BEFORE THE NATIONAL GREEN TRIBUNAL PRINCIPAL BENCH, NEW DELHI

ORIGINAL APPLICATION NO. 641/2023

IN THE MATTER OF:-

SUMAN CHAUHAN & OTHERS   ...   Applicant(s)
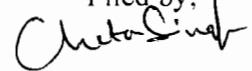
Versus

State of Uttar Pradesh & Others   ...   Respondents

NDOH: 21.05.2024

INDEX

Filed by;

Satyender Chahar & Chetan Singh
Advocate for Respondent No. 8
103, South Park Apartment, Kalkaji,
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New Delhi
Dated: 23.04.2024

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BEFORE THE NATIONAL GREEN TRIBUNAL PRINCIPAL BENCH, NEW DELHI

ORIGINAL APPLICATION NO. 641/2023

IN THE MATTER OF:

Suman Chauhan & Ors   ...Applicant(s)

Vs.

State of Uttar Pradesh & Ors.   ...Respondent(s)

REPLY TO THE APPLICATION ON BEHALF OF RESPONDENT NO. 8 DEDICATED FREIGHT CORRIDOR CORPORATION OF INDIA LIMITED.

1.   That Respondent No. 8 is a wholly owned Public Sector Enterprise under the Ministry of Railways, Government of India with the responsibility to undertake, planning, development, and mobilization of financial resources and construction, maintenance and operation of the Dedicated Freight Corridors. Shri Y.P. Sharma, Dy. Chief Manager, DFCCIL Noida Unit of Respondent No. 8 is duly authorised to file the present reply/response, swear affidavits, lead evidence and sign Vakalatnama on behalf of Respondent No. 8. A copy of the authority letter dated 14.03.2024 is annexed herewith as **Annexure R8-1**.

2.   That Respondent No. 8 constructed a railway line namely Western Dedicated Freight Corridor (**'Western DFC'**). The Western DFC will connect Dadri in Uttar Pradesh with Jawaharlal Nehru Port in Navi Mumbai, Raigad District, Maharashtra. The main purpose for constructing the Western DFC is to transport freight at higher speeds with increased load-carrying capacity.

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3. That during the construction of Western DFC, Respondent No. 8 proposed to construct a bridge for crossing the river Yamuna in District Gautam Budh Nagar before the 84th meeting of the Yamuna Standing Committee which was held on 15.05.2014. The said proposal has been accepted by the committee with the majority. The relevant portion of the minutes of the meeting are reproduced here for the sake of clarity: -

    "Item No. 84.2.7 "No Objection Certificate" for crossing river Yamuna in District G.B Nagar by Railway's Western Dedicated Freight Corridor Railway Line

    Dy. Chief Project Manager, DFCCIL, made a presentation on the salient design features of the proposed bridge across Yamuna on Dadri-Mumbai Dedicated Freight Corridor Railway Line approximately at a distance of 16 km d/s of existing Kalindi Kunj Barrage. It was informed that as per the Hydraulic studies report of M/s RITES & IRI, Roorkee, the proposed piers are likely to create an afflux of 0.3 m at bridge side and which will subside within 2 km upstream reaches of the bridge. As per the proposal, total water way provided is 529.65m. the other members of the committee agreed to the proposal. The committee cleared the proposal from flood angle subject to other mandatory clearances by statutory authorities like National Board for Wildlife etc."

    True Copy of the summary recorded in the 84th meeting is annexed herewith as **Annexure R8-2**.

4. That therefore the bridge was constructed by Respondent No. 8 after getting all statutory clearances. Thus, the said bridge is not responsible for any flood as alleged by the Applicants in his application. It is specifically denied that the smaller width of the bridge has created a obstruction in the natural flow of the river and a rise in the water level upstream of the bridge, resulting in a spill of water into the Applicant's villages as alleged or at all. On the contrary, the said bridge has been built by Respondent No. 8

based on a Hydraulic studies report issued by M/s RITES & IRI, Roorkee which includes the flood angle. The said report has been considered by all the statutory authorities and thereafter approved the same. A true copy of the Hydraulic studies report is annexed herewith as **Annexure R8-3**.

5. That it is submitted that the bridge constructed by the Respondent is not responsible for spilling the water into the Applicant's villages. All the allegations raised in this regard by the Applicant are wrong and denied. The said bridge was built by Respondent No. 8 after following all the statutory norms. Therefore, the Applicants are not entitled to get any relief from this Hon'ble Court against Respondent No. 8. The claims of the Applicant qua the Respondent No. 8 may be dismissed.

Respondent No. 8

Through
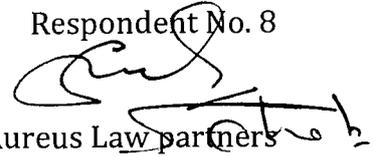
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103, South Park Apartments,
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New Delhi-110019
Satyender.chahar@aureuslaw.com
+91-9868427509

Place- New Delhi
Date-22.0?.2024

BEFORE THE NATIONAL GREEN TRIBUNAL PRINCIPAL BENCH,

NEW DELHI

ORIGINAL APPLICATION NO. 641/2023

IN THE MATTER OF:

Suman Chauhan & Ors   ...Applicant(s)
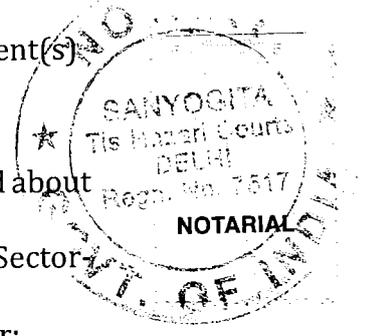
Vs.

State of Uttar Pradesh & Ors.   ...Respondent(s)

AFFIDAVIT

I, Y.P. Sharma, Dy. Chief Project Manager, DFCCIL Noida Unit, aged about 58 years having an office at, CGM Noida Unit, DFCCIL Complex, Sector 145, Noida-201310 do hereby solemnly state and affirm as under:

1.   That I am authorized representative of Respondent No. 8 and well conversant with the facts and circumstances of the case to swear and depose the present affidavit.

2.   That I have gone through the contents of the accompanying reply/response to the application and the same are true and correct to my knowledge based upon the official records.

DEPONENT

VERIFICATION: **2 2 APR 2024**
        Verified at Delhi on this ___ day of February 2024 that the contents of the present affidavit are true and correct to my knowledge. No part of it is false and nothing material has been concealed therefrom.

DEPONENT

I Identified the executant who has signed in my presence
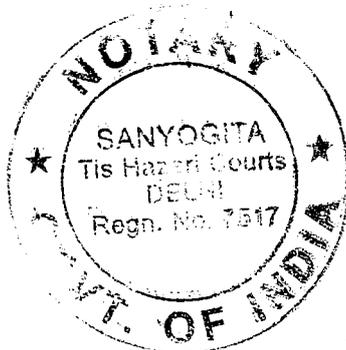
ATTESTED

NOTARY PUBLIC DELHI

2 2 APR 2024

डेडीकेटेड फ्रेट कॉरीडोर कॉर्पोरेशन ऑफ इण्डिया लि० नोएडा यूनिट

186 रत सरकार रेल मंत्रालय का उपक्रम

Dedicated Freight Corridor Corporation of India Ltd. (Noida Unit)
A Govt. of India (Ministry of Railways) Enterprise
Noida Unit, DFCCIL Complex, (Near Sector-145 Metro Station)
Sector-145, Noida-201306 PH:0120-3680888

डेडीकेटेड फ्रेट कॉरीडोर

Annexure - R 8/1

No. DFCC/Noida Unit/NGT Case/OA No. 641/2023   Date:14.03.2024

TO WHOM IT MAY CONCERN

This is to certify that, Shri Y.P. Sharma *(presently working as Deputy Chief Project Manager/Engg. in DFCCIL/Noida Unit)* is authorized to sign all the documents pertaining to NGT Case/ OA No. 641/2023 (Suman Chauhan and Others Vs State of U.P. and Others) pending before Delhi Bench on behalf of Respondent no. 8 Dedicated Freight Corridor Corporation of India Limited.

(Rakesh Kumar Gupta)

Chief General Manager
DFCCIL/Noida Unit

Ann-exure R/8/2   6

List of participants present in 84th meeting of Yamuna Standing Committee held on 15th May , 2014 at 1430 hrs in the Committee Room No. 307(S),Sewa Bhawan, R.K.Puram, New Delhi-110066.

S. No.	Name & Designation	
1.	Shri. K. N. Keshri Member (RM), CWC	In Chair
2.	Shri. Kunal Kulshretha Chief Engineer, Irrigation Department, Govt. of UP	Member
3.	Shri. R. C. Singhal Superintending Engineer ,Government of Haryana	Representing Chief Engineer, YWS (South), Government of Haryana Member
4.	Shri. V. K. Jain Chief Engineer, Irrigation and Flood Control Government of Delhi	Member
5.	Shri. Arun Kumar Sinha Member, Planning, GFCC, Patna	Member
6.	Shri. B.N. V. Satyanarayna Assistant Director-II, Hydrology(N) Dte, CWC	Representing Director, Hydrology(N) Dte, CWC Member
7.	Shri. V. D. Roy Director (FM-I), CWC	Member-Secretary
	Special Invitee	
8.	Shri. C. P. Singh Chief Engineer, FM Organization ,CWC	
	Others	
9.	Shri. K. Sambhamurti Chief Engineer-I Irrigation and Flood Control ,Govt. of Delhi	
10.	Shri. R.G. Patil Chief Research Officer, CWPRS, Pune	
11.	Shri. Devinder Kumar Dy. Chief Engineer ,DFCCIL	
12.	Shri. Ashok Sharma ACP/L&B, Delhi Police	
13.	Dr. Premchand Commandant, 103 BN RAF, CRPF	
14.	Shri Shishir Bansal Project Manager, F12 , PWD, Govt. of Delhi	
15.	Shri A.S Jangu CGM/E1PS-2, DMRC	
16.	Shri P.C. Channa Executive Engineer, F12 PWD, Govt of Delhi	
17.	Shri. Satish Chandra Deputy Director,FM-I Dte, CWC	
18.	Shri Avanti Assistant Director, FM-I Dte , CWC	

SUMMARY RECORD OF DISCUSSIONS OF 84th MEETING OF YAMUNA STANDING COMMITTEE HELD ON 15.05.2014 IN NEW DELHI.

The 84th meeting of Yamuna Standing Committee (YSC) was held in the Committee Room No.307 (S), Sewa Bhawan, R.K.Puram, New Delhi on 15th May 2014 under the Chairmanship of the Member (RM), CWC & Chairman, YSC. The list of participants is given at Annex-I.

After a brief introduction, the Chairman, YSC welcomed all the members present and requested the Member-Secretary to take up the agenda items.

Item No.84.1.0.   Confirmation of Summary Record of Discussions of 83rd meeting of Yamuna Standing Committee.

The summary record of discussions of 83rd meeting of Yamuna Standing Committee (YSC) held on 27.09.2013 were circulated vide CWC letter No. 16/1/YC/2012/FM-I/533-549 dated 04.10.2013. No comments have been received from any member of the Committee. The Committee, therefore, noted the Summary Record of discussions of 83rd meeting, as confirmed.

Item no. 84.2.1   Granting clearance to DTC for development of a bus parking complex   at IP Ash Pond opposite Millennium Park.

The proposal of DTC   for development of a bus parking complex   at IP Ash pond, opposite Millennium Park on the Right bank of river Yamuna between Nizamuddin Rail Bridge and Road Bridge was further discussed in the meeting. The representative from DTC did not attend the meeting. It was learnt from the media report that Hon'ble High Court, Delhi has given direction to DTC and DDA to relocate the BUS depot at some other alternative place. The committee felt that this item may be dropped for further consideration.

(**Action:** Member Secretary, YSC)

Item No.84.2.2 Proposed construction / extension of Receiving Sub Station (RSS) / (ESS) at Kashmiri Gate for line -6 extension under Phase –III of Delhi MRTS Projects.

The representative from Delhi Metro Rail Corporation Ltd. (DMRC) presented three options of layouts of the proposed Sub-Station. In all the three options of layout, the boundary wall was proposed very close to flood embankment of I&FC Department, NCT of Delhi.The representative of I&FC, NCT of Delhi, apprised the committee that 18 meters of space between boundary wall of campus and embankment is desirable for placing flood fighting equipment and material for use during flood. After hearing both the sides, Chairman of the committee directed DMRC to replan the sub station in such a way that the requirement of I&FC is fulfilled to the extent possible and got it vetted by CEA. Keeping in view the urgency of the work of DMRC, it was decided to resolve the issue by a sub committee headed by Chief Engineer (FMO), CWC involving representative from DMRC, I &FC NCT of Delhi, Embankment Directorate of CWC as soon as DMRC comes up with alternative plan duly vetted by CEA.

