Final Detailed Hydrographic Survey in Gandak River-NW-37
Valmiki Nagar Barrage (Triveni) to Gaighat, Patna (295.7km)

SURVEY PERIOD: 22 APRIL 2016 TO 23 JULY 2016&
1 OCT 2016 to 20 OCT 2016

Prepared for :

Inland Waterways Authority of India
(Ministry of Shipping, Govt. of India)
A-13, Sector – 1, NOIDA
Distt. Gautam Budh Nagar,
Uttar Pradesh – 201 301

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We would like to use this opportunity to pen down our profound gratitude and appreciations**to Ms. Nutan Guha Biswas, IAS, Chairperson, IWAI**for spending his valuable time and guidance for completing this Project of "Detailed Hydrographic survey in Gandak River". Shankar And Co. would also like to thanks**Shri Pravir Pandey, Vice Chairman IA&AS,Shri Alok Ranjan, Member (Finance.), Shri S.K. Gangwar, Member (Technical) &ShriShashi Bhushan Shukla, Member (Traffic.).**

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List of Abbreviations

BM	Bench Mark
CD	Chart Datum
cm	Centimeter
CWC	Central Water Commission
DGPS	Differential Global Positioning Systems
D/S	Down Stream
ETS	Electronic Total Station
GPS	Global Positioning Systems
HFL	High Flood Line
HTL	High Tension Line
IHO	International Hydrography Organisation
IWAI	Inland Waterways Authority of India
km	Kilo Meter
LAD	Least Available depth
Lat	Latitude
LBM	Local Bench Mark
LIS	Lift Irrigation Scheme
LKM	Line kilo Meter
Long	Longitude
m	Meter
MSL	Mean Sea Level
NH	National Highway
RL	Reference Level / Reduced Level
RTK	Real Time Kinematic
SBAS	Satellite-Based Augmentation System
SD	Sounding Datum
SH	State Highway
TBC	Trimble Business Center
TBM	Temporary Bench Mark
TS	Total Station
U.P.	Uttar Pradesh
U/S	Up Stream
UHF	Ultra High Frequency
WGS	World Geodetic System

SALIENT FEATURES AT A GLANCE

<table>
<tr><th>Sl. No.</th><th>Particulars</th><th>Details</th></tr>
<tr><td>1.</td><td>Name of Consultant</td><td>Shankar And Co., Navi Mumbai</td></tr>
<tr><td>2.</td><td>Region number & State(s)</td><td>Nepal, Bihar ,U.P.</td></tr>
<tr><td>3.</td><td>Waterway stretch, NW #
(from…. to; total length)</td><td>Gandak River, NW 37, from Valmiki Barrage (Triveni) to Gaighat, Patna ; 295.7km</td></tr>
<tr><td>4.</td><td>Navigability Status</td><td>Not Navigable</td></tr>
<tr><td>a)</td><td>Tidal &non tidal portions
(from… to, length, average tidal variation)</td><td>The survey Stretch of Gandak River is non-tidal.</td></tr>
<tr><td>b)</td><td>LAD status (w.r.t. CD)
i) Survey period (22Aprto 23 July 2016& 1 Oct to 20 Oct 2016.)
ii) < 1.2 m (km)
iii) 1.2 m to 1.4 m (km)
iv) 1.5 m to 1.7 m (km)
v) 1.8 m to 2.0 m (km)
vi) > 2.0 m (km)</td><td>
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<tr><th>0-30 km</th><th>30-60km</th><th>60-90 km</th><th>90-120 km</th><th>120-150 km</th><th>Total</th></tr>
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<tr><td>1.6</td><td>0.6</td><td>0</td><td>2.6</td><td>0</td><td>4.8</td></tr>
<tr><td>2.1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>2.1</td></tr>
<tr><td>5.2</td><td>29.2</td><td>0</td><td>0</td><td>0.4</td><td>34.8</td></tr>
<tr><td>9.5</td><td>0</td><td>27.2</td><td>27.4</td><td>20.4</td><td>84.5</td></tr>
<tr><td>30km</td><td>30km</td><td>30km</td><td>30km</td><td>30km</td><td></td></tr>
</table>

<table>
<tr><th>150-180 km</th><th>180-210 km</th><th>210-240 km</th><th>240-270 km</th><th>270-295.7 km</th><th>Total</th></tr>
<tr><td>1.0</td><td>0.4</td><td>0</td><td>0</td><td>8.1</td><td>9.5</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>2.6</td><td>2.6</td></tr>
<tr><td>0.4</td><td>0</td><td>0</td><td>0</td><td>1.2</td><td>1.6</td></tr>
<tr><td>1.0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1.0</td></tr>
<tr><td>27.6</td><td>29.6</td><td>30.0</td><td>30.0</td><td>13.8</td><td>131.0</td></tr>
<tr><td>30km</td><td>30km</td><td>30km</td><td>30km</td><td>25.7km</td><td>295.7km</td></tr>
</table>
ii) < 1.2 m (km)
iii) 1.2 m to 1.4 m (km)
iv) 1.5 m to 1.7 m (km)
v) 1.8 m to 2.0 m (km)
vi) > 2.0 m (km)
</td></tr>
</table>

Sl. No.	Particulars	Details
c)	Cross structures i) Dams, weirs, barragesetc (total number; with navigation locks or not) ii) Bridges, Power cables etc [total number; range of horizontal and vertical clearances]	i) Cross Structures/Bridges – 14 No's. Navigation Locks - Nil Horizontal Clearance – 30-75m Vertical Clearance –5.0-9.5m(From HFL) ii) Bridges, Power cables –14No's iii) High Tension Lines –8No's iv) HTL Vertical Clearence-18m–(From HFL)
d)	Avg. discharge	7000cu.m/sec
e)	Slope (1 in ….)	1:4.94
5.	Traffic potential	Navigational traffic is present in survey stretch of Gandak River.
a)	Present IWT operations, ferry services, tourism, cargo, if any	Local boats or ferry services are available.
b)	Important industries within 50 km	Sugar Mills and Rice mills
c)	Distance of Rail & Road from Industry	20km to 50km
6.	Consultant's recommendation for going ahead with TEF / DPR preparation	Recommended or Development of waterway

Sl. No.	Particulars	Details
7.	Any other information/ comment	Local Small craft are used to run from one bank to other bank Connecting the village and logistic transportation for that area, it is run by the villagers only.

(Signature)

Date: ___ / ___ / _____ Name of Consultant

1 Introduction

1.1 Background

The **Gandak River** (also known as**Narayani** in southern Nepal and**Gandak** in India) is one of the major rivers of Nepaland a left bank tributary of the Ganges in India. River Gandak source from the border of Tibet through Nepal to India. In Nepal the river is notable for its deep gorge through the Himalayas and its enormous hydroelectric potential. It has a total catchment area of 46,300 sq.kms (approx.17,900 sq.mi), most of it in Nepal. The basin also contains three of the world's14 mountains over 8,000m(26,000 ft)Dhaulagiri, Manaslu and Annapurna 1. Dhaulagiri is the highest point of the Gandak basin. It lies between the similar Kosi system to the east and the Karnali (Ghaghara) system to the west. Total length of river is 630km. 292km is in Indian water from Valmiki nagar Barrage to Sonepur (Bihar) accept some part of the Sushta (Nepal) area. In Gandak River there are so many Kholas (seasonal runnel which bring water from hill area during the rainy seasons). On bank of Gandak River there is two national parks one is in Nepal-Chitwan national Park and second is in India-Bihar Valmikinagar National Park. These both parks are famous for Rhinoceros and Tiger. The river bed in Nepal side is also full of the shaligrama, (one type of stone which means Vishnu in hindumythology)

Valmiki Nagar Barrage- The name of Valmiki Nagar Barrage came with the great Mahatma of Ramayana Rishi Valmiki, There is a ashram of Rishi Valmiki presently in Nepal near to the barrage so the barrage was named as Valmiki Nagar Barrage. This area is also called as Bhaisalotan and other side of the river area is called as Triveni in Nepal. The barrage is constructed by the Indian Govt. during the period of our P.M. Pandit Jawaharlal Nehru with the life time agreement from the Nepal King. The agreement is that they will not stop the water of any kholas which come from the Nepal. All kholas are in Nepal only. The barrage specially was made for the irrigation purpose of the Indian part – UP and Bihar area. All canals are on the up steam of the barrage. Two bigger canals are to discharge water for India and the third one is for Nepal. Both the bigger canals are having hydroelectricity plant, one is in east canal which is handed over to Nepal after commission and the other one is in the west canal which is in Bihar, it’s maintained by the Bihar Govt.

Historical Places on bank of Gandak- Valmiki Nagar is itself is a historical Place and other side of the bank in Nepal is TriveniGhat. Valmiki Nagar Forest Reserve is famous

for the Tiger safari. Downstream after Valmiki Nagar is West Champaran, Gopalganj, Kesaria is also the nearest temple from the Gandak river, Nandan GarhLauria, Someshwar Fort, Bhitiharawa Ashram (Mahatma Gandhi) and Sonepur(Harihar Khetra) fair (mela),Asia's biggest fair.

1.2 Tributaries of Gandak River

There are no tributaries in the Gandak River in Indian Part, only diversions.

1.3 Canal of GandakRiver

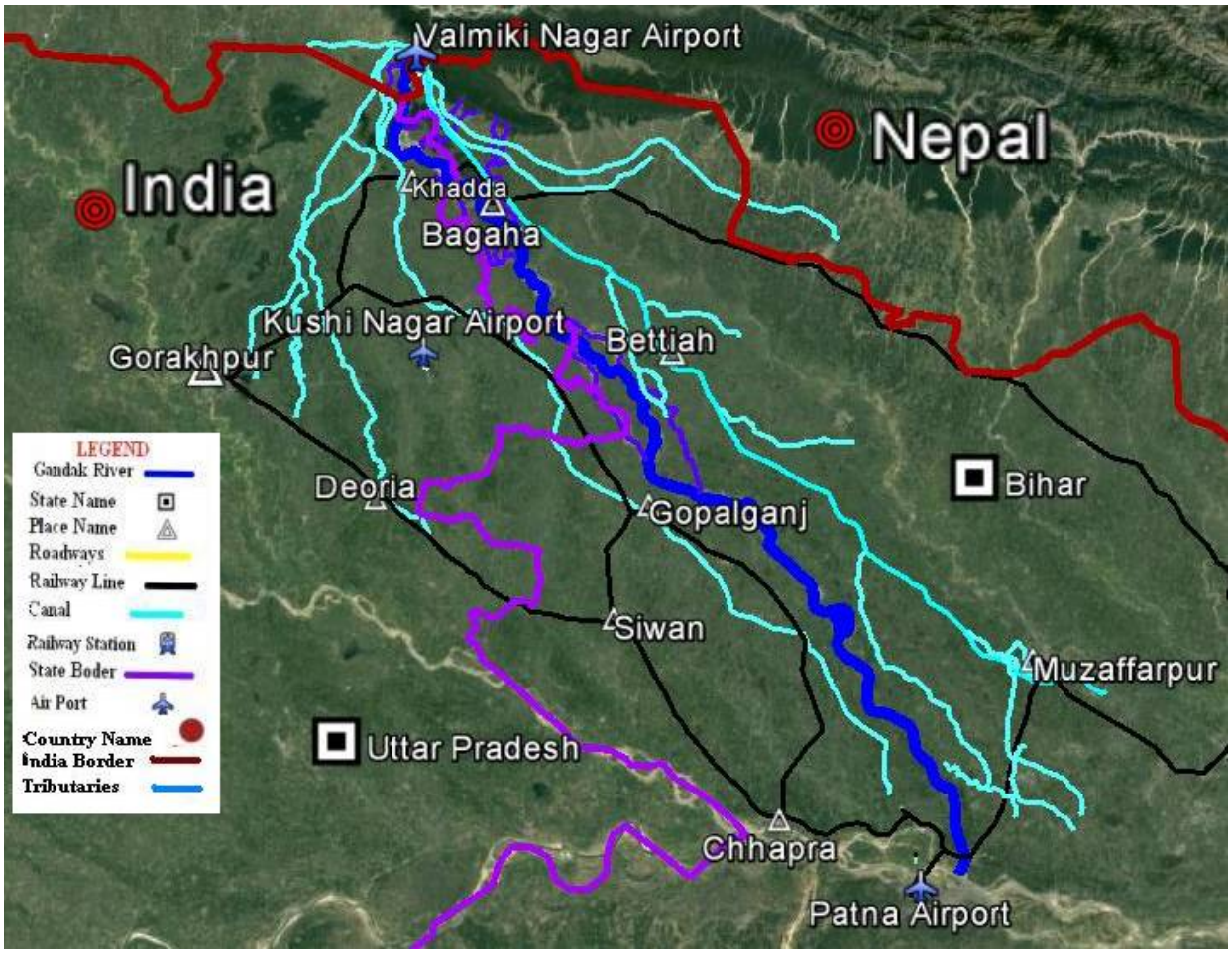


Figure 1- GandakRiver&Canals

1.4 State/District through which Gandak River passes

The Survey stretch in Gandak River Passes fromNepal toUttar Pradesh and Bihar State.

