Hydraulic Modelling at selected locations of the Ramganga River basin

INRM Consultants, New Delhi

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Contents

Abbreviations

cms/cumecs : Cubic meter per second
CS : Cross Section
CWC : Central Water Commission
DD : Degree Decimal
DGPS : Differential Geographic Positioning System
E-flow/ EF : Environmental flow
HEC RAS : Hydrologic Engineering Centers River Analysis System
m : Meter
m/s : meter per second
m^2 : square meter
UPID : Uttar Pradesh Irrigation Department

Introduction

Hydraulic studies provide the link between ecological knowledge and flows relationships (for each selected site) between discharge and water depth, flow velocity, wetted perimeter and water surface width. Fish ecologist can define species' habitat requirements in terms of depths, current velocities, or river widths, and hydraulic model can convert these parameters into specific flows in cumecs at the site. Vegetation specialist needs information on the width and levels to specify flooding requirements for riparian and floodplain vegetation. The accuracy of hydraulic analysis is crucial to the confidence in flow recommendations.

To carry out hydraulic studies for the Ramganga river basin HEC RAS Hydraulic model was used to derive Stage–discharge curves for each rated cross-section.

Scope and Objectives

Scope of study

The main scope of this segment is to perform hydraulic modeling at selected locations of Ramganga river basin and assess and analyze hydraulic characteristics at given cross section sites.

Objectives

The Main objectives of the study are:

- Hydraulic modelling at selected locations of Ramganga River basin
- Deriving a Stage-Discharge curve for all sites
- Deriving hydraulic outputs like channel velocity, width, wetted perimeter etc.

Overview: HEC RAS Model

The model is one-dimensional model. The model solves the momentum or energy equation for an incompressible homogeneous fluid. Dynamic models must also solve the continuity equation. Together these are known as the Saint Venant equations, which describe the motion of a fluid flow. Unsteady flow modeling provides for the timing and duration of the full flow hydrograph. Unsteady flow model has the ability to make systems changes

HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking, multi-user network environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities.

HEC-RAS is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. The system can handle two types of hydraulic analysis:

- Steady flow
- Unsteady flow simulation.

A key element is that all these components will use a common geometric data representation and common geometric and hydraulic computation routines. In addition to the above two hydraulic analysis options, the system also contains several hydraulic design features that can be invoked once the basic water surface profiles are computed.

The main objective of the HEC-RAS program is to compute water surface elevations at all locations of interest, by routing hydrographs through the system (unsteady flow simulation). The data needed to perform these computations are divided into geometric data and unsteady flow data. In fact geometric data are required for any of the analyses performed within HEC-RAS. However, in the case of minimum flows it may be adequate to run the model with the steady state assumption.

Data Requirements for running HECRAS

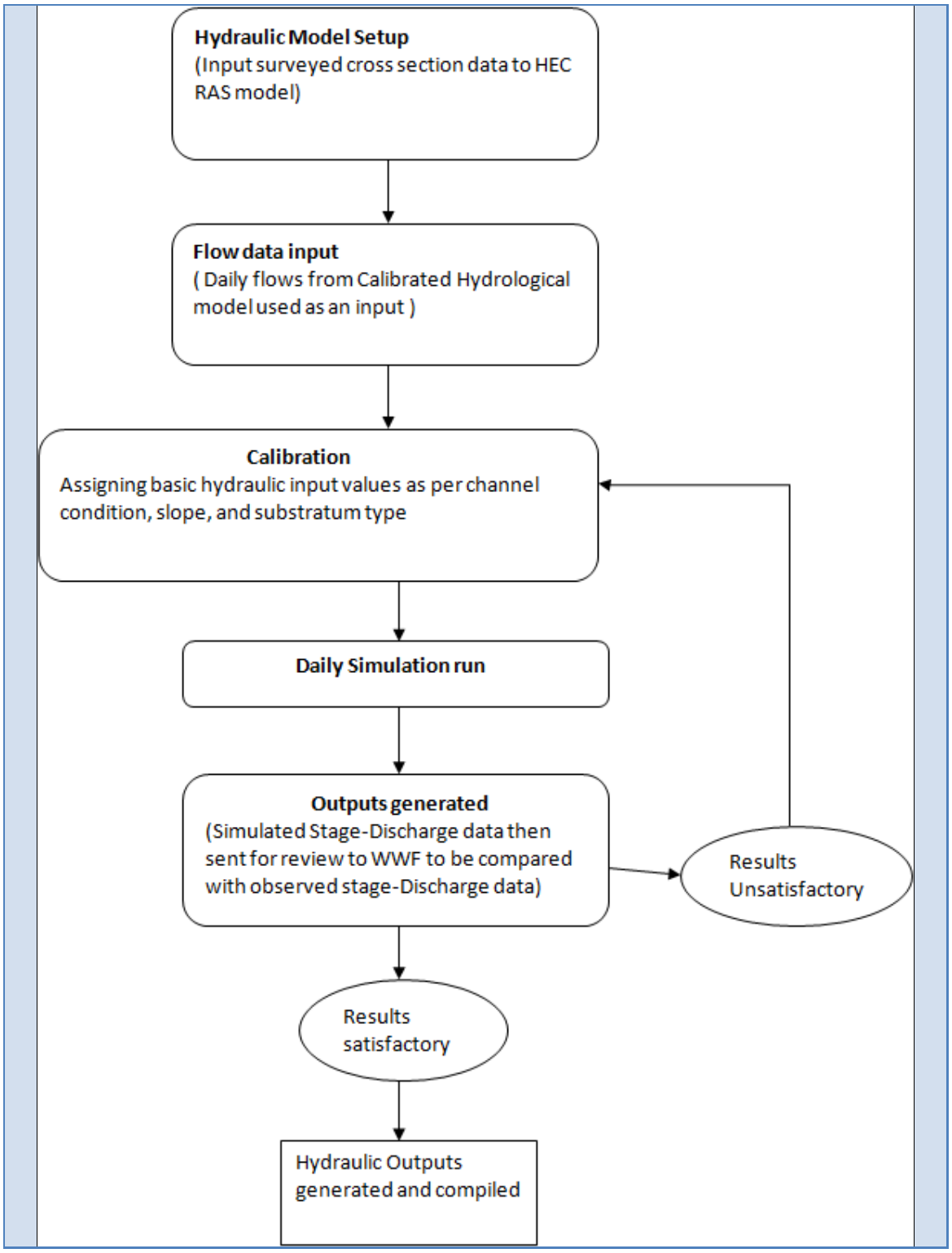
- *Geometric data* - consists of establishing the connectivity of the river system.
- *River system Schematic* - connectivity of reaches for positive flow direction.
- *Cross-section geometry* - Cross sections are located at intervals along a stream to characterize the flow carrying capability of the stream and its adjacent floodplain. They should extend across the entire floodplain and should be perpendicular to the anticipated flow lines.
- *Reach lengths* - measured distances between cross sections are referred to as reach lengths
- *Unsteady flow data* - required unsteady flow data to perform unsteady Flow Analysis are categorized as boundary condition and initial condition.

Boundary condition - During the unsteady flow analysis the computation is done assuming subcritical flow condition. The different boundary conditions required are Stage Hydrograph, Flow Hydrograph, Stage and Flow Hydrograph, Rating Curve, Normal Depth, Lateral Inflow Hydrograph etc.

Methodology

A brief methodology has been presented in .

Figure 1: Flow chart of Methodology



Hydraulic Model Setup

HEC RAS model uses basic input data like cross section profile, reach lengths, streamflow etc to drive the water profiles for various flow regimes. The basic model setup is described in subsequent paragraphs.

Input Data

Cross section data

The surveyed cross sections were used for hydraulic modeling. As per zonation study the Ramganga river stretch is divided into 6 zones and a total number of 24 sites have been identified. After joint field visits in Jan 2014 total of 8 EFA locations were selected. At each location three cross sections were taken, among which one was main cross section (crucial for flow assessment) while two others were secondary cross sections (crucial with respect to bio-diversity, species and channel morphology).

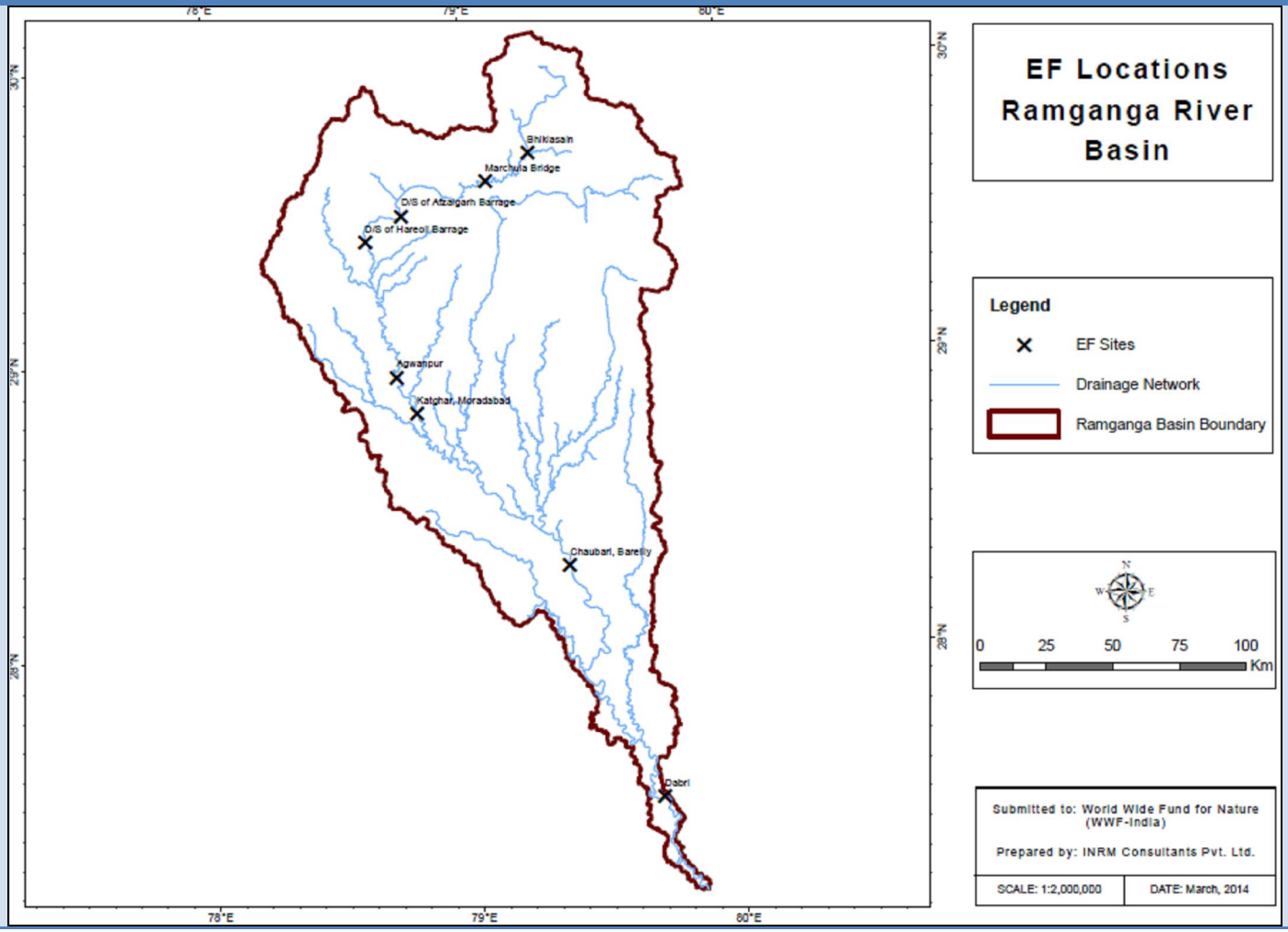
Water profile (Depth using DGPS) and velocity (using current meter) at selected points were measured and recorded at each cross section site at regular intervals. Apart from this longitudinal profile at four sites (Bhikiasain, Marchula Bridge, Chaubari and Dabri) were also carried out during boat surveys. This study focus on main cross section and outputs will be derived for the same. The details of eight EFA locations surveyed are presented in Table 1.

Table 1: Cross section sites details

EF Location	Location, DD	Cross section ID	Remarks
Bhikiasain	79.255284 29.731534	CS1	
	79.261018 29.697208	CS2	Primary Cross section
	79.257578 29.696367	CS3	
Marchula Bridge	79.097461 29.605200	CS1	
	79.092723 29.605807	CS2	Primary Cross section
	79.088623 29.591959	CS3	
D/s of Afzalgarh Barrage	78.760980 29.497251	CS1	Primary Cross section
	78.752785 29.487885	CS2	
	78.669533 29.483722	CS3	
D/s of Hareolli barrage	78.621162 29.412458	CS1	
	78.628074 29.404507	CS2	Primary Cross section
	78.631799 29.398168	CS3	
Aghwanpur	78.722661 28.951191	CS1	
	78.724339 28.949769	CS2	Primary Cross section
	78.728771 28.948014	CS3	
Katghar Rly. Bridge at Moradabad	78.799183 28.826915	CS1	
	78.799183 28.825934	CS2	Primary Cross section
	78.799575 28.823695	CS3	
Chaubari at Bareilly	79.370053 28.296459	CS1	Primary Cross section
	79.372735 28.287923	CS2	
	79.375038 28.283617	CS3	
Dabri	79.692938 27.497455	CS1	
	79.697124 27.497125	CS2	Primary Cross section
	79.701999 27.496375	CS3	

The layout of the EFA locations is presented in .

Figure 2: Layout showing locations of EFA sites



Streamflow Data

In the absence of observed discharge covering a wide range of flow at the identified sites, daily flows from calibrated SWAT hydrological model was compiled and was then used as an input to HEC RAS along with surveyed cross sections. Rating curve was then prepared using these simulated water levels and corresponding flows.

GIS Datasets

GIS data required for HEC RAS model setup was also obtained which includes:

- Cross section channel banks
- River/reach
- Cross section cut lines
- Downstream reach lengths for the left over bank, main channel and right over bank

The cross section data was first checked for data quality and corrected wherever any ambiguity is encountered. In second step GIS datasets were imported to HEC RAS and then surveyed cross section data was fed into the model to complete the basic model setup for all EFA sites.

Calibration of Model

For each EF location channel properties (like manning's coefficient, friction slope etc) were assigned based on appropriate slope, substrate type, vegetation, water quality etc. The model is then made to run with daily simulated flow values and outputs were compiled.

The observed Stage-Discharge data was not available with consultants but some data for validation was available with WWF, India. The model generated Stage-Discharge values were then sent to WWF, India for validating the simulated values, feedback was taken and channel properties were then readjusted to attain fair calibration. This process was carried out until fair calibration is achieved.

Once fair calibration is achieved and data is validated the outputs (Rating curve, velocity, wetted perimeter etc) were compiled for each cross-section site.

Detailed outputs and other relevant details for each cross section site are presented in subsequent paragraphs.

