Compliance to the 321st EAC Meeting MoM observations on four laning of Ghazipur–Balia – UP/Bihar New Greenfield Section – for Environmental Clearance

1. Type of Meeting: 321st EAC Meeting MoM, Dated: 28th February to 01st March 2023.

2. Agenda Item: 3.2

3. Name of project:
Construction of four laning of Ghazipur–Balia – UP/Bihar New Greenfield Section: Starts at Hridayapur Village (Km.0.000) near NH-24 in the State of Uttar Pradesh and ends at Bahron Singh Ke Tola Village (Km. 115.460) near NH-31 in the State of Bihar and Construction of new Buxar Spur connectivity on proposed highway near Bathoor Village (km 0.000) to Buxar Village (km 17.300) in the state of Uttar Pradesh (Total length-132.760Km) by M/s National Highways Authority of India - for Environmental Clearance.
Proposal No. IA/UP/INFRA1/415341/2023 and File No. 10/43/2021-IA.III.

4. Proponent: NHAI

5. EIA consultant: M/s Aarvee Associates, Hyderabad

The project proponent along with the EIA consultant M/s Aarvee Associates, applied for Environmental clearance of the project.

6. Observations of EAC / Additional Details Sought by MS
The 321st Meeting of Expert Appraisal Committee (EAC) of Infra-1 (IA-III) was held at INDUS Conference in a hybrid (Physical-Video Conferencing) mode hall during 28th February-1st March, 2023 under the Chairmanship of Dr. Deepak Arun Apte and tookup the application under Agenda no 3.2.

The project proponent along with the EIA consultant made a presentation through Video Conferencing and provided the required information.

The EAC, taking into account the submission made by the project proponent has a detailed deliberation in its 321st meeting on 28th February-1st March, 2023 and **Deferred** the proposal for want of following information:

The proposed alignment is passing adjacent to the River Ghaghara at Km 114.043, Tamsa River at Km.48.000 and Stream Crossing at Km 91.195 and also passing adjacent to the river meandering area which is floodplain area which will be a major risk not only to the road but also for the natural drainage and flooding related issues in nearby settlements. Also, large number of pillars will be laid to cross the floodplain area which will spoil the natural endowments and aquatic ecosystem as well which will have serious impact on its ecology and forest. PP shall explore the alternate alignment option avoiding the floodplain and forest area. In absence of such alternate, elevated corridor with maximum possible span between pillars to be explored to reduce number of pillars in the flood plain areas.

Compliance Report on EAC Observations:

The Project Proponent noted the observations and suggestions of the EAC for taking up followup action. The concerns of the EAC with the present proposl are:

- The present alignment of the highway is passing adjacent to the river meandering area which is floodplain area which will be a major risk to the road.
- Adverse effect on the natural drainage and flooding related issues in nearby settlements (drainage congestion)
- Also, large number of pillars will be laid to cross the floodplain area which will spoil the natural endowments and aquatic ecosystem as well which will have serious impact on its ecology and forest

The Project Proponent fully appreciated the observatioms and reviewed the present proposals and EAC observations by making field and technical studies with regard to the concerns expressed by the EAC. The Project Proponent is submiting the following replies on the observations for the consideration of EAC

I. Meandering of River Ghaghra River at Km. 114+042

The alignment(Existing) is crossing the river Ghaghra at Km. 114+042 and a Major bridge of length 1.163 km is proposed. At this location there is a existing two lane major bridge across the river and new bridge is proposed parallel to the existing bridge on towards down stream side of the existing bridge at a distance of 500m. The map showing the exiting and proposed bridge location is given below:

Map Showing River Ghaghra at Km. 114+042

Photographs Showing the River Ghaghra at Km. 114+042

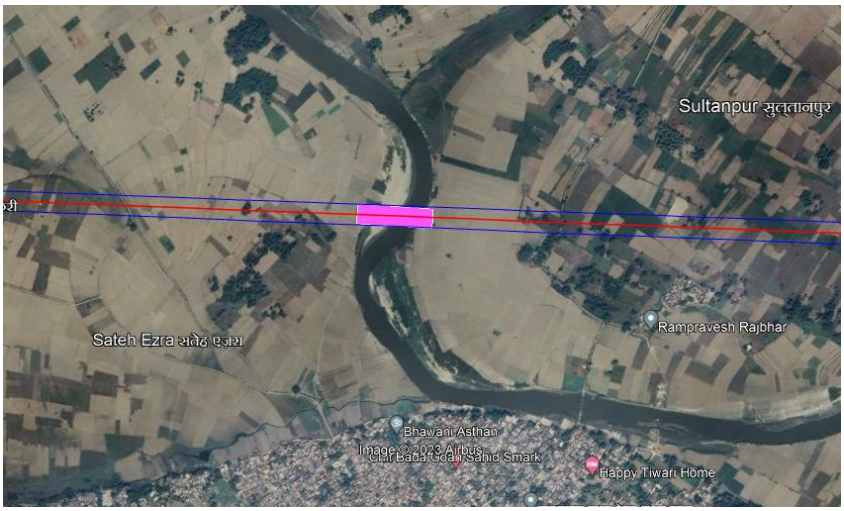
The existing two lane major bridge is known as Jay Prabha Setu is constructed with a span of 32+2x64+31x32 m. Ghaghara river is a navigational river for which navigation spans of 2x64m and vertical clearance are provided as per IWAI requirement.

Accordingly, additional two lane major bridge is proposed adjacent to the existing bridge for a length of 1.163 km. with a span of 1x32.3+17x64.6+1x32.3 m and same FRL has been main as per the existing bridge. The bridge has been designed considering the detailed Hydrology report of the particular location of the River Ghaghra and the same is given as Annexure. Hence, meandering of the river at this loation is not affecting the proposed major bridge.

II. Meandering of river Tamsa at Km. 48+000

The proposed green field alignment crosses river Tamsa at Km. 48+000, the discharge for the bridge has been calculated with AV method taking the cross section at the location of proposed bridge with actual bed slope and HFL as enquired during site visit. Bsaed on the hydrological calculations Mjajor bridge is proposed for a length of 120m across the river Tamsa The detailed hydrological report is given as Annexure.

Map Showing the River Tamsa at Km. 48+000



III. Meandering of Stream ta Km. 91+195.

A Stream is flowing through a Nouwa Bara and Balihar villages duly crossing proposed alignment at Km: 91+195. The proposed alignment in this location is crossing the stream at skew. The width of stream is 35m from bank to bank. A total skew length of 50m bridge is provided at the location. Initial discharge has been found by area velocity method taking the cross section of river at the location and slope of the river and HFL as per local enquiry.

Map Showing the Stream at Km. 91+195

IV. Meandering of River Ganga from Km. 58+000 to 63+000

The EAC suggested to explore the following alternatives.

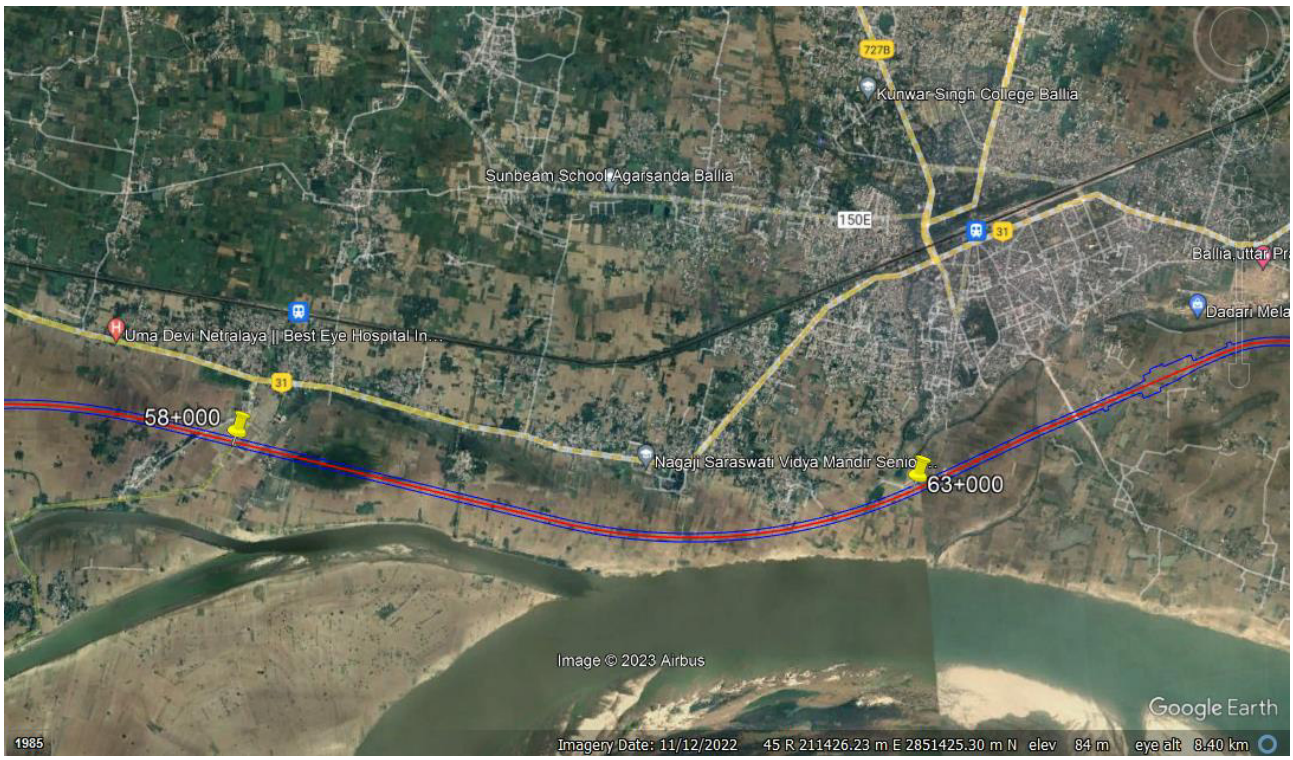
1. Alternate alignment option avoiding the floodplain and forest area.
2. In absence of such alternate, elevated corridor with maximum possible span between pillars to be explored to reduce number of pillars in the flood plain areas

(a) Alternate alignment.

