT WITH THE ICHAMATI EMBANKMENT FOLLOWING EXISTING ROAD**
OPTION 2B :	**COMPARTMNET DEVELOPMENT WITH THE ICHAMATI EMBANKMENT FOLLOWING RIVER BANK**

THE WITHOUT-PROJECT SITUATION

The Sirajganj compartment is situated behind the Brahmaputra Right Embankment (BRE) and therefore largely depends on the quality of the BRE. The objective of the BRE is to protect the land behind the embankment from flooding.

An additional complication is formed by the runoff quantities conveyed by the Ichamati river which originates from the upper catchment. Inside the compartment, the Baniajan river and Ichamati branch are the only rivers that flow through the compartment. For the study purpose, the whole area is divided in to 9 sub-compartment. The area-elevation curve for each of the sub-compartments are shown in Appendix 4.3.

In normal condition rainfall runoff of the sub-compartment 1 and 2 flows from east to west. In subcompartment 4, there are three main sources of surface flooding i.e. one from the northern side and another two are the Kagati and Painalgati khal. Most of the runoff of this sub-compartment are generally carried by Painalgati and Kagati khal to the Ichamati river. Most of the drainage of the SC 5 is carried by the Baniajan river and the Doibhanga khal. The flow direction of this sub-compartment is from north west towards south-east. Flow pattern of the SC6 is from north to south. Flow pattern of the eastern part of the Doibhanga khal is from east to west.

Flow direction of the western part of the sub-compartment-8 which comprises about 15% of the total area is from east to west and about 70% drainage water of this sub-compartment is carried by the Baniajan river and flow direction is from north to south. Flow direction of the southern part of the Baniajan river is also from north to south. Flow direction of the eastern part of Baral river of SC9 is from east to west. Flooding from Ichamati river into the SC6 and SC8 is occuring. The Fig. 9.2 shows the location of bridges, culverts etc.

At present, th opening due to the erosion and breach near Par Simla and Sonali Bazar is yet to be closed. The are 5 numbers of existing structures along the BRE and except two, the rest are not working properly. This is mainly due to improper maintenance of the structures or due to the retirement of embankment, the structures lost its function.

In the current situation, the BRE breach possibility remains and together with the increased waterlevels in the Ichamati river this will cause considerable drainage problem in the CPP Sirajganj project area.

DESCRIPTION OPTION 1:

COMPARTMENT DEVELOPEMENT SITUATION WITHOUT THE ICHAMATI EMBANKMENT

Assumptions

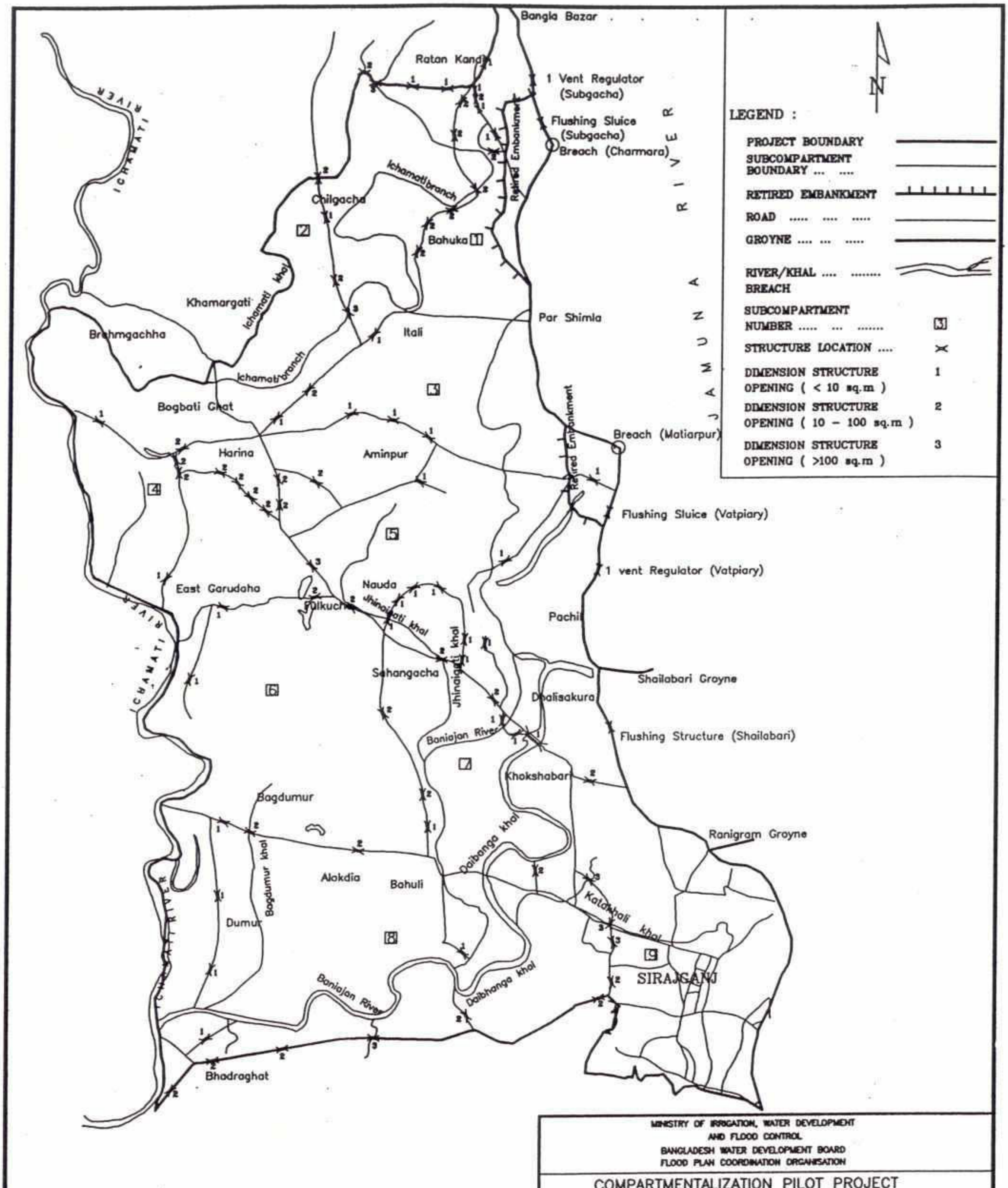
1. No embankment along the Ichamati river;
2. Stable BRE
3. Improve Drainage;
4. BRE Inlet structure
5. Sub-compartment BRE breach mechanism;
6. Internal water manangement;

This option consists of improved drainage, construction and/or rehabilitation of (BRE) inlet structures, water retention structures and internal water management control structures.

In case there is a direct breach in the CPP-Sirajganj area, the following approach is suggested:

1) confine incoming BRE breach floodwater to a restricted number of subcompartments;
2) convey these floodwaters adequately and quickly through water regulators in the subcompartment boundaries to improved drainage channels.

It is assumed that breaches might occur and to cope up with the BRE breach, breach mechanism will be developed between subcompartment and will be used to guide the water into the neighbouring SC and/or will drain into a major khal without causing excessive damage to infra-structure or crops. For this purpose the existing structures



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COMPARTMENTALIZATION PILOT PROJECT
SIRAJGANJ (FAP 20)

STRUCTURE LOCATION AND STRUCTURE DIMENSION MAP

Consultant: Euroconsult, Lahmeyer Int., Bets Ltd., HCL

Figure No. 9.2

(bridges or culvert) will be adjusted/developed to handle the breach water.

The main drainage system within the compartment is proposed to be improved. A drainage diversion regulator is proposed which keeps the Ichamati branch capacity available for drainage water from inside the compartment. Any major waterflow which originates from the area north of the compartment will only partially enter into the compartment area but will be diverted through the Ichamati khal to the Ichamati river.

Four number of inlet structurs at the BRE are being proposed. The purpose of these inlet structures are twofold i.e. to facilitate the fish migration and secondly the (supplimental) irrigation, if possible. The structure operation will be such that the first flood that usually comes in June/July could enter into the project area and after that the structures will be closed.

Sirajganj Town

Sirajganj town, due its postion, is analysed separately. It has been assigned as a separate subcompartment. Due to its environmental impact and its special status in the compartment, a special study needs to be performed.

A special feature of Sirajganj town is its severe erosion on the Bramaputra banks. After the construction of the groynes and other protective works, the erosion stopped. For the town the following points have been considered:-

- town protection
- drainage problem
- sanitation
- environmental problem
- groundwater

In order to improve the Sirajganj town sanitation problem, the Baral river also needed to be re-excavated from its intake at BRE upto the Hurasagar river with provision of one flushing sluice at its intake for flushing purposes. Numbers of existing culverts are needed to be modified to increase their flowing capacity and a few culverts are needed to be constructed at suitable location. The existing internal drainage system within town are also needed to be improved to remove waterlogging.

In option 1, the structures proposed are shown in the Table 9.1. The objective of the upstream structure of Ichamati branch (near Ratankandi) is to divert partial flow through the Ichamti khal. The major objective is to avoid BRE breach water into the project area. In order to increase the carrying capacity of the Ichamati khal, re-excavation is proposed. There are no structures proposed along the Ichamati side. The BRE side structures will be used to bring water into the project area. The primary objective is the fish migration. The structures are wide and sill level folled the inside river bed level.

Table 9.1 Proposed structures for OPTION 1

River/Khal Name	No of vents	Vent size (m)	Sill level m. +PWD
Ichamati Branch	2	1.52*3.0	9.50
Ch1(BRE)	1	2.0*1.83	10.62
Baniajan(BRE)	1	2.0*1.83	9.50
Katakhali Khal	1	2.0*1.83	9.22
Baral	2	2.0*1.83	9.70
Baniajan	6	1.52*3.0	8.70

SPECIFIC FEATURES OPTION 1:

The option 1 and its features are shown in Fig. 9.3.

COMPARTMENT DEVELOPMENT SITUATION WITHOUT ICHAMATI EMBANKMENT:

- *) **Improved Drainage** (BLUE)
- *) **Improvement inlet structures at BRE** (GREEN)
- *) **Structures at Ichamuti branch and khal** (GREEN)
- *) **Structures at Subcompartmental Boundaries** (GREEN)
- *) **Structures at Ichamuti East embankment** (GREEN)
- *) **Water retention structures** (GREEN)
- *) **Construction of structures which regulate inlet/outlet from subcompartment to subcompartment/khal.** (GREEN)
- *) **Diversion of major quantities of drainage water which comes from north of the CPP-project area through the Ichamati khal/branch** (GREEN)
- *) **BRE breach control works** (BROWN)
- *) **Sirajganj town inlet for sewage system** (BLUE/(GREEN)

DESCRIPTION OPTION 2A:

COMPARTMENT SITUATION WITH ICHAMATI EMBANKMENT FOLLOWING THE EXISTING ROAD

The assumptions of this options are as follows:-

Assumptions

1. Ichamati river embankment follows existing road;
2. Stable BRE
3. Improve Drainage;

4. BRE Inlet structure
5. Peripheral control structure
6. Sub-compartment BRE breach mechanism;
7. Internal water manangement;

The difference with **OPTION 1**, that there is an improvement of the OPTION 1 situation by including en embankment along the Ichamati river/khal which also provides protection. The Fig. 9.4 shows all the features of OPTION 2A.

SPECIFIC FEATURES OPTION 2A:

***) Flood protection embankment along Ichamati following a existing road**	**(BROWN)**
***) Improved Drainage**	**(BLUE)**
***) Inlet structures at BRE**	**(GREEN)**
***) Structures at Ichamati branch and khal**	**(GREEN)**
***) Structures at Subcompartmental Boundaries**	**(GREEN)**
***) Structures at Ichamuti East embankment**	**(GREEN)**
***) Water retention structures**	**(GREEN)**
***) Construction of structures which regulate inlet/outlet from subcompartment to subcompartment/khal.**	**(GREEN)**
***) Diversion of major quantities of drainage water which comes from north of the CPP-project area through the Ichamuti khal/branch**	**(GREEN)**
***) BRE breach control works**	**(BROWN)**
***) Sirajganj town inlet for sewage system**	**(BLUE/GREEN)**

The proposed Sirajganj town development remains the same as oulined in the OPTION 1. For modelling, the structures shown in the Table 9.2 are proposed. The objective of the upstream structure of Ichamati branch (near Ratankandi) is to divert partial flow (70% of the total flow) through the Ichamti khal. The majopr objective is not to let in BRE breach water into the project area. In order to increase the carrying capacity of the Ichamati khal, re-excavation is proposed. The Ichamati side structures are provided with the objective to regulate the flow from the Ichamti in to the project and when neeeded to retain water inside also. The BRE side structures will be used to bring water into the project area. The primary objective is the fish migration. The structures are wide and sill level followed the inside river bed level.

Table 9.2 : Proposed structures for OPTION 2A

River/Khal Name	No of vents	Vent size (m)	Sill level m. +PWD
Ichamati Branch	2	1.52*3.0	9.50
Ch1(BRE)	1	2.0*1.83	10.62
Baniajan(BRE)	1	2.0*1.83	9.50
Katakhali Khal	1	2.0*1.83	9.22
Baral	2	2.0*1.83	9.70
Baniajan	6	1.52*3.0	8.7
Ch15	1	1.52*1.83	9.90
Ch16	1	1.52*1.83	12.0
Baniajan	3	1.52*1.83	10.23

DESCRIPTION OPTION 2B:

COMPARTMENT DEVELOPMENT WITH ICHAMATI EMBANKMNET FOLLOWING THE RIVER BANK

Assumptions

1. Ichamati embankment follows a existing road along the Ichamati river bank;
2. Stable BRE
3. Improve Drainage;
4. BRE Inlet structure
5. Peripheral control structure
6. Sub-compartment BRE breach mechanism;
7. Internal water manangement;

The only diffrence with the option 2A is the Ichamati side embankment alignment. The other features remains the same and shown in Fig 9.5.

SPECIFIC FEATURES OPTION 2B:

***) Flood protection from Ichamati flooding following bank (RED)**
***) Improved Drainage (BLUE)**
***) Inlet structures at BRE (GREEN)**
***) Structures at Ichamati branch and khal (GREEN)**
***) Structures at Subcompartmental Boundaries (GREEN)**
***) Structures at Ichamati East embankment (GREEN)**
***) Water retention structures (GREEN)**
***) Construction of structures which regulate inlet /outlet from subcompartment to subcompartment/khal (GREEN)**

***) Diversion of major quantities of drainage water which comes from north of the CPP-project area through the Ichamati khal /branch (GREEN)**
***) BRE breach control works (BROWN)**
***) Sirajganj town inlet (BLUE/GREEN)**

The proposed embankment level along Ichamati river side will 1 in 20 year return period. In order to fixing up the embankment level, Dhunot water level was analysed. The Table shows the levels

Retrun Period	Value in M. PWD at Dhunot	Value at project side M. PWD
1 in 5	15.307	13.307
1 in 10	15.861	13.861
1 in 20	16.330	14.330

The proposed Sirajganj town development remains the same as oulined in the OPTION I. In OPTION 2B, the structures shown in the Table 9.3 are proposed. The objective of the upstream structure of Ichamati branch (near Ratankandi) is to divert partial flow through the Ichamti khal. The majopr objective is to avoid BRE breach water into the project area. In order to increase the carrying capacity of the Ichamati khal, re-excavation is proposed. The only diffrence with the OPTION-2A is the alignment of Ichamati side embankment. The Ichamati side embenkemnt follows the river bank. From modelling point of view, the diffrence with the OPTION 2A is the river width and the embankment height. The Ichamati side structures are provided with the objective to regulate the flow from the Ichamti in to the project and when neeeded to retain water inside also. The BRE side structures will be used to bring water into the project area. The primary objective is the fish migration. The structures are wide and sill level folled the inside river bed level. The Table 9.3 shows the structural sizes and its sill level. The proposed Sirajganj town development remains the same as oulined in the OPTION I.

The operation rule for the mentioned structure are as follows:-

* The Ichamati branch upstream structure will divert water into the Ichamtio khal. The strucure is weir and so operation rule is needed.

* The second structure on the same river will drain water when the Ichamati permits to drain.

