With reference of 234th EAC Meeting held on 27th April, 2020, ADS raised on 02.05.2020 and compliance of the same submitted on 09.05.2020. Again, ADS raised on dated 12.05.2020 and we are herewith submitting the point wise compliance of the observations raised on dated 12.05.2020 for obtaining Environmental Clearance for proposal No. IA/GJ/MIS/75732/2018 [F. No. 10-60/2018-IA.III], are as under:

Reply of ADS raised on dated 12.05.2020 for Proposal No. IA/GJ/NCP/75732/2018

S. No	ADS	Compliance
1. RESPONSE AT S. NO. VI:	It is mentioned that detailed study on 'Salt pan, water bird and water draining pattern and changes that can occur especially during rains and floods' has been carried out as per scope mentioned in ToR conditions and referred the annexures II and III. However, one perusal it is observed annexure II (page 239 of ADS reply document) is a map only that shows the distance of salt pan from the proposed alignment. Likewise, annexure III (pages 240-272) shows only certain hydraulic calculations for one major bridge and five minor bridges along with few maps (date and scale not mentioned) showing boundaries of catchment areas. The detailed of methodology for data collection, analysis and subsequent findings are not discussed and compiled in report form.	Study has been carried out and it is found that the proposed alignment does not pass through the Salt Pans. The distance of the salt pans in the study area is 3.6 km in SE direction from end chainage (Ch. 130+073) and 11.63 km away in NW direction from Ch. 95+400 (Map showing the distance between salt pans and proposed alignment is attached as **Annexure-I**). Hence, the impact of the proposed alignment on the salt pans will be insignificant. The nearest Flamingo Nest which was spotted during site visit is 4.80 km away from proposed alignment. However, the species's breeding sites are declining on account of habitat degradation prominently due to anthropogenic activities. As the bird feeds primarily on blue-green algae (Spirulina prominently) that grow in alkaline lakes/salt pans, attempts need to be made to maintain the existing salt pans and

14/5/2020

National Highways Authority of India * PIU Gandhidham *

		increase the number of such sites. This need be supported by reducing human influences, such as, disposal of sewage and industrial effluents, and excessive flooding so as to promote the enabling environment for the growth of blue-green algae. Earthworks to build supporting walls wherever necessary to prevent erosion need be given priority. Under specific circumstances, captive breeding may also be attempted to increase the population of the bird. Above all, the local inhabitants, labourers and tourists need be made aware about the unique ecosystem of the Lesser Flamingo and its significance for the ecosystem and human welfare, through exhibition, print and electronic media and "Save the Flamingo Campaign". Attempts need be made to develop people's groups and volunteers for conservation initiatives. Such human capital need be rewarded socially "in-kind/in-cash) for promoting citizens" participation in conservation of Lesser Flamingo. Detailed hydrological study has also been carried out for entire stretch for maintaining the natural drainage pattern (attached as **Annexure-II)**. The minimum vertical clearance from the existing ground provided is approximately 3m. Also, 3m x 3m RCC

		BOX culverts, underpasses at almost every kilometer, make the project road elevated in general.
2. RESPONSE AT S. NO. VII	Same as above. Annexure III (pages 240-272) shows only certain hydraulic calculations for one major bridge and five minor bridges along with few maps (date and scale not mentioned) showing boundaries of catchment areas. The detailed of methodology for data collection, analysis and subsequent findings are not discussed and compiled in report form.	The detailed methodology for data collection, analysis and subsequent findings are incorporated in the report and attached herewith as **Annexure-II.**
3. RESPONSE AT S. NO. VIII:	Map showing ESZ has been provided (pages 273-275). This does not show the distribution and movement of Wild Ass along the proposed alignment and cross over sites on the basis of Wild Ass census data collected by the State Forest Department of Gujarat.	ESZ Map has been prepared by state government and approved by central Government. Issued vide MOEF&CC notification S.O. 5138(E) dated 01.10.2018. The areas marked as the green Patches in the Map are wild Animal movement area to mitigate the movement. Such areas through with the project road pass have been provided with the proposal for construction of underpasses and culverts. for free movement of wild animals. (Maps are attached as **Annexure-III)** NHAI vide letter dated 05.02.2020 and 13.05.2020 has requested DCF Dharangedra provide the data of movement of wild Ass in the project area. Due to lockdown in the state of the Gujarat,

National Highways Authority of India * PIU Gandhidham *

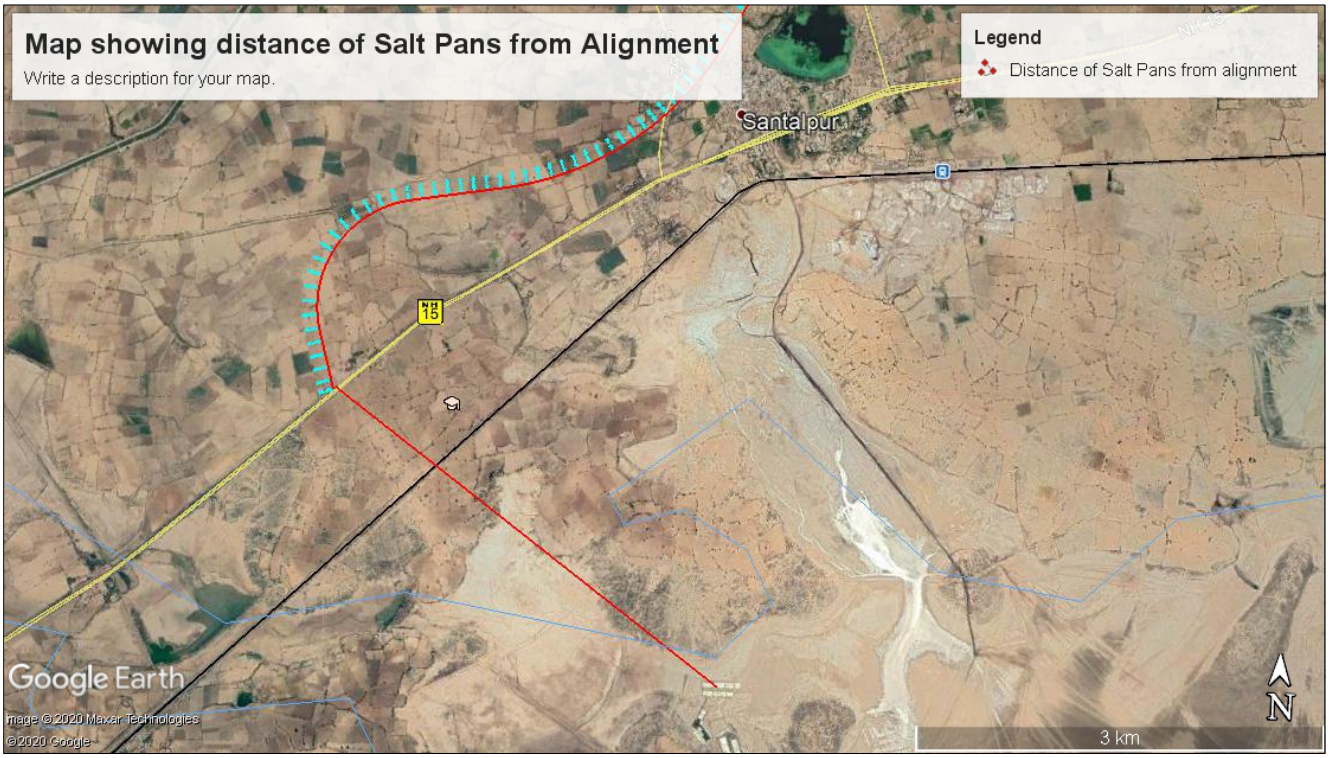
		concerned DCF Dharangadhra office was contacted is not functioning, due to Covid-19 Zone. The details required shall be submitted after the situation of the present lockdown improves However, NHAI undertakes for the compliance of the mitigation measures/ conservation plan of State Government. It is also undertaken that the same will be incorporated in project design and implementation of mitigation plan will be done in close supervision of forest department.
4. RESPONSE AT S. NO. XIX:	Not complied ADS. Only provided the list of species to be planted along with the number of trees and allocated budget (pages 384-385). Comprehensive plan is not provided. Please provide the above mentioned information/documents at the earliest for further consideration of the proposal.	Comprehensive Plan for afforestation is attached as **Annexure-IV.**

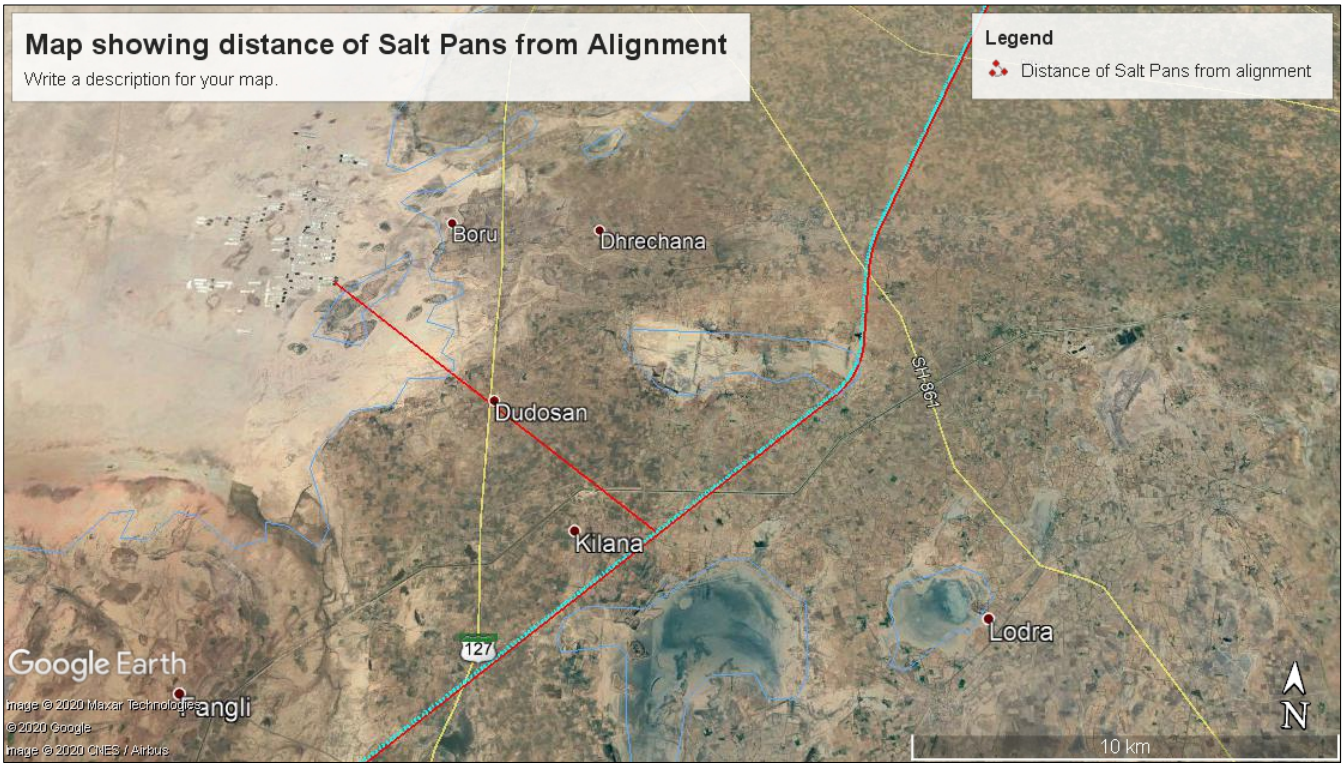
14/5/2020

National Highways Authority of India * PIU Gandhidham *

Annexure List

Annexure I	Map showing distance between Salt Pans and proposed alignment
Annexure II	Hydrology Report
Annexure III	Landuse map of WLS and ESZ
Annexure IV	Comprehensive plan for afforestation


Map showing distance of Salt Pans from Alignment
Write a description for your map.
Legend
Distance of Salt Pans from alignment
Santalpur
Google Earth
Image © 2020 Maxar Technologies
© 2020 Google
3 km
N


Map showing distance of Salt Pans from Alignment
Write a description for your map.
Legend
Distance of Salt Pans from alignment
Boru
Dhrechana
Dudosan
Kilana
Lodra
SH-861
127
Google Earth
Image © 2020 Maxar Technologies
© 2020 Google
Image © 2020 CNES / Airbus
10 km
N

STUP Consultants P. Ltd

Ishram Signature Tower, Near Iskcon Temple,
Plot No 5, Pocket B-10, Sector 13, Dwarka,
New Delhi-110 078
Tel.:011- 45616200 / 25536108 / 25614196
Fax: 011-25507017
E-mail: delhi@stupmail.com

OFFICE OF ORIGIN :

STUP ,DELHI

OWNER :

NATIONAL HIGHWAY AUTHORITY OF INDIA

PROJECT :

Consultancy services for feasibility preparation of detailed project report for imprtanat & up-gradation for Package-3 lot 4 of Bharatmala road project

TITLE :

Detailed hydrology and hydraulics report of structures

DATE	Rev. No.	MODIFICATIONS/ PURPOSE OF ISSUE	PREPARED		CHECKED		APPROVED	
			Name	Signature	Name	Signature	Name	Signature
13.05.2020	R0	FOR APPROVAL	SBB		MNG		ASJ	

This note is the property of STUP Consultants P.Ltd. It should not be used, copied or reproduced without their written permission.

DATE : 13.05.2020

PAGES : 2 + 39 = 41 Pg.

NOTE No. 12645/E/DN/0002

REV.NO (R0)

CONTENTS

Sr. No.	Item Description	Page No.
1.0	GUIDELINES FOR EXPRESSWAYS	1
2.0	DESIGN APPROACH FOR BRIDGES AND CULVERTS	1
2.1	HYDROLOGY OF BRIDGES HAVING CATCHMENT AREA MORE THAN 25 Sq.Km	2
2.1.3	HYDRAULICS OF BRIDGES HAVING CATCHMENT AREA MORE THAN 25 Sq.Km	3
2.2	HYDROLOGY OF BRIDGES HAVING CATCHMENT AREA LESS THAN 25 Sq.Km	4
2.2.3	HYDRAULICS OF BRIDGES HAVING CATCHMENT AREA LESS THAN 25 Sq.Km	5
2.2.4	DESIGN APPROACH FOR CANAL BRIDGES/CULVERTS	6
2.2.5	DESIGN APPROACH FOR BRIDGES OVER EXISTING water body	7
2.2.6	VARIOUS MEETINGS AND SITE VISITS	7
3.0	ANNEXURE : HYDRAULIC CALCULATIONS	8

1.0 INTRODUCTION

The National Highways Authority of India (NHAI) has been entrusted by Ministry of Roads Transport & Highways, Government of India with the assignment of preparation of feasibility study /Detailed project report and implementation of road stretches selected for Amritsar to Jamnagar Corridor under Bharatmala Pariyojana to 6-lane access control National Highway No. 754K(Economic Corridor-3) of Bharatmala Project starting from Vantdau, in Banaskantha district to Santalpur, in Patan district approximately (125.185 km) in the state of Gujarat.M/s. STUP Consultants Pvt. Ltd., New Delhi have been appointed as Consultants by NHAI to carry out the preparation of Feasibility study / Detailed Project Report of road stretches selected of BharatMala Scheme – Proposed New National Highway NH-754K greenfield alignment Sanchore-Santalpur section (Economic Corridor – 3) starting from Vantdau, in Banaskantha district to Ranmalpura in Patan district approximately (125.185 km), in the state of Gujarat.

