5 Linear Waterway :

Average Bed Level		=	267.20 m
HFL as per site condition & local inquiry		=	268.90 m
So, Total Depth of Water,	H	=	1.70 m

Provided 8 RCC BOX of (2 x4 x 4)m span at proposed bridge site location.

Clear Waterway (provided),	L	=	64.00 m
Total Area,	A	=	108.800 m2
Velocity ,	V	=	Q / A
		=	**0.654 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **92.553 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width 1.45 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **1.71 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **2.570 m**

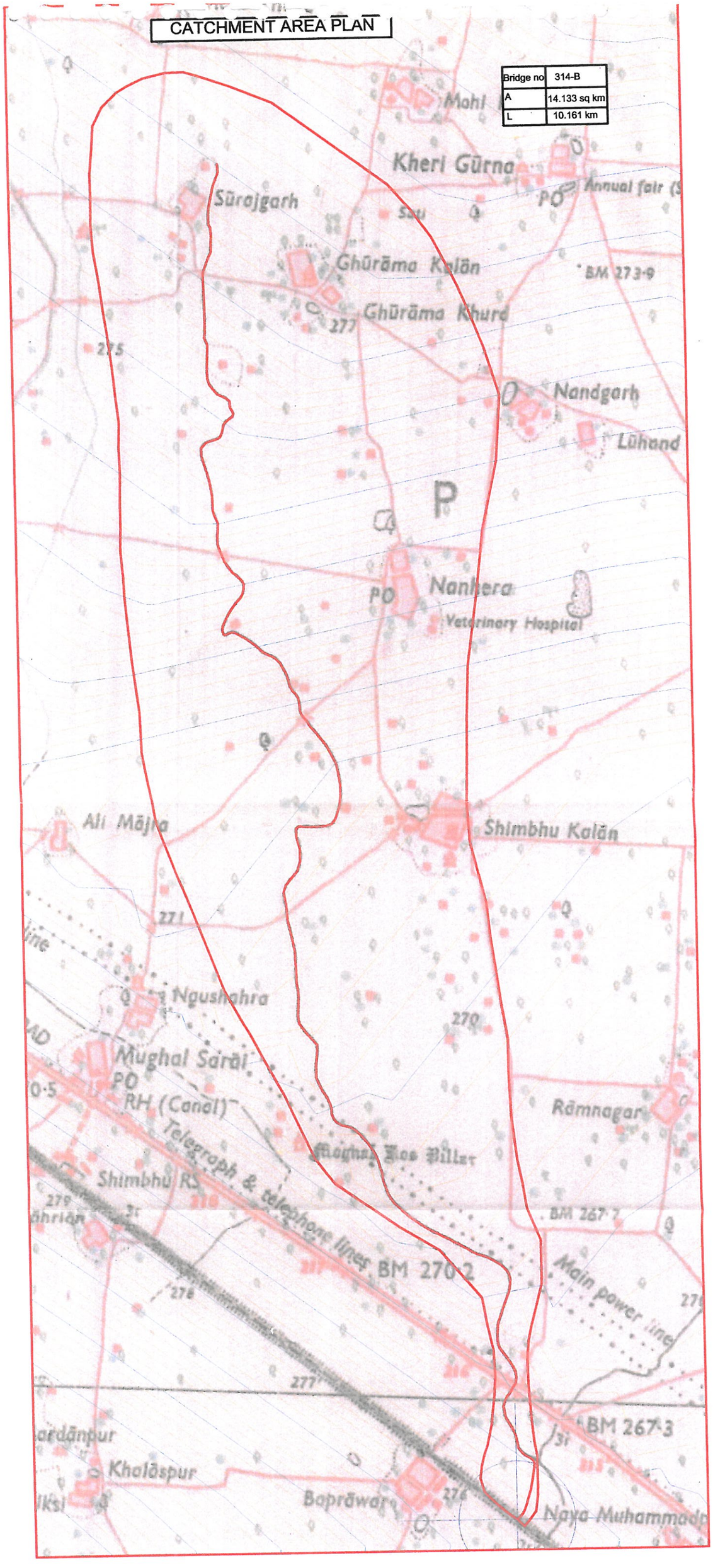
7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **266.33 m**

CATCHMENT AREA PLAN

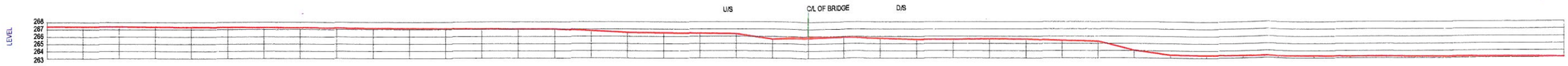
Bridge no	314-B
A	14.133 sq km
L	10.161 km



0199

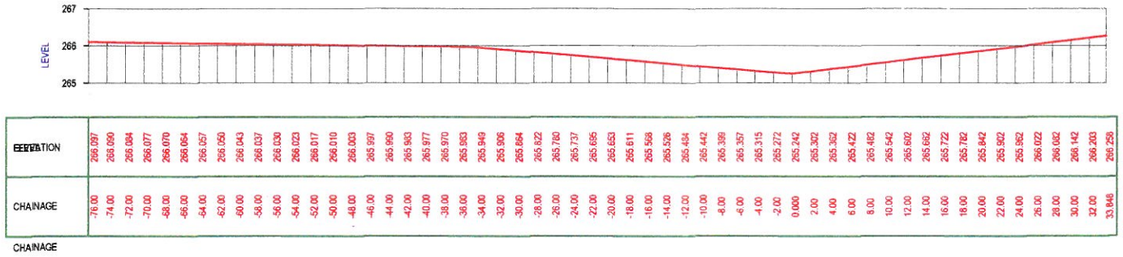
PROPOSED BRIDGE NO. BR. 034 (PRL_314-B)

Rly Km. 275/11-18, DFCC Chainage 84550



CHAINAGE	LEVEL
-1050.000	267.398
-1000.000	267.375
-950.000	267.356
-900.000	267.309
-850.000	267.287
-800.000	267.273
-750.000	267.240
-700.000	267.207
-650.000	267.179
-600.000	267.141
-550.00	267.104
-500.00	267.061
-450.00	267.018
-400.00	266.986
-350.00	266.970
-300.00	266.760
-250.00	266.493
-200.00	266.437
-150.00	266.396
-100.00	266.328
-50.00	265.590
0.000	265.958
50.00	265.669
100.00	265.674
150.00	265.540
200.00	265.536
250.00	265.580
300.00	265.544
350.00	265.375
400.00	265.266
450.00	264.030
500.00	263.377
550.000	263.345
600.000	263.304
650.000	263.272
700.000	263.257
750.000	263.214
800.000	263.189
850.000	263.186
900.000	263.161
950.000	263.124
1000.000	263.099
1044.665	263.057

LONGITUDINAL SECTION

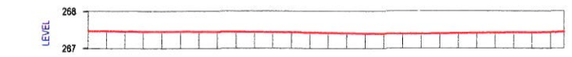


CHAINAGE	ELEVATION
-76.00	265.097
-74.00	265.090
-72.00	265.084
-70.00	265.077
-68.00	265.070
-66.00	265.064
-64.00	265.057
-62.00	265.050
-60.00	265.043
-58.00	265.037
-56.00	265.030
-54.00	265.023
-52.00	265.017
-50.00	265.010
-48.00	265.003
-46.00	264.997
-44.00	264.990
-42.00	264.983
-40.00	264.977
-38.00	264.970
-36.00	264.963
-34.00	264.949
-32.00	264.906
-30.00	264.864
-28.00	264.822
-26.00	264.780
-24.00	264.737
-22.00	264.695
-20.00	264.653
-18.00	264.611
-16.00	264.568
-14.00	264.526
-12.00	264.484
-10.00	264.442
-8.00	264.399
-6.00	264.357
-4.00	264.315
-2.00	264.272
0.000	264.242
2.00	264.302
4.00	264.362
6.00	264.422
8.00	264.482
10.00	264.542
12.00	264.602
14.00	264.662
16.00	264.722
18.00	264.782
20.00	264.842
22.00	264.902
24.00	264.962
26.00	265.022
28.00	265.082
30.00	265.142
32.00	265.203
33.948	265.258

(Bridge site)

CHAINAGE	ELEVATION
-22.00	267.157
-20.00	267.153
-18.00	267.149
-16.00	267.145
-14.00	267.141
-12.00	267.138
-10.00	267.130
-8.00	267.116
-6.00	267.102
-4.00	267.101
-2.00	267.100
0.000	267.099
2.00	267.102
4.00	267.115
6.00	267.128
8.00	267.141
10.00	267.154
12.00	267.155
14.00	267.152
16.00	267.150
18.00	267.147
20.00	267.151
22.00	267.155
24.00	267.160
26.00	267.164
27.376	267.167

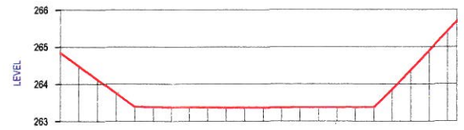
(Upstream at 520m)



CHAINAGE	ELEVATION
-30.00	267.426
-28.00	267.453
-26.00	267.449
-24.00	267.445
-22.00	267.442
-20.00	267.440
-18.00	267.438
-16.00	267.436
-14.00	267.433
-12.00	267.428
-10.00	267.423
-8.00	267.419
-6.00	267.414
-4.00	267.408
-2.00	267.402
0.000	267.395
2.00	267.389
4.00	267.382
6.00	267.376
8.00	267.385
10.00	267.393
12.00	267.401
14.00	267.407
16.00	267.412
18.00	267.417
20.00	267.422
21.478	267.425

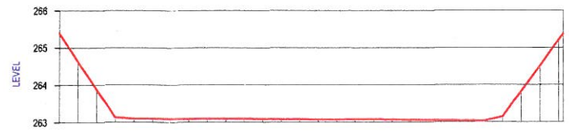
(Upstream at 1030m)

CROSS SECTION



CHAINAGE	ELEVATION
-20.00	264.847
-18.00	264.462
-16.00	264.117
-14.00	263.752
-12.00	263.387
-10.00	263.381
-8.00	263.375
-6.00	263.370
-4.00	263.365
-2.00	263.359
0.000	263.357
2.00	263.358
4.00	263.360
6.00	263.363
8.00	263.365
10.00	263.368
12.00	263.371
14.00	263.374
16.00	263.648
18.00	264.371
20.00	264.894
22.00	265.418
23.010	265.682

(Downstream at 510m)



CHAINAGE	ELEVATION
-28.00	265.382
-26.00	264.629
-24.00	263.876
-22.00	263.123
-20.00	263.085
-18.00	263.084
-16.00	263.082
-14.00	263.081
-12.00	263.078
-10.00	263.078
-8.00	263.076
-6.00	263.071
-4.00	263.066
-2.00	263.062
0.000	263.057
2.00	263.059
4.00	263.061
6.00	263.063
8.00	263.057
10.00	263.049
12.00	263.041
14.00	263.034
16.00	263.026
18.00	263.018
20.00	263.135
22.00	263.823
24.00	264.511
26.00	265.198
26.462	265.357

(Downstream at 1020m)

0200

Existing Bridge No – 315
Location – KM 277/7-9

Proposed Bridge No – 035
Location – CH: 86275

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			315
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 11
Scale :			1 : 50,000
Location :			277/7-9
Latitude :			$30^0$25'13"
Longitude :			$76^0$41'59"
Catchment Area ,	A	=	1.436 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	1.159 Km
Height of Farthest Point ,	H1	=	268.87 m
Height of Point of Interest ,	H2	=	267.42 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	1.45 m
Average Bed Level		=	267.42 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0201

In present case, **Runoff Coefficient,** C = **0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

$t_c = [L^3 / H]^{0.345}$

= **1.025 Hr**

= **61.490 Mins**

(a) t_c h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.012**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = K x R_{50} (1)

= **8.26 cm**

= **82.55 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **80.55 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **12.864 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	1.436 Sq. Km	143.61 Hectares
Length of path from Toposheet,	L	=	1.159 Km	
Difference in Levels from Toposheet,	H	=	1.45 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.97 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	126.64 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	143.61 Hectares
I_c = Critical Intensity of Rainfall	12.664 cm / Hr
Q = Maximum Discharge	**19.962 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16 (adopted in present case)
M	=	1.436 Sq Km

Hence, **Q = 20.990 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	12.864 Cumecs
Discharge by Rational Formula (IRC approach)	19.962 Cumecs
Discharge by Dicken's Formula	20.990 Cumecs
Maximum Discharge	20.990 Cumecs
Next Maximum Discharge	19.962 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **20.990 Cumecs**

5 Linear Waterway :

Average Bed Level		=	267.42 m
HFL as per site condition & local inquiry		=	269.92 m
So, Total Depth of Water,	H	=	2.50 m

Provide 4 spans of 6.1 m at proposed site location as similar to existing spans arrangement but only three span are using for passing water.

Clear Waterway (provided),	L	=	18.30 m
Total Area,	A	=	45.750 m2
Velocity ,	V	=	Q / A
		=	**0.459 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	20.990 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.600 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.600 m
	So, Vertical Clearance adopted		=	0.600 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **270.522 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **27.287 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.49 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.75 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

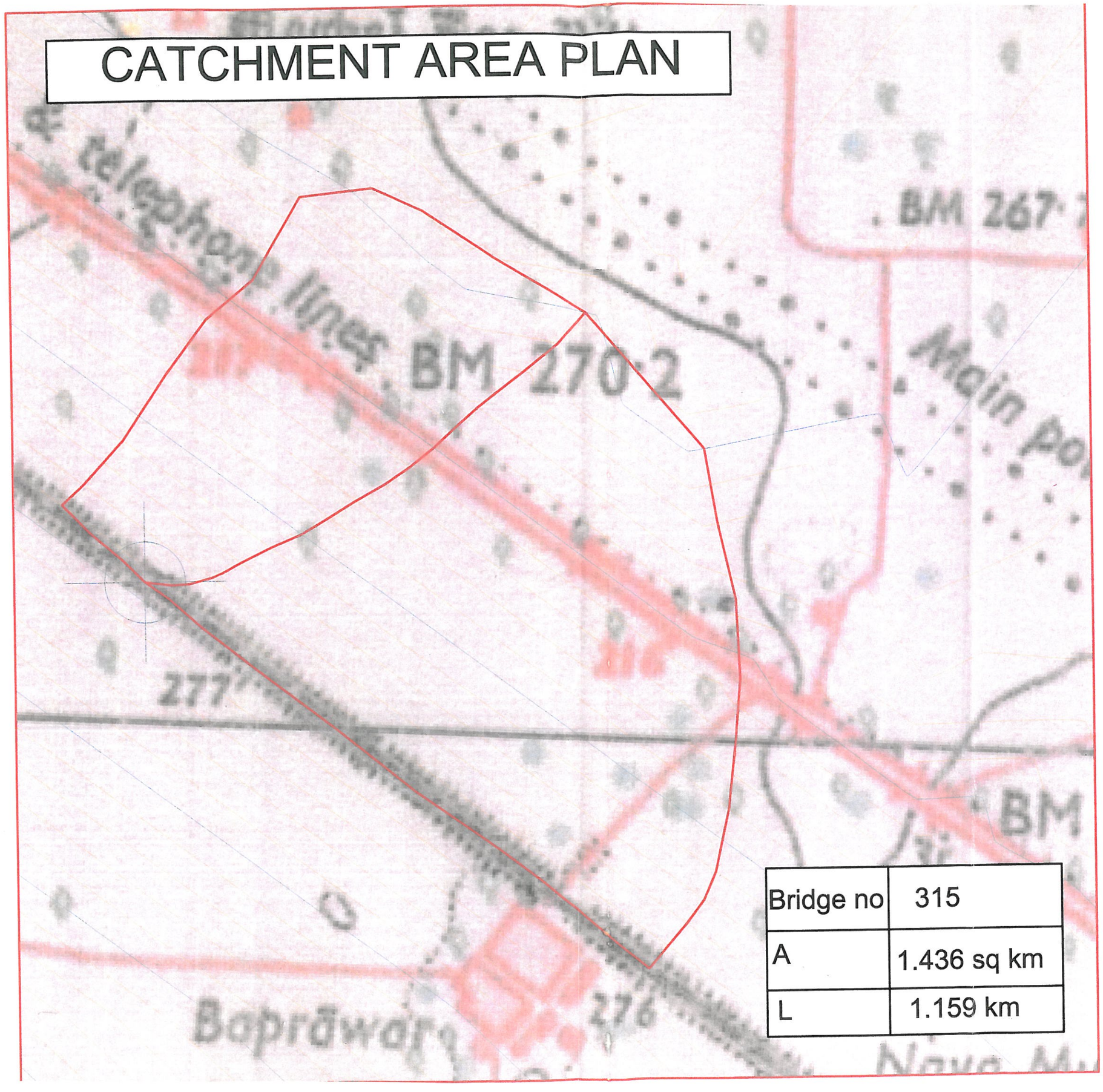
So, **Maximum Scour Depth** = **2.623 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **267.30 m**

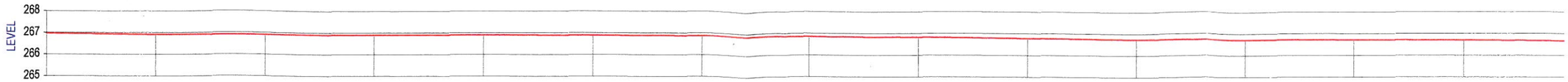
CATCHMENT AREA PLAN



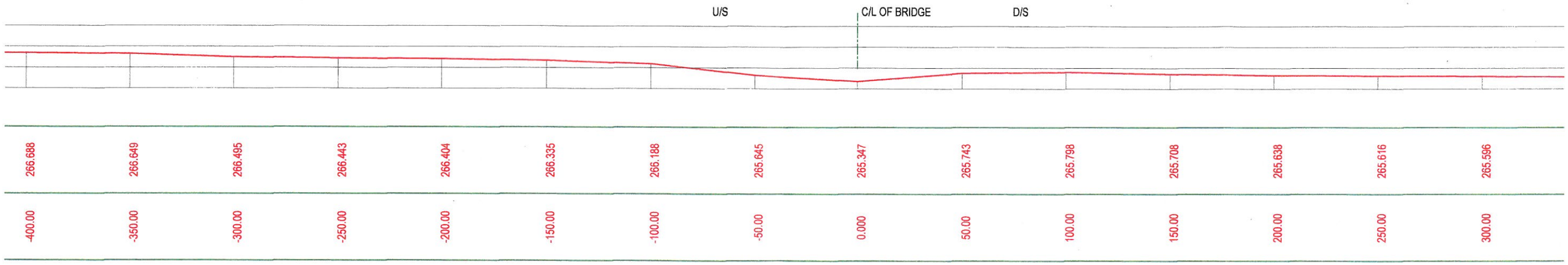
Bridge no	315
A	1.436 sq km
L	1.159 km

0205

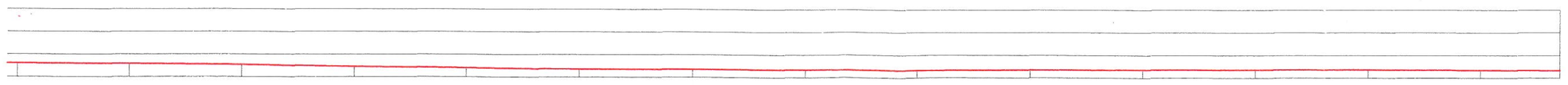
PROPOSED BRIDGE NO. BR. 035 (PRL_315)
Rly Km. 277/7-10, DFCC Chainage 86275



LEVEL	266.956	266.904	266.890	266.885	266.882	266.876	266.855	266.830	266.807	266.767	266.732	266.704	266.695	266.688
CHAINAGE	-1050.000	-1000.000	-950.000	-900.000	-850.000	-800.000	-750.000	-700.000	-650.000	-600.000	-550.00	-500.00	-450.00	-400.00



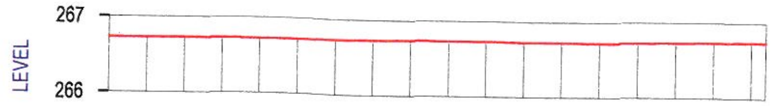
266.688	266.649	266.495	266.443	266.404	266.335	266.188	265.645	265.347	265.743	265.798	265.708	265.638	265.616	265.596
-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00	250.00	300.00



265.596	265.568	265.529	265.447	265.388	265.345	265.340	265.336	265.317	265.334	265.348	265.353	265.353	265.329	265.312
300.00	350.00	400.00	450.00	500.00	550.000	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000	985.116

