GOVERNMENT OF BANGLADESH
FLOOD PLAN COORDINATION ORGANIZATION

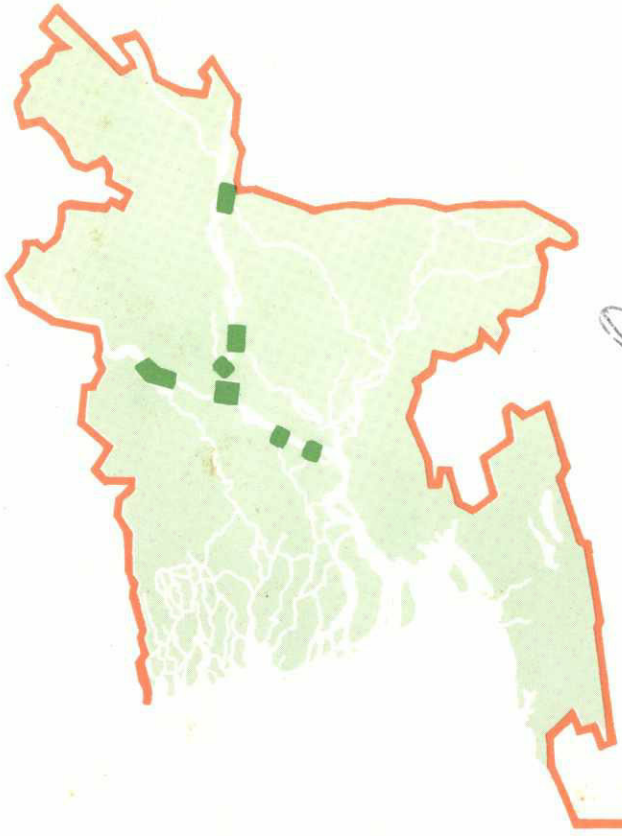
FAP 24 RIVER SURVEY PROJECT

Survey Report 9

Bathymetric pilot surveys

on

Jamuna River at Bahadurabad



DELFT HYDRAULICS
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Project ALA/90/04 — Commission of the European Communities

Survey Report 9
Bathymetric pilot surveys on Jamuna River at Bahadurabad

July 1994

FAP 24 RIVER SURVEY PROJECT

Flood Plan Coordination Organization

DELFT-DHI **Commission of the European Communities**

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July 31, 1994

Chief Engineer
Flood Plan Coordination Organization (FPCO)
7 Green Road, Dhaka.

Attention : Mr. Afzalur Rahman.
Superintending Engineer.

Subject : Report on surveys of the flood season 1993

Our ref : RSP/9.1/1029

Dear Sir,

We are taking pleasure in submitting herewith our Survey Report 9: Bathymetric pilot surveys on Jamuna River at Bahadurabad.

The report describes the initial bathymetric surveys carried out by the River Survey Project.

Thanking you.

Yours sincerely

Claus Iversen
Deputy Team Leader

Contents

Acronyms and Abbreviations

AWLR	:	Automatic water-level recorder
BIWTA	:	Bangladesh Inland Water Transport Authority
BTM	:	Bangladesh Transverse Mercator (a geodetic grid)
BWDB	:	Bangladesh Water Development Board
DGPS	:	Differential Global Positioning System for determination of latitude, longitude and altitude
DHA	:	Survey vessel A (mother ship)
DHC	:	Survey vessel C (catamaran type)
E	:	Easting (east coordinate in the BTM grid)
FPCO	:	Flood Plan Coordination Organization
GPS	:	Global Positioning System
Hydro	:	Hydrographic software package
N	:	Northing (north coordinate in the BTM grid)
PA	:	Project Adviser
PC	:	Personal computer
PWD	:	The Public Works Department's vertical geodetic datum
SLW	:	Standard Low Water (a reference level)
SoB	:	Survey of Bangladesh
UTM	:	Universal Transverse Mercator (a geodetic grid)
VHF	:	Very high frequency
WGS	:	World Geodetic System (1984)

1. Introduction

As part of the Consultancy Contract of 22 May 1992 dealing with the River Survey Project, FAP24, ALA/90/04 bathymetric surveys should be undertaken in phase 2 just before and just after the flood season, i.e. in May and November. The first survey was scheduled to take place in November 1993.

However, during the Project Advisers mission in April/May 1993 it was decided to advance the start of the bathymetric work and to carry out, as a first step, some monitoring surveys - bathymetric pilot surveys - in the left main channel of the Jamuna River at Bahadurabad over the flood season, when the morphological changes are expected to be most distinct. The purpose was to investigate the final needs of morphological monitoring by means of bathymetric surveying.

In 1993, three bathymetric surveys covering an area of approximately 10 km up- and downstream of Bahadurabad Ghat, respectively, have been carried out in the following periods:

1'st survey : 10-26 June 1993
2'nd survey : 25 August September 1993
3'rd survey : 1-20 November 1993

This report presents the results of all three pilot surveys and describes the equipment and methods used.

2. Extent and methods of survey

The survey area comprises the navigable sections of the left channel of the Jamuna River between 10 km up- and downstream of Bahadurabad Ghat, respectively; ref Fig 2.1.

Due to a variation in water-levels over the flood season the extent of the areas covered during the individual surveys has differed. The first and the second survey were carried out in high water condition (in the order of 19 m +PWD) providing the most extensive coverage, while the water-level during the last survey in November was lower (close to 15 m +PWD) allowing a more restricted extent only; ref. Dwgs. 1-3.