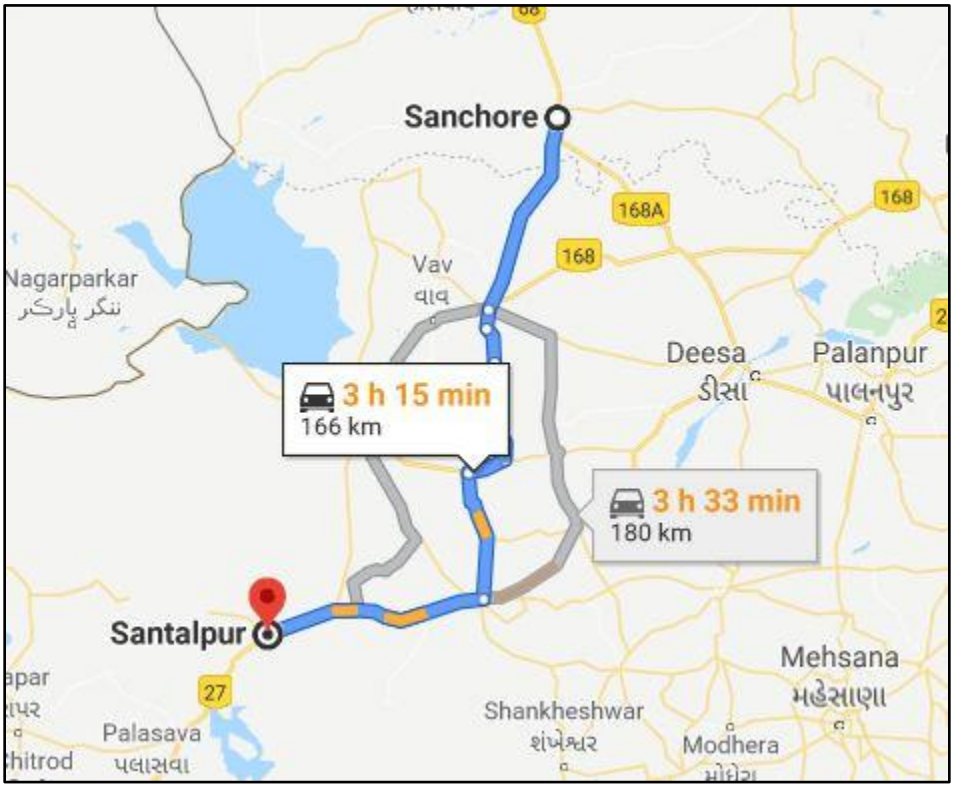


Fig 1: Map Showing The Location Of Project Area

2.0 DESIGN APPROACH FOR BRIDGES

The hydrological & hydraulic designs of cross drainage structures is an important aspect to determine the minimum required waterway, design highest flood level (HFL) and minimum proposed soffit level at proposed bridge/CD locations on the green field alignment.

The hydrological & hydraulic designs of cross drainage structures, protection works and road drainages are as per the following latest IRC codes and reports.

- IRC: SP-13 - Guidelines for the design of small bridges and culverts
- IRC: 5 - Code of practice for Road Bridges, Section I (General features of Design)
- IRC:SP-87 - Manual of Specifications and Standards for 6 lane
- IRC:SP-42 – Guidelines on Road Drainage
- Flood Estimation Report for Luni Subzone Report (subzone – 1a), A joint work of Central Water Commission (CWC); Research, Designs & Standards Organization (Min. of Railway) and India Meteorological Department & Min. of Transport

2.1 HYDROLOGY OF BRIDGES HAVING CATCHMENT AREA MORE THAN 25 SQ.KM

2.1.1 DESIGN PARAMETERS

- Catchment area, length of longest stream & Parameters for determining equivalent slope is obtained from 1 in 50,000 scale topographical sheets, obtained from Survey of India (SOI).
- **Return Period:** The design discharge is calculated for flood of 100 year return period.
- **Frequency of Rainfall:** Parameters, such as, equations for obtaining synthetic unit hydrograph, 100-year 24-hr point rainfall, conversion factor for 100-year 24-hr point rainfall to design storm duration, areal reduction factor for finding area rainfall from point rainfall, time distribution of areal rainfall, loss rate, base flow, etc. is obtained from flood estimation reports of Central Water Commission (CWC).
- **Bed Slope:** The energy slope would be taken equal to the bed slope, measured over a reasonably long reach. Bed slope of the river is obtained from toposheet.

2.1.2 METHODOLOGY

- **Design discharge:** Flood Estimation Reports for Luni Sub zone 1(a) is used for the determination of design discharges of bridges whose catchment area is more than 25 sq.km. However, where there is a dam in the upstream side of the river bridge, the maximum outflow from the spillway of the dam is added with the 100 years return period discharge of the catchment area from bridge location to the dam location.
  Determination of 1 hr. SUH for an ungauged catchment (As per the CWC "Flood Estimation Report for Subzone 1(a):

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

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

i) tp = 0.257*(A)^0.409 * (S) ^0.432

ii) qp = 2.165* (tp)^-0.893

iii) W50 = 2.654 *(qp)^-0.921

iv) W75 = 1.672 * (qp)^-0.816

v) WR50 = 1.245 * (qp)^-0.571

vi) WR75 = 0.816* (qp)^-0.559

vii) TB = 6.299 * (tp)^0.612

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 were Joined 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.

2.1.3 HYDRAULICS OF BRIDGES HAVING CATCHMENT AREA MORE THAN 25 Sq.Km

A. DESIGN PARAMETERS

- **Bed Slope:** The energy slope is taken equal to the bed slope, measured over a reasonably long reach. Bed slope of the river is obtained from topo survey data/topo sheet.

- **Roughness Coefficient:** Roughness coefficient, n is adopted as per Table 5.1 of IRC: SP-13.

- **Vertical Clearance:** The minimum vertical clearance is adopted as per Table 12.1 of IRC: SP-13.

B. METHODOLOGY

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:

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 R2/3 S1/2, 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

Afflux: Afflux of the bridge occurs, when the waterway area (opening of a bridge) is less than the unobstructed natural waterway area of the stream, i.e., when bridge contracts the stream. The afflux is calculated by using the following methods.

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

H = {(V2/17.88) +0.01524} x [{(A/a) 2-1}]

Where,

H = Afflux in meters.

V = Velocity in un-obstructed stream in meter per second.

A = Un-obstructed sectional area of the river in square meters.

a = Sectional area of the river at obstruction in square metres

Vertical Clearance: The minimum vertical clearance is adopted as per Table 12.1 of IRC: SP-13.

Minimum Proposed Soffit Level of Bridge: Design HFL (With afflux) is added to minimum vertical clearance for obtaining minimum proposed soffit level of bridge.

The detailed hydrology and hydraulics calculations are attached as Annexure-1

2.2 HYDROLOGY OF BRIDGES HAVING CATCHMENT AREA LESS THAN 25 Sq.Km

2.2.1 DESIGN PARAMETERS

- Catchment area, length of longest stream & Parameters for determining equivalent slope is obtained from 1 in 50,000 scale topographical sheets, obtained from Survey of India (SOI).

- **Return Period:** The design discharge is calculated for flood of 100 year return period.

- **Frequency of Rainfall:** Frequency of Rainfall for 24 hour 100 years return period is obtained from Flood Estimation Reports (by Central Water Commission) for Luni subzone 1(a).

- **Areal Spread Factor,'f':** The areal spread factor is conversion of of point rainfall values to areal rainfall values. This factor is taken from 'f' curve mentioned in Fig. 4.2 of IRC: SP-13.

- **Run-off Co-efficient:** Run-off Co-efficient, P is adopted as per Table 4.1 of IRC:SP-13.

2.2.2 METHODOLOGY

- **Design discharge: F**lood discharge is estimated in three ways, Dickens Formula, Modified Ingli's Formula & Rational formulae. The values obtained are compared and the highest of these values is adopted as the design discharge (Q), provided it does not exceed the next highest discharge by more than 50 percent and if it does, restrict it to 50 percent of the next highest discharge.

2.2.3 HYDRAULICS OF BRIDGES HAVING CATCHMENT AREA LESS THAN 25 Sq.Km

A. DESIGN PARAMETERS

- **Bed Slope:** The energy slope is taken equal to the bed slope, measured over a reasonably long reach. Bed slope of the river is obtained from topo survey data/topo sheet.

- **Roughness Coefficient:** Roughness coefficient, n is adopted as per Table 5.1 of IRC: SP-13.

- **Vertical Clearance:** The minimum vertical clearance is adopted as per Table 12.1 of IRC: SP-13.

B. METHODOLOGY

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:

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 R2/3 S1/2, 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

Afflux: Afflux of the bridge occurs, when the waterway area (opening of a bridge) is less than the unobstructed natural waterway area of the stream, i.e., when bridge contracts the stream. The afflux is calculated by using the following methods.

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

H = {(V2/17.88) +0.01524} x [{(A/a) 2-1}]

Where,

H = Afflux in meters.

V = Velocity in un-obstructed stream in meter per second.

A = Un-obstructed sectional area of the river in square meters.

a = Sectional area of the river at obstruction in square metres

Vertical Clearance: The minimum vertical clearance is adopted as per Table 12.1 of IRC: SP-13.

Minimum Proposed Soffit Level of Bridge: Design HFL (With afflux) is added to minimum vertical clearance for obtaining minimum proposed soffit level of bridge.

The detailed hydrology and hydraulics calculations are attached as Annexure-1.

2.2.4 DESIGN APPROACH FOR CANAL BRIDGES/CULVERTS

- Canal cross section details including design discharge, FSL, slope, etc. were obtained from Irrigation Department.

- Span arrangements were finalized based on canal cross section and presence of inspection road for canals.

- Hydraulic data received from irrigation has been introduced in respective GAD's of structures.

2.2.5 DESIGN APPROACH FOR BRIDGES OVER EXISTING WATER BODY

- Span arrangements were proposed from bank to bank of existing water bodies without permitting any earthwork in the existing water bodies.

2.2.6 VARIOUS MEETINGS AND SITE VISITS

To review the methodology of hydraulic calculation of bridges, joint site visits were conducted by NHAI and DPR consultants on the following occasions,

From 14th to 15th November 2018: Joint site visit attended by GM-NHAI, PD-NHAI & Bridge Engineer-STUP Consultants. After the joint site visit, a meeting was convened under chairmanship of GM-NHAI and based on the Hydrology and Hydraulics finalized during the meeting, the span arrangements of bridges have been finalized.

3.0 ANNEXURE : HYDRAULIC CALCULATIONS

Hydrology and Hydraulics of Minor Bridge

Bridge at KM 87+500

1 General Details

Catchment area (From toposheet)	A	=	**0.03**	Sq. KM
Existing Span Arrangement		=	New constuction	
Proposed Span Arrangement		=	**2 x 3**	m
Design Discharge		=	**1.15**	Cumec
HFL		=	21.239	m
Affluxed HFL		=	21.316	m
Vertical Clearance		=	0.450	m
			(Refer:Table 12.1, page-37 of IRC:SP:13-2004)	
Soffit level to be provided		=	21.766	m

2 Flood Estimation

Catchment Area,A = **0.03** Sq.Km

2.1 Emperical formulae

2.1.1 Dicken's formula

Constant,C = 11

Peak Run-off, Q = $C \times A^{(3/4)}$

Peak Run-off, Q = **0.79** Sq.Km

2.1.2 Modified Ingli's formula

Max Run-off, Q = 123.2A/Sqrt(A+10.36)

Max Run-off, Q = **1.145** Sq.Km

2.2 Rational formula

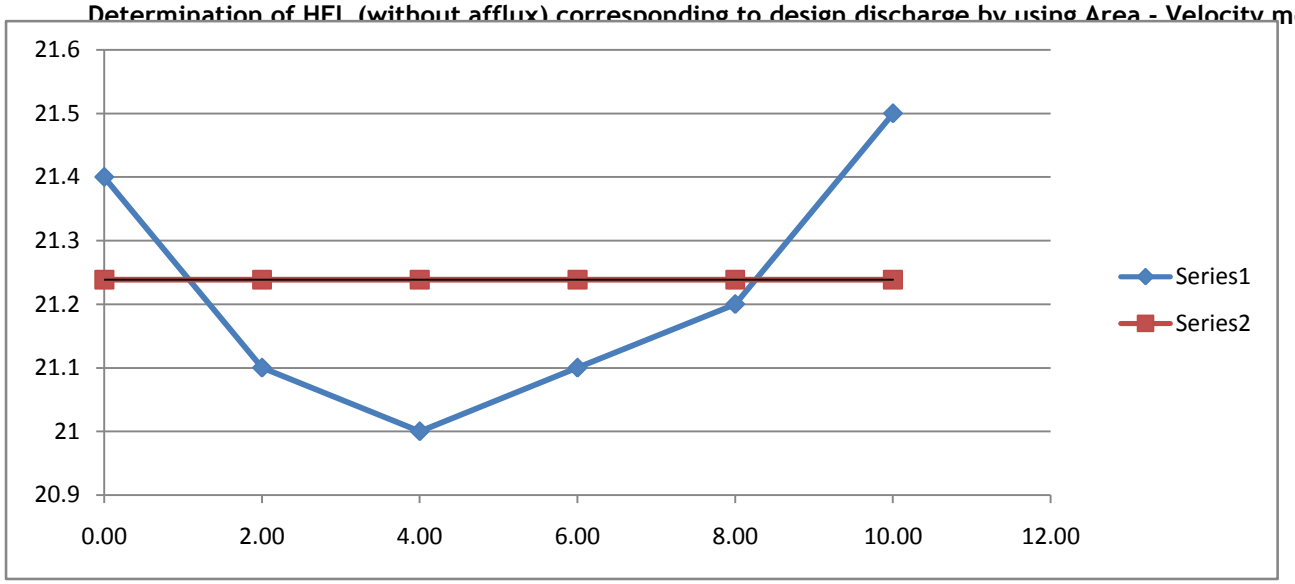
Distance from the critical point to the structure, L (From Toposheet)	=	**0.14**	Km
Level at u/s of Stream (m)	=	**24.000**	
Bed Level at Bridge (m)	=	21.000	
Fall in Level from the critical point to the structure, H (m)	=	3.000	m
Concentration Time, tc (IRC SP-13, Page no12)	=	$(0.87xL^3/H)^{0.385}$	
Concentration Time, tc (IRC SP-13, Page no12)	=	0.064	hours
Frequency of Rainfall (100 year return period), F (From Flood Estimation Report for Luni Subzone-1(a))	=	**40**	cm/day
Critical Intensity of rainfall	=	$F/T(T+1/t_c+1)$	
Critical Intensity of rainfall	=	39.16	cm/hr
Factor,f (IRC SP-13 fig 4.2, Page no- 14)	=	**1.00**	

Coefficient of Runoff, P (IRC SP-13, Table-14, Page-13)	=	**0.30**		11
Maximum Run-off, Q	=	$0.028xPxfxAxI_c$	Cumecs	
Maximum Run-off, Q (IRC SP-13, Page-13)	=	**0.99**	Cumecs	

Design Discharge

Run-off by Dicken's formula	=	0.79	Cumecs
Run-off by Modified Ingli's formula	=	1.15	Cumecs
Run-off by Rational formula	=	0.99	Cumecs
Maximum Run-off of Above Methods	=	**1.15**	Cumecs
Second Highest Run-off	=	0.99	Cumecs
50% increase in Second Highest Run-off	=	1.48	Cumecs
Design discharge, Q	**=**	**1.15**	**Cumecs**

Determination of HFL (without afflux) corresponding to design discharge by using Area - Velocity method



HFL=	21.239	m		Q=	1.15	cumec		
Offset	Bed Level	Natural HFL	Dist.	h	Avg h	Diff in h	Area	Peri-meter
(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m2)	(m)
0.00	21.4	21.24	0.00	-0.16	-0.16	0.00	0.00	0.00
2.00	21.100	21.24	2.00	0.14	-0.01	0.30	-0.02	0.00
4.00	21.000	21.24	2.00	0.24	0.19	0.10	0.38	2.00
6.00	21.100	21.24	2.00	0.14	0.19	0.10	0.38	2.00
8.00	21.200	21.24	2.00	0.04	0.09	0.10	0.18	2.00
10.00	21.500	21.24	2.00	-0.26	-0.11	0.30	-0.22	0.00
						Sum =	0.9	6.0

Rugosity Co-efficient, n = 0.04 …As per Table 5.1 of IRC :SP :13-2004

Manning coefficient is assumed considering prevailing soil conditions and shall be verified by soil report.