1.5 Map

1.5.1 Full course of the waterway

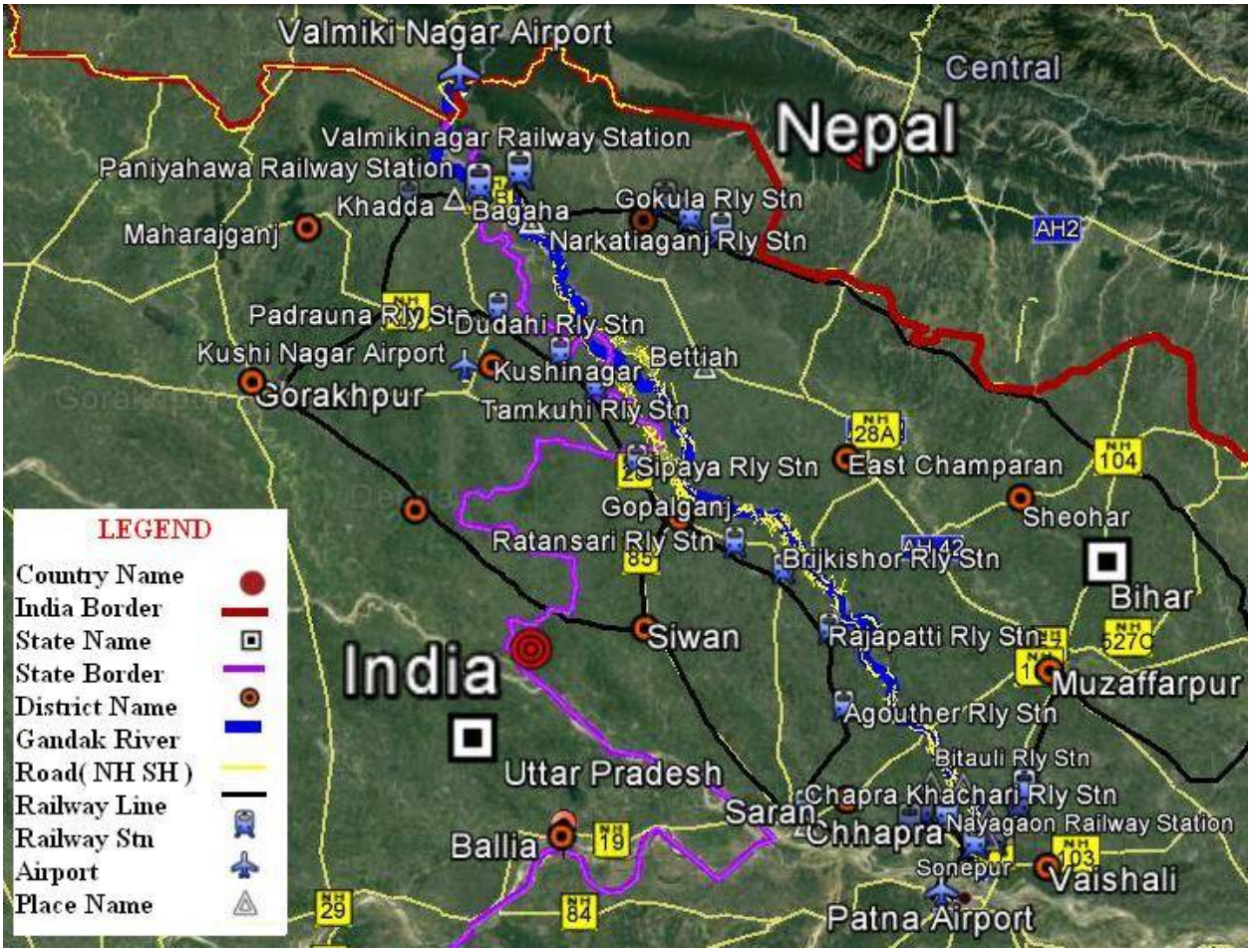


Figure 2 - Full Course of GandakRiver

1.5.2 Course of the waterway under study

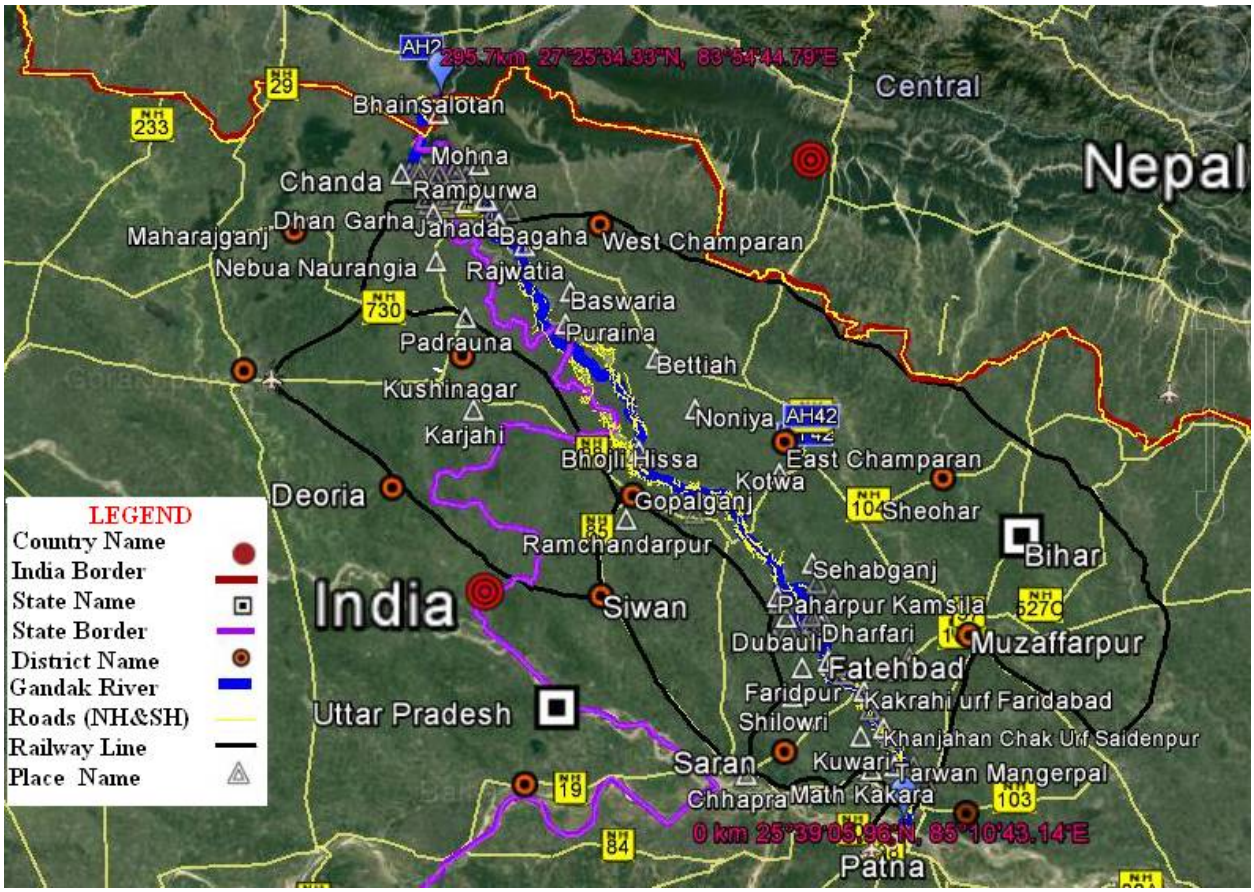


Figure 3 - Map of Gandak River

1.6 Scope of Work

The major part of the work is, to conduct detailed hydrographic survey of 295.7kms length of the Gandak river from Valmiki Nagar Barrage near TriveniGhat at Lat 27°26'22"N, Long 83°54'24"E to Gandak and Ganga rivers confluence at Hajipur Lat 25°39'18"N, Long 85°15'14"E.

Bihar (255.8km), Uttar Pradesh (33.68km)& Nepal (6.22km)

The scope of the work for undertaking Detailed Hydrographic and Topographic survey of Gandak River includes:

- Undertake hydrographic and topographic survey of proposed waterway.

- Establishing horizontal control stationsusing High precision RTK DGPS in fix mode using UHF Radio Modem with IHO accuracy standards, with minimum 24 hours observations at some permanent platform/base and vertical control station Sounding datum already established by Central Water Commission (CWC) at their gauge stations along the river also by erecting tide gauges at every 10km interval.
- BENCH MARK PILLARS - Construction of benchmark pillars (0.3mx0.3mx1.5m) RCC Pillar with 6mm thick 50mm dia GI pipe inserted, at every 10km interval. BM pillars are to be connected to MSL. Detailed description of the bench mark along with its position and value to be given in the report for future recovery. Establishing its reduced level w.r.to Mean Sea Level
- WATER LEVEL GAUGES – Water level gauges to be erected at every 10 km interval along the river. Soundings are to be reduced for datum of a gauge for 5 km length of the river on both side of a gauge. The gauges are to be connected to a nearestBMpillars by leveling and its datum value shall be established w.r.to MSL.
- WATERWAY DESCRIPTION FOR CONDUCTING HYDROGRAPHIC SURVEY – Hydrographic survey of specified waterways (295.7km length with spacing of 200m and average width 500m a total of 750.5 LKM). Average width for remaining stretches of the waterways is the average of narrow and wider portions of the river. Continuous soundings are to be taken by running the sounding boat at constant speed on the cross section, so as to get smooth contours. Intermediate line is to be run at bends if the line spacing is more than the specified above. Contractors may measure depths of shallow areas with the help of TS / RTK. The soundings are to be reduced to the chart datum established at every gauge stations.
- Current velocity and discharge measurements
- Collection and analysis of water and bottom samples.
- Collection of data other than Bathymetry and Spot levels.
- Collection of Topographical Features. Topographical surveys of proposed terminal locations 1) Vaishali 2) Kalyanpur 3) Bagaha 4)Panwaiha 5) Pitjarwa
  8) Dhanaha
- Survey chart and report preparation
- Data submission

2 Methodology Adopted

2.1 Reece

Advance Reece of the survey area was undertaken on 22April 2016. The Recee commenced from Valmiki Nagar Barrage near TriveniGhat (Downstream) to Ganga rivers confluence at Hajipur. The MSL Value of the Valmiki Nagar Barragewas obtained from the barrage pillar marked by CWC.

The Upstream portion of the Gandak River is sand and Rocky River bed with hilly lands on the river banks and the downstream of the river is densely populated. The nearest city is Bagaha situated on the right bank side of the Gandak River on downstream area. The water in the river is continuously flowing for the operation of survey boat through the entire stretch of the river.

Thick Vegetation and shrubs exists on the near river banks and beyond that the huge agriculture land. Mostly cultivation is sugar cane, paddy,wheat and maize in most part of the river plain.

2.2 Survey Resources and Methodology

The survey was commenced on 22nd Apr 2016 and completed on 20 Oct 2016. The survey was undertaken on a scale of 1:10000, with sounding line spacing kept at 200m and plotted on UTM Projection at Zone 44N and 45N as directed in the contract.

2.2.1 Survey Equipment

Equipment	Make	Eqpt. Serial No.	Qty Employed
RTK DGPS Sets	GEOMAX Zenith 10/20	-	03
Auto Level	TOPCON Auto level & Accessories	-	01
TS	Topcon, Geomax	GTS 751, Zippo 10	02
Current Meter	Virtual	-	1
Grab Sampler	Vanveen Grab	-	1
Water sampler	Water sampler	-	1
DGPS	Trimble SPS 351Differential GPS	-	1
Software	HYPACK data acquisition	Version 15	1

Equipment	Make	Eqpt. Serial No.	Qty Employed
Software	AUTOCAD	2013	1
Software	Microsoft Office	2013	1
Survey Boat	Ganga 6x2.5m		1

Table 1- Survey Equipment Used

2.2.2 Topographic Survey

The survey was commenced on 22nd Apr, 2016 and completed on 20th Oct, 2016. The weather was sunny throughout the period during survey operations between 22nd Apr 2016 to 23rd July 2016 & 1st Oct 2016 to 20th Oct 2016. The weather was favorable with moderate hot climate to the conduct of survey and the weather condition remains same for the entire duration of the survey.

The survey was undertaken as per the line plan provided and thespot level points in the cross line were spaced at 200 m interval. The plotting of the chart was done on UTM Projection at Zone 44N and 45N as directed in the contract specifications. The spot levels along the river were obtained by usingGEOMAX DGPS. The raw data was post processed using GEOMAX GEO office 3.3 to get the precise position and MSL height values of the rover locations. The topographic survey for the entire survey stretch was conducted to collect the following data:-

- Spot levels
- Delineation of Islands
- Fixing of bridges and marks
- Assess the type of river bank
- Extending the vertical and horizontal control throughout the survey area
- Collection of local information along the river Banks

The details of all spot levels are provided in the respective sheets being presented along-with this report. Additionally, a soft copy of the same in XYZ format is being handed over as deliverable data.

Figure 4- Spot leveling by DGPS

2.2.3 Bathymetric Survey and Survey Launch

The Bathymetric surveywas carried out using Survey launch Ganga inGandakRiverthroughout the stretch.

2.2.4Calibration

The equipment used for the survey was calibrated on site by the Supplier as per the specific process. Some equipment calibration certificates are placed at Annexure - 12in this report.

2.3 Description of Bench Marks/Authentic Reference Level Used

The established CWC gauges/benchmark of government organizations are available at Barrage site for the using by transferring method with RTK/DGPS for entire survey stretch of the Gandak River. The reduced level value of BM at the Valmiki Nagar Barrage was recovered as 111.252mtr(365.0 ft) from MSL as mentioned in the barrage pillar.

The reference level value is used as the initial reference for vertical control and the Reference Level value of the same was transferred to station GPS-2 through Auto Level (FlyLevelling method).The leveling data for establishing the reference Level for the newly constructed Benchmark pillars are placed at Annexure –9to this report.The final accepted WGS 84 coordinates and details of station& IWAI Benchmark established during the conduct of survey are as follows:-

Sl No	chainage	Station	Latitude	Longitude	Easting	Northing	Ht (above MSL)	Source/ Type
01	250.179	TBM−5	27°11'00.94287"N	83°58'06.30047"E	794109.424	3010252.959	093.118	S/w processed
02	295.768	GPS-2	27°26'11.51881"N	83°54'35.53564"E	787651.899	3038154.325	115.700	S/w processed
03	295.524	TBM-1	27°26'09.67473"N	83°54'26.87168"E	787415.202	3038091.971	114.862	Base line processed
04	280.168	TBM-2	27°20'21.83166"N	83°51'20.32442"E	782535.985	3027262.900	101.034	Base line processed
05	273.246	TBM-3	27°16'48.79121"N	83°52'00.93693"E	783803.404	3020728.961	97.985	Base line processed
06	256.006	TBM-4	27°13'35.64372"N	83°56'24.84837"E	791203.951	3014950.501	94.150	Base line processed
07	250.179	TBM-5	27°11'00.94286"N	83°58'06.30048"E	794109.424	3010252.959	93.118	Base line processed
08	238.005	TBM-6	27°08'16.11744"N	84°03'04.55279"E	207722.282	3005131.739	90.235	Base line processed
09	227.977	TBM-7	27°05'19.82472"N	84°06'16.38127"E	212881.486	2999580.636	86.566	Base line processed
10	211.360	TBM-8	26°58'07.15914"N	84°09'56.64891"E	218651.999	2986121.041	88.626	Base line processed
11	200.599	TBM-9	26°53'17.28190"N	84°11'38.68432"E	221268.773	2977133.402	79.438	Base line processed
12	187.632	TBM-10	26°50'10.69213"N	84°19'03.52530"E	233427.374	2971122.864	77.803	Base line processed
13	180.243	TBM-11	26°48'39.45271"N	84°22'56.36754"E	239799.874	2968179.708	76.925	Base line processed
14	169.982	TBM-12	26°44'10.51906"N	84°24'04.67809"E	241517.536	2959861.977	75.111	Base line processed
15	157.920	TBM-13	26°39'01.73218"N	84°26'58.41662"E	246129.554	2950259.316	73.176	Base line processed
16	147.133	TBM-14	26°33'57.85817"N	84°27'27.97320"E	246761.097	2940888.851	79.529	Base line processed
17	128.671	TBM-15	26°29'36.74241"N	84°35'06.25326"E	259295.076	2932605.884	68.345	Base line processed

Sl No	chainage	Station	Latitude	Longitude	Easting	Northing	Ht (above MSL)	Source/ Type
18	121.644	TBM-16	26°28'14.00634"N	84°39'06.21893"E	265894.756	2929935.966	65.887	Base line processed
19	109.775	TBM-17	26°24'35.79821"N	84°44'19.22206"E	274447.251	2923064.277	64.208	Base line processed
20	103.557	TBM-18	26°21'34.06403"N	84°44'49.31808"E	284170.204	2910107.123	66.606	Base line processed
21	92.169	TBM-19	26°17'40.34305"N	84°50'17.77513"E	284170.204	2910107.123	68.155	Base line processed
22	82.517	TBM-20	26°14'15.09683"N	84°54'53.51825"E	291717.906	2903664.873	60.674	Base line processed
22	73.197	TBM-21	26°10'12.64081"N	84°55'39.77012"E	292882.379	2896182.602	59.548	Base line processed
23	62.762	TBM-22	26°06'34.13227"N	84°57'47.65158"E	296328.308	2889401.878	58.358	Base line processed
24	48.729	TBM-23	26°00'52.01555"N	85°00'24.61190"E	300528.339	2878806.087	55.222	Base line processed
25	43.721	TBM-24	25°59'36.26206"N	85°02'59.64643"E	304804.452	2876409.82	55.476	Base line processed
26	36.434	TBM-25	25°56'09.38884"N	85°04'49.43464"E	307764.328	2869998.565	53.976	Base line processed
27	22.834	TBM-26	25°50'45.70338"N	85°09'17.82600"E	315091.877	2859930.904	52.498	Base line processed
28	12.679	TBM-27	25°45'38.19221"N	85°10'51.12057"E	317558.789	2850432.253	51.49	Base line processed
29	5.636	TBM-28	25°41'59.54684"N	85°11'49.48935"E	319093.248	2843682.066	50.802	Base line processed

Table 2 - Accepted Station coordinates (WGS-84)

2.4 Tidal Influence Zone and Tidal Variation

The survey stretch of Gandak River is non-tidal water body and no influence of tidal force was observed throughout the survey period but the discharge from the barrage use to increase/decrease the water level time to time.

2.5 Methodology to fix Chart Datum / Sounding Datum

The Gandak River is 295.7 km stretch which is between Valmiki Nagar Barrage and Gaighat, Patna. The water depth on an average of 1.2 to 10.5m is available and the water level is recorded.

2.5.1 Sounding Datum

The established CWC MSL water level values at barrage are available for the survey of Gandak River. On detailed observation and inputs from the Assistant Engineers of Barrage, in summerseason the water level on entire survey stretch of Gandak River is less as compared to monsoon season. In monsoon season there is heavy rain in the hilly areas of Nepal and in this period the water level increases in river. The Gandak River never gets dry. It is divided in 01 km stretches according to the slope of the river for dry patches, the least MSL value obtained during the conduct of Topo surveyis considered as Sounding Datum for the Dredging Volume calculations.

2.5.2 Datum Calculation

The datum for calculation of dredge volume needs to be adopted as per the gradient of the river and the average water level for the river. The slope of the Gandak River is having symmetric gradient with variation of 57.819mtrfor 295.7Km stretch. The datum for calculation of dredge volume was accepted as per Datum calculation provided by IWAI authority. The newly established Chart Datum for the stretches are as tabulated in table 5.

2.6 Average of 06 years minimum Water Levels to arrive at Chart Datum (CD)

Average of last 06 yearsminimum water level data of Gandak River is calculated to establish Sounding Datum at CWC gauges.

2.7 Transfer of Sounding Datum

The Gandak River is non-tidal river and no transfer of Sounding Datum was required.

2.8 Table indicating Tidal Variation at Different Observation Points

The survey stretch of Gandak River is non-tidal river. Level of the river depends on the discharge from the barrage.

2.9 Salient features of Dam, Barrages etc.

The details of Valmiki Nagar Barrage got from Barrage office are as tabulated in in Para 2.9.1.