(**Action:** DMRC, I&FC NCT of Delhi, CWC)

Item No. 84.2.3 Extension of Barapullah Elevated Road (Phase-III) across river Yamuna from Sarai Kale Khan to Mayur Vihar-New Corridor between Nizamuddin Bridge and DND Flyway.

The representative from the PWD, Govt. of Delhi informed that the report of the hydraulic model study carried out by CWPRS, Pune has been completed. He presented the outcome of the study. These indicate maximum afflux of 15 cm and slight change in orientation of piers to ensure streamline flow under the bridge with least afflux and no attack on the river banks.The other members of the committee were agreed to the proposal. The committee cleared the proposal from flood angle subject to compliance to suggestions of the CWPRS regarding modifications in the orientation of piers as mentioned in its report.

(**Action:** PWD, NCT of Delhi)

Item No. 84.2.4 Construction of retaining wall on the right bank of River   Yamuna between Boat Club and Qudesia Ghat to protect heavy inhabitation area of Tibetan Market

The representative of I&FC Department, NCT of Delhi made a presentation on the proposal for construction of 1100 m of RCC retaining wall on the right bank of River Yamuna between Boat Club and

Qudesia Ghat to protect heavy inhabitation area of Tibetan Market. The representative of UP informed the committee, that an expert committee set up by Ministry of Environment and Forest under the direction of National Green Tribunal (NGT) has categorically recommended that no such river/flood control structure in the proposed reach should be allowed. After detailed discussions, it was decided that the effect of afflux due to the proposed wall in the upstream reaches may be studied and proposal may be resubmitted for the consideration in the next meeting of YSC.

(Action: I&FC, NCT of Delhi)

Item No. 84.2.5 Fresh N.O.C./Clearance of YSC regarding Project i.e. Construction of Permanent Headquarter of 103 Bn of RAF at Wazirabad

The YSC in its 68th meeting held on 16.03.2005 has accorded NOC for the construction of the permanent Headquarter of the 103 Battalion at Wazirabad.

As per direction of DDA given to RAF vide letter dated 16.01.2014, the Commandant of 103 Bn RAF requested YSC to issue fresh NOC for the above proposal .During the meeting, a presentation was made by the representative of RAF highlighting the need for construction of permanent structures for RAF personnel and other developmental activities already taken place in the vicinity of the area with a request to issue fresh NOC. After discussions at length, it was decided that DDA may be asked to furnish the copies of the latest Master Plan 2021 indicating the classification of various zones and activities permitted in each of these nes. It may also be clarified by DDA whether this proposal for construction of permanent Headquarter of 103 Battalion RAF is allowed as per latest Master Plan of DDA.

(Action: Member Secretary, YSC)

Item No. 84.2.6 Delhi Police Building Programme –Construction of semi permanent Barrack for CPO's accommodation in area-I and Police Trainees in area-II at Wazirabad, Delhi.

The representative of Delhi Police made a presentation on construction of semi permanent Barrack for CPO's accommodation in area-I and Police Trainees in area-II at Wazirabad, Delhi wherein he highlighted the need for construction as per this proposal .He also stated that he was advised by DDA to get clearance of YSC in the light of Master Plan of Delhi 2021 coming into effect in 2007. The committee observed that the proposed location is between two embankments surrounded by densely populated village Sonia Vihar. However, the land between these two embankments has been earmarked as Zone "O" by DDA in its Master Plan for Delhi 2021.

After detailed discussion, it was decided that following documents would be made available by Delhi Police to Member Secretary, YSC:

1. A copy of letter from DDA allotting said land to Delhi Police.

2. A copy of letter from MHA, Government of India wherein it has been desired to get clearance/NOC om YSC.

After getting these documents, the proposal would be considered in the next meeting of YSC.

(Action: Delhi Police)

Item No. 84.2.7 "No Objection Certificate" for crossing river Yamuna in District G. B Nagar -by Railway's Western Dedicated Freight Corridor Railway Line.

Dy. Chief Project Manager, DFCCIL, made a presentation on the salient design features of the proposed bridge across Yamuna on Dadri-Mumbai Dedicated Freight Corridor Railway Line approximately at a distance of 16 km d/s of existing Kalindi Kunj Barrage. It was informed that as per the Hydraulic studies report of M/s RITES & IRI, Roorkee, the proposed piers are likely to create an afflux of 0.3 m at bridge site and which will subside within 2 km upstream reaches of the bridge. As per the proposal, total water ways provided is 529.65 m. The other members of the committee agreed to the proposal. The committee cleared the proposal from flood angle subject to other mandatory clearances by statutory authorities like National Board for Wildlife etc.

The meeting ended with a vote of thanks to the Chair.

Annexure R-8/3

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DFCC

DEDICATED FREIGHT CORRIDOR CORPORATION OF INDIA LTD.

HYDRAULIC MODEL STUDY FOR PROPOSED RAIL BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (DELHI)
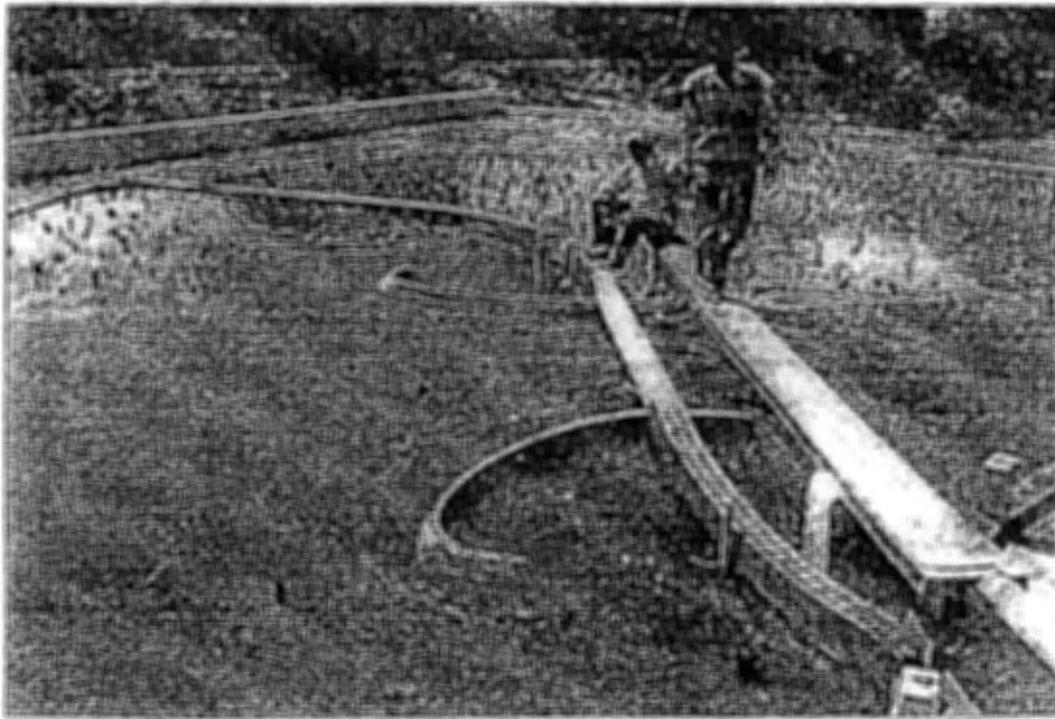
VOLUME - I
REPORT

JULY-2009

RITES
THE INFRASTRUCTURE PEOPLE

T.C

(A Govt. of India Enterprise)
Plot No. 1, Sector – 29, Gurgaon
Haryana – 122001 (India)

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HYDRAULIC MODEL STUDY FOR PROPOSED RAIL BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (DELHI)

LIST OF VOLUMES

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HYDRAULIC MODEL STUDY FOR PROPOSED RAIL BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (DELHI)

VOLUME – I

REPORT

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VOLUME – II

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2.	Layout of proposed Guide Bunds	1:2500	RITES/RCED/Y-DELHI/GB	1A
3.	Topographic Survey Plan around Proposed Rail Bridge across Yamuna River near Tughlakabad	1:10000	RITES/RCED/Y-DELHI/TP	2
4.	Cross-Section of river at BCL	HOR1:2500 VER 1:250	RITES/RCED/Y-DELHI/CS/BCL & X-SEC 0.0	3
5.	UP Stream Cross-Sections of River	HOR1:2500 VER 1:250	RITES/RCED/Y-DELHI/CS/ US- 1 to 37	4-22
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SECTION - I
INTRODUCTION

Section – I

Introduction

1.1 BACKGROUND

1.1.1 Ministry of Railways have planned to construct Dedicated Freight Corridors (DFC) covering 2762 route kms. Initially, Eastern Corridor from Ludhiana in Punjab to Sone Nagar in Bihar and Western Corridor from Jawahar Lal Nehru Port, Mumbai (Maharashtra) to Tughlakabad/Dadri (Delhi / Uttar Pradesh) have been proposed. Upgradation of transportation technology, increase in productivity and reduction in transportation cost are the main objectives of the project. Once commissioned, travel time and the cost of freight operation shall be substantially reduced. The Western Corridor will start from the Jawaharlal Nehru Port connecting Baroda, Ahmedabad & Palanpur in Gujarat, Jaipur in Rajasthan and Rewari in Haryana to Tughlakabad/Dadri (Delhi / Uttar Pradesh). The Eastern Corridor will start from Ludhiana to Sone Nagar via Ambala, Saharanpur, Khurja and Allahabad. Both the corridors would be joined by a link between Dadri and Khurja. The "Dedicated Freight Corridor Corporation of India Limited (DFCCIL)" a special purpose vehicle of Government of India is formed to undertake planning & development, mobilization of financial resources and construction, maintenance and operation of these Dedicated Freight Corridors.

1.1.2 For most of the length, both the corridors i.e. Eastern and Western have been proposed along the existing railway corridors. However, in certain stretches, detour has been inevitable. There are number of river crossings proposed on eastern and western corridors, out of these five important crossings have been identified for detailed hydraulic studies where bridges have been proposed on detoured route being far away from existing railway bridges. The locations of these bridges are on the following rivers:

(I)   Tapi near Surat,
(II)   River Narmada near Bharuch,
(III)   River Sabarmati near Ahmedabad;
(IV)   River Yamuna near Tughlakabad
(V)   River Yamuna near Allahabad.

DFCCIL had awarded the work of hydraulic model studies for above mentioned five important river bridges to RITES in Jan 2008 under contract agreement No. HQ/EN/Bridges/Model studies dated 31 March 2008.

1.1.3 Present report discusses the approach & methodology adopted, field survey, hydraulic analysis/studies to finalize the hydraulic model studies. Accordingly, the results of the studies conducted have been presented and discussed in the report for proposed bridge on River Yamuna near Tughlakabad. Model studies have been carried out at

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IRI Roorkee based on which configuration of bridge and river training/protection works have been decided.

1.2   SCOPE OF WORK

The scope of work for this study as per the contract agreement ,was as under :

1.2.1   Hydrographic & Topographic Survey, Analysis and Development of Data for Model Studies

1.2.1.1   To procure the Satellite Imageries of the river reaches in the vicinity of proposed bridges on 1:50,000 scale to assess the present configuration of the rivers.

1.2.1.2   To carryout Topographic and Hydrographic Survey of Yamuna river near Tughlakabad up to 12 km upstream of Bridge centre line (BCL) and 5 km downstream of BCL to develop the latest river courses with details of latest position of channels/dykes and other permanent features in the river over identified stretches for model studies. The extents from the proposed location of Bridge centre line are given below as required by Irrigation Research Institute (IRI), Roorkee. Modification in the proposed extent shall be decided during survey work as per site conditions in consultation with IRI, Roorkee.

1.2.1.3   To obtain River Cross sections i.e. levels of river bed between high banks or dykes including sounding in water channels for river reach as mentioned above. The cross sections shall be at 200 m interval within the river reach of 3 Km. upstream to 2 Km. downstream of BCL and 400 m in the remaining river reach of relevance. In case of sharp meander of river, X-sections at closer interval may be required which shall be decided and taken during survey work. The levels shall be connected to the Bench Mark established near the bridge site for the project, to be provided by DFCCIL.

1.2.1.4   To establish 6 Water gauges in the river stretch under survey keeping 3 gauges on each bank i.e. Two on BCL, 2 on upstream and 2 on downstream and recording gauge readings two times daily during the river survey period only in order to determine the water slopes.

1.2.1.5   To develop Topographic plans and river Cross–sections on suitable scale for laying the Hydraulic Model for testing by Hydraulic Research Institute.

1.2.1.6   Correlation of available historic hydrological/hydraulic data with additional data pertaining to the concerned reach of river to study the river behaviour.