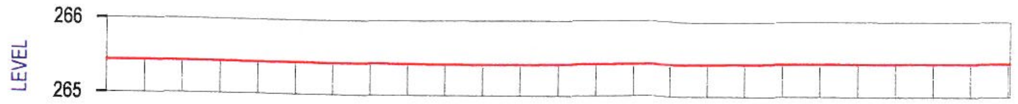
0206

LONGITUDINAL SECTION



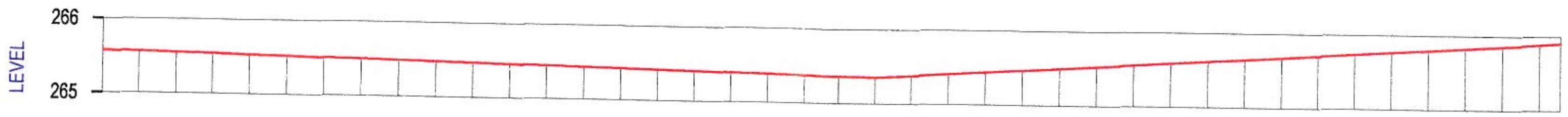
LEVEL	266.720	266.719	266.718	266.717	266.716	266.715	266.717	266.722	266.726	266.725	266.723	266.720	266.717	266.715	266.719	266.723	266.727	266.731	266.732
CHAINAGE	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	16.768

(Upstream at 480m)



LEVEL	265.430	265.428	265.426	265.423	265.421	265.419	265.417	265.414	265.410	265.405	265.401	265.403	265.407	265.410	265.414	265.418	265.421	265.425	265.428	265.429	265.430	265.431	265.432	265.434	265.435	265.435
CHAINAGE	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	28.118

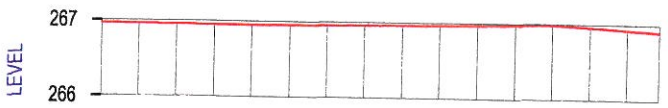
(Downstream at 480m)



LEVEL	265.567	265.557	265.546	265.536	265.525	265.515	265.504	265.494	265.483	265.473	265.462	265.452	265.441	265.431	265.420	265.410	265.399	265.389	265.378	265.368	265.357
CHAINAGE	-42.00	-40.00	-38.00	-36.00	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00

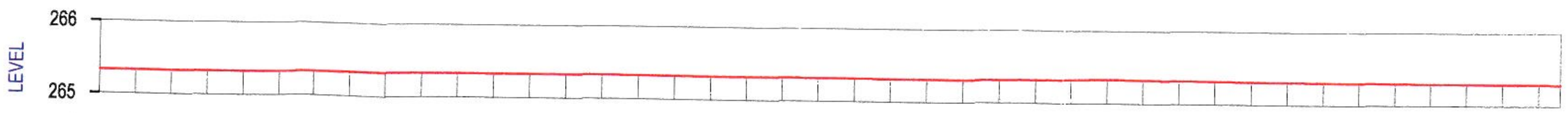
LEVEL	265.347	265.377	265.406	265.436	265.466	265.495	265.525	265.555	265.584	265.614	265.643	265.673	265.703	265.732	265.762	265.792	265.821	265.851	265.881	265.897
CHAINAGE	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	37.112

(Bridge site)



LEVEL	266.957	266.953	266.949	266.945	266.944	266.947	266.950	266.953	266.957	266.962	266.967	266.972	266.978	266.951	266.922	266.897
CHAINAGE	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	13.710

(Upstream at 990m)



LEVEL	265.317	265.318	265.318	265.319	265.320	265.320	265.321	265.322	265.323	265.323	265.324	265.325	265.324	265.323	265.321	265.320	265.318	265.317	265.315	265.314	265.312
CHAINAGE	-40.00	-38.00	-36.00	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000

LEVEL	265.310	265.307	265.304	265.301	265.304	265.312	265.320	265.323	265.319	265.316	265.312	265.308	265.305	265.303	265.300	265.298	265.295	265.293	265.290	265.288	265.286
CHAINAGE	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00	41.207

(Downstream at 990m)

0207

SHEET NO. 2 TO 2

Existing Bridge No – 316
Location – KM 278/3-5

Proposed Bridge No – 036
Location – CH: 87150

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	316
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 11
Scale :	1 : 50,000
Location :	278/3-5
Latitude :	$30^0 25'27"$
Longitude :	$76^0 41'36"$

Catchment Area ,	**A**	=	3.280 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	3.626 Km
Height of Farthest Point ,	**H1**	=	271.65 m
Height of Point of Interest ,	**H2**	=	269.05 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	2.60 m
Average Bed Level		=	269.05 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0208

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **2.728 Hr**

= **163.679 Mins**

(a) t_c h Ratio = 0.52 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.527**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **12.46 cm**

= **124.59 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **45.67 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **16.658 Cumecs**

0209

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	3.280 Sq. Km	328.00 Hectares
Length of path from Toposheet,	L	=	3.626 Km	
Difference in Levels from Toposheet,	H	=	2.60 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		2.90 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	64.03 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	328.00 Hectares
I_c = Critical Intensity of Rainfall	6.403 cm / Hr
Q = Maximum Discharge	**23.050 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,
- Q = the peak run-off in Cumecs
- M = the catchment area in Sq Km
- C = 11 - 14, where the annual rainfall is 60 - 120 cm
  14 - 19 in Madhya Pradesh
  22 in Western Ghats

C	=	16	(adopted in present case)
M	=	3.280 Sq Km	

Hence, Q = **38.996 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	16.658 Cumecs
Discharge by Rational Formula (IRC approach)	23.050 Cumecs
Discharge by Dicken's Formula	38.996 Cumecs
Maximum Discharge	38.996 Cumecs
Next Maximum Discharge	23.050 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **34.576 Cumecs**

5 Linear Waterway :

Average Bed Level		=	269.05 m
HFL as per site condition & local inquiry		=	271.50 m
So, Total Depth of Water,	H	=	2.45 m

Provide 4 spans of 6.1 m at proposed brisge site location.

Clear Waterway (provided),	L	=	24.40 m
Total Area,	A	=	59.780 m2
Velocity ,	V	=	Q / A
		=	**0.578 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	34.576 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.900 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.608 m
	So, Vertical Clearance adopted		=	0.900 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **272.402 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **44.948 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.84 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.01 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **3.020 m**

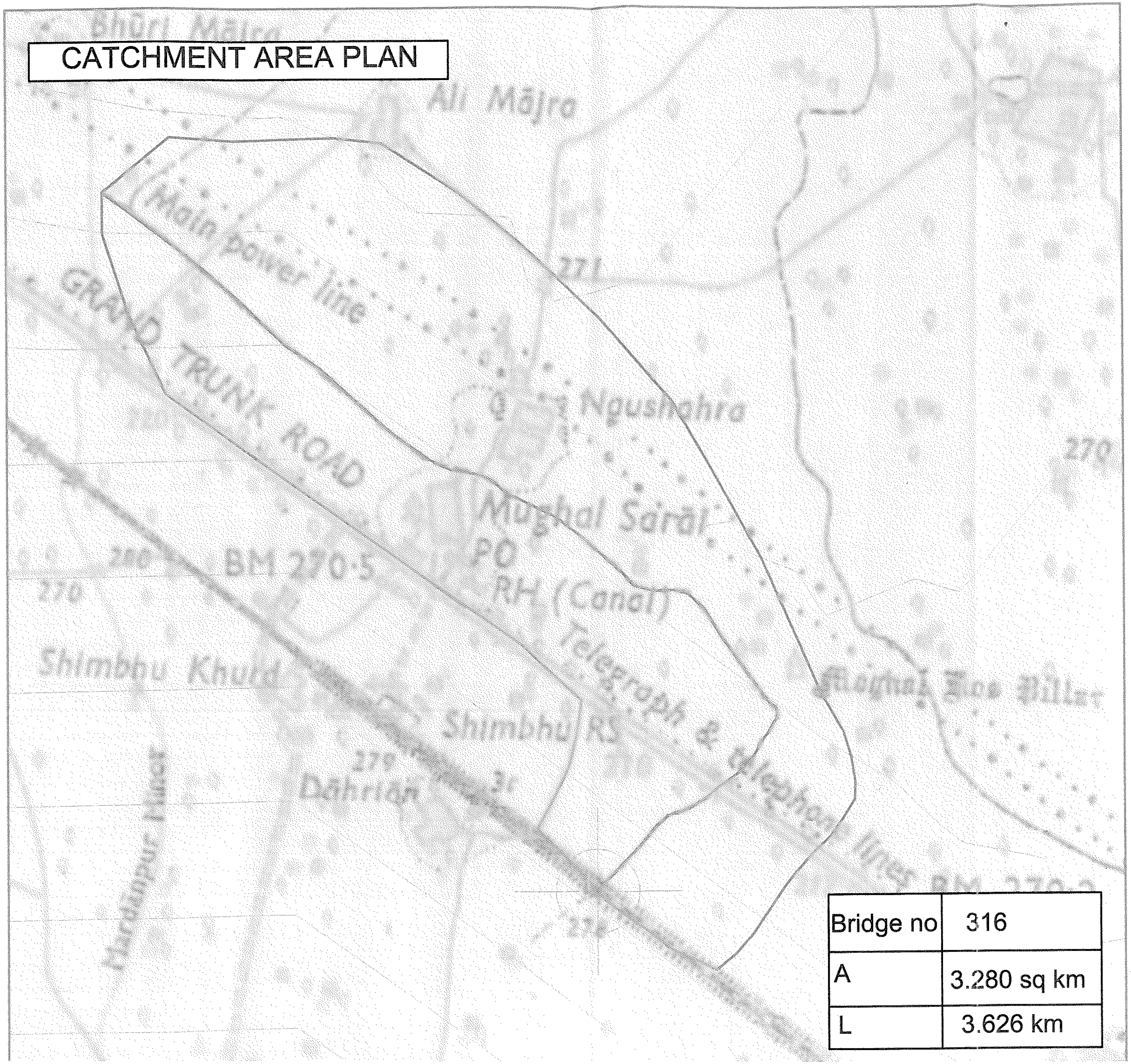
8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **268.48 m**

0211

CATCHMENT AREA PLAN

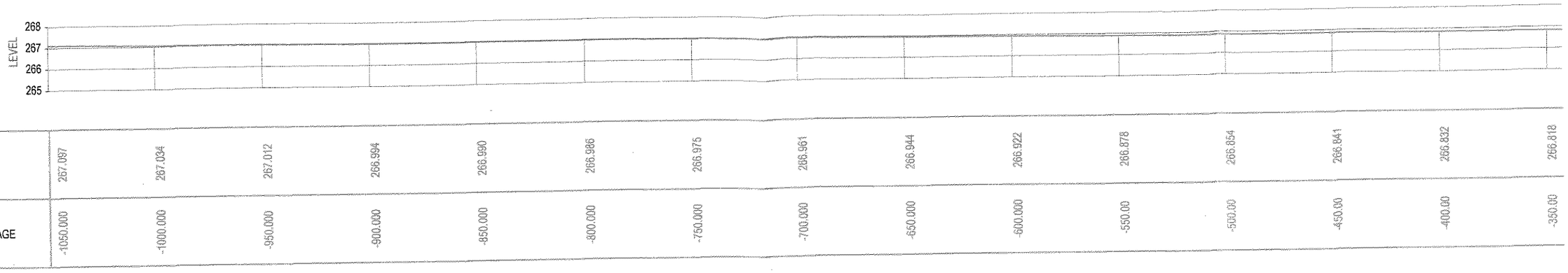


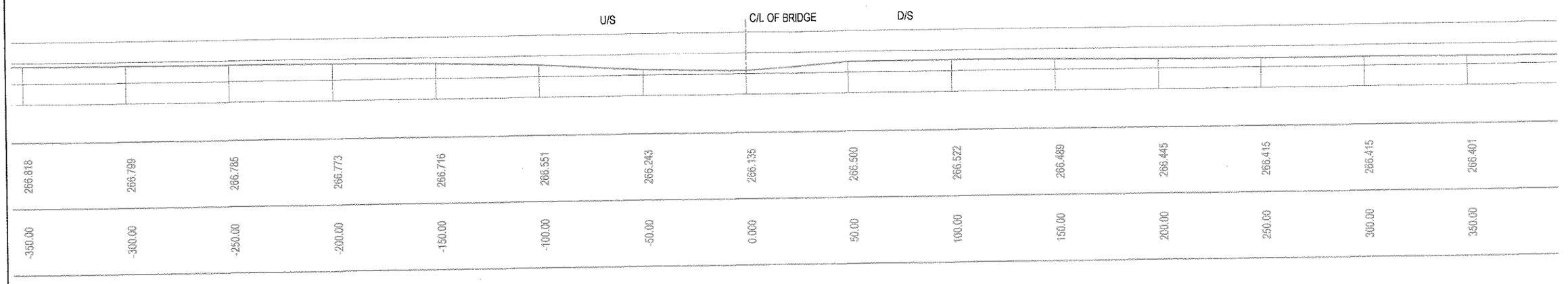
Bridge no	316
A	3.280 sq km
L	3.626 km

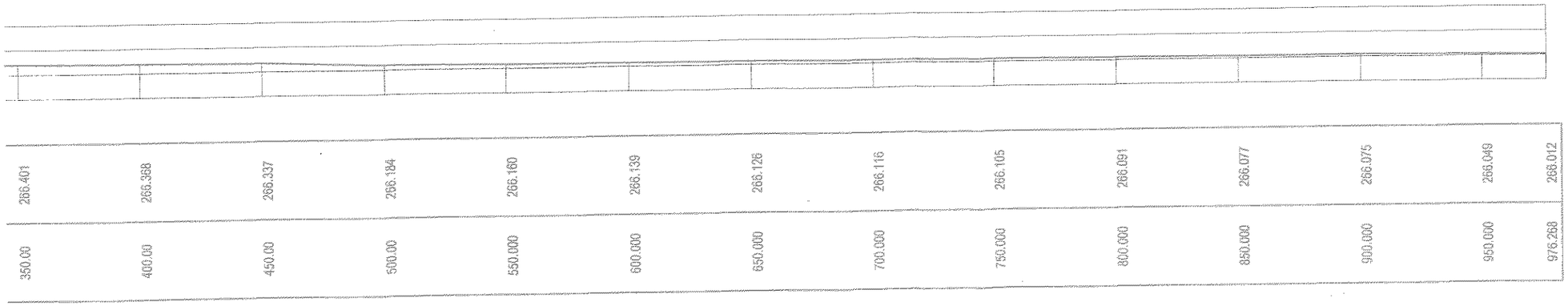
0212

PROPOSED BRIDGE NO. BR. 036 (PRL_316)

Rly Km. 2278/3-6, DFCC Chainage 87150

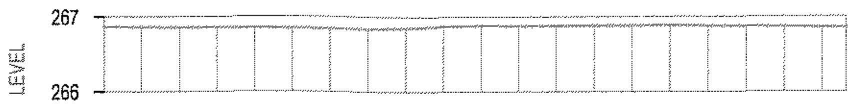






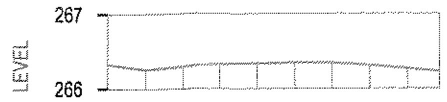
LONGITUDINAL SECTION

0213



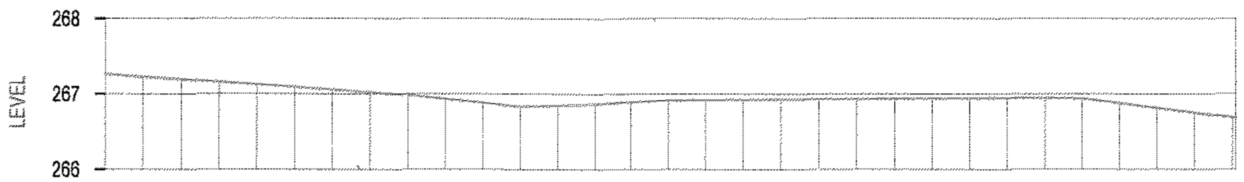
LEVEL	266.856	266.852	266.848	266.845	266.841	266.837	266.833	266.828	266.842	266.865	266.873	266.868	266.866	266.867	266.869	266.871	266.865	266.859	266.854	266.848	266.844
CHAINAGE	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	19.290

(Upstream at 490m)



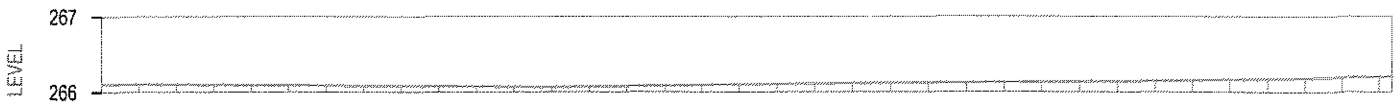
LEVEL	266.317	266.247	266.283	266.320	266.325	266.333	266.331	266.298	266.255	266.215
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	9.690

(Downstream at 480m)



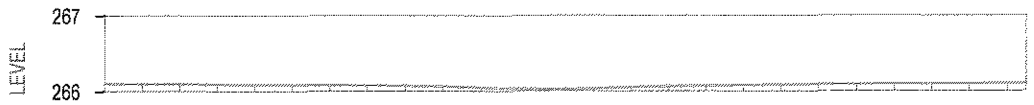
LEVEL	266.257	266.223	266.188	266.154	266.120	266.086	266.051	266.017	265.980	265.929	265.878	265.827	265.841	265.863	265.885	265.906	265.913	265.916	265.920	265.923	265.926	265.930	265.933	265.936	265.940	265.943	265.935	265.872	265.808	265.745	265.682	265.676
CHAINAGE	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	30.185

(Bridge site)



LEVEL	267.096	267.093	267.090	267.088	267.085	267.082	267.079	267.076	267.073	267.070	267.066	267.063	267.060	267.061	267.069	267.076	267.084	267.092	267.098	267.102	267.106	267.109	267.112	267.115	267.118	267.121	267.124	267.132	267.140	267.148	267.157	267.165	267.173	267.182	267.190	267.193
CHAINAGE	-36.00	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	32.684

(Upstream at 990m)



LEVEL	266.095	266.092	266.088	266.085	266.081	266.078	266.073	266.068	266.062	266.055	266.040	266.025	266.012	266.027	266.041	266.054	266.062	266.071	266.079	266.085	266.087	266.086	266.089	266.091	266.092	266.093
CHAINAGE	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	25.042

(Downstream at 990m)

Existing Bridge No – 319
Location – KM 280/17-19

Proposed Bridge No – 039
Location – CH: 89680

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	319
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 11
Scale :	1 : 50,000
Location :	280/17-19
Latitude :	$30^0$26'16"
Longitude :	$76^0$40'17"

Catchment Area ,	**A**	=	0.134 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.628 Km
Height of Farthest Point ,	**H1**	=	270.95 m
Height of Point of Interest ,	**H2**	=	270.25 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.70 m
Average Bed Level		=	270.25 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where ,

Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr.) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0215

In present case, **Runoff Coefficient,** C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **0.699 Hr**

= **41.926 Mins**

(a) t_c h Ratio = 0.27 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **0.808**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **6.59 cm**

= **65.94 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **94.37 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **1.411 Cumecs**

0216

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.134 Sq. Km	13.45 Hectares
Length of path from Toposheet,	L	=	0.628 Km	
Difference in Levels from Toposheet,	H	=	0.70 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.64 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	152.87 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	13.45 Hectares
I_c = Critical Intensity of Rainfall	15.287 cm / Hr
Q = Maximum Discharge	**2.187 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16	(adopted in present case)
M	=	0.134	Sq Km

Hence, Q = **3.553 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	1.411 Cumecs
Discharge by Rational Formula (IRC approach)	2.187 Cumecs
Discharge by Dicken's Formula	3.553 Cumecs

Maximum Discharge	3.553 Cumecs
Next Maximum Discharge	2.187 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **3.281 Cumecs**

5 Linear Waterway :

Average Bed Level		=	270.25 m
HFL as per site condition & local inquiry		=	271.75 m
So, Total Depth of Water,	H	=	1.50 m

Provided One RCC BOX of 2 x 2m span at proposed bridge site location.