The coverage of the respective survey areas has been summarized as follows:

- The surveys were carried out in east-west oriented lines with 100 m spacing.
- Water depths have been recorded for approximately every 2 m along the survey lines.
- Bank-lines have been determined by direct measurements or by estimate of the distance to shore from the last bathymetric measuring point in the respective lines.

For reduction of depth measurements water-levels recorded at Bahadurabad Ghat have been used.

During execution of work the survey areas were divided between deeper sections (main channels) to be covered by the DHA and more shallow areas to be covered either by the shallow draught catamaran (DHC) or the alu boat.

A few gaps in the recorded data coverage have been observed. This is mainly caused by errors in the administration of data in the field (missing file nos.). In the sections with missing data contour lines have been made by interpolation between the survey lines made good.

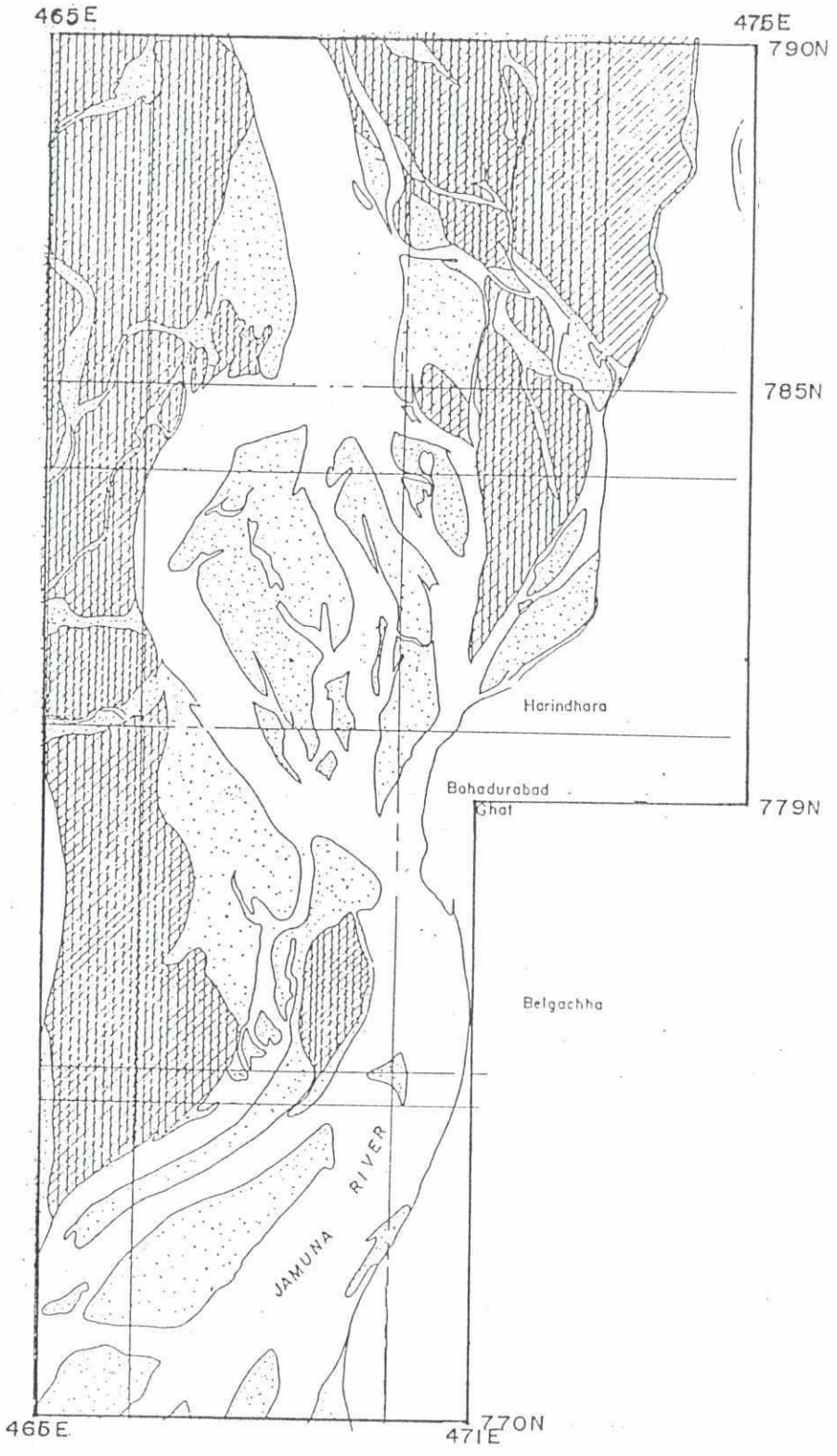

Figure 2.1 : Definition of bathymetric survey area

3. Measurement equipment and procedures

3.1 General

All the survey equipment and vessels operated by the River Survey Project have been described in detail previously, e.g. in Chapter 5 of the Test Gauging Report and only a summary focusing on the bathymetric surveying is provided in the following.

3.2 Vessels

During bathymetric surveying all three survey vessels were deployed as follows:

- Ms. DHA, a former police patrol boat, built for shallow waters. The boat has been modified for advanced survey work in Bangladesh. Ms. DHA has the following main dimensions:

  - Length over all 20.25 m
  - Breadth over all 4.70 m
  - Delft 15 m

- Ms. DHC, a newly built catamaran survey vessel. The vessel has the following main dimensions:

  - Length over all 8.70 m
  - Breadth over all 6.30 m
  - Draft 0.45 m

- A 12 feet aluminium craft with two 25 hp outboard engines

3.3 Equipment

Table 3.1 below summarizes the instrumentation used for bathymetric surveying aboard each of the survey vessels.