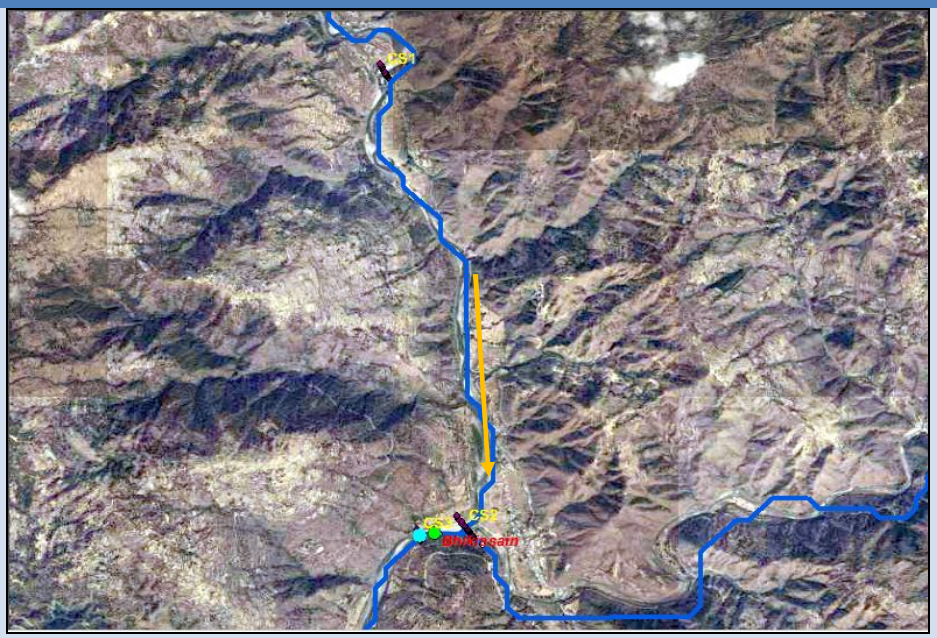
Model Outputs

Model Outputs at primary cross section site for each EF location are presented under their respective sections.

Bhikiasain

Three cross sections were surveyed at Bhikiasain but the outputs were compiled only for primary cross section (CS2) which is CWC river gauge site. The channel parameters were adjusted by carefully analyzing the substrate type, channel slope etc. Hydraulic properties were compiled and presented in Table 2. The simulated Rating curve, cross section locations and primary cross section profile has been presented in .

Figure 3: Cross Section profile and Rating curve for primary cross section site (CS2) at Bhikiasain EF location



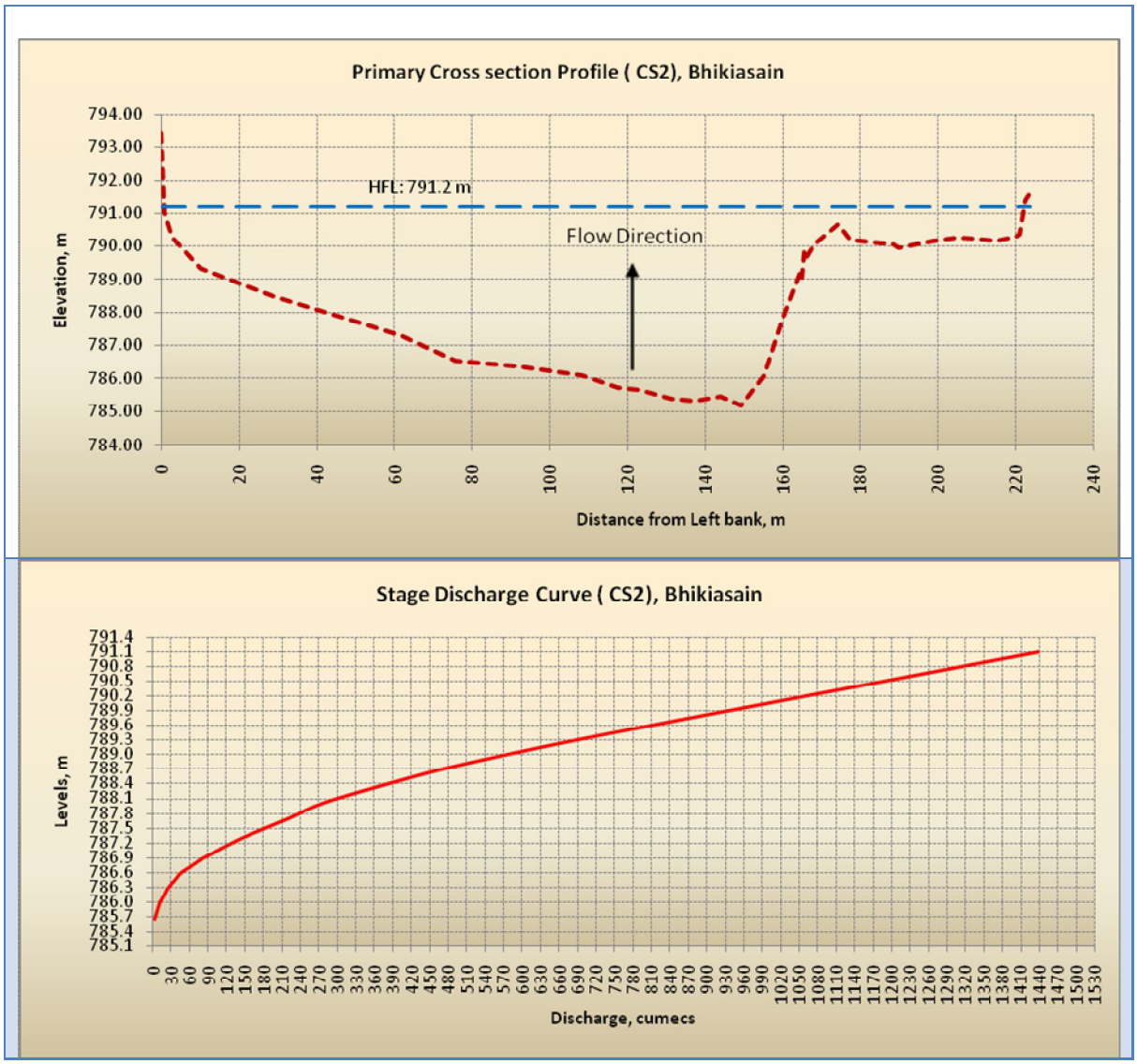

Primary Cross section Profile (CS2), Bhikiasain
Elevation, m
794.00
793.00
792.00
791.00
790.00
789.00
788.00
787.00
786.00
785.00
784.00
HFL: 791.2 m
Flow Direction
0
20
40
60
80
100
120
140
160
180
200
220
240
Distance from Left bank, m
Stage Discharge Curve (CS2), Bhikiasain
Levels, m
791.4
791.1
790.8
790.5
790.2
789.9
789.6
789.3
789.0
788.7
788.4
788.1
787.8
787.5
787.2
786.9
786.6
786.3
786.0
785.7
785.4
785.1
0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
510
540
570
600
630
660
690
720
750
780
810
840
870
900
930
960
990
1020
1050
1080
1110
1140
1170
1200
1230
1260
1290
1320
1350
1380
1410
1440
1470
1500
1530
Discharge, cumecs

Table 2: Hydraulic properties of Bhikiasain site (CS2)

S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
1	2.30	785.63	785.19	0.22	0.38	6.01	27.41	27.46	0.22
2	2.37	785.64	785.19	0.23	0.38	6.27	27.75	27.80	0.23
3	2.50	785.65	785.19	0.24	0.38	6.63	28.22	28.27	0.24
4	2.68	785.66	785.19	0.24	0.39	6.86	28.52	28.56	0.24
5	2.96	785.67	785.19	0.25	0.41	7.16	28.89	28.94	0.25
6	3.23	785.68	785.19	0.26	0.43	7.46	29.28	29.33	0.26
7	3.46	785.69	785.19	0.26	0.45	7.73	30.18	30.23	0.26
8	3.70	785.70	785.19	0.25	0.46	8.01	31.40	31.45	0.26
9	4.00	785.71	785.19	0.25	0.48	8.38	32.90	32.95	0.25
10	4.29	785.72	785.19	0.25	0.49	8.74	34.36	34.41	0.25
11	4.58	785.73	785.19	0.26	0.50	9.11	35.24	35.30	0.26
12	4.81	785.74	785.19	0.27	0.51	9.42	35.53	35.59	0.27
13	5.04	785.75	785.19	0.27	0.52	9.71	35.78	35.84	0.27
14	5.36	785.76	785.19	0.28	0.53	10.14	36.15	36.21	0.28
15	5.67	785.77	785.19	0.29	0.54	10.55	36.51	36.57	0.29
16	5.87	785.78	785.19	0.29	0.54	10.82	36.73	36.79	0.30
17	6.13	785.79	785.19	0.30	0.55	11.16	37.02	37.08	0.30
18	6.47	785.80	785.19	0.31	0.56	11.66	37.44	37.50	0.31
19	6.71	785.81	785.19	0.32	0.56	12.02	37.74	37.80	0.32
20	6.85	785.82	785.19	0.32	0.56	12.24	37.92	37.98	0.32
21	7.11	785.83	785.19	0.33	0.56	12.66	38.26	38.32	0.33
22	7.39	785.84	785.19	0.34	0.56	13.10	38.62	38.69	0.34
23	7.54	785.85	785.19	0.34	0.57	13.33	38.80	38.87	0.34
24	7.85	785.86	785.19	0.35	0.57	13.85	39.21	39.28	0.35
25	8.05	785.87	785.19	0.36	0.57	14.18	39.47	39.54	0.36
26	8.44	785.88	785.19	0.37	0.57	14.81	39.97	40.04	0.37
27	8.70	785.89	785.19	0.38	0.57	15.24	40.31	40.38	0.38
28	9.11	785.91	785.19	0.39	0.57	15.94	40.84	40.91	0.39
29	9.37	785.92	785.19	0.40	0.57	16.39	41.18	41.26	0.40
30	9.79	785.94	785.19	0.41	0.57	17.14	41.74	41.82	0.41
31	10.06	785.95	785.19	0.42	0.57	17.60	42.08	42.16	0.42
32	10.73	785.97	785.19	0.43	0.59	18.37	42.65	42.73	0.43
33	11.00	785.98	785.19	0.43	0.59	18.63	42.84	42.92	0.44
34	11.66	785.99	785.19	0.45	0.61	19.27	43.30	43.38	0.45
35	12.45	786.01	785.19	0.46	0.62	20.05	43.86	43.94	0.46
36	13.00	786.02	785.19	0.46	0.63	20.57	44.22	44.31	0.47
37	13.60	786.03	785.19	0.47	0.64	21.18	44.65	44.74	0.47
38	14.31	786.05	785.19	0.48	0.65	21.88	45.13	45.22	0.48
39	15.03	786.07	785.19	0.49	0.67	22.60	45.63	45.71	0.50
40	15.84	786.08	785.19	0.51	0.68	23.41	46.18	46.26	0.51
41	16.66	786.10	785.19	0.52	0.69	24.23	46.69	46.78	0.52
42	17.64	786.12	785.19	0.53	0.70	25.29	47.90	48.00	0.53
43	18.80	786.15	785.19	0.54	0.71	26.62	49.65	49.75	0.54
44	19.19	786.16	785.19	0.54	0.71	27.09	50.26	50.36	0.54
45	19.77	786.17	785.19	0.54	0.71	27.79	51.14	51.25	0.54
46	20.64	786.19	785.19	0.55	0.72	28.84	52.45	52.56	0.55
47	20.69	786.20	785.19	0.55	0.72	28.90	52.53	52.64	0.55
48	21.54	786.22	785.19	0.56	0.72	29.98	53.83	53.94	0.56
49	21.99	786.23	785.19	0.56	0.72	30.55	54.51	54.63	0.56
50	23.33	786.26	785.19	0.57	0.72	32.30	56.54	56.66	0.57
51	24.73	786.28	785.19	0.58	0.73	33.78	58.20	58.33	0.58

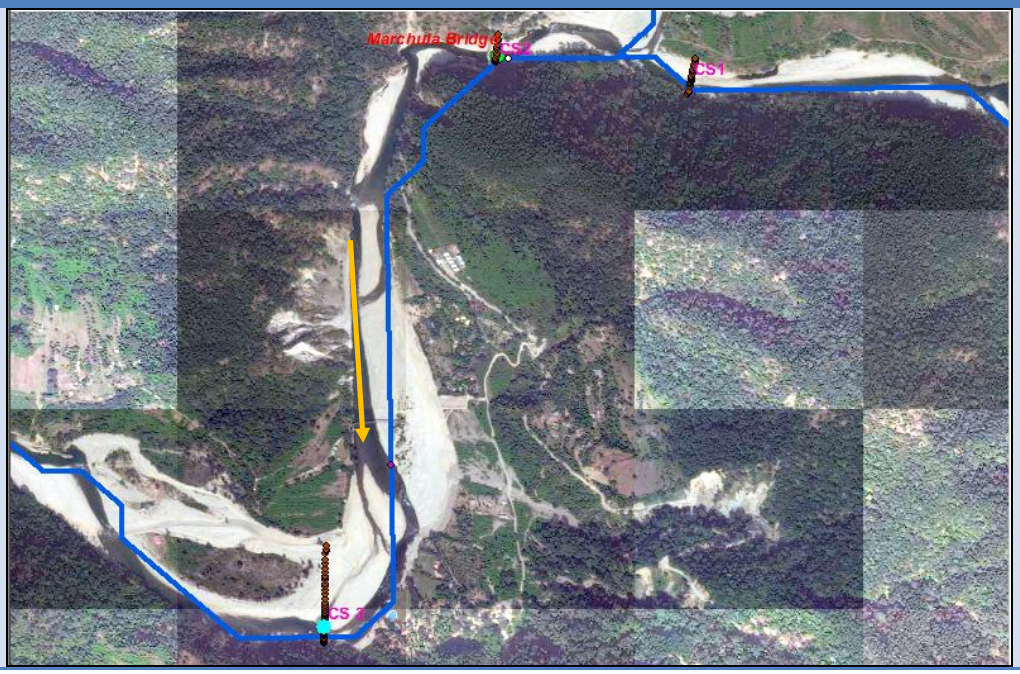
S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
52	26.38	786.31	785.19	0.59	0.75	35.20	59.75	59.88	0.59
53	27.47	786.32	785.19	0.59	0.76	36.18	60.79	60.93	0.60
54	28.83	786.34	785.19	0.60	0.77	37.39	62.07	62.20	0.60
55	29.37	786.35	785.19	0.60	0.78	37.89	62.58	62.72	0.61
56	29.67	786.36	785.19	0.61	0.78	38.16	62.85	62.99	0.61
57	31.15	786.38	785.19	0.61	0.79	39.51	64.37	64.51	0.61
58	32.26	786.39	785.19	0.61	0.80	40.56	65.89	66.03	0.62
59	32.98	786.40	785.19	0.62	0.80	41.23	66.84	66.98	0.62
60	34.99	786.43	785.19	0.62	0.81	43.27	69.66	69.81	0.62
61	36.06	786.45	785.19	0.62	0.81	44.43	71.21	71.37	0.62
62	37.06	786.46	785.19	0.63	0.81	45.50	72.62	72.77	0.63
63	38.41	786.48	785.19	0.63	0.82	47.03	74.58	74.74	0.63
64	38.99	786.49	785.19	0.63	0.82	47.69	75.41	75.57	0.63
65	40.56	786.52	785.19	0.64	0.82	49.49	77.62	77.79	0.64
66	41.79	786.54	785.19	0.64	0.82	50.97	79.41	79.57	0.64
67	44.21	786.57	785.19	0.66	0.82	53.70	81.15	81.32	0.66
68	45.21	786.58	785.19	0.67	0.83	54.49	81.35	81.53	0.67
69	46.81	786.59	785.19	0.68	0.84	55.73	81.68	81.86	0.68
70	46.96	786.60	785.19	0.68	0.84	55.83	81.70	81.88	0.68
71	48.78	786.61	785.19	0.70	0.86	57.02	82.01	82.20	0.70
72	49.65	786.62	785.19	0.70	0.86	57.58	82.15	82.34	0.70
73	51.17	786.63	785.19	0.71	0.87	58.57	82.41	82.60	0.71
74	52.45	786.64	785.19	0.72	0.88	59.41	82.63	82.82	0.72
75	53.92	786.65	785.19	0.73	0.90	60.37	82.87	83.06	0.73
76	54.80	786.66	785.19	0.73	0.90	60.96	83.02	83.21	0.73
77	56.44	786.67	785.19	0.74	0.91	62.05	83.30	83.50	0.75
78	57.89	786.68	785.19	0.75	0.92	63.06	83.56	83.75	0.75
79	59.11	786.69	785.19	0.76	0.92	63.92	83.78	83.98	0.76
80	59.75	786.70	785.19	0.77	0.93	64.37	83.89	84.09	0.77
81	61.01	786.71	785.19	0.77	0.93	65.26	84.11	84.32	0.78
82	62.32	786.72	785.19	0.78	0.94	66.19	84.35	84.55	0.79
83	63.28	786.73	785.19	0.79	0.95	66.87	84.52	84.72	0.79
84	67.07	786.76	785.19	0.82	0.97	69.60	85.20	85.41	0.82
85	68.20	786.77	785.19	0.82	0.97	70.40	85.40	85.62	0.83
86	69.46	786.78	785.19	0.83	0.97	71.30	85.62	85.84	0.83
87	70.50	786.79	785.19	0.84	0.98	72.07	85.81	86.03	0.84
88	71.58	786.80	785.19	0.85	0.98	72.88	86.01	86.23	0.85
89	72.33	786.81	785.19	0.85	0.99	73.41	86.14	86.36	0.85
90	74.16	786.82	785.19	0.86	0.99	74.74	86.47	86.69	0.87
91	75.33	786.83	785.19	0.87	1.00	75.59	86.68	86.90	0.87
92	76.30	786.84	785.19	0.88	1.00	76.32	86.86	87.08	0.88
93	81.03	786.88	785.19	0.90	1.02	79.49	87.63	87.86	0.91
94	82.75	786.89	785.19	0.91	1.03	80.41	87.85	88.09	0.92
95	85.95	786.91	785.19	0.93	1.05	82.24	88.29	88.53	0.93
96	87.58	786.92	785.19	0.94	1.05	83.23	88.53	88.77	0.94
97	94.13	786.96	785.19	0.97	1.08	87.15	89.46	89.71	0.97
98	95.63	786.97	785.19	0.98	1.09	88.05	89.67	89.93	0.98
99	97.29	786.98	785.19	0.99	1.09	89.06	89.92	90.17	0.99
100	100.65	787.01	785.19	1.01	1.10	91.13	90.40	90.66	1.01
101	101.93	787.02	785.19	1.01	1.11	91.91	90.58	90.84	1.01
102	108.61	787.06	785.19	1.05	1.13	96.04	91.54	91.82	1.05
103	109.25	787.07	785.19	1.05	1.13	96.49	91.65	91.92	1.05
104	111.29	787.08	785.19	1.06	1.14	97.74	91.94	92.21	1.07
105	119.01	787.13	785.19	1.10	1.16	102.48	93.02	93.31	1.10
106	128.32	787.19	785.19	1.14	1.19	107.90	94.25	94.55	1.14

