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GOVERNMENT OF THE PEOPLE'S REPUBLIC OF  
BANGLADESH

Flood Plan Coordination Organization

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**FAP-25**  
**FLOOD MODELLING AND MANAGEMENT**

ADDENDUM No. 1 TO CONTRACT  
NORTH CENTRAL REGION FMM

HYDROLOGIC & TOPOGRAPHIC MEASUREMENTS -1993

COMPLETION REPORT

Volume 1: Main Report

FAP-25

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S.N-8

**DONORS:**

The Government of Denmark

The Government of France

The Government of The Netherlands

**CONSULTANTS:**

Danish Hydraulic Institute

BCEOM

Euroconsult



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## Table of Contents

### Volume 1 - Main Report

1	Introduction. . . . .	1
	<i>Background</i> . . . . .	1
	<i>Project Scope</i> . . . . .	1
2	Embankment Survey . . . . .	2
	<i>Other Surveys</i> . . . . .	3
3	Water Level Gauges. . . . .	3
	<i>Other Surveys</i> . . . . .	5
4	Discharge Measurements . . . . .	5
5	Supervision . . . . .	7
6	Results and Analysis. . . . .	7
	<i>Embankment Survey</i> . . . . .	7
	<i>Water Levels</i> . . . . .	9
	<i>Discharge Measurement</i> . . . . .	12

### List of Tables

Table 1: Topographical Survey of the Gauge Stations . . . . .	6
Table 2: Details of Hydrometric Stations Installed. . . . .	10
Table 3: Recommendations of the 1992 Hydrometric Survey . . . . .	12
Table 4: Discharge Observation Data . . . . .	13

### List of Figures

Following Page

Figure 1: Location of Additional Embankment Survey . . . . .	2
Figure 2: Location of Gauging Stations - North Central Region . . . . .	4
Figure 3: Location of FINNMAP Benchmarks . . . . .	5
Figure 4: Water Level vs Discharge Plots of Gaugings . . . . .	14

### Volume 2 - Annexures

Annexure 1 . . . . .	Gauge Station Locations
Annexure 2 . . . . .	Gauge Station Details

## 1 Introduction

### *Background*

From March, 1991 to February, 1993, a pre-feasibility level study was undertaken in the North Central Region of Bangladesh to ascertain what structural or non-structural interventions were desirable to enhance the overall economic and social well-being of the population within the Region. At the conclusion of the Study, a number of possible scenarios were identified and recommendations were made to carry the investigation of these a stage further.

The Caisse Française de Développement, (CFD), and the European Economic Community, (EEC), envisage jointly funding further studies of Jamalpur project and feasibility level studies identified within the North Central Region. Schemes identified in FAP-3 as RS2, RS3 and RS4 are to be further examined. These lie to the north and south-east of the Tangail CPP respectively.

The Flood Management Model for the North Central Region will serve as the basic framework upon which later feasibility level and design level models will be based (FAP 3.1 and 3.2). While each succeeding level of study will require commensurate increases in detail, the regional model structure will provide boundary conditions for lower level models. As such, it is clear that much of the information needs for both regional and sub-regional models are complementary, particularly in respect of hydrometric and topographic data.

This hydrometric and topographic survey is designed to provide reliable information which will enable the development of the North Central Regional Flood Management Model to proceed with more confidence and will, in addition, provide data support for imminent feasibility level study projects within the region.

This survey and measurement programme was financed by the Government of France through an Addendum to its contract with BCEOM for the North Central Region FMM.

### *Project Scope*

The project scope may be described as follows:-

- the execution of a survey of the elevations of selected river embankments and their intersecting khals
- the installation and monitoring of water level gauges at selected sites throughout the North Central Region during the months of June to October, 1993



- the execution of fortnightly discharge measurements at selected sites throughout the North Central Region during the months of June to October, 1993
- the presentation of the results of the above in the form of a report and relevant drawings

## 2 Embankment Survey

A survey of the top elevations of embankments or natural levees was carried out along both banks of the following rivers between the indicated approximate chainages:-

Dhaleswari	(Ch. 34.5 - 97.0)
Barinda	(Ch. 0.0 - 35.0)
Dhantara Khal	(Ch. 1.0 - 15.0)
Bangshi South	(Ch. 40.0 - 80.0)
Kaliganga	(Ch. 0.0 - 62.0)
Bangshi	(Ch. 0.0 - 100.0)

The above chainages were based on the MIKE11 model and were intended to be indicative only, since the embankment chainage was likely to be different from the river chainage.

Spot levels at representative points along the embankment crest were required every 100 metres. The location, bottom elevation and width of intersecting khals were to be surveyed, and transects taken into the adjacent flood plain every 1000 metres along the embankment to extend for 200 metres.

The purpose of the embankment survey was to obtain more detailed information on the linkages between the flood plain and river. This data is required for hydraulic modelling if the flood plains are to be modelled separately. At a regional level, the intersecting khals would be lumped together so as to reduce the detail, but nevertheless, some qualitative estimate is required such that the correct degree of linkage is represented.

Figure 1 shows the location of the rivers along which the embankment survey was conducted. Additional lengths of embankment surveyed by SWMC under a separate contract are also shown.

The embankment survey was carried out by Hydroland Survey Ltd. under contract with BCEOM.

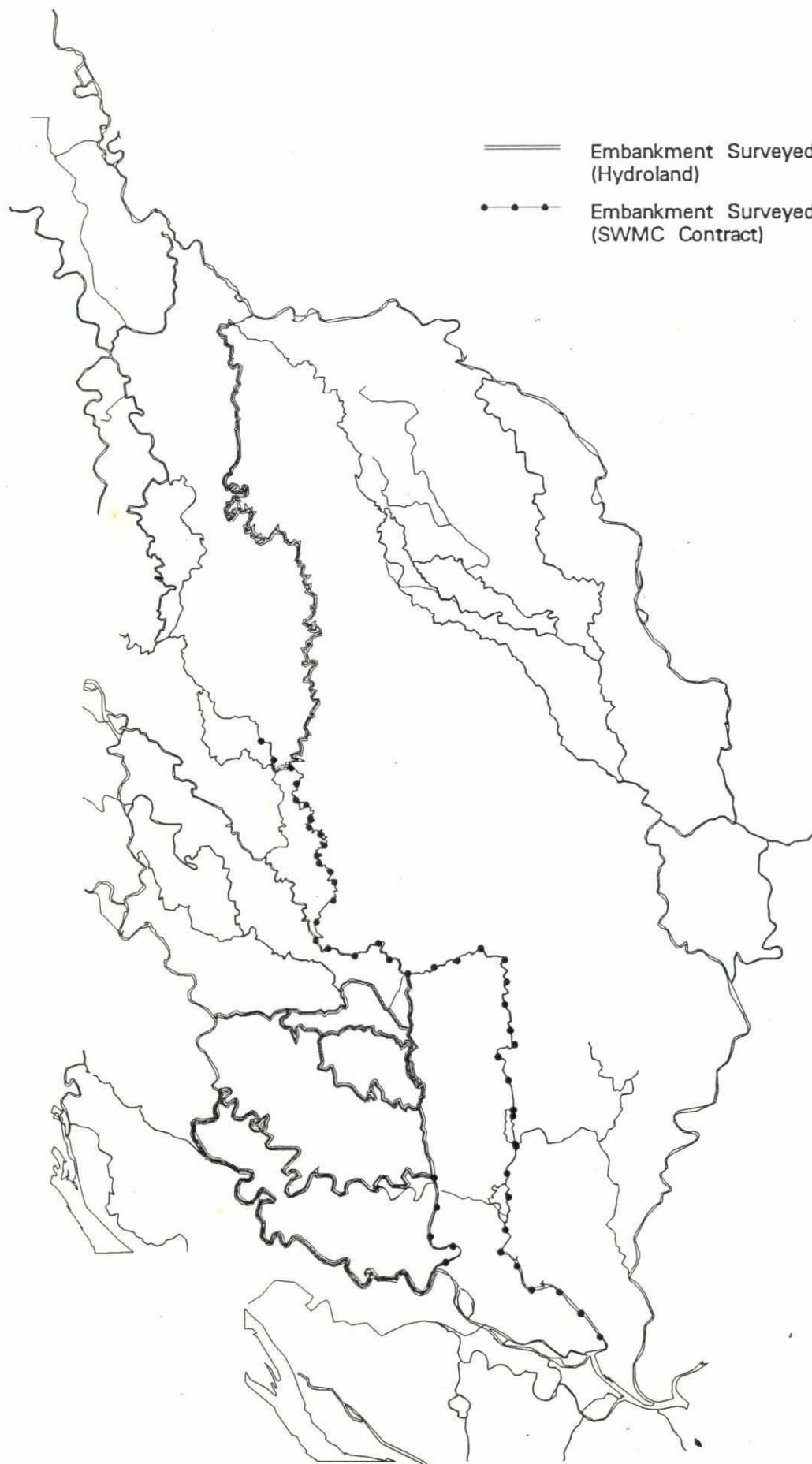


Figure 1      Location of Additional Embankment Survey  
**NORTH CENTRAL REGION**



### *Other Surveys*

In addition to the survey work contracted under this Addendum, SWMC were engaged to carry out further embankment surveys on selected watercourses in the North Central Region. The surveys were carried out on the following lengths of watercourses:-

Futikjani	(Ch.39.0 - 43.0)
Bangshi	(Ch.100.0 - 202.0)
Dhaleswari	(Ch.120.0 - 135.0)
Turag	(Ch.0.0 - 64.0)
Tongi Khal	(Ch.1.0 - 8.0)
Buriganga	(Ch.23.0 - 40.0)
Nanglai_N	(Ch.23.0 - 31.0)



In common with the contract with Hydroland Survey Ltd., SWMC surveyors were requested to identify and survey any intersecting khals on the route.