Clear Waterway (provided),	L	=	2.00 m
Total Area,	A	=	4.000 m2
Velocity ,	V	=	Q / A
		=	**0.820 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **4.265 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	2.13 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.22 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

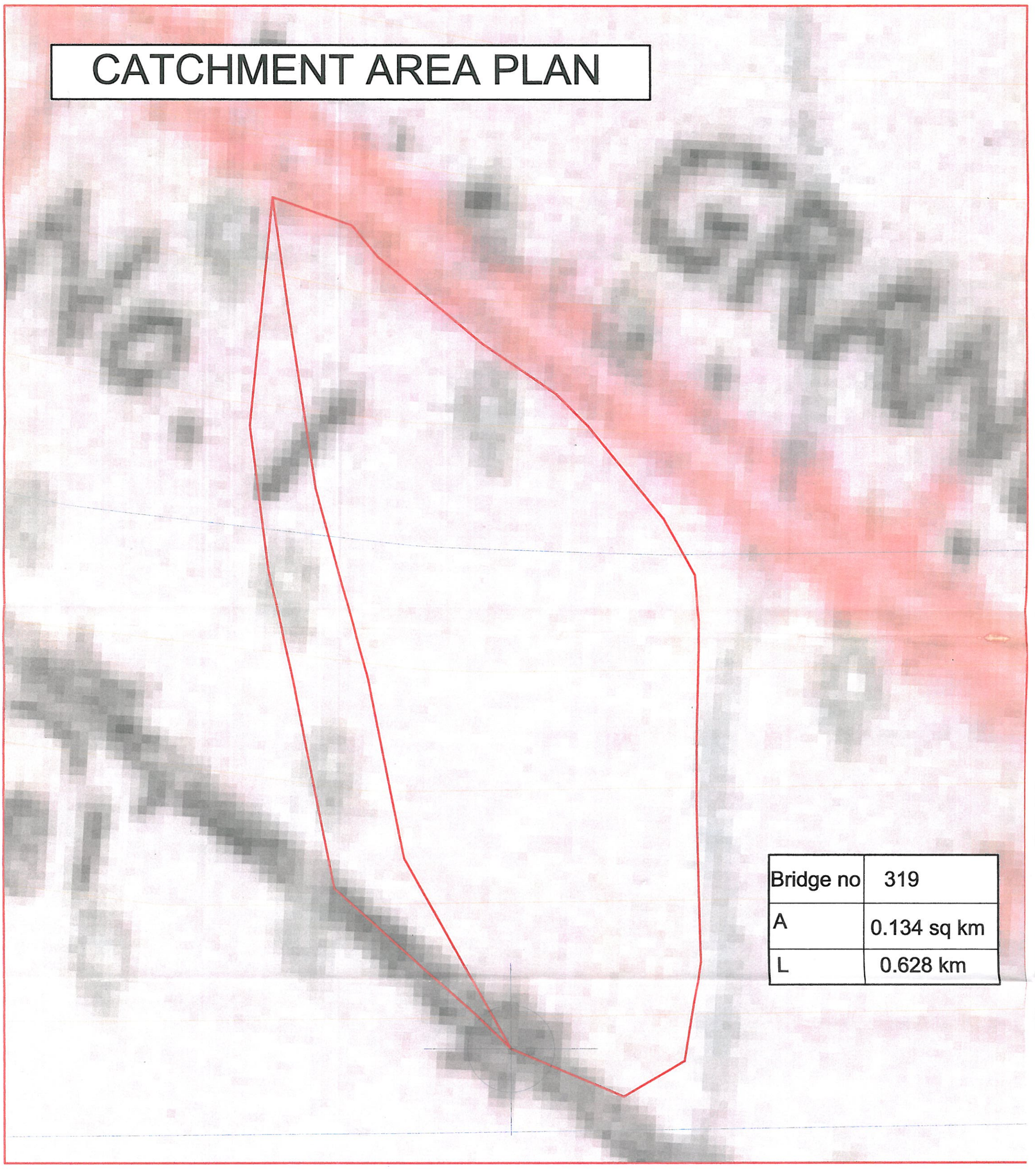
So, **Maximum Scour Depth** = **3.330 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

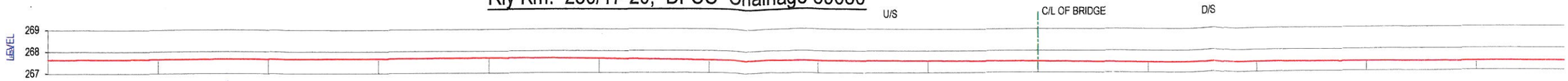
= **268.42 m**

CATCHMENT AREA PLAN

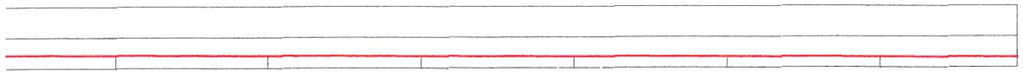


Bridge no	319
A	0.134 sq km
L	0.628 km

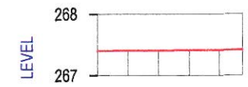
PROPOSED BRIDGE NO. BR. 039 (PRL_319)
Rly Km. 280/17-20, DFCC Chainage 89680



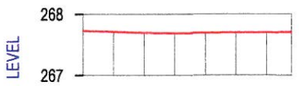
LEVEL	267.622	267.634	267.643	267.651	267.680	267.644	267.557	267.540	267.524	267.487	267.450	267.442	267.426	267.410
CHAINAGE	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00



267.410	267.401	267.368	267.355	267.344	267.330	267.313
200.00	250.00	300.00	350.00	400.00	450.00	494.873

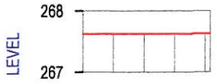


LONGITUDINAL SECTION



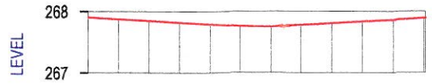
LEVEL	267.725	267.710	267.695	267.688	267.691	267.693	267.696	267.698
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	7.618

(Upstream at 245m)



LEVEL	267.618	267.620	267.622	267.621	267.620	267.620
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	4.328

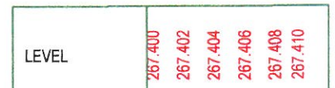
(Upstream at 440m)



LEVEL	267.899	267.870	267.841	267.812	267.783	267.754	267.744	267.772	267.800	267.829	267.857	267.885	267.886
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	10.102

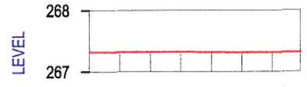
(Bridge site)

CROSS SECTION



LEVEL	267.400	267.402	267.404	267.406	267.408	267.410
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.000	3.498

(Downstream at 240m)



LEVEL	267.315	267.315	267.315	267.315	267.310	267.308	267.308	267.308
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	7.841

(Downstream at 490m)

0220

Existing Bridge No – 320
Location – KM 281/2-4

Proposed Bridge No – 040
Location – CH: 90105

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	320
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 11
Scale :	1 : 50,000
Location :	281/2-4
Latitude :	$30^0 26'24"$
Longitude :	$76^0 40'5"$

Catchment Area ,	**A**	=	0.113 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.508 Km
Height of Farthest Point ,	**H1**	=	271.08 m
Height of Point of Interest ,	**H2**	=	270.63 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.45 m
Average Bed Level		=	270.63 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where ,

Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0221

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

$t_c = [L^3 / H]^{0.345}$

= **0.653 Hr**

= **39.207 Mins**

(a) t_c h Ratio = 0.27 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **0.781**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **6.38 cm**

= **63.77 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **97.58 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **1.226 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.113 Sq. Km	11.29 Hectares
Length of path from Toposheet,	L	=	0.508 Km	
Difference in Levels from Toposheet,	H	=	0.45 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.59 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	157.28 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	11.29 Hectares
I_c = Critical Intensity of Rainfall	15.728 cm / Hr
Q = Maximum Discharge	**1.890 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm 14 - 19 in Madhya Pradesh 22 in Western Ghats

C	=	16	(adopted in present case)
M	=	0.113 Sq Km	

Hence, Q = **3.117 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	1.226 Cumecs
Discharge by Rational Formula (IRC approach)	1.890 Cumecs
Discharge by Dicken's Formula	3.117 Cumecs

Maximum Discharge	3.117 Cumecs
Next Maximum Discharge	1.890 Cumecs
The difference is beyond 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **2.835 Cumecs**

5 Linear Waterway :

Average Bed Level		=	270.63 m
HFL as per site condition & local inquiry		=	272.25 m
So, Total Depth of Water,	H	=	1.62 m

Provided One RCC BOX of 2 x 2m span at proposed bridge site location.

Clear Waterway (provided),	L	=	2.00 m
Total Area,	A	=	3.240 m2
Velocity ,	V	=	Q / A
		=	**0.875 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **3.686 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.84 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.01 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **3.021 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

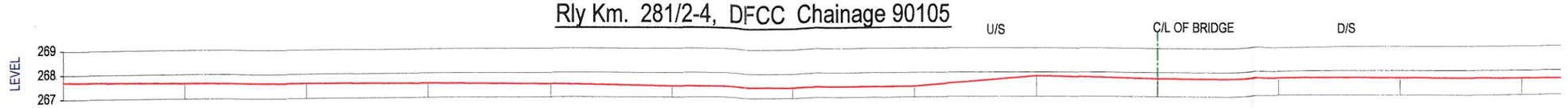
= **269.23 m**

CATCHMENT AREA PLAN

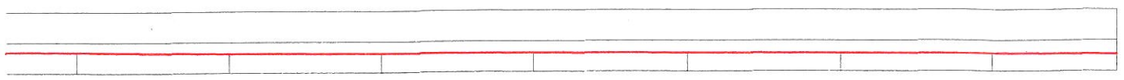
Bridge no	320
A	0.113 sq km
L	0.508 km

PROPOSED BRIDGE NO. BR. 040 (PRL_320)

Rly Km. 281/2-4, DFCC Chainage 90105

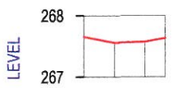


LEVEL	267.677	267.619	267.605	267.565	267.527	267.443	267.419	267.417	267.836	267.733	267.709	267.686	267.667
CHAINAGE	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00



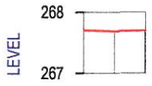
267.667	267.621	267.611	267.596	267.588	267.573	267.566	267.532
150.00	200.00	250.00	300.00	350.00	400.00	450.00	491.087

LONGITUDINAL SECTION



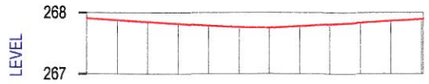
LEVEL	267.650	267.552	267.571	267.630
CHAINAGE	-2.000	0.000	2.000	3.329

(Upstream at 245m)



LEVEL	267.698	267.678	267.693	267.693
CHAINAGE	-2.000	0.000	2.000	2.038

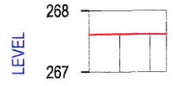
(Upstream at 430m)



LEVEL	267.899	267.870	267.841	267.812	267.783	267.754	267.744	267.772	267.800	267.829	267.857	267.885	267.886
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	10.102

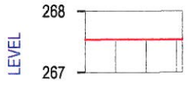
(Bridge site)

CROSS SECTION



LEVEL	267.605	267.614	267.611	267.608
CHAINAGE	-2.000	0.000	2.000	3.073

(Downstream at 240m)



LEVEL	267.526	267.531	267.529	267.526	267.525
CHAINAGE	-2.000	0.000	2.000	4.000	4.392

(Downstream at 495m)

0226

Existing Bridge No – 322
Location – KM 282/28-283/2

Proposed Bridge No – 042
Location – CH: 92000

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			322
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 11
Scale :			1 : 50,000
Location :			282/28-283/2
Latitude :			$30^0$26'59.7"
Longitude :			$76^0$39'9"
Catchment Area ,	A	=	0.093 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	0.423 Km
Height of Farthest Point ,	H1	=	270.60 m
Height of Point of Interest ,	H2	=	270.35 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	0.25 m
Average Bed Level		=	270.35 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient,** C = **0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3/H]^{0.345}$

= **0.662 Hr**

= **39.731 Mins**

(a) t_c h Ratio = 0.27 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **0.787**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **6.42 cm**

= **64.18 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **96.93 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **1.002 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.093 Sq. Km	9.30 Hectares
Length of path from Toposheet,	L	=	0.423 Km	
Difference in Levels from Toposheet,	H	=	0.25 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.60 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	156.41 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	9.30 Hectares
I_c = Critical Intensity of Rainfall	15.641 cm / Hr
Q = Maximum Discharge	**1.548 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,	Q	=	the peak run-off in Cumecs
	M	=	the catchment area in Sq Km
	C	=	11 - 14, where the annual rainfall is 60 - 120 cm
			14 - 19 in Madhya Pradesh
			22 in Western Ghats
	C	=	16 (adopted in present case)
	M	=	0.093 Sq Km
Hence,	**Q**	=	**2.695 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	1.002 Cumecs
Discharge by Rational Formula (IRC approach)	1.548 Cumecs
Discharge by Dicken's Formula	2.695 Cumecs
Maximum Discharge	2.695 Cumecs
Next Maximum Discharge	1.548 Cumecs
The difference is beyond 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **2.322 Cumecs**

5 Linear Waterway :

Average Bed Level		=	270.35 m
HFL as per site condition & local inquiry		=	272.19 m
So, Total Depth of Water,	H	=	1.84 m

Provided TwoRCC BOX of 1.2 x 1.2 m span at proposed bridge site location.

Clear Waterway (provided),	L	=	2.40 m
Total Area,	A	=	4.418 m2
Velocity ,	V	=	Q / A
		=	**0.525 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **3.018 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width 1.26 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **1.56 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = $1.5 \times d_{sm}$

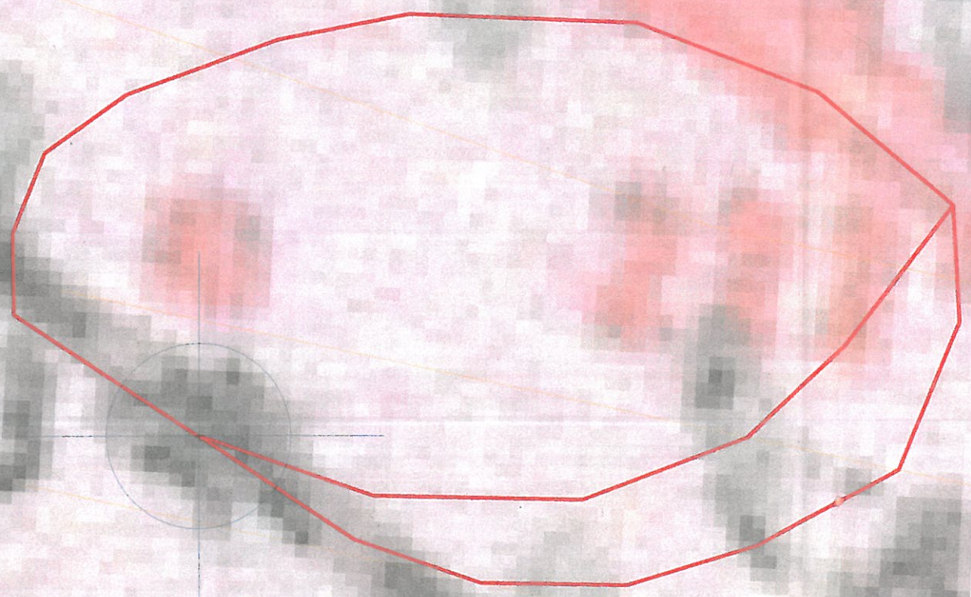
So, **Maximum Scour Depth** = **2.342 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

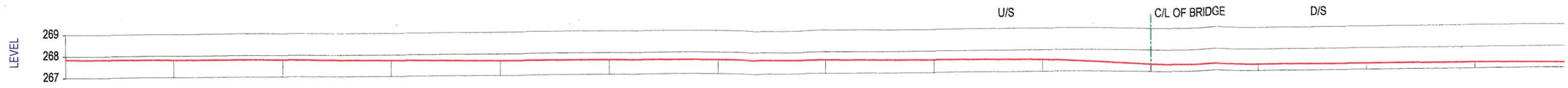
= **269.85 m**

CATCHMENT AREA PLAN

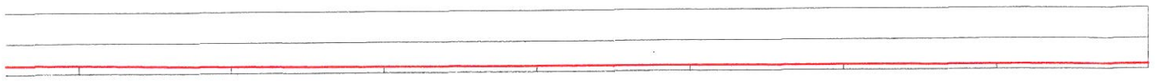


Bridge no	322
A	0.093 sq km
L	0.423 km

PROPOSED BRIDGE NO. BR. 042 (PRL_322)
Rly Km. 282/28-283/2, DFCC Chainage 92000

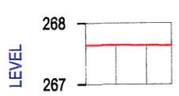


LEVEL	267.827	267.794	267.771	267.725	267.662	267.660	267.632	267.611	267.585	267.541	267.315	267.287	267.273	267.265
CHAINAGE	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00



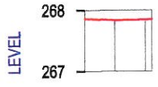
267.265	267.214	267.191	267.179	267.169	267.164	267.154	267.148
150.00	200.00	250.00	300.00	350.00	400.00	450.00	499.917

LONGITUDINAL SECTION



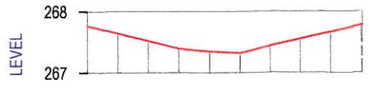
LEVEL	267.636	267.635	267.634	267.629
CHAINAGE	-2.000	0.000	2.000	3.652

(Upstream at 190m)



LEVEL	267.857	267.830	267.840	267.843
CHAINAGE	-2.000	0.000	2.000	2.439

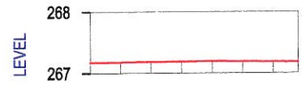
(Upstream at 480m)



LEVEL	267.764	267.639	267.514	267.390	267.342	267.315	267.429	267.544	267.659	267.774	267.778
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.000	8.065

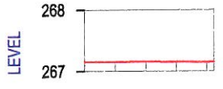
(Bridge site)

CROSS SECTION



LEVEL	267.170	267.175	267.179	267.184	267.186	267.182	267.178	267.175
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	5.638

(Downstream at 255m)



LEVEL	267.145	267.146	267.148	267.145	267.141	267.140
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	4.487

(Downstream at 495m)

0232

SHEET NO. 1 TO 1

Existing Bridge No – 323
Location – KM 285/13-15

Proposed Bridge No – 044
Location – CH: 94473

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	323
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 11
Scale :	1 : 50,000
Location :	285/13-15
Latitude :	$30^0$27'47"
Longitude :	$76^0$37'54"

Catchment Area ,	**A**	=	0.367 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	1.398 Km
Height of Farthest Point ,	**H1**	=	269.95 m
Height of Point of Interest ,	**H2**	=	269.25 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.70 m
Average Bed Level		=	269.25 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

$t_c = [L^3 / H]^{0.345}$

= **1.600 Hr**

= **95.983 Mins**

(a) t_c h Ratio = 0.43 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.253**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **$0.34 \times R_{50}$ (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **$K \times R_{50}$ (1)**

= **10.22 cm**

= **102.23 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **63.91 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = $0.278 \times C \times I \times A$

Q_{50} = **2.606 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.367 Sq. Km	36.67 Hectares
Length of path from Toposheet,	L	=	1.398 Km	
Difference in Levels from Toposheet,	H	=	0.70 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.60 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	96.11 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	36.67 Hectares
I_c = Critical Intensity of Rainfall	9.611 cm / Hr
Q = Maximum Discharge	**3.868 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16 (adopted in present case)
M	=	0.367 Sq Km

Hence, Q = **7.539 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	2.606 Cumecs
Discharge by Rational Formula (IRC approach)	3.868 Cumecs
Discharge by Dicken's Formula	7.539 Cumecs
Maximum Discharge	7.539 Cumecs
Next Maximum Discharge	3.868 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **5.802 Cumecs**

5 Linear Waterway :

Average Bed Level		=	269.25 m
HFL as per site condition & local inquiry		=	271.05 m
So, Total Depth of Water,	H	=	1.80 m

Provide 2 spans of 3.05 m at bridge site location.