Effective Clear waterway = Number of span X Span Length - Piers Thickness X No. of piers

R (m)	0.16
n	**0.040**
S	**0.0290**
V (m/s)	1.23
Q (cumec)	1.15
D_d **(max)** (m)	0.24
D_d **(av)** (m)	0.12
W (m)	8.00
L (m)	**6.00**

5 Calculation of afflux by Molesworth formula

Velocity of flow (V)	1.23	m/s
Unobstructed sectional area (A)	0.93	sq. m
Obstructed sectional area (a)	0.70	sq. m

$$\text{Afflux} = \left(\frac{V^2}{17.88} + 0.015 \right) \times ((A/a)^2 - 1) = 0.077 \text{ m}$$

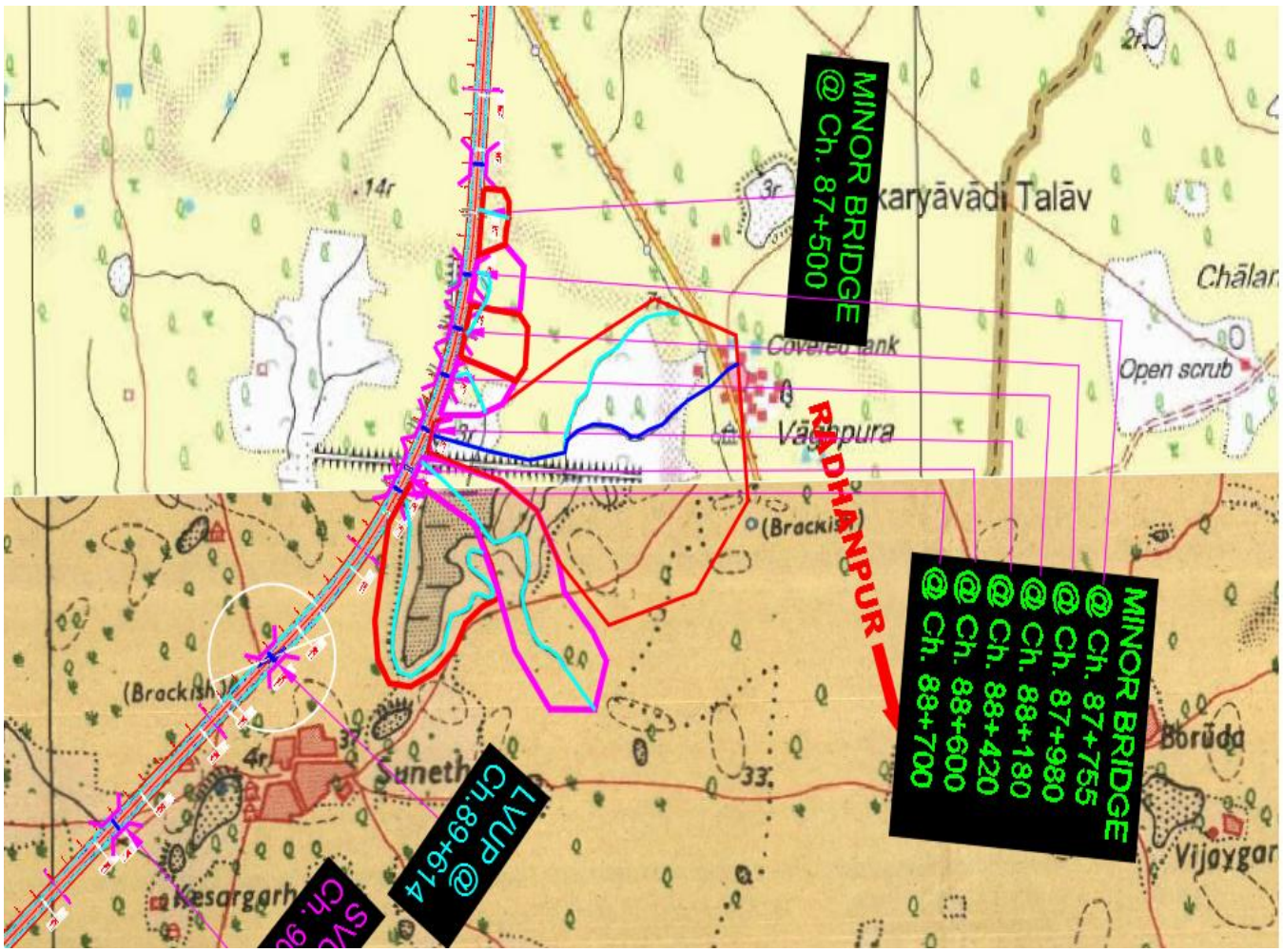
(Refer IRC -5-2015 cl.no. 106.6)

Design Afflux (h) = 0.077 m

6 Deck level

HFL (without afflux)	=	21.239		
Design HFL (including afflux)	=	21.316	m	
Minimum vertical clearance	=	**0.450**	m	
(Refer:Table 12.1, page-37 of IRC:SP:13-2004)				
Minimum Required Soffit level of bridge	=	21.766	m	...OK
Provided soffit level of bridge	=	**27.025**	m	

7 Catchment Area



Hydrology and Hydraulics of Minor Bridge

Bridge at KM 87 + 980

1 General Details

Catchment area (From toposheet)	A	=	**0.07**	Sq. KM
Existing Span Arrangement		=	New constuction	
Proposed Span Arrangement		=	**2 x 3**	m
Design Discharge		=	**2.69**	Cumec
HFL		=	20.349	m
Affluxed HFL		=	20.458	m
Vertical Clearance		=	0.450	m
			(Refer:Table 12.1, page-37 of IRC:SP:13-2004)	
Soffit level to be provided		=	20.908	m

2 Flood Estimation

Catchment Area,A = **0.07** Sq.Km

2.1 Emperical formulae

2.1.1 Dicken's formula

Constant,C = 11 ...Refer clause no.4.2 of IRC :SP:13 -2004

Peak Run-off, Q = $C \times A^{(3/4)}$

Peak Run-off, Q = **1.50** Sq.Km

2.1.2 Modified Ingli's formula

Max Run-off, Q = 123.2A/Sqrt(A+10.36)

Max Run-off, Q = **2.688** Sq.Km

2.2 Rational formula

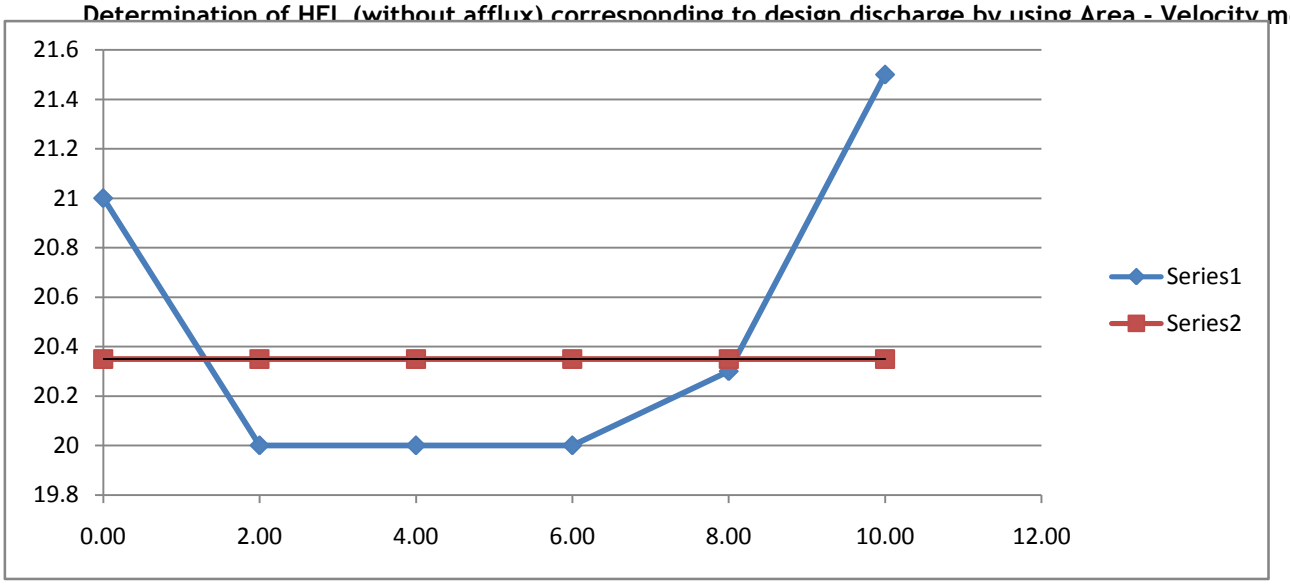
Distance from the critical point to the structure, L (From Toposheet)	=	**0.131**	Km
Level at u/s of Stream (m)	=	**21.000**	
Bed Level at Bridge (m)	=	20.000	
Fall in Level from the critical point to the structure, H (m)	=	1.000	m
Concentration Time, tc (IRC SP-13, Page no12)	=	$(0.87xL^3/H)^{0.385}$	
Concentration Time, tc (IRC SP-13, Page no12)	=	0.091	hours
Frequency of Rainfall (100 year return period), F (From Flood Estimation Report for Luni Subzone-1(a))	=	**40**	cm/day
Critical Intensity of rainfall	=	$F/T(T+1/t_c+1)$	
Critical Intensity of rainfall	=	38.21	cm/hr
Factor,f (IRC SP-13 fig 4.2, Page no- 14)	=	**1.00**	

Coefficient of Runoff, P (IRC SP-13, Table-14, Page-13)	=	**0.30**	
Maximum Run-off, Q	=	$0.028xPxfxAxI_c$	Cumecs
Maximum Run-off, Q (IRC SP-13, Page-13)	=	**2.26**	Cumecs

Design Discharge

Run-off by Dicken's formula	=	1.50	Cumecs
Run-off by Modified Ingli's formula	=	2.69	Cumecs
Run-off by Rational formula	=	2.26	Cumecs
Maximum Run-off of Above Methods	=	**2.69**	Cumecs
Second Highest Run-off	=	2.26	Cumecs
50% increase in Second Highest Run-off	=	3.39	Cumecs
Design discharge, Q	**=**	**2.69**	**Cumecs**

Determination of HFL (without afflux) corresponding to design discharge by using Area - Velocity method



HFL=	20.349	m		Q=	2.69	cumec		
Offset	Bed Level	Natural HFL	Dist.	h	Avg h	Diff in h	Area	Peri-meter
(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m2)	(m)
0.00	21	20.35	0.00	-0.65	-0.65	0.00	0.00	0.00
2.00	20.000	20.35	2.00	0.35	-0.15	1.00	-0.30	0.00
4.00	20.000	20.35	2.00	0.35	0.35	0.00	0.70	2.00
6.00	20.000	20.35	2.00	0.35	0.35	0.00	0.70	2.00
8.00	20.300	20.35	2.00	0.05	0.20	0.30	0.40	2.02
10.00	21.500	20.35	2.00	-1.15	-0.55	1.20	-1.10	0.00
						Sum =	1.8	6.0

R (m)	0.30
n	**0.040**
S	**0.0180**
V (m/s)	1.50
Q (cumec)	2.69
D_d **(max)** (m)	0.35
D_d **(av)** (m)	0.22
W (m)	8.00
L (m)	**6.00**

Rugosity Co-efficient, n = 0.04 …As per Table 5.1 of IRC :SP :13-2004

Manning coefficient is assumed considering prevailing soil conditions and shall be verified by soil report.

Effective Clear waterway = Number of span X Span Length - Piers Thickness X No. of piers

5 Calculation of afflux by Molesworth formula

Velocity of flow (V)	1.50	m/s
Unobstructed sectional area (A)	1.80	sq. m
Obstructed sectional area (a)	1.35	sq. m

$$\text{Afflux} = \left(\frac{V^2}{17.88} + 0.015 \right) \times ((A/a)^2 - 1) = 0.109 \text{ m}$$

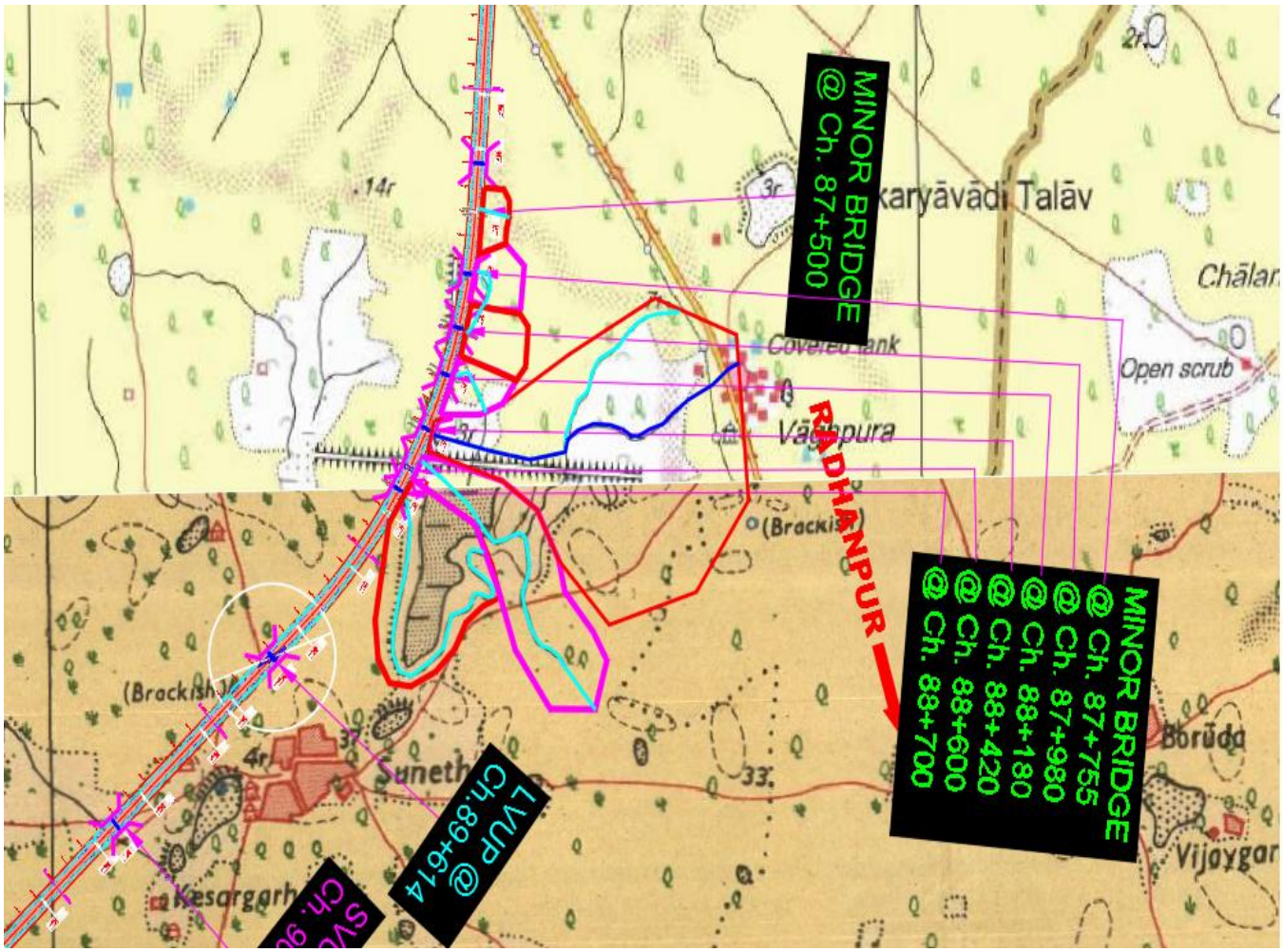
(Refer IRC -5-2015 cl.no. 106.6)