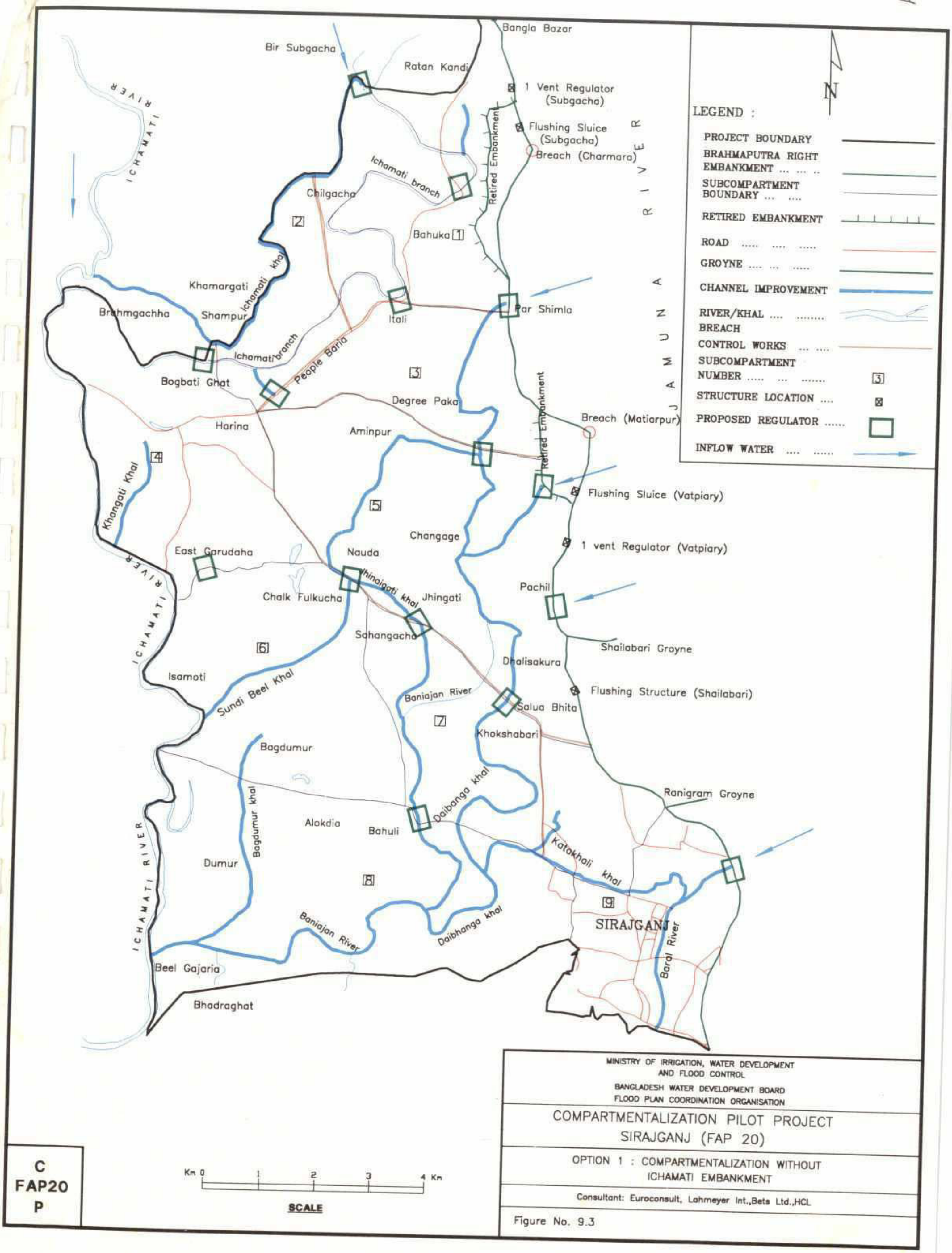
* The Ichamti river side structute will be operated when the Ichamti river stage will be low. Basically the up- and downstream water level will guide the structure operation.

* The BRE side structures will remain open, in general, till the first week of the July. But mainly these structure will depends on the arrival of first flood in the Jamuna river and its duration. The Sirajganj town structure willa allow the water to enter into the town till it reaches level 13.5 M. PWD. So the structure will remain open untill the inside water level reach the mentioned level and during receding period of Jmauna, it will start draining into the Jamuna.

* The other internal structure will be guided by the local demands. The detail water management will be the guiding factor for these structures. Apart from these, the structure will serve to mitigate the effects of the breach.

Table 9.3 : Proposed structures in OPTION 2B

River/Khal Name	No of vents	Vent size (m)	Sill level m. +PWD
Ichamati Branch	2	1.52*3.0	9.50
Ch1(BRE)	1	2.0*1.83	10.62
Baniajan(BRE)	1	2.0*1.83	9.50
Katakhali Khal	1	2.0*1.83	9.22
Baral	2	2.0*1.83	9.70
Baniajan	6	1.52*3.0	8.7
Ch15	1	1.52*1.83	9.90
Ch16	1	1.52*1.83	12.0
Baniajan	3	1.52*1.83	10.23
Baral	2	2*1.83	9.7


LEGEND :
PROJECT BOUNDARY
BRAHMAPUTRA RIGHT EMBANKMENT
SUBCOMPARTMENT BOUNDARY
RETIRED EMBANKMENT
ROAD
GROYNE
CHANNEL IMPROVEMENT
RIVER/KHAL
BREACH
CONTROL WORKS
SUBCOMPARTMENT NUMBER
STRUCTURE LOCATION
PROPOSED REGULATOR
INFLOW WATER
N
Bangla Bazar
Bir Subgacha
Ratan Kandi
1 Vent Regulator (Subgacha)
Flushing Sluice (Subgacha)
Breach (Charmara)
Retired Embankment
ICHAMATI RIVER
Ichamati branch
Chilgacha
Bahuka 1
2
Khamargati
Ichamati khal
Brahmgachha
Shampur
Itali
Par Shimla
JAMUNA RIVER
Bogbati Ghat
Ichamati branch
People Baria
3
Degree Paka
Harina
Aminpur
Breach (Matiarpur)
4
Khangati Khal
Flushing Sluice (Vatpiary)
5
Changage
1 vent Regulator (Vatpiary)
East Garudaha
Nauda
Jhingati khal
Pachil
Chalk Fulkucha
Jhingati
Sahangacha
Shailabari Groyne
6
Dhalisakura
Isamoti
Sundi Beel Khal
Baniajan River
Flushing Structure (Shailabari)
Salua Bhita
7
Khokshabari
Bagdumur
Ranigram Groyne
Bagdumur khal
Alokdia
Daibanga khal
Bahuli
Katakhali khal
Dumur
8
9
SIRAJGANJ
Baniajan River
Daibhanga khal
Baral River
Beel Gajaria
Bhadraghat
Km 0 1 2 3 4 Km
SCALE
C
FAP20
P
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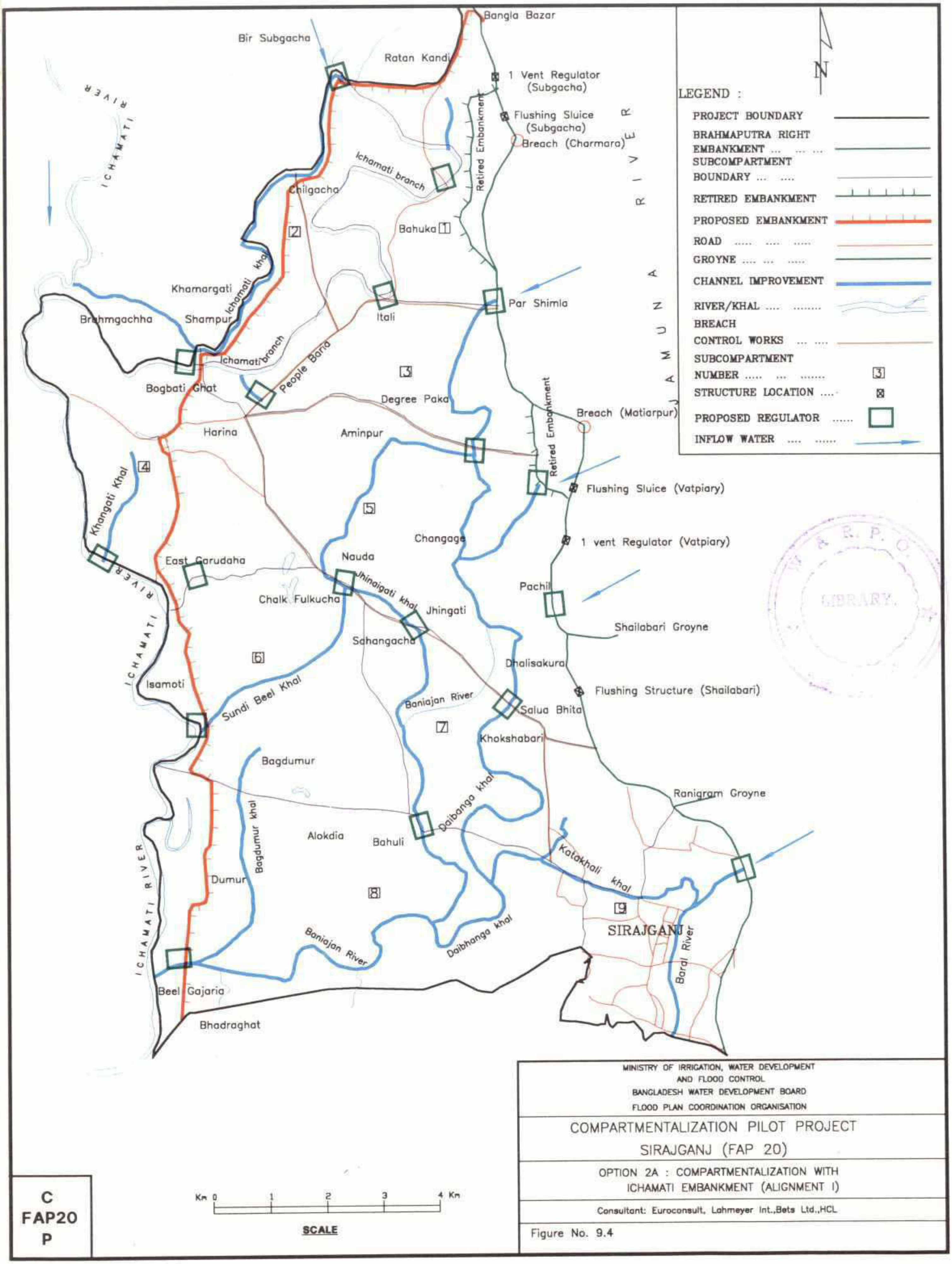
BANGLADESH WATER DEVELOPMENT BOARD
FLOOD PLAN COORDINATION ORGANISATION
COMPARTMENTALIZATION PILOT PROJECT
SIRAJGANJ (FAP 20)
OPTION 1 : COMPARTMENTALIZATION WITHOUT ICHAMATI EMBANKMENT
Consultant: Euroconsult, Lahmeyer Int.,Bets Ltd.,HCL
Figure No. 9.3



MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL
BANGLADESH WATER DEVELOPMENT BOARD
FLOOD PLAN COORDINATION ORGANISATION

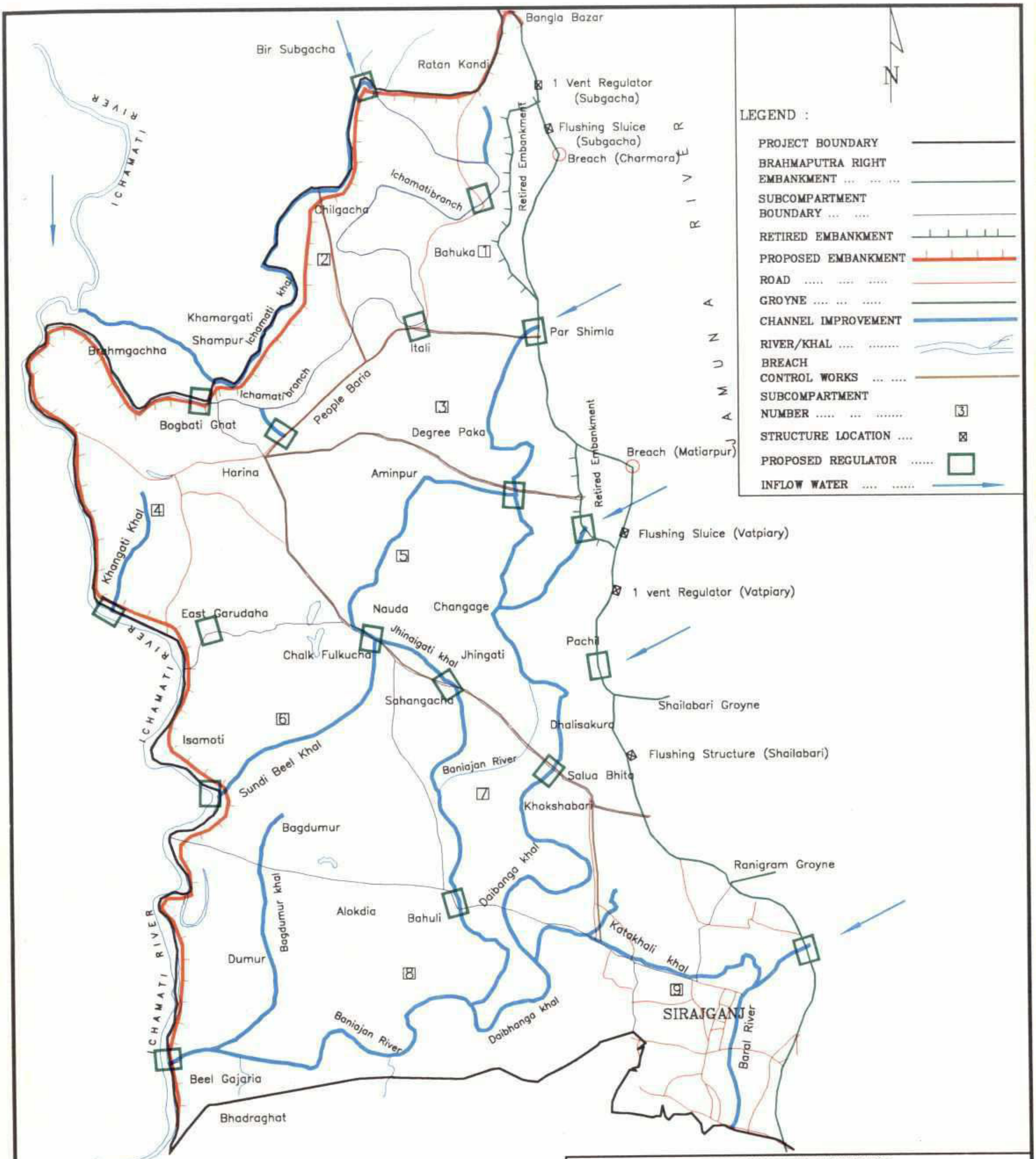
COMPARTMENTALIZATION PILOT PROJECT
SIRAJGANJ (FAP 20)

OPTION 2A : COMPARTMENTALIZATION WITH ICHAMATI EMBANKMENT (ALIGNMENT I)

Consultant: Euroconsult, Lahmeyer Int.,Bets Ltd.,HCL

Figure No. 9.4

C
FAP20
P



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COMPARTMENTALIZATION PILOT PROJECT
SIRAJGANJ (FAP 20)

OPTION 2B : COMPARTMENTALIZATION WITH ICHAMATI EMBANKMENT (ALIGNMENT II)

Consultant: Euroconsult, Lahmeyer Int.,Bets Ltd.,HCL

Figure No. 9.5

C
FAP20
P

10.0 Output Processing

The output of the MIKE11 model is composed of water levels and discharges in alternate points along a channel. Discharge and water level is not available in the same point. For sub-compartment analysis, a water level point is selected in such a way that it represents the flooding pattern of the sub-compartment.

A computer program for processing the results of the various simulation has been developed in order to determine the distribution of flooded areas for each sub-compartment.

Cropping Pattern Analysis

For each sub-compartment, the selected water level point is used to calculate the respective areas of various categories of level:

* F0 flood free land or land inundated to a depth less then 30 cm.
* F1 land inundated to a depth of 30 to 90 cm.
* F2 land inundated to a depth of 90 to 180 cm.
* F3 land inundated to a depth of 180 to 300 cm.
* F4 land inundated to a depth of more than 300 cm.