2.9.1 Salient features of Valmiki Nagar Barrage

HYDRAULIC PARTICULARS OF VALMIKI NAGAR BARRAGE				
Year of construction			REGULATOR	
01	CWC water level mark at Barrage	0km	Sill Level	111.252 m
02	Catchment area of Gandak river	46,300 sq. km	No. of Vents	36nos
03	C value adopted	560	Size of Vents (Shutter)	-
04	MFD Provided	108500 cu.m/sec	Discharge	700000 cu.m/sec
05	Length	2425ft		
06	Length between abutment	18m		
07	Level of foundation	-		
	U/S cut off	115.352 m		
	D/S cut off	101.135 m		
08	Top of shutter FSL	110.100 m		
09	M.F.S U/S	-		
10	M.F.S D/S	-		
11	Level of water cushion	110.100m		
12	Level of roadway	115.352m		
13	Width of road way	8m		
14	Level of operation Platform	115.126m		
15	Ayacut	-		

Table 3- Hydraulic particulars of Valmiki Nagar Barrage

2.10Erected IWAI Benchmark Pillars

New bench Mark Pillars were constructed as per specification at suitable locations as specified in the contract. The extension of horizontal control was made by the baseline processing of 24 hourly DGPS observations carried out with the nearest reference station. The value of these benchmarks w.r.t. MSL was obtained by Auto leveling. The final accepted co-ordinates and a Reference Level value of IWAI BM Pillars are as below:

Station	Chainage (KM)	Latitude (N) Longitude (E)	Easting Northing	Height above MSL (m)	Height above CD (m)
TBM-1	295.524	27°26'09.67473"N 83°54'26.87168"E	787415.202E 3038091.971N	114.862	4.326
TBM-2	280.168	27°20'21.83166"N 83°51'20.32442"E	782535.985E 3027262.9N	101.034	3.405
TBM-3	273.246	27°16'48.79121"N 83°52'00.93693"E	783803.404E 3020728.961N	97.985	1.934
TBM-4	256.006	27°13'35.64372"N 83°56'24.84837"E	791203.951E 3014950.501N	94.150	2.031
TBM-5	250.179	27°11'00.94286"N 83°58'06.30048"E	794109.424E 3010252.959N	93.118	2.327
TBM-6	238.005	27°08'16.11744"N 84°03'04.55279"E	207722.282E 3005131.739N	90.235	2.22
TBM-7	227.977	27°05'19.82472"N 84°06'16.38127"E	212881.486E 2999580.636N	86.566	0.838
TBM-8	211.360	26°58'07.15914"N 84°09'56.64891"E	218651.999E 2986121.041N	88.626	6.687
TBM-9	200.599	26°53'17.28190"N 84°11'38.68432"E	221268.773E 2977133.402N	79.438	-0.047
TBM-10	187.632	26°50'10.69213"N 84°19'03.52530"E	233427.374E 2971122.864N	77.803	1.275
TBM-11	180.243	26°48'39.45271"N 84°22'56.36754"E	239799.874E 2968179.708N	76.925	2.081
TBM-12	169.982	26°44'10.51906"N 84°24'04.67809"E	241517.536E 2959861.977N	75.111	2.607
TBM-13	157.920	26°39'01.73218"N 84°26'58.41662"E	246129.554E 2950259.316N	73.176	3.423
TBM-14	147.133	26°33'57.85817"N 84°27'27.97320"E	246761.097E 2940888.851N	79.529	12.235
TBM-15	128.671	26°29'36.74241"N 84°35'06.25326"E	259295.076E 2932605.884N	68.345	5.092
TBM-16	121.644	26°28'14.00634"N 84°39'06.21893"E	265894.756E 2929935.966N	65.887	3.99

Station	Chainage (KM)	Latitude (N) Longitude (E)	Easting Northing	Height above MSL (m)	BM Height above sounding datum
TBM-17	109.775	26°24'35.79821"N 84°44'19.22206"E	274447.251E 2923064.277N	64.208	4.601
TBM-18	103.557	26°21'34.06403"N 84°44'49.31808"E	284170.204E 2910107.123N	66.606	8.199
TBM-19	92.169	26°17'40.34305"N 84°50'17.77513"E	284170.204E 2910107.123N	68.155	11.317
TBM-20	82.517	26°14'15.09683"N 84°54'53.51825"E	291717.906E 2903664.873N	60.674	5.03
TBM-21	73.197	26°10'12.64081"N 84°55'39.77012"E	292882.379E 2896182.602N	59.548	5.057
TBM-22	62.762	26°06'34.13227"N 84°57'47.65158"E	296328.308E 2889401.878N	58.358	5.158
TBM-23	48.729	26°00'52.01555"N 85°00'24.61190"E	300528.339E 2878806.087N	55.222	3.758
TBM-24	43.721	25°59'36.26206"N 85°02'59.64643"E	304804.452E 2876409.82N	55.476	4.632
TBM-25	36.434	25°56'09.38884"N 85°04'49.43464"E	307764.328E 2869998.565N	53.976	4.559
TBM-26	22.834	25°50'45.70338"N 85°09'17.82600"E	315091.877E 2859930.904N	52.498	6.001
TBM-27	12.679	25°45'38.19221"N 85°10'51.12057"E	317558.789E 2850432.253N	51.49	6.67
TBM-28	5.636	25°41'59.54684"N 85°11'49.48935"E	319093.248E 2843682.066N	50.802	7.321

Table 4- Accepted BM coordinates w.r.t. established CD

2.11 Chart Datum / Sounding Datum and Reductions Details

The water availability in Gandak River is suitable for the bathymetric survey by small craft, where there is less available water we conducted the Topo survey. The least MSL level for the per-Kilometer stretch was obtained as the established chart Datum. Sounding Datum at established CWC gauges was calculated as per section 2.6. The details of Topography level converted as Depth for volume calculation is forwarded as soft copy along with the report.

Sl#	Location of CWC gauge / Dam / Barrage / Weir / Anicut / Bench Mark / tide gauges	Chainage (km)	Stretch for corrected soundings and topography levels (km)	Established Sounding Datum w.r.t. MSL (m) at col. A.	Sounding Datum of Tide Gauge w.r.t. MSL (m)	Correction in WL data for Bathymetric survey (m)	Topography level data converted as depth for volume calculation w.r.t. SD (m)
	A	B	C	D +veindicates above MSL -ve indicates below MSL	E	F = (E- WL data in MSL)	G = (E- topo levels in MSL)
1	Triveni			103.832		Details at Annexure-3	A separate xyz file is created and forwarded in digital format.
2	D/S BARRAGE						
3	TBM-1	295.524	287.8-295.6		101.130		
4	TBM-2	280.168	276.7-287.8		97.629		
5	TBM-3	273.246	264.6-276.7		96.051		
6	Khadda	257.127		92.375			
7	TBM-4	256.006	253.0-264.6		92.119		
8	TBM-5	250.179	244.1-253.1		90.791		
9	TBM-6	238.005	233.0-244.1		88.015		
10	TBM-7	227.977	219.7-233.0		85.728		
11	TBM-8	211.360	206.0-219.7		81.939		
12	TBM-9	200.599	194.1-206.0		79.485		
13	TBM-10	187.632	183.9-194.1		76.528		
14	TBM-11	180.243	175.1-183.9		74.844		
15	TBM-12	169.982	164.0-175.1		72.504		
16	TBM-13	157.920	152.5-164.0		69.753		
17	TBM-14	147.133	137.9-152.5		67.294		
18	Chatia	133.500		64.185			
19	TBM-15	128.671	125.2-137.9		63.253		
20	TBM-16	121.644	115.7-125.2		61.897		
21	TBM-17	109.775	106.7-115.7		59.607		
22	TBM-18	103.557	97.9-106.7		58.407		
23	Dumariaghat	101.248		57.960			
24	TBM-19	92.169	87.3-97.9		56.838		
25	TBM-20	82.517	77.9-87.3		55.644		

Sl#	Location of CWC gauge / Dam / Barrage / Weir / Anicut / Bench Mark / tide gauges	Chainage (km)	Stretch for corrected soundings and topography levels (km)	Established Sounding Datum w.r.t. MSL (m) at col. A.	Sounding Datum of Tide Gauge w.r.t. MSL (m)	Correction in WL data for Bathymetric survey (m)	Topography level data converted as depth for volume calculation w.r.t. SD (m)
	A	B	C	D +veindicates above MSL -ve indicates below MSL	E	F = (E- WL data in MSL)	G = (E- topo levels in MSL)
26	**TBM-21**	73.197	68.0-77.9		**54.491**		
27	**TBM-22**	62.762	55.7-68.0		**53.200**		
28	**TBM-23**	48.729	46.2-55.7		**51.464**		
29	**TBM-24**	43.721	40.0-46.2		**50.844**		
30	**Rewaghat**	42.215		50.658			
31	**TBM-25**	36.434	29.6-40.0		**49.417**		
32	**TBM-26**	22.834	17.8-29.6		**46.497**		
33	**Lalganj**	21.145		46.134			
34	**TBM-27**	12.679	9.2-17.8		**44.820**		
35	**Hajipur (Seasonal)**	6.544		43.867			
36	**TBM-28**	5.636	0.0-9.2		**43.481**		
37	**Gandhi Ghat (959.5)**	0.000		41.083			

Table 5- Chart Datum / Sounding Datum of Tide Gauge w.r.t. MSL at TBMs

2.12 HFL values of Bridges/Cross Structures

The established HFL value of 110.100m w.r.t MSL for the Valmiki Nagar barrage was provided by Barrage office. The details of established and computed HFL values for the entire stretch are as follows:-

Sl#	Location and description of CWC gauge / Dam / Barrages / Weirs / Anicut / Locks / Aqueducts / BM	Cross-structure details	Chainage (km)	Established HFL w.r.t. MSL (m)	Computed HFL at Cross-Structures w.r.t. MSL (m)
	A	**B**	**C**	**D**	**E**
1	Panwahia	Bridge	256.006	93.06	93.06
2	Mangalpur (damaged/abundant)	Bridge	240.121	-	-
3	Paya pool Bagaha (abundant)	Bridge	236.500	-	-
4	Dhanaha	Bridge	210.630	-	84.30
5	Mangalpur	Bridge	147.551	-	72.80
6	Dumriya	Bridge	103.49	63.6	63.60
7	Sunder (proposed)	Bridge	92.0	-	-
8	Matiari (proposed)	Bridge	82.7	-	-
9	Rewaghat	Bridge	43.58	55.41	55.41
10	Sonnagar (proposed)	Bridge	5.66	-	-
11	Sonnagar	Bridge	5.50	50.2	50.20
12	Sonnagar (rail)	Bridge	4.88	50.2	50.20
13	Railway	Bridge	4.85	50.2	50.20
14	Hajipur	Bridge	4.77	50.2	50.20

Table 6 – HFL values of Bridges/Cross Structures

2.13 Graph: Sounding Datum and HFL vs Chainage

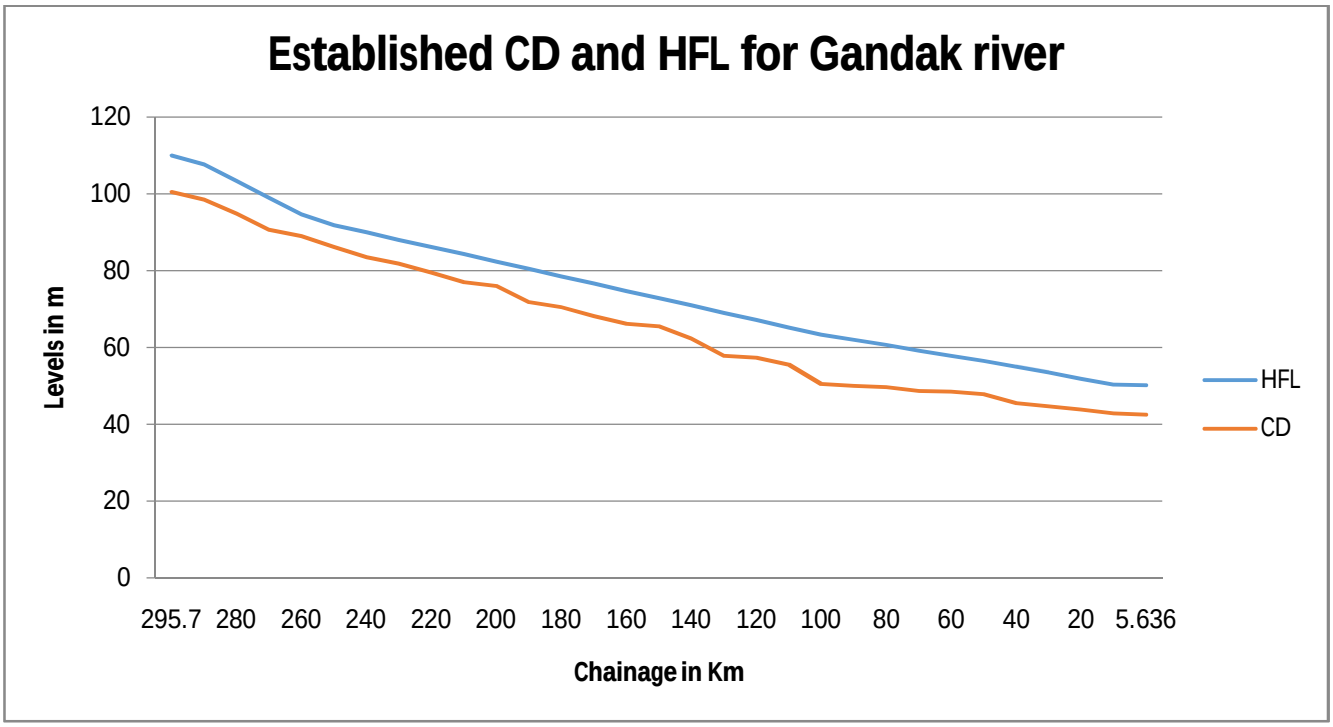


Figure 5- CD and HFL vs Chainage

2.14 Average Bed Slope

The average bed slope for the Gandak river is as follows:-

Chainage (km)		Avg. River Bed Level in (m)	Distance (km)	Slope
From	To			
0	5.636	1.207	5.636	1:4.6
5.636	12.679	1.267	7.043	1:5.5
12.679	22.834	0.75	10.155	1:13.5
22.834	36.434	1.64	13.600	1:8.3
36.434	43.721	1.061	7.287	1:6.9
43.721	48.937	0.974	5.216	1:5.34
48.937	62.515	1.911	13.578	1:7.14
62.515	73.197	1.143	10.682	1:9.35
73.197	82.773	1.124	9.576	1:8.5
82.773	92.332	2.683	9.559	1:3.6
92.332	103.557	0.859	11.388	1:13.3
103.557	109.775	1.136	6.218	1:5.5
109.775	121.644	1.562	11.869	1:7.6
121.644	128.671	2.237	7.027	1:3.14
128.671	147.133	4.039	18.462	1:4.6
147.133	157.920	0.787	10.787	1:13.8
157.920	169.982	3.518	12.062	1:3.43
169.982	180.243	1.404	10.261	1:7.35
180.243	187.632	1.18	7.389	1:6.29
187.632	200.599	3.697	12.967	1:3.5
200.599	211.360	2.514	10.761	1:4.29
211.360	227.977	1.895	16.617	1:8.77
227.977	238.005	4.579	10.028	1:2.19
238.005	250.179	0.873	12.174	1:14.0
250.179	256.006	2.261	5.827	1:2.57
256.006	273.246	3.674	17.240	1:4.69
273.246	280.168	2.821	6.922	1:2.45
280.168	295.524	7.052	15.356	1:1.89

Table 7 - Average Bed Slope

2.15 Details of Bridge, Dam, Barrages, Weirs, Anicut, etc

Sl No	Structure Name	Chainage (km)	Location	Position (Lat Long)	Position (UTM)	Length (m)	Width (m)	Height w.r.t. MSL (m)	Present condition
1	Panwahia bridge	256.006	Panwahia	**Left Bank:** 27°10'43.73"N 83°57'41.33"E **Right Bank:** 27°11'03.663"N 83°58'05.0963E	**Left Bank:** 3009705.779N 793433.410E **Right Bank:** 3010335.93 N 794074.28E	900	9.1	100.94	Operational Connecting Bihar and UP
2	Mangalpur (damaged/abandon)	240.121	Mangalpur	**Left Bank:** damaged **Right Bank:** 27°09'30.4963N 84°02'38.5231E	**Left Bank:** damaged **Right Bank:** 3007422.21N 207153.80E	97.19	9.45	-	Abundant due to damage of approach road/increase of river width.
3	Paya pool Bagaha (abundant)	236.500	Paya pool Bagaha	**Left Bank:** 27°07'32.94"N 84°02'28.24"E **Right Bank:** 27°07'36.21"N 84°02'49.12"E	**Left Bank:** 3003825.66N 206690.68E **Right Bank:** 3003912.86N 207268.35E	-	-	-	Only pillar remaining it's a very old structure
4	Dhanaha bridge	210.630	Dhanaha	**Left Bank:** 26°57'10.04"N 84°09'32.60"E **Right Bank:** 26°58'06.07"N 84°09'55.43"E	**Left Bank:** 2984377.43N 217949.07E **Right Bank:** 2986088.11N 218671.50E	1853	9	91.7	Operational, connecting UP and Bihar.
5	Mangalpur bridge	147.551	Mangalpur	**Left Bank:** 26°33'53.79"N 84°26'17.80"E **Right Bank:** 26°33'57.18"N 84°27'16.26"E	**Left Bank:** 2940802.19N 244816.16E **Right Bank:** 2940874.49N 246436.56E	1620	10.5	79.02	Operational, it's in Bihar only connecting two districts.
6	Dumriya bridge	103.49	Dumriya	**Left Bank:** 26°21'35.81"N 84°44'47.44"E **Right Bank:** 26°21'51.46"N 84°45'10.99"E	**Left Bank:** 2917510.87N 275132.53 E **Right Bank:** 2917981.23N 275793.77 E	810.3	7.8	70.6	Operational it's in Bihar