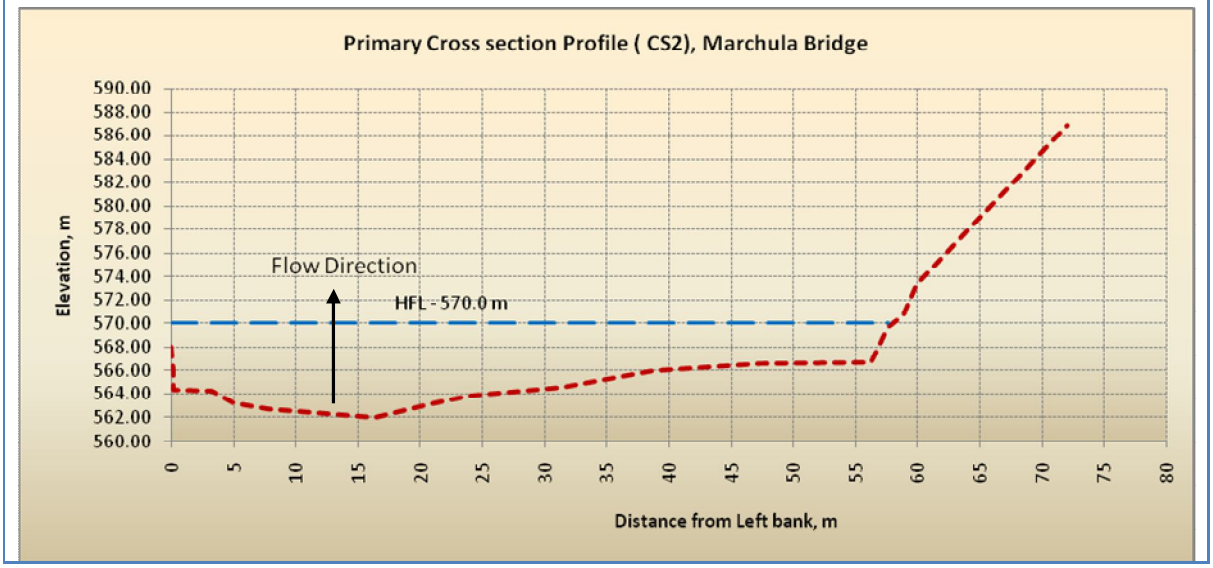
S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
107	130.95	787.20	785.19	1.15	1.20	109.40	94.59	94.89	1.16
108	131.42	787.21	785.19	1.15	1.20	109.61	94.63	94.93	1.16
109	143.16	787.28	785.19	1.21	1.23	116.21	96.10	96.41	1.21
110	152.21	787.33	785.19	1.24	1.25	121.37	97.46	97.78	1.25
111	156.43	787.35	785.19	1.26	1.26	123.78	98.21	98.54	1.26
112	157.07	787.36	785.19	1.26	1.26	124.17	98.34	98.67	1.26
113	168.14	787.42	785.19	1.30	1.29	130.37	100.26	100.60	1.30
114	179.69	787.48	785.19	1.33	1.32	136.42	102.09	102.45	1.34
115	222.34	787.70	785.19	1.46	1.39	159.66	108.87	109.26	1.47
116	282.98	788.03	785.19	1.65	1.43	197.31	119.10	119.55	1.66
117	429.41	788.56	785.19	1.95	1.62	265.19	135.33	135.87	1.96
118	499.37	788.78	785.19	2.08	1.69	294.79	140.88	141.46	2.09
119	641.89	789.18	785.19	2.33	1.81	354.17	151.56	152.33	2.34
120	824.42	789.64	785.19	2.67	1.94	424.69	158.03	159.08	2.69
121	1438.48	791.10	785.19	3.20	2.02	713.03	221.21	223.01	3.22

Marchula Bridge

Three cross sections were surveyed at Marchula Bridge but the outputs were compiled only for primary cross section (CS2) which is UPID river gauge site. The channel parameters were adjusted by carefully analyzing the substrate type, channel slope etc. Hydraulic properties were compiled and presented in Table 3. The simulated Rating curve, cross section locations and primary cross section profile has been presented in .

Figure 4: Cross Section profile and Rating curve for primary cross section site (CS2) at Marchula Bridge EF location





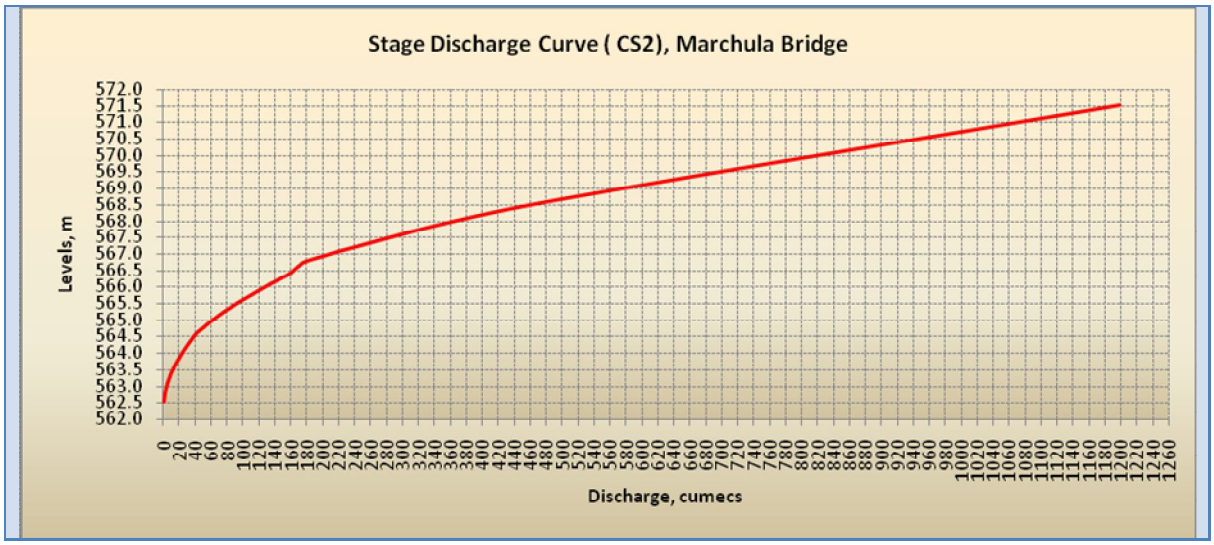

Stage Discharge Curve (CS2), Marchula Bridge
Levels, m
572.0
571.5
571.0
570.5
570.0
569.5
569.0
568.5
568.0
567.5
567.0
566.5
566.0
565.5
565.0
564.5
564.0
563.5
563.0
562.5
562.0
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740 760 780 800 820 840 860 880 900 920 940 960 980 1000 1020 1040 1060 1080 1100 1120 1140 1160 1180 1200 1220 1240 1260
Discharge, cumecs

Table 3: Hydraulic properties of Marchula Bridge site (CS2)

S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
1	0.83	562.52	562.01	0.26	0.40	2.09	8.14	8.22	0.26
2	0.94	562.54	562.01	0.27	0.42	2.26	8.47	8.56	0.27
3	1.03	562.56	562.01	0.27	0.43	2.41	8.75	8.84	0.28
4	1.25	562.60	562.01	0.29	0.45	2.79	9.40	9.50	0.30
5	1.33	562.62	562.01	0.30	0.45	2.95	9.67	9.78	0.30
6	1.45	562.64	562.01	0.31	0.46	3.18	10.04	10.15	0.32
7	1.55	562.66	562.01	0.32	0.46	3.37	10.35	10.46	0.33
8	1.66	562.68	562.01	0.33	0.46	3.59	10.66	10.78	0.34
9	1.76	562.70	562.01	0.34	0.46	3.81	11.00	11.12	0.35
10	1.84	562.72	562.01	0.35	0.46	3.98	11.23	11.36	0.35
11	2.03	562.75	562.01	0.37	0.46	4.37	11.55	11.68	0.38
12	2.15	562.77	562.01	0.39	0.47	4.63	11.75	11.88	0.39
13	2.35	562.79	562.01	0.40	0.48	4.86	11.92	12.06	0.41
14	2.50	562.81	562.01	0.41	0.50	5.04	12.05	12.19	0.42
15	2.71	562.83	562.01	0.43	0.51	5.30	12.24	12.39	0.43
16	2.93	562.85	562.01	0.44	0.53	5.56	12.43	12.58	0.45
17	3.12	562.87	562.01	0.45	0.54	5.80	12.60	12.75	0.46
18	3.34	562.89	562.01	0.47	0.55	6.07	12.80	12.96	0.47
19	3.60	562.92	562.01	0.49	0.56	6.42	13.03	13.20	0.49
20	3.83	562.94	562.01	0.50	0.57	6.72	13.24	13.41	0.51
21	4.02	562.96	562.01	0.51	0.58	6.97	13.41	13.58	0.52
22	4.24	562.98	562.01	0.53	0.58	7.26	13.60	13.78	0.53
23	4.53	563.01	562.01	0.54	0.59	7.65	13.85	14.03	0.55
24	4.86	563.04	562.01	0.57	0.60	8.10	14.13	14.33	0.57
25	5.04	563.06	562.01	0.58	0.60	8.36	14.30	14.49	0.59
26	5.30	563.08	562.01	0.59	0.61	8.68	14.49	14.70	0.60
27	5.61	563.10	562.01	0.61	0.63	8.98	14.68	14.89	0.61
28	5.87	563.12	562.01	0.61	0.63	9.24	14.84	15.05	0.62
29	6.19	563.14	562.01	0.63	0.65	9.57	15.03	15.25	0.64
30	6.52	563.16	562.01	0.64	0.66	9.90	15.23	15.45	0.65
31	6.76	563.18	562.01	0.65	0.67	10.15	15.37	15.60	0.66
32	7.34	563.22	562.01	0.67	0.68	10.75	15.72	15.95	0.68
33	7.65	563.24	562.01	0.69	0.69	11.08	15.90	16.14	0.70
34	7.95	563.26	562.01	0.70	0.70	11.39	16.07	16.31	0.71
35	8.29	563.28	562.01	0.71	0.70	11.76	16.25	16.50	0.72
36	8.55	563.30	562.01	0.73	0.71	12.04	16.36	16.62	0.74
37	9.01	563.33	562.01	0.75	0.72	12.55	16.55	16.82	0.76
38	9.77	563.38	562.01	0.78	0.73	13.39	16.87	17.15	0.79
39	10.23	563.40	562.01	0.80	0.74	13.79	17.01	17.31	0.81
40	10.78	563.43	562.01	0.81	0.76	14.25	17.18	17.49	0.83
41	11.43	563.46	562.01	0.84	0.77	14.79	17.38	17.70	0.85
42	12.94	563.54	562.01	0.88	0.80	16.09	17.84	18.18	0.90
43	14.09	563.59	562.01	0.92	0.82	17.09	18.18	18.55	0.94
44	14.81	563.63	562.01	0.94	0.84	17.73	18.40	18.78	0.96
45	15.90	563.68	562.01	0.98	0.85	18.71	18.73	19.13	1.00
46	16.77	563.72	562.01	1.00	0.86	19.41	18.96	19.38	1.02
47	18.40	563.78	562.01	1.04	0.89	20.69	19.38	19.82	1.07
48	19.35	563.82	562.01	1.07	0.90	21.44	19.62	20.07	1.09
49	19.89	563.84	562.01	1.08	0.91	21.89	19.76	20.23	1.11
50	20.56	563.87	562.01	1.10	0.92	22.45	19.94	20.41	1.13
51	21.37	563.90	562.01	1.11	0.92	23.10	20.27	20.75	1.14