1.2.1.7   Consultation with the Inland Waterways Authority for Navigational Clearances, if any.

1.2.1.8   To analyze the historic hydrological/hydraulic data and to finalize the hydraulic design parameters such as Design Discharge. Design HFL/LWL and waterway for the purpose of model studies.

1.2.1.9   To study and determine tentative bridge length, span configurations along with suitable/probable axis of crossing for testing on the Hydraulic Model.

1.2.1.10   To prepare and submit the above data to Hydraulic Research Institute for Model Studies.

1.2.2   **Hydraulic Model Studies at IRI, Roorkee**

1.2.2.1   To lay and prove the Model at the Research Station based on the Survey Data & Hydraulic Design Parameters to the extent as detailed above in Para 1.2.1.

1.2.2.2   To test the model for various alternatives for obtaining the satisfactory flow conditions and to determine the most suitable axis of crossing, optimal waterway/bridge length, discharge intensities, velocities, scour pattern and afflux along the bridge and critical locations.

1.2.2.3   Ascertaining suitable configuration & layout of the Guide Bunds or other River Training & Bridge Protection Works.

1.2.3   **Inspection/Supervision of the Hydraulic Model Studies**

1.2.3.1   Inspection during the Laying (construction) of the model for ensuring proper depiction of the site features as picked up during survey.

1.2.3.2   Supervision of model during model runs for proving and subsequently, for testing of various alternatives on the model at different stages for obtaining the most suitable/favourable flow conditions.

1.2.3.3   To submit the Report on the Hydraulic Model Studies describing the process, alternatives tested on the model & results thereof along with the conclusions & recommendations.

1.3   **PRESENT REPORT**

1.3.1   This report contains the details of topographic & hydrographic survey, hydraulic · parameters, hydraulic model study & recommendations thereof. This report is being submitted in following format.

Volume I :   Report on Hydraulic Model Study For Proposed Rail Bridge Across River Yamuna near Tughlakabad.

Section No.	Title
I	Introduction
II	Survey For Model Study
III	Hydraulic Parameters
IV	Hydraulic Model Study
V	Summary & Recommendations
Annexure – 4.1	Report of IRI, Roorkee

N.B.- Appendices & Figures are appended after respective sections.

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SECTION - II
SURVEY FOR MODEL STUDY

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6.	Down-Stream Cross-Sections of River	HOR1:2500 VER 1:250	RITES/RCED/Y-DELHI/CS/ DS -1 to 18	23-32

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Survey for Model Study   Section II

Section – II

Survey for Hydraulic Model Study

2.1   SURVEY OF YAMUNA RIVER NEAR TUGLAKABAD FOR HYDRAULIC MODEL STUDY

2.1.1   **Objective**

The objective of model survey was to pickup the river cross sections from high bank to high bank including the topographic details of adjoining area in order to construct the river model for conducting the hydraulic model studies. The river reach to be surveyed was accordingly decided in consultation with IRI, Roorkee.

2.1.2   **Extent of Survey**

Topographic and Hydrographic survey for the river was carried out for 17 km river stretch (12 km upstream and 5 km downstream of proposed bridge location) in a single working season during the month of Feb and March 2008. River cross sections between the high banks were taken @ 200m interval upto 3.0 km upstream to 2.0km downstream of bridge site and at 400m intervals in remaining river reach. At the curved reach of the river, the cross sections were taken at closer intervals to enable proper construction of model.

2.2   SCOPE OF TOPOGRAPHIC AND HYDROGRAPHIC SURVEY

The topographic and hydrographic survey carried out over the above river reach was as per the requirement projected by IRI, Roorkee for construction of the model which mainly covered the following:

2.2.2   To develop the Topographic plan covering the latest course with details of positions of channels/dykes and other permanent features for a river reach of 17 kms, comprising 12.0 kms upstream and 5.0 kms downstream of the proposed bridge location.

2.2.3   Initially, it was planned to take 26 Nos.of river cross-sections at an interval of 200m C/C in 5 kms portion (3 km u/s & 2 km d/s of BCL) and at an interval of 400mtrs in remaining river reach of 12 kms (i.e. 31 Nos. of X – sections). Thus, a total number of 57 river cross sections including bridge centre line were initially planned for survey. Accordingly, during the course of survey 57 nos. of river cross sections were taken.

2.2.4   Fixing of 6 Nos. of gauge posts at six locations (3 on each bank) over river reach and observation of water level three times daily during the entire period of river survey for water slopes and gauge correlation.

2.2.5   Development of topographic plan on a scale of 1:10,000 of the above river reach showing positions of villages, banks, islands, roads, water channels, cross sections, concrete pillars, approach embankments etc.

Hydraulic Model Study for Bridge Across River Yamuna near Tughlakabad

2.2.6   Development of the cross sections of river on the scale of horizontal 1: 2500 and vertical 1: 250 duly showing the water level with date, nature of terrain and chainages of change points along the cross section.

2.3   FIELD SURVEY

2.3.1   Reconnaissance

Reconnaissance survey was done before the starting of the instrumental survey work to locate the position of bridge centre line and the availability of approaches to reach site and arrangement for hydrographic survey. The proposed bridge site is approximately 16 km downstream of Okhla Barrage with village Yaquitpur near the left bank of the river and village Lalpur on the right bank. The left bank of the river can be approached by road originating near Okhla barrage and going towards Greater NOIDA. Similarly, Right bank of river is approachable through a road connecting Faridabad city with Lalpur village near bridge centre line. The area of survey falls in Survey of India Toposheet No. 53H/6 and 53H/7 on a scale of 1:50,000.

2.3.2   Establishing Bridge Centre Line

The details of survey pillars which were established along the proposed corridor of the DFC project near proposed bridge location were obtained from alignment survey group of RITES. The descriptions of these DFC pillars are as given below:

S/N	PILLAR NO.	N	E	RL	REMARK
1	P-16/25	55127.786	147575.180	197.259	Alignment Pillar on the Left bank of Yamuna River
2	P-16/99	55223.698	147247.516	195.267	Alignment Pillar on the Right bank of Yamuna River

DFC Pillar No. P-16/25 present on the left bank of river & pillar No. P-16/99 on right bank were physically verified and found in intact position. Accordingly, the line joining the pillar P-16/25 on left bank and P-16/99 on right bank was given as reference for the bridge alignment and hence taken as BCL for model studies.

2.3.3   Equipments For Survey

Survey equipments deployed at the site to undertake the Topographic and Hydrographic Survey included

- Total Station of Model TOPCON of 1mm least count with computer interface.

- Auto level of 1mm accuracy.

- Laptop computer loaded with latest AutoCAD and other supporting software for the processing of the survey data at the site.

- Ceeducer Echo sounder system having inbuilt DGPS system.

2.3.4 Horizontal & Vertical Control

A closed traverse was run from DFCC reference pillar P-16/25 located at left bank near Yakutpur and P-16/99 located on right bank of the river near Lalpur village in order to establish the horizontal and vertical control at site for onward progress of survey work. The survey network was made by establishing subsidiary station at suitable intervals to cover the entire area.Reference Pillar No. P -16/99 has been used as bench mark for the vertical control of model survey.

2.3.5 Mapping of Area

Positions both in plan and elevation, of all natural and artificial features of the area like waterways, trees, cultivation, houses, fences, Pucca and Kutcha road, including culverts and crossings, foot tracks, other permanent objects like telephone posts and transmission towers, etc. were picked up during survey and subsequently shown on survey maps by means of conventional symbols (preferably, symbols of 'Survey of India' Maps).

2.3.6 River Cross Sections

The bed levels were observed at an interval of 10m by taking sounding in water channel and at an interval of 25m in the dry portion (islands) by total station to represent true profile of river bed between the high banks along the cross section. Natural and man made features were also surveyed and plotted to reflect the existing features along the cross section in survey area. All the temporary as well as permanent protection work were also accurately covered and detailed in the cross sections and topographic plan.

2.3.7 Gauge Fixing & Water Level

Six number water gauges were established in the surveyed river stretch (Three on each bank, one at BCL, one at 12.1 km upstream and one at 4.6 km downstream of BCL). Observation and recording of these gauge readings were carried out three times daily during the survey period to determine the water slopes and gauge correlation for survey works. The gauges were connected to the nearest DFC pillar P-16/99 .

2.3.8

The photographs of site during field survey are placed at Figure- 2.1.

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2.4   PREPARATION OF SURVEY DRAWINGS

2.4.1   The topographic plan of the site has been prepared on a scale of 1:10,000 showing positions of permanent features like villages, banks, islands, etc. The cross sections of river have been developed on the horizontal scale of 1:2500 & vertical scale of 1:250 duly showing the water level with date and nature of terrain along with chainage of change points along the cross section.

2.4.2   All the drawings have been prepared on AutoCAD software. The details i.e. horizontal alignment with chainage of approaches on both sides of the bridge, as obtained from the alignment survey team, were subsequently, incorporated in the survey plan.

2.4.3   The drawings developed after river survey are listed below and enclosed in a separate drawing folder in volume -II.

Sl. No.	Description	Scale	Drawing No.	Sheet No.
1.	Topographic Plan Incorporating Proposed Rail Bridge & Guide Bunds across Yamuna River near Tughlakabad	1:5000	RITES/RCED/ Y-DELHI/ BR&GB	1
2.	Layout of proposed Guide Bunds	1:2500	RITES/RCED/Y-DELHI/GB	1A
3.	Topographic Survey Plan around Proposed Rail Bridge across Yamuna River near Tughlakabad	1:10000	RITES/RCED/Y-DELHI/TP	2
4.	Cross-Section of river at BCL	HOR1:2500 VER 1:250	RITES/RCED/Y-DELHI/CS/BCL & X-SEC 0.0	3
5.	UP Stream Cross-Sections of River	HOR1:2500 VER 1:250	RITES/RCED/Y-DELHI/CS/ US-37 to 1	4-22
6.	Down-Stream Cross-Sections of River	HOR1:2500 VER 1:250	RITES/RCED/Y-DELHI/CS/ DS -1 to 18	23-32

2.4.3.1   The above listed drawings at S. No. 3 to 6 were subsequently submitted to IRI, Roorkee for laying of model and conducting the model studies as detailed in subsequent sections.

2.5 RIVER MIGRATION PATTERN

2.5.1   Multidated satellite imageries were procured from National Remote Sensing Agency (NRSA) covering the river reach in the vicinity of proposed Bridge centre line for ascertaining the shifting/meandering pattern of the river in the vicinity of proposed bridge site. Accordingly, the satellite imageries procured were for the years 1997 and 2007.

2.5.2   The river courses for years 1997, 2007 and 2008 (latest ground survey) have been compared to ascertain the extent of meander & shift of the river near the bridge centre line and its vicinity. It is broadly observed that the main river channel has been flowing in a well defined corridor over a period of time and not showing any shifting tendency. The river courses have been plotted together and placed as Figure - 2.2.The satellite imagery of 2007 with proposed BCL marked is placed as Figure - 2.3.

*****

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Figure 2.1
(4 Sheets)
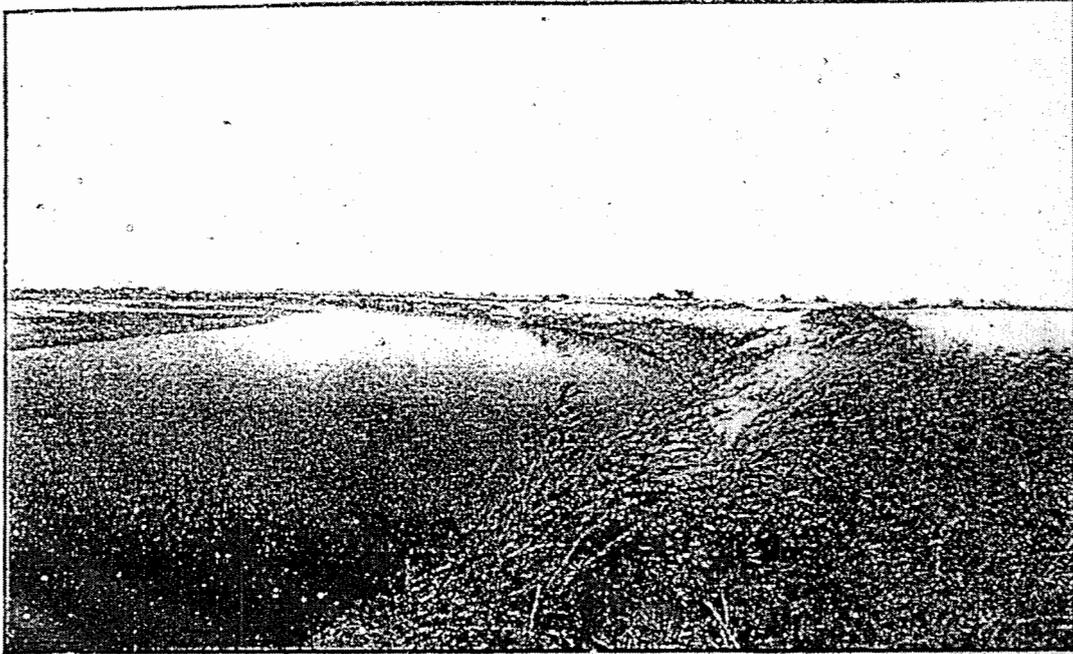
VIEW OF BANKS OF RIVER YAMUNA NEAR DELHI UPSTREAM OF
BRIDGE CENTRE LINE FROM LEFT BANK.