Sl No	Structure Name	Chainage (km)	Location	Position (Lat Long)	Position (UTM)	Length (m)	Width (m)	Height w.r.t. MSL (m)	Present condition
7	Sunder bridge (proposed)	92	Sunder	**Left Bank:** 26°17'04.63"N 84°49'35.17"E **Right Bank:** 26°17'39.08"N 84°50'18.85"E	**Left Bank:** 2909027.84N 282969.65E **Right Bank:** 2910067.63N 284199.35E	-	-	-	Under Construction
8	Matiari bridge (proposed)	82.7	Matiari	**Left Bank:** 26°13'42.24"N 84°52'20.53"E **Right Bank:** 26°14'14.41"N 84°52'36.04"E	**Left Bank:** 2902722.61N 287455.16E **Right Bank:** 2904553.61N 287915.86E	-	-	-	Under Construction
9	Rewaghat	43.58	Rewa	**Left Bank:** 25°59'07.80"N 85°02'43.81"E **Right Bank:** 25°59'35.51"N 85°02'58.20"E	**Left Bank:** 2875540.54N 304351.01E **Right Bank:** 2876387.37N 304763.87E	940	9	60.4	Operational it's in Bihar only.
10	Sonepurbridge (proposed)	5.66	Sonepur	**Left Bank:** 25°42'00.39"N 85°11'18.56"E **Right Bank:** 25°41'58.83"N 85°11'49.90"E	**Left Bank:** 2843719.85N 318231.43E **Right Bank:** 2843659.80N 319104.26E	-	-	-	Under Construction
11	Sonepur bridge	5.50	Sonepur	**Left Bank:** 25°41'59.76"N 85°11'54.52"E **Right Bank:** 25°41'58.01"N 85°11'49.85"E	**Left Bank:** 2843686.69N 318233.54E **Right Bank:** 2843634.61N 319102.61E	876	8	58.9	Operational it's in Bihar
12	Sonepurbridge (rail) u/s	4.88	Sonepur	**Left Bank:** 25°41'33.83"N 85°11'20.08"E **Right Bank:** 25°41'34.35"N 85°11'47.40"E	**Left Bank:** 2842902.04N 318262.4E **Right Bank:** 2842907.69N 319024.39E	761	7	54.2	Rail Bridge it's in Bihar.
13	Sonepur bridge (rail) d/s	4.85	Sonepur	**Left Bank:** 25°41'32.71"N 85°11'20.83"E **Right Bank:** 25°41'33.20"N 85°11'46.73"E	**Left Bank:** 2842867.34N 318282.92E **Right Bank:** 2842872.43N 319005.16E	723	7	54.2	Rail Bridge it's in Bihar

Sl No	Structure Name	Chainage (km)	Location	Position (Lat Long)	Position (UTM)	Length (m)	Width (m)	Height w.r.t. MSL (m)	Present condition
14	Hajipur bridge	4.77	Hajipur	**Left Bank:** 25°41'30.25"N 85°11'21.84"E **Right Bank:** 25°41'30.54"N 85°11'46.41"E	**Left Bank:** 2842791.19N 318310.07E **Right Bank:** 2842790.80N 318995.27E	685	5.1	53.5	Operational it's in Bihar.

Table 8 Cross Structures w.r.t. MSL

2.16 Details of Locks

There are no Locks present in the entire survey stretch of Gandak river.

2.17 Details of Aqueducts

There are no Aqueducts present in the survey stretch of Gandak river.

2.18 Details of existing Bridges and Crossings over Waterway

Sl #	Structure Name and for road / rail	Chainage (km)	Type of Structure (RCC / Iron / Wooden)	Location	Position (Lat Long)	Position (UTM)	Length (m)	Width (m)	No of Piers	Horizontal clearance (clear distance Between piers) (m)	Vertical clearance w.r.t. HFL (m)	Remarks (complete / under - construction), in use or not, condition
					Left Bank Right Bank	Left Bank Right Bank						
1	Panwahia bridge	256.006	RCC	Panwahia	**Left Bank:** 27°10'43.73"N 83°57'41.33"E **Right Bank:** 27°11'03.663"N 83°58'05.0963"E	**Left Bank:** 3009705.779 N 793433.410E **Right Bank:** 3010335.93N 794074.28E	900	9.1	14	64	9.47	Operational
2	Mangalpur (damaged/abandoned)	240.121	RCC	Mangalpur	**Left Bank:** Damaged **Right Bank:** 27°09'30.4963"N 84°02'38.5231"E	**Left Bank:** Damaged **Right Bank:** 3007422.21N 207153.80E	-	-	5	-	-	abandoned
3	Paya pool Bagaha (abundoned)	236.500	RCC	Paya pool	**Left Bank:** 27°07'32.94"N 84°02'28.24"E **Right Bank:** 27°07'36.21"N 84°02'49.12"E	**Left Bank:**3003825.66N 206690.68E **Right Bank:**3003912.86N 207268.35E	-	-	5	-	-	Only pillar
4	Dhanaha bridge	210.630	RCC	Dhanaha	**Left Bank:** 26° 57'10.04"N 84°09'32.60"E **Right Bank:** 26° 58'06.07"N 84°09'55.43"E	**Left Bank:** 2984377.43N 217949.07E **Right Bank:** 2986088.11N 218671.50E	1853	9	41	44.5	6	Operational
5	Mangalpur bridge	147.551	RCC	Mangalpur	**Left Bank:** 26°33'53.79"N 84°26'17.80"E **Right Bank:** 26°33'57.18"N 84°27'16.26"E	**Left Bank:** 2940802.19N 275132.53 E **Right Bank:** 2940874.49N 246436.56E	1620	10.5	14	55	6	Operational
6	Dumriyabridge	103.49	RCC	Dumriya	**Left Bank:** 26°21'51.46"N 84°45'10.99"E **Right Bank:** 26°21'51.46"N 84°45'10.99"E	**Left Bank:** 2917510.87N 275132.53 E **Right Bank:** 2917981.23N 275793.77 E	810.3	7.8	8	55	6	Operational
7	Sunder bridge (proposed)	92	RCC	Sunder	**Left Bank:** 26°17'04.63"N 84°50'18.85"E **Right Bank:** 26°17'39.08"N 84°50'18.85"E	**Left Bank:** 2909027.84N 282969.65E **Right Bank:** 2910067.63N 284199.35E	-	-	-	-	-	Under Construction

Sl #	Structure Name and for road / rail	Chainage (km)	Type of Structure (RCC / Iron / Wooden)	Location	Position (Lat Long)	Position (UTM)	Length (m)	Width (m)	No of Piers	Horizontal clearance (clear distance Between piers) (m)	Vertical clearance w.r.t. HFL (m)	Remarks (complete / under - construction), in use or not, condition
					Left Bank Right Bank	Left Bank Right Bank						
8	Matiari bridge (proposed)	82.7	RCC	Matiari	**Left Bank:** 26° 13'42.24"N 84°52'20.53"E **Right Bank:** 26° 14'14.41"N 84°52'36.04"E	**Left Bank:** 2902722.61N 287455.16E **Right Bank:** 2904553.61N 287915.86E	-	-	-	-	-	Damaged
9	Rewaghat bridge	43.58	RCC	Rewaghat	**Left Bank:** 25°59'07.80"N 85°02'43.81"E **Right Bank:** 25°59'35.51"N 85°02'58.20"E	**Left Bank:** 2875540.54N 304351.01E **Right Bank:** 2876387.37N 304763.87E	940	9	27	40	5	Operational
10	Sonepur bridge (proposed)	5.66	RCC	Sonepur	**Left Bank:** 25°42'00.39"N 85°11'18.56"E **Right Bank:** 25°41'58.83"N 85°11'49.90"E	**Left Bank:** 2843719.85N 318231.43E **Right Bank:** 2843659.80N 319104.26E	-	-	14	-	-	Under Construction
11	Sonepur bridge	5.50	RCC	Sonepur	**Left Bank:** 25°41'59.76"N 85°11'54.52"E **Right Bank:** 25°41'58.01"N 85°11'49.85"E	**Left Bank:** 2843634.61N 318233.54E **Right Bank:** 2843634.61N 319102.61E	876	8	27	30	8	Operational
12	Sonepur bridge (rail) u/s	4.88	RCC	Sonepur	**Left Bank:** 25°41'33.83"N 85°11'20.08"E **Right Bank:** 25°41'34.35"N 85°11'47.40"E	**Left Bank:** 2842902.04N 318262.4E **Right Bank:** 2842907.69N 319024.39E	761	7	9	75	7	Rail Bridge
13	Sonepur bridge (rail) d/s	4.85	RCC	Sonepur	**Left Bank:** 25° 41'32.71"N 85°11'20.83"E **Right Bank:** 25° 41'33.20"N 85°11'46.73"E	**Left Bank:** 2842867.34N 318282.92E **Right Bank:** 2842872.43N 319005.16E	723	7	9	75	7	Rail Bridge
14	Hajipur bridge	4.77	RCC	Hajipur	**Left Bank:** 25°41'30.25"N 85°11'21.84"E **Right Bank:** 25°41'30.54"N 85°11'46.41"E	**Left Bank:** 2842791.19N 318310.07E **Right Bank:** 2842790.80 318995.27	685	5.1	7	75	7	Operational

Table 9 - Details of cross structures

2.19 Details of other Cross structures, pipe-lines, underwater cables

There are no Pipe lines, under water cable present in the entire survey stretch of Gandak River. Cross structure like Pipa Pull is present in the Gandak during the survey period.

S. No.	Position (Lat Long)	Position (UTM)	Location
01	26°48'39.45271"N 84°22'56.36754"E	239799.874E 2968179.708N	Pitjarwa, Bihar

2.20 High Tension Lines / Electric lines / Tele-communication lines

Total of 8 High Tension electrical lines were also present in the Gandak River and the height of the high tension line were also measured by ETS.There are2 piers for electrical lines constructed in 3 places and 1 pier in 2 places of the river bed of Gandak River.

Sl No	Type of line	Chainage (km)	Location	Position (Lat Long)	Position (UTM)	No of Piers	Horizontal clearance (clear distance Between piers) (m)	Vertical clearance w.r.t. HFL (m)	Remarks (complete / under - construction)
				Left Bank Right Bank	Left Bank Right Bank				
1	HTL	295.404	Tribeni barrage	**Left Bank:** 27°26'34.63"N 83°54'16.21"E **Right Bank:** 27°24'46.35"N 84°49'32.47"E	**Left Bank:** 787104.34E 3038853.51N **Right Bank:** 787333.05E 3037987.28N	-	860	18	Complete
2	HTL	127.8	loknathpur	**Left Bank:** 26°28'37.47"N 84°35'32.89"E **Right Bank:** 26°28'53.99”N 84°35'37.38”E	**Left Bank:** 259998.62E 2930767.5N **Right Bank:** 260132.46E 2931273.76N	2	524	9	Complete
3	HTL	127.7	loknathpur	**Left Bank:** 26°28'37.72"N 84°35'35.68"E **Right Bank:** 26°28'54.10”N 84°35'40.60”E	**Left Bank:** 260076.06E 2930773.68N **Right Bank:** 260221.66E 2931275.54N	2	523	9	Complete

Sl No	Type of line	Chainage (km)	Location	Position (Lat Long)	Position (UTM)	No of Piers	Horizontal clearance (clear distance Between piers) (m)	Vertical clearance w.r.t. HFL (m)	Remarks (complete / under - construction)
				Left Bank Right Bank	Left Bank Right Bank				
				Left Bank Right Bank	Left Bank Right Bank				
4	HTL	119.310	salempur	**Left Bank:** 26°28'37.72"N 84°35'35.68"E **Right Bank:** 26°28'54.10"N 84°35'40.60"E	**Left Bank:** 268215.63E 2929542.93N **Right Bank:** 268472.76E 2930116.85N	2	628	8	Complete
5	HTL	103.330	Dumriya u/s	**Left Bank:** 26°21'40.19"N 84°44'32.56"E **Right Bank:** 26°21'51.29"N 84°44'51.01"E	**Left Bank:** 274722.16E 2917652.96N **Right Bank:** 275239.62E 2917985.59N	1	619	14	Complete
6	HTL	103.420	Dumriya d/s	**Left Bank:** 26°21'30.75"N 84°44'49.22"E **Right Bank:** 26°21'39.97"N 84°45'03.10"E	**Left Bank:** 275178.97E 2917354.22N **Right Bank:** 275568.76E 2917631.21N	-	477	14	Complete
7	HTL	59.8	Fathiabad	**Left Bank:** 26°04'59.97"N 84°57'41.49"E **Right Bank:** 26°04'51.61"N 84°58'03.02"E	**Left Bank:** 296111.77E 2886506.75N **Right Bank:** 296706.08E 2886240.11N	1	654	15	Complete
8	HTL	34.15	Murahi	**Left Bank:** 25°54'59.07"N 85°05'03.34"E **Right Bank:** 25°55'07.73"N 85°05'22.25"E	**Left Bank:** 308119.61E 2867828.92N **Right Bank:** 308649.74E 2868087.91N	-	590	15	Complete

Table 10 - High Tension Lines Details

2.21 Current Meter and Discharge Details

Virtual Velocity meterInstrument was used to log the flow rates of the river. The locations of current meter deployment are as follows:

Stretch No.	Chainage (km)	Latitude Longitude	Easting Northing (m)	Obs. Depth (m) (D)	Velocity (m/sec.) 0.5 D	Avg. Vel. (m/sec.)	X-Sectional area (sq. m.)	Discharge (Cu.m/sec)
1	0	25°39'05.96"N 85°10'43.14"E	2838365.94N 317169.80E	3.6	1.0	0.9	1102	991.8
2	5.636	25°41'51.22"N 85°11'39.40"E	2843429.83N 318808.55E	3.0	1.0	0.9	737	663.3
3	12.679	25°45'37.16"N 85°10'20.92"E	2850412.15N 316716.9E	3.4	0.9	0.8	273	341.25
4	22.834	25°50'34.57"N 85°09'17.62"E	2859588.44N 315081.21E	4.2	0.9	0.8	272	340.0
5	36.434	25°56'07.94"N 85°04'47.24"E	2869954.86N 307702.62E	3.2	0.9	0.9	402	446.7
6	43.721	26°59'12.95"N 85°02'48.48"E	2875697.19N 304483.22E	2.6	0.9	0.8	394	492.5
7	48.729	26°00'39.45"N 85°00'08.25"E	2878426.43N 300067.41E	3.4	0.9	0.8	273	341.25
8	62.762	26°06'30.91"N 84°57'50.35"E	2889301.68N 296401.72E	3.0	1.0	0.9	737	663.3
9	73.197	26°10'08.64"N 84°53'46.37"E	2896110.09E 289731.18E	3.1	0.9	0.8	281.4	351.75
10	82.517	26°14'09.81"N 84°54'51.20"E	2903503.16N 291650.93E	3.0	1.0	0.9	440.5	489.5
11	92.169	26°17'27.28"N 84°49'49.31"E	2909718.29N 283373.87E	5.0	0.9	0.8	384	480.0
12	103.557	26°21'36.92"N 84°44'50.99"E	2917543.25N 275231.48E	4.0	0.9	0.8	259	323.75
13	109.775	26°24'27.29"N 84°44'02.24"E	2922810.7N 2 73972.06E	3.1	0.9	0.8	281.4	351.75
14	121.644	26°28'05.08"N 84°43'55.67"E	2929517.17N 265908.07E	4.0	0.8	0.7	326	465.71
15	128.671	26°28'51.94"N 84°34'58.49"E	2931231.04N 259054.16E	3.0	0.8	0.7	658	941.2
16	147.133	26°33'53.87"N 84°26'35.08"E	2940795.15N 245294.57E	2.8	0.8	0.7	443.5	633.571
17	157.920	26°39'03.82"N 84°26'55.08"E	2950325.52N 246038.71E	3.0	0.8	0.8	96	120
18	169.982	26°44'07.40"N 84°24'05.17"E	2959765.7N 241529.19E	3.1	0.8	0.7	169	241.42
19	180.243	26°48'35.49"N 84°22'56.04"E	2968057.81N 239788.28E	3.0	0.8	0.7	125	178.57
20	187.632	26°50'19.19"N 84°17'43.18"E	2971431.48N 231214.08E	1.9	0.7	0.6	90	150

Stretch No.	Chainage (km)	Latitude Longitude	Easting Northing (m)	Obs. Depth (m) (D)	Velocity (m/sec.) 0.5 D	Avg. Vel. (m/sec.)	X-Sectional area (sq. m.)	Discharge (Cu.m/sec)
21	200.599	26°53'12.01"N 84°11'35.31"E	2976973.06N 221171.96E	1.5	0.8	0.7	604	862.85
22	211.360	26°58'06.17"N 84°09'49.08"E	2986095.28N 218442.63E	2.4	0.8	0.7	379.4	542
23	227.977	27°05'16.57"N 84°06'12.53"E	2999482.86N 212773.14E	1.0	0.7	0.6	435	621.43
24	238.005	27°08'12.25"N 84°03'00.58"E	3005015.32N 207609.98E	2.4	0.7	0.6	167	278.33
25	250.179	27°10'49.64"N 83°57'44.98"E	3009891.05N 793530.62E	1.0	0.7	0.6	572.8	954.66
26	256.006	27°13'40.40"N 83°49'37.42"E	3014838.62N 791272.176E	1.0	0.6	0.5	363.4	726.8
27	273.246	27°16'41.88"N 83°49'42.03"E	3020429.11N 779986.76E	1.0	0.6	0.5	312.3	624.6
28	280.168	27°20'21.46"N 83°51'11.48"E	3027245.75N 782293.09E	1.5	0.6	0.5	353	706
29	295.524	27°26'14.30"N 83°54'24.75"E	3038232.88 N 787353.46E	1.0	0.6	0.5	336	672

Table 11- Current meter deployment locations

The collected data is forwarded as deliverable data along with this report.