S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
52	22.24	563.94	562.01	1.12	0.93	23.84	20.73	21.22	1.15
53	23.26	563.98	562.01	1.13	0.94	24.72	21.27	21.78	1.16
54	24.86	564.04	562.01	1.15	0.96	25.98	22.02	22.55	1.18
55	26.10	564.09	562.01	1.17	0.97	26.98	22.59	23.14	1.19
56	29.30	564.20	562.01	1.20	0.99	29.68	24.08	24.66	1.23
57	31.34	564.27	562.01	1.23	1.00	31.47	25.02	25.62	1.26
58	34.13	564.36	562.01	1.15	1.01	33.79	28.89	29.50	1.17
59	37.03	564.45	562.01	1.18	1.02	36.46	30.12	30.83	1.21
60	38.28	564.49	562.01	1.20	1.02	37.62	30.55	31.29	1.23
61	39.22	564.52	562.01	1.22	1.02	38.51	30.87	31.65	1.25
62	40.80	564.57	562.01	1.25	1.02	40.01	31.26	32.09	1.28
63	42.45	564.61	562.01	1.28	1.03	41.36	31.48	32.36	1.31
64	44.22	564.64	562.01	1.30	1.04	42.46	31.66	32.57	1.34
65	45.83	564.68	562.01	1.33	1.05	43.48	31.83	32.77	1.37
66	47.59	564.71	562.01	1.35	1.07	44.58	32.01	32.98	1.39
67	48.70	564.74	562.01	1.37	1.07	45.43	32.13	33.14	1.41
68	50.08	564.76	562.01	1.39	1.09	46.17	32.26	33.29	1.43
69	51.89	564.80	562.01	1.41	1.10	47.31	32.43	33.50	1.46
70	52.87	564.82	562.01	1.43	1.10	48.00	32.54	33.64	1.47
71	54.79	564.86	562.01	1.45	1.11	49.29	32.74	33.88	1.51
72	58.11	564.92	562.01	1.50	1.13	51.41	33.07	34.28	1.56
73	59.21	564.94	562.01	1.52	1.14	52.16	33.18	34.42	1.57
74	62.16	565.00	562.01	1.55	1.15	53.94	33.46	34.75	1.61
75	63.90	565.03	562.01	1.58	1.16	55.00	33.62	34.94	1.64
76	65.55	565.06	562.01	1.60	1.17	55.99	33.77	35.12	1.66
77	67.37	565.09	562.01	1.62	1.18	57.08	33.93	35.33	1.68
78	69.52	565.13	562.01	1.64	1.19	58.40	34.13	35.56	1.71
79	70.65	565.15	562.01	1.66	1.19	59.15	34.24	35.70	1.73
80	73.75	565.20	562.01	1.69	1.21	60.93	34.50	36.02	1.77
81	75.15	565.23	562.01	1.71	1.22	61.79	34.63	36.17	1.78
82	77.97	565.27	562.01	1.74	1.23	63.33	34.85	36.44	1.82
83	79.76	565.30	562.01	1.76	1.24	64.32	35.00	36.62	1.84
84	81.74	565.33	562.01	1.78	1.25	65.41	35.16	36.81	1.86
85	85.06	565.38	562.01	1.81	1.26	67.29	35.43	37.14	1.90
86	85.78	565.40	562.01	1.82	1.27	67.74	35.49	37.22	1.91
87	88.54	565.44	562.01	1.85	1.28	69.22	35.70	37.47	1.94
88	95.60	565.55	562.01	1.92	1.31	73.11	36.25	38.14	2.02
89	109.56	565.74	562.01	2.04	1.36	80.38	37.26	39.36	2.16
90	116.31	565.84	562.01	2.10	1.39	83.88	37.74	39.94	2.22
91	119.28	565.88	562.01	2.13	1.40	85.43	37.95	40.19	2.25
92	123.14	565.93	562.01	2.16	1.41	87.45	38.21	40.52	2.29
93	130.35	566.03	562.01	2.20	1.43	91.26	39.01	41.42	2.34
94	131.55	566.05	562.01	2.21	1.43	91.84	39.23	41.64	2.34
95	141.42	566.17	562.01	2.23	1.46	96.93	41.02	43.55	2.36
96	145.32	566.23	562.01	2.24	1.47	99.14	41.78	44.35	2.37
97	154.29	566.34	562.01	2.26	1.48	104.07	43.42	46.10	2.40
98	157.79	566.39	562.01	2.27	1.49	106.12	44.08	46.80	2.41
99	160.90	566.43	562.01	2.28	1.49	107.79	44.61	47.37	2.42
100	164.88	566.53	562.01	2.30	1.47	112.43	46.06	48.91	2.44
101	170.45	566.64	562.01	2.22	1.45	117.75	50.13	53.08	2.35
102	176.70	566.75	562.01	2.09	1.43	123.57	56.20	59.26	2.20
103	199.90	566.92	562.01	2.23	1.50	133.02	56.30	59.62	2.36
104	210.93	567.00	562.01	2.30	1.53	137.50	56.35	59.78	2.44
105	221.46	567.08	562.01	2.37	1.56	142.33	56.40	59.96	2.52
106	478.50	568.58	562.01	3.60	2.10	227.35	57.14	63.11	3.98

S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
107	1198.44	571.52	562.01	5.71	3.01	398.55	59.25	69.79	6.73

Afzalgarh Barrage

Three cross sections were surveyed at Afzalgarh Barrage but the outputs were compiled only for primary cross section (CS1) which is CWC river gauge site. Main active channel is on the right bank. The calibration at Afzalgarh Barrage could not be carried out due to non availability of observed Stage-Discharge data. But the channel parameters were adjusted by carefully analyzing the substrate type, channel slope etc. Hydraulic properties were compiled and presented in Table 4. The simulated Rating curve, cross section locations and primary cross section profile has been presented in

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Figure 5: Cross Section profile and Rating curve for primary cross section site (CS1) at Afzalgarh Barrage EF location

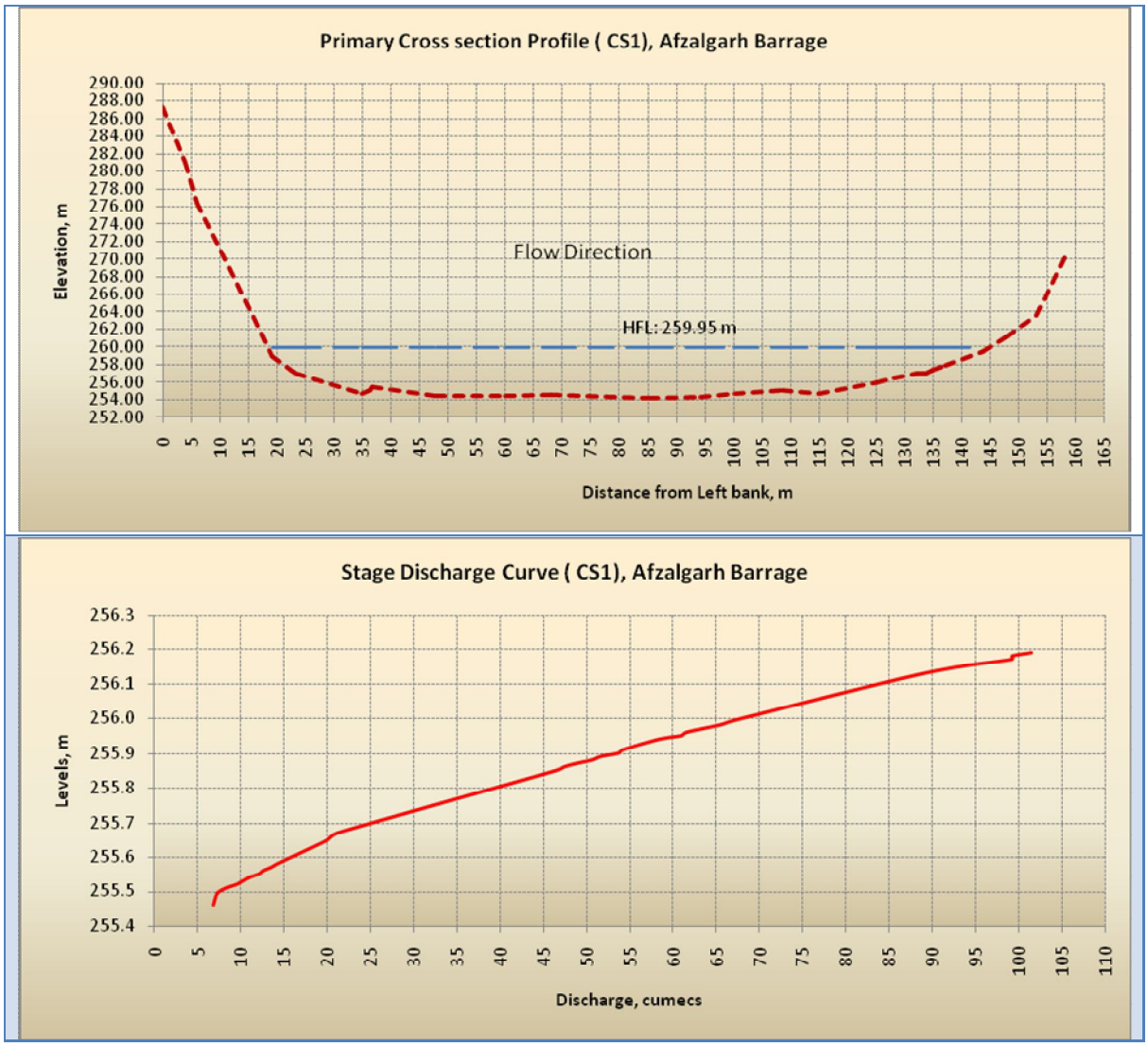

Primary Cross section Profile (CS1), Afzalgarh Barrage
Elevation, m
290.00
288.00
286.00
284.00
282.00
280.00
278.00
276.00
274.00
272.00
270.00
268.00
266.00
264.00
262.00
260.00
258.00
256.00
254.00
252.00
Flow Direction
HFL: 259.95 m
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165
Distance from Left bank, m
Stage Discharge Curve (CS1), Afzalgarh Barrage
Levels, m
256.3
256.2
256.1
256.0
255.9
255.8
255.7
255.6
255.5
255.4
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110
Discharge, cumecs

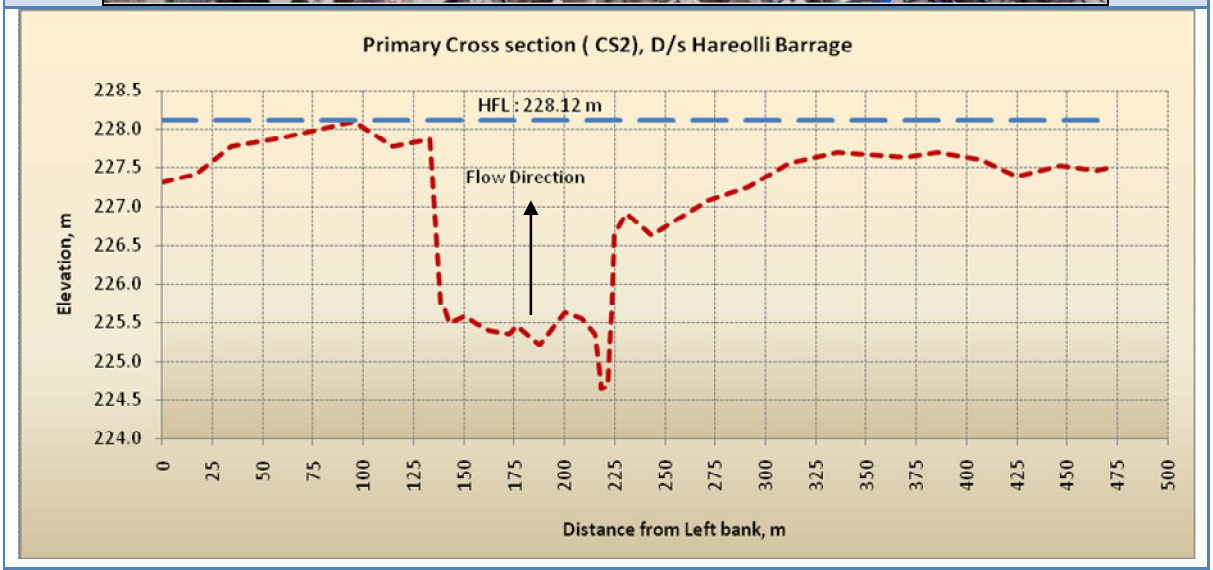
Table 4: Hydraulic properties of Afzalgarh Barrage site (CS1)

S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
1	6.80	255.46	254.11	0.85	0.09	77.36	90.16	90.61	0.86
2	7.18	255.49	254.11	0.88	0.09	80.04	90.88	91.35	0.88
3	7.60	255.50	254.11	0.88	0.09	80.48	91.00	91.47	0.88
4	8.41	255.51	254.11	0.89	0.10	81.33	91.23	91.70	0.89
5	9.57	255.52	254.11	0.90	0.12	82.49	91.42	91.90	0.90
6	10.28	255.53	254.11	0.91	0.12	83.40	91.55	92.03	0.91
7	11.01	255.54	254.11	0.91	0.13	84.18	91.67	92.15	0.92
8	12.12	255.55	254.11	0.93	0.15	85.25	91.82	92.31	0.93
9	12.62	255.56	254.11	0.93	0.15	86.00	91.93	92.42	0.94
10	13.57	255.57	254.11	0.94	0.16	86.73	92.04	92.53	0.94
11	14.24	255.58	254.11	0.95	0.16	87.96	92.22	92.71	0.96
12	18.45	255.63	254.11	0.99	0.20	92.79	92.91	93.41	1.00
13	20.03	255.65	254.11	1.01	0.21	94.78	93.20	93.70	1.02
14	21.14	255.67	254.11	1.02	0.22	96.25	93.41	93.91	1.03
15	46.48	255.85	254.11	1.18	0.41	113.70	95.87	96.40	1.19
16	47.35	255.86	254.11	1.18	0.41	114.25	95.95	96.48	1.19
17	48.79	255.87	254.11	1.19	0.42	115.19	96.08	96.61	1.20
18	50.60	255.88	254.11	1.20	0.43	116.34	96.24	96.77	1.21
19	51.62	255.89	254.11	1.21	0.44	117.03	96.33	96.87	1.21
20	53.69	255.90	254.11	1.22	0.46	118.35	96.52	97.06	1.23
21	54.24	255.91	254.11	1.22	0.46	118.75	96.57	97.11	1.23
22	58.39	255.94	254.11	1.25	0.48	121.52	96.87	97.41	1.25
23	60.92	255.95	254.11	1.26	0.49	123.18	97.04	97.59	1.27
24	61.52	255.96	254.11	1.27	0.50	123.58	97.08	97.63	1.27
25	65.26	255.98	254.11	1.29	0.52	126.03	97.33	97.88	1.29
26	66.51	255.99	254.11	1.29	0.52	126.84	97.41	97.97	1.30
27	67.99	256.00	254.11	1.30	0.53	127.86	97.51	98.07	1.31
28	89.15	256.13	254.11	1.41	0.64	140.25	98.77	99.35	1.42
29	99.16	256.17	254.11	1.45	0.68	145.01	99.25	99.84	1.46
30	99.18	256.18	254.11	1.45	0.68	145.04	99.25	99.84	1.46
31	101.43	256.19	254.11	1.46	0.69	146.09	99.35	99.95	1.47

Hareolli Barrage d/s

Three cross sections were surveyed at d/s of Hareolli barrage but the outputs were compiled only for primary cross section (CS2) which is stable in terms of cross section as there is no observed gauge site d/s of hareolli barrage. The calibration at Hareolli Barrage could not be carried out due to non availability of observed Stage-Discharge data. But the channel parameters were adjusted by carefully analyzing the substrate type, channel slope etc. Hydraulic properties were compiled and presented in Table 5. The simulated Rating curve, cross section locations and primary cross section profile has been presented in .