Equipment	DHA	DHC	Alu.cr.
DGPS Position system:			
Trimble 4000, 9 channel	X		
Trimble Navtrac, 6 channel		X	X
Bathymetric equipment:			
Elac Laz 4420 (dual frequency 30/210 kHz)	X		
Simrad EA 300 P		X	X
Navigation and on-line data processing and logging:			
PC	X	X	X
A3 plotter	X		
A4 printer	X	X	
Side scan sonar; supplementary equipment:			
EG & G Model 260	X		
Communication:			
VHF radios	X	X	
Walkie talkies	X	X	X

Table 3.1 : Bathymetric instrumentation aboard the three FAP 24 survey vessels, 1993.

All equipment used in the alu boat consist of portable units, which are only installed during actual surveying.

The echo-sounder transducers are hull mounted on the DHA, front mounted in a separate frame on DHC and over-the-side mounted on the alu boat, respectively.

The side scan sonar was deployed a few times for supplementary mapping of sand dune patterns.

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3.4 General survey control and datums

Planimetric control
The surveys were conducted in the World Geodetic System (WGS) 1984 and in the Bangladesh Transverse Mercator BTM, which is a UTM-like zone system based on the Everest 1830 ellipsoid with the following parameters:

Ellipsoid

Major axis	:	6377276.3 metres
Minor axis	:	6356075.4 metres
Flattening	:	1/300.80

Projection

Central Meridian (CM)	:	90.0° Longitude
Scale factor	:	0.9996
False easting	:	500,000
False northing	:	-2,000,000

The GPS reference station for positioning was installed in the T & T radio tower in Fulchari Ghat located on the right bank of the river.

The preparation of fix points incl. determination of coordinates was undertaken as part of the general mobilization for the routine gauging programme.

Vertical control
All the depth data have been reduced to Standard Low Water (SLW) at the Bahadurabad Ghat. SLW represents a sloping reference level (as compared with the PWD, which is a horizontal reference level).

The relationship between the two reference levels is given in the report on "Determination of standard low water and standard high water-levels in Bangladesh" issued by BIWTA (prepared by the Norwegian Interconsult A/S).

For the BWDB water-level gauging station at Bahadurabad the following figure has been obtained from this report:

Station	SLW (m+PWD)
Bahadurabad	12.03

The presented bathymetric charts thus show the depths below SLW.

The SLW datum is not accurately defined at other places than where long-term water-levels are available. For the time being it has been assumed that

the instantaneous water surface is parallel to SLW, but this assumption is not quite correct. A preliminary analysis (to be finalised and reported in the 2° Interim Report of the River Survey Project) indicates a SLW slope in the left channel around Bahadurabad of around 5 cm/km. This slope is similar to the slope at stage 15 m+PWD, whereas the slope at stage 19 m+PWD is around 7 cm/km (slightly lower at rising stage and slightly higher at falling stage).

The datum of the water-level gauging station was determined by geometric levelling from the bench-mark Finnmap 5244 situated approximately 1 km east of Bahadurabad Ghat.

The details involved in the horizontal as well as the vertical control work has been provided in Survey Report No. 7 on the "Transfer of bench-mark levels across Jamuna River at Bahadurabad".

3.5 Navigation systems

Positioning system
All the bathymetric survey work was performed with Differential Global Positioning System (DGPS). Two Trimble 4000 and two Trimble Navtrack units were used and deployed as listed in Table 3.1. A VHF telemetry link was established for transmission of differential corrections between the reference station at Fulchari Ghat and the respective receivers aboard the survey vessels.

The DGPS gives immediate positions in the World Geodetic System WGS 84, which are transformed into BTM coordinates by a PC based on-line Hydro software package, which is also controlling the actual navigation.

The positioning system has been verified by comparing the BTM coordinates of a bench-mark GPS 764 to the coordinates measured by the DGPS positioning system. According to the below positions, the deviation (= the difference between the 'true' value and the recorded value) was within the 2 m horizontal accuracy of the DGPS system operated in stationary mode.

GPS 764, coordinates	measured coordinates	discrepancy
BTM E 471086.158	BTM E 471084.4	E 1.8 m
BTM N 778478.880	BTM E 778477.4	N 1.5 m

Gyro
A Robertson SKR 82 gyro compass interfaced to the on-line navigation computer was used to provide heading control for the A-vessel.

Offsets

The positioning system antennas were selected as horizontal reference point aboard all three survey boats.

On DHC and the alu boat the echo-sounder transducer was installed below the antenna and no offset was used in the final calculation of positions.

On DHA the offset of the echo-sounder transducer was measured and entered into the navigation computer together with the gyro heading of the vessel.

On-line depth measurements were related to the water-level.

3.6 Echo-sounding

Dual and single frequency echo-sounders distributed aboard the vessels as listed in Table 3.1 have been used to record analogue and digital depths.

The beam widths were as follows:

Transducer	**beam width**
Elac:	
30 kHz	24°
200 kHz	10°
Simrad:	
200 kHz	7°

The transducer housing was mounted in the bow of the catamaran DHC and hull mounted in a small pipe moon pool aboard DHA. The alu boat carried the transducer on the port side.