2.22 Soil and Water Sample Locations

a) Soil Samples

River bed soil and water sampling was undertaken for the suitable locations evenly distributed throughout the Gandak River Stretch. The Vanveen grab and Naskin water bottles were kept standby for the collections of samples. The details of soil and water sample locations are as follows:-

Sample No.	Chainage (km)	Latitude	Longitude	Easting (m)	Northing (m)	Depth (m)
1	295.524	27°26'14.30"N	83°54'24.75"E	787353.46	3038232.88	1
2	280.168	27°20'21.46"N	83°51'11.48"E	782293.09	3027245.75	1.5
3	273.246	27°16'41.88"N	83°49'42.03"E	779986.76	3020429.11	1.0
4	256.006	27°13'40.40"N	83°49'37.42"E	791272.176	3014838.62	1.0
5	250.179	27°10'49.64"N	83°57'44.98"E	793530.62	3009891.05	1.0

Sample No.	Chainage (km)	Latitude	Longitude	Easting (m)	Northing (m)	Depth (m)
6	238.005	27°08’12.25”N	84°03'00.58”E	207609.98	3005015.32	2.4
7	227.977	27°05’16.57”N	84°06'12.53”E	212773.14	2999482.86	1.0
8	211.360	26°58’06.17”N	84°09'49.08”E	218442.63	2986095.28	2.4
9	200.599	26°53’12.01”N	84°11'35.31”E	221171.96	2976973.06	1.4
10	187.632	26°50’19.19”N	84°17'43.18”E	231214.08	2971431.48	1.9
11	180.243	26°48’35.49”N	84°22'56.04”E	239788.28	2968057.81	3.0
12	169.982	26°44’07.40”N	84°24'05.17”E	241529.19	2959765.7	3.0
13	157.920	26°38’59.30”N	84°26’59.99”E	246171.46	2950183.61	3.0
14	147.133	26°33’53.87”N	84°26'35.08”E	245294.57	2940795.15	2.8
15	128.671	26°28’51.94”N	84°34'58.49”E	259054.16	2931231.04	3.0
16	121.644	26°28’05.08”N	84°43'55.67”E	265908.07	2929517.17	4.0
17	109.775	26°24’27.29”N	84°44'02.24”E	273972.06	2922810.7	3.1
18	103.557	26°21’36.92”N	84°44'50.99”E	275231.48	2917543.25	4.0
19	92.169	26°17’27.28”N	84°49'49.31”E	283373.87	2909718.29	5.0
20	82.517	26°14’09.81”N	84°54'51.20”E	291650.93	2903503.16	3.0
21	73.197	26°10’08.64”N	84°53'46.37”E	289731.18	2896110.09	4.0
22	62.762	26°06’30.91”`N	84°57'50.35”E	296401.72	2889301.68	2.6
23	48.729	26°00’39.45”N	85°00'08.25”E	300067.41	2878426.43	3.2
24	43.721	26°59’12.95”N	85°02'48.48”E	304483.22	2875697.19	4.2
25	36.434	25°56’07.94”N	85°04'47.24”E	307702.62	2869954.86	4.0
26	22.834	25°50’34.57”N	85°09'17.62”E	315081.21	2859588.44	4.0
27	12.679	25°45’37.16”N	85°10'20.92”E	316716.9	2850412.15	4.2
28	5.636	25°41’51.22”N	85°11'39.40”E	318808.55	2843429.83	3.4
29	0.000	25°39’05.96”N	85°10'43.14”E	317169.8	2838365.94	3.4

Table 12 – Soil Sampling Locations

b) Water Sample Locations

Sample No.	Chainage (km)	Latitude	Longitude	Easting (m)	Northing (m)	Depth (m)
1	295.524	27°26'14.30"N	83°54'24.75"E	787353.46	3038232.88	1
2	280.168	27°20'21.46"N	83°51'11.48"E	782293.09	3027245.75	1.5
3	273.246	27°16'41.88"N	83°49'42.03"E	779986.76	3020429.11	1.0
4	256.006	27°13'40.40"N	83°49'37.42"E	791272.176	3014838.62	1.0
5	250.179	27°10'49.64"N	83°57'44.98"E	793530.62	3009891.05	1.0
6	238.005	27°08'12.25"N	84°03'00.58"E	207609.98	3005015.32	2.4
7	227.977	27°05'16.57"N	84°06'12.53"E	212773.14	2999482.86	1.0
8	211.360	26°58'06.17"N	84°09'49.08"E	218442.63	2986095.28	2.4
9	200.599	26°53'12.01"N	84°11'35.31"E	221171.96	2976973.06	1.4
10	187.632	26°50'19.19"N	84°17'43.18"E	231214.08	2971431.48	1.9
11	180.243	26°48'35.49"N	84°22'56.04"E	239788.28	2968057.81	3.0
12	169.982	26°44'07.40"N	84°24'05.17"E	241529.19	2959765.7	3.0
13	157.920	26°38'59.30"N	84°26'59.99"E	246171.46	2950183.61	3.0
14	147.133	26°33'53.87"N	84°26'35.08"E	245294.57	2940795.15	2.8
15	128.671	26°28'51.94"N	84°34'58.49"E	259054.16	2931231.04	3.0
16	121.644	26°28'05.08"N	84°43'55.67"E	265908.07	2929517.17	4.0
17	109.775	26°24'27.29"N	84°44'02.24"E	273972.06	2922810.7	3.1
18	103.557	26°21'36.92"N	84°44'50.99"E	275231.48	2917543.25	4.0
19	92.169	26°17'27.28"N	84°49'49.31"E	283373.87	2909718.29	5.0
20	82.517	26°14'09.81"N	84°54'51.20"E	291650.93	2903503.16	3.0
21	73.197	26°10'08.64"N	84°53'46.37"E	289731.18	2896110.09	4.0
22	62.762	26°06'30.91"N	84°57'50.35"E	296401.72	2889301.68	2.6
23	48.729	26°00'39.45"N	85°00'08.25"E	300067.41	2878426.43	3.2
24	43.721	26°59'12.95"N	85°02'48.48"E	304483.22	2875697.19	4.2

Sample No.	Chainage (km)	Latitude	Longitude	Easting (m)	Northing (m)	Depth (m)
25	36.434	25°56’07.94”N	85°04'47.24”E	307702.62	2869954.86	4.0
26	22.834	25°50’34.57”N	85°09'17.62”E	315081.21	2859588.44	4.0
27	12.679	25°45’37.16”N	85°10'20.92”E	316716.9	2850412.15	4.2
28	5.636	25°41’51.22”N	85°11'39.40”E	318808.55	2843429.83	3.4
29	0.000	25°39’05.96”N	85°10'43.14”E	317169.8	2838365.94	3.4

Table 13- Water Sampling Locations

Figure 6- Soil and Water Sampling

2.23 Analysis

The collected samples were analyzed for following properties:-

a) Soil Samples
- Grain size
- Specific gravity

- PH Value
- Cu, Cc
- Clay Silt percentage

b) Water samples

- Sediment Concentration

A detailed report on sample analysis is placed inAnnexures 11 to this report.

3 Description of Waterway

The Waterway of GandakRiver coming within survey limits is divided in to tenstretches in accordance with the topographic feature and nature of river stream. The details are as follows:

3.1 Sub-Stretch-1:

Hajpur to KhanjahanchakurfSaidenpur 0 to 30km Zone 45

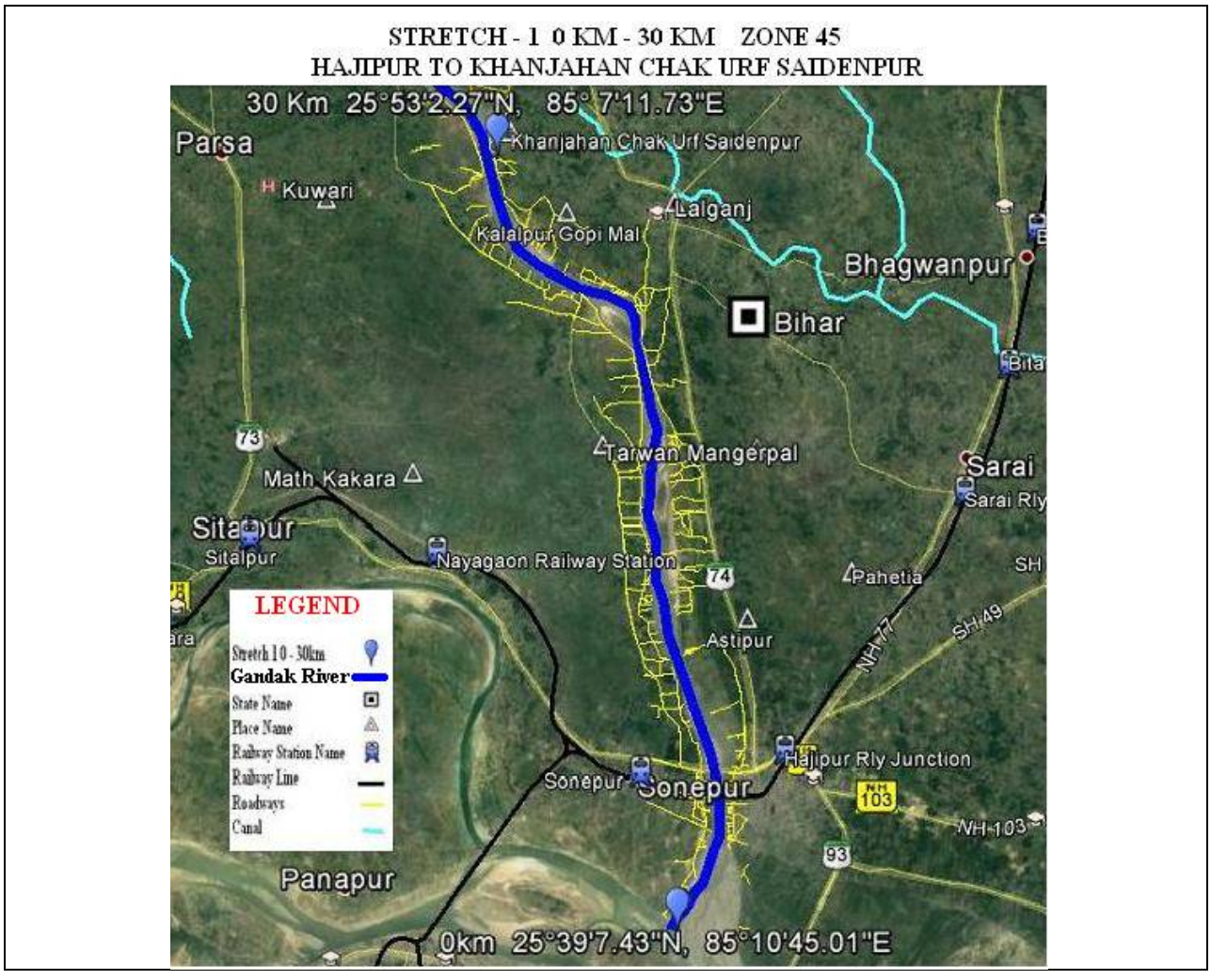


Figure 7- Stretch-01Hajpur to KhanjahanchakurfSaidenpur 0 to 30km

This stretch is between 0 to 30 Km chainage of the Ganga River Confluence. This stretch forms the upstream portion of the Ganga River Confluence. This stretch exists one cremation ground (KonharaGhat) 3 -4 Km. in the right bank and one local boat service in the left bank. There are 2 railway bridges, 2 road bridges and one high tension tower (4-5 Km) and one bridge is under construction across the river. The river bed is flat and firm and a mixture of muddy and water in nature within the river stream. When the Barrageopens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. Thereare several local boat services in the river.

The river banks of this stretch are protected with sand bags/stones in some areas. The river banks are not densely populated but in some areas people used to stay. In the right side of the bank is very rarely used to stay. Both sides of the river bank consist of agricultural land.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	0	30	0.7	10.1	1200	13115.91	-0.3	7.2	24600	1106357.1
1.5 M	0	30	0.7	10.1	900	8843.97	-0.3	7.2	24200	922552.47
2.0 M	0	30	0.7	10.3	1310	19977.22	-0.3	7.4	26150	1420943.3

Table 14 - Stretch 1 Dredging Quantity

3.2 Sub-Stretch-2:

KhanjahanchakurfSaidenpur to Kalyanpur (30 km to 60 km) Zone 45

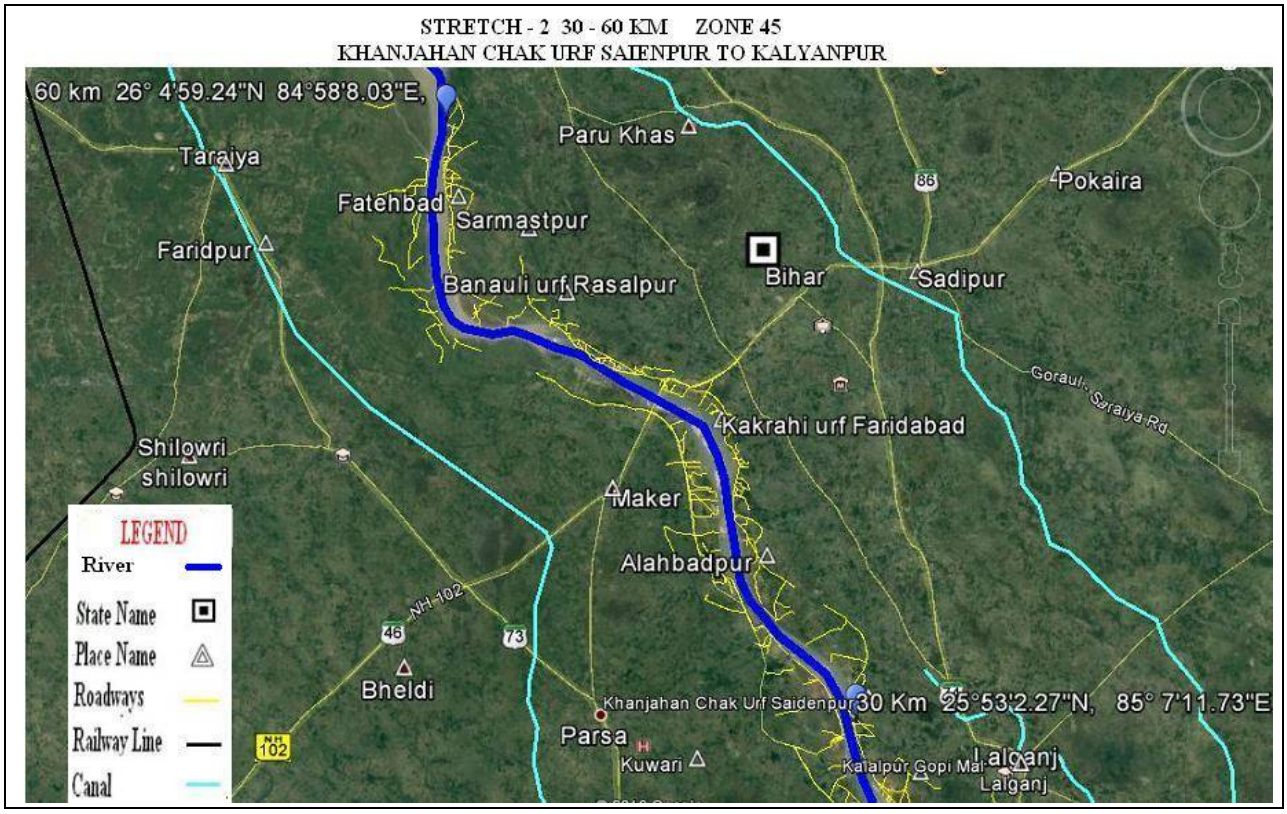


Figure 8- Stretch-02 KhanjahanchakurfSaidenpur to Kalyanpur

This stretch of Gandak River is 30 to 60 Km chainage between KhanjahanchakurfSaidenpur to Kalyanpur. Isolated small villages are spread on the both river banks. The river banks of this stretch are protected with sand bags/stones in some areas. The river banks are not densely populated but in some areas people used to stay. In the right side of the bank is very rarely used to stay.Both sides of the river bank consist of agricultural land. There is one bridge (43 – 44 Km) across the riverin NH 102 from Muzaffarpur to Chhapraand one high tension tower. The river bed is flat and firm and a mixture of muddy and water in nature within the river stream. When the Barrage opens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. There are several local boat services in the river.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	30	60	1.4	10.2	250	863.13	-0.2	7.9	6780	111233.21
1.5 M	30	60	1.4	9.3	50	66.63	-0.2	7.8	5600	80025.07
2.0 M	30	60	1.4	9.9	700	4670.96	-0.2	7.7	9215	176431.48