### **3 Water Level Gauges**

In the determination of the location of the water level gauges, the following major points were considered:-

- the location of any areas in the existing North Central Regional Model where problems remain in the calibration of water levels and/or discharges.
- specific requirements of the proposed studies, e.g. pilot drainage study in Jamalpur area.
- the recommendations of the FAP 3.2 Report, (Hydrological Studies, 1992), with regard to further monitoring (refer to Table 3)
- the importance of the Bangshi river levels for regional drainage
- relative location of FINNMAP bench marks

In some areas of the existing North Central Regional Model, problems have been experienced with calibration of water levels or discharges. Such problems could be attributed in part to lack of reliable hydrometric data. Some of the additional gauges have been located in these areas, (the Bangshi/Futikjani confluence, for example), in an effort to better understand the hydraulic behaviour of the rivers.

During the monsoon season of 1992, additional gauges were set up in the region to obtain further hydrometric data for the proposed Bhuapur-Gopalpur

development scheme, (Scheme RS2 in the FAP-3 Study). This area is bordered to the north by the Jagannathganj-Jamalpur railway, in the west by the Bhuapur to Jagannathganj BWDB embankment, in the south by the Pungli river and in the east by the Bangshi river and the western side of the Madhupur Tracts.

The monsoon of 1992 was exceptionally dry and consequently the results from the previous study were not representative of the typical wet season flows and river levels. The report made certain recommendations to improve the quality of the data and these were taken up, as far as was practicable, during this measurement programme, (see Table 3).

At the specific request of the CFD, stations established within the Jamalpur Priority Project area under the Feasibility Study, were re-installed. In addition, a number of stations were installed in the approximate location of the proposed pilot drainage area, (the exact location was not known, as this is to be determined by the Consultants appointed for final design of JPP). Of the total 40 stations installed in the region, 13 were located within the Jamalpur area.

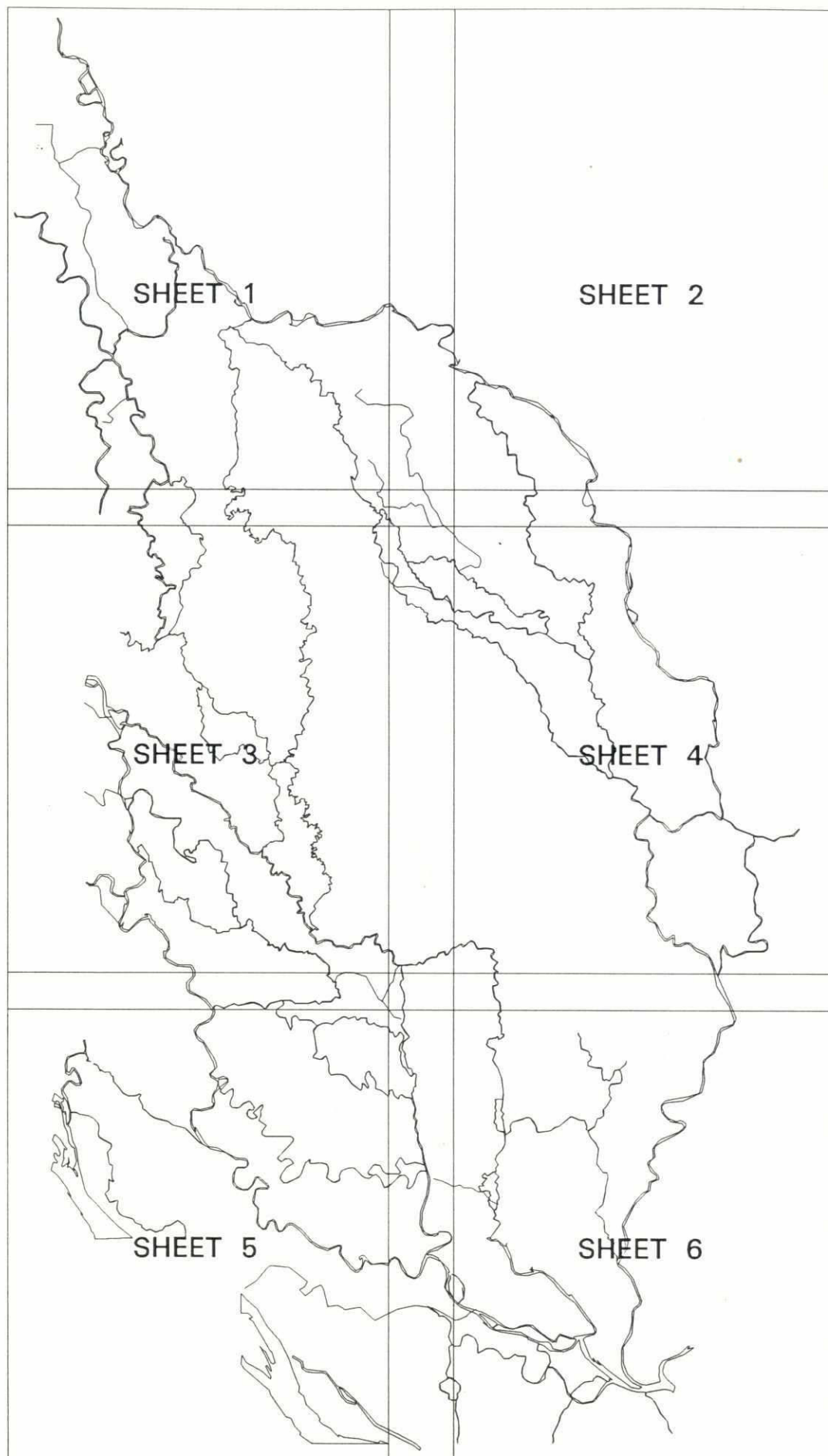
Drawing on the experience of the 1992 Hydrological Studies programme, it was decided to base all survey on FINNMAP benchmarks. This is in accordance with the recommendations of that study. The discrepancies between the BWDB and SoB benchmarks are well known and it was considered that uncertainties associated with the use of these references would be considerably reduced by using FINNMAP.

In order to reduce levelling costs and minimize possible levelling errors, stations were located as close as practicable to FINNMAP benchmarks. Overall, the average distance of one way levelling was approximately 5 kilometres, with a maximum of 21 km. and a minimum of zero. Table 1 shows the survey details of the gauging stations and gives the closure error for each levelling run. All runs were performed within the specified closure accuracy of  $12\sqrt{K}$ , where K is the levelling distance in km. and the error is expressed in millimetres. Figures 3.1 to 3.3 show the approximate locations of the FINNMAP benchmarks used for the hydrometric survey. This information should be regarded as *provisional* and reference made to Survey of Bangladesh for precise geographic locations.

It was recognised during the FAP-3 study that the Bangshi river acts as a primary drainage channel for the region, particularly during the monsoon recession. It was therefore considered useful for both the development of the NCRM for the Flood Management Model, (FMM), and for the anticipated Feasibility Studies that a more accurate representation of the water level fluctuations in the drainage pathways of the region be obtained. In addition to the Bangshi river, those other rivers likely to form the external drainage pathways for possible compartment layouts were considered and stations installed where possible.