The draught of the transducers was regularly measured in calm conditions. Regular checking of the survey vessels draught was also made. Only small differences of a few centimetres have been recorded.

The sound velocity through the water column was determined to be 1500 m/s corresponding to fresh water.

The echo-sounders were interfaced to the navigation computers and fix marks were sent from the computers with fix number, date, time, line file no. and positions.

3.7 Water-level gauges

The water-levels used for reduction of all the depth measurements have been measured by BWDB at Bahadurabad Ghat.

The reference levels for the respective gauges have been measured by geometric levelling from the bench-mark Finnmap BM 5244.

The level of Finnmap BM 5244 has been obtained from the Survey of Bangladesh (SoB) as 19.8569 m +PWD.

All water-level corrections applied to the depth data were performed during the post-processing in Dhaka.

Further installation details about the water-level recorders have been provided in Annexure 1 of the Test Gauging Report.

3.8 Bank-line survey

Identification of the bank-line during the surveys took place by direct measurements, where possible, or by positioning relative to the vessel by estimating the distance from the vessel to the river bank at the ends of the survey lines.

The procedure caused some inconveniences during the data post-processing and was changed after the pilot surveys. The new procedure implies bank-line mapping as a separate activity and by application of a separate DGPS unit for that purpose.

4. Data processing and reporting

Navigation and datalogging

Navigation and datalogging is controlled by a special software package, type Datacom Hydro, developed by Trimble Datacom in New Zealand and operated on a conventional PC. The HYDRO package has been designed especially for bathymetric surveying and conducts all necessary navigation controls such as positioning, time reference, navigation outputs and at the same time it constitutes the operation centre for the surveyor in charge.

The HYDRO package basically logs time and position together with relevant sensor inputs such as water depths and water-levels. The package also includes facilities for on-board quality check of the recorded data.

The programme created survey lines, produced pre-plotted track charts and at the same time controlled the helmsman's display showing all the necessary information for steering the vessels in the respective survey lines.

The on-line computer cycle was set to its optimum of 1 second. Thus the depth data was recorded every second corresponding to 2 m horizontal distance at a navigation speed of 4 knots, which was a normal survey speed.

The fixing interval was also 1 second. Every fix was sent to the printer for hard copy. An A3 track plotter was used to record the vessel's progress on paper charts in scale 1:10.000 with the survey lines pre-plotted.

Temporary data storage and transfer

When the data were collected and pre-checked, they were stored in the file formats of the HYDRO package for later transfer to the data processing unit in Dhaka. The actual data administration on-board was done on a file by file basis for the individual survey lines with manual tracking of the recorded data. In addition, each file contained a header with key information on measurement location and period. As often as practically possible, data was transferred to the project office for further processing. The tapes used for this transfer are considered to constitute the raw data of the project and will be the ultimate backup and data reference source.

Raw data storage

When tapes from the field were received in the project office the contents were copied immediately to disk storage for further processing. Library information in the tape contents (data type, area, time period etc) were entered into the common FIELDMAN library system and registered as external files residing on tape. The tapes were then moved to their final storage. For security reasons the raw data tapes are stored in a building separate from the project office.

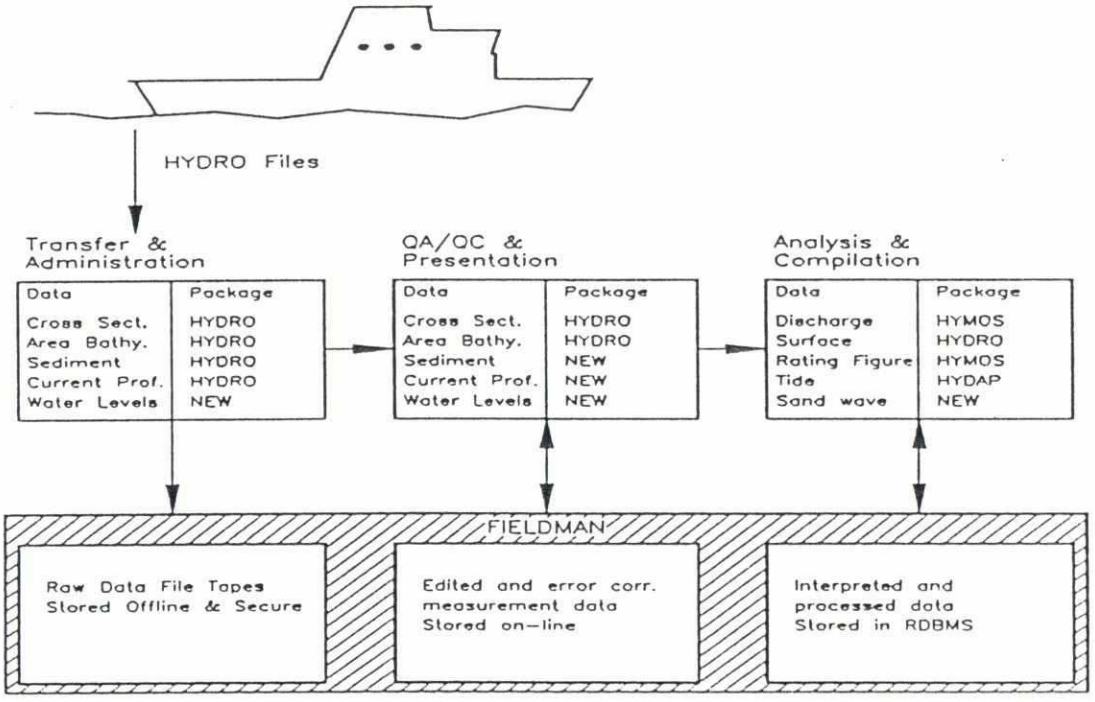


Figure 4.1 : Data flow

Quality control and data editing

In the off-line data processing in Dhaka every data file has been subject to the following processing steps:

- o Manual/semi-automatic check for spikes, errors etc.
- o Errors were edited as appropriate by deletion, interpolation and/or filtering
- o Data sets were reduced to include only useful information, so superfluous and insignificant measurements were deleted
- o Offset corrections relating to the entire data set. From the water-level gauge measurements the data has been reduced to SLW

This process produced files with only sound and valid data, allowing for subsequent application of standard processing programs.

Storage of edited data

The edited and quality assured data being the main data source for the further processing and analysis were stored on-line on optical and/or magnetic disks for immediate access.

As the number of data files is huge, a storage using ordinary naming conventions and a normal directory structure was considered inadequate. Each file was registered with its characteristics in the FIELDMAN system, meaning that a user who has selected a file will have immediate access to its contents if the file format is supported in FIELDMAN. The user can also immediately transfer the file to his working area for further presentation.

Mapping

The data are presented in the following ways:

- Key plans of each survey (attached as Dwgs. 1-3)
- Bathymetry charts, scale 1:10,000 (included in Part B of the present report)
- Contour plots, scale 1:10,000 (included in Part B of the present report)

Digitized data are stored in two ways for special or more detailed analyses:

- Files of edited sets of all recording of position, depth, and time along the survey lines
- Files of averaged and interpolated depths and bank contours in a fixed (50 m by 50 m) grid covering the entire survey area

Reporting

For practical reasons, the present reporting of the bathymetric pilot surveys is divided into two parts. The first part gives the background together with a brief summary of findings. The large-scale maps to be used for the morphological studies form the second part of the report. The first part is issued in a much higher number than the second part.

5. Summary of results

5.1 Key plans

Key plans for the three pilot surveys are attached as Dwgs. 1 - 3, which also show a track plot of all the survey lines as sailed.

5.2 Bathymetry charts

The survey results from the respective periods June, August and November have been presented in a series of bathymetry charts in scale 1:10.000 and with a survey line spacing of 100 m. This is in accordance with the Technical Specifications.

The bathymetry charts have been produced by plotting the edited data with the horizontal positions in the BTM system. The charts show as many actual soundings as practical for the scale selected for the charts.

The coverage of each chart is shown on the key plans (Dwgs. 1-3).

5.3 Contour plots

Contour curves have been generated on the basis of the depths in a fixed grid, produced by a bilinear interpolation. The grid spacing is 50 m by 50 m. The produced mesh has the orientation true north and covers the whole survey area. Based on these grid data the contour plots are produced.

An arbitrary smoothing routine is applied for the contours of these plots. The smoothing facilitates the interpretation of the plots and the comparison between different plots, at the cost of an occasional deviation between recorded and presented depths. The smoothing procedure applied causes a deviation that is roughly estimated as follows:

- between 1 and 1.5 m for appr. 3 percent of the area
- between 0.5 and 1 m for appr. 7 percent of the area
- between 0 and 0.5 m for appr. 15 percent of the area
- true value for appr. 75 percent of the area

The deviation is in either direction, as compared with navigation charts, where the presented depths contours are envelopes of minimum depths.

The isoline distance of the contour plots has been selected at 1 m (as compared with the 0.5 m distance which is stated in the Technical Specifications for lean season surveys). Hereby, the contour plots become more readable. A comparison between 0.5 m and 1 m isoline distance is shown on Fig. 5.1.