The MIKE11 model is linked with the area-elevation table to get the above mentioned inundation. A summery table is gven for all the options and shown in Table 10.1.

Table 10.1 Sub-compartment wise land types of NCA in three different options

Sub-Compartment	NCA	Option-1 F0	F1	F2	F3	Option 2A F0	F1	F2	F3	Option-2B F0	F1	F2	F3
1	750	727	23	0	0	727	23	0	0	727	23	0	0
2	709	160	224	265	60	524	131	39	15	524	131	39	15
3	893	651	206	36	0	651	206	36	0	651	206	36	0
4	1132	98	411	526	97	92	409	533	98	314	470	294	54
5	1656	1132	413	111	0	1132	413	111	0	1132	413	111	0
6	1196	119	462	541	74	526	257	343	70	537	464	195	0
7	1071	666	343	62	0	666	343	62	0	666	343	62	0
8	1981	722	774	458	27	698	780	472	31	868	716	381	16
9	191	105	80	6	0	105	80	6	0	105	80	6	0
Total	9579	4380	2936	2005	258	5121	2642	1602	214	5524	2846	1124	85
%		46	30	21	3	53	28	17	2	57	30	12	1

Fisheries Analysis

The decade wise analysis for the agriculture will be used in the fisheries also. This analysis was used to investigate how the fisheries areas in the project area would be affected by the proposed developments.

A two step analysis is used in the assessment of fish losses under the different scenario's:

(a) With the Sirajganj model for the CPP-area, the hydrological environment for the different options is simulated, resulting in the total area of beels and inundated floodplain for each decade during the period of 1st May up to 31st of November. Outside this period the Floodplain/Beel area is gradually reduced to the minimum dry season level of 20 ha.

(b) A fisheries spreadsheet model was developed. This model was calibrated with the hydrological data of A stable BRE without CPP and the floodplain/khal fisheries production, beel fisheries production and beel fishing intensity obtained through the Fisheries Household Survey and the Special Fisheries Study of the CPP project, as the 1992/1993 season can be compared with such a situation as no flood entered the CPP area. Within this model it is assumed that the total production from the floodplain and the khals is caught during the period of 20st of June to 10st of November, the period when floodplain/beels are connected with the river system and the total beel production is caught in the remaining period and area. The effect of reduced inundated floodplain area is calculated by multiplying the simulated inundated area with the calibrated floodplain production of

0.94 kg/ha/decade. It is assumed that there is a linear relation ship between "beel" fish production and the available reproductive area (which is a minimum concept). The effect of the reduced reproduction area for "Beel" fish is brought into the model by taking the Beel area of the 10st of june, under the option stable BRE/no CPP as a standard. A reduction of this area under the different options leads to a proportional reduction in total "beel" fish production.

The summery of the fisheries anallysis is shown in Table 10.2.

Table 10.2: A summary of the production figures of the different development option for the Sirajganj CPP project area.

OPTION	TOTAL FISH PRODUCTION T/YEAR	DECREMENTAL PRODUCTION T/YEAR	TOTAL VALUE (US$/YEAR)	DECREMENTAL VALUE (US$/YEAR)
Present situation, breaching of BRE	591	+209	616.000	+193.000
Without case, stable BRE & no CPP	382	-	423.000	
Option 1	401	+19	442.000	+19.000
Option 2A	379	-3	420.000	-3.000
Option 2B	364	-18	408.000	-34.000

11.0 Interpretation of the Model Results

The model is used to assess the impact of different options. In order to facilitate the model results interpretion, the sub-compartment can be classify in to two categories i.e subcomaprtments directly influnced by the Ichamati river (SC2, SC4, SC6 and SC8) and sub-compartments near BRE (SC1, SC3, SC5 and SC7). There are three number of options. Basically the number can be reduce to one i.e OPTION 2B. The fundamental difference between OPTION1 and OPTION 2B is the Ichamati river side embankment and difference between OPTION 2A and OPTION 2B is the alignment of the Ichamati river embankment.

The model results of the OPTION 2B is shown in Appendix 4.3. In SC1, influence of the proposed structure is observed. The flow is diverted through the Ichamati Khal. In SC2, upto July, the with project water level is higher than the without project situation. It is due to the retention structure proposed at the downstream of the Ichamati Branch. At begining of the August, the gate of the retention structures is open and it starts draining. In SC3, due to presence of BRE strucure, the with project premonsoon levels remains slightly higher then the withoput project situation. After the first peak, the gate are closed and the its influnce is opbserved. In SC4 and SC6, the area is influnced by the Ichamati river. One aspect is remarkable that draining capabilities largely depends on the head available in the Ichamati river. SC5 and SC7 is drained mainly by the Baniajan river. In SC7, draining is hardly possible during the monsoon. In SC8, the similar behaviour is observed. This is due to the 'backwater' or 'backflow' in Ichamati river.

In OPTION 1, the model results in SC2, SC4, SC6 and SC8 will be similar to without project situation. In SC1, SC3, SC5 and SC7 are similar to the with proeject situation.

In OPTION 2A, the only difference is in SC4, SC6 and SC8 due to the embankment alignment. The outside area is influnced by the Ichamti river. The SC1, SC2, SC3, SC5, SC7 and SC8 are to the withproject situation.

11.1 Impact on the External Areas

As described in the Options, the external areas will be affected due to the structural interventaions. The water level taken for impact assesment of both **without** and **with** projects are the maximum water levels. The year selected for the analysis are 1970 and 1990. The 1970 represents 1 in 5 year return period and 1990 is one of the breach year.

Table 11.1 Impact on the external areas in OPTION 2B

LOCATION/CONDITION	REF ON RIVER	LEVEL 90 IN M+PWD	MAX RISE IN 90(M)	LEVEL 70 IN M+PWD	MAX RISE IN 70(M)
U/S Ichamati Branch	Ichamati Branch	15.79	0.42	13.85	0.27
Confluence Ichamati Bracnh and Ichamati river	Ichamati River	14.64	0.27	13.52	0.18
Garudah Ichamati River	Ichamati River	14.23	0.18	13.06	0.12
Conflunce of Ichamati River and Baniajan river	Ichamati River	13.54	0.15	12.46	0.10

The maximum water levels are means when all the gates of the structures are closed to assess the maximum rise in water level upstream of the structural site. The Fig. 11.1 shows the location and the Table 11.1 shows the water level rise in the location points.
The following can be concluded:

- The highest rise of waterlevel is in the area just upstream of the compartment (0.30 to 0.42 m).

- The impact on the upstream of Ichamati floodplain (from the conflunce of Ichamati branch to Garudah) is significant. The south of Garudah to Bhadraghat, the impact is not significant. This is due to the backwater effect.

- The impact on the the Jamuna is remains the same.

- There is no effect on the waterlevels on the southern side.

12.0 Future Programme

The present model gives enough detail to simulate peripheral control and control upto the level of Sub-compartment. The present model is calibrated with 1992, which is a very dry year. Therfore it is recomended to verify the model with another 'wet' season so that the floodplain flow can be calibrated with sufficient detail. Regarding the use of structures in MIKE11 (version 3.0), more attention has to be given because till now the use of structures is difficult. In order to study the detailed water management of the Sirajganj area, the model needs to be modified i.e smaller channels have to be included in the model. It is proposed to transfer the entire model from DOS to UNIX to use the model with more number structure. Also running the model under DOS is problematic as it cannot open more than 12 files simultaneously.

1) Splitting the Model:

It is proposed to divide the Sirajganj model into two sub-model. The Sub-model 1 will be consists of SC1, 2, 3, 4 and SC5 and Sub-model 2 will be consists of SC6, SC7, SC8 and SC9. The main reasons for doing this divisions are as follows:-

- to study water management in detail.
- to include more channels and structures.
- to avoid DOS limitations.

2) Run for 25 years.

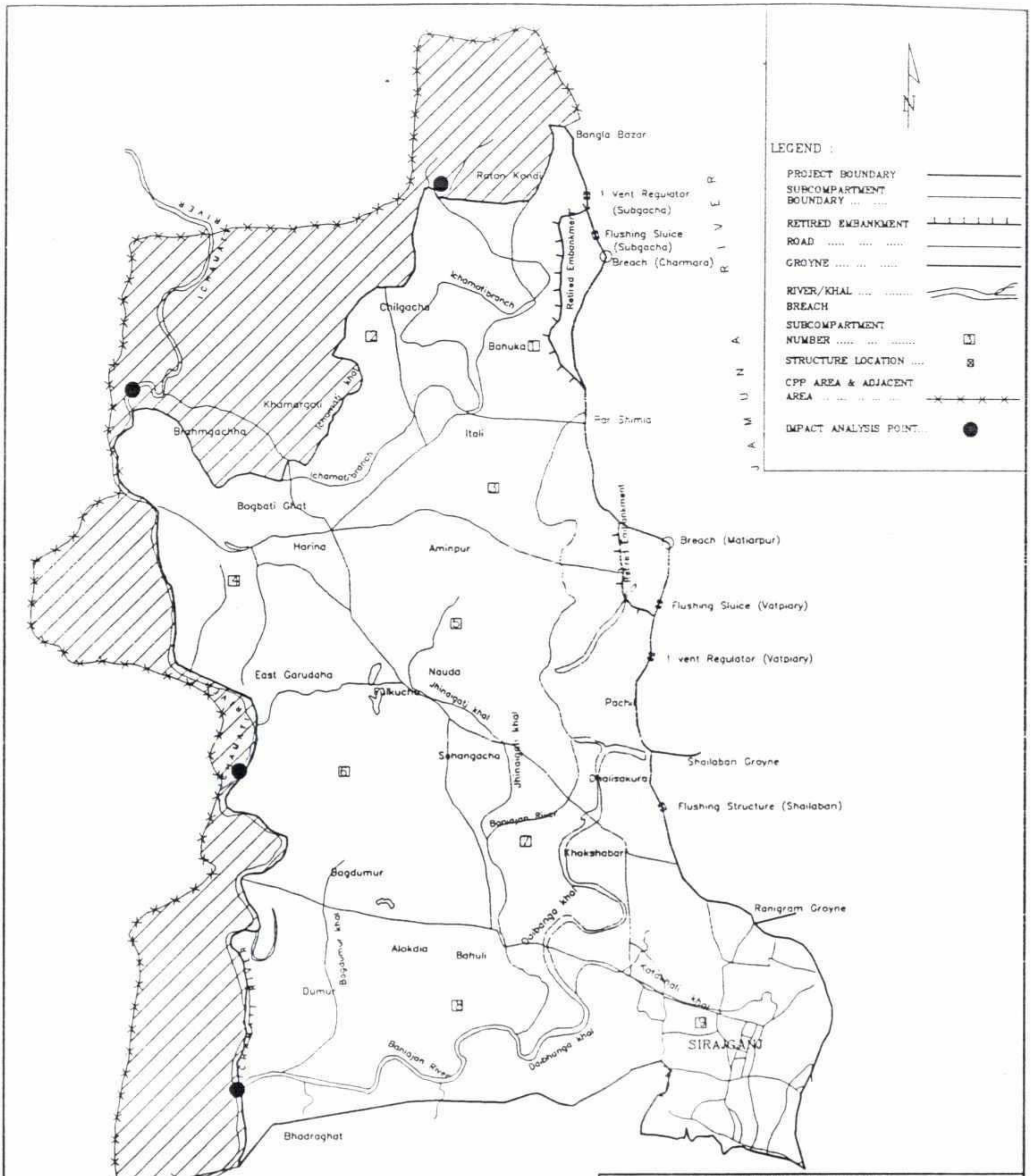
The effect of the future BLE on the compartment boundary conditions will be assessed and its impact on the water management will be verified.

3) Bangali river and connection with Jamuna.

The present trend of the Bangali river is that in course of time, the Jamuna might linked with Bangali river. If this is so, the hydraulics of this area will change considerably and needed to be studied.

4) Refining the whole model with 1993 measurement.

The main model will be updated for 1993 situation and this model will provide necessary boundary conditions for the sub-models.



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SIRAJGANJ (FAP 20)

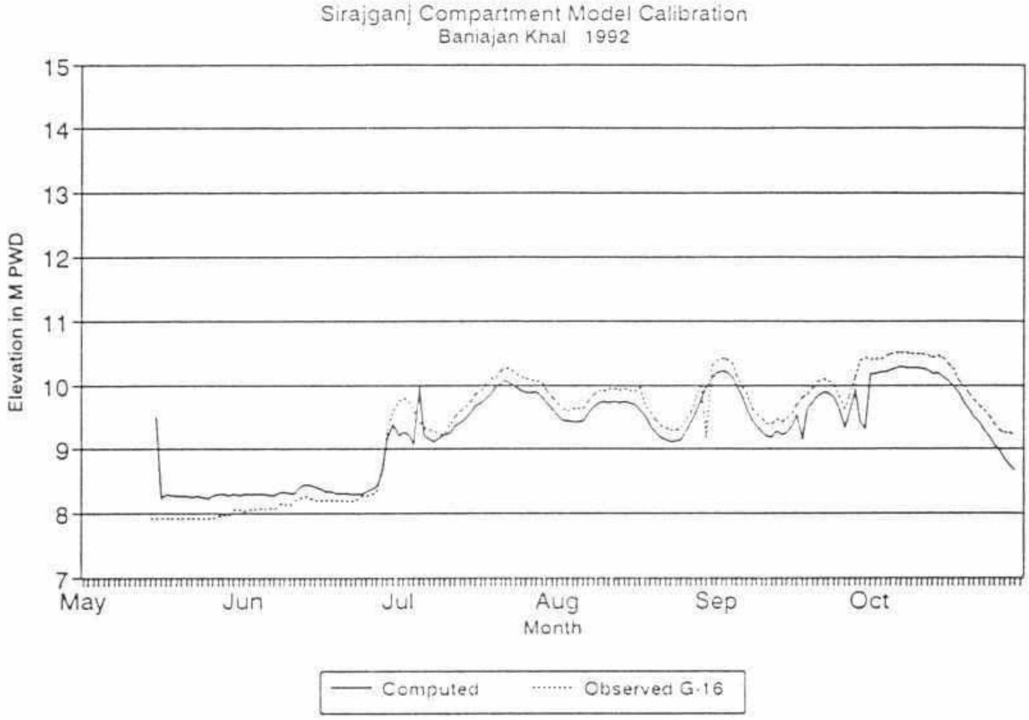
ADJACENT AREAS

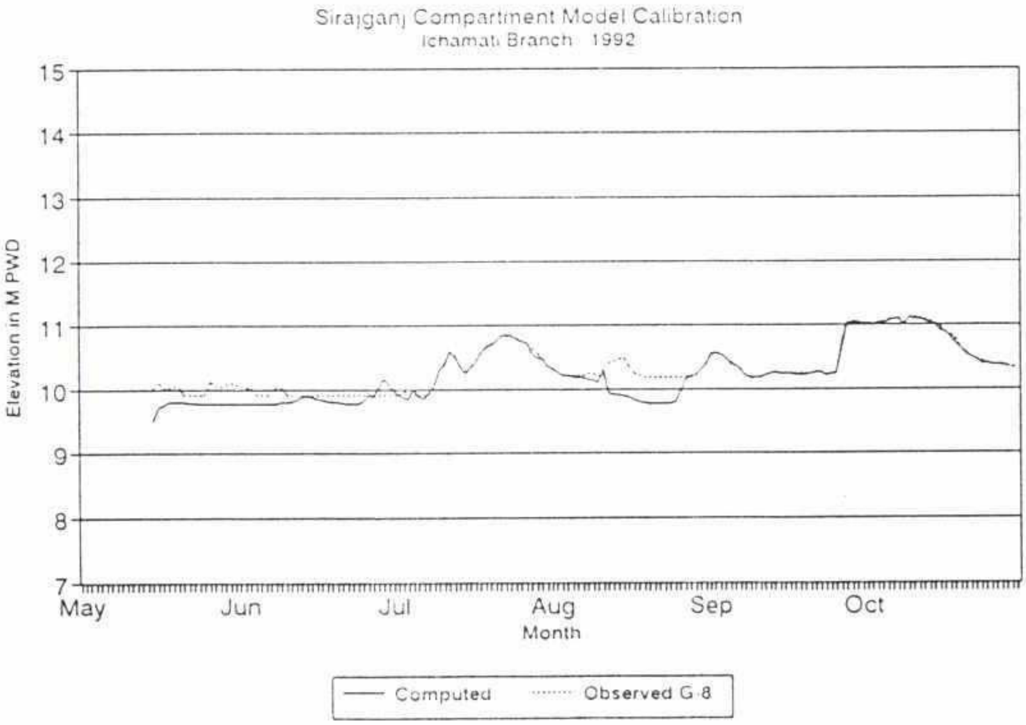
Consultant: Euroconsult, Lahmeyer Int., Bets Ltd., HCL

Figure No. II.1

APPENDIX 4.1

Comparison of calibrated and measured water levels at key locations.
Computed Discharges at key locations.