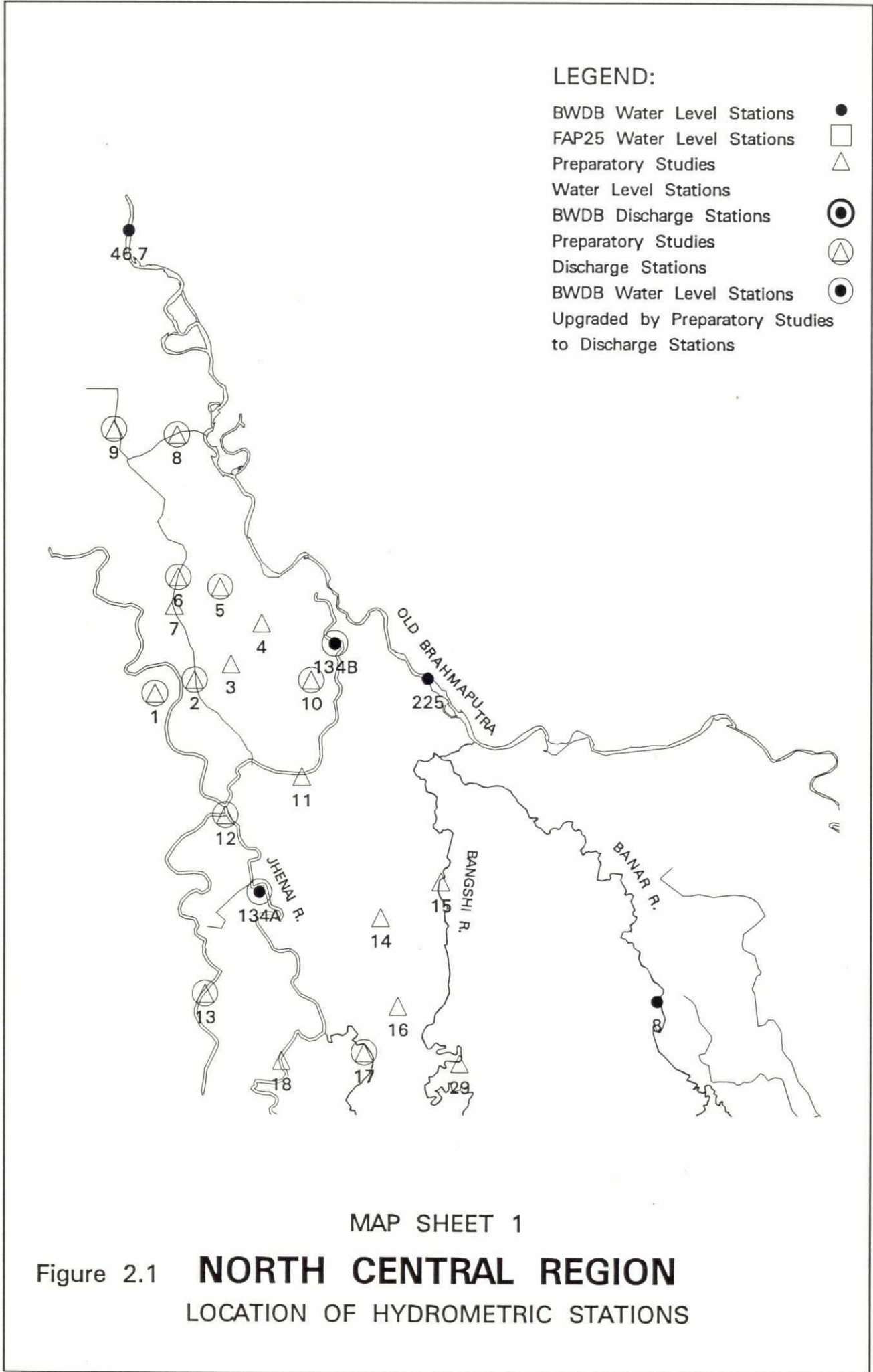




## **NORTH CENTRAL REGION**

Figure 2

MAP SHEET INDEX





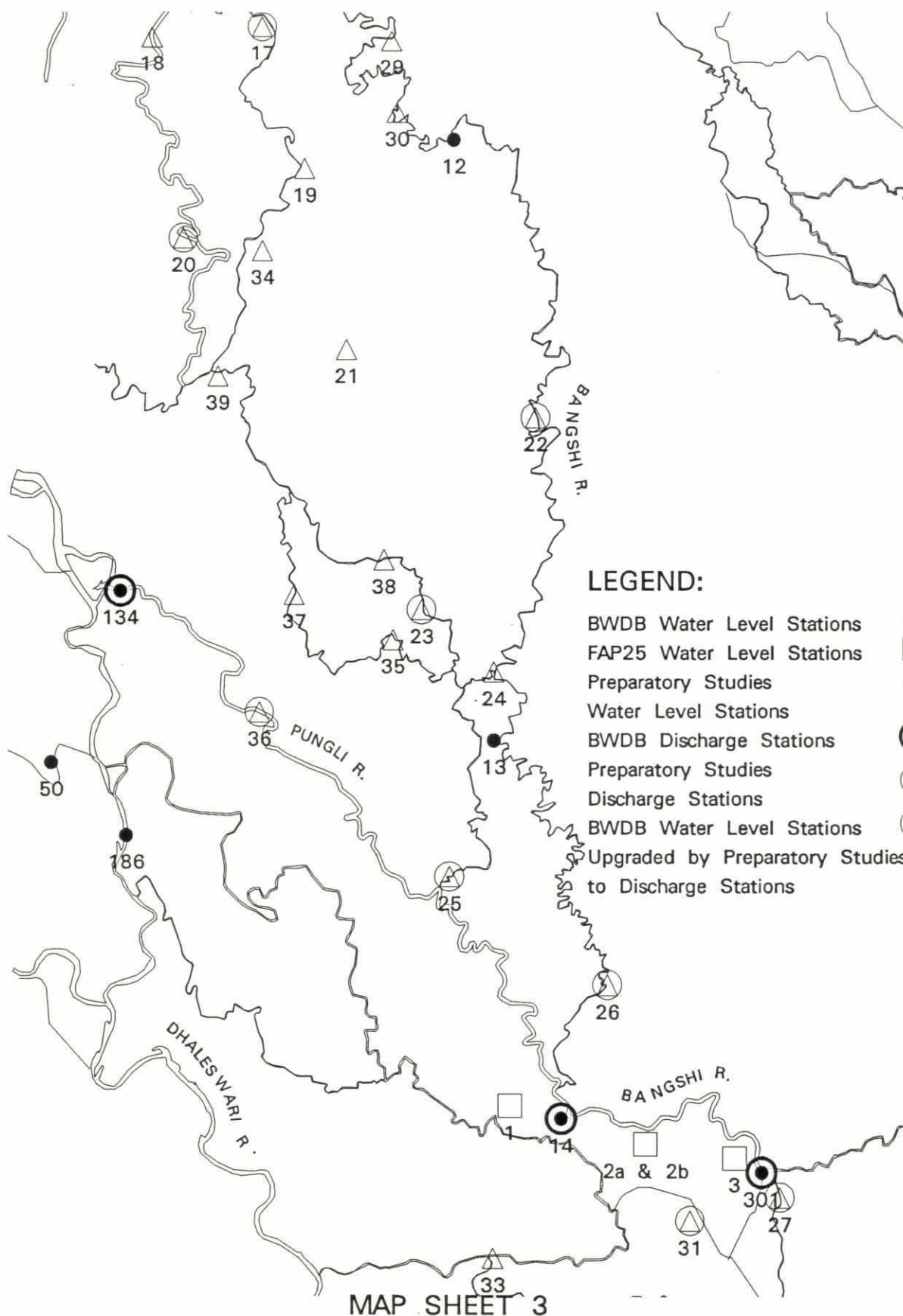
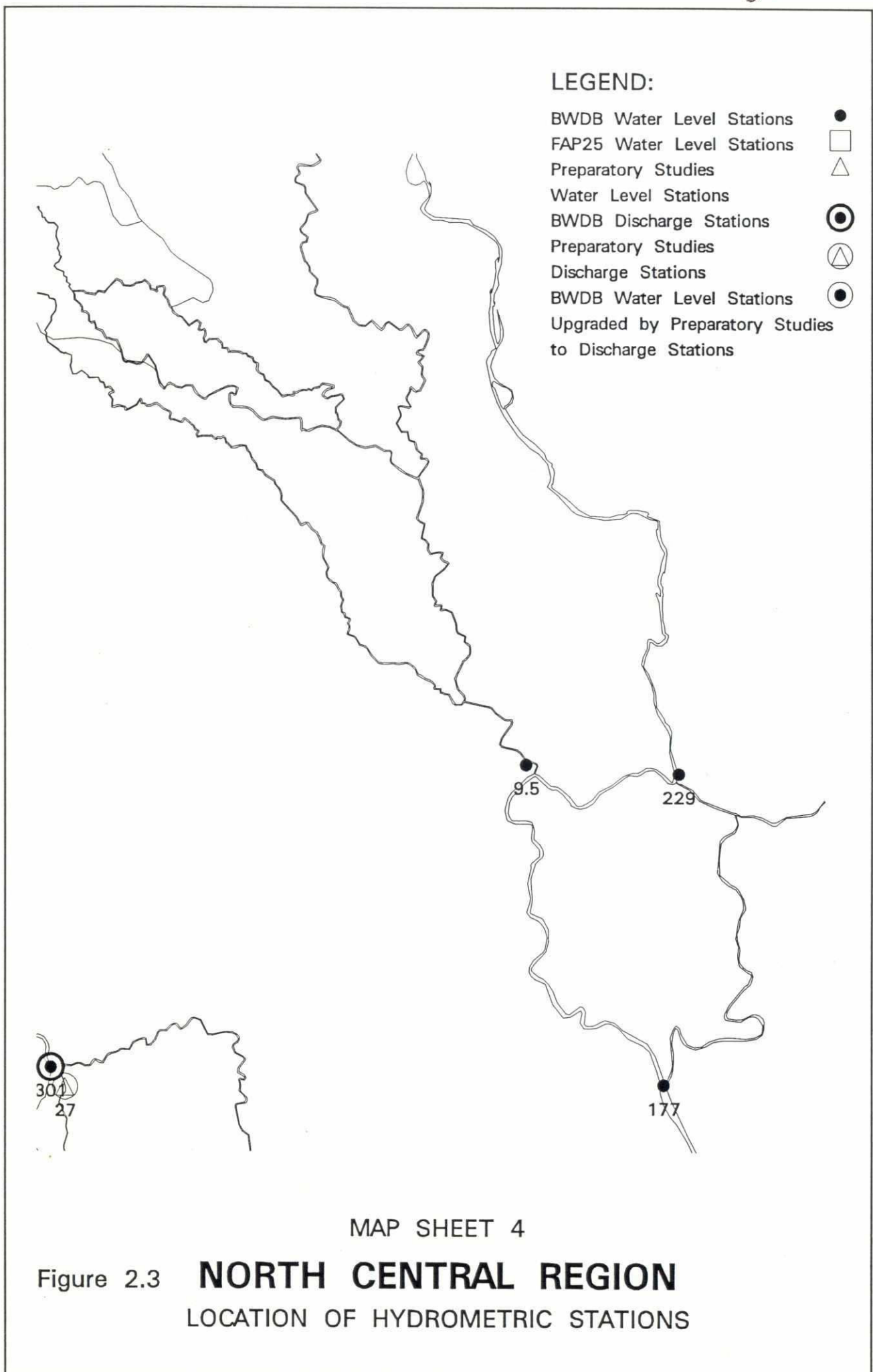
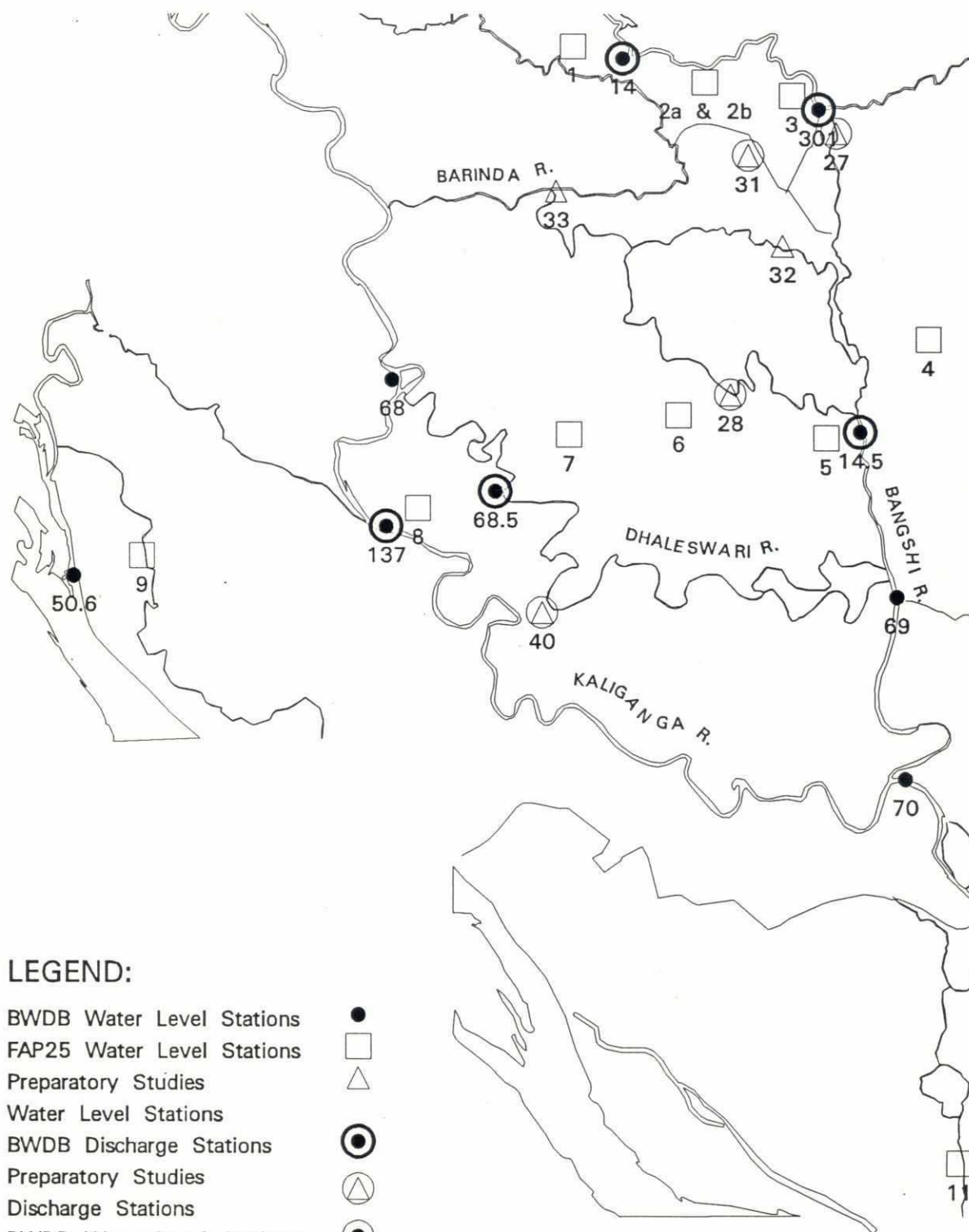