Figure 6: Cross Section profile and Rating curve for primary cross section site (CS2) at Hareolli Barrage EF location



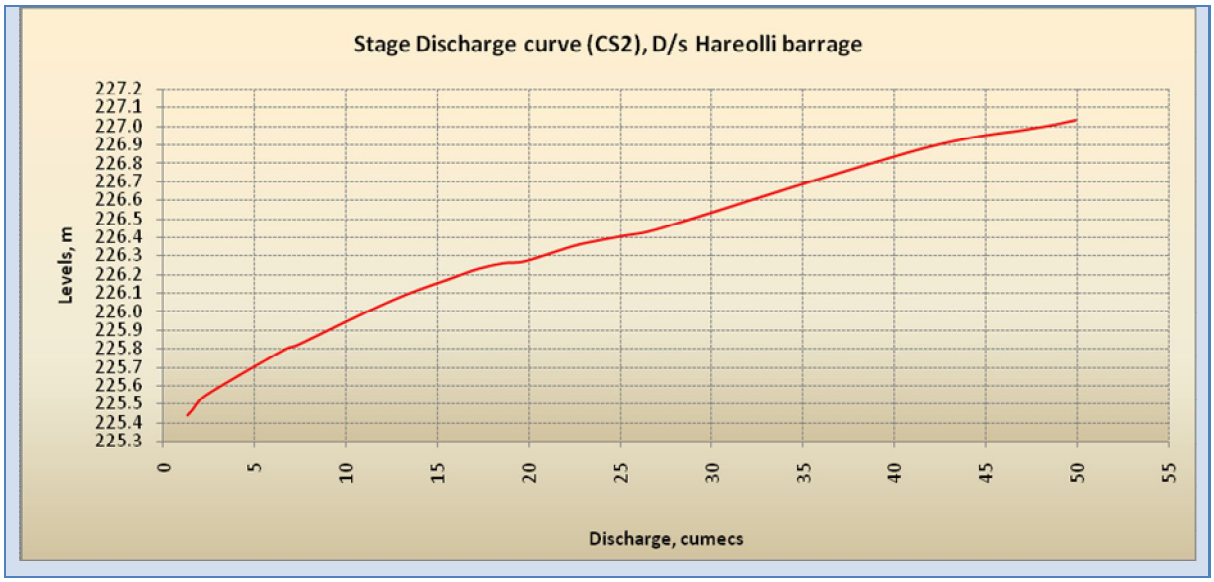

Stage Discharge curve (CS2), D/s Hareolli barrage
Levels, m
227.2
227.1
227.0
226.9
226.8
226.7
226.6
226.5
226.4
226.3
226.2
226.1
226.0
225.9
225.8
225.7
225.6
225.5
225.4
225.3
0
5
10
15
20
25
30
35
40
45
50
55
Discharge, cumecs

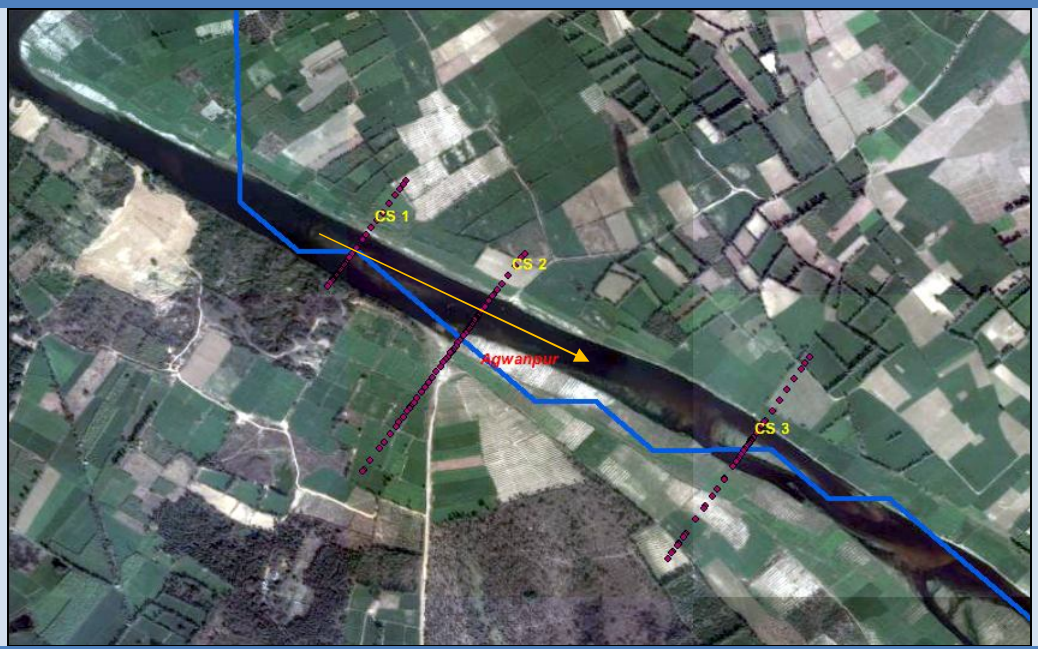
Table 5: Hydraulic properties of Hareolli Barrage site (CS2)

S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
1	1.32	225.44	224.64	0.17	0.18	7.16	43.12	43.40	0.17
2	1.60	225.47	224.64	0.17	0.19	8.64	49.15	49.43	0.18
3	2.34	225.55	224.64	0.20	0.19	12.82	63.82	64.13	0.20
4	6.70	225.80	224.64	0.39	0.20	33.46	85.01	85.42	0.39
5	7.32	225.82	224.64	0.41	0.21	34.89	85.08	85.50	0.41
6	12.53	226.06	224.64	0.64	0.23	55.45	86.15	86.67	0.64
7	15.80	226.18	224.64	0.76	0.24	66.01	86.69	87.27	0.76
8	17.24	226.23	224.64	0.80	0.25	69.95	86.89	87.49	0.81
9	18.64	226.26	224.64	0.83	0.26	72.89	87.04	87.65	0.84
10	19.78	226.27	224.64	0.84	0.27	73.35	87.06	87.68	0.84
11	22.37	226.35	224.64	0.91	0.28	80.42	87.42	88.07	0.92
12	23.72	226.38	224.64	0.94	0.29	82.93	87.55	88.21	0.95
13	25.35	226.41	224.64	0.97	0.30	85.72	87.69	88.37	0.98
14	26.94	226.44	224.64	1.00	0.31	88.61	87.84	88.53	1.01
15	41.65	226.88	224.64	1.07	0.32	131.83	122.26	123.10	1.08
16	47.21	226.98	224.64	1.10	0.33	144.59	130.15	131.00	1.11
17	48.45	227.00	224.64	1.11	0.33	147.50	131.59	132.46	1.12
18	49.94	227.03	224.64	1.12	0.33	150.84	133.23	134.10	1.13

Aghwanpur

Three cross sections were surveyed at d/s of Aghwanpur but the outputs were compiled only for primary cross section (CS2 which is stable in terms of banks) as there is no observed gauge site d/s of hareolli barrage. The calibration at Aghwanpur could not be carried out due to non availability of observed Stage-Discharge data. But the channel parameters were adjusted by carefully analyzing the substrate type, channel slope etc. Streamflow at Aghwanpur is almost perennial due to contribution from irrigation return flow from upstream catchment. It was observed that that main active channel depth at Aghwanpur is low (vast flood plain beyond left bank which was not surveyed) therefore outputs were only presented for bank to bank level. Hydraulic properties were compiled and presented in Table 6. The simulated Rating curve, cross section locations and primary cross section profile has been presented in .

Figure 7: Cross Section profile and Rating curve for primary cross section site (CS2) at Aghwanpur EF location



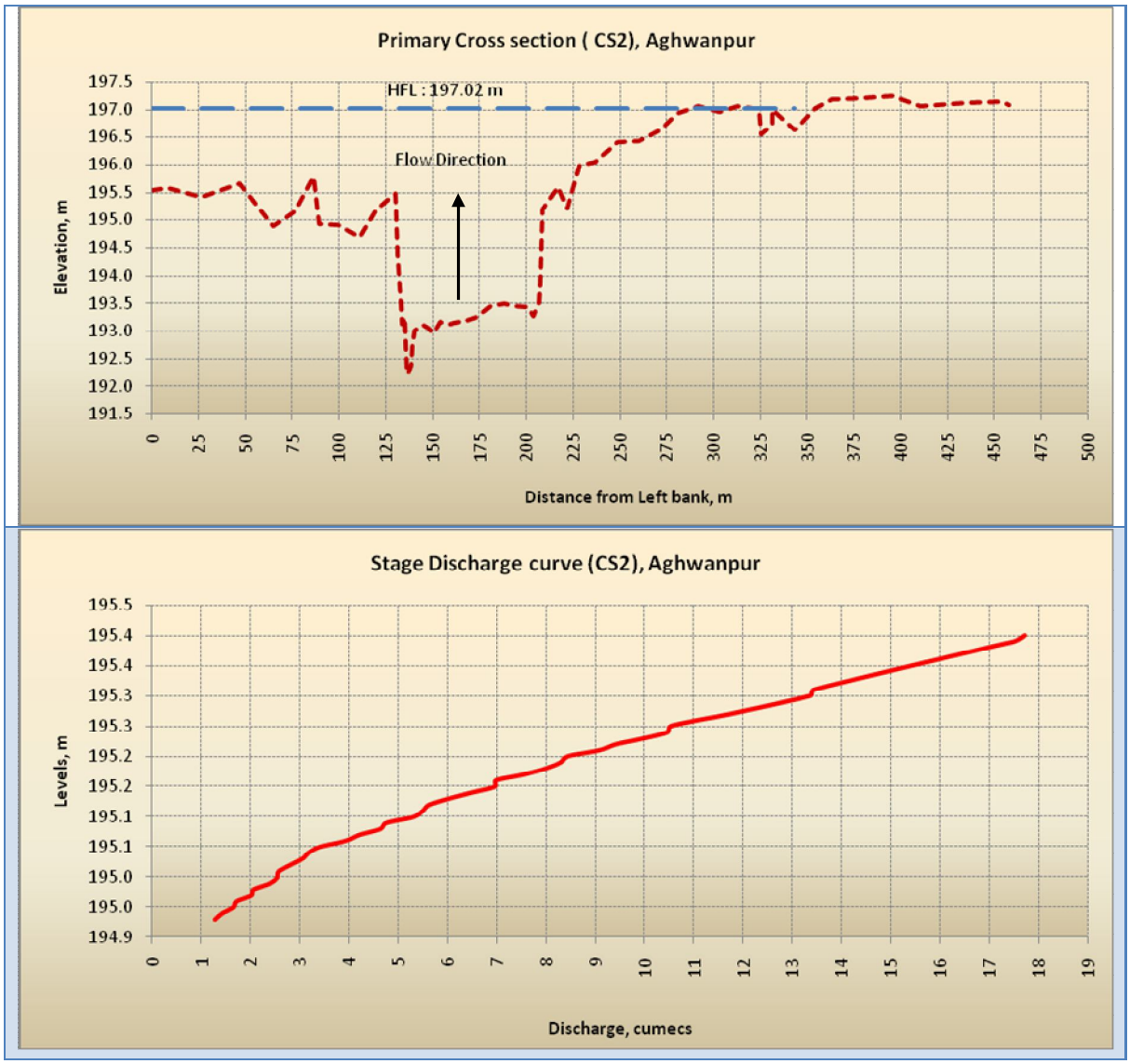

Primary Cross section (CS2), Aghwanpur
HFL : 197.02 m
Flow Direction
Elevation, m
Distance from Left bank, m
Stage Discharge curve (CS2), Aghwanpur
Levels, m
Discharge, cumecs

Table 6: Hydraulic properties of Aghwanpur site (CS2)

S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
1	1.28	194.93	192.22	1.22	0.01	132.17	106.45	108.18	1.24
2	1.42	194.94	192.22	1.22	0.01	133.04	107.20	108.93	1.24
3	1.65	194.95	192.22	1.22	0.01	134.32	108.28	110.03	1.24
4	1.72	194.96	192.22	1.22	0.01	134.82	108.70	110.45	1.24
5	2.02	194.97	192.22	1.22	0.01	136.49	110.08	111.85	1.24
6	2.06	194.98	192.22	1.22	0.02	136.79	110.33	112.11	1.24
7	2.39	194.99	192.22	1.22	0.02	138.72	111.91	113.71	1.24
8	2.55	195.00	192.22	1.22	0.02	139.85	112.83	114.63	1.24
9	2.58	195.01	192.22	1.22	0.02	140.02	112.97	114.77	1.24
10	3.05	195.03	192.22	1.22	0.02	143.02	115.36	117.19	1.24
11	3.18	195.04	192.22	1.22	0.02	143.44	115.69	117.53	1.24
12	3.41	195.05	192.22	1.22	0.02	144.89	116.83	118.68	1.24
13	3.93	195.06	192.22	1.22	0.03	146.79	118.30	120.17	1.24
14	4.21	195.07	192.22	1.22	0.03	147.62	118.94	120.81	1.24
15	4.64	195.08	192.22	1.22	0.03	149.19	120.13	122.02	1.24
16	4.76	195.09	192.22	1.22	0.03	149.77	120.57	122.47	1.24
17	5.31	195.10	192.22	1.22	0.04	151.66	121.99	123.90	1.24
18	5.50	195.11	192.22	1.22	0.04	152.29	122.46	124.38	1.24
19	5.63	195.12	192.22	1.23	0.04	153.64	123.46	125.39	1.24
20	6.02	195.13	192.22	1.23	0.04	154.55	124.13	126.06	1.25
21	6.49	195.14	192.22	1.23	0.04	156.07	125.24	127.18	1.25
22	6.97	195.15	192.22	1.23	0.04	157.83	126.33	128.29	1.25
23	6.99	195.16	192.22	1.23	0.04	157.99	126.40	128.37	1.25
24	7.58	195.17	192.22	1.24	0.05	160.11	127.48	129.46	1.26
25	8.01	195.18	192.22	1.24	0.05	161.24	128.05	130.03	1.26
26	8.31	195.19	192.22	1.24	0.05	162.58	129.01	131.01	1.26
27	8.44	195.20	192.22	1.24	0.05	164.24	130.34	132.34	1.26
28	9.09	195.21	192.22	1.24	0.05	165.55	131.38	133.38	1.26
29	9.43	195.22	192.22	1.24	0.06	166.60	132.23	134.24	1.26
30	10.00	195.23	192.22	1.24	0.06	167.93	133.48	135.50	1.26
31	10.47	195.24	192.22	1.24	0.06	169.61	135.02	137.05	1.26
32	10.54	195.25	192.22	1.24	0.06	170.06	135.44	137.47	1.26
33	11.09	195.26	192.22	1.24	0.06	171.06	136.34	138.38	1.26
34	11.74	195.27	192.22	1.24	0.07	172.98	138.08	140.12	1.26
35	13.38	195.30	192.22	1.24	0.08	177.77	142.31	144.37	1.26
36	13.45	195.31	192.22	1.24	0.08	178.25	142.72	144.79	1.26
37	16.97	195.38	192.22	1.24	0.09	189.71	152.35	154.47	1.26
38	17.51	195.39	192.22	1.24	0.09	190.97	153.37	155.49	1.26
39	17.73	195.40	192.22	1.24	0.09	191.77	154.01	156.14	1.26

Katghar Railway Bridge, Moradabad

Three cross sections were surveyed at Katghar, Moradabad but the outputs were compiled only for primary cross section (CS2) which is CWC river streamflow gauge site. Main active channel is on the right bank and primary cross section is located just d/s of railway bridge near CWC river gauge site. During field visits it was also observed that there was large scale river bed mining being carried out which must have altered the channel cross section . The calibration at Katghar cross section site was found satisfactory and Hydraulic properties were compiled and presented in Table 7. The simulated Rating curve, cross section locations and primary cross section profile has been presented in