Sirajganj Compartment Model Calibration
Baniajan Khal 1992
Elevation in M PWD
15
14
13
12
11
10
9
8
7
May
Jun
Jul
Aug
Sep
Oct
Month
Computed
Observed G-16


Sirajganj Compartment Model Calibration
Ichamati Branch 1992
Elevation in M PWD
15
14
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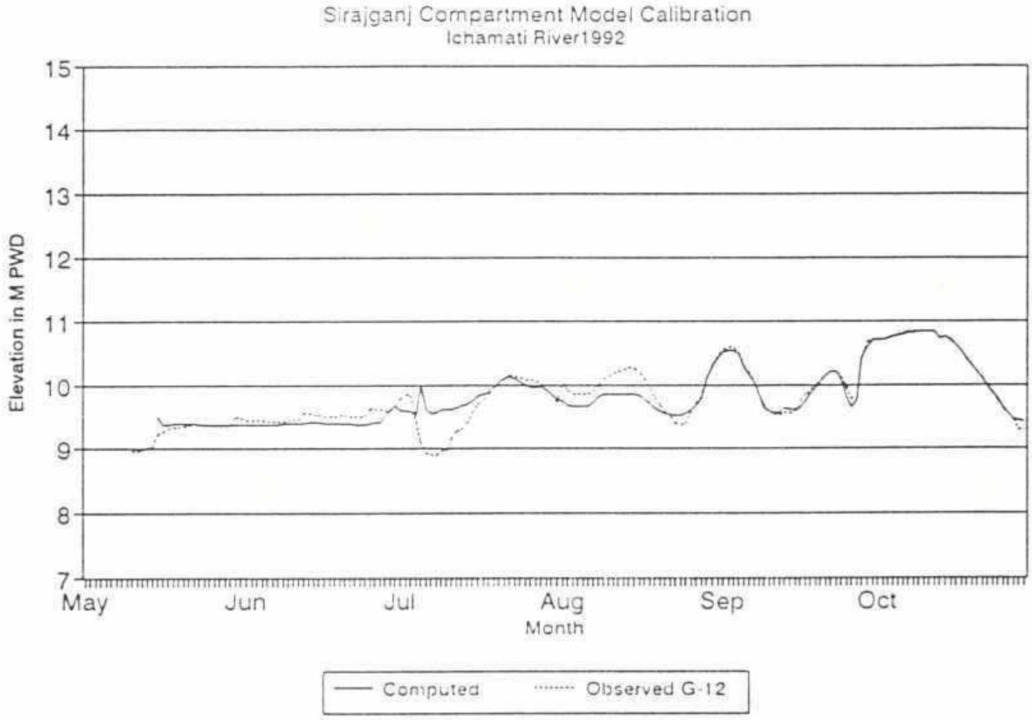
12
11
10
9
8
7
May
Jun
Jul
Aug
Sep
Oct
Month
Computed
Observed G-8


Sirajganj Compartment Model Calibration
Ichamati River1992
Elevation in M PWD
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11
10
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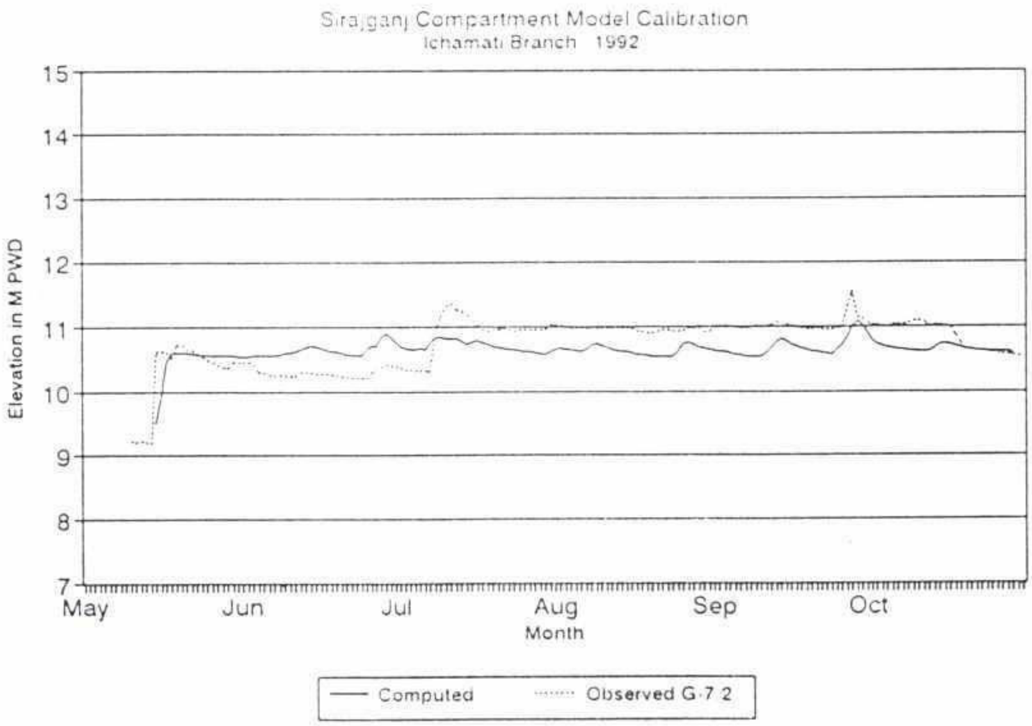
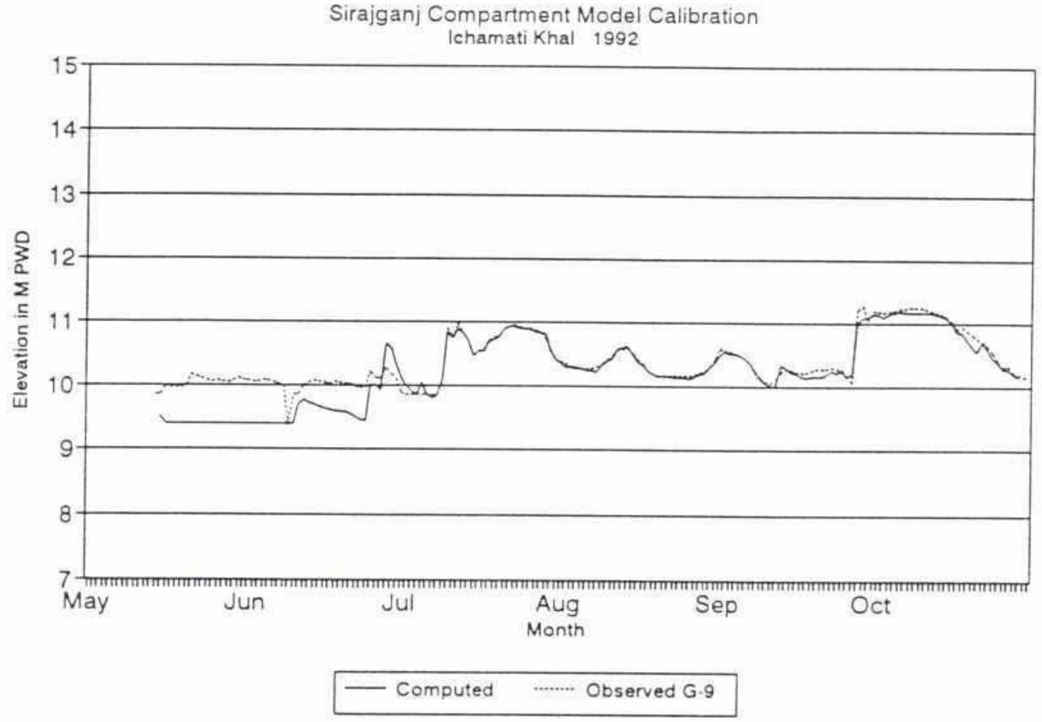
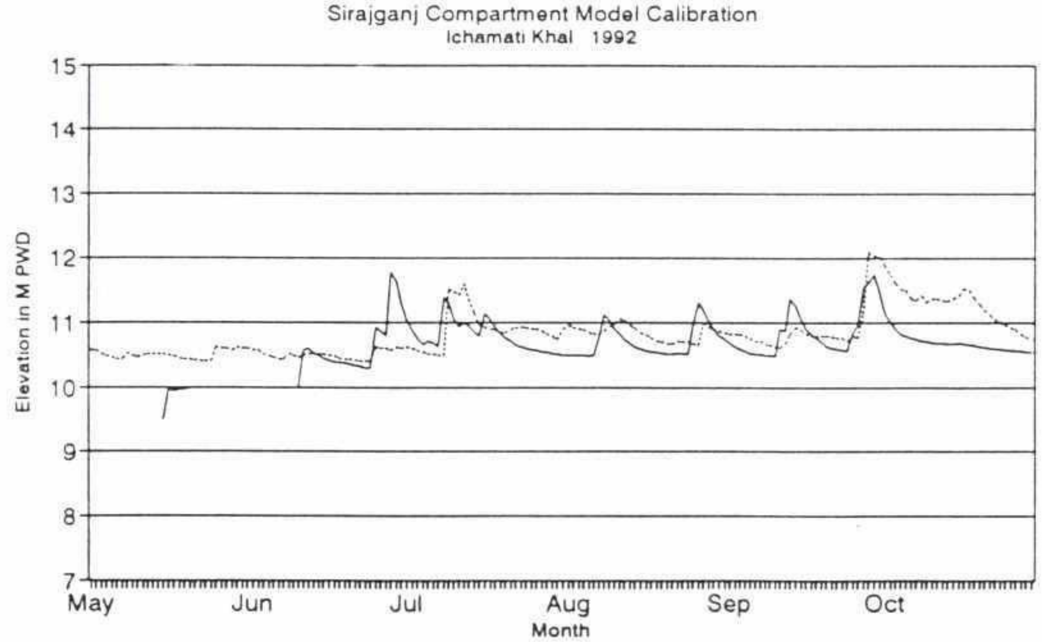
7
May
Jun
Jul
Aug
Sep
Oct
Month
Computed
Observed G-12


Sirajganj Compartment Model Calibration
Ichamati Branch 1992
Elevation in M PWD
15
14
13
12
11
10
9
8
7
May
Jun
Jul
Aug
Sep
Oct
Month
Computed
Observed G-7.2


Sirajganj Compartment Model Calibration
Ichamati Khal 1992
Elevation in M PWD
15
14
13
12
11
10
9
8
7
May
Jun
Jul
Aug
Sep
Oct
Month
Computed
Observed G-9


Sirajganj Compartment Model Calibration
Ichamati Khal 1992
Elevation in M PWD
15
14
13
12
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May
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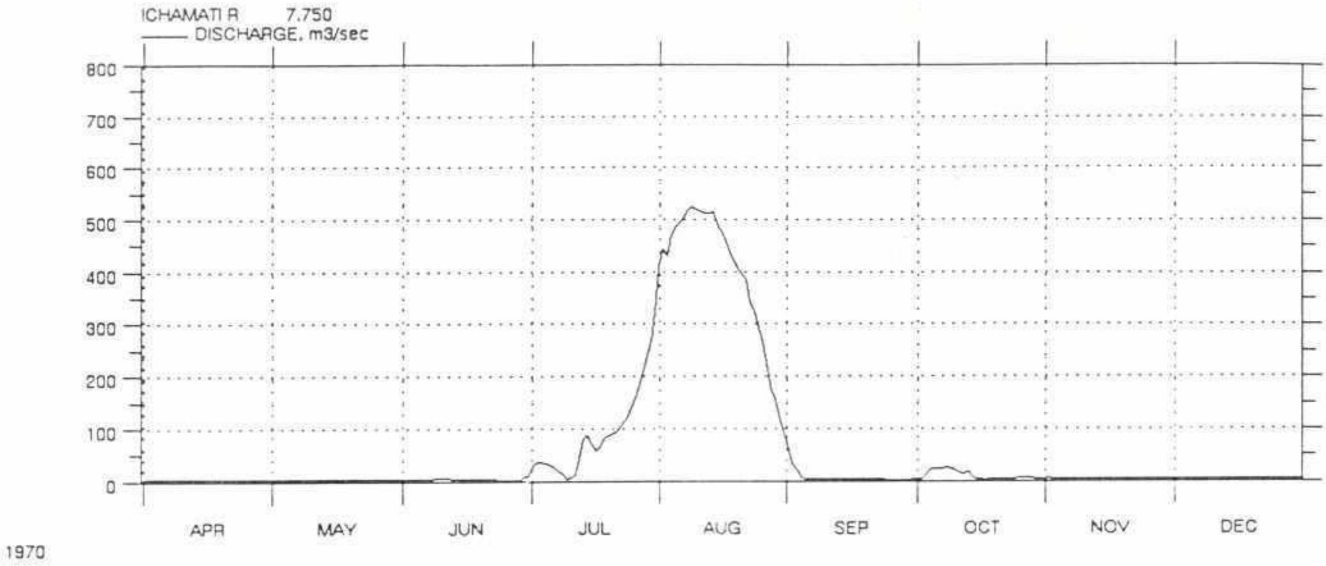
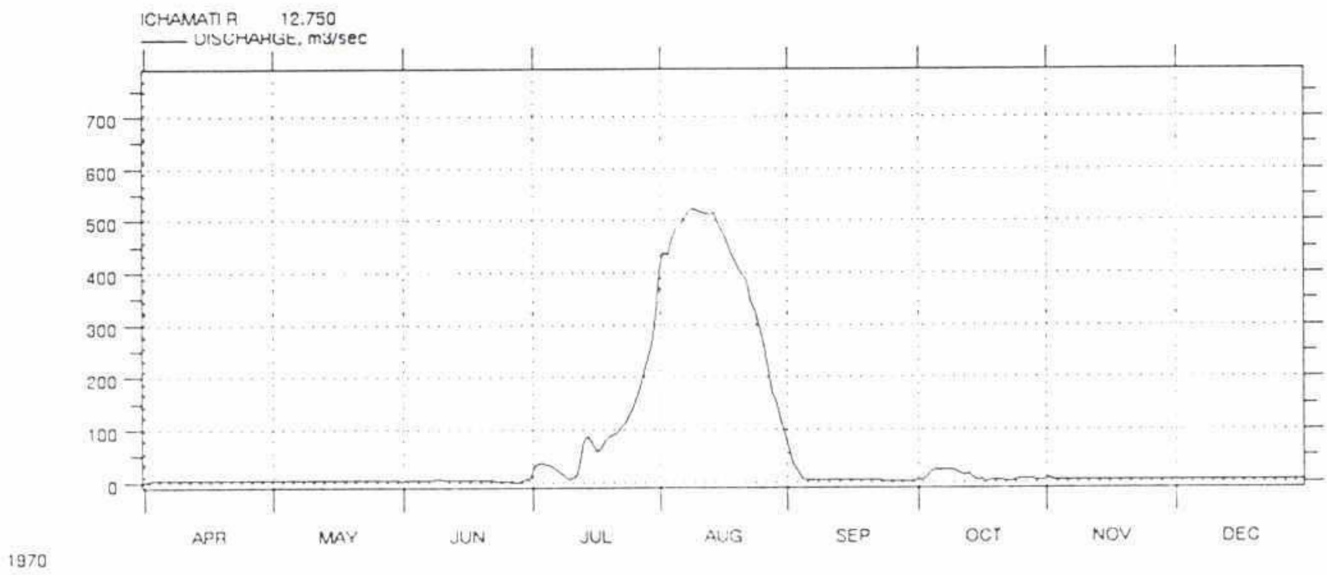
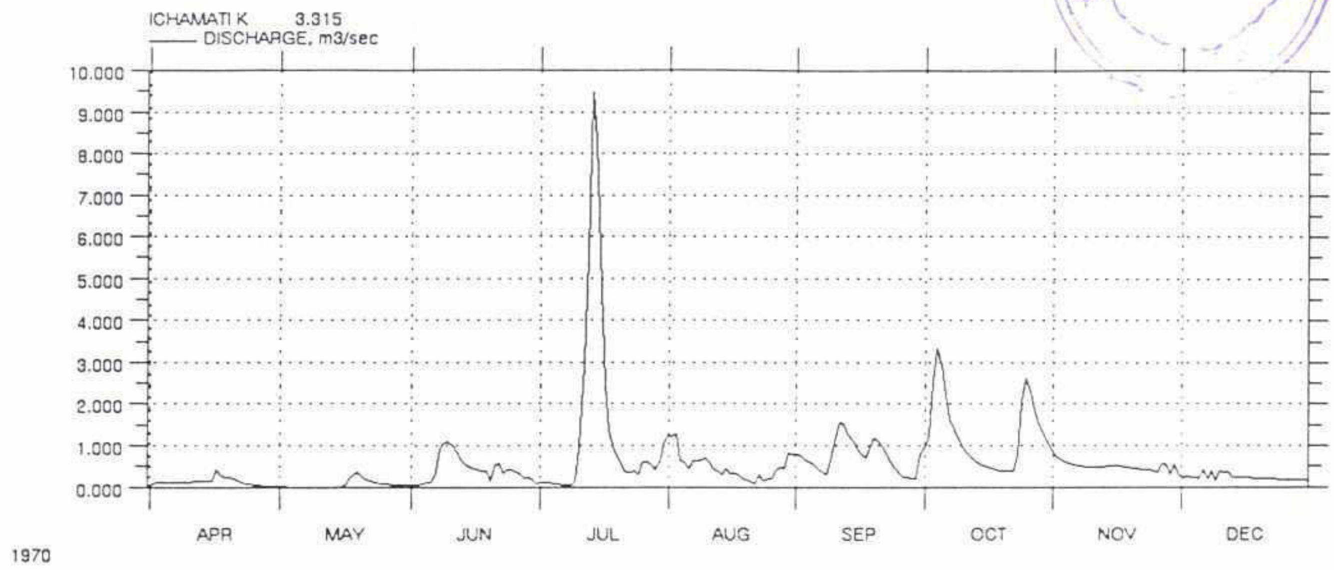
Jul
Aug
Sep
Oct
Month