VIEW OF RIVER YAMUNA NEAR DELHI AND BANKS DOWNSTREAM OF
BRIDGE CENTRE LINE.

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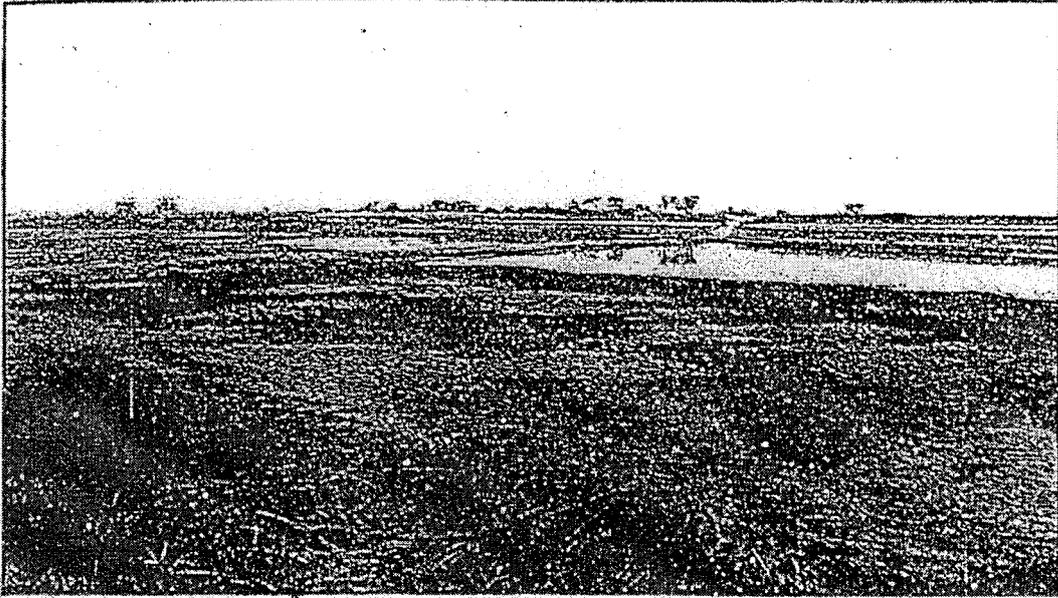
VIEW OF RIVER YAMUNA NEAR DELHI AND ITS BANKS DOWN STREAM OF BRIDGE CENTRE LINE.

VIEW OF RIVER YAMUNA AND ITS BANKS DOWN STREAM OF BRIDGE CENTRE LINE.

T.C

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GENERAL TERRAIN OF RIVER YAMUNA AND ITS BANKS NEAR BRIDGE CENTRE LINE.

VIEW OF RIVER YAMUNA AND ITS BANKS NEAR BRIDGE CENTRE LINE FROM LEFT BANK.

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VIEW OF SURVEY UNDER PROGRESS FOR RIVER YAMUNA NEAR
BRIDGE CENTRE LINE.

T. C

FIGURE - 2.2
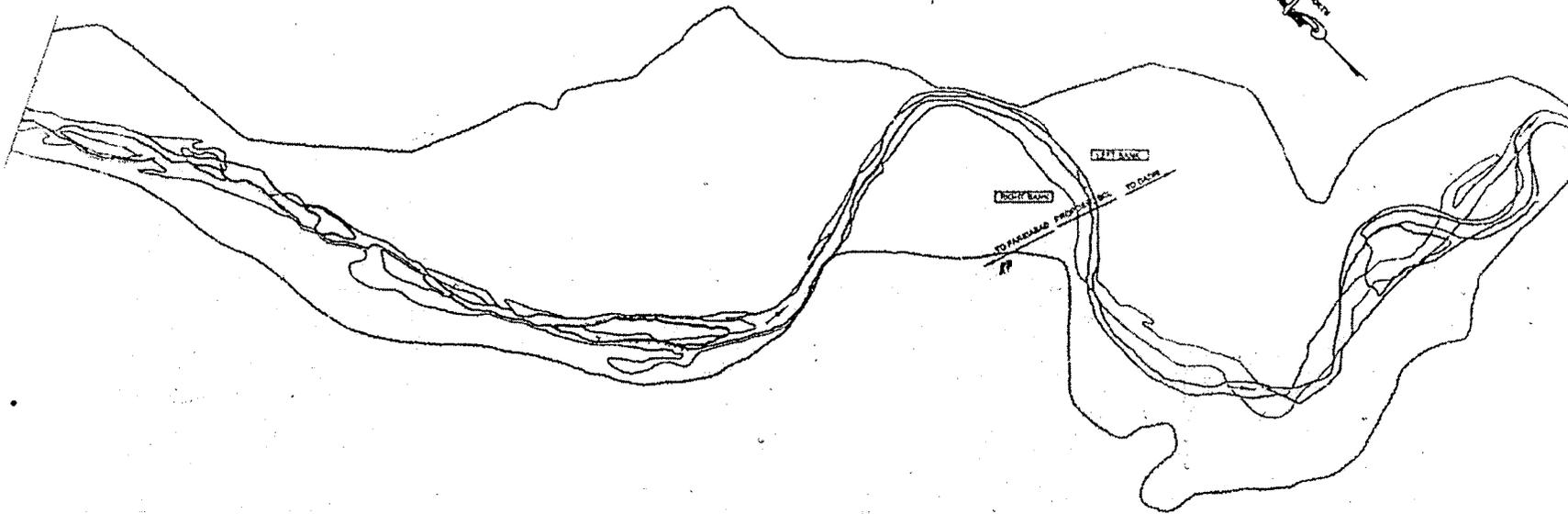
LEGEND

SURVEY - 2008	
SATELLITE IMAGERY - 2007	
SATELLITE IMAGERY - 2006	
SATELLITE IMAGERY - 1997	
FIRM BANK	

SCALE:

0   500   1000   1500   2000m
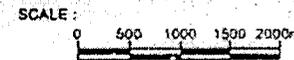
PROPOSED RAIL BRIDGE ACROSS
RIVER YAMUNA NEAR TUGHLAKABAD

COMPARATIVE RIVER COURSES
OF PREVIOUS YEARS

RITES

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SECTION - III
HYDRAULIC PARAMETERS

30

Figure 2.3
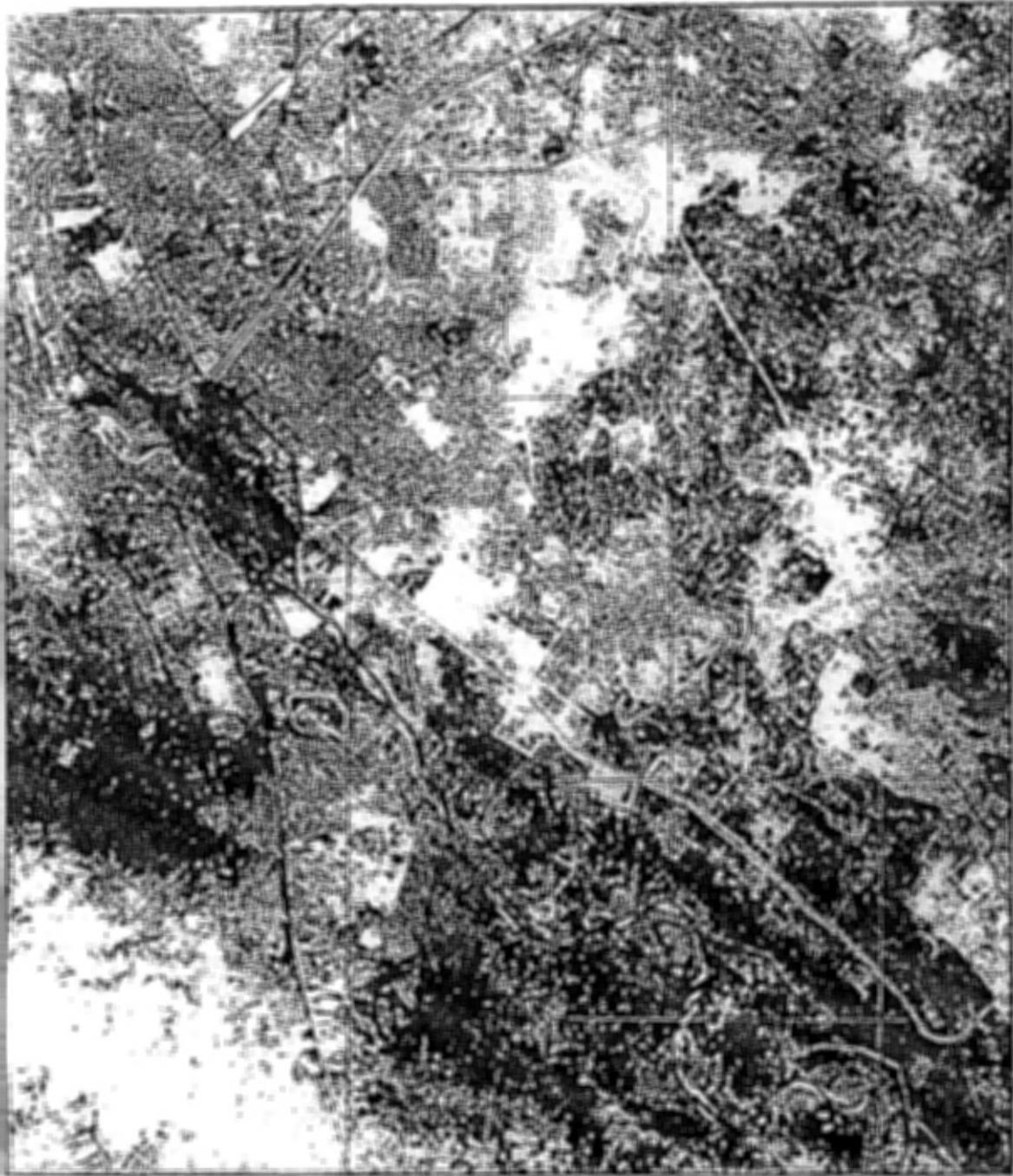
Proposed Bridge Center Line for Rail Bridge across River Yamuna at near Tughlakabad

Satellite imagery on 14th JAN 2007.

Section - III

Hydraulic Parameters

3.1   GENERAL

3.1.1   The hydraulics is the study of the flow parameters and the forecasting of flow behaviour through a water stream or river. For this historical hydraulic data of the river pertaining to water level and discharge at different gauging station is collected by various State and Central agencies primarily for the flood management. The flood forecasting is also important for the structures built on, along or near the river not only to ensure that their utility area is free from the flood hazards but also to construct the structure strong enough so as to be able to withstand the future floods during the life time of structure.

3.2   RIVER YAMUNA

Yamunotri, which is in north of Haridwar in the Himalayan Mountains, is the source of the Yamuna. The river Yamuna , a major tributary of river Ganges,. originates from the Yamunotri glacier near Banderpoonch peaks ($38^0 59'$N $78^0 27'$ E) in the Mussourie range of the lower Himalayas at an elevation of about 6400m above mean sea level in district Uttarkashi (Uttrakhand).

The river passes through National Capital Delhi where Wazirabad barrage has been constructed on the river to store the water for water supply and further down stream, Okhla Barrage has been constructed for diversion of Yamuna water for irrigation purpose. In the lean period almost entire flow of the river is retained/ diverted at Wazirabad and Okhla Barrage.

The proposed bridge centre line (BCL) is approximately 16km downstream from the Okhla Barrage near village Yaquitpur, being on the left bank of the river and village Lalpur on the right bank of the river.

3.3   HYDRAULIC DATA

3.3.1   Hydraulic data (Gauge and Discharge) has been collected to the extent possible from various departments viz. Central Water Commission, Okhla Barrage office, RITES Report on Delhi Metro Rail Bridge .