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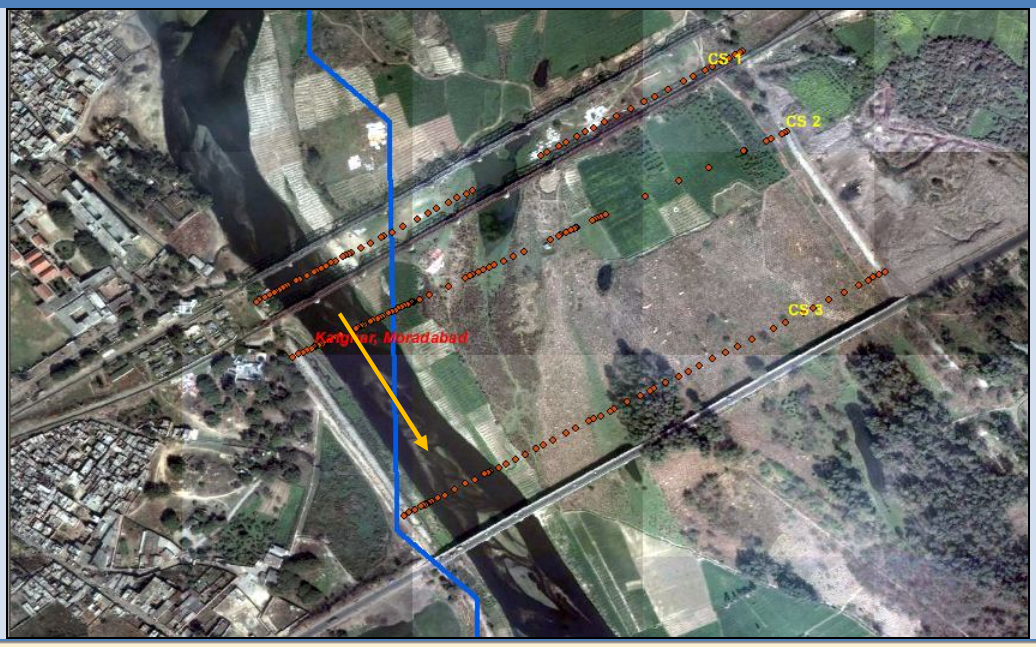
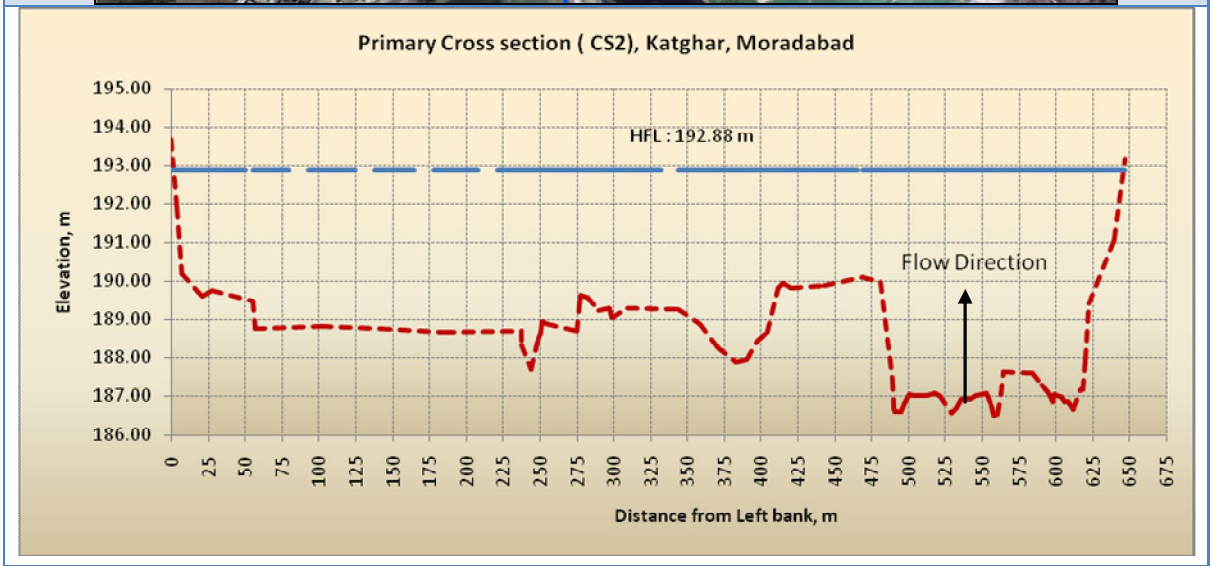
Figure 8: Cross Section profile and Rating curve for primary cross section site (CS2) at Katghar EF location





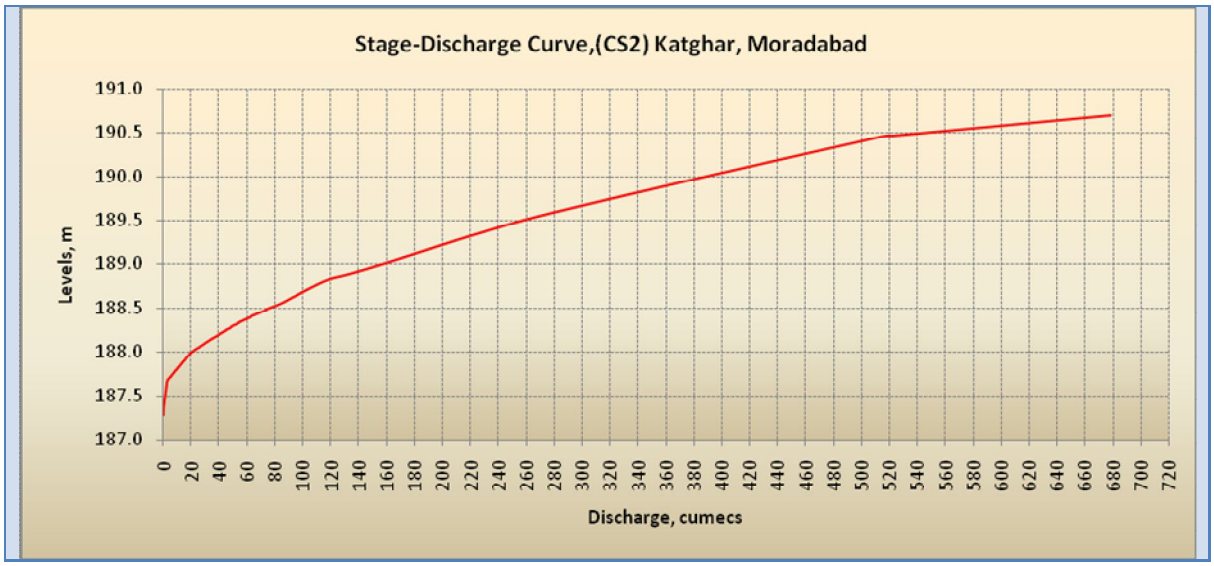

Stage-Discharge Curve,(CS2) Katghar, Moradabad
Levels, m
191.0
190.5
190.0
189.5
189.0
188.5
188.0
187.5
187.0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
Discharge, cumecs

Table 7: Hydraulic properties of Katghar, Moradabad site (CS2)

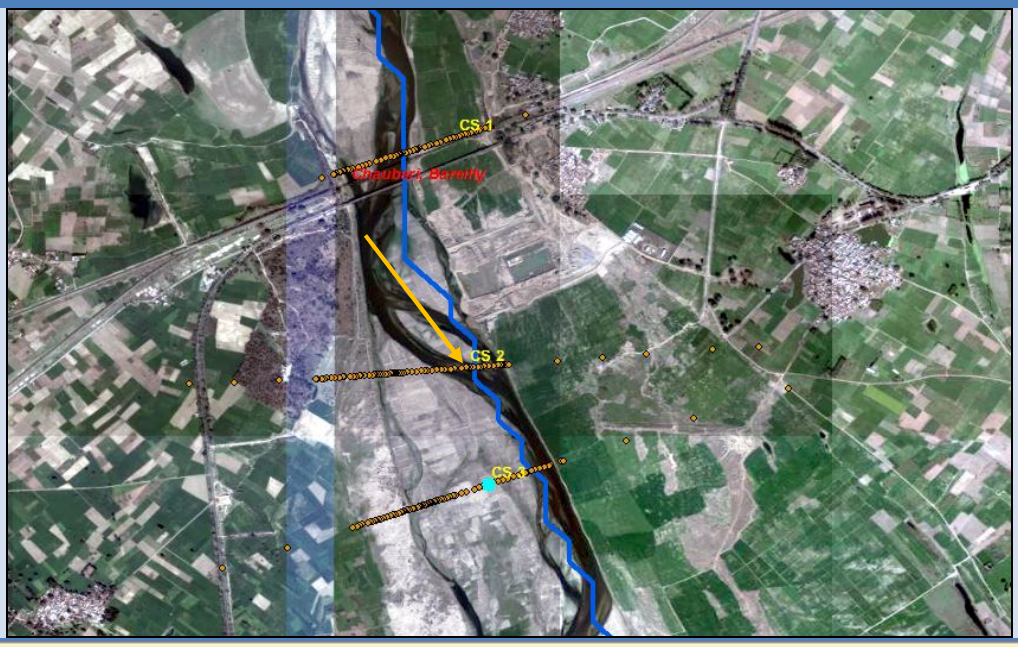
S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
1	0.11	187.28	186.53	0.37	0.00	37.32	101.59	102.17	0.37
2	0.12	187.29	186.53	0.38	0.00	38.34	101.85	102.44	0.38
3	0.14	187.30	186.53	0.38	0.00	39.38	102.12	102.71	0.38
4	0.15	187.31	186.53	0.40	0.00	40.49	102.40	103.00	0.40
5	0.18	187.32	186.53	0.40	0.00	41.50	102.67	103.28	0.40
6	0.21	187.33	186.53	0.41	0.01	42.47	102.93	103.55	0.41
7	0.23	187.35	186.53	0.43	0.01	44.95	103.60	104.24	0.43
8	0.24	187.36	186.53	0.44	0.01	45.60	103.77	104.41	0.44
9	0.29	187.37	186.53	0.44	0.01	46.67	104.05	104.71	0.45
10	0.36	187.38	186.53	0.45	0.01	47.58	104.29	104.96	0.46
11	0.47	187.39	186.53	0.46	0.01	48.86	104.63	105.30	0.47
12	0.55	187.40	186.53	0.48	0.01	49.94	104.92	105.60	0.48
13	0.64	187.41	186.53	0.48	0.01	51.05	105.21	105.90	0.48
14	0.69	187.42	186.53	0.49	0.01	51.74	105.39	106.09	0.49
15	0.88	187.44	186.53	0.51	0.02	54.17	106.08	106.79	0.51
16	0.98	187.45	186.53	0.52	0.02	55.48	106.45	107.17	0.52
17	1.01	187.46	186.53	0.52	0.02	55.87	106.56	107.28	0.53
18	1.11	187.47	186.53	0.53	0.02	57.21	106.93	107.66	0.53
19	1.29	187.49	186.53	0.55	0.02	59.44	107.56	108.30	0.55
20	1.38	187.50	186.53	0.56	0.02	60.43	107.84	108.59	0.56
21	1.47	187.51	186.53	0.57	0.02	61.90	108.24	109.00	0.57
22	1.52	187.52	186.53	0.57	0.02	62.44	108.39	109.15	0.58
23	1.59	187.53	186.53	0.58	0.03	63.42	108.66	109.43	0.58
24	1.68	187.54	186.53	0.59	0.03	64.64	109.00	109.77	0.59
25	1.81	187.55	186.53	0.60	0.03	66.30	109.46	110.23	0.61
26	1.85	187.56	186.53	0.61	0.03	66.88	109.62	110.40	0.61
27	1.95	187.57	186.53	0.61	0.03	68.06	109.94	110.72	0.62
28	2.02	187.58	186.53	0.62	0.03	69.13	110.23	111.02	0.63
29	2.11	187.59	186.53	0.63	0.03	70.26	110.54	111.33	0.64
30	2.21	187.60	186.53	0.64	0.03	71.52	110.88	111.68	0.65
31	2.30	187.61	186.53	0.64	0.03	72.83	112.19	113.00	0.65
32	2.38	187.62	186.53	0.63	0.03	73.71	116.40	117.21	0.63
33	2.44	187.63	186.53	0.61	0.03	74.91	121.90	122.72	0.62
34	2.52	187.64	186.53	0.60	0.03	75.97	126.57	127.39	0.60
35	2.60	187.65	186.53	0.59	0.03	77.40	130.93	131.76	0.59
36	2.66	187.66	186.53	0.60	0.03	78.31	130.97	131.80	0.60
37	2.83	187.67	186.53	0.61	0.04	80.06	131.05	131.89	0.61
38	3.09	187.68	186.53	0.61	0.04	81.07	131.10	131.94	0.62
39	3.50	187.69	186.53	0.62	0.04	82.10	131.14	131.99	0.63
40	4.65	187.71	186.53	0.64	0.05	85.08	131.46	132.31	0.65
41	5.80	187.73	186.53	0.66	0.07	87.99	131.93	132.79	0.67
42	6.16	187.74	186.53	0.67	0.07	88.75	132.05	132.92	0.67
43	6.82	187.75	186.53	0.68	0.08	90.55	132.35	133.21	0.69
44	7.32	187.76	186.53	0.69	0.08	91.94	132.57	133.44	0.69
45	7.86	187.77	186.53	0.70	0.08	93.29	132.79	133.67	0.70
46	8.19	187.78	186.53	0.70	0.09	94.14	132.92	133.81	0.71
47	8.79	187.79	186.53	0.72	0.09	95.65	133.17	134.05	0.72
48	9.36	187.80	186.53	0.72	0.10	97.18	133.41	134.30	0.73
49	10.08	187.81	186.53	0.74	0.10	99.02	133.71	134.61	0.74
50	10.27	187.82	186.53	0.74	0.10	99.65	133.81	134.71	0.75
51	10.95	187.83	186.53	0.75	0.11	101.28	134.06	134.97	0.76