Figure 2.2 **NORTH CENTRAL REGION**  
LOCATION OF HYDROMETRIC STATIONS

32







# LEGEND:

- BWDB Water Level Stations ●
- FAP25 Water Level Stations □
- Preparatory Studies Water Level Stations △
- BWDB Discharge Stations ○
- Preparatory Studies Discharge Stations △
- BWDB Water Level Stations Upgraded by Preparatory Studies to Discharge Stations ○

MAP SHEET 5

Figure 2.4

## **NORTH CENTRAL REGION** LOCATION OF HYDROMETRIC STATIONS

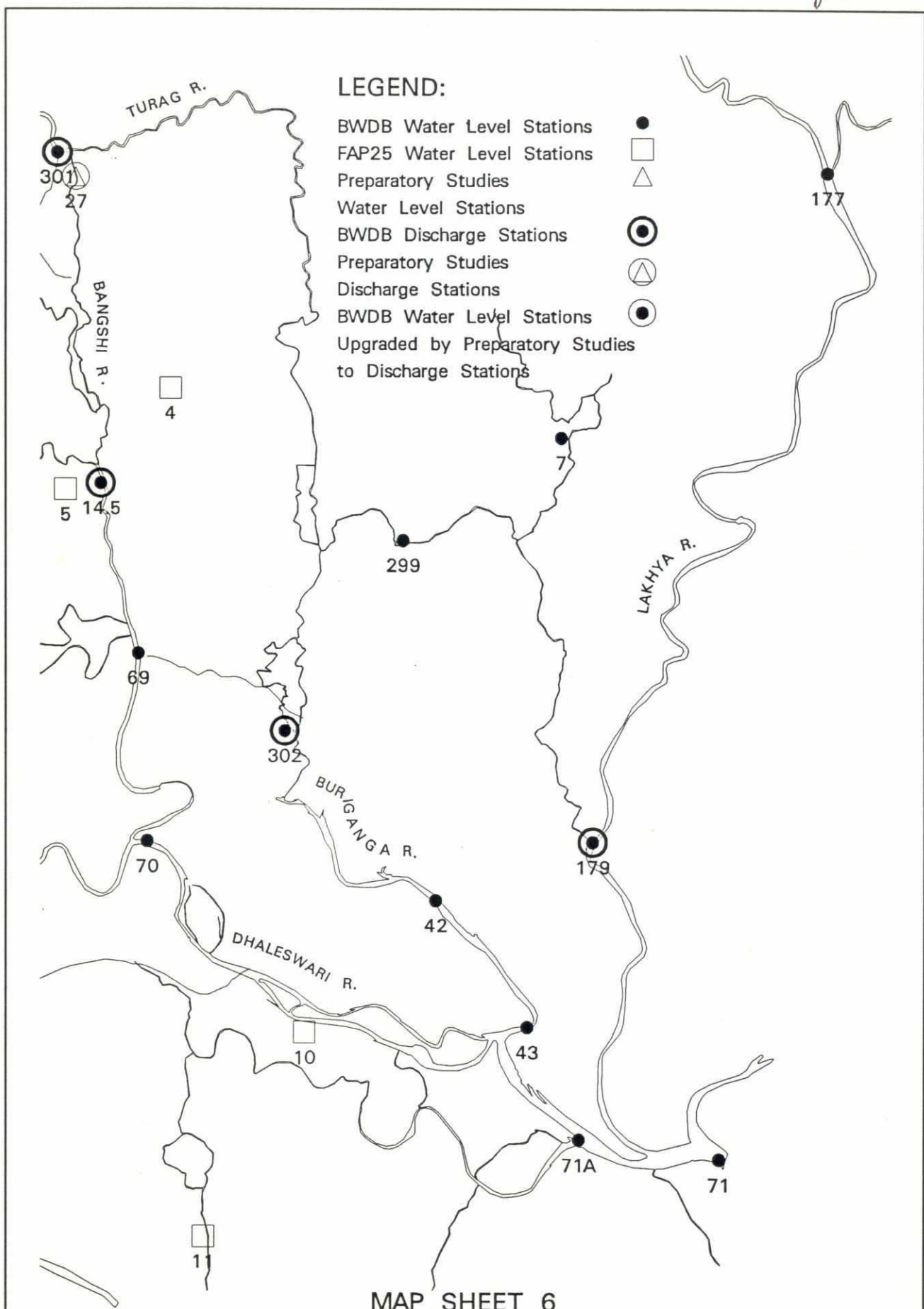


Figure 2.5 **NORTH CENTRAL REGION**  
LOCATION OF HYDROMETRIC STATIONS

2

Stations chosen for these preparatory studies do not necessarily represent the ideal, both in number and location. Practical constraints of time available for installation and budget restrictions largely dictated the distribution and total number of stations. Moreover, when feasibility level modelling is taken up, additional stations may well be required to obtain further details of the water level behaviour in the more detailed khal network that must be defined as modelling progresses and the needs of the future study become clear.

The location of each water level gauge is shown in Figures 2.1 to 2.5. Gauge details are noted in Table 2 and further supplementary information relating to access, location and temporary bench marks is contained in Annexures 1 and 2 accompanying this report.

The provision, installation and monitoring of the water level gauges was provided by Hydroland Survey Ltd. under contract with BCEOM.

#### *Other Surveys*

Under the overall budget of the FMM, 12 flood plain gauges were installed, 5 along the Dhaka-Aricha road, 4 along the Dhaka-Tangail road, 1 along the Savar-Kaliakair road and 2 along the Dhaka-Mawa road. Water levels were recorded twice per day during the monsoon period June 1st to October 31st. Full details of this survey may be found in the FAP-25 Interim Report.

## **4 Discharge Measurements**

In support of the model calibration exercises, discharge measurements were programmed to take place on a fortnightly basis on 20 of the 40 water level stations. Similar discharge measurements were undertaken at 4 additional stations: Baushi Bridge and Jhenai Offtake, (BWDB water level stations) and Elashin and Mirzapur, (SWMC stations).