The present alignment has been finalised towards the southern side of Balia town duly considering various possible alternatives at the time of issue of the Terms of Reference. Public hearings and in consultation and on the demand of local authorities and villagers. Alternate alignment avoiding the floodplains is not feasible and uneconomical as it involves large diplacement of settlements and huge land acquisition costs and R&R compensationsm. If we go further North to Balia, alignment is closely passing near to Surhatal Bird sanctuary ESZ.

(b) Risk due to Meandering.

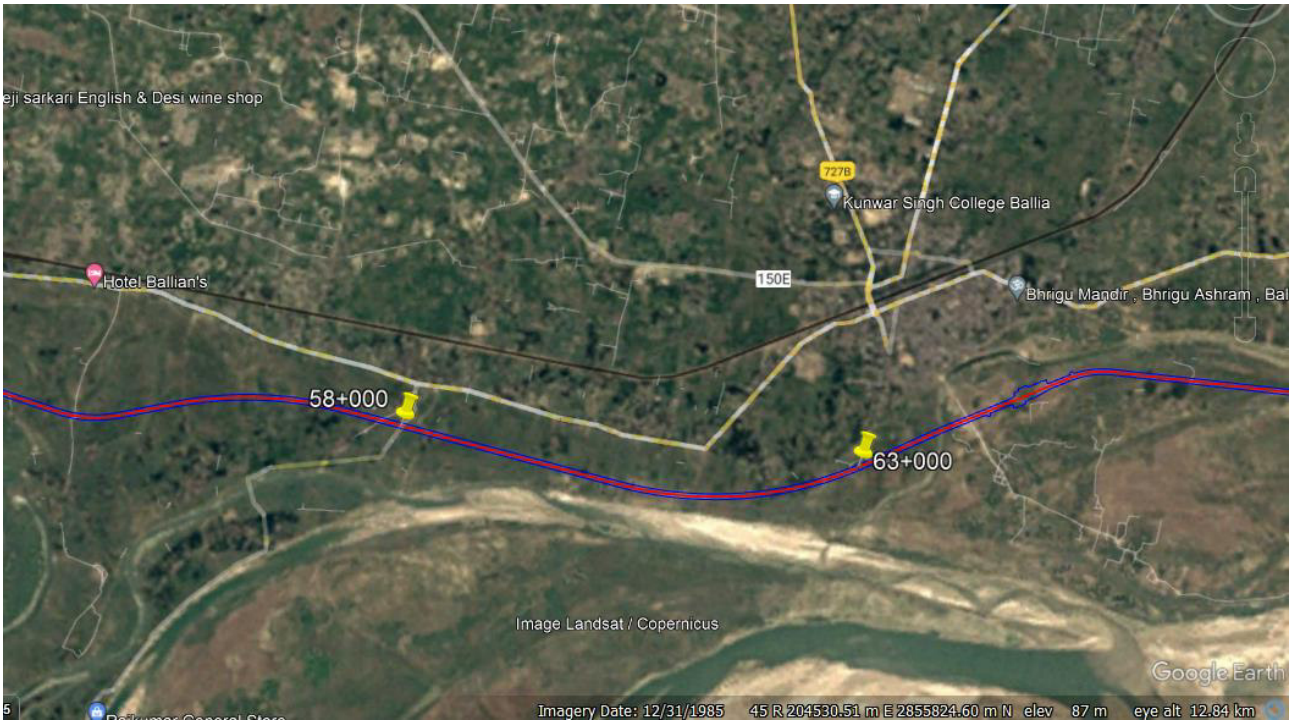
The possibility of any risk due to the meandering is analysed with respet to the following aspects. The location of the alignment is passing through the shortest distance between the highway alignment and the meandering is 180m. The alignment is located safely away from the meandering. Google image showing the alignment and the meandering is given below.



River Ganga near Balia Town (Google Image dated 11/12/2022)

Eroson of the meandering bank.

- Historical Google images from 1985 have been studied. The river course appears to be stable over tha past 38years. No change in the river course near the meandering has been noticed. This fact has been confirmed from local enquiry.



River Ganga near Balia Town (Google Image dated 31/12/1985)

- As per the Geotec investigation report, the nature of the soil of the river bank is dense sand.
- The tendency of natural rivers at meandering is to straighten the river course. The expansion of the outer edge of the meandering bank towards the alignment is unlikely.
- The river course at the meandering is uniform from bank to bank without any branching / Islands.

From the above facts, it can be expected that the meandering reach will not experience significant erosion in future to pose any risk to the highway which is located at about 180m away

(c) Drainage congestion.

The average natural ground level of the flood plains along the meandering between ch 58 and 63km is about +59.00m. The yearly maximum water levels recorded by Central Water Commission (CWC) at Buxur site and Gaaighat on Ganga are available for the period 2001 to 2022 (Annexure 1). These stations are located upstream of the meandering reach near Balia. The average peak water level at Buxur is about 59m with a maximum of 61.43m recorded in 2013. similarly the average peak annual water level recorded at Gaaighat is about 58.5m with a maximum of 60.39m. Thus the average peak annual waterlevel of Ganga near Balia would be less than 59m. This indicates that there will not be significant backflows through the flood plains even during Ganga floods.

To understand the possibility of drainage congestion in the flood plains corresponding to the design flood of 100yr frequency, 2D numerical modelling of the Ganga reach between 58km and 63km including embankment and flood plains has been carried out considering 100yr design flood as 70000cumec. HEC-RAS 6.3.1 has been selected as the numerical modelling software for this study

The effect of road embankment on the Ganga flood flow regime at Ballia reach is studied using numerical hydraulic modelling. From the 1D and 2D hydraulic modelling exercise conducted , it can be concluded that the effect of the construction of road embankment within the floodplain of Ganga River reach at Ballia is fully mitigated by the inclusion of balancing Minor bridge of 2x5x5m at 200m center to center within the 5 km reach of interest and construction of elevated corridor for a length of 600m is proposed a the nearest loaction from Km. 61+300 to 61+900. Report on the 2D model studies is enclosed as Annexure.

(d) Construction of elevated corridor

2D numerical modelling exercise of the reach corresponding to 100yr return flood revealed that drainage congestion issue is not accentuated due to the construction of highway embankment with adequate balancing culverts. Construction of elevated corridor will cost about 700crores rupees as against the estimated cost of 120crore rupees for the construction of embankment with balancing culverts. Considering safety and economy, the present proposal of embankment with balancing minor bridges and a elevated corridor for a length of 600m is adequate.

Annexures
Hydrological Report

1. Introduction

The National Highways Authority of India (*herein after referred to as the "Authority"* or *"NHAI"*) is engaged in the development of the National highways. As part of this endeavor, NHAI has decided to take up the preparation of DPR for construction of green field alignment from Ghazipur – Ballia- Up/Bihar and construction new spur to connect Buxar in the state of UP. The project is the major state connectivity corridor which connects the state of UP and Bihar.

The 4-lane highway starts near Gazipur from design chainage Km. 0+000 and ends at Manjhighat Km. 117.120 and 4-lane Buxar Spur of length 17.270 km is proposed from main line to connect Buxar in the state of Bihar. The corridor traverses through Gazipur and Ballia districts in state of UP and Saran district in the state of Bihar.

2. Objective of the Study

The main objective of the hydrological and hydraulic study is to determine the required size of Bridges / Structures to allow the estimated design flow of the streams to cross the road safely, and sufficient to transmit the flow without risk including maintenance of water balance of the area without any embankment issues.

The hydrological and hydraulic study for the project has been based on:

- Topographic survey data of structures
- Topographical data and maps of streams, upstream and downstream
- Rainfall pattern of the project site
- Site study of the characteristics of the catchment areas, HFL from local enquiries and tell-tale marks,

3. HYDROLOGICAL DETAILS OF THE PROJECT AREA

3.1 Location

The project road alignment under consideration lies in the hydrometeorological sub-zone of Middle Ganga Plains. The alignment falls in the Middle Ganga plain sub-zone 1(f) as de-marked by the Flood Estimation Report of Central Water Commission (CWC).