3.3.2   Hydraulic data/information collected for proposed bridge on River Yamuna at Tuglakabad in summarised as under:

A. Mohana Gauge Discharge Site (48 km d/s of BCL)

Gauge and Discharge data observed at the Mohana G & D site of CWC for the period from year 1984 to 2006 has been collected from CWC, which has been used for calculating design discharge at Mohana. Bed level and water levels of Mohana gauge site of CWC for May, 2008

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have also been collected to determine river slope for transfer of HFL from Mohana to BCL.

B. Okhla Barrage (16 km u/s of BCL)

Yearly gauge discharge data observed at Okhla Barrage for the period from 1920 to 2007 has been collected from Okhla Barrage office. The design discharge of Okhla Barrage is 3 lacs cusec (8,496 cumec).

C. RITES Report on Delhi Metro Rail Bridge (33 km u/s of BCL).

As per RITES Report (year 1993) Hydraulic Parameters used for Metro Bridge are given below.

Design Discharge   = 9911 cumec for water way

                             (12743 cumec for scour)

Design HFL   = RL 208.9 m (for 12743 cumec)

D. Gauge RL's observed during Field Survey:

Gauge readings at BCL, 12.1 km u/s and 4.6 km d/s of BCL were observed thrice daily during the period of field survey.

3.4   DESIGN DISCHARGE

3.4.1   The nearest G & D site in close vicinity is at Mohana (48 km d/s of proposed bridge site). The data for Mohana site has been obtained from CWC.The Upper Yamuna Division was contacted to provide maximum released discharge data of Okhla Barrage.The Mohana Discharge data has been used for developing Gauge-Discharge relation. For statistical analysis discharge data of both Mohana and Okhla Barrage have been used for estimation of design flood discharge. The results and observations are detailed in subsequent paras.

3.4.2   Log Pearson Method for Mohana Discharge Data

The Mohana Discharge data (annual maximum) has been analysed using the Log-Pearson distribution model. The observed values for the period 1984-2006 have been used and calculations are placed below.

Table 3.1 Discharge calculation using Log Pearson distribution						
S.N.	Year	Discharge Q (cumec)	$Q_i = \log Q$	$Q_i - Q_{im}$	$(Q_i - Q_{im})^2$	$(Q_i - Q_{im})^3$
1	1984	1081.96	3.03	-0.05	0.003	-0.0001
2	1985	1255.51	3.10	0.01	0.000	0.000003

3	1986	1202.8	3.08	0.00	0.000	-0.0000001
4	1987	100.48	2.00	-1.08	1.172	-1.27
5	1988	3830.11	3.58	0.50	0.248	0.12
6	1989	2658.75	3.42	0.34	0.116	0.04
7	1990	1876.95	3.27	0.19	0.036	0.01
8	1991	763.68	2.88	-0.20	0.041	-0.01
9	1992	1977.88	3.30	0.21	0.045	0.01
10	1993	1427.98	3.15	0.07	0.005	0.0003
11	1994	1830	3.26	0.18	0.032	0.01
12	1995	3030	3.48	0.40	0.157	0.06
13	1996	2858.34	3.46	0.37	0.138	0.05
14	1997	2016.41	3.30	0.22	0.048	0.01
15	1998	2193	3.34	0.26	0.066	0.02
16	1999	845.35	2.93	-0.16	0.025	-0.004
17	2000	1778	3.25	0.17	0.027	0.005
18	2001	1110.19	3.05	-0.04	0.002	0.000
19	2002	908.7	2.96	-0.13	0.016	-0.002
20	2003	885.3	2.95	-0.14	0.019	-0.003
21	2004	431.51	2.63	-0.45	0.202	-0.09
22	2005	715.68	2.85	-0.23	0.053	-0.01
23	2006	452.62	2.66	-0.43	0.184	-0.08
N=23			ΣQ_i =70.95		$\Sigma(Q_i - Q_{im})^2$ = 2.634	$\Sigma(Q_i - Q_{im})^3$ =-1.14

Mean Log (Q) i.e. (Q_{im}) = $\Sigma Q_i / N$ = 3.08

Standard Deviation (σ) = $\sqrt{[\Sigma(Q_i - Q_{im})^2/(N-1)]}$ = 0.346

Skewness Coefficient (G) = $[N/(N-1)(N-2)]^* [\Sigma(Q_i-Q_{im})^3 / \sigma^2]$

              = -1.367

For 100 Years $K_{P\,100}$ = 1.3403, For G = -1.367

                       (Refer RDSO .Technical Monogram no. 50)

LOG Q_T = $Q_{im} + K_{P\,100} \times \sigma$

        = 3.5485

Q_{100} = ANTILOG (3.5485)

Q_{100} = 3535.72 cumec SAY 3536 cumec

3.4.3 Gumbel's Distribution method for Mohana Discharge Data

The same data as used in the Log-Pearson distribution as shown above has been put to fit Gumbel Distribution and calculations are placed below.

YEAR	MAX. "Q"(cumec)	"Q-μ"	"(Q-μ)²"
1984	1081.96	-449.83	202348.202
1985	1255.51	-276.28	76331.3591
1986	1202.8	-328.99	108235.278
1987	100.48	-1431.31	2048652.05
1988	3830.11	2298.32	5282268.83
1989	2658.75	1126.96	1270035.9
1990	1876.95	345.16	119134.525
1991	763.68	-768.11	589994.976
1992	1977.88	446.09	198995.124
1993	1427.98	-103.81	10776.7869
1994	1830	298.21	88928.4262
1995	3030	1498.21	2244629.3
1996	2858.34	1326.55	1759731.44
1997	2016.41	484.62	234855.28
1998	2193	661.21	437196.939
1999	845.35	-686.44	471201.664
2000	1778	246.21	60618.7218
2001	1110.19	-421.60	177747.66
2002	908.7	-623.09	388242.774
2003	885.3	-646.49	417951.007
2004	431.51	-1100.28	1210618.95
2005	715.68	-816.11	666037.661
2006	452.62	-1079.17	1164610.7
N= 23	ΣQ = 35231.2		$\Sigma(Q-\mu)^2$ = 19229143.6

Mean Discharge, $\mu = \Sigma Q/N$

$=1531.79$

Standard Deviation, $\sigma = \sqrt{\{\Sigma(Q-\mu)^2/(N-1)\}}$

$=934.907$

The factors for the Gumbel's distribution are:

$\alpha = 0.7797 \times \sigma = 728.95$

$\upsilon = \mu - 0.5772 \times \alpha = 1111.04$

For the 100 year return period (T) design discharge has been calculated as :

$Q_{100} = \upsilon + \alpha\{-\ln\{-\ln(1-^1/_T)\}\} = 4464.31$ cumec SAY 4465 cumec.

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3.4.4   Chow's Frequency Factor Method for Mohana Discharge Data

The Mohana discharge data (annual maximum) has also   been
analysed using Chow's frequency factor method . The observed values
for the period 1984-2006 have been used . The calculations are placed
below.

YEAR	MAX. "Q"(cumec)	"Q-μ"	"(Q-μ)²"
1984	1081.96	-449.83	202348.202
1985	1255.51	-276.28	76331.3591
1986	1202.8	-328.99	108235.278
1987	100.48	-1431.31	2048652.05
1988	3830.11	2298.32	5282268.83
1989	2658.75	1126.96	1270035.9
1990	1876.95	345.16	119134.525
1991	763.68	-768.11	589994.976
1992	1977.88	446.09	198995.124
1993	1427.98	-103.81	10776.7869
1994	1830	298.21	88928.4262
1995	3030	1498.21	2244629.3
1996	2858.34	1326.55	1759731.44
1997	2016.41	484.62	234855.28
1998	2193	661.21	437196.939
1999	845.35	-686.44	471201.664
2000	1778	246.21	60618.7218
2001	1110.19	-421.60	177747.66
2002	908.7	-623.09	388242.774
2003	885.3	-646.49	417951.007
2004	431.51	-1100.28	1210618.95
2005	715.68	-816.11	666037.661
2006	452.62	-1079.17	1164610.7
N= 23	$\sum Q$ = 35231.2		$\sum (Q-\mu)^2$ = 19229143.6

Mean Discharge, μ   = $\sum Q/N$

= 1534.79

Standard Deviation, σ   = $\sqrt{\{\sum (Q-\mu)^2 /(N-1)\}}$

= 934.907

Return Period   = 100 years

For N = 23 $K(C)_T$ = 3.68 (Refer RDSO .Technical Monogram no. 50)

Q_{100} = $\mu + K(C)_T \times \sigma$

= 4972.25 Say 4975 cumec.

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3.4.5   Log Pearson Method for Okhla Barrage Discharge Data

The Okhla Barrage Discharge data (annual maximum) has been analysed using the Log-Pearson distribution model. The observed values for the period 1920-2007 have been used and calculations are placed below.

Year	Max Discharge (Q) cumec	$Q_i = \log Q$	$Q_i - Q_{im}$	$(Q_i - Q_{im})^2$	$(Q_i - Q_{im})^3$
1920	1656.6	3.22	-0.12	0.015	-0.002
1922	1925.0	3.28	-0.06	0.003	-0.0002
1923	1319.9	3.12	-0.22	0.049	-0.01
1924	5812.7	3.76	0.42	0.178	0.08
1925	2478.9	3.39	0.05	0.003	0.000
1926	1722.4	3.24	-0.11	0.011	-0.001
1927	2212.5	3.34	0.00	0.000	0.00
1929	2205.7	3.34	0.00	0.000	0.000
1930	1824.5	3.26	-0.08	0.007	-0.001
1933	2986.1	3.48	0.13	0.018	0.002
1934	2212.6	3.34	0.00	0.000	0.000
1935	1390.1	3.14	-0.20	0.040	-0.01
1936	1328.8	3.12	-0.22	0.048	-0.01
1937	2013.1	3.30	-0.04	0.001	-0.0001
1938	1305.6	3.12	-0.23	0.051	-0.01
1939	858.7	2.93	-0.41	0.167	-0.07
1940	2499.4	3.40	0.06	0.003	0.00
1941	1365.4	3.14	-0.21	0.043	-0.01
1942	2558.9	3.41	0.07	0.004	0.0003
1943	2437.1	3.39	0.04	0.002	0.0001
1944	1001.8	3.00	-0.34	0.117	-0.04
1945	2005.4	3.30	-0.04	0.002	-0.0001
1946	1819.0	3.26	-0.08	0.007	-0.001
1947	3786.7	3.58	0.24	0.056	0.01
1948	2202.7	3.34	0.00	0.000	0.00
1949	1589.9	3.20	-0.14	0.020	-0.003
1950	1940.8	3.29	-0.05	0.003	-0.0002
1951	1677.3	3.22	-0.12	0.014	-0.002
1952	2306.5	3.36	0.02	0.000	0.00001
1953	1951.6	3.29	-0.05	0.003	-0.0001
1954	2037.2	3.31	-0.03	0.001	-0.00004
1955	3691.9	3.57	0.22	0.051	0.01
1956	5032.0	3.70	0.36	0.129	0.05
1957	2569.9	3.41	0.07	0.005	0.0003
1958	2641.8	3.42	0.08	0.006	0.0005
1959	2493.5	3.40	0.05	0.003	0.0002
1960	2277.2	3.36	0.01	0.000	0.0000
1961	3115.7	3.49	0.15	0.023	0.0035
1962	3747.7	3.57	0.23	0.054	0.01
1963	5042.2	3.70	0.36	0.130	0.05
1964	3596.5	3.56	0.21	0.046	0.01

Year	Q_i	Q_{im}	$Q_i - Q_{im}$	$(Q_i - Q_{im})^2$	$(Q_i - Q_{im})^3$
1965	1750.1	3.24	-0.10	0.010	-0.001
1966	3253.6	3.51	0.17	0.029	0.005
1967	4393.0	3.64	0.30	0.090	0.03
1968	2778.6	3.44	0.10	0.010	0.001
1969	2030.0	3.31	-0.03	0.001	-0.00004
1970	1919.3	3.28	-0.06	0.004	-0.0002
1971	3763.8	3.58	0.23	0.054	0.01
1972	2496.5	3.40	0.05	0.003	0.0002
1973	2417.2	3.38	0.04	0.002	0.0001
1974	2225.6	3.35	0.01	0.000	0.0000
1975	2938.1	3.47	0.13	0.016	0.0020
1976	4152.1	3.62	0.28	0.076	0.02
1977	2998.6	3.48	0.13	0.018	0.002
1978	6212.5	3.79	0.45	0.203	0.09
1979	2182.7	3.34	0.00	0.000	0.00
1980	3350.3	3.53	0.18	0.033	0.01
1981	2685.8	3.43	0.09	0.008	0.001
1982	1842.2	3.27	-0.08	0.006	-0.0005
1983	3327.2	3.52	0.18	0.032	0.01
1984	1227.4	3.09	-0.25	0.064	-0.02
1985	2680.5	3.43	0.09	0.007	0.001
1986	2235.3	3.35	0.01	0.000	0.00
1987	801.0	2.90	-0.44	0.193	-0.08
1988	6626.6	3.82	0.48	0.229	0.11
1989	4580.5	3.66	0.32	0.101	0.03
1990	2743.1	3.44	0.10	0.009	0.00
1991	621.0	2.79	-0.55	0.302	-0.17
1992	3177.1	3.50	0.16	0.025	0.004
1993	2076.7	3.32	-0.03	0.001	-0.00002
1999	2092.3	3.32	-0.02	0.000	0.00
2000	2853.5	3.46	0.11	0.013	0.001
2001	2125.6	3.33	-0.01	0.000	0.00
2002	2066.3	3.32	-0.03	0.001	0.000
2003	1252.0	3.10	-0.24	0.060	-0.01
2004	524.7	2.72	-0.62	0.387	-0.24
2005	1314.9	3.12	-0.22	0.050	-0.01
2006	703.2	2.85	-0.50	0.245	-0.12
2007	782.6	2.89	-0.45	0.201	-0.09
$N = 79$		ΣQ_i =264.05		$\Sigma(Q_i - Q_{im})^2$ = 3.797	$\Sigma(Q_i - Q_{im})^3$ =-0.37