72



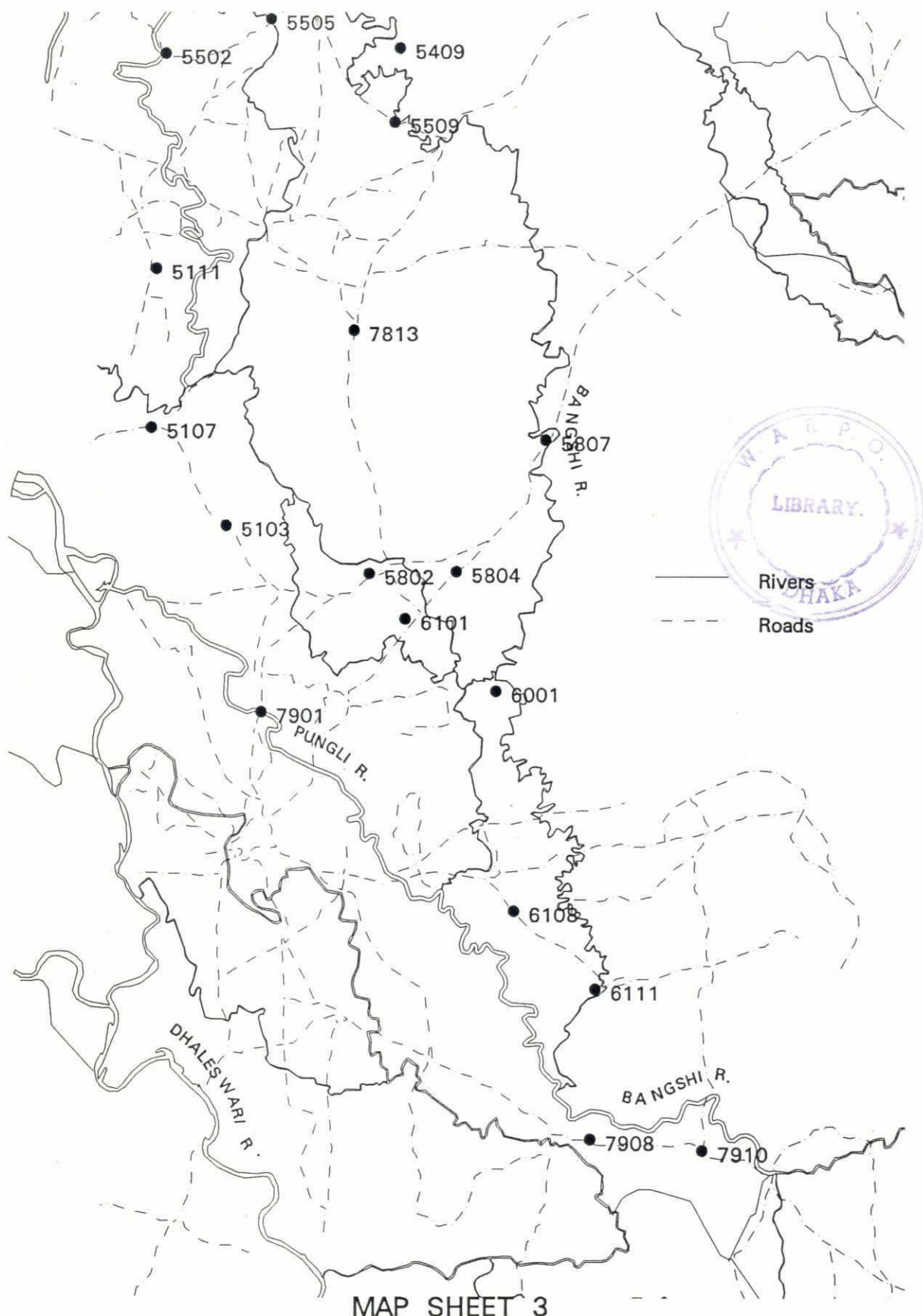
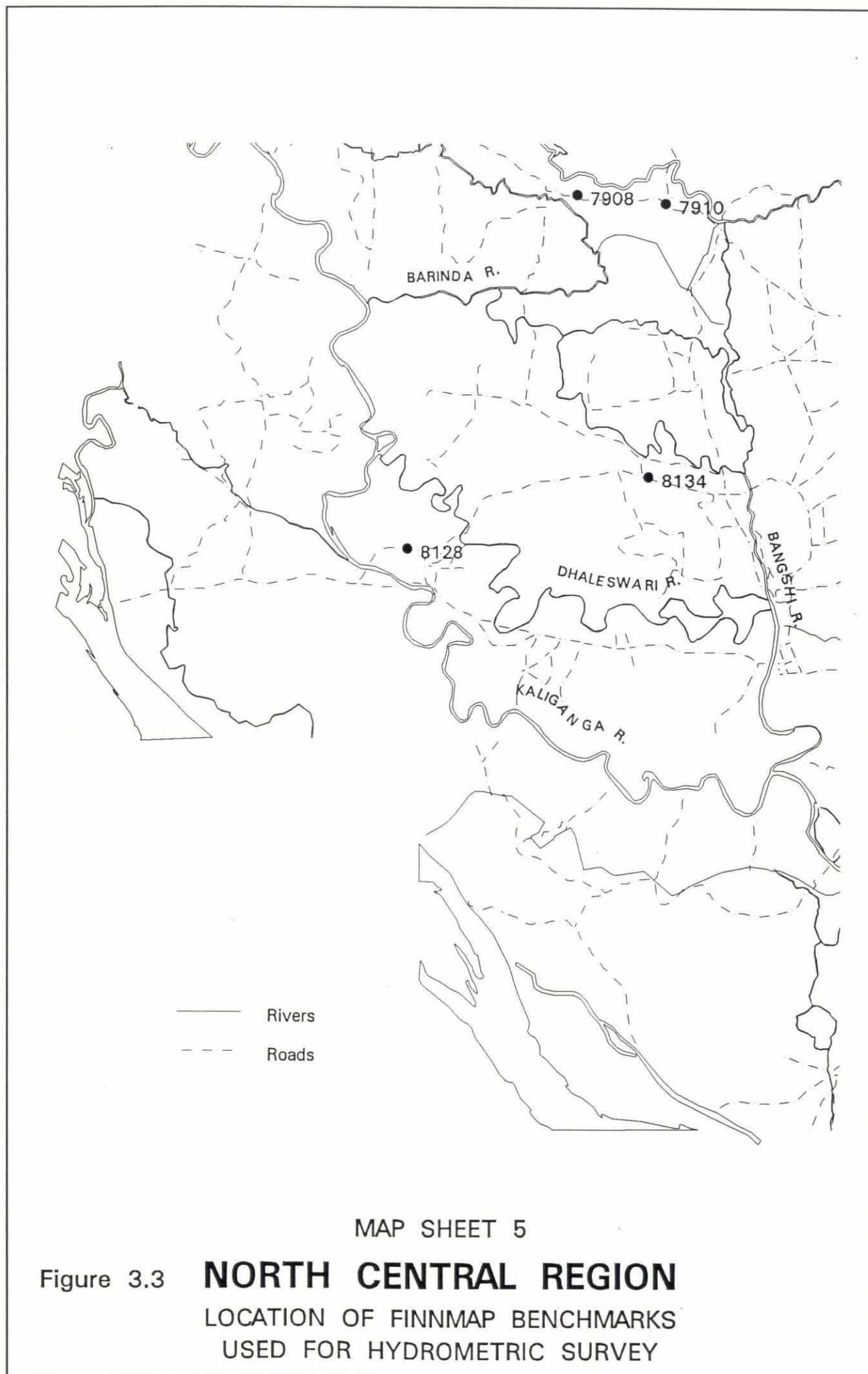


Figure 3.2 **NORTH CENTRAL REGION**  
LOCATION OF FINNMAP BENCHMARKS  
USED FOR HYDROMETRIC SURVEY





**Table 1: Topographical Survey of the Gauge Stations**

Gauge Station		TBM Level meter (PWD)	Reference FM Benchmark		Survey	
			Code	m (PWD)	Distance km	Close err mm
01	Belamari	17.859	5211	18.370	7.815	3
02	Char Atiapara	18.565	5304	19.101	14.051	16
03	Daluabari	18.834	5304	19.101	10.162	4
04	Hat Gobindah	19.256	5304	19.101	2.406	8
05	Gobindah	18.649	5304	19.101	5.856	16
06	Poyla Bridge	17.895	5305	19.512	6.639	7
07	Khashimara	17.362	5212	18.925	9.751	11
08	Islampur	20.478	5309	19.774	2.117	1
09	Delipur	19.455	5309	19.774	7.685	21
10	Madhyachar	18.180	5301	17.888	5.484	9
11	Hazipara	16.532	5123	17.371	2.853	3
12	Benjail Rampur	17.031	5123	17.371	9.054	8
13	Jhalopara	17.839	5118	16.676	2.171	4
14	Digpaith	15.050	5406	15.287	7.659	15
15	Rashidpur	15.287	5406	15.287	--	--
16	Rubshanti	17.700	5506	15.070	2.550	2
17	Koyra	14.775	5505	15.527	0.250	0
18	Bhengula	14.776	5502	14.629	0.720	1
19	Dhopa Kandi	13.937	5304	19.101	21.390	29
20	Delua Bazar	13.010	5111	14.308	6.680	3
21	Baniapara	15.046	7813	12.559	5.200	0
22	Ganjana	10.578	5807	11.811	1.828	4
23	Pach Charan	12.629	6101	11.363	1.400	6
24	Ratanganj	10.175	6001	10.175	--	--
25	Nakasim	10.240	6108	11.224	2.891	0
26	Patharghata	10.466	6111	7.991	0.707	2
27	Latifpur	12.493	7912	9.901	0.916	4
28	Kalampur	9.322	8134	6.658	2.046	3
29	Mollabari	14.001	5409	15.879	0.920	2
30	Kait Kai	14.661	5509	14.999	0.970	1
31	Tekibari Chandpu	9.602	7910	10.859	5.436	1
32	Dhantara	9.854	8134	6.658	13.932	15
33	Saforta	9.575	7908	10.771	13.002	28
34	Gopalpur	13.605	5111	14.308	15.200	24
35	Kuturia	11.418	6101	11.363	2.700	8
36	Pungli Bridge	14.219	7901	14.219	--	--
37	Bill Palima	12.351	5103	12.299	2.150	4
38	Kalihati	18.192	5802	11.919	1.630	4
39	Nalsafa	14.377	5107	13.754	6.290	2
40	Mitara	11.462	8128	7.996	10.992	24

Note: Refer to Figures 3.1 to 3.3 for approximate benchmark locations

The work was undertaken by BWDB Hydrology under a Memorandum of Understanding with BCEOM.

## 5 Supervision

Throughout the water level measurement period, (June to October), and during the gauge post installation, local supervision was provided by a Desh Upodesh staff Hydrologist. The contractor's practices and progress were monitored during installation of the gauges and gauge readers reliability and accuracy checked frequently during the monitoring period.

Similar local supervision was provided through a Desh Upodesh staff topographer, whose duties were to monitor the practices and progress of the topographic survey of embankments and gauge post levelling.

## 6 Results and Analysis

### *Embankment Survey*

The embankment survey was carried out along both banks of the specified watercourses as follows:-

<u>River/Watercourse</u>	<u>Left Bank</u>	<u>Right Bank</u>
Dhaleswari	102.68 km	103.5 km
Barinda	22.49 km	22.53 km
Dhantara Khal	11.57 km	11.31 km
Bangshi South	53.58 km	51.05 km
Kaliganga	78.02 km	72 km
Bangshi	123.62 km	126.40 km

Survey details were plotted to the following scales:-

#### Embankment Long Section

Horizontal Scale 1:5,000

Vertical Scale 1:20

#### Khal Cross sections

Horizontal Scale 1:500

Vertical Scale 1:20

Flood Plain Transects

Horizontal Scale 1:500

Vertical Scale 1:20

Copies of the survey drawings are limited in number and therefore are not issued with every copy of this report.