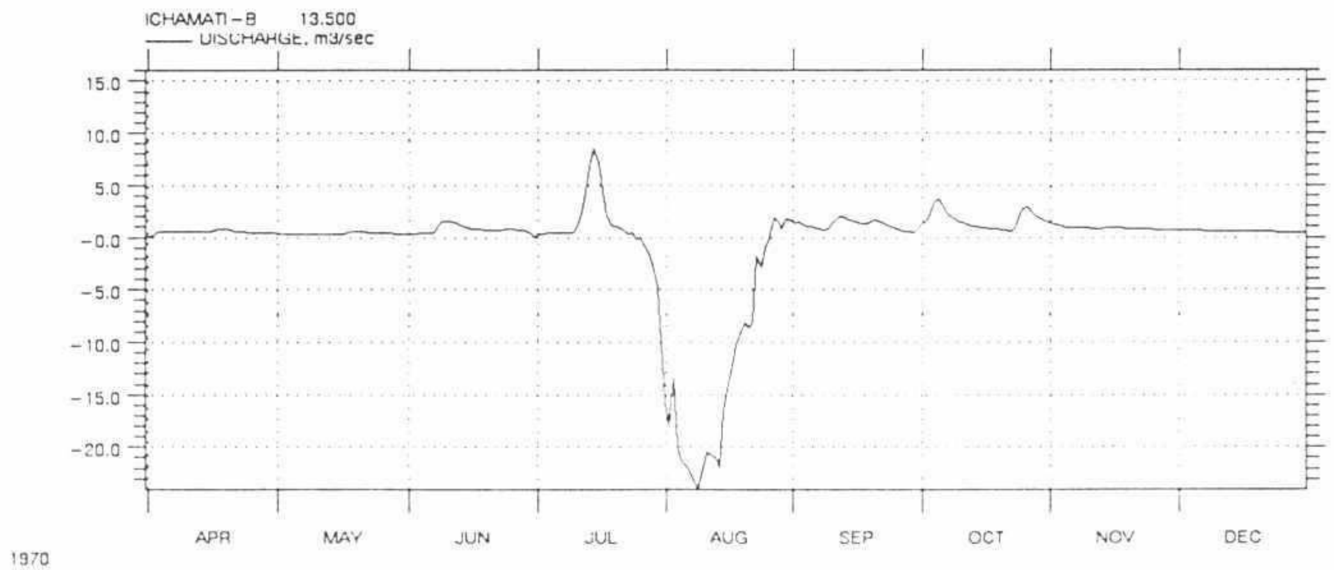
37





	Compartmentalization Pilot Project, Sirajganj Compartment Computed Discharges	
DATA FILE : SGBASE.RDF RESULT FILE : TEST70.RRF	BOUNDARY FILE : SGBASE.BSF CALCULATED : 13 – MAY – 1993, 16:23	**MIKE 11** Dwg no.:





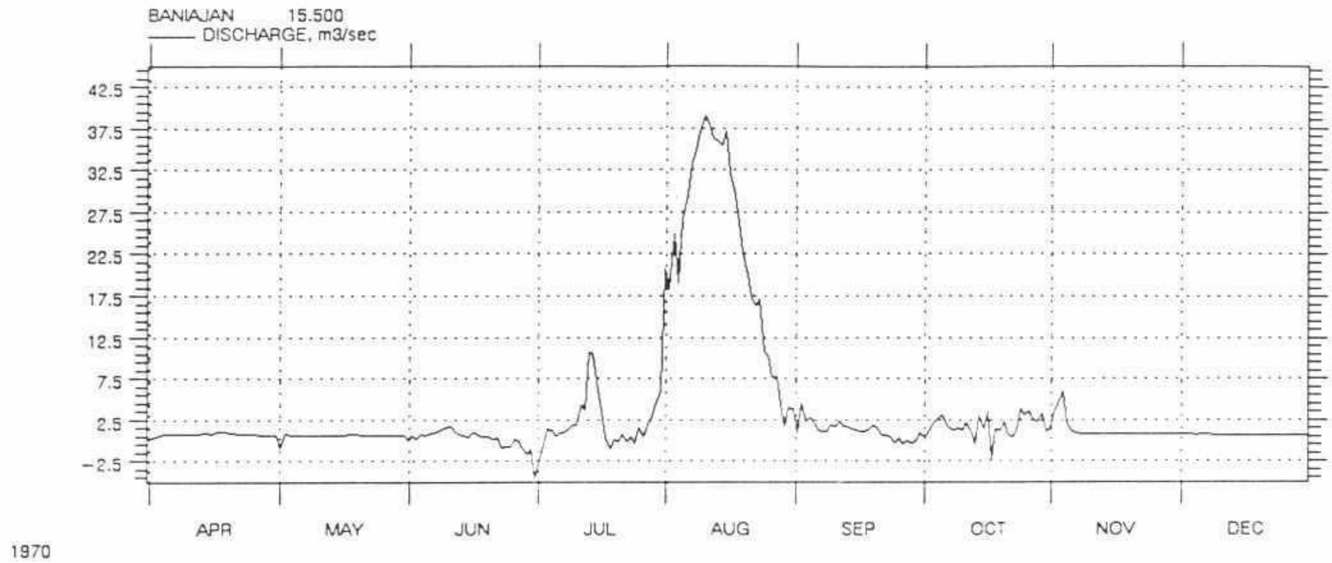
Compartmentalization Pilot Project, Sirajganj Compartment
Computed Discharges

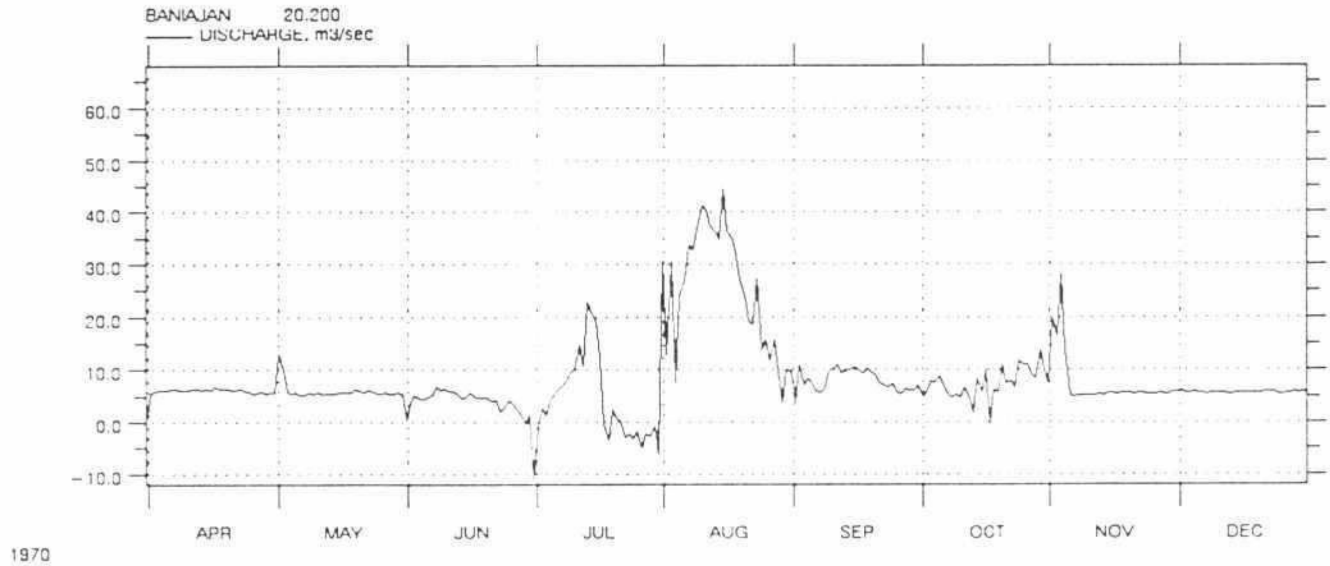
MIKE 11

Dwg no.:

DATA FILE : SGBASE.RDF
RESULT FILE : TEST70.RRF

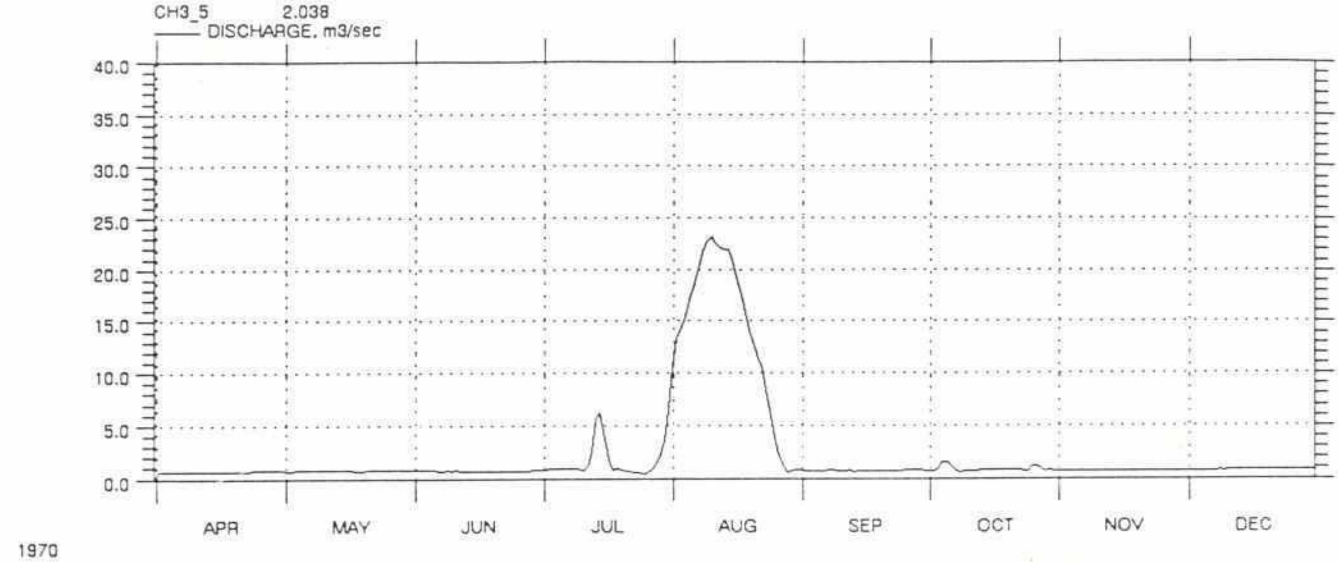
BOUNDARY FILE : SGBASE.BSF
CALCULATED : 13 – MAY – 1993, 16:23

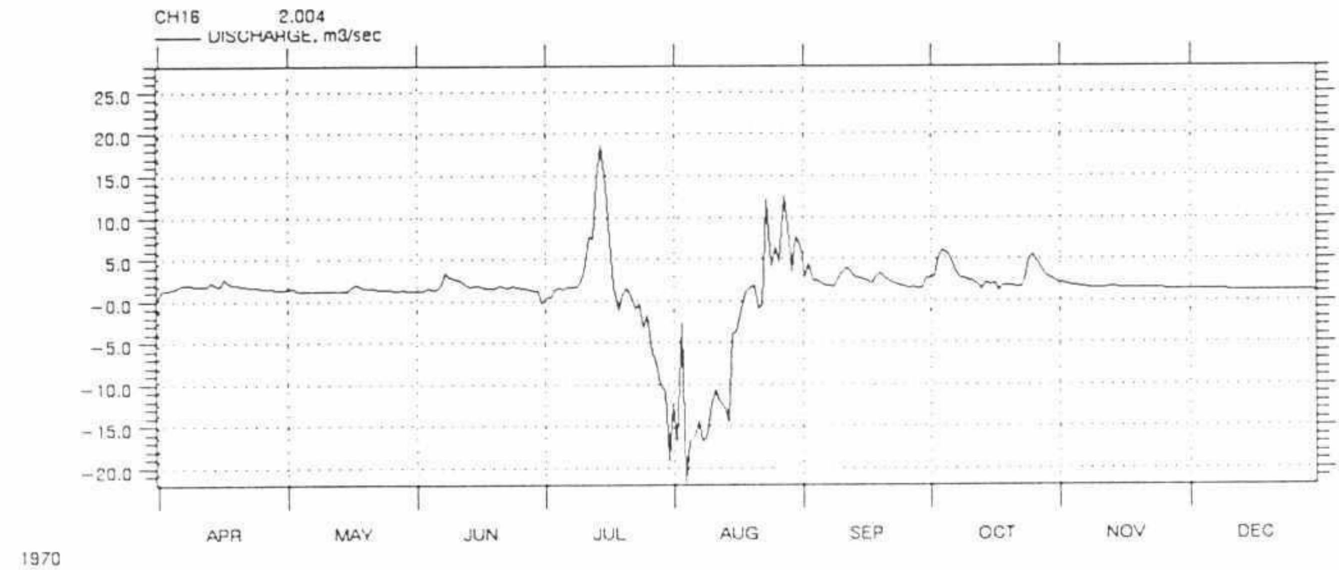




	Compartmentalization Pilot Project, Sirajganj Compartment Computed Discharges

DATA FILE : SGBASE.RDF RESULT FILE : TEST70.RRF	BOUNDARY FILE : SGBASE.BSF CALCULATED : 13 – MAY – 1993, 16:23	**MIKE 11** Dwg no.:



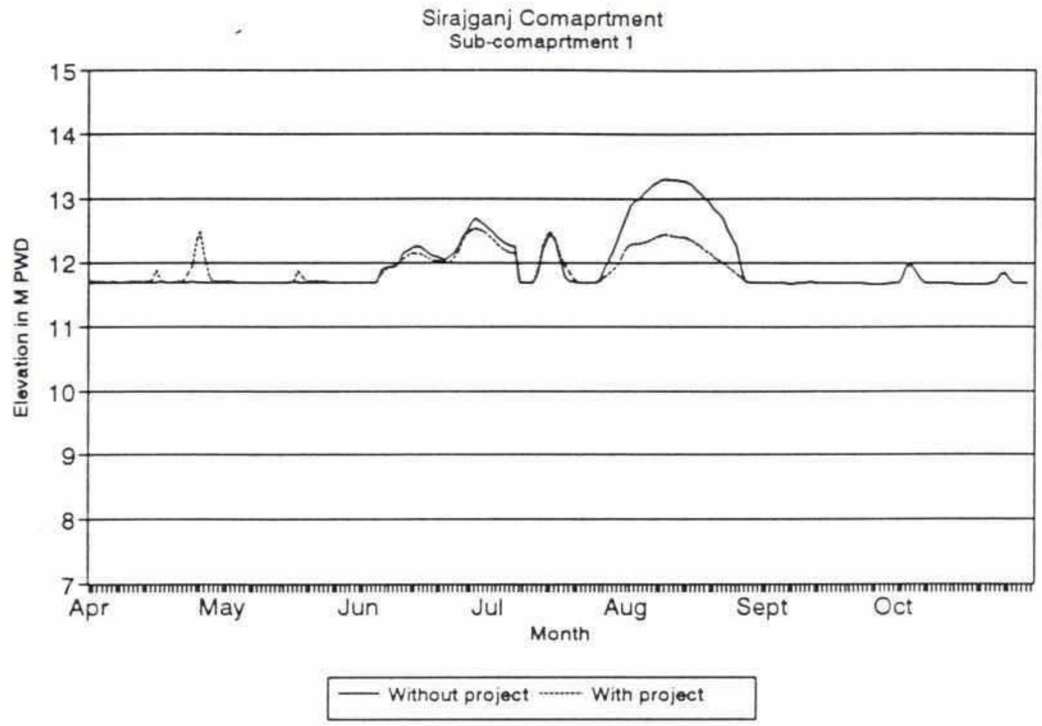


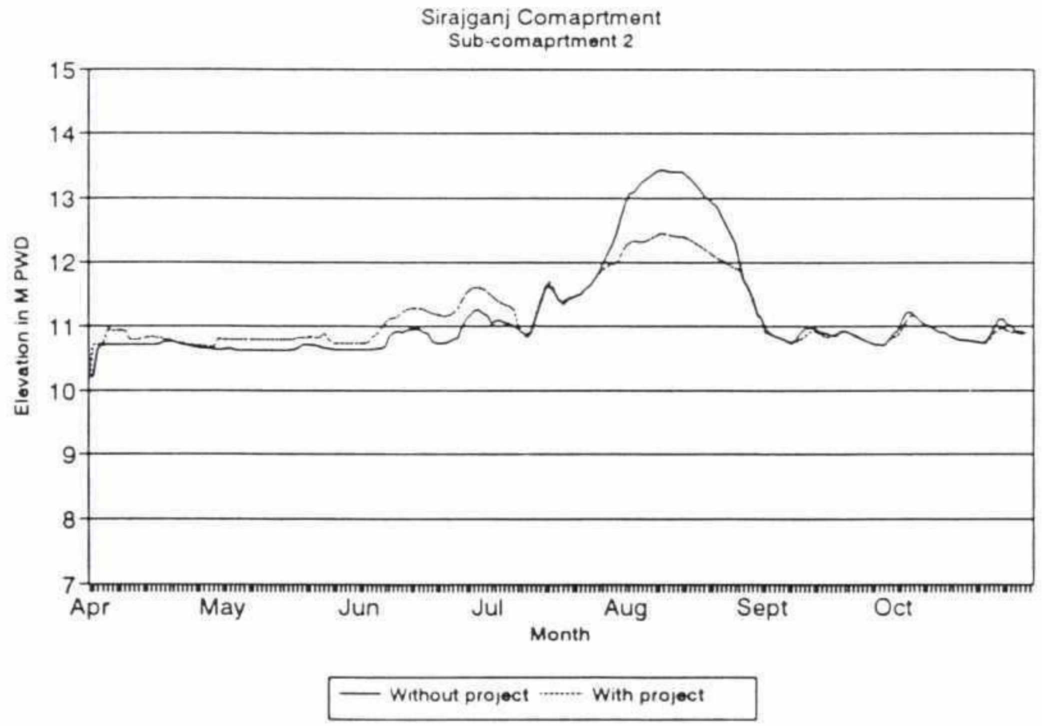
	Compartmentalization Pilot Project, Sirajganj Compartment Computed Discharges	
DATA FILE : SGBASE.RDF RESULT FILE : TEST70.RRF	BOUNDARY FILE : SGBASE.BSF CALCULATED : 13 – MAY – 1993, 16:23	**MIKE 11** Dwg no.:

APPENDIX 4.2

Simulated water levels of Without and With project situation OPTION 2B

96


Sirajganj Comaprtment
Sub-comaprtment 1
Elevation in M PWD
15
14
13
12
11
10
9
8
7
Apr
May
Jun
Jul
Aug
Sept
Oct
Month
Without project
With project


Sirajganj Comaprtment
Sub-comaprtment 2
Elevation in M PWD
15
14
13
12
11
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9
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Apr
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Sept
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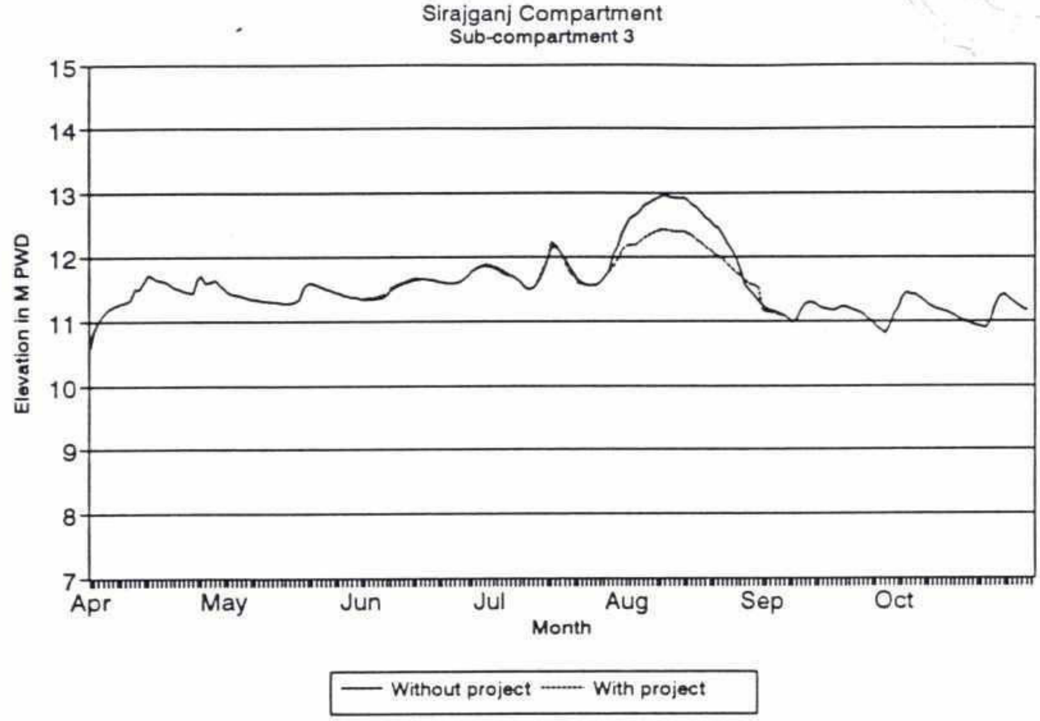
Month
Without project
With project

98



Sirajganj Compartment
Sub-compartment 3
Elevation in M PWD
15
14
13
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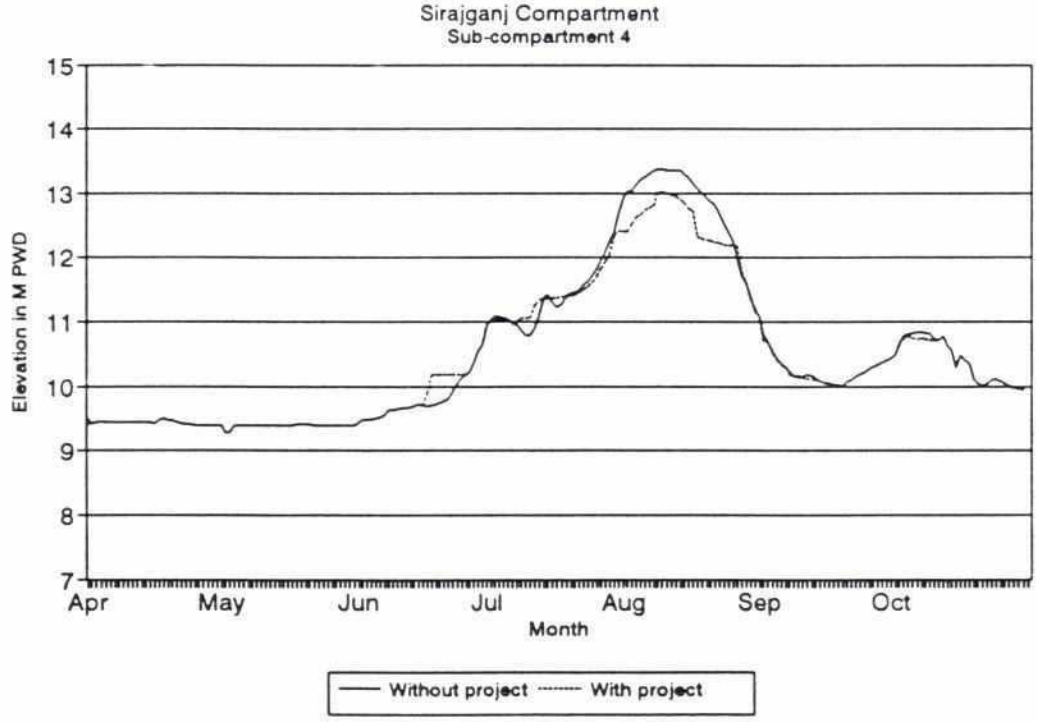
9
8
7
Apr
May
Jun
Jul
Aug
Sep
Oct
Month
Without project
With project



Sirajganj Compartment
Sub-compartment 4
Elevation in M PWD
15
14
13
12
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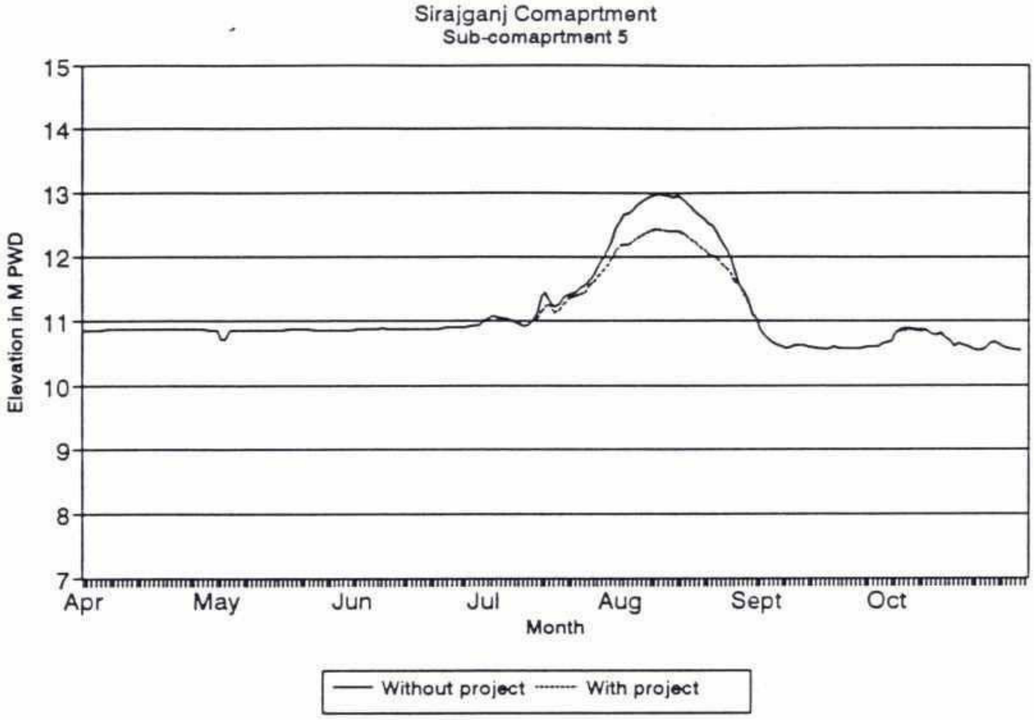
Month
Without project
With project

9.R


Sirajganj Comaprtment
Sub-comaprtment 5
15
14
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10
9
8
7
Elevation in M PWD
Apr
May
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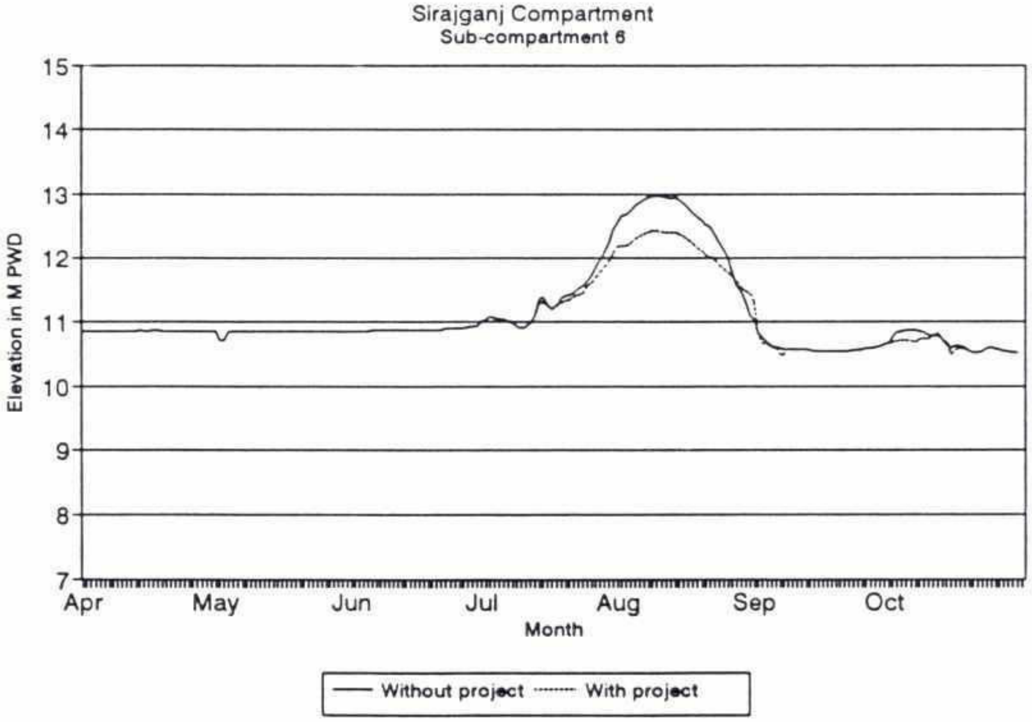
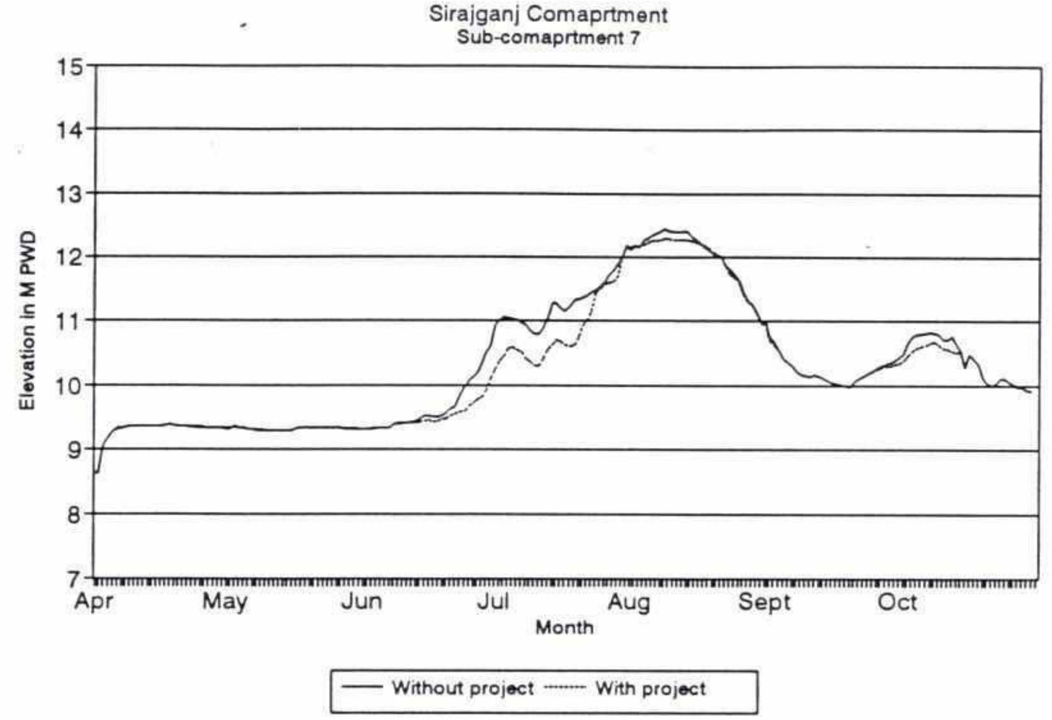
Jul
Aug
Sept
Oct
Month
Without project
With project