3.2 River System

There are large numbers of rivers crossing this sub zone. Main rivers flowing in this subzone are Yamuna, Ganga, Ghagra, Gomati, Gandak, Kosi and Mahananda. Ghagra river & Tamsa are passing through the project road alignment. Ganga river is flowing along the project road alignment at Ballia. Ghagra river Crosses the alignment near Mahjighat.

3.3 Topography and Relief, Land use

Middle Ganga Plain sub-zone 1(f) comprises mostly of plains. The Elevation in the plain area varies in between 75 to 150m, the subzone is made of thick alluvium. The low-lying flood plains adjacent to riverbanks are formed of new alluvium.

The project road section is situated in the vicinity of the Ganga river. The soil is highly fertile and irrigation facilities are well developed. The land use along the project road is agricultural cultivation.

3.4 Rainfall and Temperature

The mean annual rainfall in the subzone varies in the range of 1000 to 2000 mm and near to the project road it is approximately 1600mm.The maximum amount of rainfall s received in between June / July and September / October months due to the onset of southwest monsoon.

The climate is extremely hot and cold in the region. Annual temperature lies between 16 to 40^{o}c.

4. DATA COLLECTION

4.1 REQUIREMENTS FOR HYDROLOGICAL AND HYDRAULIC DESIGN

The hydrological study aims at estimating the peak discharge of the flood generated by the run-off of rainfall within the catchment's area. The hydrological study requires:

- Knowledge of the characteristics of peak rainfall in the regions
- Knowledge of the characteristics of the catchment areas
- Topographic data about the stream, upstream and downstream

Survey of India Topo maps to a scale of 1:50,000 and 1,250,000 for identification of

catchment area and its characteristics. Easily available DEM have been processed to get the catchment area for the large rivers.

4.2 HYDROLOGICAL DATA

Hydrological surveys have been done at all the major and minor river crossings with a view to obtain the cross section of the rivers at the center line of the road and up to a reasonable distance at upstream and downstream. The High Flood Levels (HFL) have been obtained from existing flood marks or ascertained from local enquiry with knowledgeable persons.

The characteristics of the catchment areas have been ascertained from Survey of India topo-sheets to a scale of 1:50,000, from which, catchment area at the proposed bridge site, length of the stream and fall in elevation from originating point to the point of crossing, could be determined. The catchment area

For determining the characteristics of peak rainfall regimes, CWC report No. GP/10/1984 – Flood Estimation Report for Middle Ganga Plain, Sub-Zone 1 (f) has been referred, report has been jointly prepared by CWC, MOST, Ministry of Railways and IMD and contains all the rainfall data required for estimation of design discharge of 25, 50 and 100 year return periods by applying the Synthetic Unit Hydrograph approach, the parameters of which have been indicated in the above report.

4.3 CROSS SECTION AND LONGITUDINAL SECTION AT BRIDGES

For the calculation HFL of the stream, topographical survey has been carried out across and along the water courses to determine the cross-section and the slope. Several cross-sections have been taken at regular intervals on both upstream and downstream side of the structure, including one at the proposed location of the structure.

5. Approach For Hydrological Design of Bridges

5.1 Return Period

Design engineers essentially need the design flood of a specific return period for fixing the waterway vis-à-vis the design water level of the bridges depending upon their size and importance to ensure safety as well as economy.

The bridges have been designed as per given return period as 1 in 100 years.

5.1.1 Hydrological Analysis of Bridges

For the project site, considering smaller bridges, Empirical methods viz. Dickens's formula, rational method and Area velocity method are adopted to evaluate the design flood peak, and these are discussed in detail below. As per national and international practices, synthetic unit hydrograph is used for catchment area greater than 25 Km^2 and lesser than 1500 Km^2 as per National and international practices, it is not used for smaller catchment areas. Hydraulic Calculation has been carried out based on Flood Estimation Report for Middle Ganga Plains (Sub Zone-1(f)).

HEC HMS has been used to evaluate the peak discharge for the some of the major bridges where the catchment is too large, and the catchment delineation has been done from the easily available DEM using the QGIS.

Hydrological analysis includes the peak flood estimation for the bridges that depend upon the data obtained from hydrological study.

(a) Flood Estimation for the Catchment Areas less than 25 sq.km

The following method will be used to estimate the peak discharge for bridge sites for catchment area less than 25 sq.km:

Rational Formula:

As per Rational formula,

Q = 0.0278 C Ic A where,

Q = design discharge (m^3/s)

C = runoff coefficient value varies between 0 and 1.0, here it has been considered as 0.7considering the catchment as Plateau, lightly covered. (As per IRC SP 13-2004, Table 4.1)

A = catchment area (ha.)

Ic = maximum intensity which can occur in concentration time tc in cm/h,tc = time of concentration (h) which is given by 0.87* (L3/H) ^0.385

Discharge by Dicken's formula

Here, Peak Discharge is calculated by following formula:

$Q = CA^{3/4}$

Where, Q is peak runoff in m^3/s A is Catchment area in Km^2

C is Dicken's constant

= 11-14 where the annual rainfall is between 600 mm to 1200 mm

= 14- 19 where the annual rainfall is more than 1200 mm

= 22 in Western Ghats

(b) Flood Estimation when Catchment Area more than 25 sq. km

The following methods will be used to estimate the peak discharge for bridge sites on major streams forcatchment area more than 25 sq. km:

Synthetic Unit Hydrograph Method

For the project site, considering smaller bridges, two methods viz. Dickens's formula and Area velocity method are adopted to evaluate the design flood peak, and these are discussed in detail below. As per national and international practices, synthetic unit hydrograph is used for catchment area greater than 25 Km2 and lesser than 1500 Km2. Calculations have been carried out based on Flood Estimation Report for Middle Ganga Plains (Sub Zone-1(f)).

Step By step method as described in Flood Estimation Report for Middle Ganga Plains (Sub Zone-1f) will be followed as mentioned below.

a) Physiographic parameters of the ungauged catchment viz. A, L and S have been determinedfrom topo-sheets or field observations.

b) SUH parameters have been computed using the following equations:

i)	qp	=	0.409 / (L/√ S)^0.456
ii)	tp	=	1.217 / (qp)^1.034
iii)	W50	=	1.743 / (qp)^1.104
iv)	W75	=	0.902 / (qp)^1.108
v)	WR50	=	0.736 / (qp)^0.928
vi)	WR75	=	0.478 / (qp)^0.902
vii)	TB	=	16.432 * (tp)^0.646
viii)	Tm	=	tp + (tr/2)
ix)	Qp	=	qp x A

c) The estimated parameters of unit graph in (b) are plotted to scale. The plotted points werejoined to draw synthetic unit graph.

d) The design storm duration has been taken as equal to base period (TB) of unit graph.

e) Estimation of point rainfall and areal rainfall has been done for the catchment under study.

f) Time distribution of area rainfall is computed.

g) Estimation of effective rainfall unit has been done after taking design loss rate into account.

h) Base flow has been estimated.

i) Finally, estimation of 50 year/100year flood peak has been done.

Design Discharge

Fixing of Design Discharge

As recommended in IRC: SP-13, discharge values obtained from above methods shall be compared andthe highest of these values shall be adopted as design discharge, provided it does not exceed the next highest discharge by more than 50%. If it does, then restrict it to that limit.

Highest value of flood discharges obtained from above methods as per the applicable catchment area has been considered as Design Discharge (Q).

5.1.1 Hydraulic Design of Bridges

Hydraulic analysis involves the fixing of linear waterway, designed water level corresponding to adopted designed flood discharge and afflux under natural and restricted conditions.

Codal provisions stipulates that the waterway should be determined by the Area-Velocity method taking into account the design flood level and its water spread. The waterway so found should also be compared and appropriate length of bridge is fixed.

Water Level corresponding to Design Discharge /HFL

Computation of water level is done generally with the help of Manning's Equation in area velocity method corresponding to Designed Flood Discharge as described below:

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Area – Velocity Method

Area – Velocity method is used to calculate the water level corresponding to Design discharge. The velocity is calculated using the Manning's formula as given below:

V = $1/n\ R^{2/3}\ S^{1/2,}$ and

Q = V. A

Where

Q	=	Discharge in Cumec
V	=	Velocity in m/sec
R	=	Hydraulic mean depth in m
S	=	Flood slope/bed slope
n	=	Co-efficient of rugosity
A	=	Area of the cross - section

The value of 'n' depends upon soil type and rivers bed characteristics, observed as natural stream with banks consisting of some weeds and stones with fair status as 0.035 and are taken from Table 3 in IRC SP13- 2004.