The number of sheets provided for the preparation of profiles for different watercourses are indicated below:-

Long Section Profiles :

Watercourse	Left Bank	Right Bank
Dhaleswari	21	21
Barinda	4	3
Dhantara Khal	2	3
Bangsi South	10	10
Kaliganga	16	16
Bangshi	25	27

Cross-section Profiles :

Watercourse	Left Bank	Right Bank
Dhaleswari	13	13
Barinda	1	-
Dhantara Khal	-	-
Bangsi South	2	2
Kaliganga	6	8
Bangshi	10	9

Transect Profiles :

Watercourse	Left bank	Right Bank
Dhaleswari	23	23
Barinda	4	4
Dhantara Khal	2	2
Bangsi South	12	11
Kaliganga	16	13
Bangshi	26	27



#### Equipment and Survey Gear Used :

- GPS (Global Positioning System)	1
- Level Instrument (Sokkisha B2 & Topcon ATD3, Japan)	6
- Measuring Tape	6

#### *Water Levels*

Water levels were monitored 5 times per day, commencing at 0600 hrs and thence every 3 hours until 1800 hrs. Gauge readers were also instructed to maintain vigilance during periods of heavy rainfall and to be prepared to continue monitoring though the night should river levels exhibit any rapid rises. The behaviour of rivers included in this survey are dominated by the behaviour of the major boundary rivers and they do not react swiftly to local rainfall. In this situation, there was no call to monitor rivers during the night.

At 39 of the 40 stations, 2 gauge posts were installed, each 3 metres in height. One station only required 1 gauge post as the water level variation did not warrant any additional post. When the water level registered on both upper and lower posts, and both gauges were visible, readings were taken of both gauges. Each station was located using a GPS and the data has been incorporated into a Geographical Information System used by FAP-25 for the FMM.

The quality of the records taken was generally good, yielding a high degree of confidence in the results. Office checks were made on the raw data by means of visual inspection of graphical plots of hourly water level at each station. In this way, datum changes, gross reading errors or mispunchings were screened out and adjusted accordingly. The Annexures to this report include the water level data, (reduced to PWD datum), and graphical plots of the variation of mean daily water level are also shown for each station.

Inspection of the records show that the highest water levels were attained throughout the area in late July and again in early September. This pattern of river response is also exhibited by the Jamuna river.

For security reasons, all gauges were removed to storage during the month of November and will be available for re-installation prior to the next monsoon in 1994.

Table 2: Details of Hydrometric Stations Installed

Nr.	River Name	Station Name	Location		Gauge Zero (m PWD)	
			Lat (°N)	Long (°E)	Lower	Upper
1 (D)	Kalu Mondal Daha	Belamari	24 54 48	89 46 50	13.766	15.873
2 (D)	Datbhanga	Char Atiapara	24 55 06	89 48 08	12.361	14.777
3	Lohajong	Dhaluabari	24 55 55	89 49 32	14.141	15.858
4	Nangla Khal	Hat Gobindah	24 57 26	89 51 20	15.285	17.281
5 (D)	Nangla Khal	Gobindapur	24 59 08	89 48 39	15.9	-
6 (D)	Madar Daha	Poyla Bridge	24 59 17	89 47 23	13.429	15.829
7	Madar Daha	Khashimara	24 58 37	89 46 38	13.365	15.527
8 (D)	Old Brahmaputra	Islampur	24 05 03	89 47 29	15.714	16.464
9 (D)	Deli	Delirpar	25 05 23	89 44 25	15.341	17.126
10 (D)	Bhabki Khal	Madhyachar	24 54 58	89 53 57	13.873	15.908
11	Jhinai	Hazipur	24 51 14	89 52 59	13.086	14.386
12 (D)	Chatal / Jhinai	Benjail Rampur	24 49 36	89 49 37	13.104	14.649
13 (D)	Branch of Jamuna	Jhalopara	24 44 37	89 49 23	11.432	13.437
14	Bangshi	Digpaith	24 45 48	89 55 53	12.202	13.877
15	Kairar Khal	Rashidpur	24 44 41	89 59 32	11.364	12.504
16	Kuchiamara	Rubshanti	24 41 49	89 57 20	11.011	13.335
17 (D)	Jhinai	Koyra	24 40 09	89 55 59	11.027	13.478
18	Jhinai	Bhengula	24 37 26	89 51 37	10.201	11.441
19	Katakhali Khal	Dhopa Kandi	24 35 30	89 57 17	10.501	11.952
20 (D)	Jhinai	Belua Bazar	24 33 36	89 52 57	8.193	10.533
21	Dahitoke	Baniapara	24 29 58	89 58 39	8.064	10.843
22 (D)	bangshi	Ganjana	24 27 54	90 04 54	7.308	9.171
23 (D)	Jhinai	Pach Charan	24 22 02	90 01 10	7.513	9.613
24	Jhinai	Ratangonj	24 20 07	90 03 33	7.39	9.731

Nr.	River Name	Station Name	Location		Gauge Zero (m PWD)	
			Lat (°N)	Long (°E)	Lower	Upper
25 (D)	Nangila	Nakasim	24 13 52	90 02 04	6.676	9.943
26 (D)	Bangshi	Patharghata	24 10 34	90 07 19	4.144	5.911 7.218 from (3/09/93)
27 (D)	Bangshi	Latifpur	24 04 09	90 13 02	3.745	6.39
28 (D)	Bangshi	Kalampur	23 55 53	90 09 27	3.648 4.567 from 17/09/93	6.587
29	Bangshi	Mollabari	24 40 07	90 00 14	10.422	11.951
30	Bangshi	Kait Kai	24 36 44	90 00 55	8.406	10.055
31 (D)	Barinda	Tekibari Chandpu	24 03 27	90 10 04	5.15	7.001
32	Dhantara	Dhantara	24 01 04	90 08 32	5.252	7.306
33	Warshi	Saforta	24 02 20	90 03 29	6.592	8.344
34	Bairan	Gopalpur	24 33 01	89 55 50	9.292	11.479
35	Sapa	Kuturia	24 21 07	90 00 13	7.452	9.106
36 (D)	Pungli	Pungli Bridge	24 18 56	89 55 36	8.005	9.18
37	Borni	Bill Palima	24 22 29	89 56 55	7.773	9.149
38	Jhinai	Kalihati	24 23 31	89 59 54	7.496	9.511
39	Jhinai / Lohajang	Nalsafa	24 29 14	89 54 11	8.154	10.174
40 (D)	Mitara Khal	Mitara	23 48 58	90 03 00	3.973	5.822

## Notes:

Station nos. 1 to 13 located in Jamalpur area  
 (D) indicates fortnightly discharge measurements made  
 Station locations determined from GPS measurements



23

**Table 3: Recommendations of 1992 Hydrological Survey**

Station	Recommendation	Action Taken
S1	Discharge survey should be monitored during future monsoon.	Programme initiated as Station No. 26
S2	Discharge survey should be monitored during future monsoon	Programme initiated as Station No. 25
S3	Station should be moved and re-sited in the proximity of FMBM 5807	Now station No. 22
S4	This station should be removed.	Done
S6	Discharge monitoring not necessary at this point	Discharge not measured
SG8	This station should be transferred to Tangail-Bhuapur road at the crossing of the Pungli river	Done. Station installed as No. 36

*Discharge Measurement*

Table 4 shows the processed results of the discharge measurement programme. In general, the results exhibit consistency, with only one example of obvious unreliability, (Station 6, August 5th). No discharge was recorded at station 5 for the first 3 months of the programme and subsequent discharge monitoring at this location was suspended.

Figure 4 shows examples of stage/discharge plots of the processed data for each station, (except Station 5, where no discharge was recorded). With the exception of Stations 25 and 26, the results indicate a relationship between water level and discharge exists at the station. Insufficient range of water levels were covered to permit definitive relationships to be established in the form of rating equations, but the spot gaugings may be used in the calibration process of new models.

Stations 25, (on the Nanglai South), and 26, (on the Bangshi), lie a short way upstream of the confluence of these rivers with the Pungli and are clearly affected by backwater from this river.

Table 4: Discharge Observation Data

no	Code BWDB F3Q ?	Code Gauge FMM	Date 1993	Water Level m PWD	Disch. m <sup>3</sup> /s	Mean Vel. m/s
1	Q01	PS-9	11-Jul	18.29	28.5	0.24
2	Q01	PS-9	25-Jul	18.34	35.4	0.13
3	Q01	PS-9	08-Aug	17.55	24.7	0.26
4	Q01	PS-9	22-Aug	17.85	26.7	0.27
5	Q01	PS-9	05-Sep	18.09	27.5	0.27
6	Q01	PS-9	19-Sep	16.09	3.5	0.09
7	Q01	PS-9	03-Oct	16.51	10.6	0.20
8	Q01	PS-9	17-Oct	15.92	1.9	0.05

1	Q02	PS-8	11-Jul	18.54	13.0	0.67
2	Q02	PS-8	25-Jul	18.64	16.6	0.68
3	Q02	PS-8	08-Aug	17.71	12.6	1.14
4	Q02	PS-8	22-Aug	18.06	13.8	1.02
5	Q02	PS-8	05-Sep	18.24	15.0	0.88
6	Q02	PS-8	19-Sep	16.66	0.7	0.41
7	Q02	PS-8	03-Oct	16.73	1.6	0.11
8	Q02	PS-8	17-Oct	16.73	1.5	0.12

1	Q03	PS-5	08-Jul	16.16	#0	#0
2	Q03	PS-5	22-Jul	16.56	#0	#0
3	Q03	PS-5	05-Aug	16.26	#0	#0
4	Q03	PS-5	19-Aug	17.15	#0	#0
5	Q03	PS-5	02-Sep	17.50	#0	#0
6	Q03	PS-5	16-Sep	16.14	#0	#0
7	Q03	PS-5				
8	Q03	PS-5				

1	Q04	PS-6	24-Jun	14.85	43.8	0.13
2	Q04	PS-6	08-Jul	16.08	71.8	0.13
3	Q04	PS-6	22-Jul	16.46	148.3	0.27
4	Q04	PS-6	05-Aug	16.23	22.9	0.05
5	Q04	PS-6	19-Aug	17.04	221.0	0.39
6	Q04	PS-6	02-Sep	17.30	228.0	0.39
7	Q04	PS-6	16-Sep	15.30	46.4	0.10
8	Q04	PS-6	14-Oct	14.80	40.9	0.10