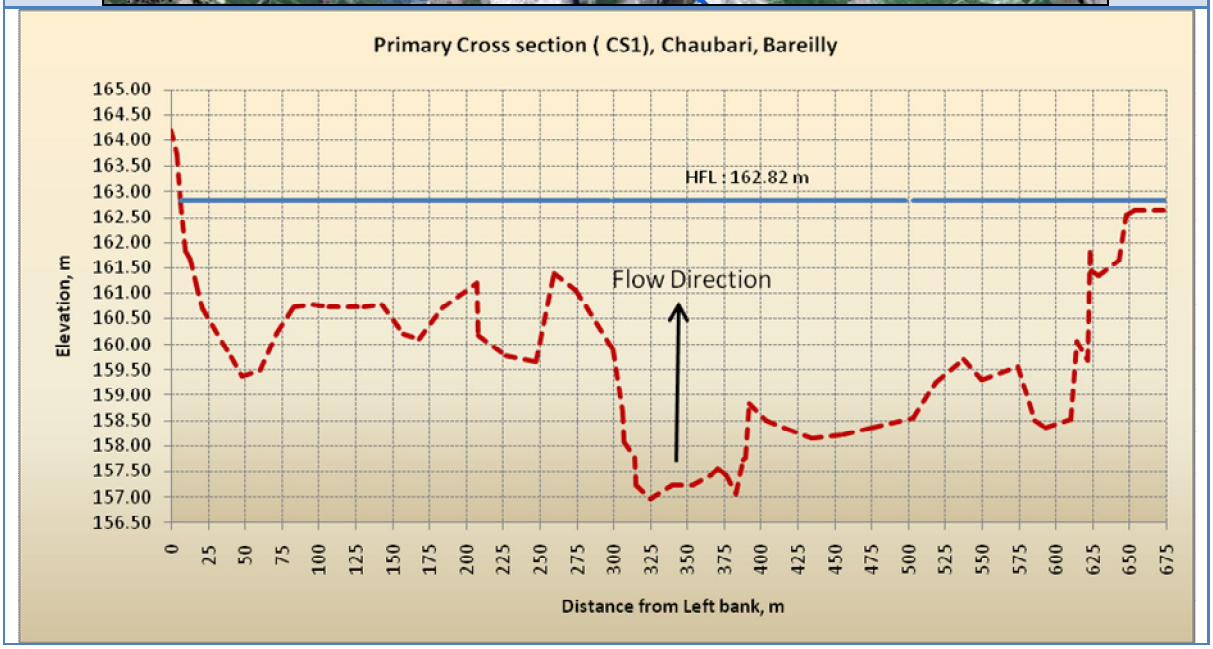
S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
52	11.44	187.84	186.53	0.76	0.11	102.51	134.26	135.17	0.77
53	12.16	187.85	186.53	0.77	0.12	104.37	134.56	135.48	0.78
54	12.33	187.86	186.53	0.77	0.12	104.87	134.64	135.56	0.78
55	13.06	187.87	186.53	0.79	0.12	106.70	134.92	135.85	0.79
56	13.60	187.88	186.53	0.80	0.13	108.10	135.14	136.08	0.80
57	13.94	187.89	186.53	0.80	0.13	108.88	135.27	136.20	0.81
58	15.24	187.91	186.53	0.81	0.14	112.28	137.93	138.87	0.81
59	15.69	187.92	186.53	0.81	0.14	113.32	139.31	140.26	0.81
60	16.09	187.93	186.53	0.81	0.14	114.70	141.11	142.06	0.81
61	18.34	187.97	186.53	0.82	0.15	120.65	146.74	147.72	0.82
62	19.06	187.98	186.53	0.82	0.16	122.03	147.39	148.37	0.83
63	19.30	187.99	186.53	0.83	0.16	123.43	148.04	149.03	0.83
64	21.92	188.02	186.53	0.85	0.17	128.30	150.29	151.30	0.85
65	22.55	188.03	186.53	0.85	0.17	129.21	150.71	151.72	0.86
66	23.59	188.04	186.53	0.86	0.18	130.81	151.43	152.45	0.86
67	24.82	188.05	186.53	0.87	0.19	132.68	152.28	153.31	0.87
68	25.92	188.06	186.53	0.87	0.19	134.34	153.03	154.06	0.88
69	26.64	188.07	186.53	0.88	0.20	135.50	153.55	154.59	0.88
70	27.64	188.08	186.53	0.88	0.20	136.99	154.22	155.26	0.89
71	28.62	188.09	186.53	0.89	0.21	138.58	154.92	155.98	0.90
72	29.48	188.10	186.53	0.89	0.21	140.00	155.55	156.61	0.90
73	30.45	188.11	186.53	0.90	0.22	141.57	156.25	157.31	0.91
74	34.42	188.15	186.53	0.92	0.23	147.74	158.95	160.03	0.93
75	39.01	188.19	186.53	0.95	0.25	154.75	161.95	163.07	0.96
76	40.59	188.21	186.53	0.96	0.26	157.58	163.15	164.28	0.97
77	42.83	188.23	186.53	0.97	0.27	161.03	164.60	165.74	0.98
78	44.83	188.25	186.53	0.99	0.27	164.23	165.93	167.09	0.99
79	45.45	188.26	186.53	0.99	0.28	165.21	166.34	167.50	0.99
80	47.40	188.27	186.53	1.00	0.28	168.06	167.28	168.45	1.00
81	48.12	188.28	186.53	1.00	0.28	169.16	167.64	168.81	1.01
82	49.64	188.30	186.53	1.01	0.29	172.21	168.61	169.80	1.02
83	52.67	188.32	186.53	1.03	0.30	176.52	169.99	171.19	1.04
84	54.20	188.34	186.53	1.04	0.30	178.67	170.67	171.88	1.05
85	56.96	188.36	186.53	1.06	0.31	182.95	171.83	173.06	1.06
86	58.22	188.37	186.53	1.06	0.32	184.57	172.26	173.50	1.07
87	59.60	188.38	186.53	1.07	0.32	186.31	172.72	173.97	1.08
88	62.63	188.40	186.53	1.09	0.33	190.32	173.77	175.04	1.10
89	62.89	188.41	186.53	1.09	0.33	190.83	173.90	175.18	1.10
90	72.41	188.47	186.53	1.13	0.36	202.03	177.11	178.45	1.14
91	73.80	188.48	186.53	1.14	0.36	203.97	177.80	179.14	1.15
92	74.23	188.49	186.53	1.15	0.36	205.93	178.48	179.83	1.15
93	79.11	188.52	186.53	1.16	0.37	211.34	180.39	181.77	1.17
94	85.18	188.56	186.53	1.18	0.39	218.71	183.26	184.68	1.19
95	93.34	188.63	186.53	1.22	0.41	231.56	188.17	189.65	1.23
96	94.81	188.64	186.53	1.23	0.41	233.63	188.94	190.43	1.24
97	97.58	188.67	186.53	1.24	0.41	238.78	190.47	191.99	1.25
98	116.88	188.82	186.53	1.31	0.42	281.42	381.05	382.75	1.32
99	133.30	188.89	186.53	1.32	0.43	309.66	399.49	401.29	1.33
100	158.50	189.01	186.53	1.34	0.44	360.18	409.73	411.68	1.35
101	176.34	189.10	186.53	1.39	0.45	394.93	417.33	419.37	1.40
102	225.18	189.35	186.53	1.49	0.45	504.29	481.87	484.19	1.50
103	278.91	189.59	186.53	1.59	0.45	623.64	504.69	507.15	1.60
104	514.43	190.46	186.53	1.80	0.45	1130.70	626.90	629.58	1.80
105	523.47	190.47	186.53	1.81	0.46	1138.53	627.05	629.73	1.82
106	678.32	190.70	186.53	2.03	0.53	1286.99	629.87	632.62	2.04

Chaubari, Bareilly

Three cross sections were surveyed at Chaubari, bareilly but the outputs were compiled only for primary cross section (CS1) which is near CWC river streamflow gauge site upstream of railway bridge. The calibration at Chaubari cross section site was found satisfactory and Hydraulic properties were compiled and presented in Table 8. The simulated Rating curve, cross section locations and primary cross section profile has been presented in .

Figure 9: Cross Section profile and Rating curve for primary cross section site (CS1) at Chaubari, Bareilly EF location





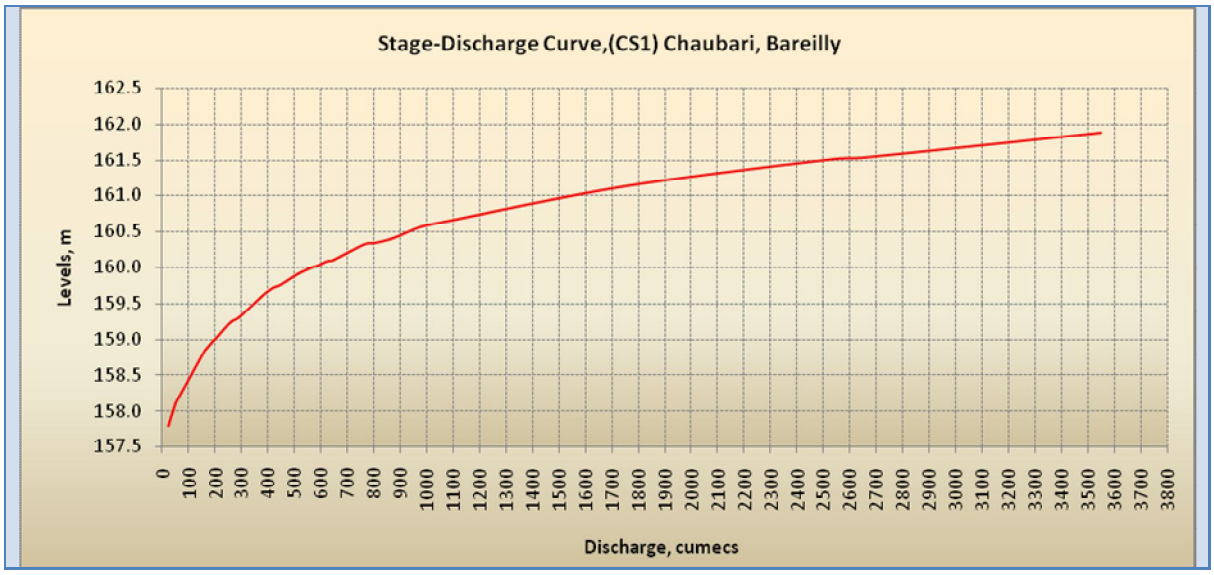

Stage-Discharge Curve,(CS1) Chaubari, Bareilly
Levels, m
162.5
162.0
161.5
161.0
160.5
160.0
159.5
159.0
158.5
158.0
157.5
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
Discharge, cumecs

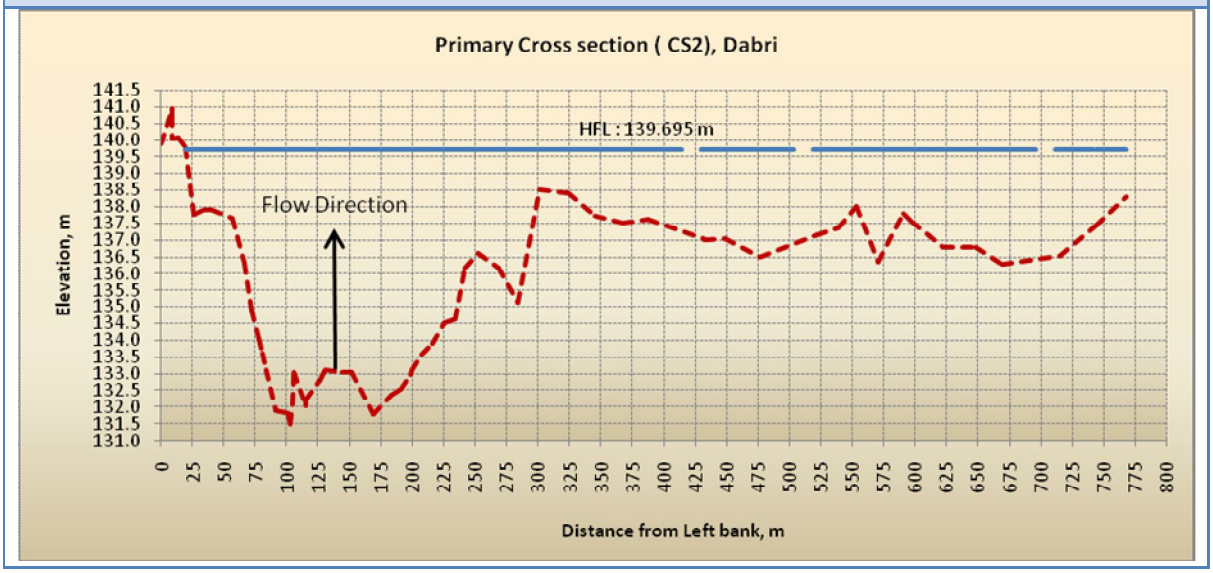
Table 8: Hydraulic properties of CS1 of Chaubari, Bareilly

S.no	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
1	22.06	157.79	156.97	0.52	0.55	39.80	75.87	76.05	0.52
2	23.02	157.80	156.97	0.53	0.57	40.68	76.15	76.34	0.53
3	24.16	157.81	156.97	0.54	0.58	41.73	76.48	76.67	0.55
4	25.82	157.84	156.97	0.56	0.59	43.51	77.04	77.23	0.56
5	27.70	157.86	156.97	0.58	0.61	45.37	77.62	77.82	0.58
6	28.45	157.87	156.97	0.59	0.62	45.87	77.77	77.97	0.59
7	29.61	157.88	156.97	0.60	0.63	47.08	78.15	78.35	0.60
8	30.47	157.89	156.97	0.61	0.64	47.63	78.32	78.52	0.61
9	32.27	157.92	156.97	0.63	0.65	49.54	78.90	79.11	0.63
10	34.73	157.94	156.97	0.65	0.67	51.57	79.52	79.74	0.65
11	35.39	157.95	156.97	0.65	0.68	52.25	79.73	79.94	0.66
12	36.29	157.96	156.97	0.66	0.69	52.91	79.93	80.14	0.66
13	38.97	157.99	156.97	0.69	0.70	55.68	80.76	80.98	0.69
14	39.95	158.00	156.97	0.69	0.71	56.12	80.89	81.12	0.69
15	42.69	158.03	156.97	0.72	0.72	59.14	81.78	82.02	0.72
16	43.75	158.05	156.97	0.73	0.73	59.99	82.03	82.27	0.73
17	45.34	158.06	156.97	0.74	0.74	61.27	82.41	82.65	0.74
18	49.11	158.11	156.97	0.78	0.75	65.29	83.20	83.45	0.78
19	50.43	158.12	156.97	0.80	0.76	66.51	83.27	83.53	0.80
20	157.40	158.82	156.97	0.81	0.83	188.65	232.10	232.69	0.81
21	158.10	158.83	156.97	0.81	0.84	189.22	232.28	232.88	0.81
22	183.70	158.94	156.97	0.91	0.85	215.71	237.21	237.84	0.91
23	193.80	158.98	156.97	0.94	0.86	226.31	238.94	239.59	0.95
24	209.10	159.04	156.97	0.99	0.87	240.43	241.22	241.90	1.00
25	235.20	159.15	156.97	1.08	0.88	266.61	245.40	246.11	1.09
26	252.70	159.22	156.97	1.14	0.89	284.51	248.22	248.96	1.15
27	267.00	159.26	156.97	1.17	0.91	293.77	249.67	250.42	1.18
28	287.40	159.30	156.97	1.20	0.94	304.17	251.98	252.75	1.21
29	382.50	159.62	156.97	1.22	0.96	396.86	324.80	325.69	1.22
30	400.30	159.67	156.97	1.24	0.97	413.27	333.69	334.60	1.24
31	420.50	159.72	156.97	1.24	0.98	429.35	346.32	347.28	1.24
32	443.30	159.75	156.97	1.24	1.00	441.41	354.06	355.05	1.25
33	487.60	159.85	156.97	1.29	1.02	478.13	369.32	370.41	1.29
34	514.10	159.91	156.97	1.33	1.03	500.98	376.64	377.79	1.33
35	531.30	159.94	156.97	1.34	1.04	510.08	379.88	381.05	1.34
36	568.30	160.00	156.97	1.37	1.07	532.08	387.58	388.80	1.37
37	587.00	160.02	156.97	1.38	1.09	540.97	390.65	391.89	1.38
38	619.70	160.08	156.97	1.41	1.10	565.03	398.62	399.91	1.42
39	634.80	160.09	156.97	1.42	1.11	570.02	400.03	401.33	1.42
40	646.30	160.10	156.97	1.42	1.13	571.24	400.38	401.68	1.43
41	718.80	160.24	156.97	1.47	1.14	632.03	429.46	430.90	1.47
42	770.50	160.33	156.97	1.52	1.15	671.83	441.11	442.67	1.52
43	802.60	160.34	156.97	1.52	1.19	673.30	441.54	443.10	1.52
44	874.20	160.41	156.97	1.56	1.24	706.22	450.94	452.60	1.57
45	978.50	160.57	156.97	1.65	1.25	780.73	471.53	473.40	1.66
46	1081.00	160.65	156.97	1.69	1.32	819.82	481.98	483.95	1.70
47	1753.00	161.13	156.97	1.83	1.62	1082.60	588.92	591.49	1.84
48	2539.00	161.51	156.97	2.11	1.93	1316.35	621.83	624.72	2.12
49	2651.00	161.53	156.97	2.12	2.00	1325.65	622.65	625.55	2.13
50	3551.00	161.88	156.97	2.43	2.29	1548.54	634.22	637.38	2.44

Dabri

Three cross sections were surveyed at Dabri but the outputs were compiled only for primary cross section (CS2) which is CWC river streamflow gauge site. The calibration at Dabri cross section site was found satisfactory and Hydraulic properties were compiled and presented in Table 9. The simulated Rating curve, cross section locations and primary cross section profile has been presented in .