Afflux

For streams with non-erodible beds, the afflux may be worked out by Moles worth formula given below:

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Molesworth Formula: (Clause 106.6.2 of IRC: 5-2015**)**

$$h = (V^2/17.88 + 0.015) \times ((A/a)2-1)$$

Where, h = afflux in m,

V = average velocity of the water in the stream prior to constriction in m/s,

A = Unobstructed sectional area of the river at the proposed site in sq. m,

a = Constricted area of the river at the bridge site in sq. m

6 SCOUR CALCULATION

6.1 SCOUR DEPTH CALCULATION FOR DESIGN OF FOUNDATION

6.1.1 Design Discharge of Foundation

To provide for an adequate margin of safety against an abnormal flood of magnitude higher than the design discharge (Q) the foundations, protection works, and training works except free board, shall be designed for a higher flood discharge. The magnitude of this discharge shall be computed by increasingthe design discharge (Q), by the percentage indicated in Table 6.1:

Table 6.1: Percentage Increase over Design Discharge for Scour of Bridges

Catchment less than 500 Sq.km	30%
Catchment more than 500 Sq.km and up to 5,000 Sq.km.	30-20%
Catchment more than 5000 Sq.km and up to 25,000 Sq.km.	20-10%
Catchment more than 25,000 Sq.km	<10%

6.1.1 Calculation of Mean Scour Depth

Scour depth

As per I.R.C.:78-2014, Clause: 703.2 and as explained in IRC: SP 13, mean scour depth in meter belowthe Highest flood Level is given by the following Equation:

$$D_{sm} = 1.34 \times \left[\frac{{D_b}^2}{K_{sf}}\right]^{\frac{1}{3}}$$

D_b = Unit discharge in m3/s per meter width obtained by total design discharge divided by the effective linear waterway width between abutments

D_b = total discharge (QR) /Regime width (W)

Silt factor

Alluvial Streams:

For the regime characteristics of an alluvial channel, Lacey suggested a silt factor and its value dependsupon the size and looseness of the grains of the alluvium. As per IRC: 78 – 2014, for the design of piersand abutments located in a straight reach and having individual foundations without any floor protection works, the maximum depth of scour from the highest flood level is given by the relation,

$$K_{sf} = 1.76 \times \sqrt{d_m}$$

Where, dm is the weighted mean diameter of the particles in mm.

Clay soil: Generally, scour in clay is less than sand. In clay silt factor given by formula

$$Ksf = F\ (1 + \sqrt{C})$$

Where,

C = Cohesion in Kg/cm2

F = 1.5 for φ ≥ 10o and < 15o

= 1.75 for φ ≥ 5o and < 10o

= 2.0 for φ < 5o

Maximum scour depth

The maximum depth of scour below the highest flood Level (HFL) at obstructions and configurationsof the channel should be estimated from the value of 'dsm' on the following basis:

For the design of piers and abutments located in a straight reach and having individualfoundations without any floor protection works

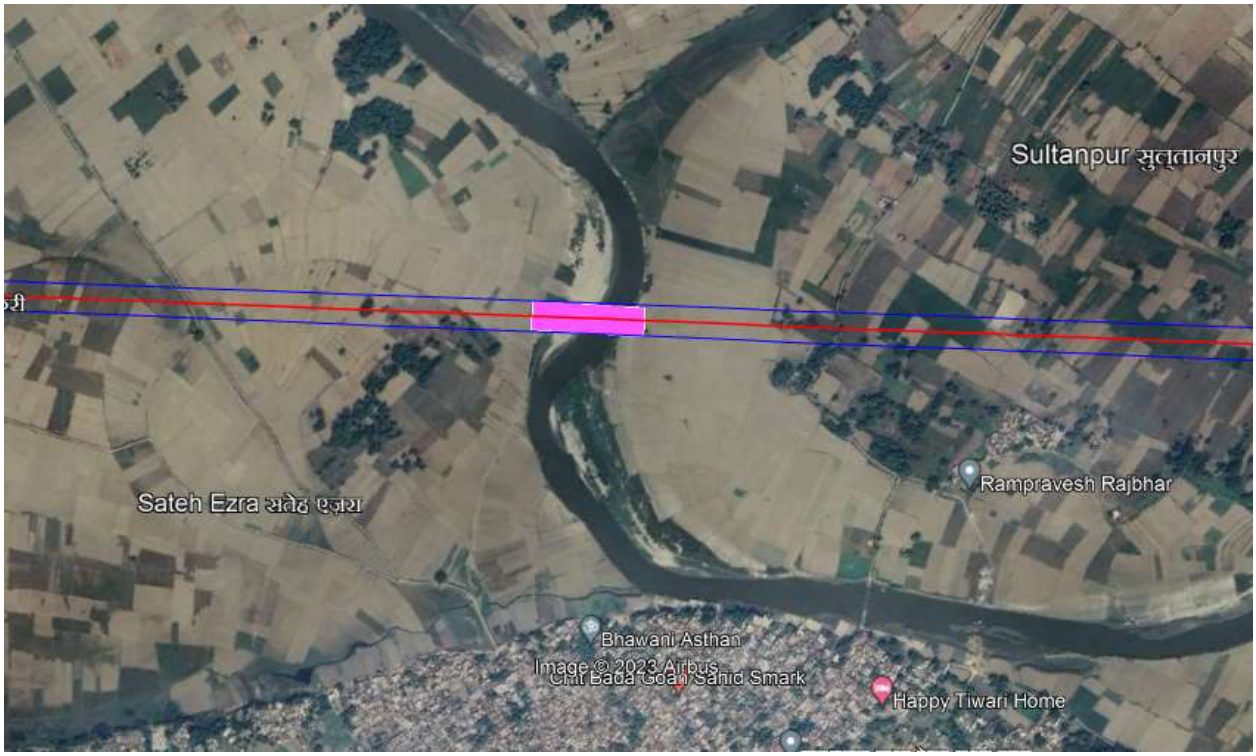
(i) In the vicinity of piers = 2.00 * dsm

(ii) Near abutments = 1.27 * dsm

7. Proposals of Major Bridges

7.1 Major Bridge at Km 48+000

Tamsa river crosses proposed green field alignment at km.48+000. Major bridge is proposed for a length of 120m (Bank to bank). Discharge for the bridge has been calculated with AV method taking the cross section at the location of proposed bridge with actual bed slope and HFL as enquired during site visit. The detailed hydrological calculations are enclosed in the annexures.



7.2 Minor Bridge at Km 91+195

A Stream Flowing through village Nouwa Bara and Balihar crossing proposed alignment at Km: 91+195. The proposed alignment in this location is crossing the stream at skew. The width of stream is 35m from bank to bank.

A total skew length of 50m bridge is provided at the location. Initial discharge has been found by area velocity method taking the cross section of river at the location and slope of the river and HFL as per local enquiry.

7.3 Major Bridge at Km 114+042

Ghaghara river crosses alignment at km. 114+042, at this location existing two lane bridge for a length of 1.163 km is retained and additional new two lane bridge is down stream of the existing major bridge near Manjhi ghat which is the border of UP and Bihar states.

The existing two lane major bridge is known as Jay Prabha Setu is constructed with a span of 32+2x64+31x32 m. Ghaghara river is a navigational river for which navigation spans of 2x64m and vertical clearance are provided as per IWAI requirement.

Accordingly, additional two lane major bridge is proposed adjacent to the existing bridge for a length of 1.163 km. with a span of 1x32.3+17x64.6+1x32.3 m and same FRL has been main as per the existing bridge.

ANNEXURES

aarvee associates
architects engineers & consultants pvt. ltd.

Project:	**CONSULTANCY SERVICES FOR PREPARATION OF FSR CUM DPR OF 4 LANING OF GHAZIPUR BALLIA – UP/BIHAR SECTION FROM Km 0.000 TO Km 128.000 OF NH-19 AND CONSTRUCTION OF 2/4 LANING FLY OVER AT BALLIA (FROM CHANDRA SHEKHAR MOD TO SATISH CHANDRA COLLEGE) IN THE STATE OF UP. PACKAGE – II (FROM Km 33.100 TO Km 78.100)**
Title:	**Hydrology Report for MJB at Ch. 48+000**
Client:	**NHAI**
Design Consultant:	**Aarvee Associates Architects Engineers & Consultants Pvt. Ltd.**

Assessment of 100 yrs Design flood for MJB at Ch. 48+000

As per CWC Flood Estimation Report of Middle Ganga plain subzone – 1(f)

Particulars of the catchment				
Name of Sub-zone	Middle Ganga Subzone - 1(f)	Catchment Area (A, sq. km)		4140.000
Name of tributary		Length of longest stream(L,km)		330.000
River system	Ganga River	Lc (km)		165.000
Shape of catchment	Fan shaped	Location	Latitude	25°45'22.95"N
Topography	Plains		Longitude	84° 0'2.39"E

The bridge site is located on Ganga River. The synthetic unit graph for the site is derived based on the Flood Estimation Report of Middle Ganga Subzone - 1(f) published by Central Water Commission.