1	Q05	134B	09-Jul	16.84	282.8	0.72
2	Q05	134B	23-Jul	17.25	357.0	0.80
3	Q05	134B	06-Aug	16.02	153.0	0.53
4	Q05	134B	20-Aug	16.88	199.0	0.52
5	Q05	134B	03-Sep	17.17	213.9	0.53
6	Q05	134B	17-Sep	15.42	103.0	0.56
7	Q05	134B	01-Oct	15.49	115.4	0.57
8	Q05	134B	15-Oct	14.96	54.1	0.47

1	Q06	PS-10	09-Jul	16.07	22.2	0.30
2	Q06	PS-10	23-Jul	16.39	47.8	0.49
3	Q06	PS-10	06-Aug	15.46	7.7	0.11
4	Q06	PS-10	20-Aug	16.35	33.3	0.29
5	Q06	PS-10	03-Sep	16.64	44.2	0.35
6	Q06	PS-10	17-Sep	14.83	1.4	0.05
7	Q06	PS-10	01-Oct	14.83	1.3	0.04
8	Q06	PS-10	15-Oct	14.61	#0	#0



Unreliable data

#0

No flow

no	Code BWDB F3Q ?	Code Gauge FMM	Date 1993	Water Level m PWD	Disch. m <sup>3</sup> /s	Mean Vel. m/s
1	Q07	PS-2	10-Jul	15.93	254.0	0.34
2	Q07	PS-2	24-Jul	16.58	338.0	0.36
3	Q07	PS-2	07-Aug	15.32	127.6	0.19
4	Q07	PS-2	21-Aug	16.35	257.1	0.24
5	Q07	PS-2	04-Sep	16.77	363.1	0.31
6	Q07	PS-2	18-Sep	14.29	86.7	0.14
7	Q07	PS-2	02-Oct	14.35	171.1	0.24
8	Q07	PS-2	16-Oct	13.79	5.9	0.01

1	Q08	PS-1	10-Jul	16.45	22.3	0.10
2	Q08	PS-1	24-Jul	16.84	75.7	0.22
3	Q08	PS-1	07-Aug	15.01	#0	#0
4	Q08	PS-1	21-Aug	16.20	30.3	0.12
5	Q08	PS-1	04-Sep	16.61	59.5	0.22
6	Q08	PS-1	18-Sep	14.49	12.2	0.09
7	Q08	PS-1	02-Oct	14.50	13.6	0.10
8	Q08	PS-1	16-Oct	14.30	#0	#0

1	Q09	PS-12	12-Jul	15.72	474.0	0.74
2	Q09	PS-12	26-Jul	16.12	482.0	0.64
3	Q09	PS-12	09-Aug	15.15	351.0	0.58
4	Q09	PS-12	23-Aug	15.73	479.0	0.70
5	Q09	PS-12	06-Sep	15.94	430.3	0.58
6	Q09	PS-12	20-Sep	13.51	112.2	0.37
7	Q09	PS-12	04-Oct	14.16	188.2	0.47
8	Q09	PS-12	18-Oct	13.15	85.6	0.32

1	Q10	134A	13-Jul	15.22	131.0	0.45
2	Q10	134A	27-Jul	15.55	158.0	0.48
3	Q10	134A	10-Aug	15.08	123.0	0.45
4	Q10	134A	23-Aug	15.40	126.0	0.42
5	Q10	134A	07-Sep	15.40	134.7	0.45
6	Q10	134A	21-Sep	13.40	32.8	0.16
7	Q10	134A	05-Oct	(1)	95.5	0.39
8	Q10	134A	19-Oct	(1)	25.3	0.14

1	Q11	PS-13	14-Jul	14.33	910.0	0.97
2	Q11	PS-13	28-Jul	14.75	1181.0	1.08
3	Q11	PS-13	11-Aug	14.81	1184.0	1.00
4	Q11	PS-13	26-Aug	14.83	1184.0	0.97
5	Q11	PS-13	09-Sep	14.62	924.4	0.84
6	Q11	PS-13	22-Sep	13.19	172.1	0.17
7	Q11	PS-13	06-Oct	13.95	469.5	0.44
8	Q11	PS-13	20-Oct	12.52	128.2	0.16

1	Q12	PS-17	05-Jul	13.18	12.4	0.30
2	Q12	PS-17	18-Jul	13.24	12.6	0.28
3	Q12	PS-17	02-Aug	13.34	14.4	0.32
4	Q12	PS-17	16-Aug	13.52	23.6	0.41
5	Q12	PS-17	30-Aug	13.66	23.7	0.42
6	Q12	PS-17	13-Sep	13.27	11.4	0.27
7	Q12	PS-17	27-Sep	11.97	3.1	0.17
8	Q12	PS-17	11-Oct	12.35	4.5	0.23

(1) BWDB data not yet available



Table 4: Discharge Observation Data

no	Code BWDB F3Q ?	Code Gauge FMM	Date 1993	Water Level m PWD	Disch. m3/s	Mean Vel. m/s
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1	Q13	PS-20	10-Jul	11.93	67.1	0.46
2	Q13	PS-20	24-Jul	12.42	84.3	0.51
3	Q13	PS-20	08-Aug	12.07	63.0	0.43
4	Q13	PS-20	19-Aug	12.24	72.9	0.49
5	Q13	PS-20	02-Sep	12.53	79.3	0.47
6	Q13	PS-20	16-Sep	12.11	58.8	0.45
7	Q13	PS-20	30-Sep	11.40	44.4	0.41
8	Q13	PS-20	14-Oct	10.82	27.0	0.33

1	Q14	PS-22	08-Jul	10.10	84.6	0.44
2	Q14	PS-22	22-Jul	10.70	130.0	0.58
3	Q14	PS-22	07-Aug	10.15	60.1	0.37
4	Q14	PS-22	21-Aug	9.64	38.2	0.24
5	Q14	PS-22	04-Sep	10.63	107.8	0.50
6	Q14	PS-22	18-Sep	10.07	62.1	0.34
7	Q14	PS-22	02-Oct	9.63	62.1	0.38
8	Q14	PS-22	16-Oct	9.18	29.5	0.22

1	Q15	PS-23	11-Jul	10.13	85.8	0.66
2	Q15	PS-23	25-Jul	10.49	94.3	0.66
3	Q15	PS-23	08-Aug	10.26	94.1	0.70
4	Q15	PS-23	22-Aug	10.17	94.0	0.71
5	Q15	PS-23	05-Sep	10.53	109.4	0.70
6	Q15	PS-23	19-Sep	10.20	87.1	0.69
7	Q15	PS-23	03-Oct	9.85	69.9	0.64
8	Q15	PS-23	17-Oct	9.43	42.0	0.53

1	Q16	PS-36	11-Jul	10.93	284.0	0.89
2	Q16	PS-36	25-Jul	11.05	285.0	0.80
3	Q16	PS-36	08-Aug	10.44	212.0	0.80
4	Q16	PS-36	22-Aug	10.69	266.0	0.82
5	Q16	PS-36	05-Sep	11.14	287.8	0.74
6	Q16	PS-36	19-Sep	10.06	136.8	0.56
7	Q16	PS-36	03-Oct	10.03	125.3	0.65
8	Q16	PS-36	17-Oct	9.32	88.3	0.59

1	Q17	PS-25	03-Jul	8.96	28.7	0.28
2	Q17	PS-25	17-Jul	8.93	31.2	0.32
3	Q17	PS-25	31-Jul	9.35	18.6	0.17
4	Q17	PS-25	14-Aug	9.37	31.9	0.27
5	Q17	PS-25	28-Aug	9.49	43.1	0.38
6	Q17	PS-25	11-Sep	9.52	21.0	0.20
7	Q17	PS-25	25-Sep	8.83	25.0	0.37
8	Q17	PS-25	09-Oct	8.75	9.6	0.15

1	Q18	PS-26	08-Jul	7.75	79.3	0.36
2	Q18	PS-26	22-Jul	8.11	82.7	0.32
3	Q18	PS-26	05-Aug	8.21	69.1	0.27
4	Q18	PS-26	19-Aug	8.08	66.9	0.28
5	Q18	PS-26	02-Sep	8.50	71.2	0.24
6	Q18	PS-26	16-Sep	8.45	56.8	0.19
7	Q18	PS-26	30-Sep	7.58	99.9	0.46
8	Q18	PS-26	14-Oct	7.22	97.5	0.54

no	Code BWDB F3Q ?	Code Gauge FMM	Date 1993	Water Level m PWD	Disch. m3/s	Mean Vel. m/s
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1	Q19	NCQ6	06-Jul	9.54	917.0	0.83
2	Q19	NCQ6	20-Jul	9.20	879.0	0.80
3	Q19	NCQ6	03-Aug	9.68	1013.0	0.84
4	Q19	NCQ6	17-Aug	10.42	1702.0	1.11
5	Q19	NCQ6	31-Aug	10.45	1728.0	1.19
6	Q19	NCQ6	14-Sep	9.78	941.2	0.90
7	Q19	NCQ6	28-Sep	9.47	861.2	0.84
8	Q19	NCQ6	12-Oct	9.29	825.4	0.77

1	Q20	NCQ3	06-Jul	7.53	91.2	0.62
2	Q20	NCQ3	20-Jul	7.57	100.0	0.68
3	Q20	NCQ3	03-Aug	7.98	107.0	0.64
4	Q20	NCQ3	17-Aug	7.98	108.0	0.64
5	Q20	NCQ3	31-Aug	8.21	125.0	0.74
6	Q20	NCQ3	14-Sep	8.28	127.5	0.76
7	Q20	NCQ3	28-Sep	7.49	86.8	0.68
8	Q20	NCQ3	12-Oct	(1)	84.2	0.71