Design Afflux (h) = 0.109 m

6 Deck level

HFL (without afflux)	=	20.349	
Design HFL (including afflux)	=	20.458	m
Minimum vertical clearance	=	**0.450**	m
(Refer:Table 12.1, page-37 of IRC:SP:13-2004)			
Minimum Required Soffit level of bridge	=	20.908	m ...OK
Provided soffit level of bridge	=	**26.67**	m

7 Catchment Area



Hydrology and Hydraulics of Minor Bridge

Bridge at KM 88+180

1 General Details

Catchment area (From toposheet)	A	=	**0.05**	Sq. KM
Existing Span Arrangement		=	New constuction	
Proposed Span Arrangement		=	**2 x 3**	m
Design Discharge		=	**2.06**	Cumec
HFL		=	22.197	m
Affluxed HFL		=	22.340	m
Vertical Clearance		=	0.450	m
			(Refer:Table 12.1, page-37 of IRC:SP:13-2004)	
Soffit level to be provided		=	22.790	m

2 Flood Estimation

20

Catchment Area,A = **0.05** Sq.Km

2.1 Emperical formulae

2.1.1 Dicken's formula

Constant,C = 11 ...Refer clause no.4.2 of IRC :SP:13 -2004

Peak Run-off, Q = $C \times A^{(3/4)}$

Peak Run-off, Q = **1.23** Sq.Km

2.1.2 Modified Ingli's formula

Max Run-off, Q = 123.2A/Sqrt(A+10.36)

Max Run-off, Q = **2.059** Sq.Km

2.2 Rational formula

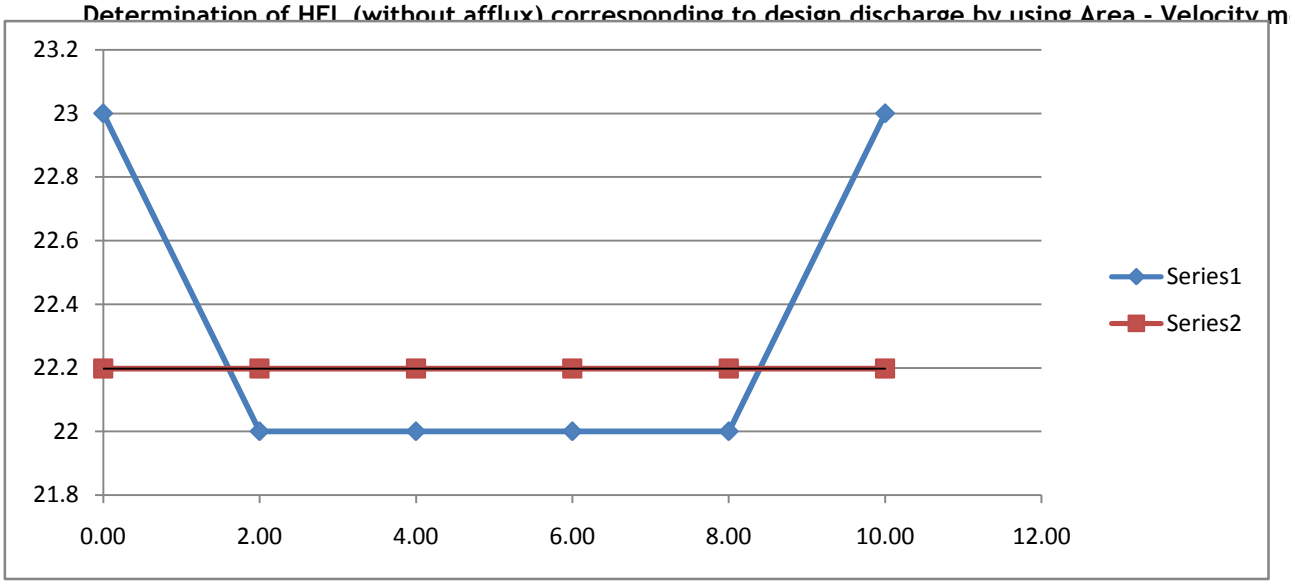
Distance from the critical point to the structure, L (From Toposheet)	=	**0.24**	Km
Level at u/s of Stream (m)	=	**24.000**	
Bed Level at Bridge (m)	=	22.000	
Fall in Level from the critical point to the structure, H (m)	=	2.000	m
Concentration Time, tc (IRC SP-13, Page no12)	=	$(0.87xL^3/H)^{0.385}$	
Concentration Time, tc (IRC SP-13, Page no12)	=	0.140	hours
Frequency of Rainfall (100 year return period), F (From Flood Estimation Report for Luni Subzone-1(a))	=	**40**	cm/day
Critical Intensity of rainfall	=	$F/T(T+1/t_c+1)$	
Critical Intensity of rainfall	=	36.56	cm/hr
Factor,f (IRC SP-13 fig 4.2, Page no- 14)	=	**1.00**	

Coefficient of Runoff, P (IRC SP-13, Table-14, Page-13)	=	**0.30**		21
Maximum Run-off, Q	=	$0.028xPxfxAxI_c$	Cumecs	
Maximum Run-off, Q (IRC SP-13, Page-13)	=	**1.66**	Cumecs	

Design Discharge

Run-off by Dicken's formula	=	1.23	Cumecs
Run-off by Modified Ingli's formula	=	2.06	Cumecs
Run-off by Rational formula	=	1.66	Cumecs
Maximum Run-off of Above Methods	=	**2.06**	Cumecs
Second Highest Run-off	=	1.66	Cumecs
50% increase in Second Highest Run-off	=	2.48	Cumecs
Design discharge, Q	**=**	**2.06**	**Cumecs**

Determination of HFL (without afflux) corresponding to design discharge by using Area - Velocity method



HFL=	22.197	m		Q=	2.06	cumec		
Offset	Bed Level	Natural HFL	Dist.	h	Avg h	Diff in h	Area	Peri-meter
(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m2)	(m)
0.00	23	22.20	0.00	-0.80	-0.80	0.00	0.00	0.00
2.00	22.000	22.20	2.00	0.20	-0.30	1.00	-0.61	0.00
4.00	22.000	22.20	2.00	0.20	0.20	0.00	0.39	2.00
6.00	22.000	22.20	2.00	0.20	0.20	0.00	0.39	2.00
8.00	22.000	22.20	2.00	0.20	0.20	0.00	0.39	2.00
10.00	23.000	22.20	2.00	-0.80	-0.30	1.00	-0.61	0.00
						Sum =	1.2	6.0

Rugosity Co-efficient, n = 0.04 …As per Table 5.1 of IRC :SP :13-2004

Manning coefficient is assumed considering prevailing soil conditions and shall be verified by soil report.

Effective Clear waterway = Number of span X Span Length - Piers Thickness X No. of piers

R (m)	0.20
n	**0.040**
S	**0.0420**
V (m/s)	1.74
Q (cumec)	2.06
D_d **(max)** (m)	0.20
D_d **(av)** (m)	0.15
W (m)	8.00
L (m)	**6.00**

5 Calculation of afflux by Molesworth formula

Velocity of flow (V)	1.74	m/s
Unobstructed sectional area (A)	1.18	sq. m
Obstructed sectional area (a)	0.89	sq. m

$$\text{Afflux} = \left(\frac{V^2}{17.88} + 0.015 \right) \times ((A/a)^2 - 1) = 0.143 \text{ m}$$

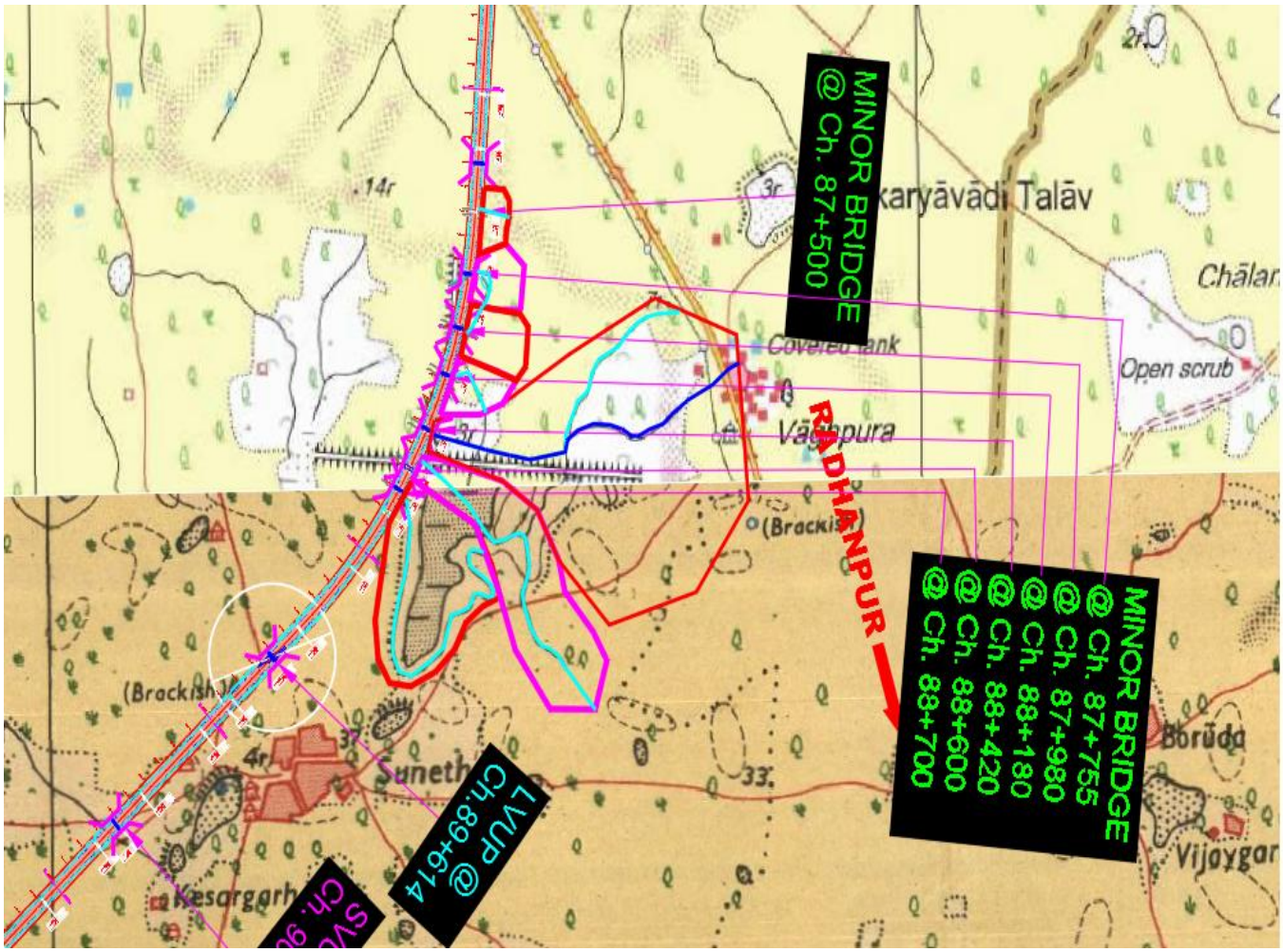
(Refer IRC -5-2015 cl.no. 106.6)

Design Afflux (h) = 0.143 m

6 Deck level

HFL (without afflux)	=	22.197		
Design HFL (including afflux)	=	22.340	m	
Minimum vertical clearance	=	**0.450**	m	
(Refer:Table 12.1, page-37 of IRC:SP:13-2004)				
Minimum Required Soffit level of bridge	=	22.790	m	...OK
Provided soffit level of bridge	=	**27.578**	m	

7 Catchment Area



Hydrology and Hydraulics of Minor Bridge

Bridge at KM 103+332

1 General Details

Catchment area (From toposheet)	A	=	**2.45**	Sq. KM
Existing Span Arrangement		=	New constuction	
Proposed Span Arrangement		=	**2 x 25**	m
Design Discharge		=	**38.98**	Cumec
HFL		=	14.414	m
Affluxed HFL		=	14.458	m
Vertical Clearance		=	0.900	m
			(Refer:Table 12.1, page-37 of IRC:SP:13-2004)	
Soffit level to be provided		=	15.358	m

2 Flood Estimation

Catchment Area,A = **2.45** Sq.Km

2.1 Emperical formulae

2.1.1 Dicken's formula

Constant,C = 11 ...Refer clause no.4.2 of IRC :SP:13 -2004

Peak Run-off, Q = $C \times A^{(3/4)}$

Peak Run-off, Q = **21.56** Sq.Km

2.1.2 Modified Ingli's formula

Max Run-off, Q = 123.2A/Sqrt(A+10.36)

Max Run-off, Q = **84.433** Sq.Km

2.2 Rational formula

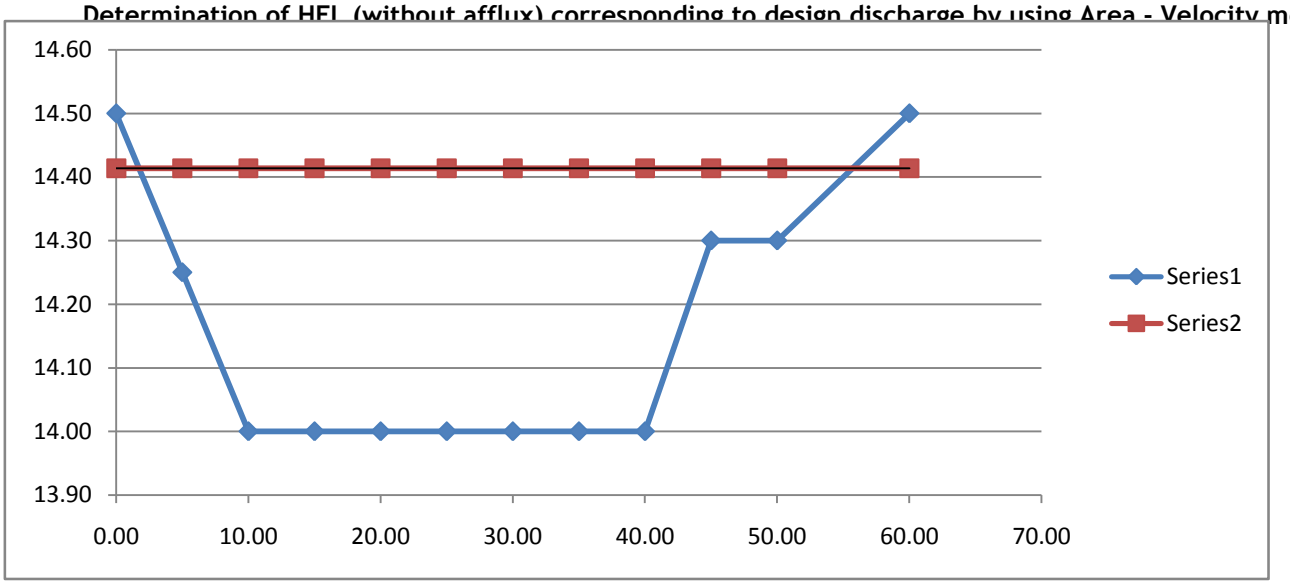
Distance from the critical point to the structure, L (From Toposheet)	=	**3.035**	Km
Level at u/s of Stream (m)	=	**17.000**	
Bed Level at Bridge (m)	=	14.000	
Fall in Level from the critical point to the structure, H (m)	=	3.000	m
Concentration Time, tc (IRC SP-13, Page no12)	=	$(0.87xL^3/H)^{0.385}$	
Concentration Time, tc (IRC SP-13, Page no12)	=	2.238	hours
Frequency of Rainfall (100 year return period), F (From Flood Estimation Report for Luni Subzone-1(a))	=	**40**	cm/day
Critical Intensity of rainfall	=	$F/T(T+1/t_c+1)$	
Critical Intensity of rainfall	=	12.87	cm/hr
Factor,f (IRC SP-13 fig 4.2, Page no- 14)	=	**0.98**	