I Synthetic Unit Graph

A Statistical Slope

S No	Reduced distance Starting from Point of study	Reduced Levels of River Bed	Length of Each Segment Li	Height Above Datum *(Difference Between Datum and the ith R.L)	$(D_{i-1}+Di)$	Li* $(D_{i-1}+Di)$ (4) x (6)
	(kms)	(m)	(km)	(m)		(m x km)
1	*2*	*3*	*4*	*5*	*6*	*7*
1	0.00	53.72	0.000	0	0	0.0
2	6.00	57	6.000	3.28	3.28	19.7
3	29.00	58	23.000	4.28	7.56	173.9
4	57.00	60	28.000	6.28	10.56	295.7
5	100.00	68	43.000	14.28	20.56	884.1
6	160.00	72	60.000	18.28	32.56	1953.6
7	226.00	82	66.000	28.28	46.56	3073.0
8	264.00	84.92	38.000	31.2	59.48	2260.4
9	296.00	87.38	32.000	33.66	64.87	2075.8
10	330.00	90	34.000	36.28	69.94	2378.1
					∑ Li(Di-1+Di) =	13114.1
S =	**∑ Li(Di-1+Di)/L^2 =**		**0.120**	**m / km**		
L =	330.00	km Lc =	**165.000**	km		

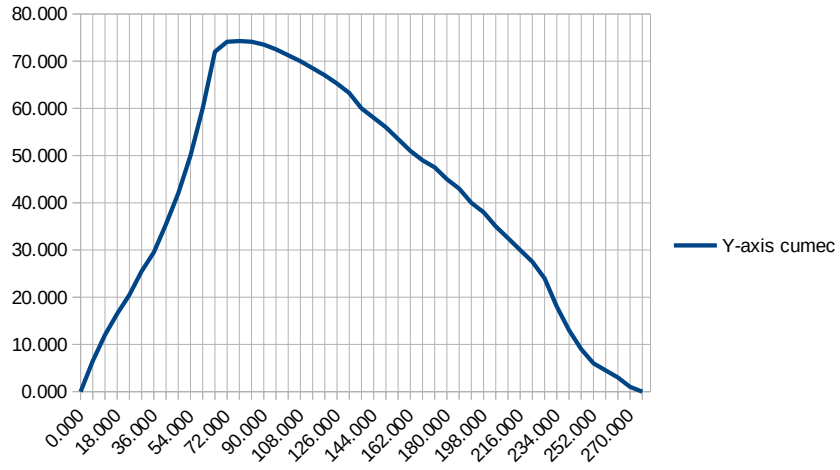
B U G Parameters

A	S	L	Lc
4140.000	**0.120**	**330.000**	**165.000**

The following relationships have been derived for estimating the 6-hour synthetic unit graph parameters of the catchment from FER of Middle Ganga subzone - 1(f)

1	qp =	**0.409/(L/SQRT(S))^0.456**	0.0179	cumecs/sqkm
2	tp =	**1.217/qp^1.034**	77.80	Hrs
3	W_{50} =	**1.743/qp^1.104**	147.65	Hrs
4	W_{75} =	**0.902/qp^1.108**	77.65	Hrs
5	W_{R50} =	**0.736/qp^0.928**	30.72	Hrs
6	W_{R75} =	**0.478/qp^0.902**	17.97	Hrs
7	T_B =	**16.432*tp^0.646**	273.69	Hrs
8	T_m =	**tp+(tr/2)**	72.00	Hrs
		Say,	72.000	Hrs
9	Q_p =	$Q_p * A$	74.248	m^3/sec
10	Vol ∑Qi		41400000	m^3
	Volume due to 1cm excess RF		40785072	m^3
	Ratio		**0.99**	

Say, 69 Hrs



Assessment of 100 yrs Design flood for MJB at Ch. 48+000

As per CWC Flood Estimation Report of Middle Ganga plain subzone – 1(f)

I Design storm (100 year return storm)

A Storm duration (TD)

The design storm duration is adopted as 1.1 times tp = 1.1 X tp =	85.58	hrs
Rounding it to the nearest hour TD (limited to 24 hrs) =	24.00	hrs

B Point Rainfall

The 100 year 24 hour point rainfall for the catchment is 280 mm from plate-10 of the Flood Estimation Report for Middle Ganga Sub-Zone - 1(f)	280	mm
	28	cm

C TD (24hr) rainfall

Conversion factor of 1 is taken from of FER of Middle Ganga subzone - 1(f) to convert 24 hr rainfall to 24 hr rainfall. Thus the 24 hr rainfall = 280 X 1 =	1.000	
	28	cm

D Areal Rainfall

The Areal to Point Rainfall % as per 0 of the FER report of Middle Ganga subzone - 1(f) is 0.74 for 4140 sq.km. Therefore the 100 year 24 hour areal rainfall is =	0.74	
	20.72	cm
The Loss rate for the given catchment as per FER of Middle Ganga is =	0.3	Cm/hr

E Temporal Distribution of Rainfall

Using the distribution percentages given in FER report for 100 year 24 hr areal rainfall is split into 6hr rainfall increments as below.

Duration hours	Distribution coefficient	Storm Rainfall cm	Rainfall increments cm	Loss Rate Cm / hr	Excess rainfall cm
0	0.00	0.00	0.00	0	0.00
6	0.70	14.50	14.50	1.8	12.70
12	0.84	17.40	2.90	1.8	1.10
18	0.93	19.27	1.86	1.8	0.06
24	1.00	20.72	1.45	1.8	0.00
		sum	20.72		13.87

Assessment of 100 yrs Design flood for MJB at Ch. 48+000
As per CWC Flood Estimation Report of Middle Ganga plain subzone – 1(f)
Computation of 100 yrs return flood

As per Unit Hydrograph the Peak dischage is happened at 77.8 hrs	**74.25 m3/sec**	
Base flow of the catchment per km	**0.050**	
Base flow of the catchment	**207**	m3/sec

		6	12	18		Total Hydrograph (cumecs)
					DRH	
Time	Ordinate	0.06	12.70	1.10		
0	0.0				0.0	207.0
6	6.5	0.4			0.4	207.4
12	12.0	0.7	82.6		83.3	290.3
18	16.5	1.0	152.4	7.2	160.5	367.5
24	20.5	1.2	209.6	13.2	224.0	431.0
30	25.5	1.5	260.4	18.2	280.0	487.0
36	29.5	1.8	323.9	22.6	348.2	555.2
42	35.5	2.1	374.7	28.1	404.8	611.8
48	42.0	2.5	450.9	32.5	485.8	692.8
54	50.0	3.0	533.4	39.1	575.5	782.5
60	60.0	3.6	635.0	46.2	684.8	891.8
66	72.0	4.3	762.0	55.0	821.3	1028.3
72	74.1	4.4	914.4	66.0	984.8	1191.8
78	74.2	4.5	941.1	79.2	1024.7	1231.7
84	74.1	4.4	942.9	81.5	1028.9	1235.9
90	73.5	4.4	941.1	81.7	1027.2	1234.2
96	72.5	4.4	933.5	81.5	1019.3	1226.3
102	71.3	4.3	920.8	80.9	1005.9	1212.9
108	70.0	4.2	904.9	79.8	988.8	1195.8
114	68.5	4.1	889.0	78.4	971.5	1178.5
120	67.0	4.0	870.0	77.0	951.0	1158.0
126	65.3	3.9	850.9	75.4	930.2	1137.2
132	63.3	3.8	828.7	73.7	906.2	1113.2
138	60.0	3.6	803.3	71.8	878.7	1085.7
144	58.0	3.5	762.0	69.6	835.1	1042.1
150	56.0	3.4	736.6	66.0	806.0	1013.0
156	53.5	3.2	711.2	63.8	778.2	985.2
162	51.0	3.1	679.5	61.6	744.1	951.1
168	49.0	2.9	647.7	58.9	709.5	916.5
174	47.5	2.9	622.3	56.1	681.3	888.3
180	45.0	2.7	603.3	53.9	659.9	866.9
186	43.0	2.6	571.5	52.3	626.3	833.3
192	40.0	2.4	546.1	49.5	598.0	805.0
198	38.0	2.3	508.0	47.3	557.6	764.6
204	35.0	2.1	482.6	44.0	528.7	735.7
276	0.0	0.0	444.5	41.8	486.3	693.3
			0.0	38.5	38.5	245.5
				0.0	0.0	207.0