Mean Log (Q) i.e. (Q_{im}) = $\Sigma Q_i / N$ = 3.34

Standard Deviation (σ) = $\sqrt{[\Sigma(Q_i - Q_{im})^2/(N-1)]}$ = 0.221

Skewness Coefficient (G) = $[N/(N-1)(N-2)]^*[\Sigma(Q_i - Q_{im})^3/\sigma^3]$

= -0.45

For 100 Years $K_{P\,100}$ = 1.9918, For G = -0.45

(Refer RDSO .Technical Monogram no. 50)

LOG Q_T = $Q_{im} + K_{P\,100} \times \sigma$

= 3.782

Q_{100} = ANTILOG (3.782)

Q_{100} = 6053.4cumec SAY 6055 cumec

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3.4.6   Gumbel's Method for Okhla Barrage Discharge Data

The Okhla Barrage Discharge data (annual maximum) has been analysed using the Gumble Distribution method. The observed values for the period 1920-2007 have been used and calculations are placed below.

Year	Max Discharge (Q) cumec	"Q-μ"	"(Q-μ)²"
1920	1656.6	-822.43	676384.89
1922	1925.0	-554.01	306929.99
1923	1319.9	-1159.08	1343474.43
1924	5812.7	3333.66	11113318.54
1925	2478.9	-0.13	0.02
1926	1722.4	-756.59	572429.22
1927	2212.5	-266.51	71025.20
1929	2205.7	-273.33	74710.78
1930	1824.5	-654.49	428362.67
1933	2986.1	507.04	257085.04
1934	2212.6	-266.45	70995.01
1935	1390.1	-1088.97	1185855.94
1936	1328.8	-1150.22	1322998.20
1937	2013.1	-465.97	217125.52
1938	1305.6	-1173.47	1377042.12
1939	858.7	-1620.33	2625468.99
1940	2499.4	20.41	416.43
1941	1365.4	-1113.59	1240077.55
1942	2558.9	79.87	6378.96
1943	2437.1	-41.94	1759.35
1944	1001.8	-1477.19	2182076.79
1945	2005.4	-473.67	224365.81
1946	1819.0	-659.99	435586.75
1947	3786.7	1307.72	1710119.63
1948	2202.7	-276.34	76361.35
1949	1589.9	-889.08	790469.37
1950	1940.8	-538.23	289695.39
1951	1677.3	-801.72	642751.76
1952	2306.5	-172.48	29750.34
1953	1951.6	-527.41	278163.48
1954	2037.2	-441.80	195189.88
1955	3691.9	1212.87	1471056.62
1956	5032.0	2553.01	6517874.73
1957	2569.9	90.89	8260.67
1958	2641.8	162.73	26480.92
1959	2493.5	14.51	210.66
1960	2277.2	-201.80	40724.45
1961	3115.7	636.70	405381.28
1962	3747.7	1268.71	1609617.26
1963	5042.2	2563.21	6570051.52
1964	3596.5	1117.52	1248844.52

1965	1750.1	-728.89	531273.55
1966	3253.6	774.57	599960.15
1967	4393.0	1913.98	3663304.31
1968	2778.6	299.56	89734.27
1969	2030.0	-449.06	201650.50
1970	1919.3	-559.71	313271.56
1971	3763.8	1284.77	1650632.02
1972	2496.5	17.49	305.86
1973	2417.2	-61.83	3823.11
1974	2225.6	-253.42	64220.54
1975	2938.1	459.05	210724.03
1976	4152.1	1673.07	2799161.65
1977	2998.6	519.53	269909.81
1978	6212.5	3733.49	13938980.88
1979	2182.7	-296.36	87831.56
1980	3350.3	871.23	759038.53
1981	2685.8	206.75	42746.49
1982	1842.2	-636.87	405608.25
1983	3327.2	848.17	719390.11
1984	1227.4	-1251.66	1566656.13
1985	2680.5	201.45	40584.04
1986	2235.3	-243.73	59403.99
1987	801.0	-1678.04	2815802.42
1988	6626.6	4147.55	17202133.27
1989	4580.5	2101.48	4416231.34
1990	2743.1	264.09	69743.19
1991	621.0	-1857.98	3452084.58
1992	3177.1	698.06	487281.29
1993	2076.7	-402.28	161832.88
1999	2092.3	-386.73	149561.77
2000	2853.5	374.51	140260.95
2001	2125.6	-353.42	124904.09
2002	2066.3	-412.74	170352.52
2003	1252.0	-1227.04	1505636.45
2004	524.7	-1954.32	3819383.22
2005	1314.9	-1164.10	1355123.24
2006	703.2	-1775.83	3153556.75
2007	782.6	-1696.39	2877746.58
N = 79	$\sum Q =$ 195843.12		$\sum(Q-\mu)^2 =$ 117564717.9

Mean Discharge, μ = $\sum Q/N$
= 2479.027
Standard Deviation, $\sigma = \sqrt{\{\sum(Q-\mu)^2/(N-1)\}}$
= 1227.697

The factors for the Gumbel's distribution are:
$\alpha = 0.7797 \times \sigma = 957.235$
$\upsilon = \mu - 0.5772 \times \alpha = 1926.51$

For the 100 year return period (T) design discharge has been calculated as :

$Q_{100} = \upsilon + \alpha[-\ln\{-\ln(1 - 1/_T)\}] = 6329.94$ SAY 6330 cumec.

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3.4.7   Chow's Frequency Factor Method for Okhla Barrage Discharge
           Data

The Okhla Barrage Discharge data (annual maximum) has also been
analysed using the Chow's frequency method. The observed values for
the period 1920-2007 have been used and calculations are placed
below.

Year	Max Discharge (Q) cumec	"Q-μ"	"(Q-μ)²"
1920	1656.6	-822.43	676384.89
1922	1925.0	-554.01	306929.99
1923	1319.9	-1159.08	1343474.43
1924	5812.7	3333.66	11113318.54
1925	2478.9	-0.13	0.02
1926	1722.4	-756.59	572429.22
1927	2212.5	-266.51	71025.20
1929	2205.7	-273.33	74710.78
1930	1824.5	-654.49	428362.67
1933	2986.1	507.04	257085.04
1934	2212.6	-266.45	70995.01
1935	1390.1	-1088.97	1185855.94
1936	1328.8	-1150.22	1322998.20
1937	2013.1	-465.97	217125.52
1938	1305.6	-1173.47	1377042.12
1939	858.7	-1620.33	2625468.99
1940	2499.4	20.41	416.43
1941	1365.4	-1113.59	1240077.55
1942	2558.9	79.87	6378.96
1943	2437.1	-41.94	1759.35
1944	1001.8	-1477.19	2182076.79
1945	2005.4	-473.67	224365.81
1946	1819.0	-659.99	435586.75
1947	3786.7	1307.72	1710119.63
1948	2202.7	-276.34	76361.35
1949	1589.9	-889.08	790469.37
1950	1940.8	-538.23	289695.39
1951	1677.3	-801.72	642751.76
1952	2306.5	-172.48	29750.34
1953	1951.6	-527.41	278163.48
1954	2037.2	-441.80	195189.88
1955	3691.9	1212.87	1471056.62
1956	5032.0	2553.01	6517874.73
1957	2569.9	90.89	8260.67
1958	2641.8	162.73	26480.92
1959	2493.5	14.51	210.66
1960	2277.2	-201.80	40724.45
1961	3115.7	636.70	405381.28
1962	3747.7	1268.71	1609617.26

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Year	Q	(Q-μ)	(Q-μ)²
1963	5042.2	2563.21	6570051.52
1964	3596.5	1117.52	1248844.52
1965	1750.1	-728.89	531273.55
1966	3253.6	774.57	599960.15
1967	4393.0	1913.98	3663304.31
1968	2778.6	299.56	89734.27
1969	2030.0	-449.06	201650.50
1970	1919.3	-559.71	313271.56
1971	3763.8	1284.77	1650632.02
1972	2496.5	17.49	305.86
1973	2417.2	-61.83	3823.11
1974	2225.6	-253.42	64220.54
1975	2938.1	459.05	210724.03
1976	4152.1	1673.07	2799161.65
1977	2998.6	519.53	269909.81
1978	6212.5	3733.49	13938980.88
1979	2182.7	-296.36	87831.56
1980	3350.3	871.23	759038.53
1981	2685.8	206.75	42746.49
1982	1842.2	-636.87	405608.25
1983	3327.2	848.17	719390.11
1984	1227.4	-1251.66	1566656.13
1985	2680.5	201.45	40584.04
1986	2235.3	-243.73	59403.99
1987	801.0	-1678.04	2815802.42
1988	6626.6	4147.55	17202133.27
1989	4580.5	2101.48	4416231.34
1990	2743.1	264.09	69743.19
1991	621.0	-1857.98	3452084.58
1992	3177.1	698.06	487281.29
1993	2076.7	-402.28	161832.88
1999	2092.3	-386.73	149561.77
2000	2853.5	374.51	140260.95
2001	2125.6	-353.42	124904.09
2002	2066.3	-412.74	170352.52
2003	1252.0	-1227.04	1505636.45
2004	524.7	-1954.32	3819383.22
2005	1314.9	-1164.10	1355123.24
2006	703.2	-1775.83	3153556.75
2007	782.6	-1696.39	2877746.58
N = 79	$\sum Q =$ 195843.12		$\sum(Q-\mu)^2 =$ 117564717.9

Mean Discharge, μ = $\sum Q/N$
= 2479.027

Standard Deviation, σ = $\sqrt{\sum\{(Q-\bar{\mu})^2/N-1\}}$
= 1227.697

Return Period = 100 years
$K(c)_{100}$ = 3.491
Q_{100} = $\mu + K(c)_{100} \times \sigma$

= 6764.92 Say 6765 cumec

T.C

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3.4.8   Summary of various results for Design Discharge

The results obtained based on the above various methods adopted are tabulated in Table – 3.1 along with the other collected data.

Table 3.1: Summary of various results for Design Discharge

S. No	Data Used /Source	Method of calculation	Design Discharge (cumec)
1.	Mohana G & D site (48 km d/s of BCL).	Log Pearson	3536
2.	Mohana G & D site (48 km.d/s of BCL).	Gumble Distribution	4465
3.	Mohana G & D site (48 km d/s of BCL).	Chow's frequency factor	4975
4.	Okhla Barrage (16km u/s of BCL).	Log Pearson	6055
5.	Okhla Barrage (16km u/s of BCL).	Gumble Distribution	6330
6.	Okhla Barrage (16km u/s of BCL.	Chow's frequency factor	6765
7.	Design discharge of Okhla Barrage.	-	8496
8.	Delhi Metro Bridge (33 km u/s of BCL)	Adopted Design Discharge	9911

3.4.9   Review of Hydraulic Parameters by Expert

Based on the above results, design discharge of 9911 cumec was recommended by RITES which was got reviewed by Dr. S. Ponnuswamy, an eminent bridge expert .After detailed review; he also recommended design discharge as 9911 cumec. The review report of Dr. S. Ponnuswamy is enclosed as Appendix 3.1.

3.4.10   Recommended Design Discharge

After review of the recommendations of Dr. S Ponnuswamy and importance of other factors, RITES initially adopted design discharge as 9911 cumec(for 100 years return period).Subsequently after detailed deliberation on the return periods to be adopted, design discharge of 10000 cumec was finally adopted for model study based on DFCCIL letter no. HQ/EN/Bridge/Model Studies dated 24.11.08   (Appendix-3.2).