Table 15 - Stretch 2 Dredging Quantity

3.3 Sub-Stretch-3:

Kalyanpur to Karanpura (60km to 90km) Zone 45

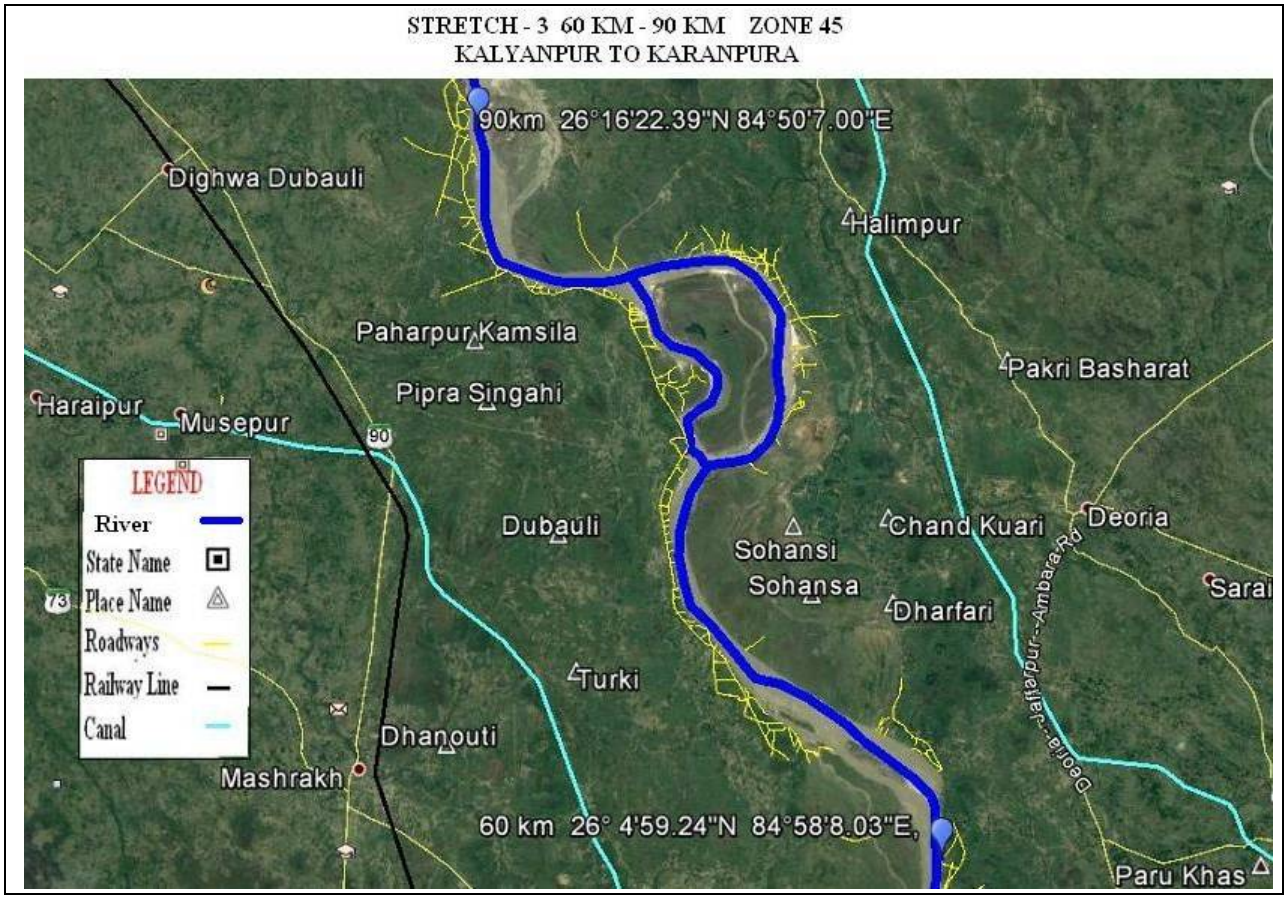


Figure 9- Stretch-03 Kalyanpur to Karanpura

This stretch of Gandak River is 60 to 90 Km chainage between Kalyanpur to Karanpura. Both sides river banks are populated with small villages. Themajor portions of the river banks of this stretch are unprotected but some areas are protected with sand bags/stones etc.Both sides of the river bank consist of agricultural land. There is one bridge in Matiariunder construction (80 – 83 Km) across the river. The river bed is flat and firm and a mixture of muddy and water in nature within the river stream. When the Barrage opens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. There are several local boat services in the river.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	60	90	1.1	9.7	750	8425.66	-0.3	8.0	10270	248875.01
1.5 M	60	90	1.1	9.6	600	4468.21	-0.3	7.9	8880	196115.76
2.0 M	60	90	1.0	9.6	1100	16679.45	-0.3	7.9	12870	345261.85

Table 16 - Stretch 3 Dredging Quantity

3.4 Sub-Stretch-4:

Karanpura to Salempur (90km to 120km) Zone 45

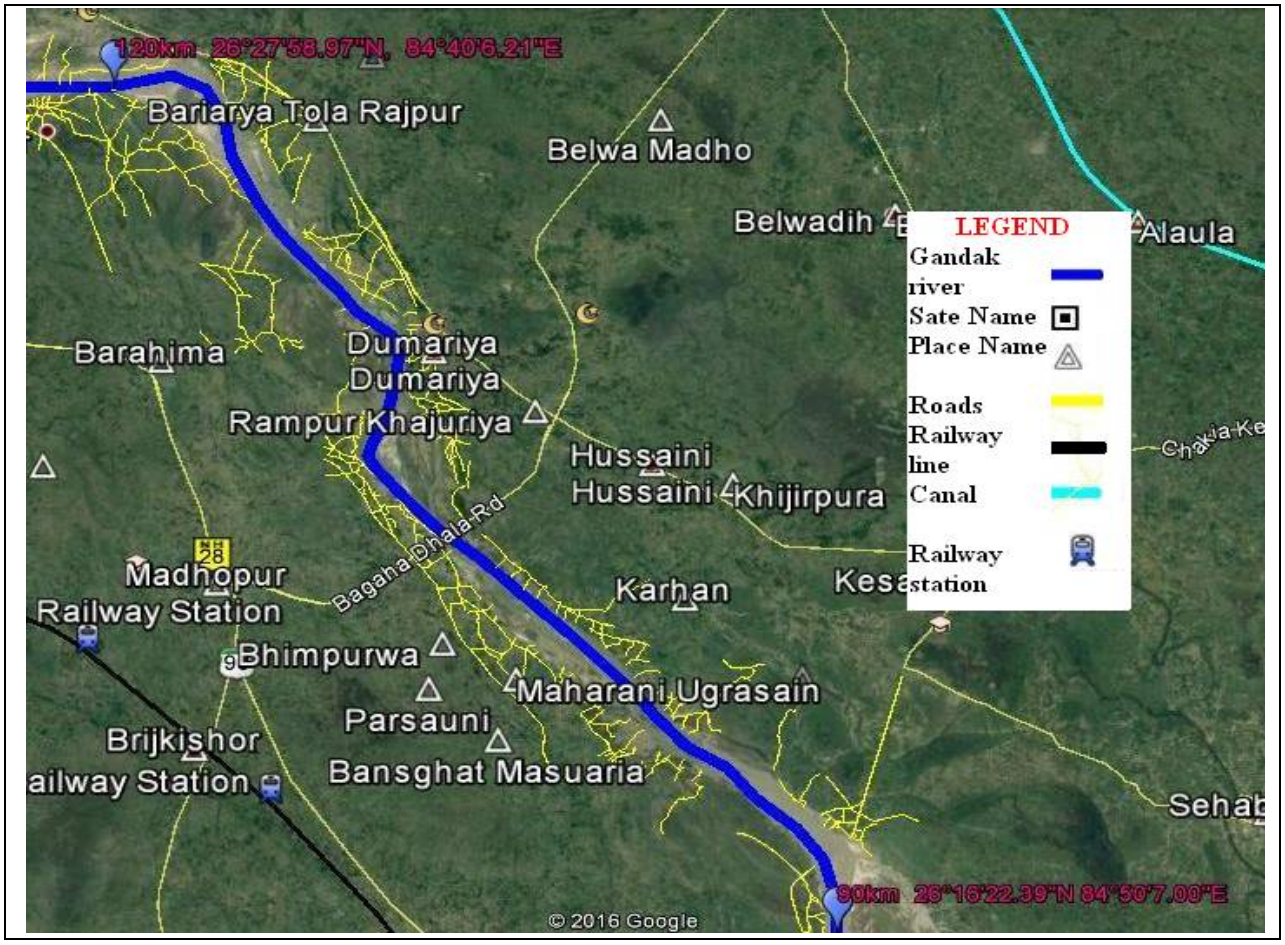


Figure 10- Stretch-04Karanpura to Salempur–

This stretch of Gandak River 90 to 120 Km chainage between Karanpura to Salempur. Both sides' river banks are populated with small villages. The major portions of the river banks of this stretch areunprotected but some areas are protected with sand bags/stones etc.Both sides of the river bank consist of agricultural land. There is one bridge in SunderpurGhatunder construction (91 – 92 Km). There are 2 bridges in DumriyaGhat out of which one bridge is damaged (103 -104 Km) across the river in NH 28 from Mohammedpur to Kajuria and one high tension tower across the river. SH 74 arepassing through parallel to the right side of the river bank. The river bed is flat and firm and a

mixture of muddy and water in nature within the river stream. When the Barrage opens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. There are several local boat services in the river.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	90	120	1.4	10.2	200	671.1	-0.3	8.3	13520	272160.13
1.5 M	90	120	1.2	10.2	50	74.86	-0.3	8.4	11220	200914.5
2.0 M	90	120	1.4	10.2	560	2457.64	-0.3	8.2	16100	411190.18

Table 17 - Stretch 4 Dredging Quantity

3.5 Sub-Stretch-5:

Salempurto Rampur (120km to 150km) Zone 45

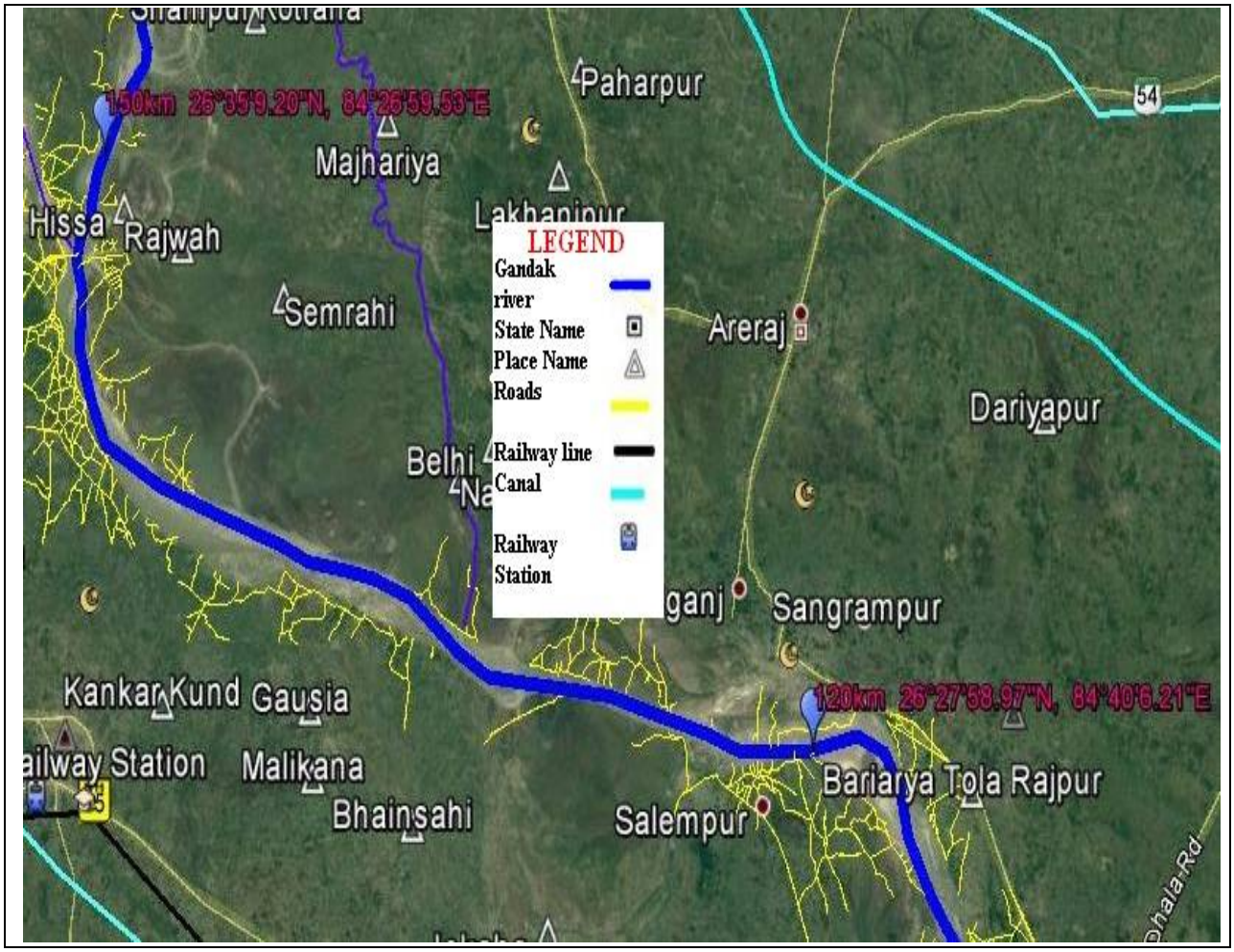


Figure 11 -Stretch-05Salempurto Rampur

This stretch of Gandak River 120 to 150 Km chainage between Salempur to Rampur. Both sides' river banks are populated with small villages. The major portions of the river banks of this stretch areunprotected but some areas are protected with sand bags/stones etc.Both sides of the river bank consist of agricultural land. There is one bridge in Mangalpur (147 – 148 Km). There are three high tension towers across the river the river bed is flat and firm and a mixture of muddy and water in nature within the river stream.

When the Barrage opens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. There are several local boat services in the river.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	120	150	0.5	8.3	8150	188908.66	-0.3	6.8	20460	996260.16
1.5 M	120	150	0.5	8.4	7450	140785.35	-0.3	7.0	19610	837601.33
2.0 M	120	150	0.5	8.4	9100	271071.14	-0.3	7.1	24700	1267375.5

Table 18 - Stretch 5 Dredging Quantity

3.6 Sub-Stretch-6:

Rampur to Nautan(150km to 180km) Zone 45

Figure 12 - Stretch-06 Rampur to Nautan

This stretch of Gandak River 150 to 180 Km chainage between Rampur to Nautan. Both sides' river banks are populated with small villages. The major portions of the river banks of this stretch are unprotected but some areas are protected with sand bags/stones etc. 0Both sides of the river bank consist of agricultural land. The river bed is flat and firm and a mixture of muddy and water in nature within the river stream. When the Barrage opens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. There are several local boat services in the river. This stretch of

GandakRiver is diverted as three branches and passes through UP and Bihar states and the land in between the branches is fully used for agriculture purpose and slightly populated.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	150	180	0.5	7.7	4680	49868.53	-0.2	7.0	16560	302533.79
1.5 M	150	180	0.6	7.8	3680	26072.42	-0.1	7.6	13720	214679.11
2.0 M	150	180	0.6	7.8	10950	107434.99	-0.2	7.0	20350	469079.9