100 yrs flood Discharge	**1235.9**	**cumec**

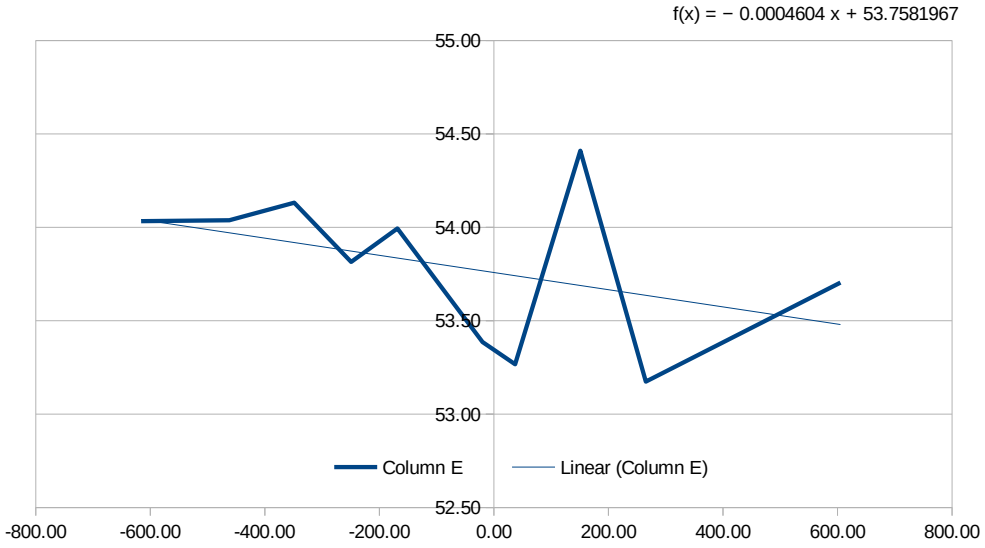
Job code:	Project:	4 laning of Ghazipur – Up/ Bihar border		aarvee associates architects engineers & consultants pvt. ltd.
	Job Name:	Hydrology Report for MJB at Ch. 48+000		
2114	Designed By:	Srivalli	Date : 05/05/21	Rev: 0
	Checked By:	PKM	Date : 05/05/21	

Calculation of Bed Slope

Chainage	Lowest Bed Level
-616.00	54.03
-462.00	54.04
-348.72	54.13
-249.31	53.82
-168.48	53.99
-19.90	53.39
37.09	53.27
150.98	54.41
265.31	53.17
605.15	53.70

Slope 0.0005 (Slope is 1 in 2172)

SFL -

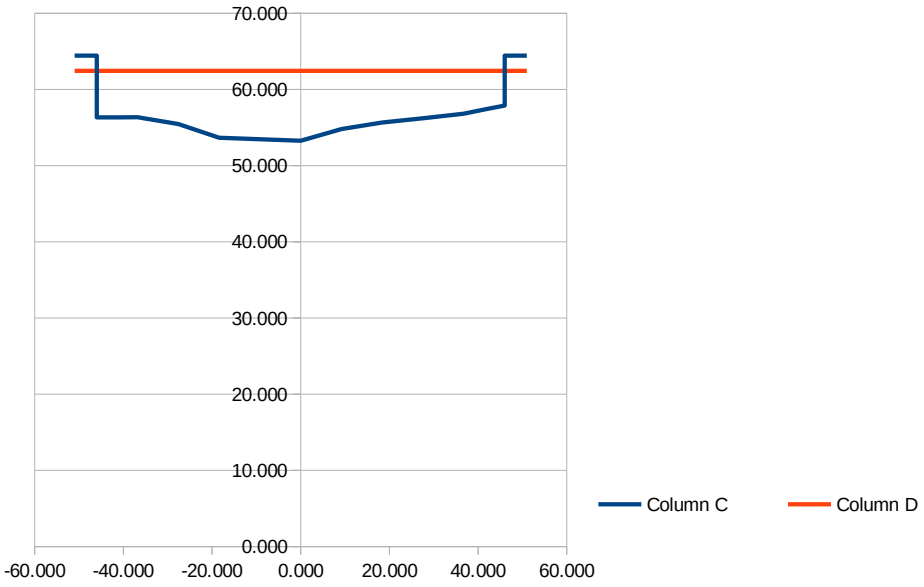


Job code:	Project	4 laning of Ghazipur – Up/ Bihar border			aarvee associates architects engineers & consultants pvt. ltd.
	Job Name	Hydrology Report for MJB at Ch. 48+000			
2114	Designed By	Srivalli	Date :	05/05/21	Rev: 0
	Checked By	PKM	Date :	05/05/21	

Calculations

Calculation of Highest Flood Level

1	Cross Section at		37.00	m	D/S	HFL =	62.440	m	
S. No.	Chainage	Bed level	HFL	Depth of water	Avg. Depth of water	Distance	Area	Vertical Ht at Bed level	Wetted perimeter
	(m)	(m)	(m)	(m)	(m)	(m)	(Sq.m)	(m)	(m)
1	-51.000	64.440	62.440						
2	-46.000	64.440	62.440						
3	-46.000	56.330	62.440	6.11	3.05	0.000	0.00	8.11	8.11
4	-41.400	56.330	62.440	6.11	6.11	4.600	28.10	0.00	4.60
5	-36.800	56.355	62.440	6.09	6.10	4.600	28.05	0.02	4.60
6	-27.600	55.462	62.440	6.98	6.53	9.200	60.09	0.89	9.24
7	-18.400	53.661	62.440	8.78	7.88	9.200	72.48	1.80	9.37
8	-9.200	53.464	62.440	8.98	8.88	9.200	81.67	0.20	9.20
9	0.000	53.267	62.440	9.17	9.07	9.200	83.48	0.20	9.20
10	9.200	54.801	62.440	7.64	8.41	9.200	77.33	1.53	9.33
11	18.400	55.667	62.440	6.77	7.21	9.200	66.29	0.87	9.24
12	27.600	56.220	62.440	6.22	6.50	9.200	59.77	0.55	9.22
13	36.800	56.820	62.440	5.62	5.92	9.200	54.46	0.60	9.22
14	41.400	57.372	62.440	5.07	5.34	4.600	24.58	0.55	4.63
15	**46.000**	57.880	62.440	4.56	4.81	4.600	22.14	0.51	4.63
16	46.000	64.440	62.440						
17	51.000	64.440	62.440						
						ΣA	658.44	ΣP	100.6



Job code:	Project	4 laning of Ghazipur – Up/ Bihar border			aarvee associates architects engineers & consultants pvt. ltd.
	Job Name	Hydrology Report for MJB at Ch. 48+000			
2114	Designed By	Srivalli	Date :	05/05/21	Rev: 0
	Checked By	PKM	Date :	05/05/21	

Calculations

Highest Flood Level	HFL	=	62.440	m
Lowest Bed Level	LBL	=	53.267	m
Peak discharge	Q_{peak}	=	1235.90	cumec
Wetted area	A	=	658.44	sq.m
Wetted perimeter	P	=	100.60	m
Hydraulic mean depth	R	=	6.55	m
Manning's constant	n	=	0.040	
Bed slope of channel	S	=	0.0005	
Velocity	V	=	1.88	m/s
Discharge	Q	=	1235.90	cumec

Cl.106.6 IRC:5-2015

Molesworth's equation for computing approximate afflux given below:

h = $[(V^2/17.88)+0.015]x[(A/A_1)^2-1]$

Afflux calculations

Discharge, Q	=	1235.903	cumec
HFL (Without Afflux)	=	62.440	m
Max Avg Depth, d	=	7.549	m
Area before constriction, An1	=	658.444	sq m
Average velocity prior to constriction, Vn1=Q/An1	=	1.877	m/s
Span * no. of span	=	23	4
Peir dia	=	1	m
Abutment width	=	1	m
Area after constriction, An2=An2* - no. of piers * avg width of piers * avg depth(d)	=	633.799	sq m
Afflux due to constriction (By Molesworth Formula), h= [(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	=	0.016	m
Alluxed HFL	=	**62.455**	**m**

Hydrological & Hydraulic Details for Bridge at Ch. 48+000

Peak Discharge, Q (cumecs)	1235.90
Linear Waterway,L (m) (min. required)	92.00
Velocity (m/sec)	1.88
Lowest Bed Level (m)	53.267
Observed/Calculated HFL (m)	62.440
Afflux (m)	0.016
Design HFL Including afflux (m)	62.455
Mini. Free Board (m)	1.200
Min. Soffit level of the proposed bridge as per calculations (m)	63.655
Existing Soffit Level (m)	-
Min. Soffit Level to be adopted (Should not be lower than existing bridge) (m)	63.655
Catchment area (sq. km)	4140.00
Recommendation	New construction
Remarks	-

aarvee associates
architects engineers & consultants pvt. ltd.