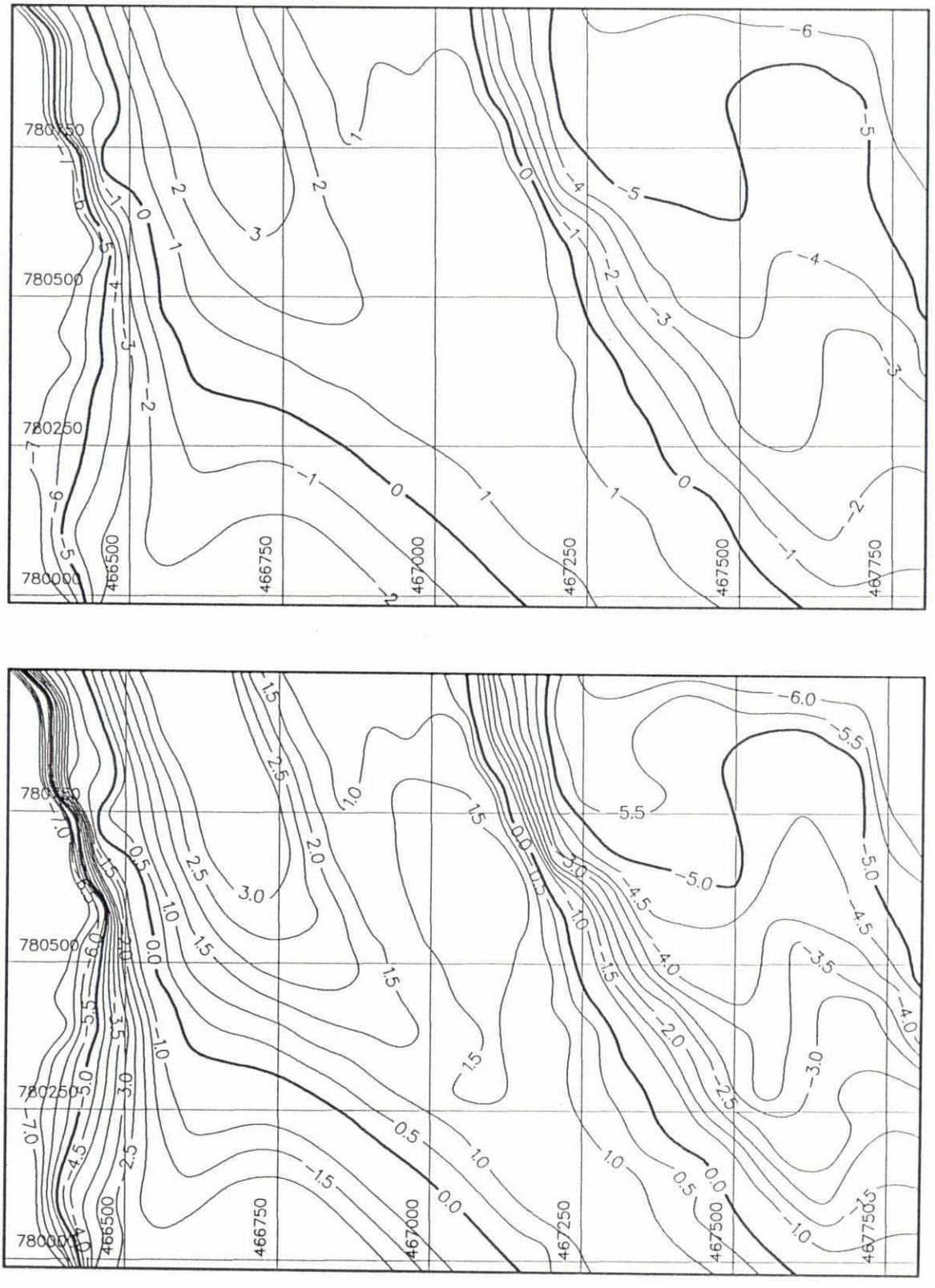


Figure 5.1 : Sample contour plots with 0.5 m and 1 m isoline distance (scale 1:10,000)

5.4 Water-levels

The water-level at Bahadurabad Ghat during the surveys is shown on Fig. 5.2. The time variation of the water-level during the pilot surveys may be summarised as follows:

- During the June 93 survey (17 days), the level varied between 18.82 and 18.15 m+PWD. The largest day-to-day variation was minus 19 cm
- During the August/September 93 survey (12 days), the water-level varied between 19.32 and 19.12 m+PWD. The largest day-to-day variation was minus 10 cm.
- During the November 93 survey (12 days), the water level declined gradually from 15.69 to 15.15 m+PWD, the largest day-to-day variation being minus 6 cm.