Table 19 - Stretch 6 Dredging Quantity

3.7 Sub-Stretch-7:

Nautanto Dhanha(180km to 210km) Zone 45

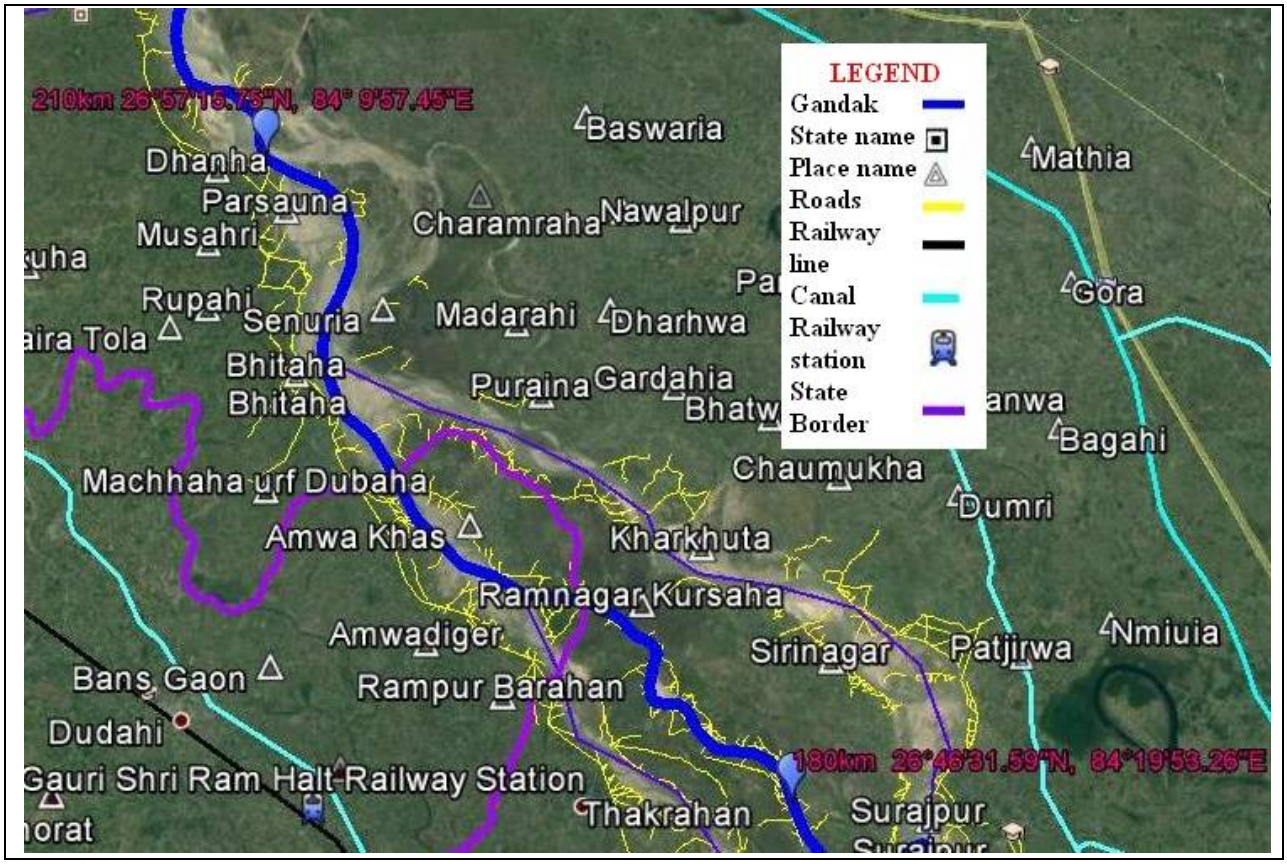


Figure 13- Stretch-07 Nautan to Dhanha

This stretch of Gandak River 180 to 210 Km chainage between Nautan to Dhanha. Both sides' river banks are populated with small villages. The major portions of the river banks of this stretch are unprotected but some areas are protected with sand bags/stones etc.Both sides of the river bank consist of agricultural land. The river bed is flat and firm and a mixture of muddy and water in nature within the river stream. When the Barrage opens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. There are several local boat services in the river. This stretch of Gandak River is diverted as three branches and passes through UP and Bihar states and the land in between the branches is fully used for agriculture purpose and slightly populated.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	180	210	0.5	6.5	5910	84381.21	06	6.6	5100	94186.61
1.5 M	180	210	0.5	6.4	5160	54592.23	0.6	6.7	3270	65283.89
2.0 M	180	210	0.5	9.0	10080	149219.81	0.6	6.5	8410	157130.34

Table 20 - Stretch 7 Dredging Quantity

3.8 Sub-Stretch-8:

Dhanha to Mangalpur(Bagaha)(210km to 240km) Zone 45

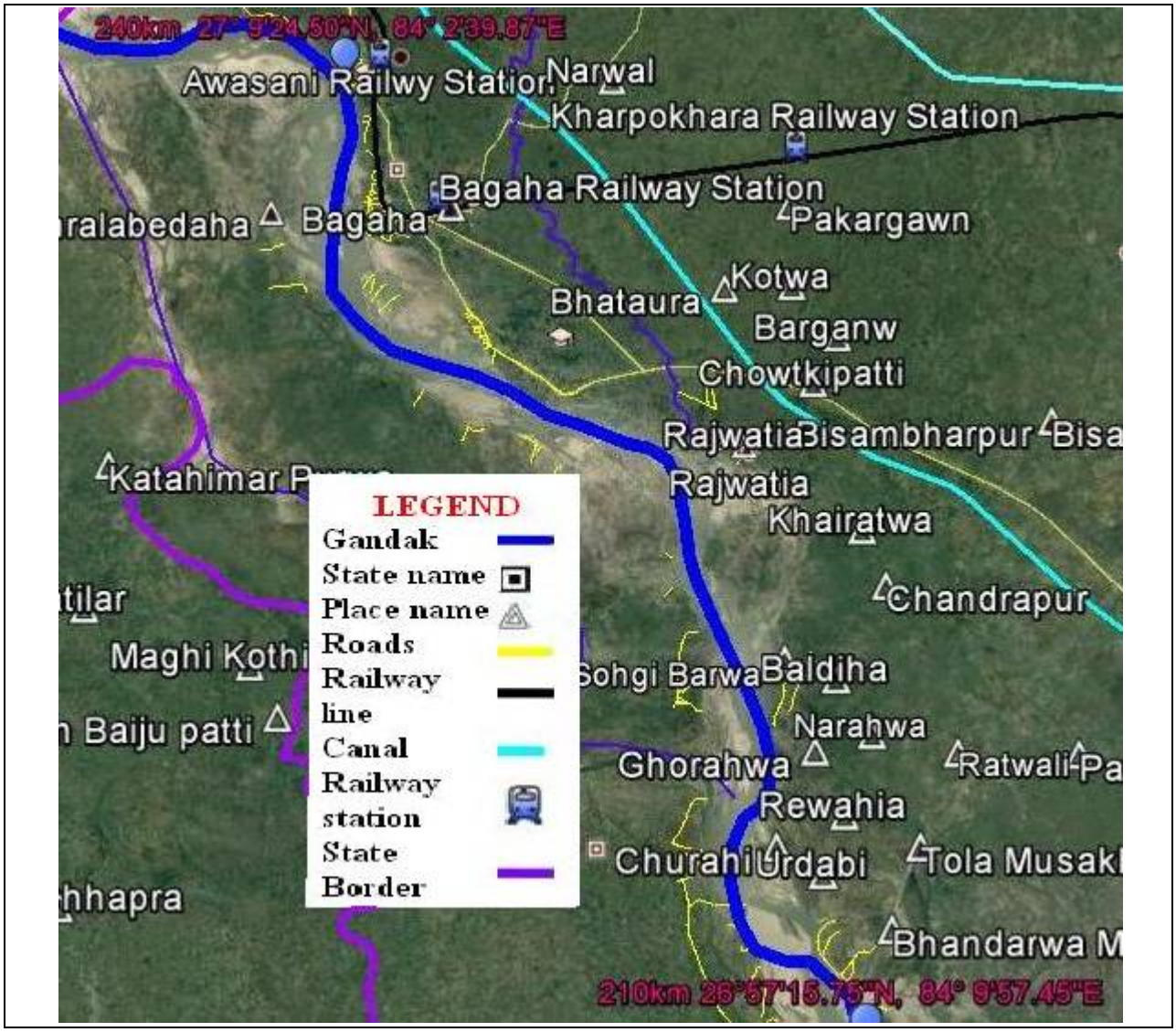


Figure 14- Stretch-08 Dhanha to Mangalpur

This stretch of Gandak River 210 to 240 Km chainage between Dhanha toMangalpur. Both sides' river banks are populated with small villages. The major portions of the river banks of this stretch are unprotected but some areas are protected with sand bags/stones etc.Both sides of the river bank consist of agricultural land. The river bed is flat and firm and a mixture of muddy and water in nature within the river stream. There is one bridge in Dhanha (211-212 Km) across the river. There are two damaged bridges Bagaha, MangalpurBagaha across the river. The nearestBahaga 1, Bahaga 2 city and Bahaga railway station is situated in the right side of the bank. NH 28B is passing parallel through the right side of the bank. When the Barrage opens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. There are several local boat services in the river.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	210	240	0.5	4.8	2460	158239.52	0.6	6.2	3300	24194.44
1.5 M	210	240	0.5	4.8	1300	98087.12	0.7	6.2	2200	11357.99
2.0 M	210	240	0.5	4.8	5110	287730.26	0.7	6.2	5200	57362.7

Table 21 - Stretch 8 Dredging Quantity

3.9 Sub-Stretch-9:

Mangalpur to GonhiJungal(240km to 270km) Zone 45 and 44

Figure 15 - Stretch-09 Mangalpur to GondiJungal

This stretch of Gandak River 240 to 270 Km chainage betweenMangalpurto Gondi Jungal. This stretch consist Zone 45 (240 – 245) and Zone 44 (245 – 270). Both sides' river banks are populated with small villages. The major portions of the river banks of this stretch are unprotected but some areas are protected with sand bags/stones etc.Both sides of the river bank consist of agricultural land. The river bed is flat and firm and a mixture of muddy and water in nature within the river stream. There is one bridge in Panwaiha (249-250 Km connecting UP – Bihar across the river. The nearestPanwaiha (UP) railway station is situated in the left side of the bank. SH 28B is passing parallel through the right side of the bank. This Stretch of the river starts from Bihar and cross to UP. When the Barrage opens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. There are several local boat services in the river.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	240	270	0.5	4.6	11900	291925.55	-0.3	5.5	18000	670896.76
1.5 M	240	270	0.5	4.8	15800	184306.35	-0.3	5.5	15400	545216.74
2.0 M	240	270	0.5	4.6	21800	499510.08	-0.3	5.5	21800	892303.62

Table 22 - Stretch 9 Dredging Quantity

3.10 Sub-Stretch-10:

GonhiJungalto Valmiki Nagar (270km to 295.7km) Zone 44

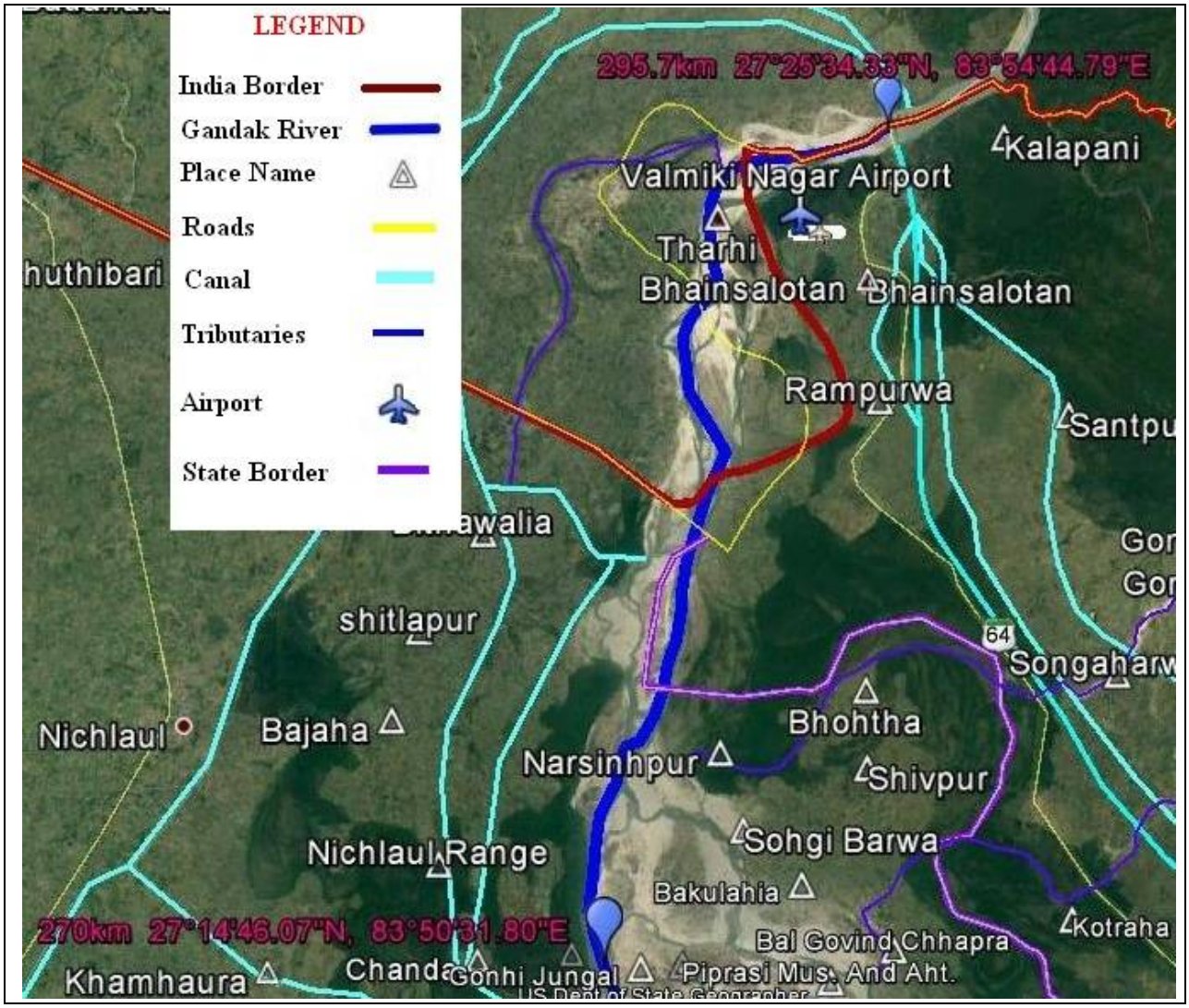


Figure 16 - Stretch-10GonhiJungal toValmiki Nagar

This stretch of Gandak River 270 to 295.7 Km chainage between Gondi Jungal to Valmiki Nagar Barrage. This stretch consist Zone 44. Both sides river banks are populated with small villages. The major portions of the river banks of this stretch are unprotected but some areas are protected with sand bags/stones etc.Both sides of the river bank consist of agricultural land. The river bed is flat and firm and a mixture of mud&

stones in nature. The Valmiki Nagar Barrage is nearest to the Valmiki Nagar airport situated in the right side of the bank. This Stretch of the river starts from UP and cross to Bihar. This stretch of Gandak River crosses to Nepal from India (281 – 288 Km) and back. SH 64 is passing parallel through the right side of the bank and cross to the Barrage to Nepal. Some thick forest (Valmiki Nagar) in the right bank. When the Barrage opens during the rainy season in Nepal, there will be heavy water flow to the river and the river bank. There are several local boat services in the river.

QTY	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (km)	Dredging Qty. (cu.m.)
1.7 M	270	295.7	0.0	4.4	13750	209243.09	-0.3	5.3	9770	607810.58
1.5 M	270	295.7	0.0	4.3	11210	133455.44	-0.3	5.2	9320	527562.88
2.0 M	270	295.7	0.5	4.4	17200	358891.69	-0.3	5.3	10960	736185.37

Table 23 - Stretch 10 Dredging Quantity

3.11 Other Aspects of Waterway

3.11.1 Fishing

Fishing activities exist on some areas of the entire stretch of the GandakRiver.

3.11.2 Industries

No industries exist near to the survey area.

3.11.3 Crops

The river banks are sparsely spread vegetation on the entire stretch of the river. Some thick forest areas found near Valmiki NagarBarrage.

3.11.4 Settlements

The overall River banks are populated for the entire survey stretch. The Bagaha city is located near the stretch-09 of the Gandak River.The both river banks in the entire stretch is populated. All these stretches are well connected with the roads and state run public transport system.

3.11.5 Drinking Water

No water from Gandak River is source of Drinking water.

3.11.6 Important Cities/Towns

The town situated near to Gandak River isHajipur City. And various towns are also situated near to the river banks. These are small towns which are connected with frequent state transport buses runs from Patna City.

3.11.7 Transportation

Local Taxis and Autos are also available occasionally along the entire River stretch, and these can be made available from the nearby towns.

3.11.8 Road Network

The both sides of Gandak River are well connected with road network and frequent state transport buses runs from Patna City to different areas. Local Taxis and Autos are also available along the entire River stretch. All major road networks line national and state

highwaysare connected with entire. The details of National Highway present in the project influence area are NH-19, NH-102, NH-28, and NH-28B which connects Patna City. The state Highways SH-64, SH54 and SH-74 also passing parallel to the entire stretch connects Patna city.