Project:	**CONSULTANCY SERVICES FOR PREPARATION OF FSR CUM DPR OF 4 LANING OF GHAZIPUR BALLIA – UP/BIHAR SECTION FROM Km 0.000 TO Km 128.000 OF NH-19 AND CONSTRUCTION OF 2/4 LANING FLY OVER AT BALLIA (FROM CHANDRA SHEKHAR MOD TO SATISH CHANDRA COLLEGE) IN THE STATE OF UP.** **PACKAGE – III (FROM Km 78.100 TO Km 117.210)**
Title:	**Hydrology Report for MIB at Km.91+195**
Client:	**NHAI**
Design Consultant:	**Aarvee Associates Architects Engineers & Consultants Pvt. Ltd.**

Project code	Project:	4 laning of Ghazipur – Up/ Bihar border		aarvee associates architects engineers & consultants pvt. ltd.
	Job Name:	Hydrology Report for MIB at Km. 91+195		
2114	Designed By:	SV	Data: 5/5/2021	Revision No : 0
	Checked By:	PKM	Data: 5/5/2021	

Ref.	Calculations					
	Assessment of design flood for Minor Bridge at Ch. 91+195					
	Particulars of catchment					
	Catchment Area, M			=	15.60	sq. km
	Length of catchment, L			=	10.70	km
IRC: SP: 13-2004. Article 4.2	***By Dickens formula,***					
	Peak run-off, $Q = CM^{3/4}$			=	128.26	cumecs
	where, C				16.34	
IRC: SP: 13-2004. Article 4.3	***By Ryve's formula,***					
	Peak run-off, $Q = CM^{2/3}$			=	53.07	cumecs
	where, C			=	8.5	
	By Rational formulae,					
						@8 ac t
	Time of concentration,	t_c =	(0.87 x (L^3/ H)^385	=	11.21	hour
	One hour rainfall intensity	Io =	(F/T) x ((T+1)/(t+1))		14.58	cm per hour
	The critical or design intensity,	I_c =	Io x (2/(tc+1))	=	2.39	cm per hour
	Peak run-off,	Q =	0.028*P*A*Ic*f	=	40.05	cumecs
	where, F			=	28.00	cm
	T			=	24.00	hour
	L			=	10.70	km
	H			=	2.00	m
	f			=	0.96	
	P			=	0.40	
	Peak Discharge			=	**79.60**	cumecs

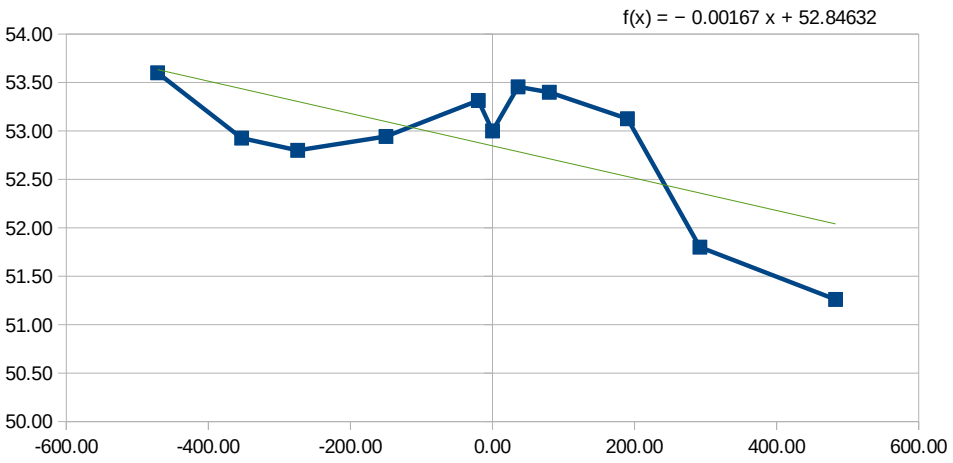
Project code	Project:	4 laning of Ghazipur – Up/ Bihar border		aarvee associates architects engineers & consultants pvt. ltd.
	Job Name:	Hydrology Report for MIB at Km. 91+195		
2114	Designed By:	SV	Data: 5/5/2021	Revision No : 0
	Checked By:	PKM	Data: 5/5/2021	

Calculation of Bed Slope

Chainage	Lowest Bed Level	Bed Slope
-471.41	53.60	-0.0057
-353.18	52.93	-0.0016
-274.30	52.80	0.0012
-150.00	52.94	0.0029
-20.00	53.31	-0.0157
0.00	53.00	0.0126
36.00	53.46	-0.0013
80.00	53.40	-0.0025
190.00	53.13	-0.0130
292.00	51.80	-0.0028
483.00	51.26	

Slope 0.0017 (Slope is 1 in 599)

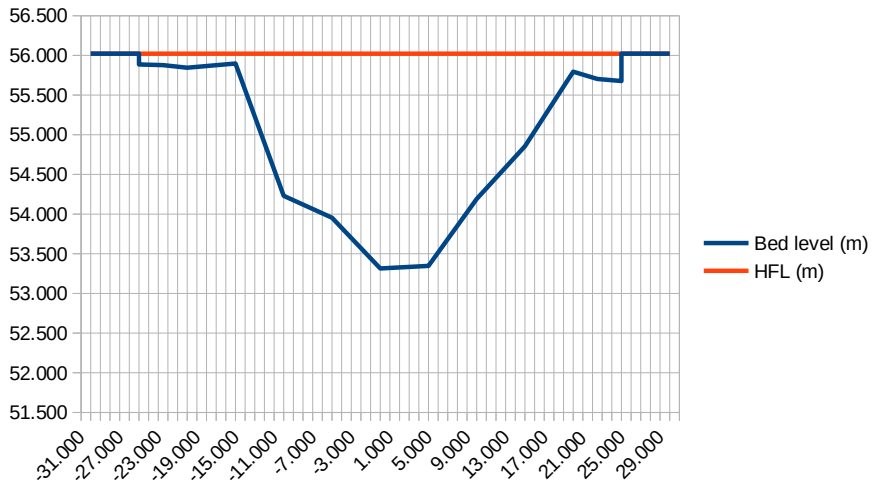
SFL -



Project code	Project:	4 laning of Ghazipur – Up/ Bihar border		aarvee associates architects engineers & consultants pvt. ltd.
	Job Name:	Hydrology Report for MIB at Km. 91+195		
2114	Designed By:	SV	Data: 5/5/2021	Revision No : 0
	Checked By:	PKM	Data: 5/5/2021	
	Calculations			

Calculation of Highest Flood Level

	Cross Section at		**20.00**	**U/S**		**HFL =**	**56.022**	**m**	
S. No.	Chainage	Bed level	HFL	Depth of water	Av. Depth of water	Distance	Area	Vertical Ht at Bed level	Wetted perimeter
	(m)	(m)	(m)	(m)	(m)	(m)	(Sq.m)	(m)	(m)
1	-30.000	56.022	56.022	0.00					
2	-25.000	56.022	56.022	0.00					
3	-25.000	55.886	56.022	0.14	0.07	0.000	0.00	0.14	0.14
4	-22.500	55.878	56.022	0.14	0.14	2.500	0.35	0.01	2.50
5	-20.000	55.844	56.022	0.18	0.16	2.500	0.40	0.03	2.50
6	-15.000	55.898	56.022	0.12	0.15	5.000	0.76	0.05	5.00
7	-10.000	54.230	56.022	1.79	0.96	5.000	4.79	1.67	5.27
8	-5.000	53.955	56.022	2.07	1.93	5.000	9.65	0.28	5.01
9	0.000	53.315	56.022	2.71	2.39	5.000	11.94	0.64	5.04
10	5.000	53.347	56.022	2.68	2.69	5.000	13.46	0.03	5.00
11	10.000	54.191	56.022	1.83	2.25	5.000	11.27	0.84	5.07
12	15.000	54.855	56.022	1.17	1.50	5.000	7.50	0.66	5.04
13	20.000	55.794	56.022	0.23	0.70	5.000	3.49	0.94	5.09
14	22.500	55.703	56.022	0.32	0.27	2.500	0.68	0.09	2.50
	25.000	55.677	56.022						
	25.000	56.022	56.022						
	30.000	56.022	56.022						
						ΣA	64.28	ΣP	48.16



Project code	Project:	4 laning of Ghazipur – Up/ Bihar border		aarvee associates architects engineers & consultants pvt. ltd.
	Job Name:	Hydrology Report for MIB at Km. 91+195		
2114	Designed By:	SV	Data: 5/5/2021	Revision No : 0
	Checked By:	PKM	Data: 5/5/2021	
	Calculations			

Highest Flood Level	HFL	=	56.022	m
Lowest Bed Level	LBL	=	53.315	m
Peak discharge	Q_{peak}	=	**79.60**	**cumec**
Wetted area	A	=	64.28	sq.m
Wetted perimeter	P	=	48.16	m
Hydraulic mean depth	R	=	1.33	m
Manning's constant	n	=	0.040	
Bed slope of channel	S	=	0.0017	
Velocity	V	=	**1.24**	**m/s**
Discharge	Q	=	**79.60**	**cumec**

Cl.106.6 IRC:5-2015

Molesworth's equation for computing approximate afflux given below:

h = $[(V^2/17.88)+0.015]x[(A/A_1)^2-1]$

E) Afflux calculations

Discharge, Q	=	79.602 cumec	
HFL (Without Afflux)	=	56.022 m	
Max Avg Depth, d	=	2.336 m	
Area before constriction, An1	=	64.276 sq m	
Average velocity prior to constriction, Vn1=Q/An1	=	1.238 m/s	
Span * no. of span	=	25.000	2
Peir dia	=	1	m
Abutment width	=	1	m
Area after constriction, An2=An2* - no. of piers * avg width of piers * avg depth(d)	=	57.268 sq m	
Afflux due to constriction (By Molesworth Formula), h= [(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	=	0.022 m	
Alluxed HFL	=	**56.044 m**	