Clear Waterway (provided),	L	=	6.10 m
Total Area,	A	=	10.980 m2
Velocity ,	V	=	Q / A
		=	**0.528 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	5.802 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.600 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.600 m
	So, Vertical Clearance adopted		=	0.600 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **271.652 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **7.543 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width 1.24 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **1.54 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = $1.5 \times d_{sm}$

So, **Maximum Scour Depth** = **2.316 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **268.74 m**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3/H]^{0.345}$

= 0.336 Hr

= 20.173 Mi

(a) t_c h Ratio = 0.18 (s

(b) 1 h Ratio = 0.34 (om Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$ = **0.532** om Fig. 4 of RBF - 16)

(d)

(i) R_{50} (24) = 24.00 cr

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= 8.16 c

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= 4.34 c

= 43.41 m

(v) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$ n

= **129.11 mm / Hr**

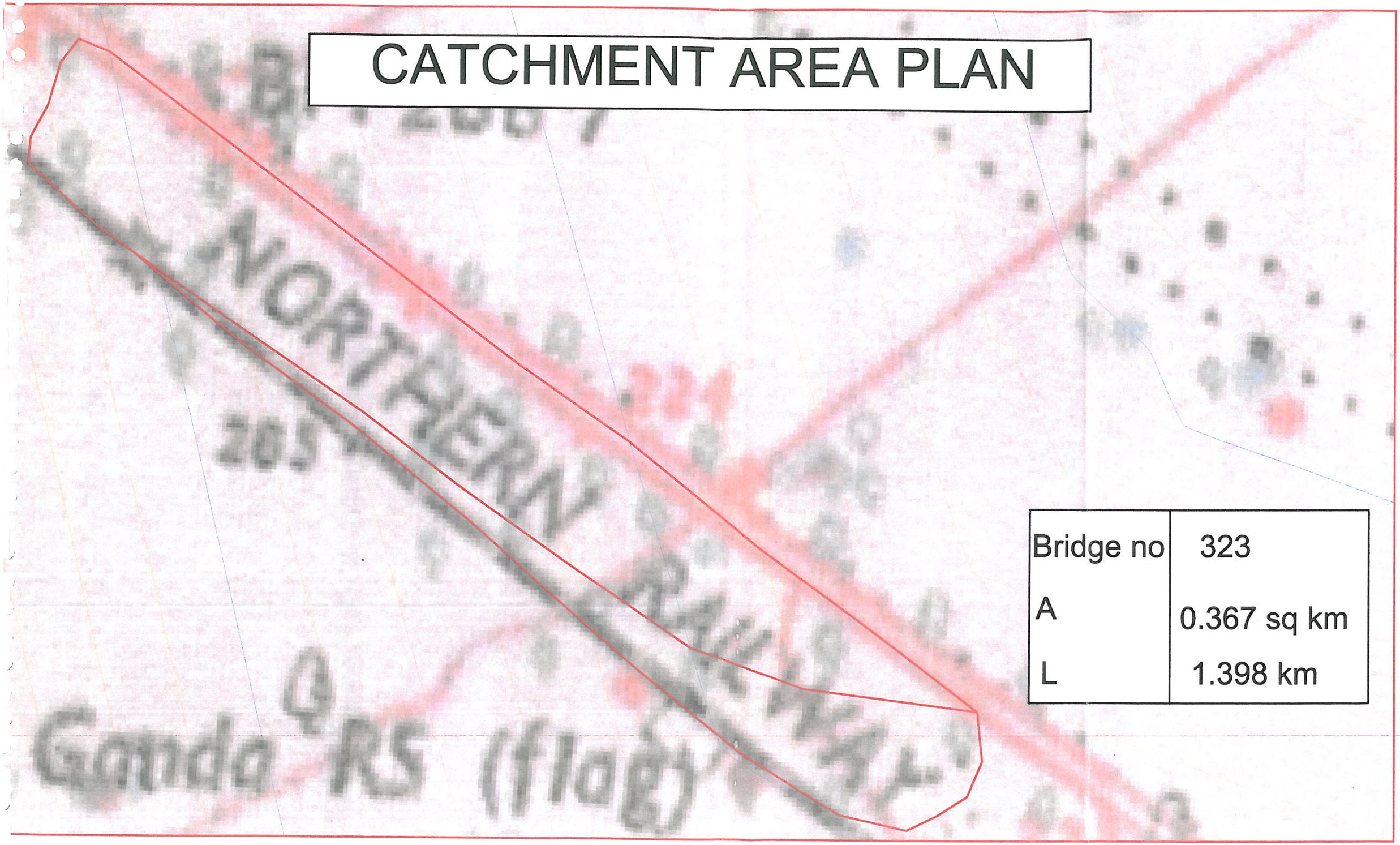
Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = 1.093 C umecs

0237

CATCHMENT AREA PLAN



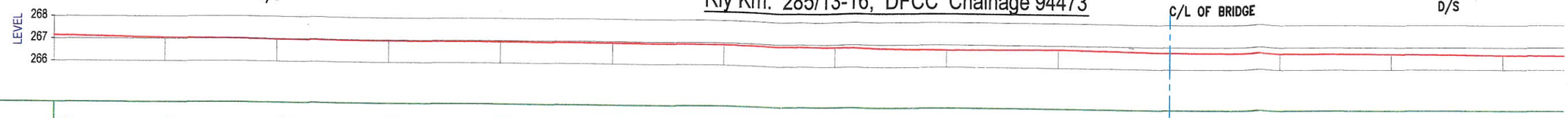
Bridge no	323
A	0.367 sq km
L	1.398 km

0237 A

PROPOSED BRIDGE NO. BR. 044 (PRL_323)

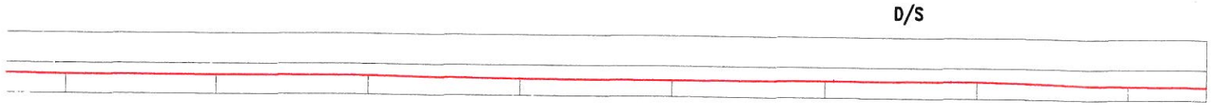
Rly Km. 285/13-16, DFCC Chainage 94473

U/S

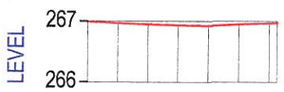


LEVEL	267.125	267.019	266.970	266.952	266.933	266.913	266.893	266.857	266.741	266.800	266.732	266.709	266.681	266.630
CHAINAGE	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00

D/S

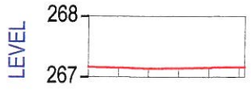


266.630	266.621	266.606	266.544	266.527	266.539	266.552	266.439	266.425
150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	525.890



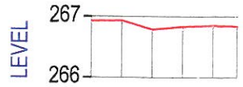
LEVEL	266.985	266.963	266.942	266.925	266.918	266.943	266.963	266.968
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	4.517

(Upstream at 255m)



LEVEL	267.156	267.145	267.132	267.139	267.150	267.155	267.156
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.00	6.380

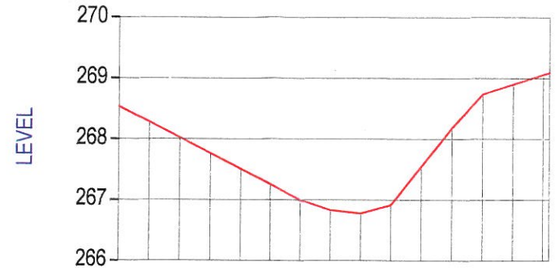
(Upstream at 505m)



LEVEL	266.917	266.927	266.784	266.831	266.845	266.832
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	9.609

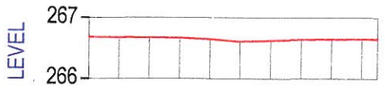
(Bridge site)

CROSS SECTION



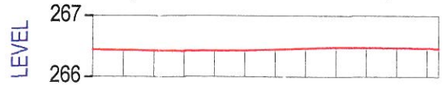
LEVEL	268.530	268.274	268.018	267.763	267.507	267.251	266.995	266.829	266.773	266.909	267.544	268.178	268.729	268.891	269.054	269.086
CHAINAGE	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	12.400

(Downstream at 00m)



LEVEL	266.678	266.672	266.667	266.661	266.640	266.601	266.619	266.636	266.640	266.645	266.647
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	9.036

(Downstream at 250m)



LEVEL	266.435	266.428	266.422	266.415	266.420	266.425	266.441	266.458	266.475	266.470	266.465	266.460	266.458
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	12.748

(Downstream at 505m)

0237B

Existing Bridge No – 324
Location – KM 285/26-28

Proposed Bridge No – 046
Location – CH: 94850

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			324
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 11
Scale :			1 : 50,000
Location :			285/26-28
Latitude :			$30^0$28'28"
Longitude :			$76^0$36'49"
Catchment Area ,	**A**	=	0.076 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.204 Km
Height of Farthest Point ,	**H1**	=	268.95 m
Height of Point of Interest ,	**H2**	=	268.75 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.20 m
Average Bed Level		=	268.75 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient,** **C** = **0.4**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.076 Sq. Km	7.62 Hectares
Length of path from Toposheet,	L	=	0.204 Km	
Difference in Levels from Toposheet,	H	=	0.20 m	

Maximum Rainfall, F = 240.00 mm

Duration of Storm, T = 24 Hrs

One Hour Rainfall, $I_o = (F / T) \times (T + 1) / (1 + 1)$ = 125.00 mm / Hr

Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7) $t_c = (0.87 \times L^3 / H)^{0.385}$ = 0.28 Hrs

Critical Rainfall Intensity, $I_c = I_o \times [2 / (1 + t_c)]$ = 195.19 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered) 0.400

f = Fraction of maximum point intensity at centre of storm, depends on area 0.98

A = Catchment Area in Hectares 7.62 Hectares

I_c = Critical Intensity of Rainfall 19.519 cm / Hr

Q = Maximum Discharge **1.632 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q = the peak run-off in Cumecs

M = the catchment area in Sq Km

C = 11 - 14, where the annual rainfall is 60 - 120 cm
14 - 19 in Madhya Pradesh
22 in Western Ghats

C = 16 (adopted in present case)

M = 0.076 Sq Km

Hence, Q = **2.320 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	1.093 Cumecs
Discharge by Rational Formula (IRC approach)	1.632 Cumecs
Discharge by Dicken's Formula	2.320 Cumecs
Maximum Discharge	2.320 Cumecs
Next Maximum Discharge	1.632 Cumecs
The difference is within 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **2.320 Cumecs**

5 Linear Waterway :

Average Bed Level		=	268.75 m
HFL as per site condition & local inquiry		=	270.25 m
So, Total Depth of Water,	H	=	1.50 m

Provide 1 spans of 3.05m at bridge site location.

Clear Waterway (provided),	L	=	3.05 m
Total Area,	A	=	4.575 m2
Velocity ,	V	=	Q / A
		=	**0.507 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	2.320 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.450 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.600 m
	So, Vertical Clearance adopted		=	0.600 m

Minimum Soffit Level = HFL + Vertical Clearance

= **270.852 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) 30%

Increased Design Discharge **3.016 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^{\,2} / K_{sf})^{1/3}$

D_b = Design discharge per metre width 0.99 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **1.33 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **1.5 x d_{sm}**

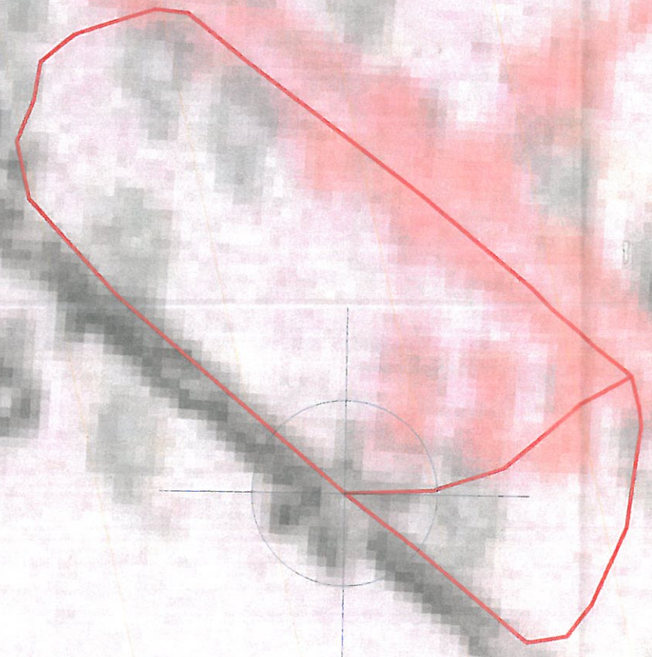
So, **Maximum Scour Depth** = **1.995 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **268.26 m**

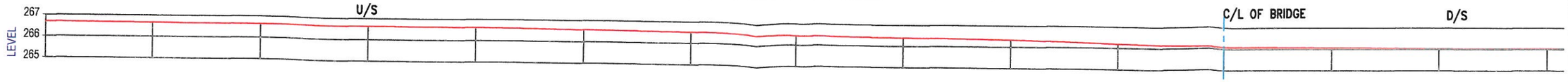
CATCHMENT AREA PLAN



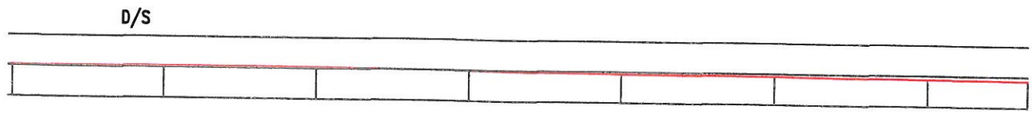
Bridge no	324
A	0.076 sq km
L	0.204 km

PROPOSED BRIDGE NO. BR. 046 (PRL_324)

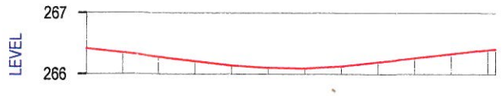
Rly Km. 285/26-28; DFCC Chainage 94850



LEVEL	266.676	266.648	266.632	266.623	266.607	266.554	266.515	266.430	266.385	266.334	266.192	266.082	266.050	266.025	266.019
CHAINAGE	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00

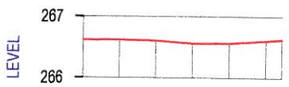


	266.019	266.033	266.033	265.983	265.922	265.877	265.855
	150.00	200.00	250.00	300.00	350.00	400.00	450.00	482.945



LEVEL	266.411	266.342	266.273	266.204	266.135	266.099	266.092	266.124	266.192	266.260	266.328	266.396	266.411
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	12.426

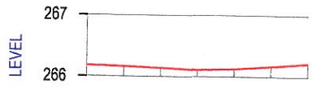
(Downstream at 00m)



LEVEL	266.609	266.613	266.598	266.559	266.560	266.603	266.625
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.00	6.870

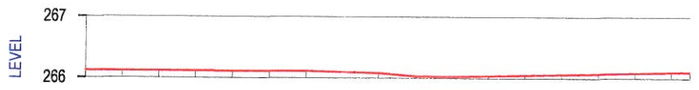
(Upstream at 260m)

LONGITUDINAL SECTION



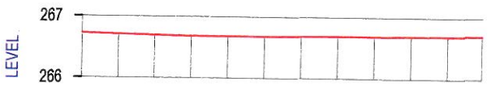
LEVEL	266.168	266.158	266.136	266.106	266.122	266.165	266.214
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00

(Bridge site)



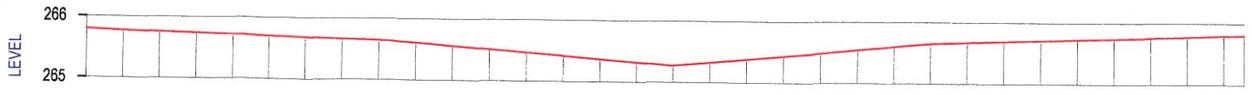
LEVEL	266.115	266.114	266.112	266.111	266.110	266.109	266.107	266.095	266.077	266.026	266.025	266.037	266.049	266.062	266.074	266.086	266.099	266.105
CHAINAGE	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	16.984

(Downstream at 240m)



LEVEL	266.715	266.701	266.688	266.675	266.676	266.676	266.679	266.682	266.685	266.689	266.693	266.696
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	11.885

(Upstream at 515m)



LEVEL	265.785	265.767	265.748	265.730	265.711	265.693	265.675	265.656	265.638	265.602	265.554	265.506	265.458	265.410	265.362	265.314	265.266	265.318	265.373	265.427	265.481	265.535	265.589	265.643	265.665	265.683	265.700	265.718	265.736	265.753	265.771	265.788	265.798
CHAINAGE	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.000	32.000	33.125

CROSS SECTION

(Downstream at 490m)

0242

SHEET NO. 1 TO 1

Existing Bridge No – 324A
Location – KM 287/5-7

Proposed Bridge No – 051
Location – CH: 96263

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			324A	
Name of Nallah / Stream / River :			Local Stream	
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)	
G.T Sheet No :			53 B / 11	
Scale :			1 : 50,000	
Location :			287/5-7	
Latitude :			$30^0$28'	Approx.
Longitude :			$76^0$36'50"	Approx.
Catchment Area ,	A	=	0.496 Sq Km	
Length of Longest Stream course from source to the bridge site ,	L	=	1.305 Km	
Height of Farthest Point ,	H1	=	270.15 m	
Height of Point of Interest ,	H2	=	269.05 m	
Height of the Farthest Point above Point of Interest along the river ,	H	=	1.10 m	
Average Bed Level		=	269.05 m	

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0243

Runoff Coefficient, C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **1.275 Hr**

= **76.476 Mins**

(a) t_c h Ratio = 0.38 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.117**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **9.12 cm**

= **91.18 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **71.54 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **3.948 Cumecs**

0244

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.496 Sq. Km	49.63 Hectares
Length of path from Toposheet,	L	=	1.305 Km	
Difference in Levels from Toposheet,	H	=	1.10 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.24 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	111.48 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	49.63 Hectares
I_c = Critical Intensity of Rainfall	11.148 cm / Hr
Q = Maximum Discharge	**5.887 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm 14 - 19 in Madhya Pradesh 22 in Western Ghats

C	=	16 (adopted in present case)
M	=	0.496 Sq Km

Hence, Q = **9.460 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	3.948 Cumecs
Discharge by Rational Formula (IRC approach)	5.887 Cumecs
Discharge by Dicken's Formula	9.460 Cumecs

Maximum Discharge	9.460 Cumecs
Next Maximum Discharge	5.887 Cumecs
The difference is beyond 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **8.830 Cumecs**

5 Linear Waterway :

Average Bed Level		=	269.05 m
HFL as per site condition & local inquiry		=	272.05 m
So, Total Depth of Water,	H	=	3.00 m

Provided One RCC BOX of 6 x 4 m span at proposed bridge site location.

Clear Waterway (provided),	L	=	6.00 m
Total Area,	A	=	18.000 m2
Velocity ,	V	=	Q / A
		=	**0.491 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **11.479 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width 1.91 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **2.07 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **3.098 m**

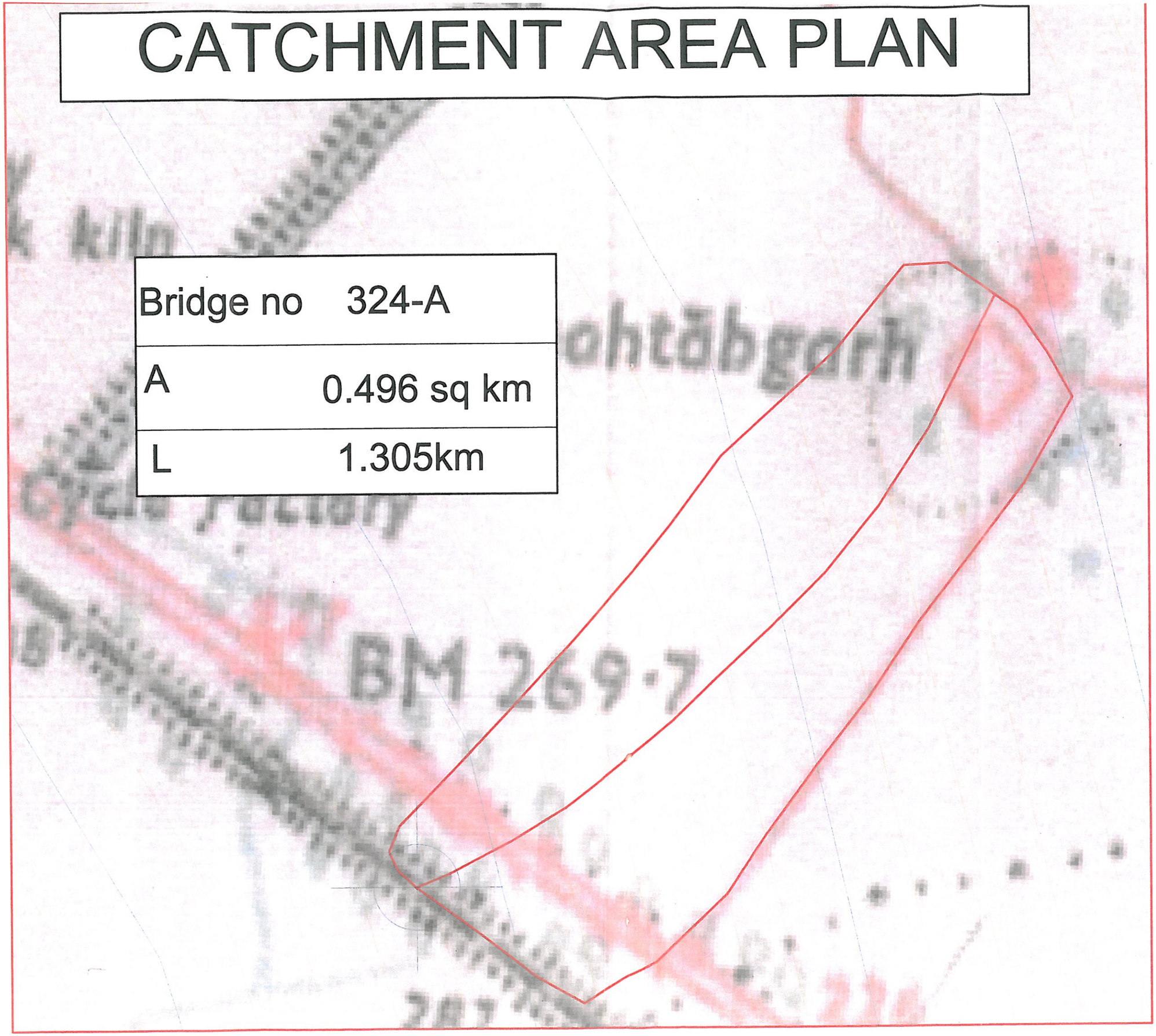
7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **268.95 m**