Coefficient of Runoff, P (IRC SP-13, Table-14, Page-13)	=	**0.30**		26
Maximum Run-off, Q	=	$0.028xPxfxAxI_c$	Cumecs	
Maximum Run-off, Q (IRC SP-13, Page-13)	=	**25.98**	Cumecs	

Design Discharge

Run-off by Dicken's formula	=	21.56	Cumecs
Run-off by Modified Ingli's formula	=	84.43	Cumecs
Run-off by Rational formula	=	25.98	Cumecs
Maximum Run-off of Above Methods	=	**84.43**	Cumecs
Second Highest Run-off	=	25.98	Cumecs
50% increase in Second Highest Run-off	=	38.98	Cumecs
Design discharge, Q	**=**	**38.98**	**Cumecs**

Determination of HFL (without afflux) corresponding to design discharge by using Area - Velocity method



HFL=	14.414	m		Q=	38.98	cumec		
Offset	Bed Level	Natural HFL	Dist.	h	Avg h	Diff in h	Area	Peri-meter
(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m2)	(m)
0.00	14.50	14.41	0.00	-0.09	-0.09	0.00	0.00	0.00
5.00	14.25	14.41	5.00	0.16	0.04	0.25	0.19	5.01
10.00	14.00	14.41	5.00	0.41	0.29	0.25	1.44	5.01
15.00	14.00	14.41	5.00	0.41	0.41	0.00	2.07	5.00
20.00	14.00	14.41	5.00	0.41	0.41	0.00	2.07	5.00
25.00	14.00	14.41	5.00	0.41	0.41	0.00	2.07	5.00
30.00	14.00	14.41	5.00	0.41	0.41	0.00	2.07	5.00
35.00	14.00	14.41	5.00	0.41	0.41	0.00	2.07	5.00
40.00	14.00	14.41	5.00	0.41	0.41	0.00	2.07	5.00
45.00	14.30	14.41	5.00	0.11	0.26	0.30	1.32	5.01
50.00	14.30	14.41	5.00	0.11	0.11	0.00	0.57	5.00
60.00	14.50	14.41	10.00	-0.09	0.01	0.20	0.14	10.00
						Sum =	15.9	50.0

R (m)	0.32
n	**0.040**
S	**0.0440**
V (m/s)	2.45
Q (cumec)	38.98
D_d **(max)** (m)	0.41
D_d **(av)** (m)	0.32
W (m)	50.00
L (m)	**47.10**

Rugosity Co-efficient, n = 0.04 …As per Table 5.1 of IRC :SP :13-2004

Manning coefficient is assumed considering prevailing soil conditions and shall be verified by soil report.

Effective Clear waterway = Number of span X Span Length - Piers Thickness X No. of piers

5 Calculation of afflux by Molesworth formula

Velocity of flow (V)	2.45	m/s
Unobstructed sectional area (A)	15.93	sq. m
Obstructed sectional area (a)	15.01	sq. m

$$\text{Afflux} = \left(\frac{V^2}{17.88} + 0.015 \right) \times ((A/a)^2 - 1) = 0.044 \text{ m}$$

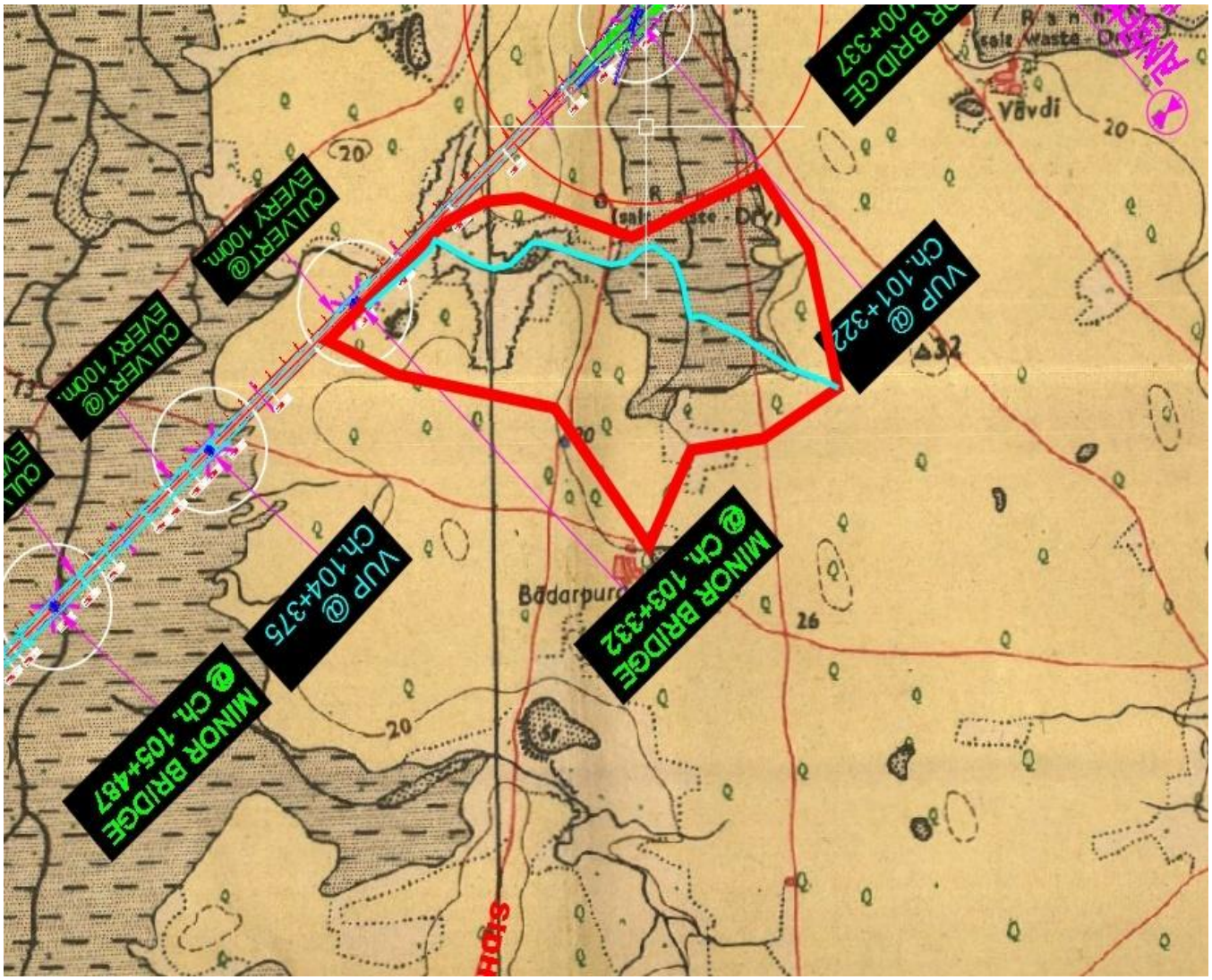
(Refer IRC -5-2015 cl.no. 106.6)

Design Afflux (h) = 0.044 m

6 Deck level

HFL (without afflux)	=	14.414	
Design HFL (including afflux)	=	14.458	m
Minimum vertical clerance	=	**0.900**	m
(Refer:Table 12.1, page-37 of IRC:SP:13-2004)			
Minimum Required Soffit level of bridge	=	15.358	m ...OK
Provided soffit level of bridge	=	**20.375**	m

7 Catchment Area



Hydrology and Hydraulics of Minor Bridge

Bridge at KM 105+487

1 General Details

Catchment area (From toposheet)	A	=	**5.36**	Sq. KM
Existing Span Arrangement		=	New constuction	
Proposed Span Arrangement		=	**2 x 20**	m
Design Discharge		=	**136.25**	Cumec
HFL		=	8.914	m
Affluxed HFL		=	9.065	m
Vertical Clearance		=	0.900	m
			(Refer:Table 12.1, page-37 of IRC:SP:13-2004)	
Soffit level to be provided		=	9.965	m

2 Flood Estimation

30

Catchment Area,A = **5.36** Sq.Km

2.1 Emperical formulae

2.1.1 Dicken's formula

Constant,C = 11 ...Refer clause no.4.2 of IRC :SP:13 -2004

Peak Run-off, Q = $C \times A^{(3/4)}$

Peak Run-off, Q = **38.73** Sq.Km

2.1.2 Modified Ingli's formula

Max Run-off, Q = 123.2A/Sqrt(A+10.36)

Max Run-off, Q = **166.436** Sq.Km

2.2 Rational formula

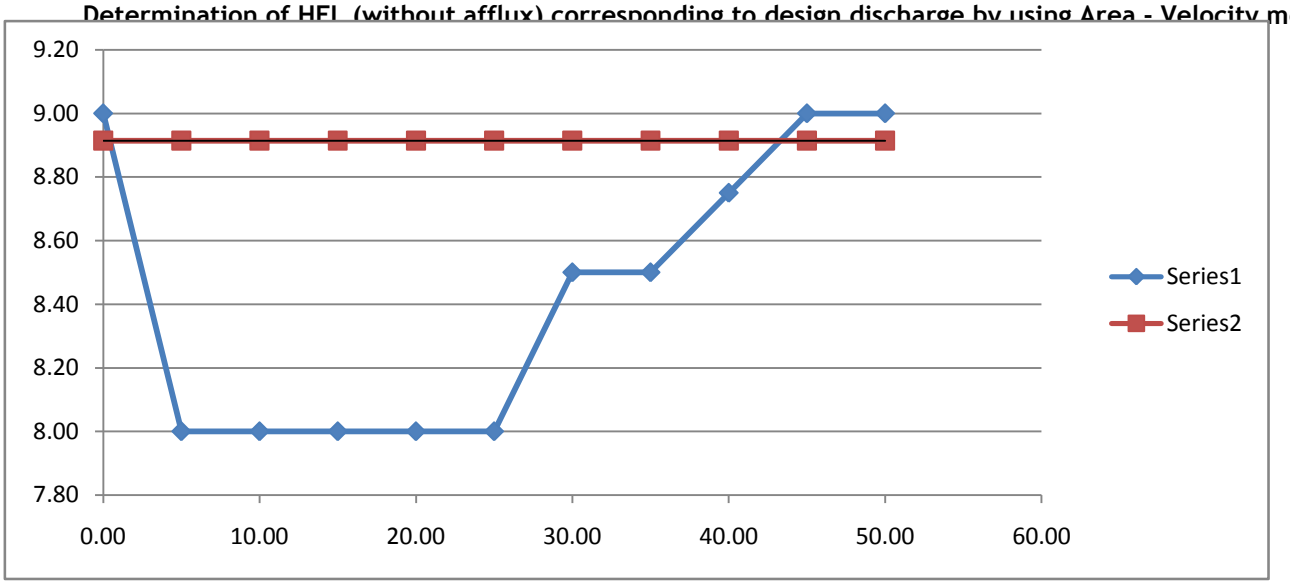
Distance from the critical point to the structure, L (From Toposheet)	=	**1.486**	Km
Level at u/s of Stream (m)	=	**11.000**	
Bed Level at Bridge (m)	=	8.000	
Fall in Level from the critical point to the structure, H (m)	=	3.000	m
Concentration Time, tc (IRC SP-13, Page no12)	=	$(0.87xL^3/H)^{0.385}$	
Concentration Time, tc (IRC SP-13, Page no12)	=	0.981	hours
Frequency of Rainfall (100 year return period), F (From Flood Estimation Report for Luni Subzone-1(a))	=	**40**	cm/day
Critical Intensity of rainfall	=	$F/T(T+1/t_c+1)$	
Critical Intensity of rainfall	=	21.03	cm/hr
Factor,f (IRC SP-13 fig 4.2, Page no- 14)	=	**0.96**	

Coefficient of Runoff, P (IRC SP-13, Table-14, Page-13)	=	**0.30**		31
Maximum Run-off, Q	=	$0.028xPxfxAxI_c$	Cumecs	
Maximum Run-off, Q (IRC SP-13, Page-13)	=	**90.83**	Cumecs	

Design Discharge

Run-off by Dicken's formula	=	38.73	Cumecs
Run-off by Modified Ingli's formula	=	166.44	Cumecs
Run-off by Rational formula	=	90.83	Cumecs
Maximum Run-off of Above Methods	=	**166.44**	Cumecs
Second Highest Run-off	=	90.83	Cumecs
50% increase in Second Highest Run-off	=	136.25	Cumecs
Design discharge, Q	**=**	**136.25**	**Cumecs**

Determination of HFL (without afflux) corresponding to design discharge by using Area - Velocity method



HFL=	8.914	m		Q=	136.25	cumec		
Offset	Bed Level	Natural HFL	Dist.	h	Avg h	Diff in h	Area	Peri-meter
(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m2)	(m)
0.00	9.00	8.91	0.00	-0.09	-0.09	0.00	0.00	0.00
5.00	8.00	8.91	5.00	0.91	0.41	1.00	2.07	5.10
10.00	8.00	8.91	5.00	0.91	0.91	0.00	4.57	5.00
15.00	8.00	8.91	5.00	0.91	0.91	0.00	4.57	5.00
20.00	8.00	8.91	5.00	0.91	0.91	0.00	4.57	5.00
25.00	8.00	8.91	5.00	0.91	0.91	0.00	4.57	5.00
30.00	8.50	8.91	5.00	0.41	0.66	0.50	3.32	5.02
35.00	8.50	8.91	5.00	0.41	0.41	0.00	2.07	5.00
40.00	8.75	8.91	5.00	0.16	0.29	0.25	1.45	5.01
45.00	9.00	8.91	5.00	-0.09	0.04	0.25	0.20	5.01
50.00	9.00	8.91	5.00	-0.09	-0.09	0.00	-0.43	0.00
						Sum =	27.4	45.1

R (m)	0.61
n	**0.040**
S	**0.0770**
V (m/s)	4.97
Q (cumec)	136.25
D_d **(max)** (m)	0.91
D_d **(av)** (m)	0.68
W (m)	40.00
L (m)	**38.00**

Rugosity Co-efficient, n = 0.04 …As per Table 5.1 of IRC :SP :13-2004

Manning coefficient is assumed considering prevailing soil conditions and shall be verified by soil report.