Hydrological & Hydraulic Details for Bridge at Ch. 91+195

Peak Discharge, Q (cumecs)	79.602
Linear Waterway (Minimum required), L (m)	50.000
Velocity (m/sec)	1.238
Lowest Bed Level (m)	53.315
Observed/Calculated HFL (m)	56.022
Afflux (m)	0.023
Design HFL Including afflux (m)	56.045
Minimum Free Board (m)	0.900
Min. Soffit level of the proposed bridge as per calculations (m)	56.945
Existing Soffit Level (m)	-
Min. Soffit Level to be adopted (Should not be lower than existing bridge) (m)	56.945
Catchment area (sqr km)	15.600
Recommendation	New construction
Remarks	-

COVER PAGE

GHAGHRA RIVER – FINAL REPORT ON DETAILED HYDROGRAPHIC SURVEYS

FROM FAIZABAD (UTTAR PRADESH) TO CHHAPRA (BIHAR)

NATIONAL WATERWAY NO-40

LENGTH 353.6 KM

SURVEY PERIOD: FROM 25 APRIL 2016 TO 18 JULY 2016

CLIENT

	INLAND WATERWAYS AUTHORITY OF INDIA **A-13, Sector-1,** **NOIDA** **DIST-Gautam Budha Nagar** **UTTAR PRADESH** **PIN- 201 301(UP)** **Email:** hc.iwai@nic.in **Web:** www.iwai.nic.in

SURVEY CONTRACTOR:

	Global Marine Infratech Pvt. Ltd. **Siksha Sandhan, Ground Floor,** **ND-7, VIP Area, IRC Village,** **Bhubaneswar – 751015** **Ph: +91 674 2550599** **Fax: +91 674 2551899** **Email:** info@gmiindia.in **Web:** www.gmiindia.in

S. NO.	R/C	Site Name	River name	CD	Warning Level	Danger Level	HFL	Date	HFL in last 20 yrs.	HFL to adopt
1	Ghaghara	Chhapra (Seasonal)	Ghaghara	**43.589**	52.680	53.680	54.590	9/3/1982	54.310	**54.310**
2	Ghaghara	Gangpur Siswan (Seasonal)	Ghaghara	**51.851**	56.040	57.040	58.010	9/18/1983	57.980	**57.980**
3	Ghaghara	Darauli	Ghaghara	**55.647**	59.820	60.820	61.740	8/29/1998	61.740	**61.740**
4	Ghaghara	Turtipar	Ghaghara	**58.743**	63.010	64.010	66.000	8/28/1998	66.000	**66.000**
5	Ghaghara	Ayodhya	Ghaghara	**87.925**	91.730	92.730	94.010	10/11/2009	94.010	**94.010**

2.6 Transfer of Sounding Datum table for Tidal Rivers :-

NA

2.7 Table indicataing tidal variation at different observation points (say at every 10KM):-

As Tide poles have been erected at every 10 km ,we have observed water level from 06:00 hrs to 18:00 hrs throughout the survey. To find out tidal variation at different observation points (say at every 10 km) ,we have taken the difference between lowest and highest water level reading .

Tide pole #	Chainage (km)	Tidal variation (m)	Remarks
1	352.76	0	Tide data enclosed
2	344.044	0	Tide data enclosed
3	334.788	0	Tide data enclosed
4	320.86	0.05	Tide data enclosed
5	314.84	0.12	Tide data enclosed

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 / MHGH (m)	Remarks (complete / under - construction)
				Left Bank	RiGHt Bank	Left Bank	RiGHt Bank				
6	HTL	306.8	MEHABOOBGANJ	26°38'28.33"N 82°25'5.01"E	26°38'54.93"N 82°25'28.50"E	641145.00 E 2947479.00 N	642054.31 N 619761.00 E	2	1050	15	Complete
7	HTL	343.2	AYOUDHYA	26°48'40.21"N 82°12'24.66"E	26°48'56.19"N 82°12'18.28"E	619942.50 E 2966090.63 N	2966580.00 N 619761.00 E	2	1100	14	Complete

2.17 Details of existing Bridges and crossing over waterways in following format:-

Sl No	Structure Name and for road / rail	Chainage (km)	Type of Structure (RCC / Iron / Wooden)	Location	Position (UTM)		Position (Lat Long)		Length (m)	Width (m)	No of Piers	Horizontal clearance (clear distance Between piers) (m)	Vertical clearance w.r.t. HFL / MHGH (m)	Remarks (complete / under - construction), in use or not, condition
					Left Bank	Right Bank	Left Bank	Right Bank						
1	MANJI BRIDGE	17.7	RCC	MANJI	257460.00 m E 2857750.00 m N	257969.00 m E 2858322.00 m N	25°49'4.48"N 84°34'50.34"E	25°49'23.37"N 84°35'8.23"E	1250	10	32	40M	7M	
2	MANJI RLY BRIDGE UNC	18.12	IRON	MANJI	257221.00 m E 2858151.00 m N	257637.00 m E 2858617.00 m N	25°49'17.36"N 84°34'41.50"E	25°49'32.75"N 84°34'56.12"E	-	-	-	-	-	Under-Construction
3	MANJI RLY BRIDGE	18.16	IRON	MANJI	257204.00 m E 2858183.00 m N	257611.00 m E 2858642.00 m N	25°49'18.39"N 84°34'40.87"E	25°49'33.54"N 84°34'55.17"E	1250	6	17	43M	6M	
4	DARAULI PIPE BRIDGE	86.5	PONTOON	DARAULI	211485.00 m E 2886772.00 m N	212043.00E 2887551.00 m N	26° 4'16.65"N 84° 6'57.95"E	26° 4'42.35"N 84° 7'17.39"E	950	9	-	-	-	Pontoon-Bridge
5	TRUTIPAR RLY BRIDGE	114.72	IRON	TRUTIPAR	787025.64 m E 2894794.49 m N	787849.97 m E 2895595.10 m N	26° 8'38.18"N 83°52'14.87"E	26° 9'3.58"N 83°52'45.16"E	1125	6	17	45M	6M	
6	TRUTIPAR BRIDGE	116.65	RCC	TRUTIPAR	786456.21 m E 2896700.85 m N	786831.39 m E 2896905.03 m N	26° 9'40.48"N 83°51'55.90"E	26° 9'46.84"N 83°52'9.56"E	800	9	18	40M	7M	

Stretch No.	Chainage (km)	Position				Observed Depth (m) (D)	Velocity (m/sec.)	Average Velocity (m/sec.)	X-Sectional area (sq. m.)	Discharge (Cu.m)
		Latitude	Longitude	Easting (m)	Northing(m)		0.5 D			
ZONE-44										
CM 34	22.27	25° 50’ 11”.2908 N	078° 32’ 53”.4255 E	254241.38	2859866.61	2.1	0.87	0.85	220.8	187.6
CM 35	12.20	25° 46’ 18”.1662 N	078° 36’ 4”.397 E	259429.73	2852593.28	2.7	0.84	0.84	106.5	89.46
CM 36	02.24	25° 44’ 7”.0814 N	078° 41’ 14”.0672 E	267988.7	2848404.55	2.4	0.76	0.77	540	415.8

2.21 (a) Soil sample locations

Sample No.	Chainage (km)	Latitude	Longitude	Easting (m)	Northing (m)	Depth (m)
BS1	353.16	26° 48’ 14”.2149 N	082° 06’ 44”.1443 E	610548.19	2965204.95	2.8
BS2	343.39	26° 48’ 39”.8326 N	082° 12’ 12”.6898 E	619612.12	2966075.88	9.4
BS3	335.86	26° 49’ 12”.671 N	082° 16’ 36”.8467 E	626895.21	2967157.54	2.7
BS4	326.35	26° 44’ 20”.3766 N	082° 17’ 43”.0513 E	628814.59	2958182.1	3.3
BS5	316.60	26° 43’ 9”.5973 N	082° 22’ 34”.5403 E	636891.27	2956088.67	2.4
BS6	306.24	26° 38’ 26”.0711 N	082° 25’ 35”.7003 E	641994.79	2947419.41	4.5
BS7	297.20	26° 41’ 12”.0184 N	082° 29’ 49”.131 E	648942.84	2952606.01	2.8
BS8	289.25	26° 38’ 54”.9662 N	082° 32’ 41”.3701 E	653754.85	2948445.45	1.2
BS9	278.65	26° 36’ 32”.7873 N	082° 37’ 4”.8408 E	661095.54	2944160.5	2.7
BS10	268.23	26° 32’ 47”.4351 N	082° 40 ‘38”.8883 E	667107.24	2937302.12	4.5
BS11	258.04	26° 33’ 42”.2159 N	082° 46’ 37”.7808 E	677016.95	2939121.79	9.1
BS12	248.28	26° 33’ 28”.6096 N	082° 50’ 50”.2292 E	684009.29	2938801.91	2.8