Sirajganj Compartment
Sub-compartment 6
15
14
13
12
11
10
9
8
7
Elevation in M PWD
Apr
May
Jun
Jul
Aug
Sep
Oct
Month
Without project
With project


Sirajganj Comaprtment
Sub-comaprtment 7
Elevation in M PWD
15
14
13
12
11
10
9
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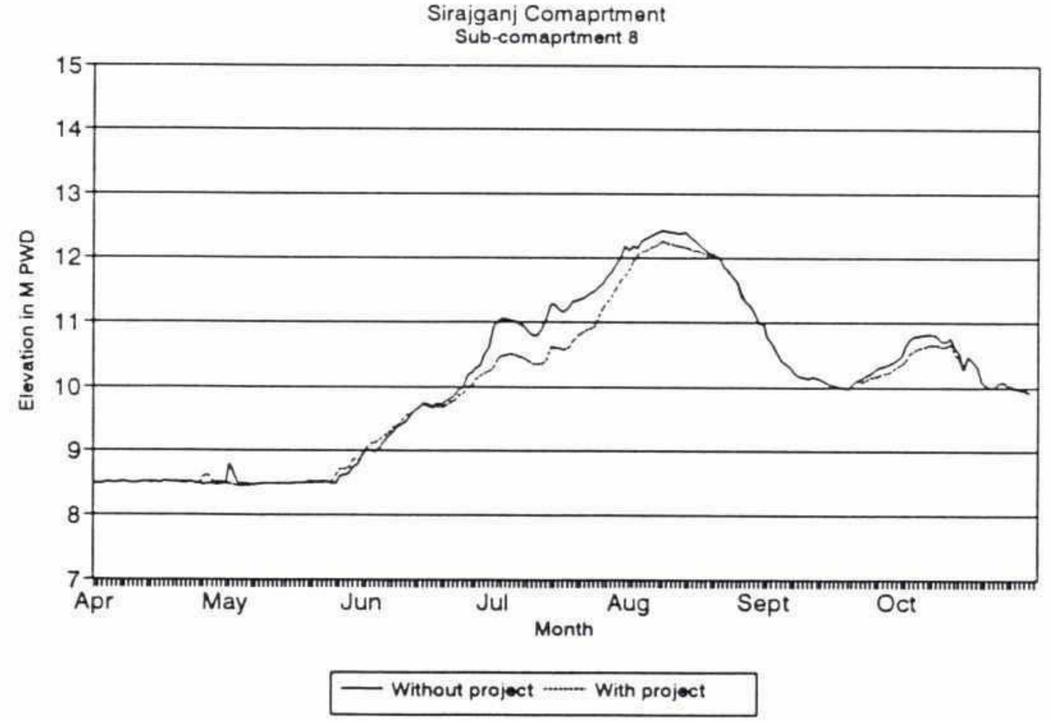
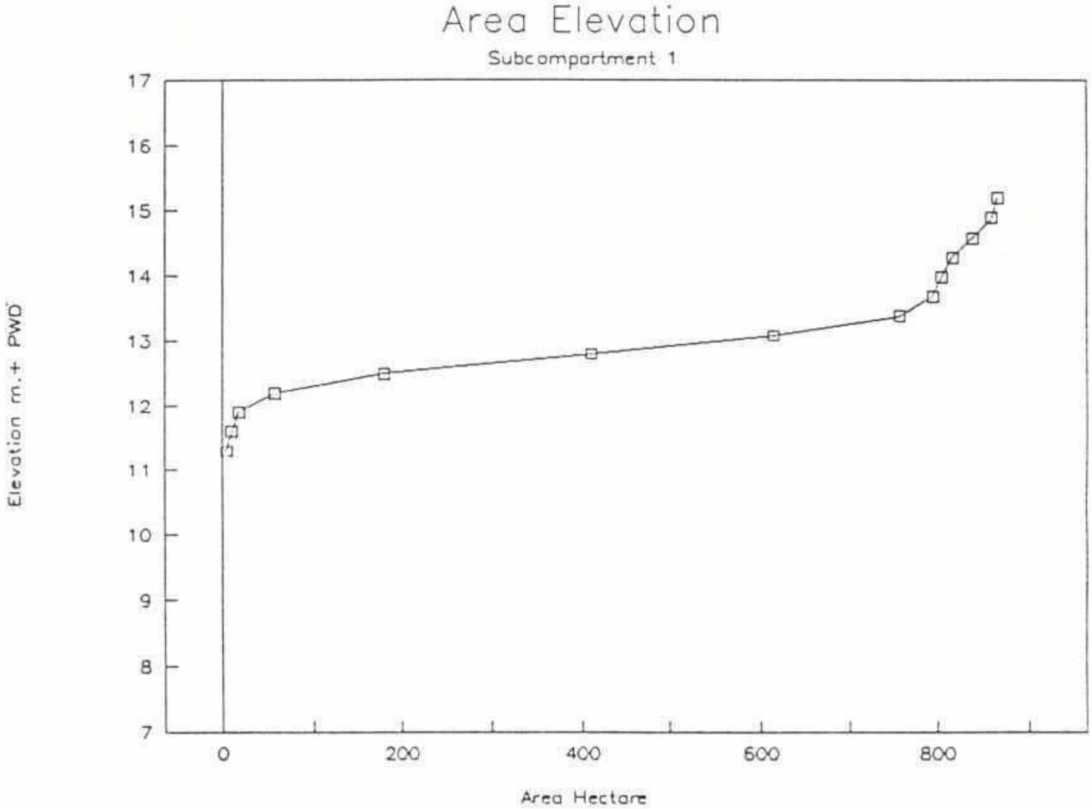
Apr
May
Jun
Jul
Aug
Sept
Oct
Month
Without project
With project

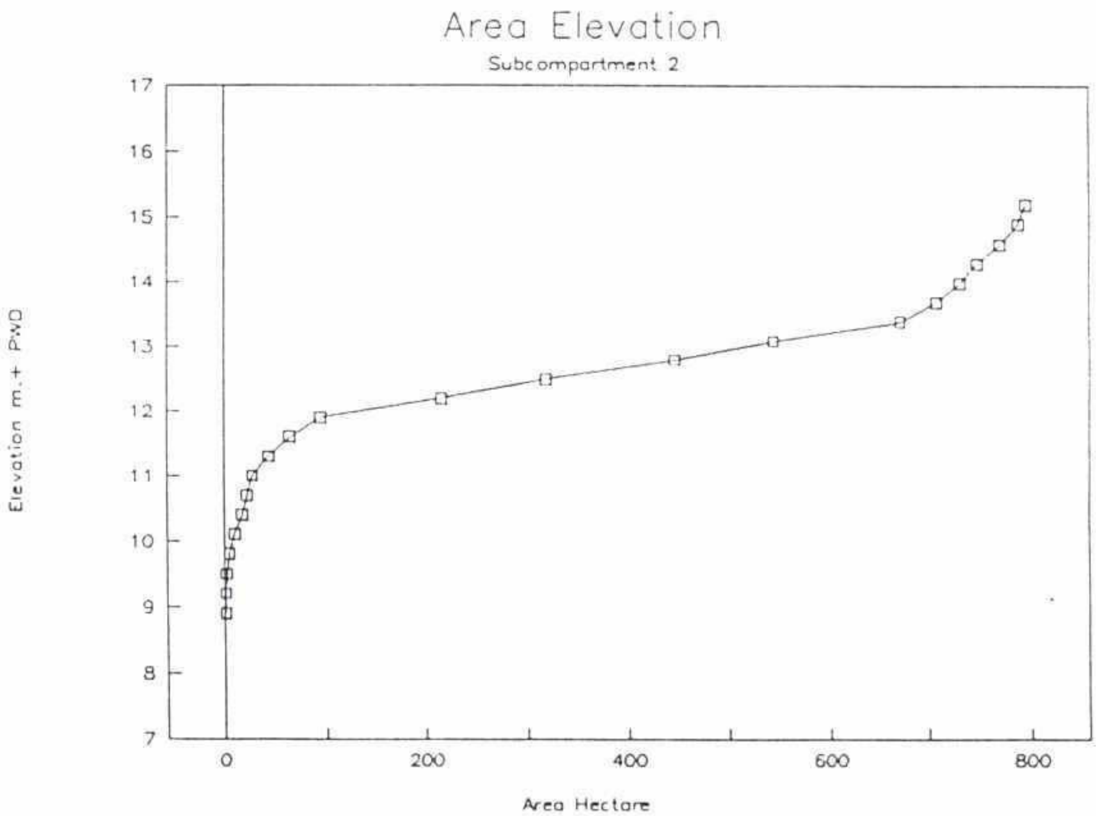

Sirajganj Comaprtment
Sub-comaprtment 8
Elevation in M PWD
15
14
13
12
11
10
9
8
7
Apr
May
Jun
Jul
Aug
Sept
Oct
Month
Without project
With project