Effective Clear waterway = Number of span X Span Length - Piers Thickness X No. of piers

5 Calculation of afflux by Molesworth formula

Velocity of flow (V)	4.97	m/s
Unobstructed sectional area (A)	27.40	sq. m
Obstructed sectional area (a)	26.03	sq. m

$$\text{Afflux} = \left(\frac{V^2}{17.88} + 0.015 \right) \times ((A/a)^2 - 1) = 0.151 \text{ m}$$

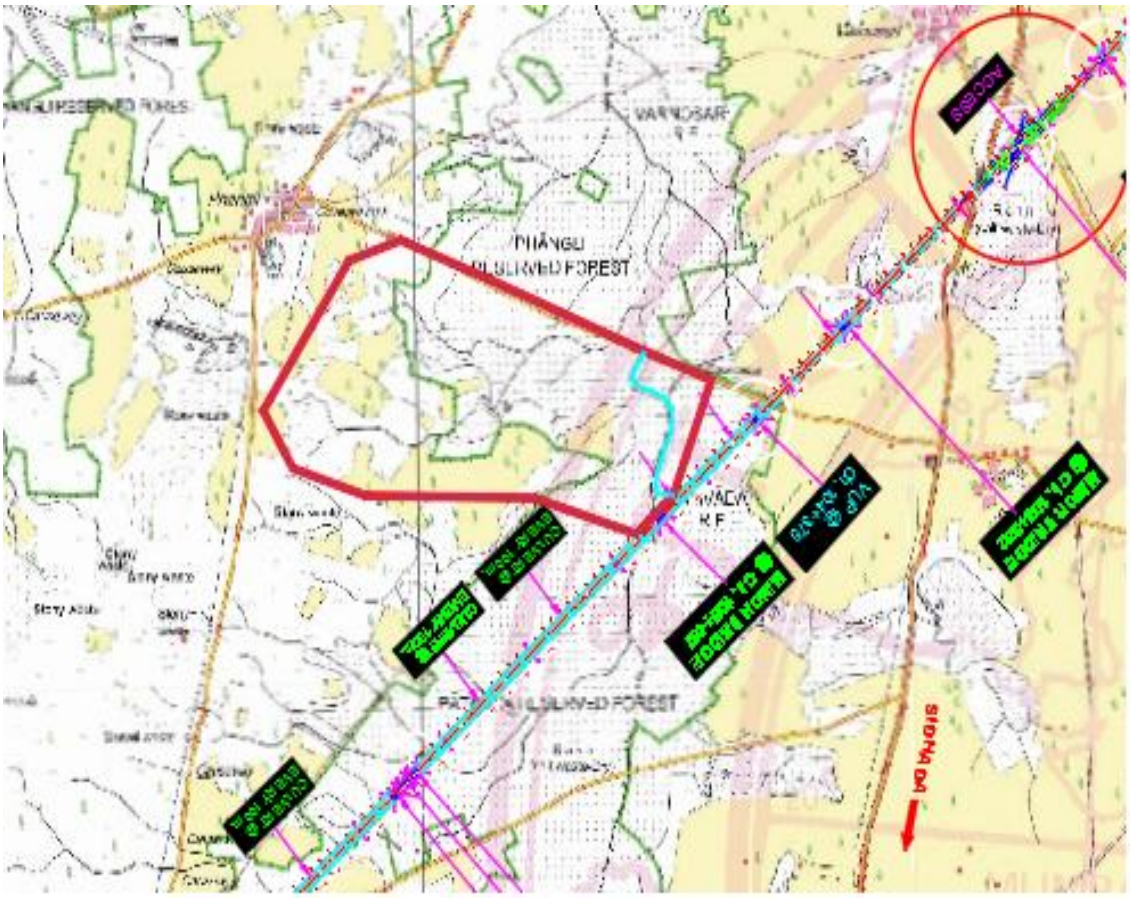
(Refer IRC -5-2015 cl.no. 106.6)

Design Afflux (h) = 0.151 m

6 Deck level

HFL (without afflux)	=	8.914	
Design HFL (including afflux)	=	9.065	m
Minimum vertical clerance	=	**0.900**	m
(Refer:Table 12.1, page-37 of IRC:SP:13-2004)			
Minimum Required Soffit level of bridge	=	9.965	m ...OK
Provided soffit level of bridge	=	**13.8755**	m

7 Catchment Area



Hydrology and Hydraulics of Major Bridge

Bridge at KM 83+868

1 General Details

Catchment area	A	=	116.27	Sq. KM
Existing Span Arrangement		=		
Proposed Span Arrangement		=	3 x 30	m
Design Discharge		=	1980.28	Cumec
HFL		=	19.740	m
Affluxed HFL		=	20.340	m
Vertical Clearance		=	1.200	(Refer:Table 12.1, page-37 of IRC:SP:13-2004)
Existing Soffit level		=	-	
Soffit level to be provided		=	21.540	m

2 Catchment Parameters

River / Stream / Nala
Luni

Watershed Area in Sq Km (A)	**116.27**	
Longest Length in Km (L)	**33.34**	
Length of the longest stream from the point opposite to C.G. (Lc) Km	**19.32**	
Point Rainfall Value (100 years) in mm	**400**	(Refer: Isopluvial map of CWC report)
CWC Subzone	**1(a)**	Luni subzone

3 Estimation of Design Discharge

Synthetic Unit Hydrograph Method (CWC Subzone 1(a))

1. Equivalent Slope (derived from Toposheet)

Sl No.	Distance	Elevation	Segment Length	Segment Length	Ht. above datum	Di + Di-1	Li X (Di +Di-1)
	m	m	m	km	Di, m	m	in km x m
1	**0**	**17**			0		
2	**6000**	**25**	6000	6.00	8	8	48.00
3	**15000**	**30**	9000	9.00	13	21	189.00
2	**33340**	**86**	18340	18.34	69	82	1503.88
						Sum	1740.88
	Equivalent Stream Slope (Seq) = $\sum$Li * (Di + Di-1) / L^2						
				Slope (S)	1.57	m/km	

Establishing relationship between Physiographic and Representative Unitgraph Parameters:

tr = = **1.0** hrs

t_p = $0.257\ (A)^{0.409} \times (S)^{0.432}$ = **2.2** hrs = **2.00** hrs **Adopted**

q_p = $2.165 \times (t_p)^{-0.893}$ = **1.17** cumec/sq.km.

Qp = $q_p \times A$ = **135.55** Cumec

T_B = $6.299 \times (t_P)^{0.612}$ = **9.63** hrs = **10.00** hrs Adopted

W_{50} = $2.654 \times (q_p)^{-0.921}$ = **2.30** hrs

W_{75} = $1.672 \times (q_p)^{-0.816}$ = **1.48** hrs

W_{R-50} = $1.245 \times (q_p)^{-0.571}$ = **1.14** hrs

W_{R-75} = $0.816 \times (q_p)^{-0.559}$ = **0.75** hrs

t_m = $t_p + t_r/2$ = **2.50** hrs = **3.00** hrs Adopted

Base Flow = **0.05** cumec/sq.km. ….as per para 3.6 of CWC report 1(a)

Loss Rate = **0.50** cm/hr ….as per para 3.5 of CWC report 1(a)

Synthetic U.G Parameters

X-Value		Y-Value	
0.00	0	0	0
t_m-W_{R50}	1.86	Q_p*0.5	67.77
t_m-W_{R75}	2.25	Q_p*0.75	101.66
t_m	3.00	Q_p*1.0	135.55
t_m+W_{75}-W_{R75}	3.73	Q_p*0.75	101.66
t_m+W_{50}-W_{R50}	4.16	Q_p*0.5	67.77
TB	10.000	0.00	0

t_p = Time lag from centre of unit rainfall duration to the peak of unit

q_p = Peak discharge of unit hydrograph per unit area in

W_{50} = Width of unit hydrograph measured at 50%

W_{75} = Width of unit hydrograph measured at 75% of peak discharge (Q_p) in hours

W_{R50} = Width of unit hydrograph measured at 50% of Q_p between the rising limb of unit hydrograph and Q_p ordinate in hours

W_{R75} = Width of unit hydrograph measured at 75% of Q_p between the rising limb of unit hydrograph and Q_p ordinate in hours

T_B = Base period of unit hydrograph in hours

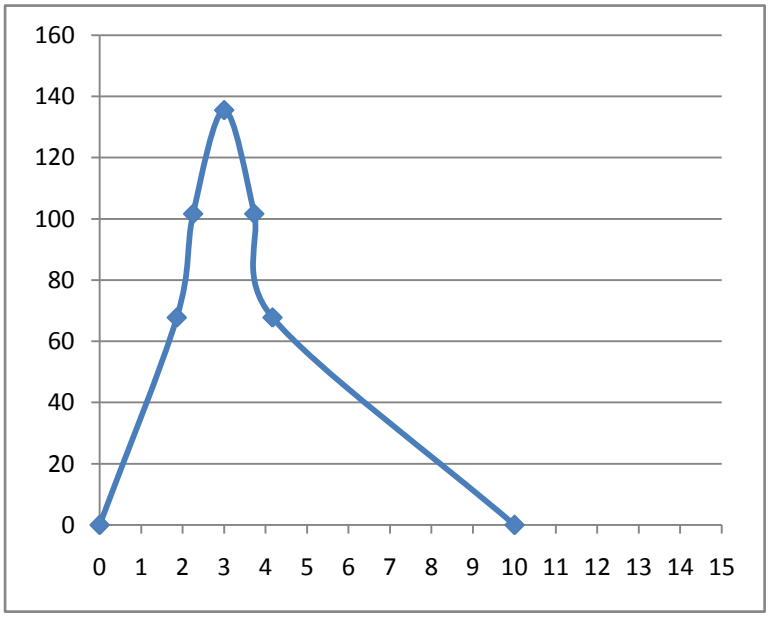
T_m = Time from start of rise to the peak of unit hydrograph in hours

t_r = Unit rainfall duration in hours

Q_p = Peak discharge of unit hydrograph in cumecs

A = Catchment area in sq.km

Hrs.	UH Ordinates m^3/s
0	0
1.86	67.8
2.25	101.7
3.00	135.5
3.73	101.7
4.16	67.8
10.00	0.0



Estimation of Design Storm

Design storm duration (T_D) = 1.1 t_p hrs.
= 2.2 hrs.
Adopted = 2.0 hrs.

Estimation of Point Rainfall and Areal Rainfall for Storm Duration

100 year 24 hr Point Rainfall = 40 cm
…...From isopluvial map of subzone 1(a)

Conversion factor = 0.49
….Duration vs. Conversion Ratio; subzone 1(a) Fig.-10

100 year 1 hr Point Rainfall = 19.6 cm
Areal reduction factor = 0.77
….Point to areal rainfall ratio subzone 1(a) Annexure-4.2

100 year 1 hr Areal Rainfall = 15.07 cm
Loss rate = 0.50 cm/hr
…Subzone 1(a) Para 3.5

Hourly effective rainfall increments

Duration (hr)	Distribution Coeff.	Rainfall cm	Incremental Rainfall (cm)	Loss rate (cm/hr)	Effective Hourly Rainfall (cm)
1	1.00	15.07	15.07	0.50	14.57

Estimation of Base Flow

Design base flow = 0.05 cumec per sq.km.
Para 3.6, CWC FER Subzone 1(a)

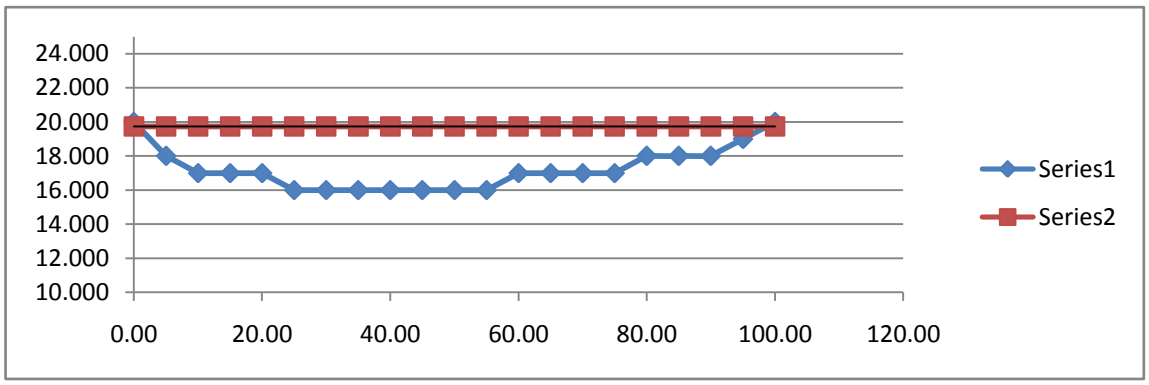
Base flow for the catchment under study = 5.81335 cumecs

Estimation of 50 Year Flood Peak

50 year flood peak			
Time in hours	SUG ordinates (cumec)	1 -hour effective rainfall (cm)	Direct runoff (cumec)
0	135.5	14.57	1974.5
Total =			1974.47
Add base flow =			5.81335
Peak Discharge (Q_{100}) =			**1980.28**

STUP Consultants P. Ltd.	Date: 13-05-2020	Note: 12645/E/DN/0002
		Rev. R0
	By : SBB	Sheet: 38 .

4 **Determination of HFL (without afflux) corresponding to design discharge by using Area - Velocity method**



HFL=	19.740	m		Q=	1980.28	cumec		
Offset	Bed Level	Natural HFL	Dist.	h	Avg h	Diff in h	Area	Peri-meter
(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m2)	(m)
0.00	20.000	19.74	0.00	-0.26	-0.26	0.00	0.00	0.00
5.00	18.000	19.74	5.00	1.74	0.74	2.00	3.70	5.39
10.00	17.000	19.74	5.00	2.74	2.24	1.00	11.20	5.10
15.00	17.000	19.74	5.00	2.74	2.74	0.00	13.70	5.00
20.00	17.000	19.74	5.00	2.74	2.74	0.00	13.70	5.00
25.00	16.000	19.74	5.00	3.74	3.24	1.00	16.20	5.10
30.00	16.000	19.74	5.00	3.74	3.74	0.00	18.70	5.00
35.00	16.000	19.74	5.00	3.74	3.74	0.00	18.70	5.00
40.00	16.000	19.74	5.00	3.74	3.74	0.00	18.70	5.00
45.00	16.000	19.74	5.00	3.74	3.74	0.00	18.70	5.00
50.00	16.000	19.74	5.00	3.74	3.74	0.00	18.70	5.00
55.00	16.000	19.74	5.00	3.74	3.74	0.00	18.70	5.00
60.00	17.000	19.74	5.00	2.74	3.24	1.00	16.20	5.10
65.00	17.000	19.74	5.00	2.74	2.74	0.00	13.70	5.00
70.00	17.000	19.74	5.00	2.74	2.74	0.00	13.70	5.00
75.00	17.000	19.74	5.00	2.74	2.74	0.00	13.70	5.00
80.00	18.000	19.74	5.00	1.74	2.24	1.00	11.20	5.10
85.00	18.000	19.74	5.00	1.74	1.74	0.00	8.70	5.00
90.00	18.000	19.74	5.00	1.74	1.74	0.00	8.70	5.00
95.00	19.000	19.74	5.00	0.74	1.24	1.00	6.20	5.10
100.00	20.000	19.74	5.00	-0.26	0.24	1.00	1.20	5.10
						Sum =	264.0	101.0

R (m)	2.61
n	**0.040**
S	**0.0250**
V (m/s)	7.50
Q (cumec)	**1980.28**
D_d **(max)** (m)	3.74
D_d **(av)** (m)	2.78
W (m)	95.00
L (m)	**87.10**

Rugosity Co-efficient, n = 0.04 …As per Table 5.1 of IRC :SP :13-2004

Manning coefficient is assumed considering prevailing soil conditions and shall be verified by soil report.