Figure 10: Cross Section profile and Rating curve for primary cross section site (CS2) at Dabri EF location



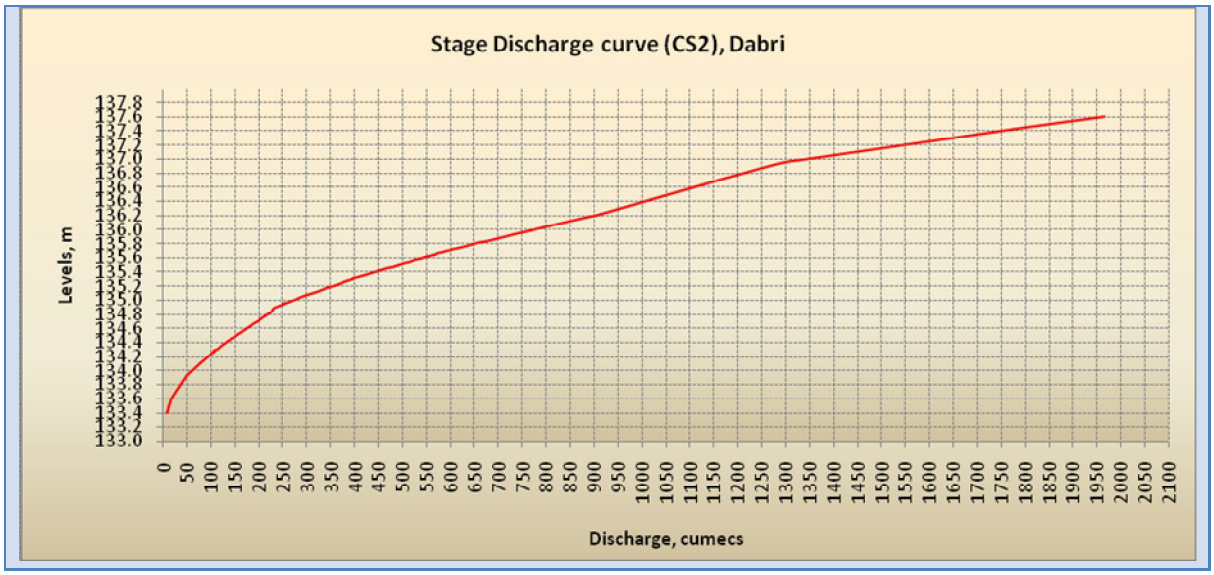

Stage Discharge curve (CS2), Dabri
Levels, m
137.8
137.6
137.4
137.2
137.0
136.8
136.6
136.4
136.2
136.0
135.8
135.6
135.4
135.2
135.0
134.8
134.6
134.4
134.2
134.0
133.8
133.6
133.4
133.2
133.0
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
2050
2100
Discharge, cumecs

Table 9: Hydraulic properties of CS2 of Dabri

S.no.	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
1	7.21	133.39	131.48	0.87	0.07	106.65	121.87	122.72	0.88
2	7.61	133.40	131.48	0.88	0.07	107.71	122.06	122.91	0.88
3	8.20	133.41	131.48	0.89	0.07	109.61	122.39	123.24	0.90
4	9.80	133.45	131.48	0.92	0.09	113.93	123.14	124.00	0.93
5	10.51	133.47	131.48	0.93	0.09	116.20	123.53	124.39	0.94
6	11.44	133.49	131.48	0.95	0.10	118.54	123.94	124.80	0.96
7	12.02	133.50	131.48	0.96	0.10	120.47	124.27	125.13	0.97
8	13.41	133.53	131.48	0.99	0.11	124.26	124.92	125.79	1.00
9	13.67	133.54	131.48	1.00	0.11	125.19	125.08	125.95	1.00
10	14.45	133.56	131.48	1.01	0.11	127.59	125.48	126.36	1.02
11	15.07	133.57	131.48	1.02	0.12	129.01	125.73	126.60	1.03
12	16.11	133.59	131.48	1.04	0.12	131.64	126.19	127.06	1.05
13	16.96	133.60	131.48	1.04	0.13	132.87	126.48	127.35	1.05
14	18.04	133.61	131.48	1.05	0.13	134.32	126.84	127.72	1.06
15	18.89	133.62	131.48	1.06	0.14	135.45	127.14	128.02	1.07
16	19.82	133.63	131.48	1.07	0.15	136.69	127.47	128.35	1.07
17	20.69	133.64	131.48	1.07	0.15	137.86	127.78	128.66	1.08
18	21.68	133.65	131.48	1.08	0.16	139.21	128.14	129.02	1.09
19	22.72	133.66	131.48	1.09	0.16	140.59	128.50	129.38	1.09
20	23.74	133.67	131.48	1.09	0.17	141.97	128.86	129.74	1.10
21	24.38	133.68	131.48	1.10	0.17	142.83	129.09	129.97	1.11
22	25.18	133.69	131.48	1.11	0.18	143.92	129.37	130.26	1.11
23	26.40	133.70	131.48	1.11	0.18	145.57	129.80	130.69	1.12
24	27.58	133.71	131.48	1.12	0.19	147.10	130.20	131.09	1.13
25	28.44	133.72	131.48	1.13	0.19	148.36	130.53	131.41	1.14
26	29.76	133.73	131.48	1.14	0.20	150.15	130.99	131.88	1.15
27	31.47	133.75	131.48	1.15	0.21	152.43	131.58	132.47	1.16
28	32.50	133.76	131.48	1.16	0.21	153.88	131.95	132.84	1.17
29	35.23	133.79	131.48	1.18	0.22	157.59	132.90	133.79	1.19
30	36.47	133.80	131.48	1.19	0.23	159.17	133.30	134.19	1.19
31	37.04	133.81	131.48	1.19	0.23	159.99	133.50	134.40	1.20
32	38.34	133.82	131.48	1.20	0.24	161.73	133.94	134.84	1.21
33	39.41	133.83	131.48	1.21	0.24	163.16	134.30	135.20	1.22
34	39.96	133.84	131.48	1.21	0.24	163.90	134.49	135.39	1.22
35	40.97	133.85	131.48	1.22	0.25	165.30	134.84	135.74	1.23
36	42.07	133.86	131.48	1.23	0.25	166.79	135.22	136.12	1.23
37	43.14	133.87	131.48	1.23	0.26	168.23	135.57	136.48	1.24
38	44.29	133.88	131.48	1.24	0.26	169.81	135.97	136.87	1.25
39	45.13	133.89	131.48	1.25	0.26	170.89	136.23	137.14	1.25
40	46.02	133.90	131.48	1.25	0.27	172.29	136.58	137.49	1.26
41	47.01	133.91	131.48	1.26	0.27	173.52	136.89	137.79	1.27
42	48.14	133.92	131.48	1.27	0.27	175.05	137.22	138.13	1.28
43	50.96	133.94	131.48	1.28	0.29	177.85	137.65	138.56	1.29
44	52.54	133.95	131.48	1.29	0.29	179.11	137.85	138.76	1.30
45	53.97	133.96	131.48	1.30	0.30	180.41	138.05	138.96	1.31
46	55.53	133.97	131.48	1.31	0.31	181.75	138.26	139.17	1.32
47	57.65	133.98	131.48	1.32	0.31	183.58	138.54	139.45	1.33
48	58.46	133.99	131.48	1.32	0.32	184.25	138.64	139.55	1.33
49	60.51	134.00	131.48	1.33	0.33	186.03	138.91	139.82	1.34
50	61.95	134.01	131.48	1.34	0.33	187.25	139.09	140.01	1.35
51	63.99	134.02	131.48	1.35	0.34	188.90	139.35	140.26	1.36

S.no.	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
52	65.29	134.03	131.48	1.36	0.34	190.13	139.53	140.45	1.36
53	66.22	134.04	131.48	1.36	0.35	191.21	139.70	140.62	1.37
54	68.94	134.05	131.48	1.37	0.36	193.24	140.01	140.93	1.38
55	70.13	134.06	131.48	1.38	0.36	194.30	140.18	141.10	1.39
56	71.95	134.07	131.48	1.39	0.37	195.78	140.41	141.33	1.39
57	74.55	134.09	131.48	1.40	0.38	198.01	140.76	141.68	1.41
58	76.73	134.10	131.48	1.41	0.38	199.90	141.06	141.98	1.42
59	78.20	134.11	131.48	1.41	0.39	201.10	141.25	142.17	1.42
60	79.24	134.12	131.48	1.43	0.39	203.10	141.56	142.49	1.44
61	81.87	134.13	131.48	1.43	0.40	204.25	141.74	142.67	1.44
62	83.14	134.14	131.48	1.44	0.41	205.24	141.89	142.82	1.45
63	85.19	134.15	131.48	1.45	0.41	206.95	142.16	143.10	1.46
64	88.43	134.17	131.48	1.46	0.42	209.53	142.56	143.50	1.47
65	90.22	134.18	131.48	1.47	0.43	211.17	142.82	143.75	1.48
66	92.80	134.19	131.48	1.48	0.44	213.39	143.16	144.10	1.49
67	93.91	134.20	131.48	1.48	0.44	214.11	143.27	144.21	1.49
68	100.10	134.24	131.48	1.52	0.46	219.85	144.16	145.10	1.53
69	102.45	134.25	131.48	1.52	0.46	221.43	144.40	145.34	1.53
70	106.76	134.27	131.48	1.54	0.47	225.00	144.95	145.89	1.55
71	104.73	134.28	131.48	1.54	0.47	225.22	144.98	145.92	1.55
72	112.34	134.30	131.48	1.56	0.49	229.25	145.59	146.54	1.57
73	116.43	134.32	131.48	1.58	0.50	232.19	146.04	146.99	1.59
74	119.63	134.34	131.48	1.59	0.51	234.46	146.38	147.33	1.60
75	123.09	134.36	131.48	1.60	0.52	236.96	146.76	147.71	1.61
76	132.41	134.40	131.48	1.64	0.54	243.51	147.75	148.70	1.65
77	133.46	134.41	131.48	1.64	0.55	244.28	147.86	148.82	1.65
78	139.42	134.43	131.48	1.66	0.56	248.48	148.49	149.45	1.67
79	141.84	134.45	131.48	1.67	0.57	250.20	148.75	149.71	1.68
80	145.79	134.46	131.48	1.69	0.58	253.02	149.16	150.13	1.70
81	154.55	134.51	131.48	1.72	0.60	259.22	150.08	151.05	1.73
82	160.12	134.53	131.48	1.73	0.61	263.21	151.06	152.03	1.74
83	172.77	134.59	131.48	1.72	0.63	272.28	157.43	158.40	1.73
84	179.97	134.62	131.48	1.72	0.65	277.57	160.46	161.44	1.73
85	187.86	134.66	131.48	1.75	0.66	283.45	160.91	161.89	1.76
86	196.37	134.69	131.48	1.78	0.68	288.41	161.28	162.27	1.79
87	205.27	134.74	131.48	1.82	0.69	295.87	161.84	162.84	1.83
88	212.53	134.77	131.48	1.85	0.71	301.02	162.22	163.23	1.86
89	214.44	134.78	131.48	1.85	0.71	302.71	162.35	163.35	1.86
90	226.15	134.83	131.48	1.90	0.73	310.74	162.95	163.96	1.91
91	231.08	134.88	131.48	1.94	0.72	319.60	163.59	164.61	1.95
92	253.00	134.94	131.48	2.00	0.77	329.54	164.09	165.13	2.01
93	250.69	134.95	131.48	2.00	0.76	330.74	164.16	165.19	2.01
94	259.20	134.96	131.48	2.01	0.78	332.69	164.25	165.30	2.03
95	277.63	135.01	131.48	2.06	0.82	340.13	164.63	165.69	2.07
96	283.83	135.03	131.48	2.07	0.83	343.17	164.78	165.84	2.08
97	295.44	135.06	131.48	2.09	0.85	347.69	165.01	166.08	2.11
98	319.03	135.11	131.48	2.15	0.89	357.31	165.50	166.57	2.16
99	330.65	135.14	131.48	2.17	0.91	362.11	165.89	166.97	2.18
100	334.87	135.15	131.48	2.17	0.92	363.68	166.16	167.24	2.19
101	341.16	135.17	131.48	2.18	0.93	366.21	166.59	167.69	2.20
102	357.15	135.20	131.48	2.21	0.96	372.41	167.65	168.76	2.22
103	368.13	135.23	131.48	2.22	0.98	377.19	168.47	169.58	2.24
104	373.03	135.24	131.48	2.23	0.98	379.14	168.80	169.92	2.25
105	373.79	135.25	131.48	2.23	0.99	379.40	168.84	169.96	2.25
106	391.85	135.29	131.48	2.26	1.01	386.69	170.07	171.21	2.27

S.no.	Simulated flow, cumecs	Water surface elevation, m	Min. Channel elevation, m	Hydraulic Radius, m	Velocity channel, m/s	Flow Area, m^2	Top Width, m	Wetted perimeter, m	Hydraulic Depth, m
107	396.17	135.30	131.48	2.26	1.02	388.45	170.36	171.51	2.28
108	395.89	135.31	131.48	2.27	1.01	390.79	170.76	171.91	2.29
109	403.99	135.32	131.48	2.28	1.03	392.23	171.00	172.15	2.30
110	424.72	135.36	131.48	2.30	1.07	398.62	172.06	173.23	2.32
111	466.62	135.45	131.48	2.35	1.13	413.73	174.56	175.75	2.37
112	476.34	135.46	131.48	2.37	1.14	417.04	175.10	176.30	2.38
113	480.69	135.47	131.48	2.37	1.15	418.53	175.34	176.55	2.39
114	503.86	135.52	131.48	2.40	1.18	426.72	176.67	177.90	2.42
115	511.41	135.53	131.48	2.41	1.19	429.00	177.04	178.27	2.42
116	516.31	135.54	131.48	2.41	1.20	431.11	177.38	178.61	2.43
117	523.16	135.56	131.48	2.42	1.21	433.55	177.77	179.01	2.44
118	527.98	135.57	131.48	2.43	1.21	434.96	178.00	179.24	2.44
119	535.64	135.58	131.48	2.44	1.22	438.22	178.52	179.77	2.45
120	550.02	135.61	131.48	2.45	1.24	442.90	179.27	180.53	2.47
121	567.48	135.64	131.48	2.47	1.26	448.93	180.23	181.50	2.49
122	572.84	135.66	131.48	2.48	1.27	451.19	180.59	181.86	2.50
123	580.85	135.67	131.48	2.49	1.28	453.53	180.96	182.24	2.51
124	590.52	135.69	131.48	2.50	1.29	456.98	181.50	182.79	2.52
125	599.57	135.70	131.48	2.51	1.30	459.75	181.94	183.23	2.53
126	601.07	135.71	131.48	2.51	1.31	460.30	182.02	183.32	2.53
127	609.44	135.72	131.48	2.52	1.32	462.53	182.37	183.67	2.54
128	633.62	135.76	131.48	2.54	1.35	470.50	183.62	184.93	2.56
129	658.33	135.81	131.48	2.57	1.38	478.65	184.88	186.21	2.59
130	676.46	135.83	131.48	2.59	1.40	483.84	185.68	187.03	2.61
131	733.99	135.93	131.48	2.65	1.46	502.20	188.49	189.87	2.66
132	771.80	135.99	131.48	2.68	1.50	513.40	190.18	191.58	2.70
133	776.17	136.00	131.48	2.68	1.51	514.67	190.37	191.77	2.70
134	890.72	136.18	131.48	2.79	1.62	549.43	195.80	197.27	2.81
135	905.97	136.20	131.48	2.79	1.63	554.41	197.44	198.92	2.81
136	1278.93	136.92	131.48	3.09	1.67	763.66	405.75	407.44	3.10
137	1349.41	137.00	131.48	3.14	1.69	797.41	423.88	425.59	3.15
138	1771.09	137.42	131.48	3.39	1.76	1004.96	544.12	545.96	3.40
139	1966.19	137.60	131.48	3.45	1.78	1106.13	609.54	611.44	3.46

Summary and Conclusions

The following observations and conclusions can be drawn with the hydraulic modeling results and analysis:

- Eight EF locations were shortlisted for EF analysis and three cross sections were surveyed at each EF site (one primary cross section site and two secondary sites).
- Hydraulic modelling was carried out only for primary cross section site.
- Model was calibrated/validated using observed Stage-discharge data at Moradabad, Bareilly and Dabri (although data only available with WWF, India and not shared with consultants) whereas for other sites appropriate channel properties were fed to model to generate fair outputs in absence of observed data.
- Stage-Discharge curves along with other hydraulic properties were generated using HEC RAS model and compiled for each primary cross section site.
- While surveying there was a constraint of stretching cross section beyond certain distance due to vast flood plain and unapproachable areas therefore results were only compiled upto lowest bank level (beyond which water spills through main channel and enters flood plain).
- EF locations like D/s of Hareolli barrage and Aghwanpur the main active channel has small water bearing capacity therefore simulated Stage-Discharge data was only presented from bank to bank.
- The outputs generated from hydraulic modelling in conjunction with hydrological model will further assist to assessing demand and supply scenario(from various thematic groups) for environmental flow assessment.