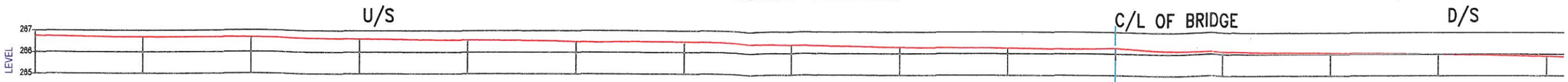
CATCHMENT AREA PLAN

Bridge no	324-A
A	0.496 sq km
L	1.305km



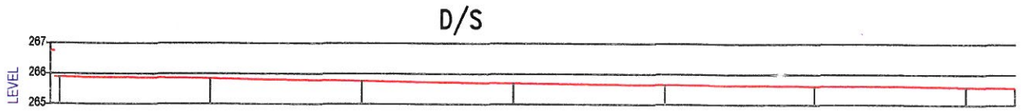
0247

PROPOSED BRIDGE NO. BR.051 (324A)
Rly Km. 287/5-8, DFCC Chainage 96263



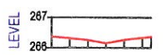
LEVEL	266.745	266.686	266.667	266.606	266.557	266.486	266.478	266.368	266.286	266.246	266.254	266.104	266.050	265.988	265.887
CHAINAGE	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00

LONGITUDINAL SECTION



LEVEL	265.887	265.838	265.755	265.684	265.642	265.612	265.587	265.559
CHAINAGE	200.00	250.00	300.00	350.00	400.00	450.00	500.00	516.184

LONGITUDINAL SECTION



LEVEL	266.339	266.307	266.252	266.143	266.259	266.355	266.355								
CHAINAGE	-8.00	-4.00	-2.00	0.000	2.00	4.00	6.00								

(Bridge site)

LEVEL	266.537	266.534	266.530	266.527	266.522	266.517	266.521	266.529	266.536	266.540	266.544	266.547			
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	11.185			

(Upstream at 245m)

LEVEL	266.775	266.763	266.750	266.738	266.740	266.748	266.750	266.751	266.748	266.746					
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00					

(Upstream at 490m)

CROSS SECTION

LEVEL	266.332	266.313	266.294	266.275	266.256	266.237	266.218	266.200	266.181	266.162	266.143	266.158	266.189	266.220	266.251	266.281	266.312	266.343	266.374	266.404	266.435
CHAINAGE	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00

(Downstream at 00m)

LEVEL	265.845	265.843	265.841	265.839	265.837	265.826	265.810	265.819	265.829	265.836	265.833	265.830	265.826	265.826	
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	12.877	

(Downstream at 245m)

LEVEL	265.525	265.528	265.532	265.536	265.544	265.553	265.556	265.556	265.553	265.551	265.548	265.547			
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	11.977			

(Downstream at 495m)

CROSS SECTION

0248

SHEET NO.-1

Existing Bridge No – 324B
Location – KM 287/11-13

Proposed Bridge No – 052
Location – CH: 96433

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			324B
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 11
Scale :			1 : 50,000
Location :			287/11-13
Latitude :			$30^0$28' Approx.
Longitude :			$76^0$36'50" Approx.
Catchment Area ,	A	=	0.537 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	1.356 Km
Height of Farthest Point ,	H1	=	271.05 m
Height of Point of Interest ,	H2	=	270.05 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	1.00 m
Average Bed Level		=	270.05 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0249

In present case, **Runoff Coefficient,** C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **1.371 Hr**

= **82.232 Mins**

(a) t_c h Ratio = 0.39 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.158**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **9.45 cm**

= **94.49 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **68.94 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **4.113 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.537 Sq. Km	53.65 Hectares
Length of path from Toposheet,	L	=	1.356 Km	
Difference in Levels from Toposheet,	H	=	1.00 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.35 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	106.50 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	53.65 Hectares
I_c = Critical Intensity of Rainfall	10.650 cm / Hr
Q = Maximum Discharge	**6.080 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16	(adopted in present case)
M	=	0.537 Sq Km	

Hence, Q = **10.030 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	4.113 Cumecs
Discharge by Rational Formula (IRC approach)	6.080 Cumecs
Discharge by Dicken's Formula	10.030 Cumecs
Maximum Discharge	10.030 Cumecs
Next Maximum Discharge	6.080 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **9.120 Cumecs**

5 Linear Waterway :

Average Bed Level		=	270.05 m
HFL as per site condition & local inquiry		=	272.25 m
So, Total Depth of Water,	H	=	2.20 m

Provided One RCC BOX of 6 x 4 m span at proposed bridge site location.

Clear Waterway (provided),	L	=	6.00 m
Total Area,	A	=	13.200 m2
Velocity ,	V	=	Q / A
		=	**0.691 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **11.856 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.98 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.11 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

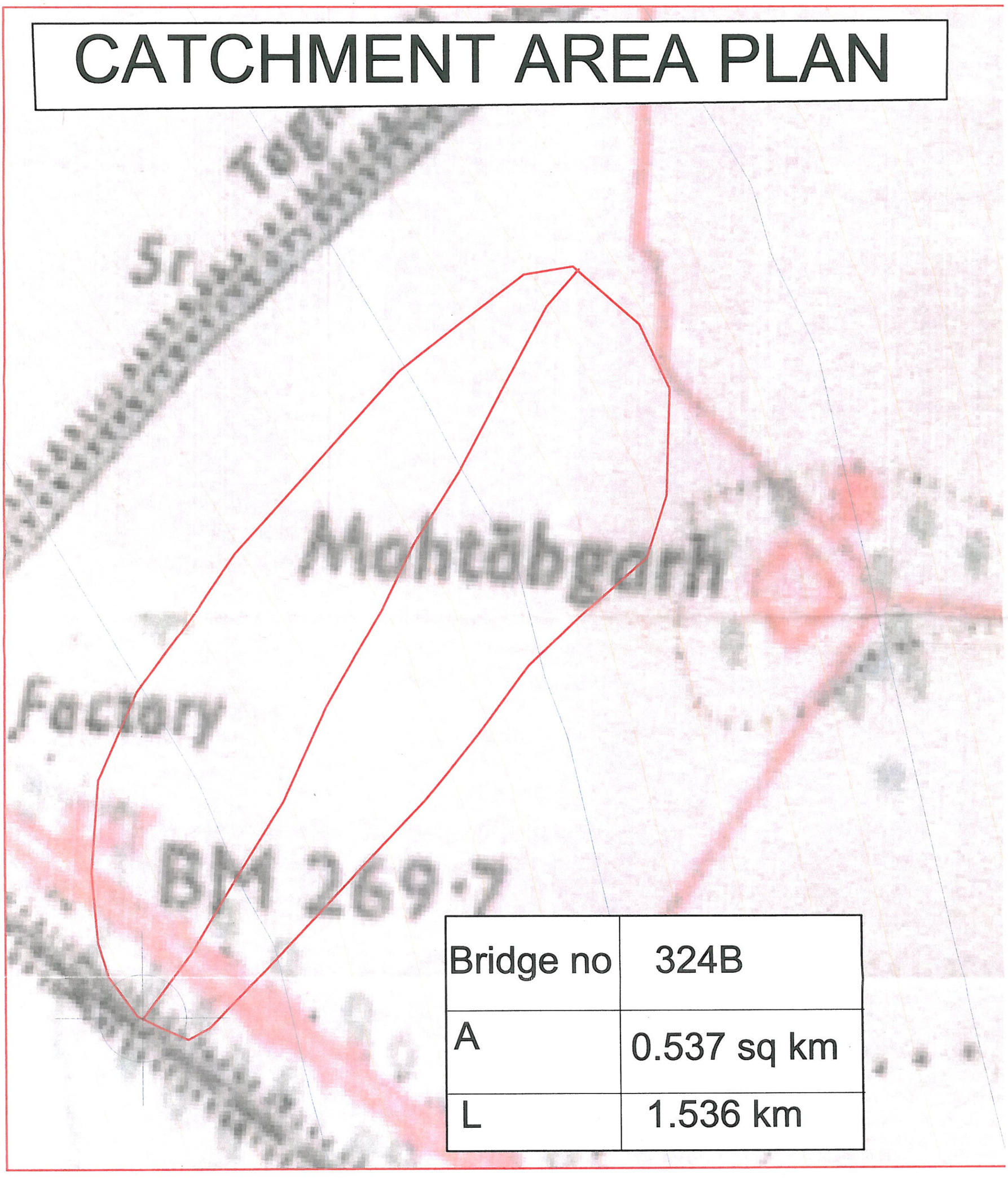
So, **Maximum Scour Depth** = **3.165 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

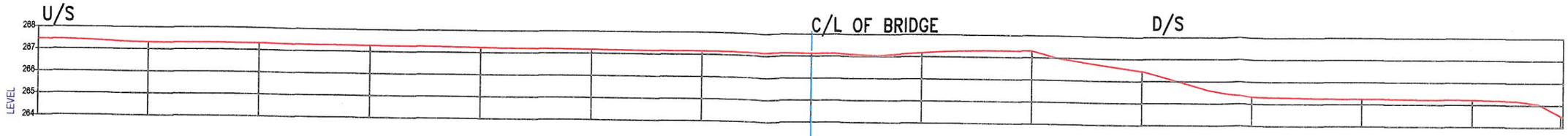
= **269.09 m**

CATCHMENT AREA PLAN



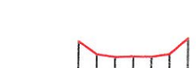
Bridge no	324B
A	0.537 sq km
L	1.536 km

PROPOSED BRIDGE NO. BR.052 (324B)
Rly Km. 287/11-14, DFCC Chainage 96433



LEVEL	267.437	267.305	267.291	267.267	267.225	267.165	267.140	267.126	267.179	267.296	266.441	265.313	265.241	265.214	264.520
CHAINAGE	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00	250.00	300.00	340.00

LONGITUDINAL SECTION



LEVEL	267.587	267.609	267.552	267.568	267.598	267.634	267.662		
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00		

(Bridge site)

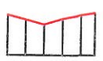
LEVEL	267.205	267.197	267.188	267.173	267.159	267.180	267.191	267.194	267.198
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00

(Upstream at 595m)

LEVEL	267.457	267.461	267.464	267.468	267.459	267.449	267.439	267.440	267.445	267.448	267.451	267.454	267.457	267.456	267.455	267.454	267.453	267.452	267.451	267.450	267.449
CHAINAGE	-12.000	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.000	12.997	14.00	16.00	18.00	20.00	22.00	24.00	24.997

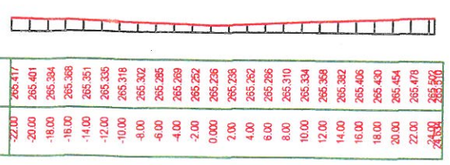
(Upstream at 990m)

CROSS SECTION



LEVEL	265.585	265.761	265.672	265.759	265.682	265.932
CHAINAGE	0.000	2.000	4.000	6.000	8.000	9.923

(Downstream at 00m)



LEVEL	265.417	265.401	265.394	265.368	265.351	265.335	265.318	265.302	265.285	265.269	265.252	265.236	265.236	265.252	265.266	265.310	265.334	265.358	265.382	265.406	265.430	265.454	265.478	265.502	265.526
CHAINAGE	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	24.997

(Downstream at 125m)

CROSS SECTION

025

SHEET NO.-1

DETOUR PORTION (2-D-7)

Proposed Bridge No – 054
Location – CH: 96688

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	2 - D - 7
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo - Ganga Plains, 1 (e)
G.T Sheet No :	53 B / 10, 53 B / 11, 53 B / 13 & 53 B / 14
Scale :	1 : 50,000
Location :	96688
Latitude :	30^0 28' 29"
Longitude :	76^0 36' 51"

Catchment Area ,	A	=	252.985 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	51.508 Km
Length of the main stream from a point opposite to the centroid of the catchment area to the site along the main stream ,	Lc	=	29.268 Km
Average Bed Level		=	267.85 m

1 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	252.985 Sq. Km	25298.50 Hectares
Length of path from Toposheet,	L	=	51.508 Km	
Difference in Levels from Toposheet,	H	=	96.15 m	

Maximum Rainfall, F		=	179.22 mm
Duration of Storm, T		=	2 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	134.42 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		15.51 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	16.29 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.600
f = Fraction of maximum point intensity at centre of storm, depends on area	0.90
A = Catchment Area in Hectares	25298.50 Hectares
I_c = Critical Intensity of Rainfall	1.629 cm / Hr
Q = Maximum Discharge	**622.999 Cumecs**

2 Discharge by Dicken's Formula :

	Q	=	$C \times M^{3/4}$
where,	Q	=	the peak run-off in Cumecs
	M	=	the catchment area in Sq Km
	C	=	11 - 14, where the annual rainfall is 60 - 120 cm
			14 - 19 in Madhya Pradesh
			22 in Western Ghats
	C	=	11 (adopted in present case)
	M	=	252.985 Sq Km
Hence,	Q	=	**697.772 Cumecs**

3 Discharge by Ryve's Formula :

	Q	=	$C \times M^{2/3}$
where,	Q	=	the peak run-off in Cumecs
	M	=	the catchment area in Sq Km
	C	=	6.8 for areas within 25 Km of the coast
			8.5 for areas between 25 & 160 Km of the coast
			10.0 for limited areas near the hills
	C	=	10 (adopted in present case)
	M	=	252.985 Sq Km
Hence,	Q	=	**400.003 Cumecs**

4 Discharge by Flood Estimation Report - SUG :

Name of Railway Section	Kesri to Sahnewal
Name of River/Nallah/Stream	PECHIS DARA
Name of nearest Village/Town	Near RAJPURA
RD/Location	2-D-7 ,Near Km. 325
Longitude	: 76^0 36' 51"E
Latitude	:30^0 28' 29"N
GT Sheet No.	53B/11,53B/10,53B/14 & 53B/13
Sub-Zone	Upper Ganga Plains Sub-Zone-1(e)
Shape of catchment	Fern Elongated

Base flow = 0.05 Cumecs/Sq.km.

12.65 Cumecs

G.T Sheet scale 1:50000

Estimation of Equivalent stream slope

S. No.	Reduced Distance Starting from Point of Study (kms)	Reduced Levels of River/stream/nallah Bed (m)	Length of each Segment L_i (km)	Height Above Datum *(D_i Difference Between the Datum and the ith R.L. (m)	$(D_{i-1} + D_i)$	$L_i (D_{i-1} + D_i)$ (4) x (6) (m x km)
1	2	3	4	5	6	7
1	0.000	267.850	0	0	0	0.000
2	0.210	269.700	0.21	1.85	1.85	0.390
3	9.975	277.000	9.765	9.15	11	107.410
4	12.494	278.000	2.519	10.15	19.3	48.620
5	19.593	284.000	7.099	16.15	26.3	186.700
6	21.993	288.000	2.40	20.15	36.30	87.120
7	23.995	292.000	2.00	24.15	44.30	88.690
8	37.471	317.000	13.48	49.15	73.30	987.790
9	45.639	333.000	8.17	65.15	114.30	933.600
10	51.508	364.000	5.87	96.15	161.30	946.670
					$\Sigma L_i (D_{i-1} + D_i)$ =	3386.990

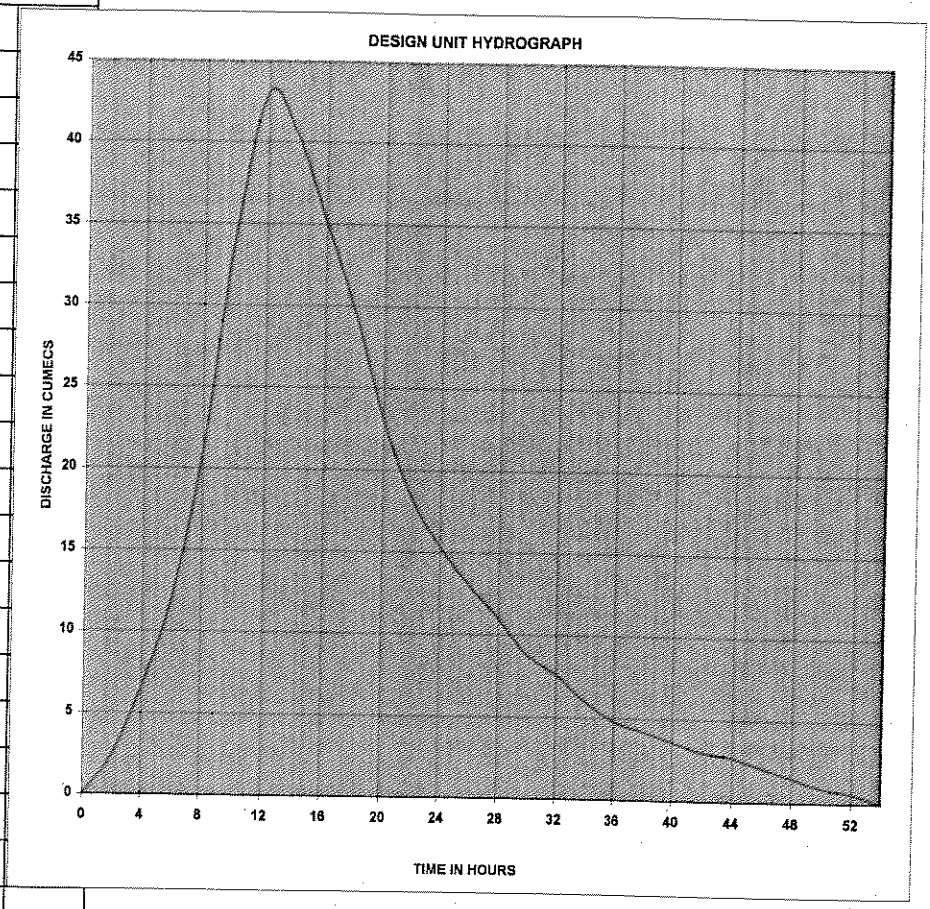
$$S = \frac{\Sigma L_i (D_{i-1} + D_i)}{L^2} = 1.277 \text{ m/km}$$

0257

Synthetic Unitgraph Parameters:

Catchment area A =	252.99 Sq.Km.	
d =	1.0 cm depth	
$t_i = t_r$ (the unit duration of the UG) =	2.0 hr	
$\Sigma Q_i\ t_i = A \times d / (0.36 \times t_r)$ =	351.368	Cumec./sec.
L =	51.508 km	
Lc =	29.27 km	
L/(sqrt(s)) =	45.59	
$t_p = 1.858*(qp)^{-1.038}$=	11.68 hrs	
Say	12.0 hrs	
$q_p = 2.030*(L/\sqrt{S})-0.649$ =	0.17 Cumec/Sq.Km.	
Q_p = Catchment area x q_p =	43.05 cumecs	
$W_{50} = 2.217*(q_p)-0.990$ =	12.80 hrs	
$W_{75} = 1.477*(q_p)-0.876$ =	6.97 hrs	
$W_{R50} = 0.812*(q_p)-0.907$ =	4.05 hrs	
$W_{R75} = 0.606(q_p)-0.791$ =	2.46 hrs	
$Q_{50} = 0.5 \times Q_p$ =	21.53 cumecs	
$Q_{75} = 0.75 \times Q_p$ =	32.29 cumecs	
$T_B = 7.744*(t_p)0.779$ =	53.66 hrs	
Say	54.0 hrs	
$T_m = t_p + t_r/2 = t_p + 2/2$ =	13.0 hrs	

S.No.	Unit Graph(1 cm 1 hour)		
	Time	Ordinate	
0	0	0	
1	2	2.4	
2	4	6.60	
3	6	12.00	
4	8	21.0	
5	10	34.5	
6	12	43.05	
7	14	40.4	
8	16	35.1	
9	18	29.7	
10	20	23.1	
11	22	18.3	
12	24	15.3	
13	26	13	
14	28	11	
15	30	8.8	
16	32	7.6	
17	34	6	
18	36	4.8	
19	38	4.2	
20	40	3.6	
21	42	3	
22	44	2.7	
23	46	2.1	
24	48	1.5	
25	50	0.9	
26	52	0.6	
27	54	0	
		351.25	5.00



Strom duration=1.1*tp T_D= 12.85 Say 14.00 Hours

From Plate,the 50 -Year return period,24 hour point rainfall =240 mm . 240 mm Based on Longi.&Lati.of Bridge site

Convertion factor,Areal Rainfall =84 % of Point Rainfall 84 201.6 mm Based on storm duration Td hrs.