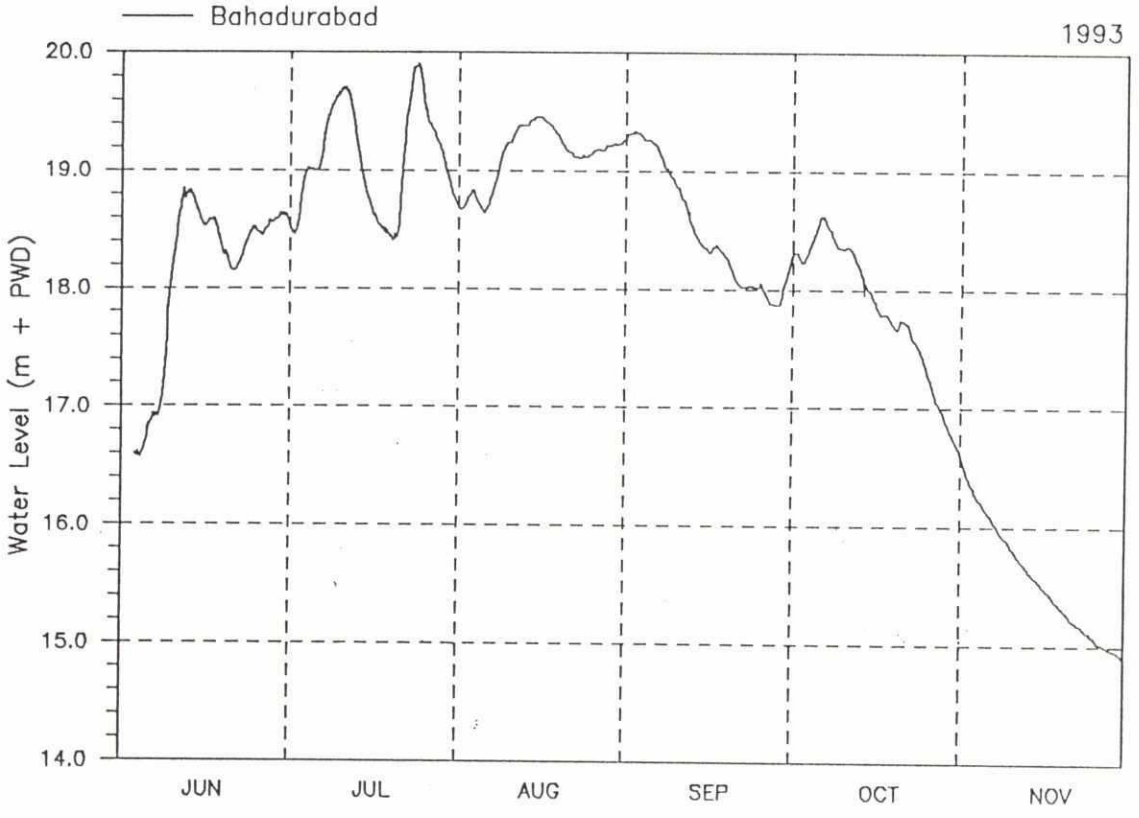
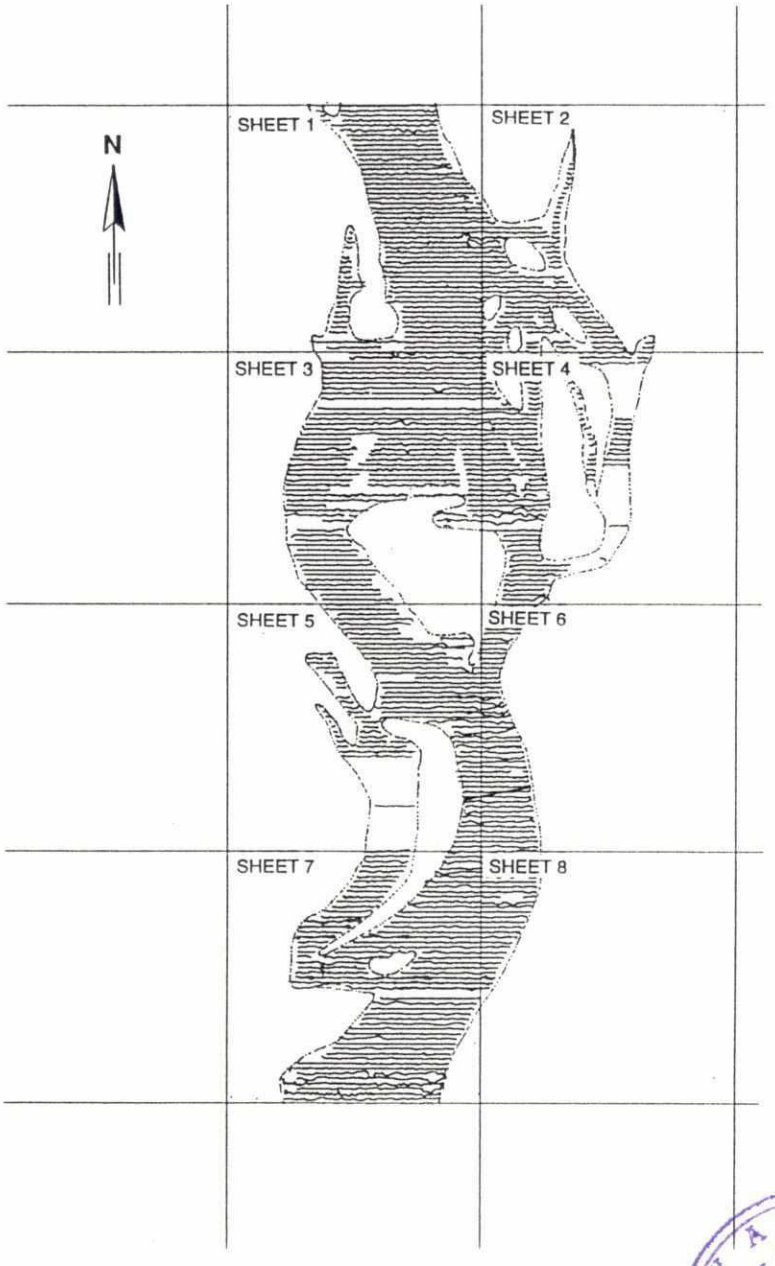