1	Q21	PS-31	07-Jul	6.78	175.0	0.77
2	Q21	PS-31	21-Jul	6.92	201.0	0.81
3	Q21	PS-31	04-Aug	7.17	252.0	0.93
4	Q21	PS-31	18-Aug	7.18	247.0	0.94
5	Q21	PS-31	01-Sep	7.39	288.8	1.02
6	Q21	PS-31	15-Sep	7.39	281.9	1.01
7	Q21	PS-31	29-Sep	6.81	221.8	0.91
8	Q21	PS-31	13-Oct	6.55	185.0	0.79

1	Q22	PS-27	06-Jul	6.61	127.0	0.70
2	Q22	PS-27	20-Jul	6.68	131.0	0.71
3	Q22	PS-27	03-Aug	7.06	164.0	0.78
4	Q22	PS-27	17-Aug	6.94	156.0	0.75
5	Q22	PS-27	31-Aug	7.21	175.0	0.77
6	Q22	PS-27	14-Sep	7.31	180.3	0.78
7	Q22	PS-27	28-Sep	6.52	131.5	0.69
8	Q22	PS-27	12-Oct	6.32	103.9	0.62

1	Q23	PS-40	11-Jul	6.27	42.6	0.53
2	Q23	PS-40	25-Jul	6.72	56.7	0.62
3	Q23	PS-40	08-Aug	6.50	50.7	0.60
4	Q23	PS-40	22-Aug	7.11	65.1	0.66
5	Q23	PS-40	05-Sep	7.51	83.9	0.72
6	Q23	PS-40	19-Sep	6.75	58.3	0.60
7	Q23	PS-40	03-Oct	6.46	49.1	0.57
8	Q23	PS-40	17-Oct	5.80	27.1	0.45

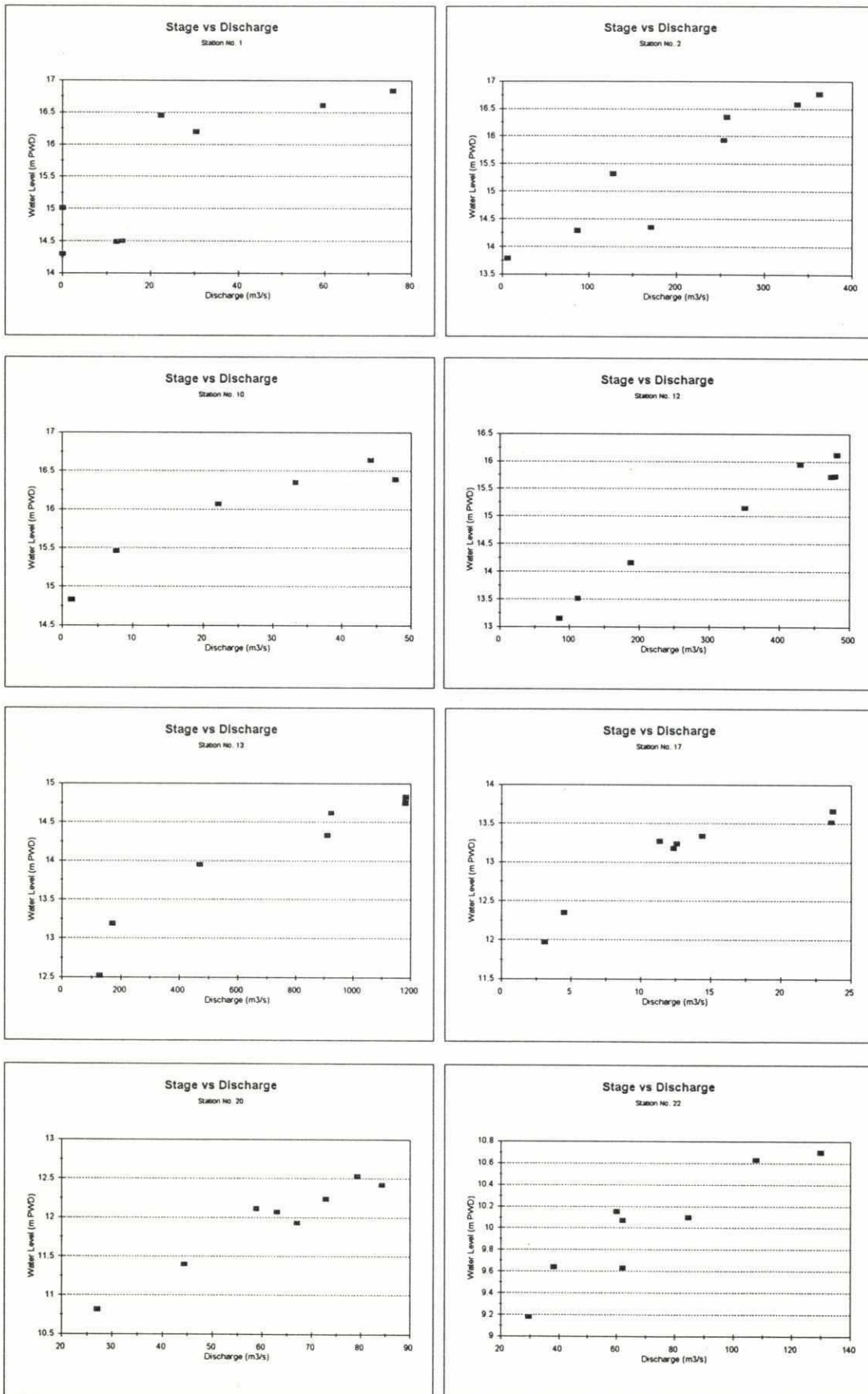
1	Q24	PS-28	10-Jul	6.23	154.0	0.73
2	Q24	PS-28	24-Jul	6.86	211.0	0.84
3	Q24	PS-28	07-Aug	6.45	159.0	0.69
4	Q24	PS-28	21-Aug	6.55	212.0	0.83
5	Q24	PS-28	04-Sep	7.40	280.5	0.86
6	Q24	PS-28	18-Sep	6.68	177.0	0.70
7	Q24	PS-28	02-Oct	6.45	147.8	0.70
8	Q24	PS-28	16-Oct	5.87	99.5	0.61

(1) SWMC data not yet available



2A

Figure 4: Water Level vs Discharge Plots of Gaugings



CD

Figure 4: Water Level vs Discharge Plots of Gaugings

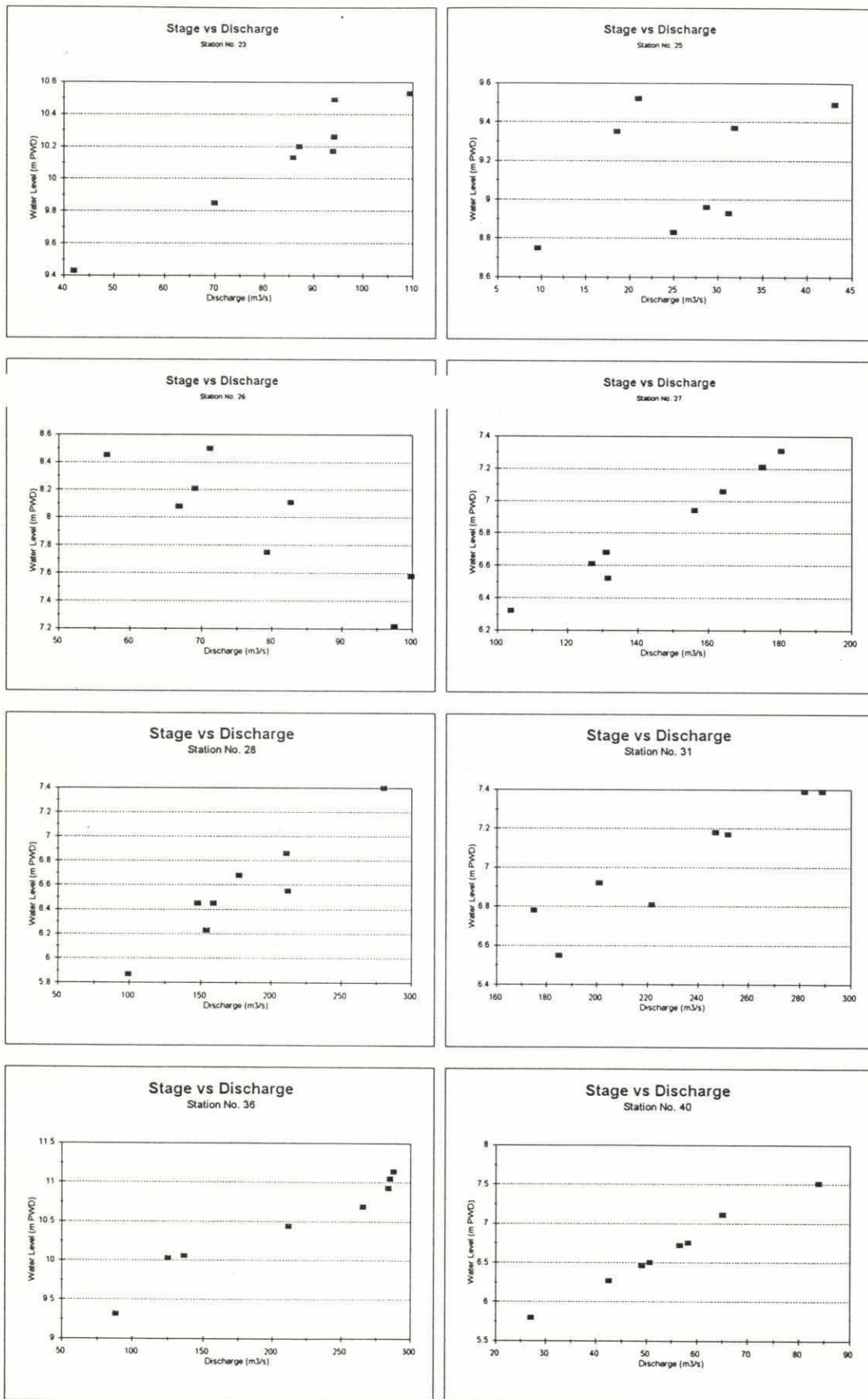


Figure 4: Water Level vs Discharge Plots of Gaugings