Areal reduction factor,for TD=12.0hr &C.A.=252.39 Sq.km. =88.9% 88.9 179.22 mm Based on C.A.& Storm duration

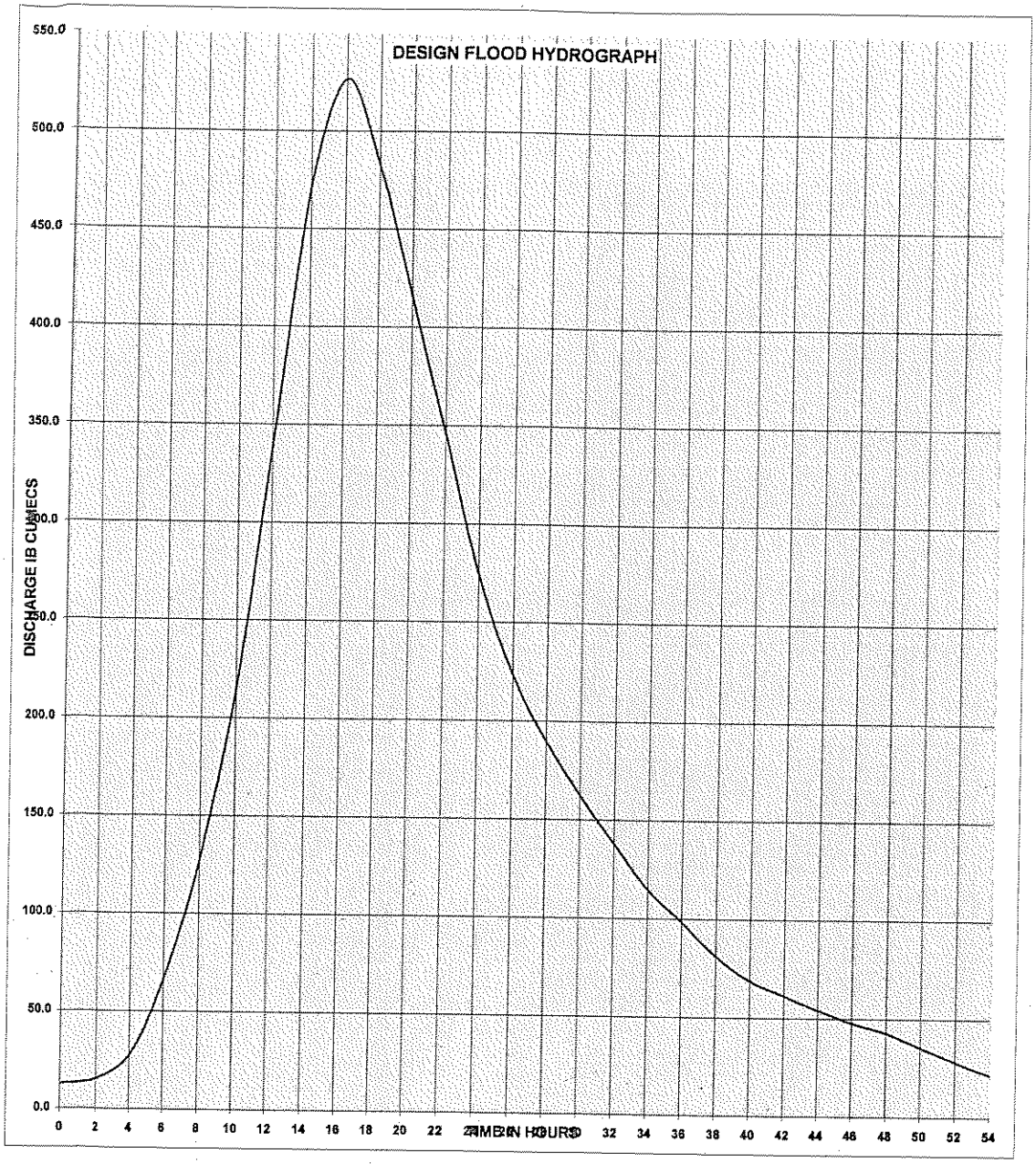
Hourly rainfall increments Design Loss rate = 0.30 cm / hour 6.0 mm/2-hr.

Hours	Storm Percentage	Storm Rainfall	Excess Rainfall	Incremental R.E.
0	0	0	0	0
2	48	86.03	80.03	80.03
4	69	123.66	111.66	31.64
6	82	146.96	122.96	11.30
8	89	159.51	123.51	0.55
10	95	170.26	122.26	-1.25
12	100	179.22	119.22	-3.04

50-Year and T_D (14.0 hr.)areal rainfall has been split into 2-hr. rainfall increments using time distribution coefficients

Estimation of Design Flood Hydrograph

Unit Graph(1 cm 2 hour)			R.E.	R.E.								Base flow		Total discharge (Cum)
S.No.	Time	Ordinate	Peak to Peak	Reverse order	1.13	3.164	8.003	0.055		0	0			
0	0	0			0						12.65		12.65
1	2	2.4			2.71	0.00					12.65		15.36
2	4	6.6			7.46	7.59	0.00				12.65		27.70
3	6	12			13.56	20.88	19.21	0.00			12.65		66.30
4	8	21			23.73	37.97	52.82	0.13	0.00		12.65		127.30
5	10	34.5	0.55	11.3	38.99	66.44	96.04	0.36	0.00	0.00	12.65		214.48
6	12	43.05	80.03	31.64	48.65	109.16	168.06	0.66	0.00	0.00	12.65		339.18
7	14	40.4	31.64	80.03	45.65	136.21	276.10	1.16	0.00	0.00	12.65		471.77
8	16	35.1	11.3	0.55	39.66	127.83	344.53	1.90	0.00	0.00	12.65		**526.56**
9	18	29.7			33.56	111.06	323.32	2.37	0.00	0.00	12.65		482.96
10	20	23.1			26.10	93.97	280.91	2.22	0.00	0.00	12.65		415.85
11	22	18.3			20.68	73.09	237.69	1.93	0.00	0.00	12.65		346.04
12	24	15.3			17.29	57.90	184.87	1.63	0.00	0.00	12.65		274.34
13	26	13			14.69	48.41	146.45	1.27	0.00	0.00	12.65		223.47
14	28	11			12.43	41.13	122.45	1.01	0.00	0.00	12.65		189.66
15	30	8.8			9.94	34.80	104.04	0.84	0.00	0.00	12.65		162.28
16	32	7.6			8.59	27.84	88.03	0.72	0.00	0.00	12.65		137.83
17	34	6			6.78	24.05	70.43	0.61	0.00	0.00	12.65		114.51
18	36	4.8			5.42	18.98	60.82	0.48	0.00	0.00	12.65		98.36
19	38	4.2			4.75	15.19	48.02	0.42	0.00	0.00	12.65		81.02
20	40	3.6			4.07	13.29	38.41	0.33	0.00	0.00	12.65		68.75
21	42	3			3.39	11.39	33.61	0.26	0.00	0.00	12.65		61.31
22	44	2.7			3.05	9.49	28.81	0.23	0.00	0.00	12.65		54.23
23	46	2.1			2.37	8.54	24.01	0.20	0.00	0.00	12.65		47.77
24	48	1.5			1.70	6.64	21.61	0.17	0.00	0.00	12.65		42.76
25	50	0.9			1.02	4.75	16.81	0.15	0.00	0.00	12.65		35.37
26	52	0.6			0.68	2.85	12.00	0.12	0.00	0.00	12.65		28.29
27	54	0			0.00	1.90	7.20	0.08	0.00	0.00	12.65		21.83
28	56					0.00	4.80	0.05	0.00	0.00	12.65		17.50
29	58						0.00	0.03	0.00	0.00	12.65		12.68
30	60							0.00	0.00	0.00	12.65		12.65
	Qp =	527	Cumecs										


DESIGN FLOOD HYDROGRAPH
DISCHARGE IB CUMECS
TIME IN HOURS
550.0
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
2
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5 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (IRC approach)	622.999 Cumecs
Discharge by Dicken's Formula	697.772 Cumecs
Discharge by SUG	527.000 Cumecs
Discharge by Ryve's Formula	400.003 Cumecs
Maximum Discharge	697.772 Cumecs
Next Maximum Discharge	622.999 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **697.772 Cumecs**

6 Linear Waterway :

Regime Width, $W = 4.8 \times Q^{1/2}$ = **126.794 m**

In accordances with Para - 4.5.3 with a value of C = 2.67 of IRS - Code of Practice for the Design of Sub-structures & Foundations of Bridges, also IRC - SP : 13 - 1998, Clause : 8.5 & Clause : 104.3 of IRC : 5 - 1998

Minimum waterway provided = (2 / 3) of Regime Width = **84.529 m**

Provide 4 span of 30.5 m at bridge site location.

7 Vertical Clearance :

	Design Discharge	Q =	697.772 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1	=	1.200 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8	=	1.500 m
	So, Vertical Clearance adopted	=	1.500 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **273.752 m**

8 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **907.104 Cumecs**

Total Water Way provided, L = 122.00 m

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^{\,2} / K_{sf})^{1/3}$

D_b = Design discharge per metre width 7.44 Cumecs / m

K_{sf} = Silt factor 1.743

d_{sm} = **4.24 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **6.363 m**

Maximum scour depth, as per IRC:78-2000, Clause 703.3

Scour Depth For Pier = $2^* d_{sm}$ = **8.483 m**

Scour Depth For Abutment = $1.27^* d_{sm}$ = **5.387 m**

9 Maximum Scour Level :

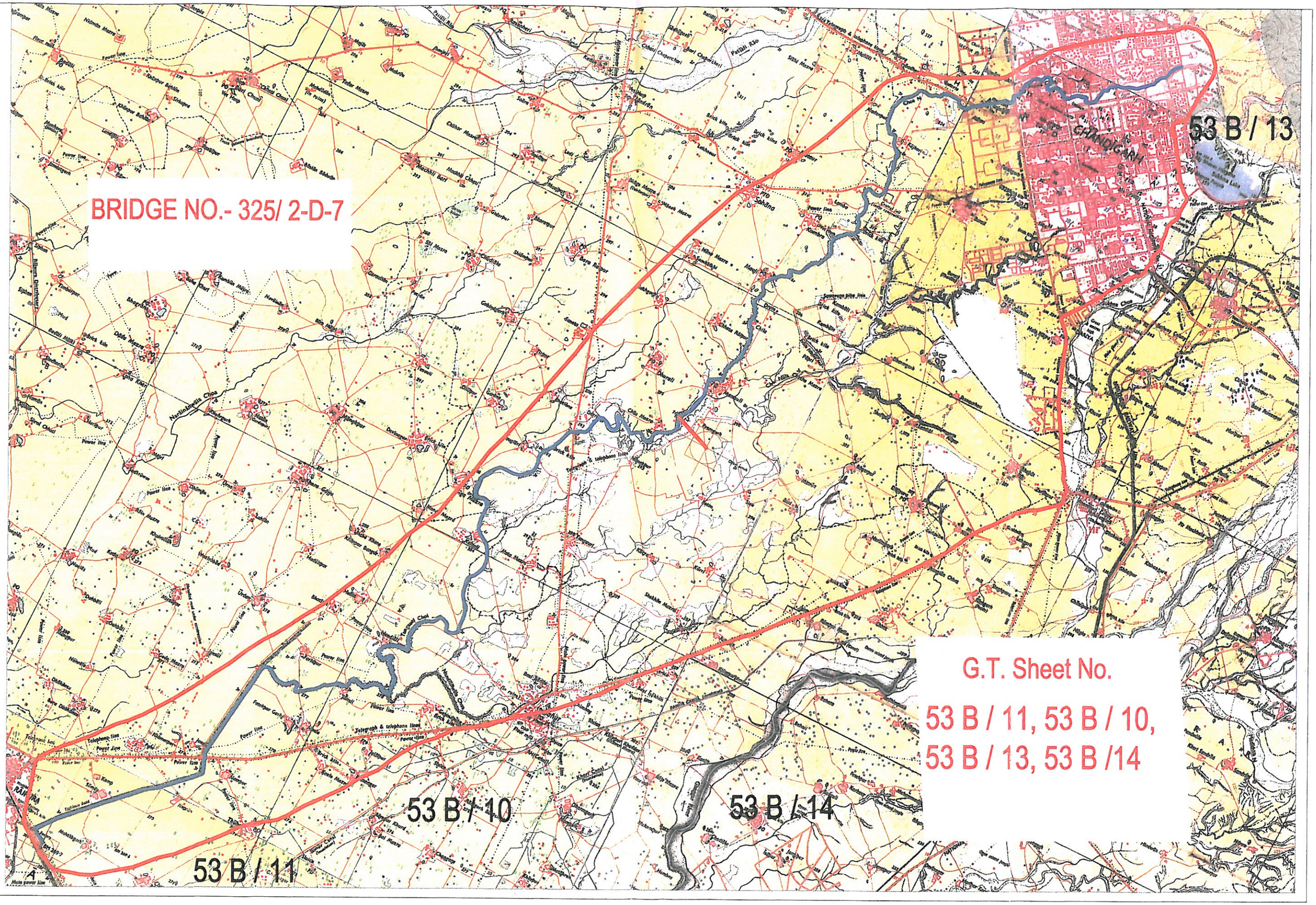
Maximum Scour Level = HFL - Maximum Scour Depth

As per IRS = **265.89 m**

As per IRC

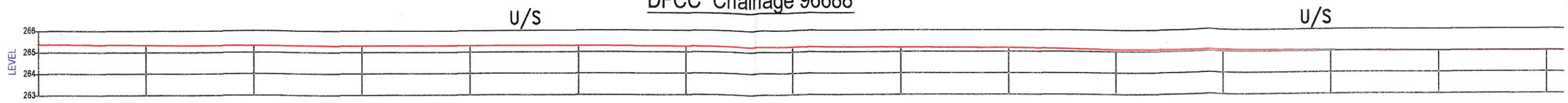
For Pier = **263.77 m**

For Abutment = **266.87 m**


BRIDGE NO.- 325/ 2-D-7
53 B / 13
53 B / 10
53 B / 11
53 B / 14
G.T. Sheet No.
53 B / 11, 53 B / 10,
53 B / 13, 53 B /14

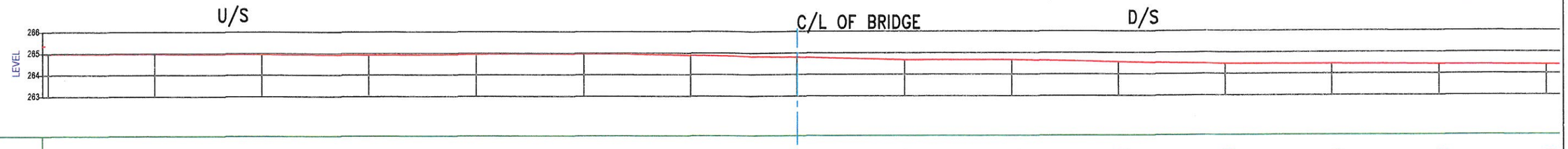
PROPOSED BRIDGE NO.BR.054,(2-D-7)

DFCC Chainage 96688



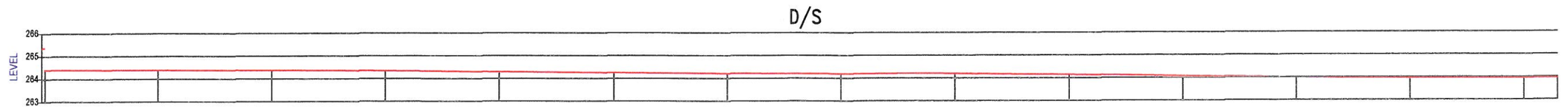
LEVEL	265.358	265.327	265.307	265.295	265.289	265.278	265.253	265.214	265.185	265.166	265.086	265.052	265.005	264.977	264.970
CHAINAGE	-1000.00	-950.00	-900.00	-850.00	-800.00	-750.00	-700.00	-650.00	-600.00	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00

LONGITUDINAL SECTION



LEVEL	264.977	264.970	264.957	264.926	264.948	264.966	264.893	264.792	265.187	265.365	264.802	264.458	264.444	264.422	264.399
CHAINAGE	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00	250.00	300.00	350.00

LONGITUDINAL SECTION



LEVEL	264.399	264.385	264.370	264.339	264.289	264.243	264.212	264.186	264.190	264.138	264.064	263.991	263.959	263.948	263.945
CHAINAGE	350.00	400.00	450.00	500.00	550.000	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000	1000.000	2014.795

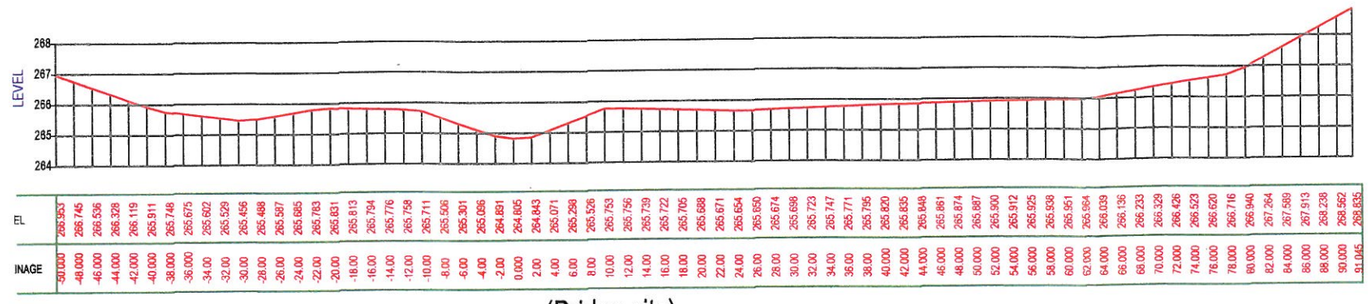
LONGITUDINAL SECTION

0265

SHEET NO.-1 TO 2

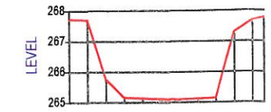
PROPOSED BRIDGE NO.054,(2-D-7)

DFCC Chainage 96688



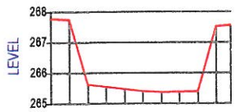
EL	263.953	266.745	266.536	266.328	266.119	265.911	265.748	265.675	265.602	265.529	265.456	265.488	265.587	265.685	265.783	265.831	265.813	265.794	265.776	265.758	265.711	265.506	265.301	265.096	264.891	264.805	264.843	265.071	265.299	265.526	265.753	265.756	265.739	265.722	265.705	265.688	265.671	265.654	265.650	265.674	265.698	265.723	265.747	265.771	265.795	265.820	265.835	265.848	265.861	265.874	265.887	265.900	265.912	265.925	265.938	265.951	265.964	266.039	266.136	266.233	266.329	266.426	266.523	266.620	266.716	266.940	267.264	267.589	267.913	268.236	268.562	268.835
INAGE	-50.000	-48.000	-46.000	-44.000	-42.000	-40.000	-38.000	-36.000	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.000	42.000	44.000	46.000	48.000	50.000	52.000	54.000	56.000	58.000	60.000	62.000	64.000	66.000	68.000	70.000	72.000	74.000	76.000	78.000	80.000	82.000	84.000	86.000	88.000	90.000	91.045

(Bridge site)



LEVEL	267.711	267.686	265.752	265.156	265.131	265.107	265.089	265.109	265.129	267.294	267.671	267.765
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	11.288

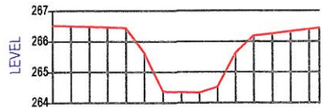
(Upstream at 245m)



LEVEL	267.769	267.743	265.615	265.544	265.473	265.401	265.363	265.376	265.389	267.506	267.554
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	9.560

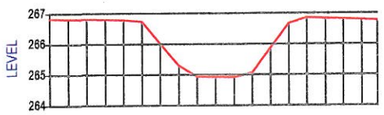
(Upstream at 500m)

CROSS SECTION



LEVEL	266.522	266.503	266.483	266.464	266.444	265.630	264.362	264.344	264.326	264.513	265.617	266.174	266.247	266.320	266.392	266.433
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	15.172

(Downstream at 450m)



LEVEL	263.825	265.815	265.805	265.795	265.785	265.731	265.010	264.289	263.940	263.929	263.919	264.059	264.860	265.660	265.846	265.825	265.804	265.783	265.765
CHAINAGE	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	17.673

(Downstream at 955m)

CROSS SECTION

0266

SHEET NO.-2 TO 2

Existing Bridge No – 326
Location – KM 291/15-17

Proposed Bridge No – 059
Location – CH: 100564

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	326
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 11
Scale :	1 : 50,000
Location :	291/15-17
Latitude :	$30^0$29'45"
Longitude :	$76^0$34'46"

Catchment Area ,	A	=	0.380 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	1.504 Km
Height of Farthest Point ,	H1	=	269.49 m
Height of Point of Interest ,	H2	=	268.19 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	1.30 m
Average Bed Level		=	268.19 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0267

In present case, **Runoff Coefficient,** C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **1.394 Hr**

= **83.617 Mins**

(a) t_c h Ratio = 0.40 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.170**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **9.55 cm**

= **95.48 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **68.52 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **2.893 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.380 Sq. Km	37.97 Hectares
Length of path from Toposheet,	L	=	1.504 Km	
Difference in Levels from Toposheet,	H	=	1.30 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.37 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	105.37 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	37.97 Hectares
I_c = Critical Intensity of Rainfall	10.537 cm / Hr
Q = Maximum Discharge	**4.256 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16 (adopted in present case)
M	=	0.380 Sq Km

Hence, Q = **7.739 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	2.893 Cumecs
Discharge by Rational Formula (IRC approach)	4.256 Cumecs
Discharge by Dicken's Formula	7.739 Cumecs

Maximum Discharge	7.739 Cumecs
Next Maximum Discharge	4.256 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **6.385 Cumecs**

5 Linear Waterway :

Average Bed Level		=	268.19 m
HFL as per site condition & local inquiry		=	269.45 m
So, Total Depth of Water,	H	=	1.26 m

Provided One RCC BOX of 3 x 3m span at proposed bridge site location.