Figure 5.2 : Water-level at Bahadurabad Ghat



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	21 June 1994	Key plan, June 1993	Drawing 1
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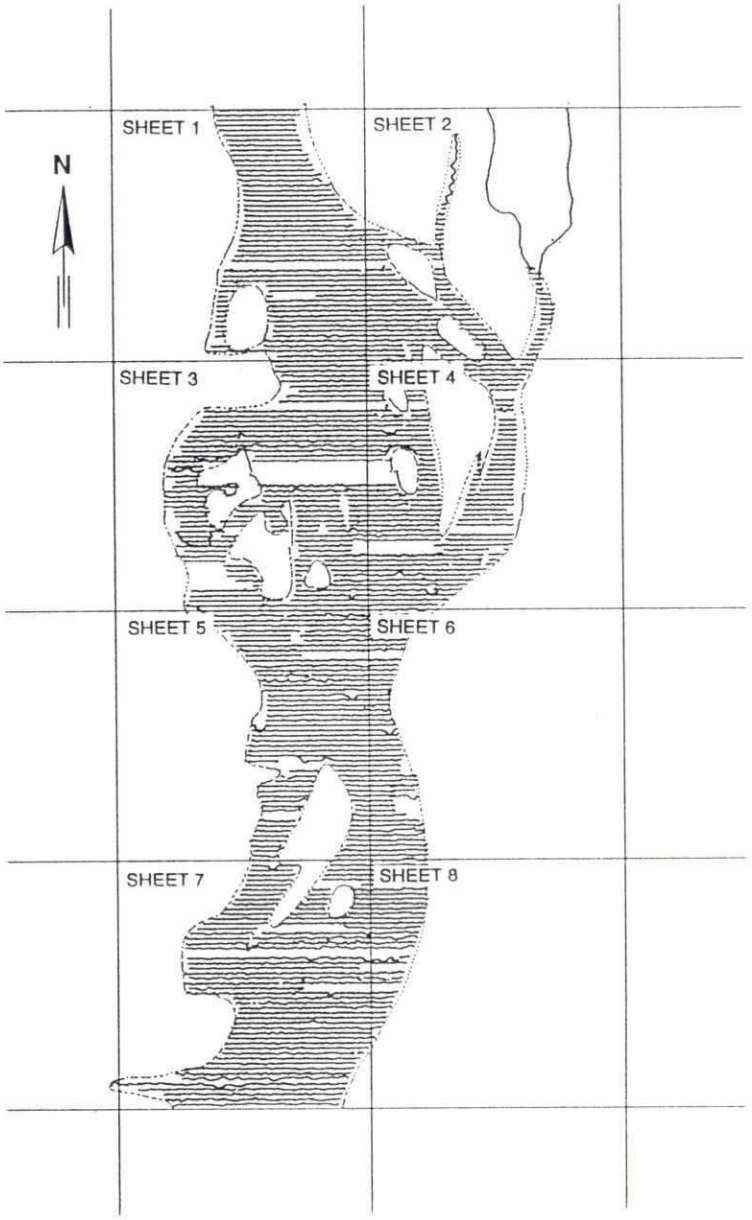

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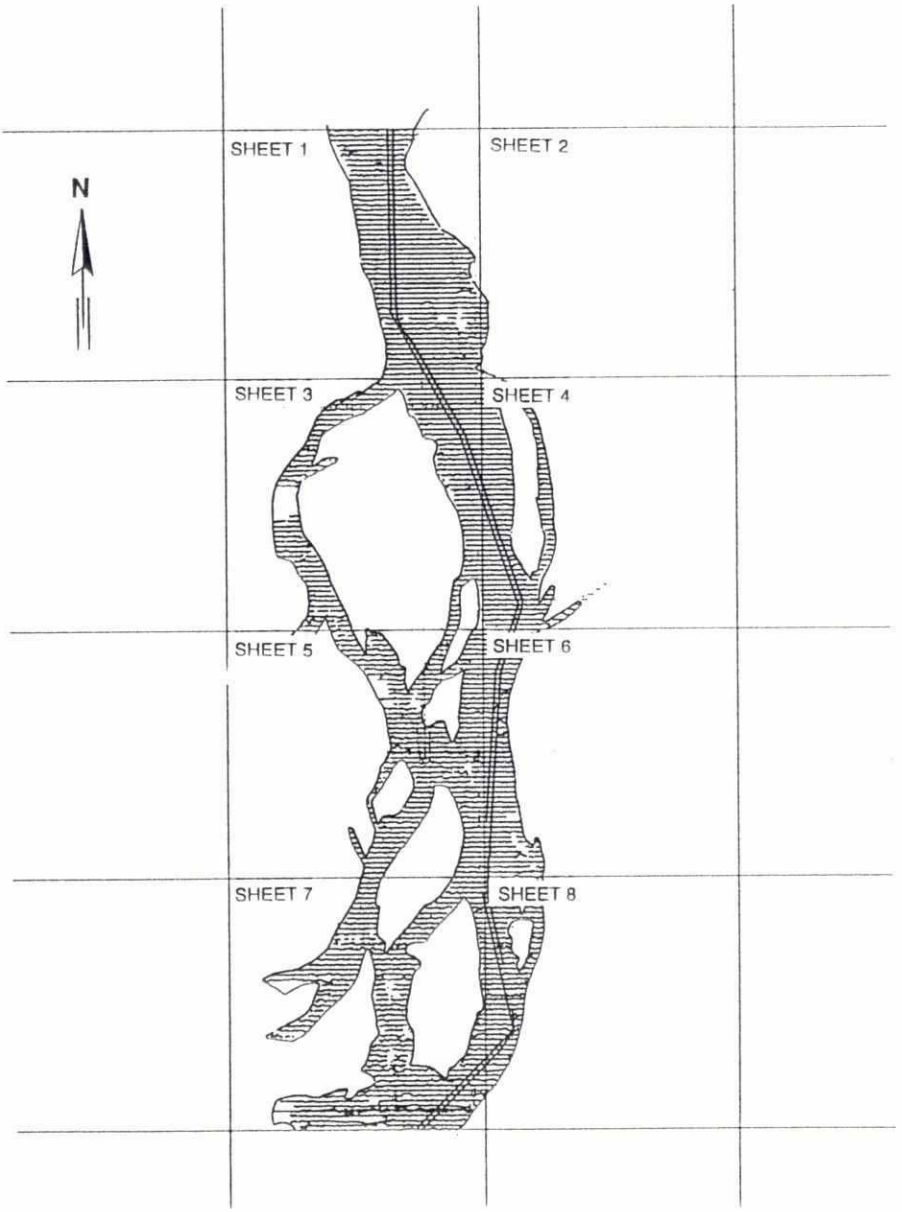

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	21 June 1994	Key plan, November 1993	Drawing 3
	MIF/PN		