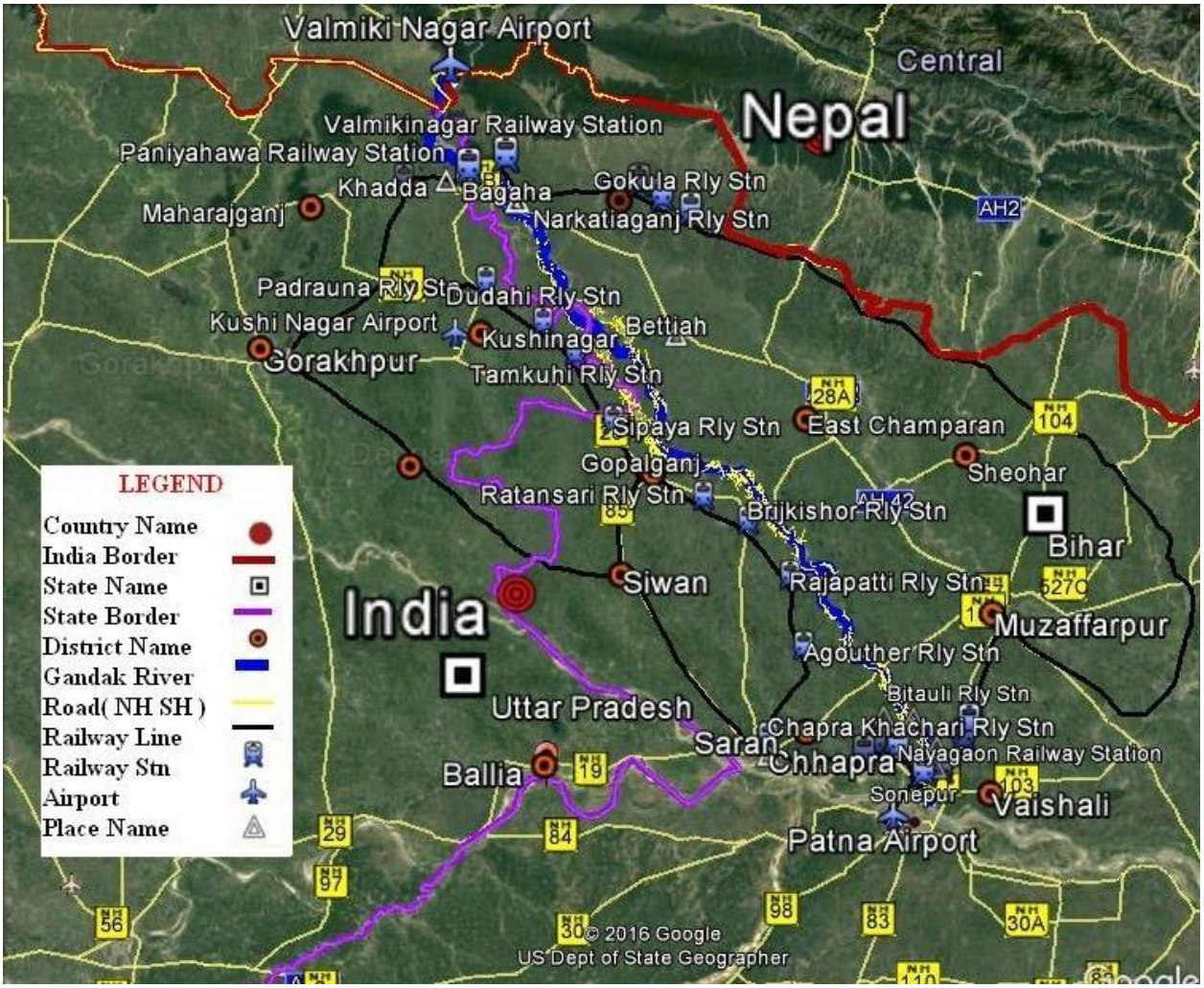


Figure 17 - Road Network

3.11.8.1 Rail Network

The Patna- Bagaha railway network from Patna Junction runs parallel to the Gandak Right Bank Side up to Bahaga and then diverts towards Gorakpur. The stations are near

and approachable from the area near Gandak River.Bahaga is the important railway station near to the survey stretch of GandakRiver.

3.11.9 Land Use

The Bagaha city is situated near to the river banks of Gandak River. The land near Bahaga city used for agricultural purpose. No industries are situated nearGandak River the land on the entire stretches of Gandak River is utilized for agricultural purpose.

3.11.10 Construction Material

The area being near to Patna and Gorakhpur city, all type of modern construction materials like cement, Iron etc. are available. Gandak River is sandy in nature but no sand mining activities is observed on the survey stretch of Gandak River.

3.11.11Cargo Movement

Bagaha and Panwaiha railway stations are situated near the stretch GandakRiver. Cargo movement or passenger movement is expected to be there in this stretch of Gandak River.

3.11.12Passenger Ferry Services

Local boats/Ferry service is available in some parts of the survey stretch of the Gandak river.

3.11.13Historic importance

The small towns of Valmiki Nagar and Vaishali are the Historical places situated near to the Gandak river. Patna city is also situated at Ganga confluence.

3.11.14Tourism

No prominent tourist spot situated near to the Gandak river.

3.11.15Irrigation Canals and Outlets

A right bank canal is from Valmiki Nagar Barrage (Tiveni).

4 Terminals

The Gandak River is 295.7 Km in length with various boats/ferry servicesavailable in the stretch of the Gandak River.

4.1 Proposed Locations for Construction of New Terminals

The locations of the terminals can be considered on the Downstream of Valmiki Nagar Barrage for tourism purpose only. The detail of the proposed location for construction of terminal is as follows.

SlNo	Chainage (km)	Location	Lat	Long	Easting	Northing	Land Use	Owner
01	43.7	Vaishali	25°59'8.0122"N	85°02'48.0592"E	304469.208	2875545.295	Downstream of Valmiki Nagar Barrage	Private Land
The proposed location is on the Downstream of Valmiki Nagar Barrage and is 43.7Km from Patna Gaighat. The area is well connected with road network. The Depth in the area need to be improved for the berthing of boats throughout the period.								
Sl No	Chainage (km)	Location	Lat	Long	Easting	Northing	Land Use	Owner
02	103.124	Kalyanpur	26°21'45.8295 "N	84°44'55.195"E	275352.848	2917815.464	Downstream of Valmiki Nagar Barrage	Private Land
The proposed location is on the Downstream of Valmiki Nagar Barrage and is 103 - 104Km from Patna Gaighat. The area is well connected with road network. The Depth in the area need to be improved for the berthing of boats throughout the period.								
Sl No	Chainage (km)	Location	Lat	Long	Easting	Northing	Land Use	Owner
03	181.0	Pitjarwa	26°48'41.409 "N	84°24'57.4682"E	243146.228	2968171.393	Downstream of Valmiki Nagar Barrage	Private Land
The proposed location is on the Downstream of Valmiki Nagar Barrage and is 180 - 181Km from Patna Gaighat. The area is well connected with road network. The Depth in the area need to be improved for the berthing of boats throughout the period.								

Sl No	Chainage (km	Location	Lat	Long	Easting	Northing	Land Use	Owner
04	211.560	Dhanaha	26°58'7.0953 "N	84°09'54.5572"E	218594.250	2986120.371	Downstream of Valmiki Nagar Barrage	Private Land
	The proposed location is on the Downstream of Valmiki Nagar Barrage and is 211 – 212 Km from Patna Gaighat. The area is well connected with road network. The Depth in the area need to be improved for the berthing of boats throughout the period.							
Sl No	Chainage (km	Location	Lat	Long	Easting	Northing	Land Use	Owner
05	238.0	Bagaha	27°08'16.9379 "N	84°03'5.6322"E	207752.611	3005156.303	Downstream of Valmiki Nagar Barrage	Private Land
	The proposed location is on the Downstream of Valmiki Nagar Barrage and is 238Km from Patna Gaighat. The area is well connected with road network. The Depth in the area need to be improved for the berthing of boats throughout the period. One sugarcane factory is situated near Bagaha. There is one railway station in Bahaga connected to Patna/Gorakhpur.							
Sl No	Chainage (km	Location	Lat	Long	Easting	Northing	Land Use	Owner
06	250.150	Paniwahia	27°11'1.7532 "N	83°58'6.4253"E	794112.270	30102777.992	Downstream of Valmiki Nagar Barrage	Private Land
	The proposed location is on the Downstream of Valmiki Nagar Barrage and is 250Km from Patna Gaighat. The area is well connected with road network. The Depth in the area need to be improved for the berthing of boats throughout the period. There is one railway station in Paniwahia connected to UP – Bihar.							

Table 24 - Proposed Terminals

5 Fairway Development

The Gandak River is flowing river with some major sharp curves or deviation of river stream.

5.1 Design channel of the waterway

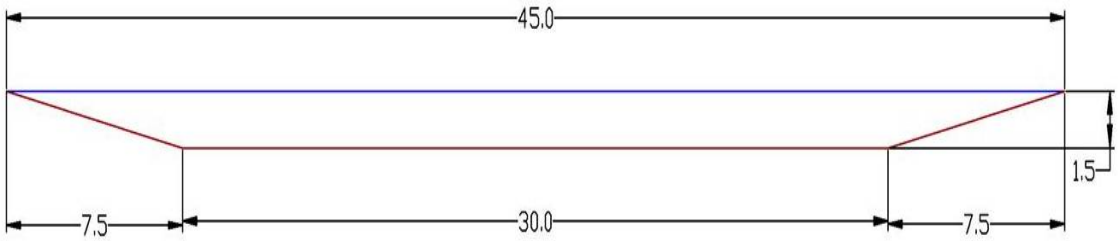
Channel of 1.7m channel depth with dimension of 30m bottom widthand side slope of 1:5 is proposed.

5.2 Fairway Dimensions

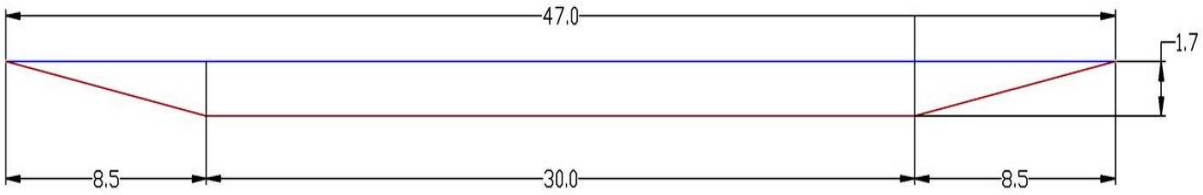
As per the specification of the survey, dredging quantity was required to be estimated for different channel classifications along the deepest route. Quantity for 1.5, 1.7& 2.0m channeldepth with dimension of 30m bottom widthand side slope of 1:5 is shown below.

Min. Max. Depth and Dredging Quantity

1.5 M

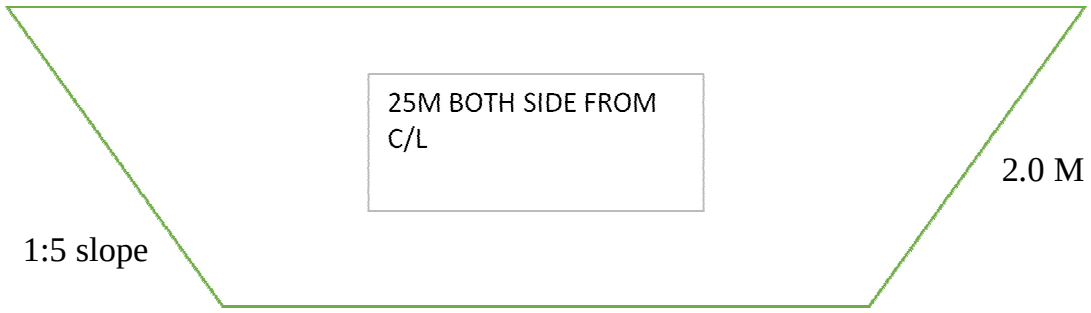


1.7 M



2.0 M

50M TOP WIDTH



30M BOTTOM WIDTH

5.3 Calculation of Dredging Quantity

The dredge volume calculations were accomplished using the HYPACK dredge volume computation utility. The channel template was created as per the different classification and kilo meter wise dredging calculation was carried out (Enclosed inAnnexure2). The Hypack Standard volume algorithm was used to calculate the dredge volume in each segment. The stretch wise summary of the dredge volume for different class of fairway is as follows: -

Dredging calculation for different classification and stretches

QUANTITY 1.5M

Chainage (km)		Observed					Reduced w. r. t. Sounding Datum				
		Observed depth (m)		Length of Shoal (m)	Dredging quantity (cu.m.)	Dredging quantity (cu.m.)	Reduced depth (m)		Length of Shoal (m)	Dredging quantity (cu.m.)	Dredging quantity (cu.m.)
From	To	Max.	Min.		Per km drg	Accum.drg.	Max	Min.		Per km drg	Accum.drg.
0	30	10.1	0.7	900	8843.97	8843.97	7.2	-0.3	24200	922552.47	922552.47
30	60	9.3	1.4	50	66.63	8910.60	7.8	-0.2	5600	80025.07	1002577.54
60	90	9.6	1.1	600	4468.21	13378.81	7.9	-0.3	8880	196115.76	1198693.30
90	120	10.2	1.2	50	74.86	13453.67	8.4	-0.3	11220	200914.50	1399607.80
120	150	8.4	0.5	7450	140785.35	154239.02	7.0	-0.3	19610	837601.33	2237209.13
150	180	7.8	0.6	3680	26072.42	180311.44	7.6	-0.1	13720	214679.11	2451888.24
180	210	6.4	0.5	5160	54592.23	234903.67	6.7	0.5	3270	65283.89	2517172.13
210	240	4.8	0.5	9580	98087.12	332990.79	6.2	0.7	1300	11357.99	2528530.12
240	270	4.8	0.5	15800	184306.35	517297.14	5.5	-0.3	15400	545216.74	3073746.86
270	295.7	4.3	0.0	11210	133455.44	650752.58	5.2	-0.3	9320	527562.88	3601309.74
			Total	**54,480**	**650752.58**			**Total**	**112,520**	**3601309.74**	

Table 25- Dredge Volumes Quantity 1.5m

QUANTITY 1.7M

Chainage (km)		Observed					Reduced w. r. t. Sounding Datum				
		Observed depth (m)		Length of Shoal (m)	Dredging quantity (cu.m.)	Dredging quantity (cu.m.)	Reduced depth (m)		Length of Shoal (m)	Dredging quantity (cu.m.)	Dredging quantity (cu.m.)
From	To	Max.	Min.		Per km drg	Accum.drg.	Max	Min.		Per km drg	Accum. drg.
0	30	10.1	0.7	1200	13115.91	13115.91	7.2	-0.3	24600	1106357.10	1106357.10
30	60	10.2	1.4	250	863.13	13979.04	7.9	-0.2	6780	111233.21	1217590.31
60	90	9.7	1.1	750	8425.66	22404.70	8.0	-0.3	10270	248875.01	1466465.32
90	120	10.2	1.4	200	671.10	23075.80	8.3	-0.3	13520	272160.13	1738625.45
120	150	8.3	0.5	8150	188908.66	211984.46	6.8	-0.3	20460	996260.16	2734885.61
150	180	7.7	0.5	4680	49868.53	261852.99	7.0	-0.2	16560	302533.79	3037419.40
180	210	6.5	0.5	5910	84381.21	346234.20	6.6	0.5	5100	94186.61	3131606.01
210	240	4.8	0.5	11900	158239.52	504473.72	6.2	0.6	2460	24194.44	3155800.45
240	270	4.6	0.5	19800	291925.55	796399.27	5.5	-0.3	18000	670896.76	3826697.21
270	295.7	4.4	0.0	13750	209243.09	1005642.36	5.3	-0.3	9770	607810.58	4434507.79
			Total	**66,590**	**1005642.36**			**Total**	**127,520**	**4434507.79**	

Table 26- Dredge Volumes Quantity 1.7m

QUANTITY 2.0M

Chainage (km)		Observed					Reduced w. r. t. Sounding Datum				
		Observed depth (m)		Length of Shoal (m)	Dredging quantity (cu.m.)	Dredging quantity (cu.m.)	Reduced depth (m)		Length of Shoal (m)	Dredging quantity (cu.m.)	Dredging quantity (cu.m.)
From	To	Max.	Min.		Per km drg	Accum.drg.	Max	Min.		Per km drg	Accum. drg.
0	30	10.3	0.7	1310	19977.22	19977.22	7.4	-0.3	26150	1420943.34	1420943.34
30	60	9.9	1.4	700	4670.96	24648.18	7.7	-0.2	9215	176431.48	1597374.82
60	90	9.6	1.0	1100	16679.45	41327.63	7.9	-0.3	12870	345261.85	1942636.67
90	120	10.2	1.4	560	2457.64	43785.27	8.2	-0.3	16100	411190.18	2353826.85
120	150	8.4	0.5	9100	271071.14	314856.41	7.1	-0.3	24700	1267375.45	3621202.30
150	180	7.8	0.6	10950	107434.99	422291.40	7.0	-0.2	20350	469079.90	4090282.20
180	210	9.0	0.5	10080	149219.81	571511.21	6.5	0.5	8410	157130.34	4247412.54
210	240	4.8	0.5	19050	287730.26	859241.47	6.2	0.7	5110	57362.70	4304775.24
240	270	4.6	0.5	23200	499510.08	1358751.55	5.3	-0.3	21800	892303.62	5197078.86
270	295.7	4.4	0.5	17200	358891.69	1717643.24	5.3	-0.3	10960	736185.37	5933264.23
			Total	**93,250**	**1717643.24**			**Total**	**155,665**	**5933264.23**	

Table 27- Dredge Volumes Quantity 2.0m

6 Conclusion

The aim of the survey undertake bathymetric survey, topographic survey, a collection of data on cargo movement, industry survey, tourism facilities etc. in the project area; prepare detailed hydrographic survey charts, topographic survey charts, and feasibility report.

6.1 Description of Waterways

The surveyed stretch of GandakRiver is 295.7 km in length and there is some scope for navigational possibility. This survey stretch starts from the Ganga Confluence, Patna to Valmiki Nagar Barrage. The river banks are well connected with road network and major distribution of settlements are there near to Patna City. The road is near parallel on both sides throughout the river stretch. There is scope of cargo transportation due to availability of railway stations in Bagaha and Panwaiha in both banks of the river.

6.2 Methods for making waterway feasible

The waterway may be developed as navigational River by carrying out capital dredging to achieve the navigability.

Boat jetties may be constructed at the upstream of Ganga Confluence for tourism / ferry purposes.Scope for Cargo movement or passenger movement is envisaged through this River.

6.3 Modifications/ Improvement measures

Improvement measures for design and depth improvement is required on first phase of the development. Both River banks are unprotected only some parts are protected with Stones/sand bags. There issigns of erosion of river banks are found in the unprotected stretch of GandakRiver.The purpose of the survey was for assessing the river stretch from Ganga Confluence to Valmiki Nagar Barrage for development of water transport facilities in the new National Waterway (NW-106). All conspicuous objects within and in the vicinity of the survey area have been fixed. The deliverable sheets contain mean sea level values of elevation information, important landmarks with the state of the river banks. The survey is considered complete in all respects.