3.5   HIGH FLOOD LEVEL

3.5.1   River flood slope is required to transfer gauge data from nearest gauge site to BCL (Bridge Centre Line) for assessing design HFL for the proposed bridge and to develop G-D curve at BCL. River slope 1 in 10400 has been calculated based on water level at BCL and Mohana site (May 2008) for transfer of gauge data from Mohana to BCL.

3.5.2   Gumbel's Method for Mohana gauge data

Probabilistic variance, best fitting extreme value distribution Type I i.e. Gumbel's distribution, has been applied on the annual maximum gauge data of Mohana Site. The calculations are placed below.

Year	Max. gauge levels at Mohana H RL(m)	$(H - \mu)$	$(H - \mu)^2$
1984	190.52	-0.36	0.131
1985	190.98	0.10	0.0097
1986	190.845	-0.04	0.0013
1987	188.54	-2.34	5.483
1988	192.26	1.38	1.90
1989	191.45	0.57	0.323
1990	190.95	0.07	0.0047
1991	190.34	-0.54	0.293
1992	191.24	0.36	0.129
1993	190.72	-0.16	0.0261
1994	191.41	0.53	0.279
1995	191.88	1.00	0.997
1996	191.5	0.62	0.383
1997	191.42	0.54	0.29
1998	190.91	0.03	0.00081
1999	190.75	-0.13	0.0173
2000	191	0.12	0.014
2001	191.04	0.16	0.0251
2002	190.96	0.08	0.00615
2003	190.67	-0.21	0.0447
2004	190	-0.88	0.777
2005	190.85	-0.03	0.00099
2006	190.04	-0.84	0.708
N = 23	$\sum H = 4390.275$		$\sum(H-\mu)^2 = 11.843$

Mean Discharge, $\mu = \sum H/N$
          =190.88

Standard Deviation, $\sigma = \sqrt{\{\sum(H-\mu)^2/(N-1)\}}$
          =0.73

The factors for the Gumbel's distribution are:
$\alpha = 0.7797 \times \sigma = 0.57$
$u = \mu - 0.5772 \times \alpha = 190.55$
For the 100 year return period (T) design HFL has been calculated as:
$H_{100} = u + \alpha[-\ln\{-\ln(1-1/_T)\}] = 193.18$ m
Design HFL transferred to BCL = RL 197.8m

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3.5.3   Log Pearson method for Mohana gauge data

The Mohana data (annual maximum) has also been analysed using the Log-Pearson distribution model. The observed values for the period 1984-06 have been used. The calculations as per the RDSO Technical Monogram-50 have been carried out and presented below.

Year	gauge H RL(m)	$H_i = \log H$	$H_i - H_{im}$	$(H_i - H_{im})^2$	$(H_i - H_{im})^3$
1984	190.52	2.280	0.00082024	0.00000067	0.00000000
1985	190.98	2.281	0.00022708	0.00000005	0.00000000
1986	190.845	2.281	0.00008002	0.00000001	0.00000000
1987	188.54	2.275	0.00535731	0.00002870	0.00000015
1988	192.26	2.284	0.00312813	0.00000979	0.00000003
1989	191.45	2.282	0.00129456	0.00000168	0.00000000
1990	190.95	2.281	0.00015885	0.00000003	0.00000000
1991	190.34	2.280	0.00123075	0.00000151	0.00000000
1992	191.24	2.282	0.00081792	0.00000067	0.00000000
1993	190.72	2.280	0.00036457	0.00000013	0.00000000
1994	191.41	2.282	0.00120381	0.00000145	0.00000000
1995	191.88	2.283	0.00226890	0.00000515	0.00000001
1996	191.5	2.282	0.00140797	0.00000198	0.00000000
1997	191.42	2.282	0.00122650	0.00000150	0.00000000
1998	190.91	2.281	0.00006787	0.00000000	0.00000000
1999	190.75	2.280	0.00029626	0.00000009	0.00000000
2000	191	2.28	0.00027256	0.00000007	0.00000000
2001	191.04	2.28	0.00036350	0.00000013	0.00000000
2002	190.96	2.28	0.00018160	0.00000003	0.00000000
2003	190.67	2.28	-0.00047844	0.00000023	0.00000000
2004	190	2.28	-0.00200721	0.00000403	-0.00000001
2005	190.85	2.28	-0.00006865	0.00000000	0.00000000
2006	190.04	2.28	-0.00191579	0.00000367	-0.00000001
N = 23		$\Sigma H_i = 52.46$		$\Sigma(H_i - Q_{im})^2$ = 0.000062	$\Sigma(H_i - H_{im})^3$ = -0.00000012

Mean Log (H) i.e. (H_{im})   = $\Sigma H_i/N$ = 2.28

Standard Deviation (σ)   = $\sqrt{[\Sigma(H_i - H_{im})^2/(N-1)]}$ = 0.002

Skewness Coefficient,(G) = $[N/(N-1)(N-2)]^* [\Sigma(H_i - H_{im})^3/\sigma^3]$
                             = -1.2756

For 100 Years   = $K_{P\,100}$, FOR G = -1.2756
                             = 1.4020

LOG H_T = $H_{im} + K_{P\,50} \times \sigma$
              = 2.283

$H_T°$ = ANTILOG (2.283)

H_T = 191.91 m

HFL Transferred to BCL = RL 196.53 m

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3.5.4   The gauge discharge curve was initially developed at BCL by using the gauge and discharge data of Mohana site . The data was found to be widely scattered on which the regressed curve was developed. Alternatively an attempt was made to develop the synthetic Gauge – Discharge curve using Manning's method. The cross sectional area at higher water levels accommodating the water spread over the banks has also been considered.

The Gauge discharge data thus developed was found to be following smooth pattern at 1.4 km u/s of BCL. As such, this section appeared to be most suitable for applying Manning formula. The river cross-section at this location has been divided in three zones i.e. left food plain, central deep channel and right flood plain for which areas and wetted perimeters have been measured on undistorted AutoCAD drawing and used for calculations. River bed slope of 1 in 5300 has been used based on the observed gauge during field survey. The Manning's coefficient n = 0.025 has been used in calculation.

The G-Q curve developed (Fig-3.1) based on this data is described by following equation:

$$\text{Gauge "G"} = 185.92(Q)^{0.0078}$$

Fig 3.1 G & Q Curve

$$G = 185.92(Q)^{0.0078}$$
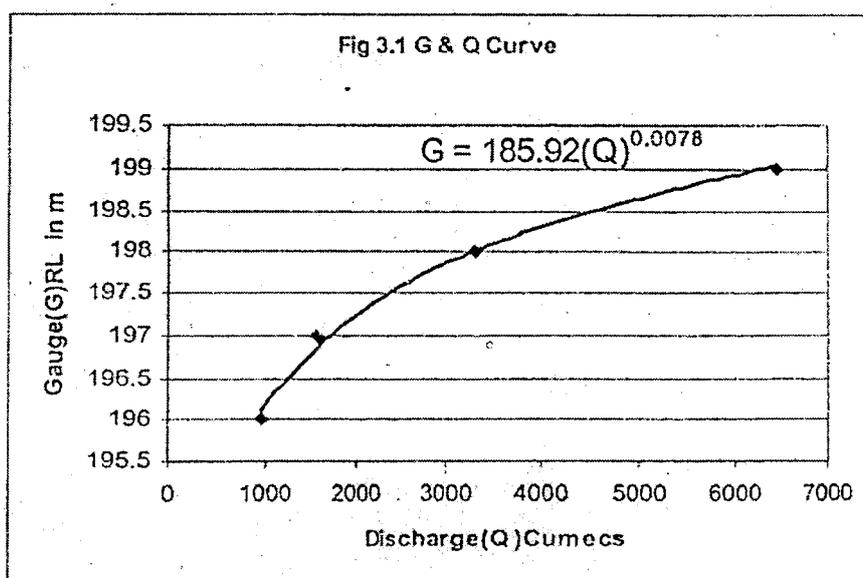
Based on the above G –Q relationship,

Computed HFL for 9911 cumec at 1.4 km u/s of BCL = RL 199.74m

Computed HFL Transferred to BCL   = 199.5 m

The above G-Q relationship was supplied to IRI, Roorkee for proving of model by observing the water levels for the corresponding discharge.

3.5.5   Summary of Various results of Design HFL Calculations

S.N.	Location	Method of calculation	HFL RL(m)
1.	Mohana gauge site	Gumbel' Distribution (HFL transferred to BCL 48 km u/s)	197.8
2.	Mohana gauge site	Log Pearson (HFL transferred to BCL 48 km u/s)	196.53
3.	Metro Rail Bridge	Design HFL transferred to BCL	202.72*
4.	Synthetic G-Qcurve at 1.4 km u/s of BCL site for 9911 cumec.	Manning's formula (HFL transferred to BCL)	199.5

*Note: Due to obstruction caused by Okhla Barrage (between BCL and Metro Bridge) the river bed level might have gone up over a Period of 90 years. Hence it will not be appropriate to consider transferred HFL from Metro Bridge to BCL.

3.5.6   **Review of Hydraulic Parameters by Expert**

The above calculations were examined by the expert. Finally Dr. S.Ponnuswamy recommended HFL as RL **199.49** for design discharge of **9911 cumec** based on study using Manning's formula. The review report of Dr. S. Ponnuswamy is enclosed as **Appendix-3.1.** .

3.5.7   **Recommendation**

Model was successfully proven for design discharge of 10000 cumec (revised design discharge by DFCCIL) and HFL of RL **199.5m** was achieved for recommended design discharge. So based on model proving a design HFL of RL **199.5m** is recommended for design discharge of **10000 cumec.**

3.6   **Bridge Length with Lacey's Waterway:**

The clear waterway and corresponding bridge length calculated by Lacey's formula is as under.

$P_w = 1.811 \times c \times \sqrt{Q}$

P_w = wetted perimeter

Q = Design Discharge in cumec

C = a coefficient normally equal to 2.67

For present case Q = 10000 cumec

So, Lacey Waterway $P_w = 1.811 \times 2.67 \times \sqrt{10000}$

$= 483.54$ m

C/c spacing of pier	= 48.15m (clear span = 45.7m)
No. of Span	= 10.58 spans

Say 11 spans(considering clear span of 45.7m)

No . of obstruction	= 10

Additional waterway to account for obstruction = 2x10x2.5 (assumed width/dia of pier)

= 50 m

Total bridge length required = 483.54+50

= 533.54 m ✓

No. of spans	= 11.08

Say 11 (considering span length of 48.15 m)

Keeping above in view it was proposed to conduct model experiments starting from a bridge length of 529.65m (11 spans of 48.15m) which has been discussed in subsequent Section IV.

3.7   Navigational Clearance

Inland Waterway Authority of the India (IWAI) was approached to ascertain the vertical and horizontal clearance requirement for navigational purpose for the river Yamuna. It is learnt that river Yamuna is not being used for navigational purposes. Presently there are three declared national waterways of IWAI which do not include the river Yamuna (refer appendix 3.3 at end of this section). Accordingly no minimum horizontal and vertical clearance is required to be maintained at proposed bridge location for navigational purpose.

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Comments on

Hydraulic Parameters for Model Study of
Proposed Railway Bridge on River YAMUNA near Tughlakabad/ Faridabad
for Dedicated Freight Corridor (DFC)

Introduction

RITES have been assigned the job of conducting a model study for a bridge proposed across River Yamuna between Tughlakabad and Faridabad on the proposed Dedicated Freight Corridor between Mumbai and Delhi. They have engaged the UPIRI to build the model and conduct the study, for which RITES has carried out a detailed topographical survey of the river for 12 km upstream and 5 km downstream. They have also collected hydraulic data for the river from different sources. The river is fairly straight in this reach but the proposed alignment is slightly oblique to the lay of the river due to other constraints. The river has its origin in Haryana at the foothills of Himalayas and passes through semi-arid region. Based on the collected data and their own field observations and subsequent design calculations, RITES engineers have tentatively arrived at the major parameters to be used for the model study as follows:

Design flood- D_{50} 9911 cumecs for waterway
         and 12743 cumec for foundation design

HFL   197.50 m (further revised as 199.74)

They have asked for a review of the same, particularly on the approach adopted on slope apart from confirmation on Design discharge and HFL.

These have been studied in detail and following comments and recommendations are offered.