Clear Waterway (provided),	L	=	3.00 m
Total Area,	A	=	3.780 m2
Velocity ,	V	=	Q / A
		=	**1.689 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **8.300 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^{\,2} / K_{sf})^{1/3}$

D_b = Design discharge per metre width	2.77 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.64 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

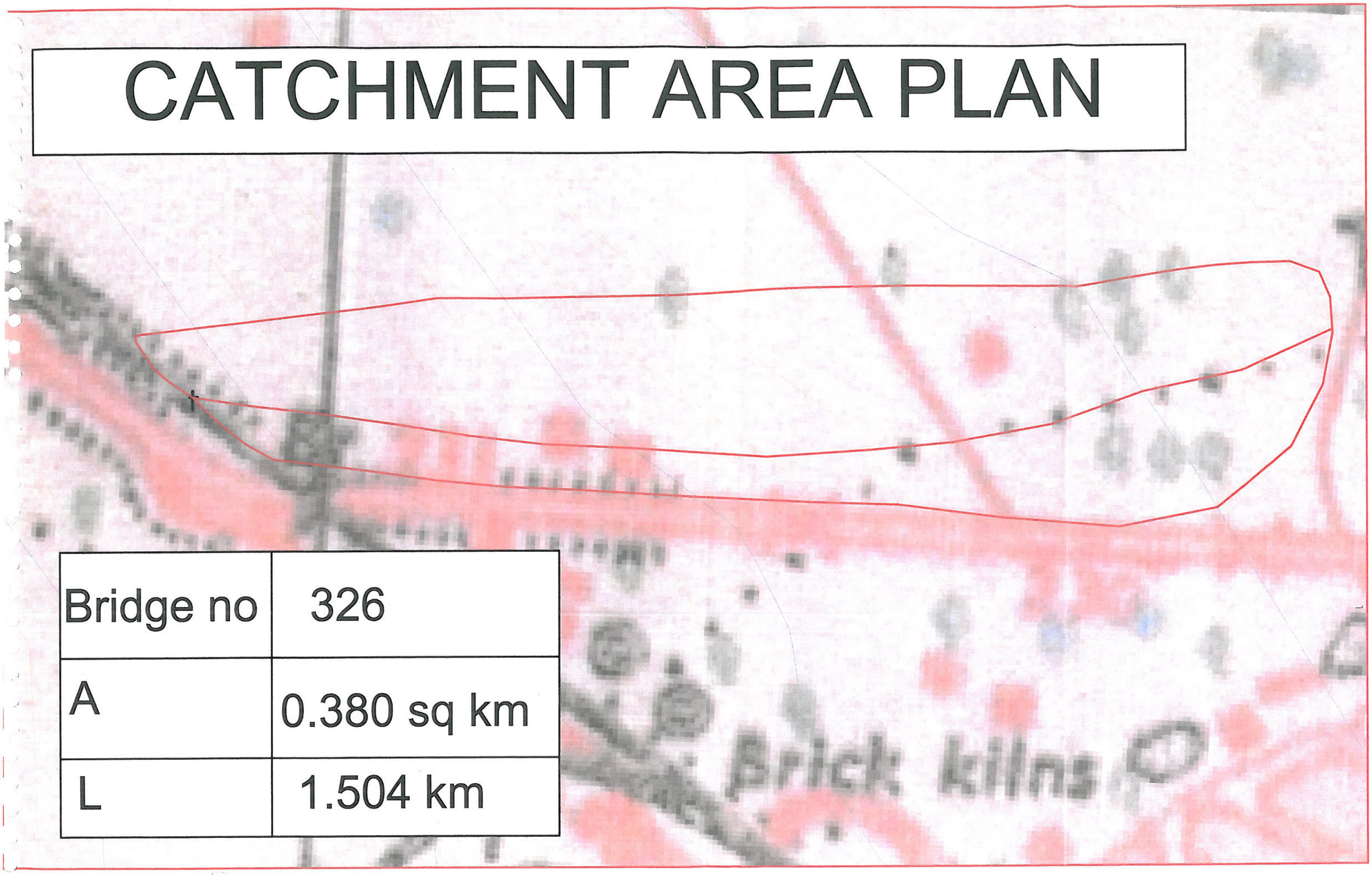
So, **Maximum Scour Depth** = **3.961 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.49 m**

CATCHMENT AREA PLAN



Bridge no	326
A	0.380 sq km
L	1.504 km

PROPOSED BRIDGE NO. BR. 059(PRL_326)
Rly Km. 291/15-17, DFCC Chainage 100564

U/S

C/L OF BRIDGE

LEVEL	265.625	265.594	265.564	265.551	265.541	265.525	265.436	265.378	265.354	265.357	265.135	265.053	265.019	264.997
CHAINAGE	-500.000	-450.000	-400.000	-350.000	-300.000	-250.000	-200.000	-150.000	-100.000	-50.000	0.000	50.000	100.000	150.000

LONGITUDINAL SECTION

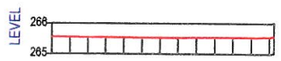
D/S

LEVEL	264.997	264.983	264.856
CHAINAGE	150.000	200.000	235.182

LONGITUDINAL SECTION

LEVEL	265.305	265.296	265.286	265.276	265.210	265.144	265.170	265.205	265.240	265.276	265.318			
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.000			

(Bridge site)



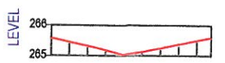
LEVEL	265.348	265.545	265.543	265.540	265.538	265.535	265.532	265.534	265.537	265.539	265.542	265.544	265.546	
CHAINAGE	-12.000	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.000	

(Upstream at 255m)

LEVEL	265.589	265.604	265.618	265.633	265.631	265.627	265.628	265.632	265.636	265.640	265.644	265.647		
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	11.926		

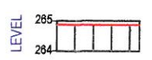
(Upstream at 490m)

CROSS SECTION



LEVEL	265.570	265.438	265.397	265.175	265.015	265.112	265.237	265.382	265.466	265.592
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	9.541

(Downstream at 85m)



LEVEL	264.865	264.862	264.858	264.855	264.854	264.853
CHAINAGE	-8.000	-4.000	-2.000	0.000	2.000	3.095

(Downstream at 242m)

CROSS SECTION

0272

SHEET NO.-1

Existing Bridge No – 327
Location – KM 291/26-27

Proposed Bridge No – 060
Location – CH: 100835

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			327
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 11
Scale :			1 : 50,000
Location :			291/26-27
Latitude :			$30^0$29'51"
Longitude :			$76^0$34'36"
Catchment Area ,	A	=	0.505 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	1.702 Km
Height of Farthest Point ,	H1	=	269.30 m
Height of Point of Interest ,	H2	=	267.75 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	1.55 m
Average Bed Level		=	267.75 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0273

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **1.491 Hr**

= **89.440 Mins**

(a) t_c h Ratio = 0.41 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.219**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **9.94 cm**

= **99.44 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **66.71 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **3.749 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.505 Sq. Km	50.54 Hectares
Length of path from Toposheet,	L	=	1.702 Km	
Difference in Levels from Toposheet,	H	=	1.55 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.48 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	100.82 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	50.54 Hectares
I_c = Critical Intensity of Rainfall	10.082 cm / Hr
Q = Maximum Discharge	**5.422 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm 14 - 19 in Madhya Pradesh 22 in Western Ghats

C	=	16	(adopted in present case)
M	=	0.505	Sq Km

Hence, Q = **9.591 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	3.749 Cumecs
Discharge by Rational Formula (IRC approach)	5.422 Cumecs
Discharge by Dicken's Formula	9.591 Cumecs
Maximum Discharge	9.591 Cumecs
Next Maximum Discharge	5.422 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **8.132 Cumecs**

5 Linear Waterway :

Average Bed Level		=	267.75 m
HFL as per site condition & local inquiry		=	269.45 m
So, Total Depth of Water,	H	=	1.70 m

Provided Two RCC BOX of 3 x 3m span at proposed bridge site location.

Clear Waterway (provided),	L	=	6.00 m
Total Area,	A	=	10.188 m2
Velocity ,	V	=	Q / A
		=	**0.798 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **10.572 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.76 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.95 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **2.932 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

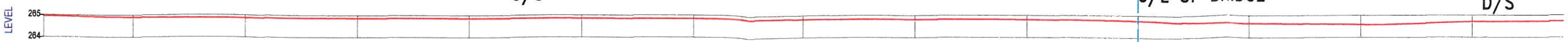
= **266.52 m**

CATCHMENT AREA PLAN

Bridge no	327
A	0.505 sq km
L	1.702 km

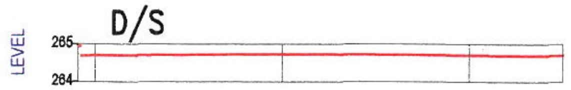
0277

PROPOSED BRIDGE NO. BR. 060(PRL_327)
Rly Km. 291/26-27, DFCC Chainage 100835



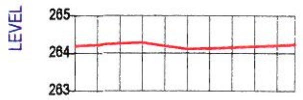
LEVEL	264.935	264.884	264.857	264.851	264.842	264.836	264.827	264.807	264.799	264.789	264.742	264.623	264.556	264.689
CHAINAGE	-490.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00

LONGITUDINAL SECTION



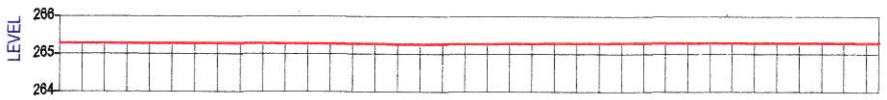
LEVEL	264.689	264.720	264.693	264.683
CHAINAGE	150.00	200.00	250.00	274.70

LONGITUDINAL SECTION



LEVEL	264.785	264.810	264.835	264.848	264.785	264.734	264.748	264.764	264.782	264.800	264.814
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00

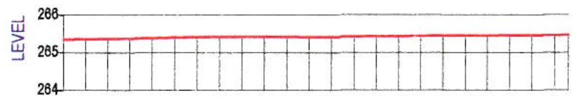
(Bridge site)



LEVEL	264.847	264.847	264.846	264.846	264.845	264.845	264.844	264.844	264.843	264.843	264.842	264.841	264.839	264.838	264.837	264.836	264.835	264.837	264.839	264.842
CHAINAGE	-40.00	-38.00	-36.00	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00

LEVEL	264.844	264.846	264.848	264.851	264.853	264.855	264.856	264.856	264.856	264.856	264.856	264.856	264.856	264.856	264.856	264.856	264.858	264.856
CHAINAGE	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	33.632

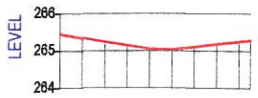
(Upstream at 245m)



LEVEL	264.895	264.902	264.908	264.915	264.921	264.927	264.933	264.939	264.942	264.940	264.938	264.936	264.936	264.940	264.944	264.949	264.953	264.956	264.958	264.960	264.962	264.964	264.966	264.967
CHAINAGE	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	27.641

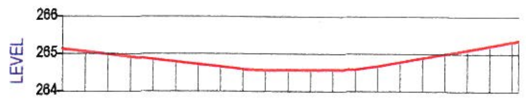
(Upstream at 495m)

CROSS SECTION



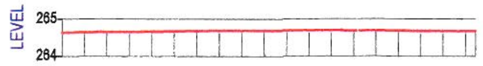
LEVEL	264.959	264.891	264.823	264.756	264.694	264.681	264.731	264.779	264.826	264.849
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	7.500

(Downstream at 20m)



LEVEL	265.112	265.044	264.976	264.908	264.841	264.773	264.705	264.637	264.569	264.548	264.554	264.559	264.564	264.569	264.660	264.770	264.879	264.988	265.097	265.207	265.316	265.347
CHAINAGE	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	22.366

(Downstream at 100m)



LEVEL	264.626	264.633	264.640	264.647	264.654	264.661	264.668	264.675	264.681	264.681	264.678	264.676	264.673	264.671	264.668	264.666	264.663	264.661	264.658	264.657
CHAINAGE	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	18.935

(Downstream at 263m)

0278

CROSS SECTION

Existing Bridge No – 328
Location – KM 291/31-33

Proposed Bridge No – 061
Location – CH: 101086

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			328
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 11
Scale :			1 : 50,000
Location :			291/31-33
Latitude :			$30^0$29'55"
Longitude :			$76^0$34'31"
Catchment Area ,	**A**	=	1.503 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	3.795 Km
Height of Farthest Point ,	**H1**	=	270.75 m
Height of Point of Interest ,	**H2**	=	268.35 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	2.40 m
Average Bed Level		=	268.35 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0279

In present case, **Runoff Coefficient,** **C** = **0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **2.940 Hr**

= **176.385 Mins**

(a) t_c h Ratio = 0.53 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.558**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **12.71 cm**

= **127.10 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **43.24 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **7.227 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	1.503 Sq. Km	150.31 Hectares
Length of path from Toposheet,	L	=	3.795 Km	
Difference in Levels from Toposheet,	H	=	2.40 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		3.16 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	60.13 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	150.31 Hectares
I_c = Critical Intensity of Rainfall	6.013 cm / Hr
Q = Maximum Discharge	**9.921 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16 (adopted in present case)
M	=	1.503 Sq Km

Hence, Q = **21.720 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	7.227 Cumecs
Discharge by Rational Formula (IRC approach)	9.921 Cumecs
Discharge by Dicken's Formula	21.720 Cumecs
Maximum Discharge	21.720 Cumecs
Next Maximum Discharge	9.921 Cumecs
The difference is beyond 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **14.882 Cumecs**

5 Linear Waterway :

Average Bed Level		=	268.35 m
HFL as per site condition & local inquiry		=	268.67 m
So, Total Depth of Water,	H	=	0.32 m

Provide 2 spans of 9.15 m at bridge site location.

Clear Waterway (provided),	L	=	18.30 m
Total Area,	A	=	5.801 m2
Velocity ,	V	=	Q / A
		=	**2.565 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	14.882 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.600 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.600 m
	So, Vertical Clearance adopted		=	0.600 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **269.269 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **19.346 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.06 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.39 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **1.5 x d_{sm}**

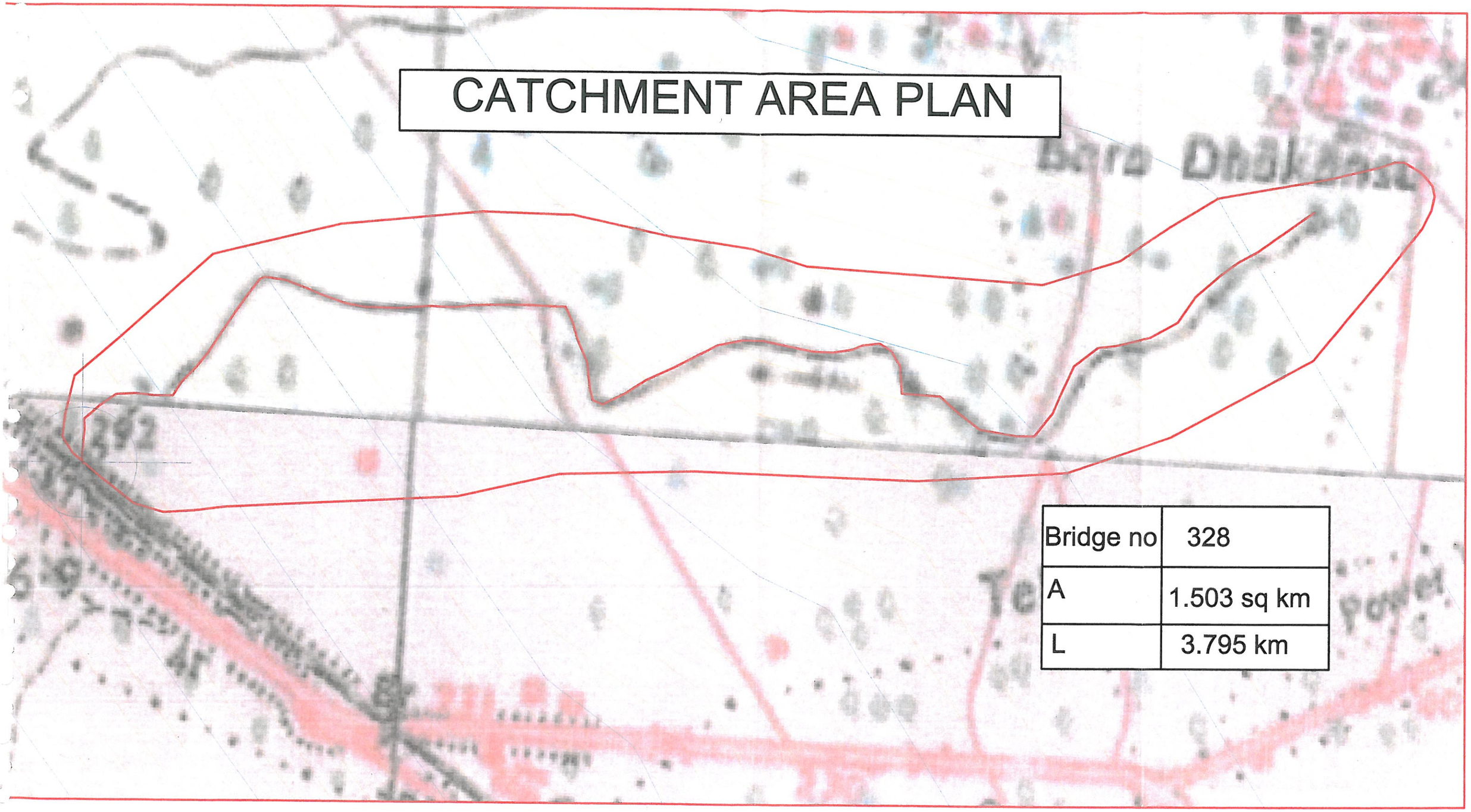
So, **Maximum Scour Depth** = **2.086 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

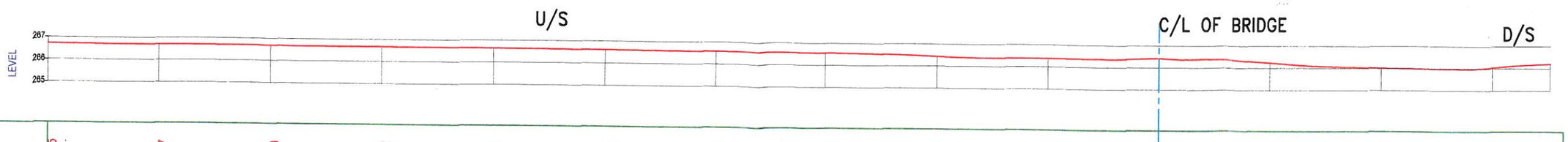
= **266.58 m**

CATCHMENT AREA PLAN



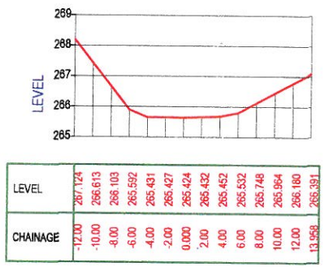
Bridge no	328
A	1.503 sq km
L	3.795 km

PROPOSED BRIDGE NO. BR.061 (PRL_328)
Rly Km. 291/32-34, DFCC Chainage 101086



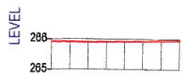
LEVEL	265.705	265.687	265.670	265.652	265.630	265.602	265.567	265.542	265.426	265.374	265.418	265.224	265.005	265.034	265.204
CHAINAGE	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	156.043

LONGITUDINAL SECTION



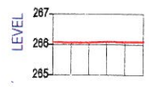
LEVEL	267.124	266.613	266.103	265.592	265.431	265.427	265.424	265.432	265.452	265.532	265.748	265.964	266.180	266.391										
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	13.958										

(Bridge site)



LEVEL	265.614	265.602	265.598	265.602	265.606	265.611	265.623	265.634	
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	

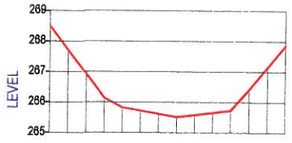
(Upstream at 250m)



LEVEL	265.713	265.706	265.707	265.723	265.719	265.715
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.00

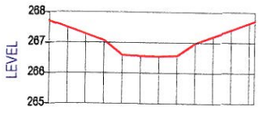
(Upstream at 500m)

CROSS SECTION



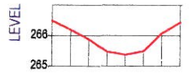
LEVEL	267.325	268.800	266.274	265.749	265.541	265.472	265.402	265.333	265.380	265.429	265.479	265.936	268.426	266.895										
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00										

(Downstream at 15m)



LEVEL	267.501	265.659	265.517	265.375	265.027	265.025	265.024	265.026	265.318	265.464	265.611	266.767	266.881											
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	10.294											

(Downstream at 110m)



LEVEL	265.398	265.785	265.592	265.308	265.237	265.310	265.714	265.952	
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	

(Downstream at 175m)

CROSS SECTION

0284

SHEET NO.-1

Existing Bridge No – 329
Location – KM 293/13-15

Proposed Bridge No – 062
Location – CH: 102518

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			329
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 10
Scale :			1 : 50,000
Location :			293/13-15
Latitude :			$30^0$30'20"
Longitude :			$76^0$33'53"
Catchment Area ,	**A**	=	1.034 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	3.536 Km
Height of Farthest Point ,	**H1**	=	270.70 m
Height of Point of Interest ,	**H2**	=	267.45 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	3.25 m
Average Bed Level		=	267.45 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0285

In present case, **Runoff Coefficient,** C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **2.461 Hr**

= **147.660 Mins**

(a) t_c h Ratio = 0.50 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.482**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = K x R_{50} (1)

= **12.09 cm**

= **120.93 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **49.14 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **5.649 Cumecs**

0286

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	1.034 Sq. Km	103.38 Hectares
Length of path from Toposheet,	L	=	3.536 Km	
Difference in Levels from Toposheet,	H	=	3.25 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		2.59 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	69.65 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	103.38 Hectares
I_c = Critical Intensity of Rainfall	6.965 cm / Hr
Q = Maximum Discharge	**7.904 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16	(adopted in present case)
M	=	1.034	Sq Km

Hence, Q = **16.404 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	5.649 Cumecs
Discharge by Rational Formula (IRC approach)	7.904 Cumecs
Discharge by Dicken's Formula	16.404 Cumecs
Maximum Discharge	16.404 Cumecs
Next Maximum Discharge	7.904 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **11.856 Cumecs**

5 Linear Waterway :

Average Bed Level		=	267.45 m
HFL as per site condition & local inquiry		=	269.15 m
So, Total Depth of Water,	H	=	1.70 m

Provide 4 spans of 3.05 m at bridge site location.