APPENDIX 4.3

Area-Elevation for each Sub-compartment

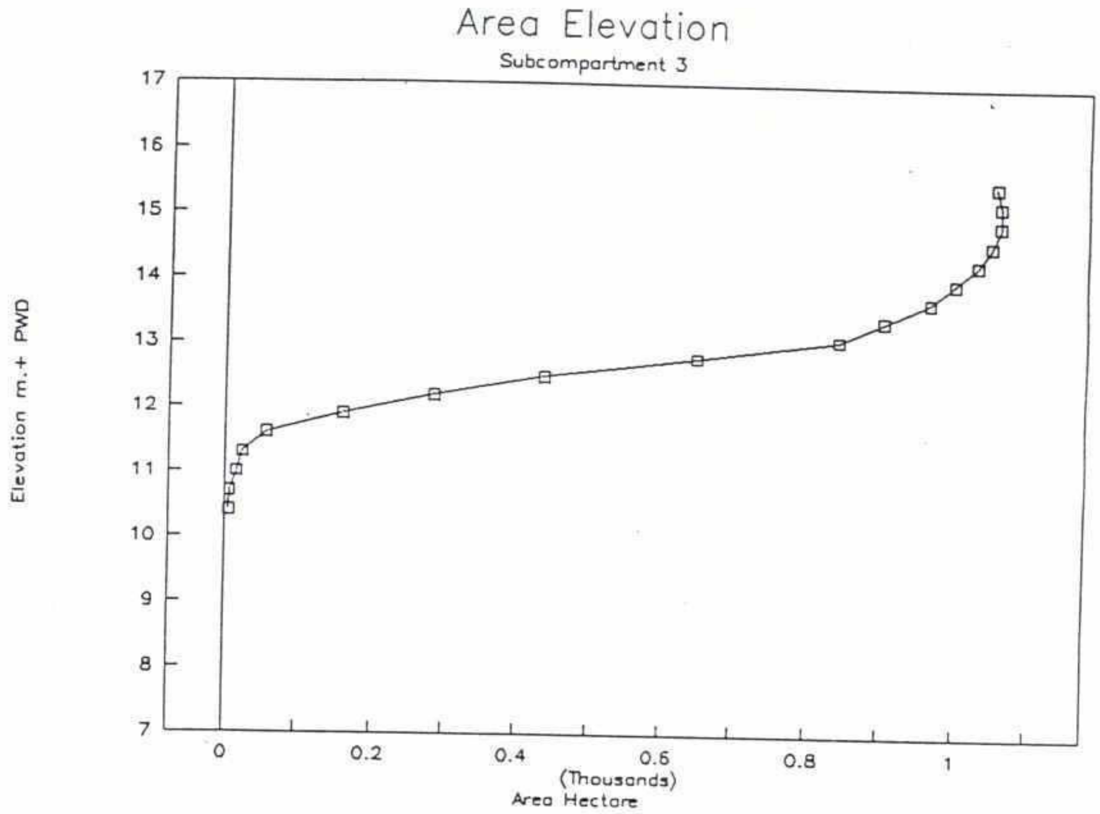


Area Elevation
Subcompartment 1
Elevation m.+ PWD
Area Hectare

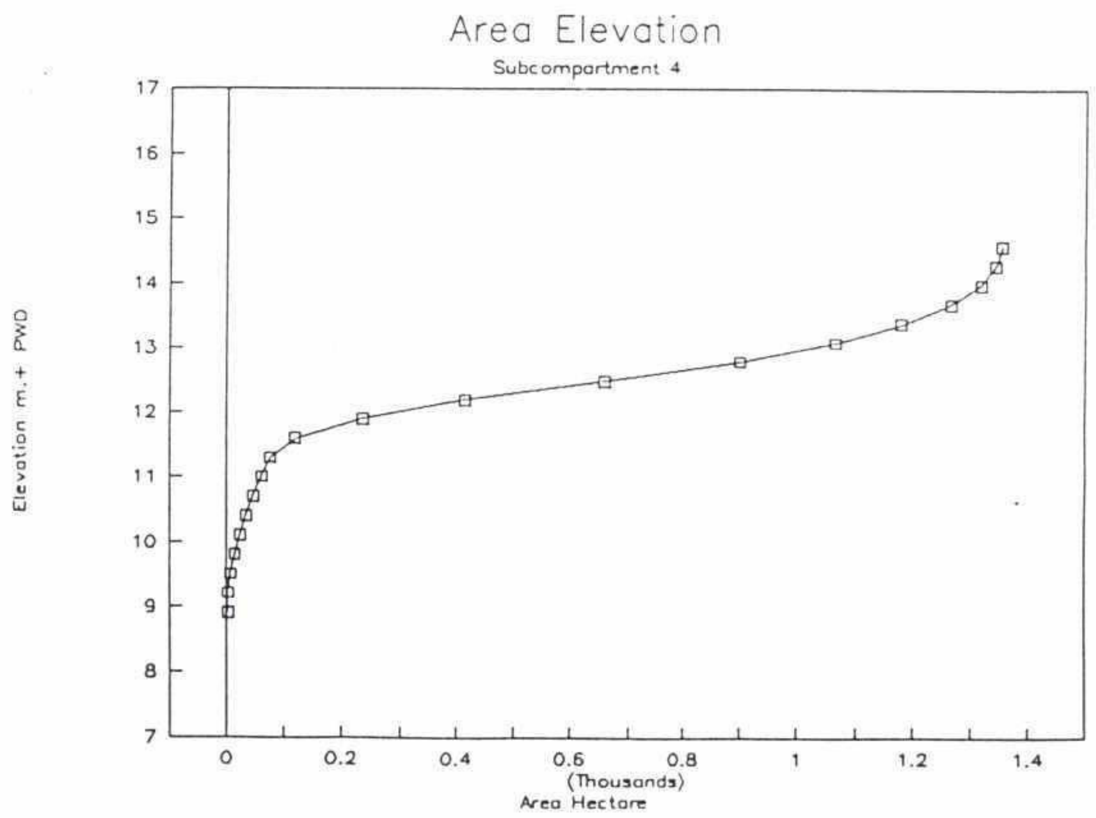


Area Elevation
Subcompartment 2
Elevation m.+ PWD
Area Hectare

92

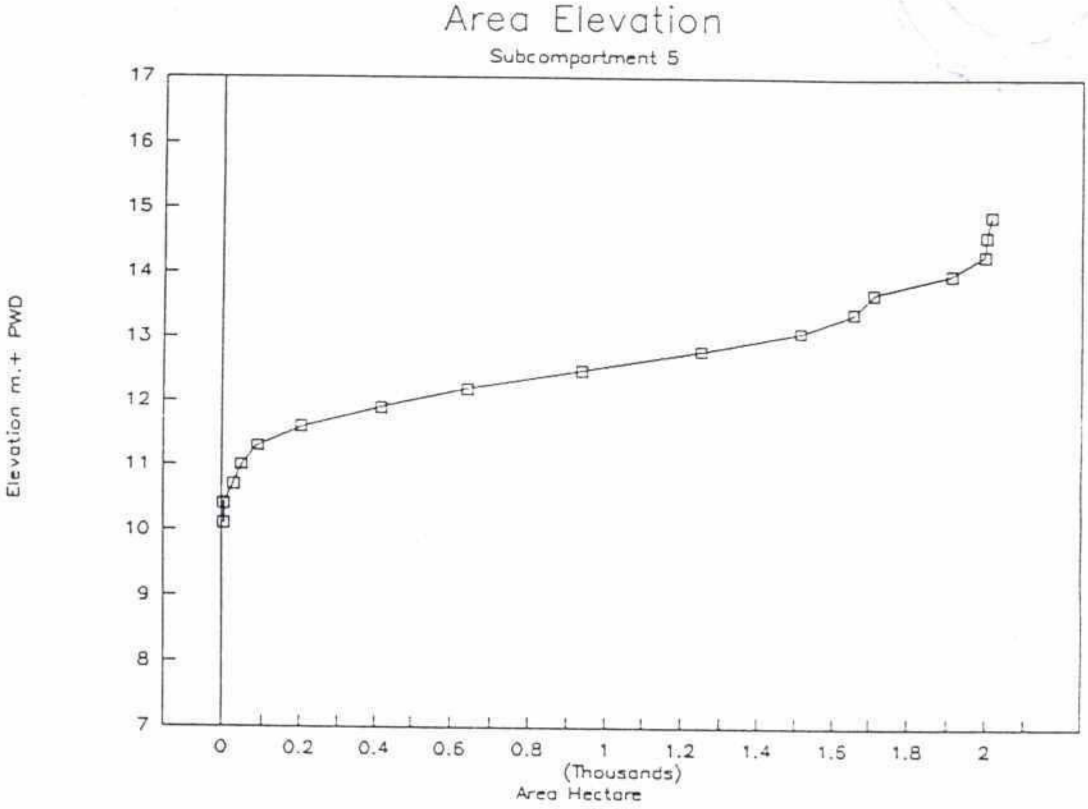


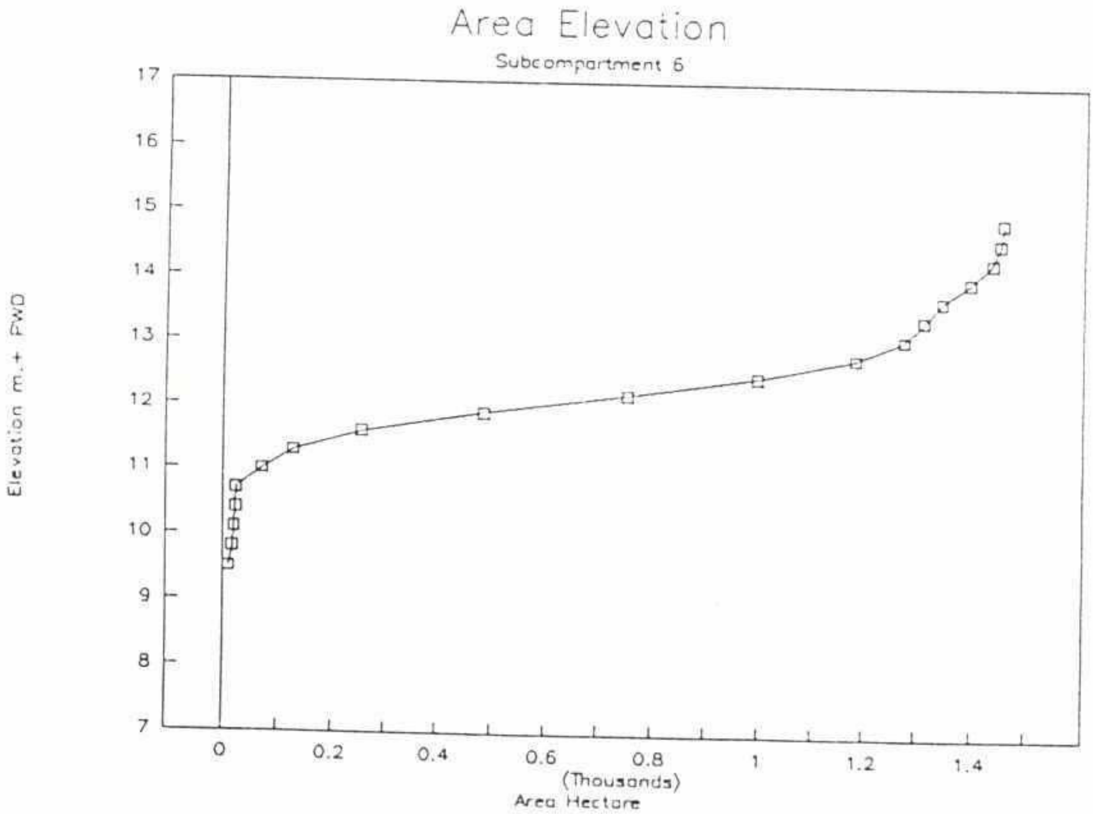
Area Elevation
Subcompartment 3
Elevation m.+ PWD
17
16
15
14
13
12
11
10
9
8
7
0
0.2
0.4
0.6
0.8
1
(Thousands)
Area Hectare

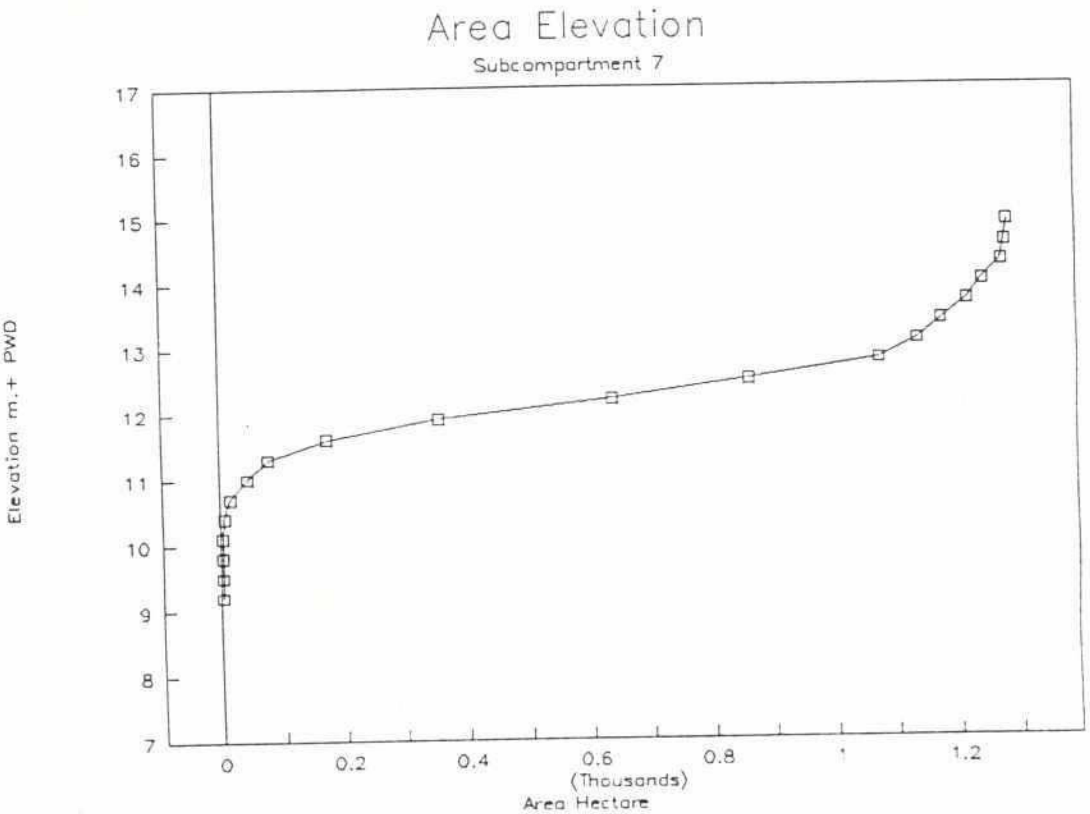


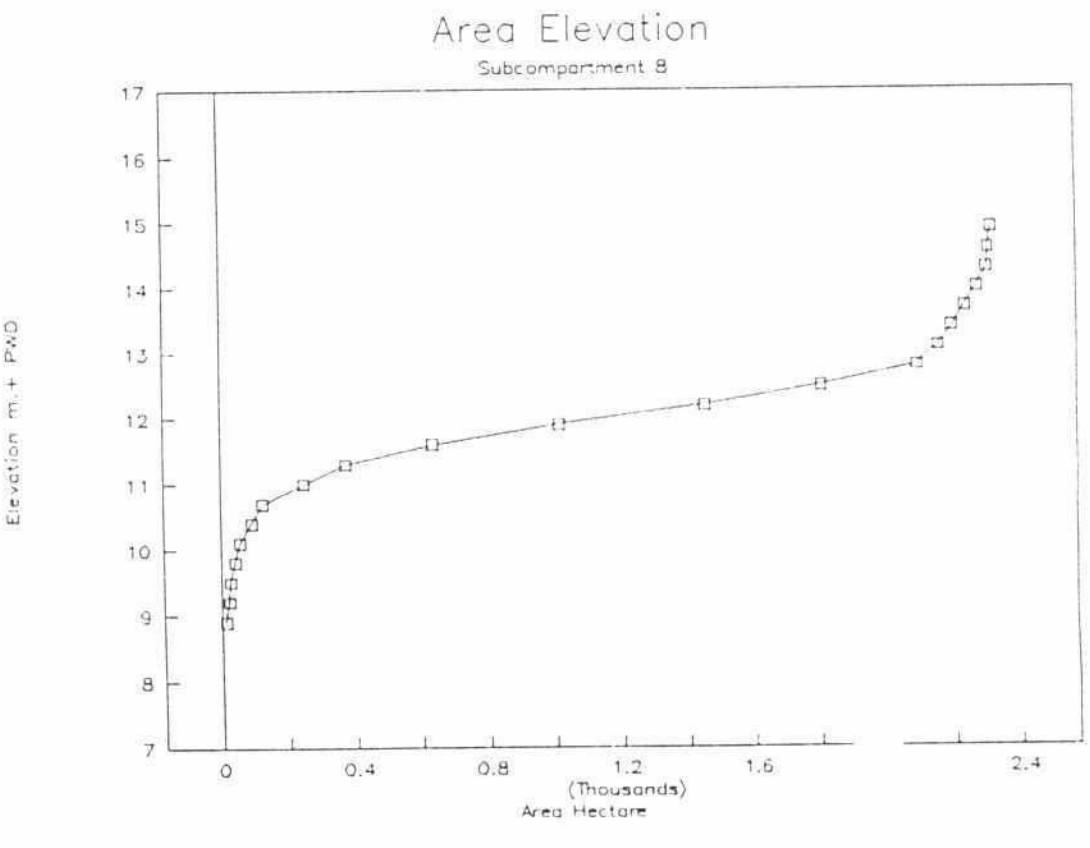
Area Elevation
Subcompartment 4
Elevation m.+ PWD
17
16
15
14
13
12
11
10
9
8
7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
(Thousands)
Area Hectare

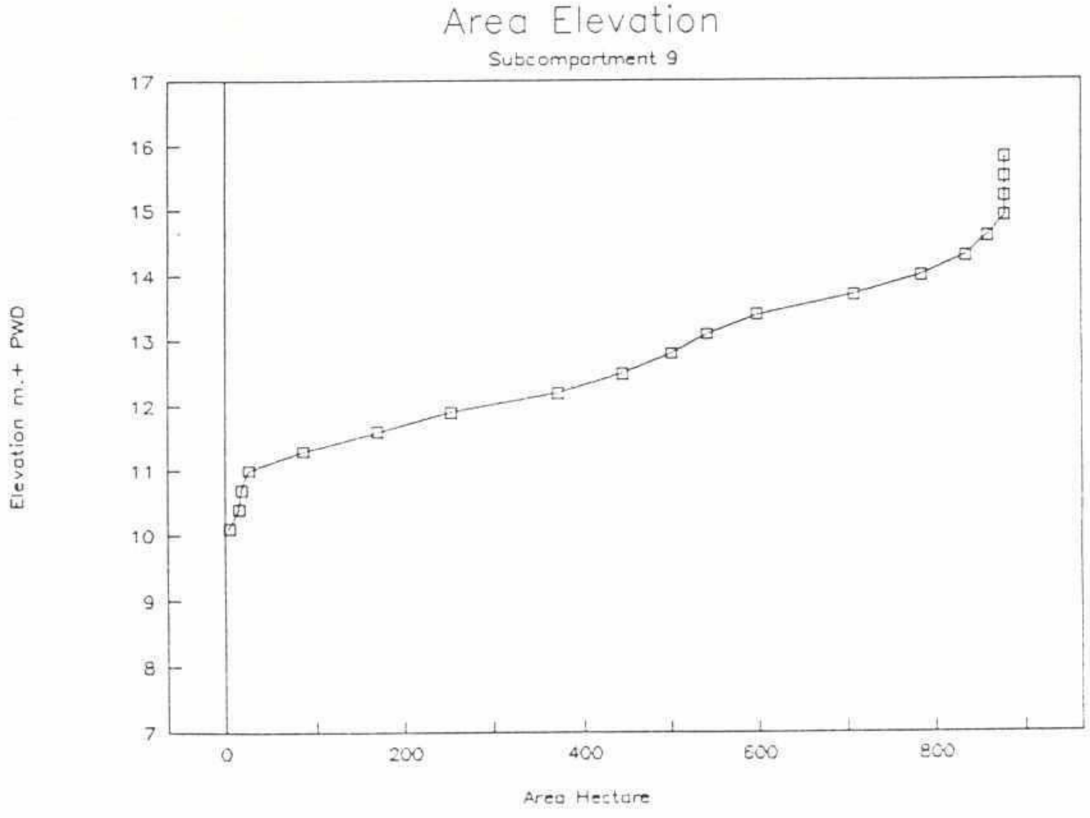
80


Area Elevation
Subcompartment 5
Elevation m.+ PWD
17
16
15
14
13
12
11
10
9
8
7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
Area Hectare


Area Elevation
Subcompartment 6
Elevation m.+ PWD
17
16
15
14
13
12
11
10
9
8
7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
(Thousands)
Area Hectare


Area Elevation
Subcompartment 7
Elevation m.+ PWD
17
16
15
14
13
12
11
10
9
8
7
0
0.2
0.4
0.6
0.8
1
1.2
(Thousands)
Area Hectare


Area Elevation
Subcompartment 8
Elevation m.+ PWD
17
16
15
14
13
12
11
10
9
8
7
0
0.4
0.8
1.2
1.6
2.4
(Thousands)
Area Hectare


Area Elevation
Subcompartment 9
Elevation m.+ PWD
Area Hectare
17
16
15
14
13
12
11
10
9
8
7
0
200
400
600
800