Effective Clear waterway = Number of span X Span Length - Piers Thickness X No. of piers

5 Calculation of afflux by Molesworth formula

Velocity of flow (V)	7.50	m/s
Unobstructed sectional area (A)	263.99	sq. m
Obstructed sectional area (a)	242.03	sq. m

$$\text{Afflux} = \left(\frac{V^2}{17.88} + 0.015 \right) \times ((A/a)^2 - 1) = 0.600 \text{ m}$$

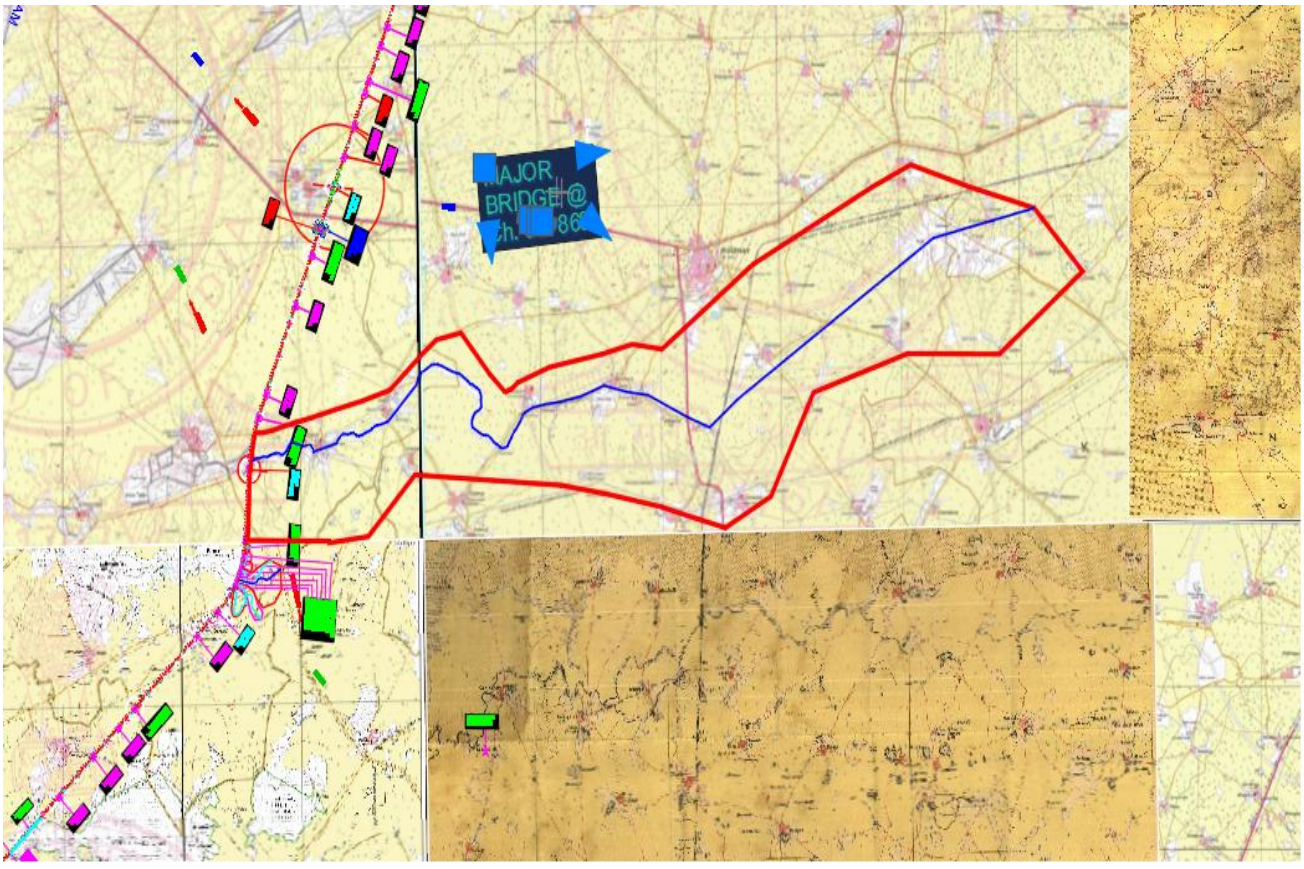
(Refer IRC -5-2015 cl.no. 106.6)

Design Afflux (h) = 0.600 m

6 Deck level

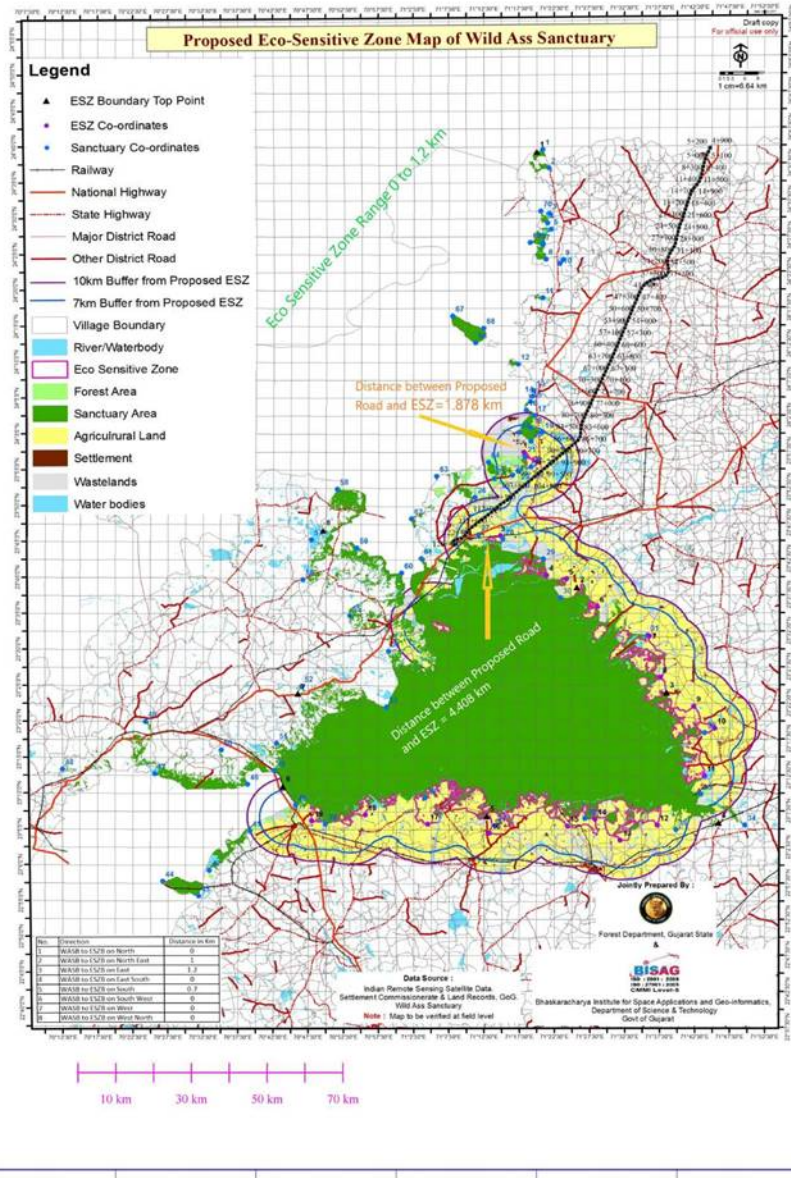
HFL (without afflux)	=	19.740	m
Design HFL (including afflux)	=	20.340	m
Minimum vertical clearance	=	1.200	m
(Refer:Table 12.1, page-37 of IRC:SP:13-2004)			
Minimum proposed Soffit level of bridge	=	**21.540**	m ...OK
Provided soffit level of bridge	=	21.757	m

7 Catchment Area

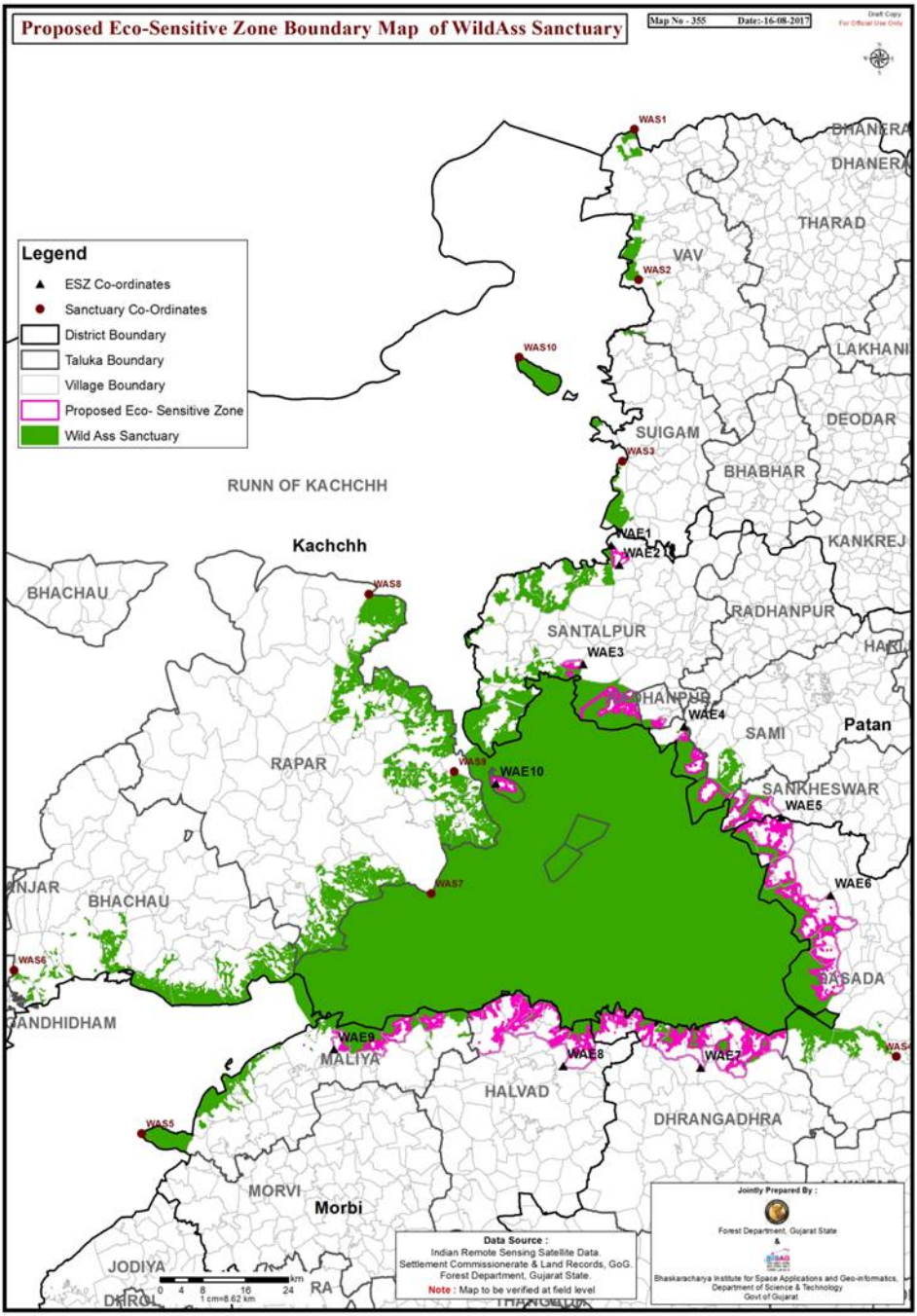


Map Showing Project Road Alignment in respect to Wild Ass Sanctuary Boundary and its ESZ.

Name of Project: - Proposed new NH-754K greenfield alignment Sanchore -Santalpur section (EC-3) starting from Vantdau, in Banaskantha district to Ranmalpura in Patan district, from km 4+888 to km 130+073.

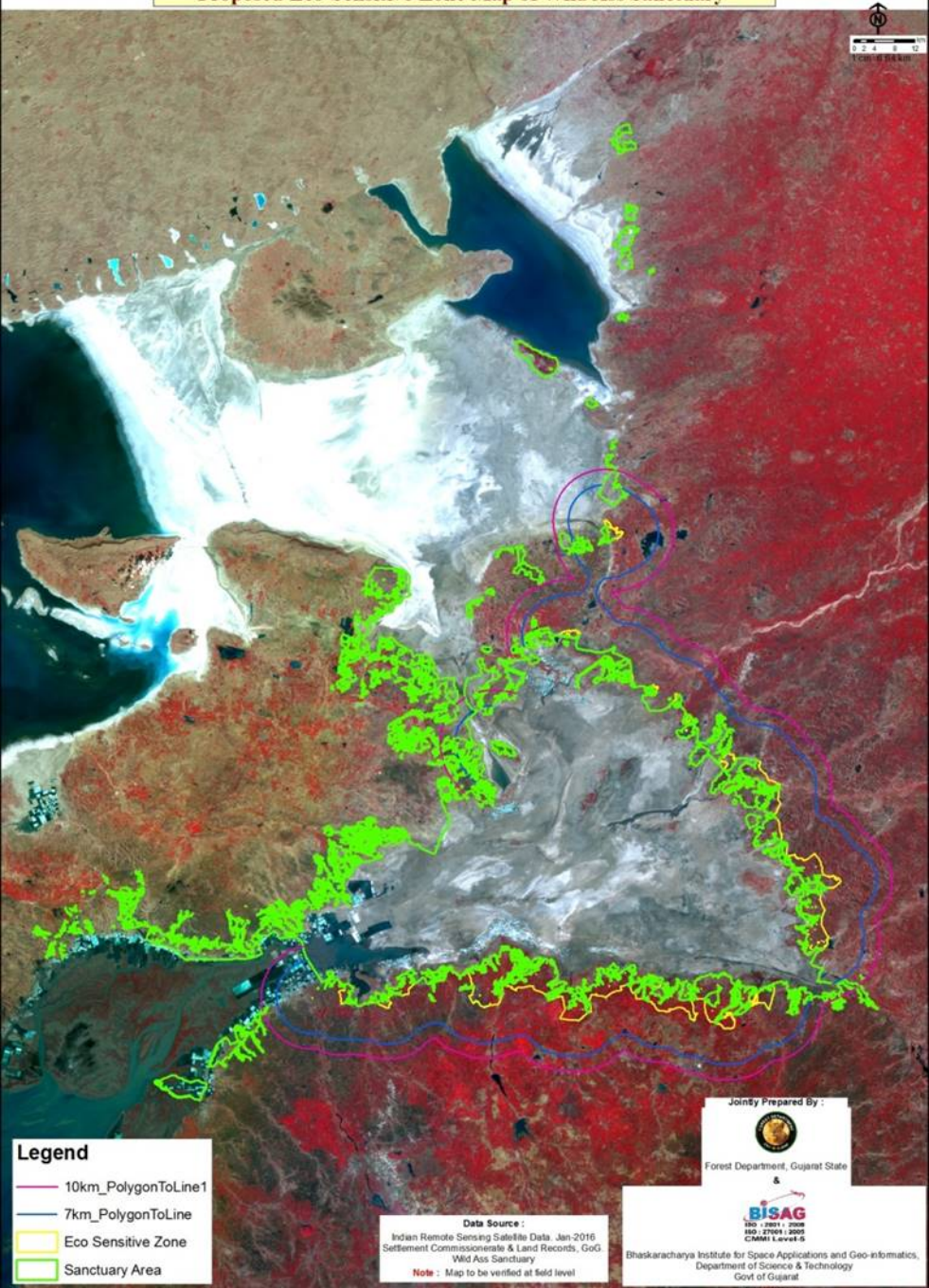


No.	Direction	Distance in Km
1	WASB to ESZB on North	0
2	WASB to ESZB on North East	1
3	WASB to ESZB on East	1.2
4	WASB to ESZB on East South	0
5	WASB to ESZB on South	0.7
6	WASB to ESZB on South West	0
7	WASB to ESZB on West	0
8	WASB to ESZB on West North	0


Proposed Eco-Sensitive Zone Boundary Map of WildAss Sanctuary
Map No - 355 Date:-16-08-2017
Draft Copy
For Official Use Only
Legend
ESZ Co-ordinates
Sanctuary Co-Ordinates
District Boundary
Taluka Boundary
Village Boundary
Proposed Eco- Sensitive Zone
Wild Ass Sanctuary
WAS1
WAS2
WAS3
WAS4
WAS5
WAS6
WAS7
WAS8
WAS9
WAS10
WAE1
WAE2
WAE3
WAE4
WAE5
WAE6
WAE7
WAE8
WAE9
WAE10
DHANERA
THARAD
VAV
LAKHANI
DEODAR
SUIGAM
BHABHAR
RUNN OF KACHCHH
Kachchh
KANKREJ
BHACHAU
RADHANPUR
SANTALPUR
RAPAR
SAMI
Patan
SANKHESWAR
BHACHAU
GANDHIDHAM
MALIYA
HALVAD
DHRANGADHRA
MORVI
Morbi
JODIYA
DHROL
0 4 8 16 24 km
1 cm=8.62 km
Data Source :
Indian Remote Sensing Satellite Data
Settlement Commissionerate & Land Records, GoG.
Forest Department, Gujarat State.
Note : Map to be verified at field level
Jointly Prepared By :
Forest Department, Gujarat State
&
Bhaskaracharya Institute for Space Applications and Geo-informatics,
Department of Science & Technology
Govt of Gujarat

Proposed Eco-Sensitive Zone Map of Wild Ass Sanctuary

Draft copy
For official use only



PLANTATION PLAN

Tree plantation is the most effective, economical and useful remedy for control of environmental pollution. Besides, it is the cheapest way of landscape improvement. Trees have innumerable direct and indirect benefits of supplying timber and fuel at maturity. During their life time, they supply fodder, fruits, seeds, help in controlling soil erosion and water conservation, offer shade and are oxygen producing industries to combat ever increasing air pollution. Big foliage trees also help in reducing noise and dust pollution.