Clear Waterway (provided),	L	=	12.20 m
Total Area,	A	=	20.716 m2
Velocity ,	V	=	Q / A
		=	**0.572 m/sec**

6 Vertical Clearance :

	Design Discharge	Q =	11.856 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1	=	0.600 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8	=	0.600 m
	So, Vertical Clearance adopted	=	0.600 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **269.750 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **15.412 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.26 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.57 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **2.349 m**

8 Maximum Scour Level :

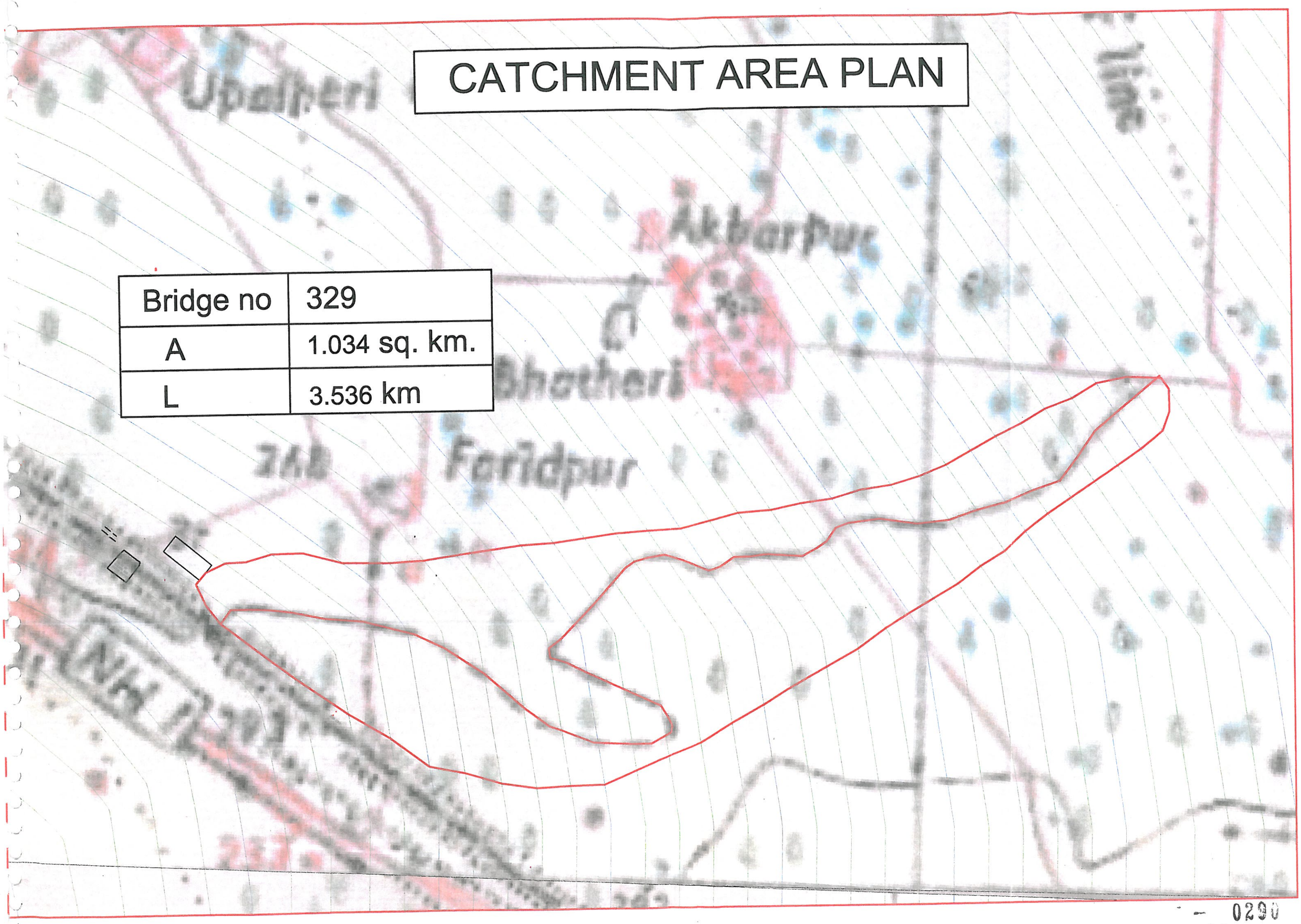
Maximum Scour Level = HFL - Maximum Scour Depth

= **266.80 m**

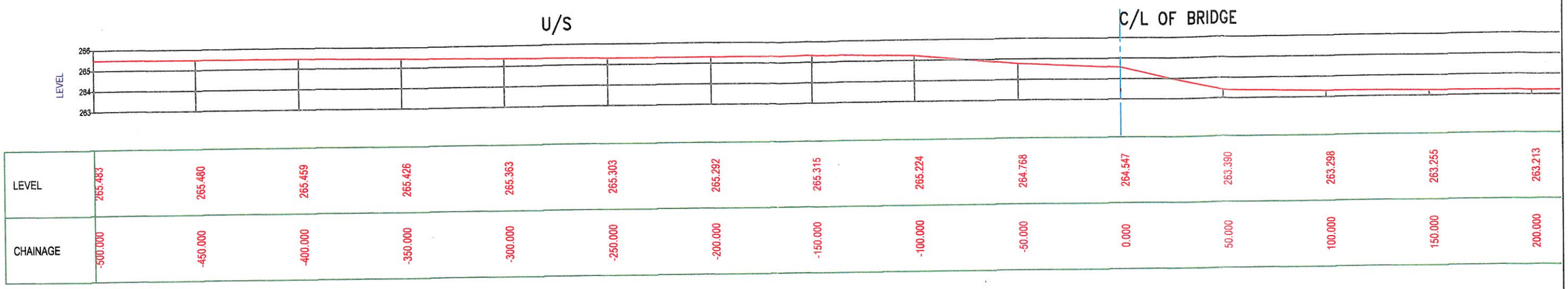
PB No.	Br.No.	Km	Chainage	Up Stream	Down Stream	Difference in M	
						Up Stream	Down Stream
001	287	248/15-18	56653	88.292	78.295		
003	290	253/1-3	61240	7.429	3.68		
016	299	263/21-23	72637	14.09	11.403		
017	300	264/21-24	73445	18.445	11.47		
018	301	264/33-36	73695	10.018	7.867		
019	302	266/19-22	75644	2.172	3.432		
021	304	267/25-27	76908	3.084	2.63		
033	314A	275/7-10	84355	24.687	31.789		
032	314	275/1-8	84206	49.087	26.462		
039	319	280/17-20	89680	7.618	7.841		
040	320	281/2-4	90105	3.329	4.392		
052	324B	287/11-14	96433	12.971	24.634		
059	326	291/15-17	100564	12.472	9.541		
060	327	291/26-27	100835	33.632	22.566		
061	328	291/32-34	101086	8	12		

CATCHMENT AREA PLAN

Bridge no	329
A	1.034 sq. km.
L	3.536 km

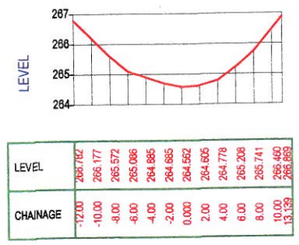


PROPOSED BRIDGE NO. BR.062 (PRL_329)
Rly Km. 293/14-16, DFCC Chainage 102518



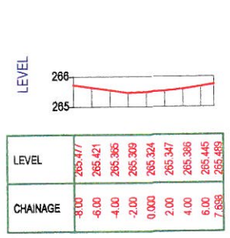
CHAINAGE	-500.000	-450.000	-400.000	-350.000	-300.000	-250.000	-200.000	-150.000	-100.000	-50.000	0.000	50.000	100.000	150.000	200.000
LEVEL	265.483	265.480	265.459	265.426	265.363	265.303	265.292	265.315	265.224	264.768	264.547	263.390	263.298	263.255	263.213

LONGITUDINAL SECTION



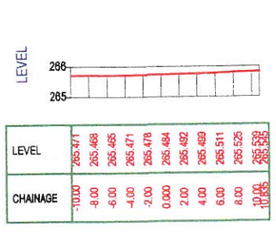
CHAINAGE	-12.000	-10.000	-8.000	-6.000	-4.000	-2.000	0.000	2.000	4.000	6.000	8.000	10.000	13.150
LEVEL	266.762	266.177	265.572	265.086	264.885	264.685	264.562	264.605	264.778	265.208	265.741	266.460	266.889

(Bridge site)



CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	7.688
LEVEL	265.477	265.421	265.365	265.309	265.324	265.347	265.386	265.445	265.489

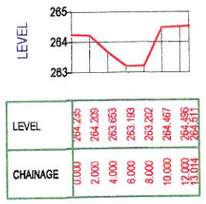
(Upstream at 250m)



CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	10.835
LEVEL	265.471	265.468	265.465	265.471	265.478	265.484	265.492	265.499	265.511	265.525	265.539	265.545

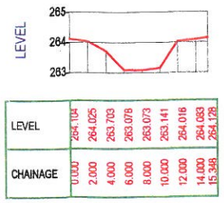
(Upstream at 500m)

CROSS SECTION



CHAINAGE	0.000	2.000	4.000	6.000	8.000	10.000	12.000	13.014
LEVEL	264.235	264.209	263.653	263.193	263.202	264.467	264.496	264.511

(Downstream at 227m)



CHAINAGE	0.000	2.000	4.000	6.000	8.000	10.000	12.000	14.000	15.346
LEVEL	264.104	264.025	263.703	263.078	263.073	263.141	264.018	264.083	264.128

(Downstream at 516m)

CROSS SECTION

0291

SHEET NO.-1

Existing Bridge No – 330
Location – KM 294/4-6

Proposed Bridge No – 063
Location – CH: 103190

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			330	
Name of Nallah / Stream / River :			Local Stream	
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)	
G.T Sheet No :			53 B / 10	
Scale :			1 : 50,000	
Location :			294/4-6	
Latitude :			$30^0 30'25"$	Approx.
Longitude :			$76^0 33'58"$	Approx.
Catchment Area ,	A	=	1.060	Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	1.298	Km
Height of Farthest Point ,	H1	=	268.30	m
Height of Point of Interest ,	H2	=	266.85	m
Height of the Farthest Point above Point of Interest along the river ,	H	=	1.45	m
Average Bed Level		=	266.85	m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where ,

Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient,** **C** = **0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

$t_c = [L^3 / H]^{0.345}$

= **1.152 Hr**

= **69.138 Mins**

(a) t_c h Ratio = 0.36 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.060**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **8.65 cm**

= **86.51 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **75.08 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **8.849 Cumecs**

0293

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	1.060 Sq. Km	106.00 Hectares
Length of path from Toposheet,	L	=	1.298 Km	
Difference in Levels from Toposheet,	H	=	1.45 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.11 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	118.47 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	106.00 Hectares
I_c = Critical Intensity of Rainfall	11.847 cm / Hr
Q = Maximum Discharge	**13.783 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm 14 - 19 in Madhya Pradesh 22 in Western Ghats

C	=	16	(adopted in present case)
M	=	1.060	Sq Km

Hence, Q = **16.715 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	8.849 Cumecs
Discharge by Rational Formula (IRC approach)	13.783 Cumecs
Discharge by Dicken's Formula	16.715 Cumecs
Maximum Discharge	16.715 Cumecs
Next Maximum Discharge	13.783 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **16.715 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.85 m
HFL as per site condition & local inquiry		=	269.45 m
So, Total Depth of Water,	H	=	2.60 m

Provide 3 spans of 3.05 m at bridge site location.

Clear Waterway (provided),	L	=	9.15 m
Total Area,	A	=	23.790 m2
Velocity ,	V	=	Q / A
		=	**0.703 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	16.715 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.600 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.600 m
	So, Vertical Clearance adopted		=	0.600 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **270.052 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **21.729 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^{\,2} / K_{sf})^{1/3}$

D_b = Design discharge per metre width	2.37 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.39 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **1.5 x d_{sm}**

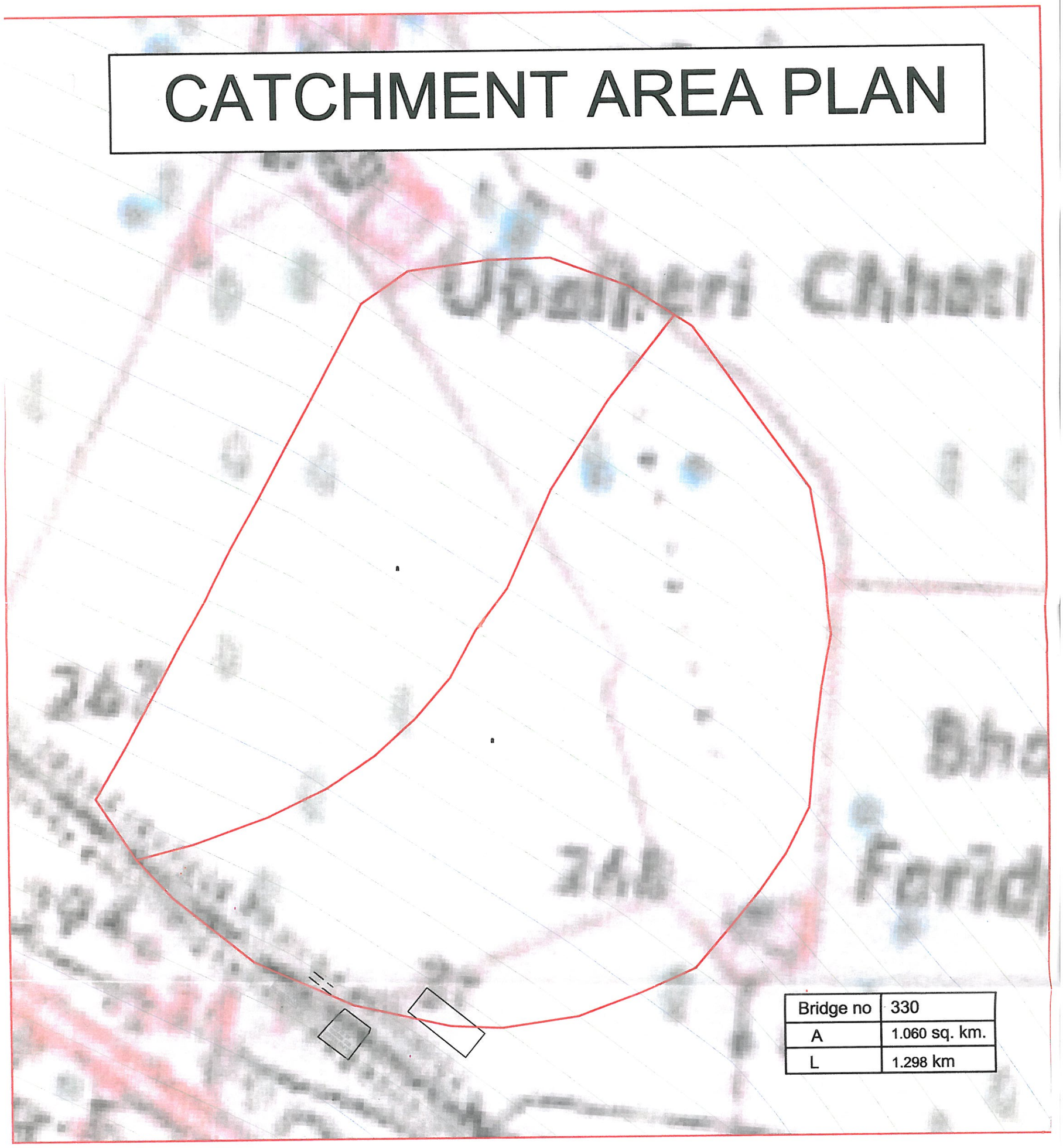
So, **Maximum Scour Depth** = **3.578 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.87 m**

CATCHMENT AREA PLAN

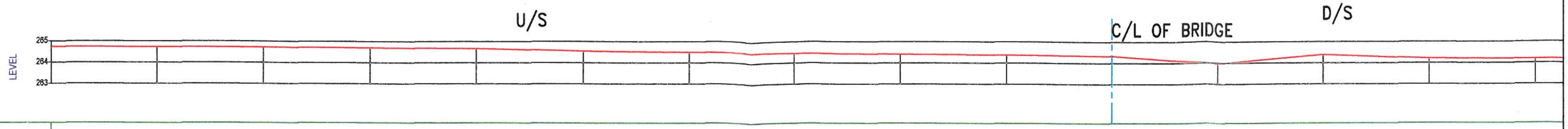


Bridge no	330
A	1.060 sq. km.
L	1.298 km

0290

PROPOSED BRIDGE NO. BR.063 (PRL_330)

Rly Km. 294/4-6, DFCC Chainage 103190

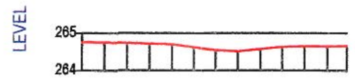


LEVEL	264.725	264.714	264.704	264.687	264.659	264.538	264.487	264.437	264.395	264.369	264.325	263.949	264.374	264.203	264.174
CHAINAGE	-500.000	-450.000	-400.000	-350.000	-300.000	-250.000	-200.000	-150.000	-100.000	-50.000	0.000	50.000	100.000	150.000	200.000

LONGITUDINAL SECTION

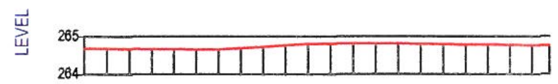
LEVEL	264.134	264.122	264.116	264.102	264.100
CHAINAGE	350.000	400.000	450.000	500.000	505.996

LONGITUDINAL SECTION



LEVEL	264.505	264.496	264.486	264.477	264.465	264.413	264.362	264.336	264.378	264.420	264.428	264.432	264.435
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	11.758

(Bridge site)



LEVEL	264.453	264.450	264.446	264.443	264.439	264.436	264.432	264.456	264.482	264.508	264.534	264.537	264.537	264.536	264.535	264.533	264.528	264.523	264.518	264.514	264.509	264.505
CHAINAGE	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	41.570

(Upstream at 242m)

LEVEL	264.739	264.738	264.737	264.736	264.735	264.732	264.729	264.726	264.723	264.719	264.716	264.720	264.725	264.729	264.734	264.735
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	14.450

(Upstream at 495m)

CROSS SECTION

LEVEL	265.418	264.936	264.454	264.155	264.160	264.166	264.171	264.176	264.177	264.178	264.179	264.180	264.181	264.182	264.310	264.814	265.318	265.562
CHAINAGE	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	16.971

(Downstream at 270m)

LEVEL	265.382	265.012	264.643	264.273	264.126	264.122	264.119	264.116	264.112	264.109	264.105	264.102	264.102	264.105	264.108	264.111	264.114	264.374	264.746	265.118	265.483
CHAINAGE	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	17.963

(Downstream at 508m)

0297

CROSS SECTION