Objectives of Tree Plantations

The main objectives of planting along the Highways are as follows:

- To provide for aesthetic enhancement of the project corridors
- To reduce the impacts of air pollution and dust, as trees and shrubs are known to be natural sink for air pollutants.
- To provide much needed shade on glaring hot roads during summer.
- To reduce the impact of ever increasing noise pollution caused due to increase in number of vehicles.
- To arrest soil erosion at the embankment slopes.
- Prevention of glare from the headlight of incoming vehicles.
- Climatic amelioration,
- Moderating the effect of wind and incoming radiation
- To define the ROW especially, to highlight sharp horizontal curves during night

Plantation will be done in accordance with Green Highways (Plantation, Transplantation, Beautification and Maintenance) Policy -2015 Certain species are listed in Table 3 for developing green belt with the objective of pollution control, carbon sequestration and as source of food especially for birds and amenity purpose. The list is neither complete nor exhaustive. Depending upon the suitability, availability and desirability, other local species will be considered. As per Green Highways (Plantation, Transplantation, Beautification and Maintenance) Policy -2015 Plantation, transplantation, beautification and maintenance and

landscaping activities will be the integrated components for all new highways projects. Application of this policy will be done in collaboration with NGHM, Respective Regional Offices (ROs) of NHAI/MORTH and others concerned. Green Corridors development will be in compliance to the IRC:SP:21-2009, guidelines, circulars, advisory issues by NGHM and its amendments thereof. Green Highway Division (GHD) will work under NHAI and will be responsible for planning, implementation and monitoring of GHPs for MoRTH, NHAI.

NHAI proposed to plant more than 20,000 no. of trees along the carriageway and more than 55000 no. of shrubs along the median. The tentative cost for plantation and 5 yrs maintenance is Rs. 5,70,00,000/-. It is stated that the indigenous species of local economic and ecological (soil and water conservation) importance need be given priority over commercial and non- native species.

Table 1: Area identified for landscaping & tree plantation

S. No.	Type of plantation	Location (Km)	Remarks
1.	Shrubs	In median except structures	The native and local species will be preferred as per IRC SP:21:2009 and Green Highway policy, 2015
2.	Landscaping	All service areas/ interchanges/ O&M centres/toll booths.	
3.	Plantations	Available open land within RoW.	

Technical Specification for Plantation along the sides of alignment

The technical specification approached for this project is as follows:

Table 2: Technical Specification of Plantation (I & II Row)

Distance from embankment	3.3 ft away from the toe of embankment/55 ft. away from central traffic line
Distance from preceding row	15 ft
Spacing between plant to plant	10 ft
Canopy Shape & Size	Cylindrical, oblong with small CSA
Size of the pits	60x60x60 cm
Height of the plant	1.5 to 2 m

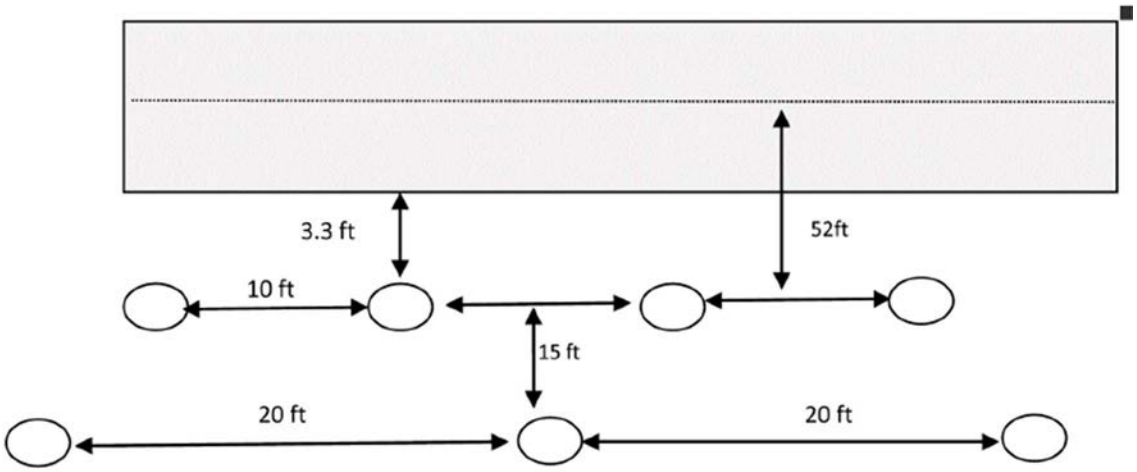


Figure 1: Technical Specification of Plantation (II Row)

Table 3: Technical Specification of Plantation (Penultimate Row)

Distance from preceding row	15 ft
Distance from embankment	3.3 ft away from the toe of embankment/55 ft away from central traffic line
Spacing between plant to plant	10 ft
Canopy Shape & Size	Cylindrical, oblong with small CSA
Size of the pits	60x60x60 cm
Height of the plant	More than 2 m

The Contractor shall plant trees and shrubs of required numbers and types at the appropriate locations within Right of Way and in the land earmarked by the Authority as per Schedule D.

Drip irrigation system for avenue plantation by gravity/pressure sources with all necessary components / systems and emitting devices at plants shall be provided without any extra costs to ensure irrigation of tree plantation.

The Contractor shall maintain trees and shrubs in good condition during 5 years of maintenance period as per the maintenance schedule.

The inner and outer of RoW tree sapling for when brought to the site shall be minimum 5 feet height and two years of age and they shall be planted in tree guard. At the end of maintenance

period, all trees should have achieved its height. In case of any eventualities of failure in growth, the sufficient number of saplings shall be kept to replace the affected trees.

Specification for Median Plantation

The Shrubs will be planted in the median, will be of low or medium height for prevention of the headlight glare. One or two rows of flowering shrubs may be provided according to the varying width of the median in different sections. Where median is less than 1.5 m, only grass turf is recommended. Median Plants shall have age of minimum one year when brought to the site. They should have achieved growth of 5 years at the end of maintenance period. At the end of maintenance period, all trees should have achieved its height. In case of any eventualities of failure in growth, the sufficient number of saplings shall be kept to replace the affected shrubs.

Transplantation

Transplantation is not recommended in EMP of this report since survival rate is very low even when best scientific approach is taken. Old trees undergo stress of transplantation due to change in soil ecology and neighbourhood and therefore survive success is very low.

Protection Measures

Protection may be done by fencing. Fencing of single row plantation will be done by using tree guards (iron/brick/bamboo). The fencing of multiple row plantations shall be done preferably by barbed wire. A five strand barbed wire fencing with cross strands, stretched on angle iron poles fixed at distance of 4 m from one another is recommended. The specification for barbed wire fencing will be done as per IRC:SP:21-2009.

Table 4: Suitable plant species for Plantation along the project

Sl. No.	SCIENTIFIC NAME	LOCAL/ENGLISH NAME
TREE SPECIES		
1.	Ailanthus excels	Maharukh
2.	Azadirachta indica	Neem
3.	Banbusa arundinacea	Thorny Bamboo

4.	Dendrocalamus strictus	Lathibans
5.	Dalbergia sissoo	Shisham
6.	Ficus religiosa	Pipal
7.	Tectona grandis	Sagaun
8.	Terminalia arjuna	Koha
SHRUB SPECIES		
9.	Duranta repens	Golden Dewdrop
10.	Tabernaemontana divaricate	Crape Jasmine
11.	Hibiscus rosasinensis	China Rose
12.	Hamelia patens	Scarlet bush
13.	Murraya paniculata	Kamini
HERB SPECIES		
14.	Achyranthus aspera	Latjeera
15.	Acorus calamus	Bach
GRASS SPECIES		
16.	Agrostis spp.	-
17.	Apluda mutica	Phuli
18.	Bothriochloa pertusa	-
19.	Cenchrus ciliaris	-
20.	Cenchrus setigerus	-
21.	Chrysopogon fulvus	Ghoriya
22.	Cymbopogon martini	Rusa
23.	Cynodon dactylon	Dub
24.	Dichanthium annulatum	Kel
25.	Digitaria spp.	-
26.	Eregrostis tenella	-
27.	Iseilema laxum	-
28.	Panicum flaccidum	-
29.	Sporobolus spp.	-
30.	Themeda triandra	-

Plantation operations and practices for Greenbelt and open space replantation

The plantation strategy should include operations, such as, Development of seedlings/saplings of the tree and shrub species, Land/site preparation for transplanting/seeding, Transplanting, and Post-transplanting maintenance under the guidance of a field -oriented botanist or agriculture professional or field staff of the Forest Department.

(A) Development of planting material

For tree and shrub species, the seedlings and saplings could be raised in nursery in poly bags of standard size or root trainer trays. The healthy certified seed material should be used for this purpose. These materials can also be arranged on demand from the nurseries owned by Forest Department or private organizations. Healthy and disease-free planting material is pre-requisite for success of the plantation.

(B) Site preparation

This activity need be undertaken well in advance before monsoon for rainy season species and during October -November for winter species. Thorny bushes and weeds need to be removed completely from the site. It should be followed by soil and water conservation work using physical measures, such as, surface rain water harvesting, trenches, stone bunds; engineering structures, such as, small check dams; and biological devices, such as, planting of fast spreading grass and leguminous species and bushy materials.

For planting seedling/sapling, pits of appropriate size (1×1×1m for tree species, 0.5×0.5×0.5 m for shrub species) need be prepared well in advance. The top soil of 30 cm depth need be kept aside for mixing with FYM to promote microbial growth for nutrient recycling.

After digging, the pit must be kept unfilled and uncovered so that sterilization through sun rays could occur. It should follow by filling stone -free soil (3 part) and well-decomposed weed-free compost or dump manure (1 part). For improving soil fertility, neem/castor/ground cake can be used. The basal dressing of urea, ammonium phosphate, potassium sulphate or DAP could be applied in morning hours at appropriate interval.

(C) Seeding and Transplanting

This operation must be done after rain showers. In case of grass and leguminous species, direct seeding could be practiced to establish a surface cover to check soil loss and grass growth for herbivores and nesting sites for birds.

The plantation should be done in rows following 5×5 spacing both row to row and plant to plant using healthy seedling/sapling. While planting, the poly bag should be moistened first. The poly bag should not be removed completely, only the bottom part of it should be removed by cutting it with a sharp blade without disturbing planting material. The planted material should be watered slowly to avoid soil disturbances.

(D) **Post-planting maintenance**

The transplanted material needs attentive care for complete one year at least, followed by care during stressful seasons particularly. The maintenance operations include watering, removal of weeds, prevention and control of diseases and pests using bio-pesticides preferably, and trimming, and fertilization. No specific amount could be mentioned for watering, etc., as it is selective to species, hence, based on field conditions, the maintenance activities should be done. The fertilization could be carried out at an interval of 30 days avoiding occurrence of rains. The gaps caused on account of mortality, should be filled by replanting the same species.

Plantations in ROW notified as Forest (Protected/Reserved/PAs)

There are sections of highways where the plantations in ROW have been notified as Forest (Protected/Reserved/PAs). For these areas permission for tree cutting is granted by Forest Department under the Forest Conservation Act, 1980. While granting the permission, the forest department stipulates the conditions not only for compensatory afforestation (CA) but also for avenue plantation. In these cases, the amount for avenue plantation is deposited with the Forest Department and normally the work of avenue plantation is taken up by Forest Department apart from CA. Such plantations can also be given to Forest Development Corporations of Gujarat State which can sign a MoU with NGHM for plantation and management activities and also sharing the sustainable harvest earnings with NGHM.

Above all, the development of green space must get value similar to Highway development.

Activity Schedule for Plantation

Plantation activities are highly time specific, as the plants respond to the seasonal variations in climatic conditions. Even in highly mechanized irrigated plantations, the growth of plants is not uniform throughout the year and is governed by the atmospheric factors, It is therefore, vital to plan the planting activities in advance as per the prevailing climatic conditions of the area, especially the time and duration of monsoon. Generally, plantations works are started in our country with the onset of monsoon. However, if it is possible to provide irrigation. It is advisable to utilize the high temperatures of summers. Generally, plants respond well to Irrigation during peak summer seasons, as the conditions are very favourable for growth if moisture is not the limiting factor.

Activity schedule for avenue plantation and median plantation is given in below table;

Table 5 Activities Schedule For Avenue Plantation/Median Plantation

Year	Month		Activities to be done
Ist Year	Jan-March	1	Surveying & cleaning of the area
		2	Digging of Pits
		3	Procurement of Angles Iron and barbed wire(or other fencing material), and erecting the fence
2nd Year	April-June	1	Purchase of Farm yard manure
		2	Brick/iron etc. guard for 1st row
		3	Plantation along the Highway
		4	Filling up of Pits with Farm Yard manure and Soil
	July-August	1	Transportation of Plants
		2	Planting of Saplings
		3	Watering
		4	Weeding and hoeing
	Sep-Nov	1	Weeding and hoeing
		2	Watering 4 times a month
	Dec-Feb	1	Weeding and hoeing
		2	Maintenance
	March	1	Watering 4 times a month
3rd year	April-June	1	Watering 6 times a month
	July-August	1	Casualty Replacement (20% of the total plants)
		2	Weeding
		3	maintenance by Mali
	Sep-Nov	1	Watering 2 times a month
		2	maintenance by Mali
	Dec-Feb	1	maintenance by Mali
	March	1	Watering 4 times a month
		2	maintenance by Mali
4th Year	April-March	1	Watering
		2	Casualty Replacement (10% of the total plants)
		3	maintenance by Mali

Table 6: Proposed Monitoring Arrangement

Phase	Monitoring Parameter	Monitoring by	Release of Payment
1st Year (Advance Soil Work)	No. of pits	Environmental Manager, Environmental Officer of Supervision Consultant & Representative of Forest Deptt.	December –50% of the total amount
2nd Year (Plantation of Saplings)	Survival % of saplings	Environmental Manager, Environmental Officer of Supervision Consultant & Representative of Forest Deptt.	April-20% of the total amount
3rd Year (Maintenance of Plantation)	Survival % before & after Causality replacement	Environmental Manager, Environmental Officer of Supervision Consultant & Representative of Forest Deptt.	April-20% of the total amount
4th Year (Maintenance of Plantation)	Survival % before & after Causality replacement	Environmental Manager, Environmental Officer of Supervision Consultant & Representative of Forest Deptt.	April-10% of the total amount