Bridge site

Proposed bridge is to be located at 15.25 km downstream of Okhla barrage near Delhi and 48 km upstream of. Mohana Gauge. Discharge site. River Hindon, a major tributary of the river, joins Yamuna just upstream of Mohana. There are a number of Railway and Road bridges in Delhi and environs upstream of Okhla barrage. Of these, the ones built for the DMRC's ISBT- Shahdara line and the one for NOIDA are recent ones. The former had been built just upstream of the ISBT Road bridge and it was built based on Model studies done in the CWPRS at Khadakvasla. The waterway of DMRC bridge near ISBT has been designed for a flood discharge of 9911 cumecs. Well foundations for same have been designed for 12743 cumecs. The Northern Railway's most recent bridge on the river near Nizamideen (also upstream of Okhla barrage) on their freight bypass line has, it is learnt been designed for a discharge of 12743 cumecs (presumably foundation design discharge)

The left bank of the river is not sharply defined, but there are dykes / marginal bunds on either side. The right bank is more sharply defined and higher than left bank difference in level being about 2 metres. During floods the flow spills over and inundates the countryside on both sides but more on left bank, the topography of the ground being flat. Considering the size of the river and configuration as can be seen from the map supplied, the reach within the flood dykes proposed to be included for the model study is quite adequate.

Catchment area at site is 17950 sq km at Okhla and 27, 730 sq k at Mohana. The large difference in a short length of 63.25 km is due to confluence of Hindon River in between the proposed site and Mohana site.

Hydraulic data relied upon

RITES engineers have collected the discharge data for Okhla Barrage 15.25 km upstream for 88 years and for Mohana gauging site 48 km downstream for 23 years. They have also collected stage discharge data for the gauging sites at Okhla and Mohana. Bed levels and water levels have been observed at Mohana for May 2008. Flood slope computed using this data comes to 1 in 10399. This has been rechecked with more comparable data on specific dates and revised figure comes to 1 in 8109.

In addition bed levels and water levels for a month (April- May) have been observed at a point 12.1 km upstream and 4.8 km downstream for arriving at flood slope. Close to bridge site. This works out to 1 in 5300.

The discharge data from Okhla barrage and Mohana gauging data have been used to work out the design flood with a 100 year return period i.e., for arriving at 100 year return period flood. They have been compared with the Design flood used for the DMRC bridge upstream and highest has been recommended for design of the proposed bridge.

The gauge discharge data at Mohana have been used for plotting Gauge discharge curves. They have been used to predict the HFL with 50 year return period. By applying the flood slope mentioned above, RITES engineers have tried to arrive at the design HFL at proposed site. According to these computations, the design HFL works out to 197.50.Similar computations done for 100 year return period resulted in 199.105 as possible HFL.

Subsequently RITES engineers have subsequently, after the undersigned review, worked out HFL by slope area method using Manning's formula for passing design discharge of 9911 cumecs and found that the HFL for that discharge would be 199.74 without taking into account scour.

Following comments are offered after study of all data and some additional computations.

Design Flood

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Design flood with 50 year frequency has been arrived at by using three different methods viz., Log Pearson, Gumbell and Chow. It is felt that not much reliance can be made on usage of the data from Mohana Gauge site for design of this bridge for following reasons.

There is large difference in catchment area and despite that fact the figures are consistently much lower at Mohana than the discharge at Okhla for corresponding periods. At the same time, one has to consider the fact that a number of canals take off from the river upstream of and including Okhla barrage. It is also for shorter period. Hence computations based on Mohana site data are not considered here.

Most reliable method is to use unit hydrograph. In absence of required direct observations and this is not be possible. The area is too large for deriving any single synthetic unit hydrograph based on RDSO Monograph No. 50. The existing bridges, built about 20 km upstream have been designed for a design flood of 9910 cumecs and foundation design discharge varying from 12743 cumecs to 14865 cumecs. To sum up, the different methods give results as given below.

Okhla Barrage data – Log Pearson 100 year flood	6055 cumecs
Okhla Barrage data- Gumbel Distn 100 year flood	6330 cumecs
Okhla Barrage data- Chow's Frequecy- 100 year return	6765 cumecs
Okhla Barrage data- Design discharge	8499 cumecs
Okhla Barrage data- Actual maximum in 88 years	6627 cumecs
Design discharge of Northern Railway Bridge and DMRC Bridges near Okhla	9911 cumecs

The highest is the design discharge adopted for the railway bridges upstream. It is logical to adopt the maximum of these values. It appears the river has significant valley storage in this area as observed from the discharge data comparison between Tejawala, Okhla Barrage and Mohana Gauge site for corresponding flood stages.

Considering the importance of the bridge and its position downstream of a number of bridges designed for higher discharge of 9911 cumecs, Therefore, a design discharge of 9911 cumecs for waterway and 12743 cumecs for foundation designs as adopted for the railway bridges upstream may be adopted. In fact, this figure has been recommended by CWC for the railway bridges mentioned above.

Recommended Design flood   *9911 cumecs for Waterway*
12743 cumecs for foundation

Design HFL

RITES has developed gauge discharge curves for the gauging site at Mohana and regressed the curves upto proposed design flood discharge to arrive at likely HFL at respective sites. By applying the mean slope observed between different sites, they have interpolated the likely HFL at proposed site. Based on the HFL records for 23 years at Mohana, the 100 year return period HFL has been worked out using statistical methods at Mohana as follows. Corresponding level at BCL has been arrived at adopting a flood slope of 1 in 8100.

Log Pearson method	191.91 + 5.925	= 197.835
Gumbel's method	193.18 + 5.925	= 199.105

Alternatively, since actual cross section at site is available, the likely HFL that will be reached at this high discharge has been worked out, developing Synthetic Gauge-Discharge curves. They have been developed for the site using the surveyed cross sectional data and the observed flood slope of 1 in 5300 mentioned above. While doing so, the extra cross sectional area of coverage due to water spreading over the bank edges has been considered. Width of flowing water considered at higher stages is spread between the dykes. The regime width (width between high bank edges) is about 400m, beyond which there will be shallow depth of flow at high floods extending upto flood bunds. Discharge at various stages has been worked out with n= 0.25, using Manning's Formula. It has been done taking into consideration the additional area of flow likely due to scour at higher stages of river. As per Consultant's view, at floods of such magnitude in a river with alluvial bed, scour will be present at such high discharge level. GD curves have been plotted and regressed. When the bridge is put in, some afflux is likely to develop and the same may be derived based on the observations in model.

Estimated HFL for 9910 cumecs without considering scour	199.74
Estimated HFL with 10 % scour	199.49

It is recommended that HFL of 199.49 can be adopted for the model initially and based on afflux, final design HFL determined. It is noted that the flood bund crests are at 199.78 and the estimated HFL, which will correspond to an extraordinary one will still be below the same. Need for raising the bund may be decided after confirming these levels and afflux by model study.

Width of area for model study.

Survey has been done from flood bund to flood bund. The left bank is lower. The model should cover the full area bounded by the flood bunds and extending for 17 km length surveyed..

S. _____ _____
(S. _____ _____)
Advisory Consultant
28ᵉ _____ 2005

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T.C

Appendix-3.2

डेडीकेटेड फ्रेट कोरीडोर कॉर्पोरेशन ऑफ इण्डिया लि.
(भारत सरकार का उपक्रम)
Dedicated Freight Corridor Corporation of India Ltd.
(A Government of India Enterprise)

Surinder Kaul
Group General Manager
Design.

No. HQ/EN/Bridges/Model Studies   Dt.24.11.2008.

Dear Shri Mohan,

Sub: Consultancy on Model Studies of Five important River Bridges on DFC.

Ref :   1.   This office letter no. HQ/EN/Bridges/Model Studies dated. 01.10.2008
        2.   RITES letter no. RITES/RCED/DFC – Model Studies/18 dated .29.10.2008
                    ****

Considering the flood data available and calculated values of 50 yrs & 100 yrs highest flood, following design discharges be considered for model studies & designs for five important bridges.

S. No.	River	Design discharge
1	Sabarmati	15,000
2	Narmada	72,000
3	Yamuna (Faridabad)	10,000
4	Yamuna (Allahabad)	56,000
5	Tapi	43,000

With best wishes,

                                                    Yours Sincerely,

                                                    (Surinder Kaul)

Shri Ajai Mohan
Group General Manager/Civil(RCED)
M/s RITES Limited
Gurgaon – 122 001.

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SECTION - IV
HYDRAULIC MODEL STUDY

Section – IV

Hydraulic Model Study

4.1   INTRODUCTION

4.1.1   Modeling by scaling down the geometrical dimensions of river, structures and other temporary / permanent features to validate it for hydraulic behaviour of the river, is a convenient method of predicting the river behaviour with and without human intervention. Owing to number of complex factors affecting the hydrological structures, adequate answer to various problems cannot yet be obtained by analytical methods. Small scale hydraulic models have, therefore, become effective and handy for design engineers as it is possible to impose design condition on the model for any number of times and sufficiently for longer duration to have thorough testing. In order to revise/modify the conceptual designs and to get a better feel of the river in pre-bridge / post bridge conditions, physical model study is valuable to arrive at guide lines for an optimum design of various bridge components and river training/protection measures based on the river configuration tested to the model.

4.1.2   For the proposed five important bridges on detoured portion of dedicated freight corridor, the hydraulic model studies have been carried out at Irrigation Research Institute, Roorkee.

4.2   ENGAGEMENT OF IRI, ROORKEE

IRI, Roorkee is one of the most prestigious hydraulic research institute in India. Accordingly, as per the agreement with DFCCIL, Irrigation Research Institute, Roorkee was engaged by RITES for taking up the model studies for river Yamuna at Tughlakabad.

4.2.1   The following terms of reference for carrying out the model studies were advised to UP-IRI:

1) To lay and prove the Model based on the Survey Data & Hydraulic Design Parameters as made available by RITES.

2) To test the model for various alternatives for obtaining the satisfactory flow conditions and to determine the most suitable axis of crossing, optimal waterway/bridge length, discharge intensities; velocities, scour pattern and afflux along the bridge and at critical locations.

3) Ascertaining suitable configuration & layout of the Guide Bunds or other River Training & Bridge Protection Works.

4.2.2   The following data/drawings were made available by RITES to IRI. Roorkee to construct a physical model and conduct the studies thereon:

I. Topographic survey plan (1:10,000) of the river of year 2008 in the reach between 12 km upstream to 5 km downstream of the bridge.

II. River cross sections (1:2500 H and 1: 250 V) in the above study reach at 200 & 400 m interval.

III. The design discharge of river, 10,000 cumec.

IV. H. F. L. at design discharge = 199.5 m.

V. River bed slope = 1 in 5300.

VI. Gauge-Discharge curve of the river at B.C.L.

4.2.3   Gauge-discharge (G-Q) curve of the river Yamuna at the proposed bridge centre line (B.C.L.) was supplied by RITES. From this G-Q data the stage-discharge curves at the bridge axis, in the upstream of B.C.L. at km 1.4, 3.8 and 5.8 were developed by IRI Roorkee for proving of the model and conducting onward experiments.

4.2.4   IRI, Roorkee developed an arbitrary single peak flood hydrograph having flood peak of 10,000 cumec for the purpose of testing each proposal of the study under simulated flood conditions.

4.2.5   The details of model studies and findings have been discussed in subsequent paras. The hydraulic model study report of IRI, Roorkee has been placed under **Annexure 4.1.**

4.3   THE MODEL

4.3.1   As per the survey drawings/data supplied by RITES, a distorted or vertically exaggerated physical model with mobile bed and rigid banks was built on the following scales:

    Horizontal   :   1:250
    Vertical   :   1:30
    Discharge   :   1:41,080

4.3.2   For the purpose of conducting model study, the supplied entire river reach from 12 km upstream to 5 km downstream of the proposed bridge was represented in the model. All existing pucca works such as flood dykes on banks as well as cultivated area and forestation etc. were also represented as per the drawings supplied by RITES. The river bed in the model was laid (dressed) in locally available sand and was made to conform to the supplied river survey of the year 2008. The discharge fed into the model was measured with a sharp crested weir arrangement provided at the head of the model. During the running of model, the surface water levels and flow velocities were measured with the help of a scale graduated according to the vertical scale of the model and current meter respectively. The surface flow lines were observed by making use of suitable floats.

4.4   PROVING OF THE MODEL

4.4.1   All existing ground features were replicated in the model. Further , the river bed was dressed to conform to the river survey data of the

year 2008. Fine cohesive clay was used in laying the river bed in the model to make it least erodible as per site conditions. The ground levels of the flood plains on both sides of the river were represented in accordance with the supplied fly levels.

4.4.2   After preparing the model according to the supplied data, the arbitrary flood hydrograph having a maximum peak of 10,000 cumec was run in the model. Various flood stages varying from 1000 cumec to 10,000 cumec were run in the model maintaining corresponding water levels at 2.0 Km. downstream section. At each flood stage of river, the water levels were observed at downstream, B.C.L and upstream sections. These water levels were found to be in close proximity of the theoretical water levels computed at these sections using slope of 1 in 5300 i.e. 0.189 m per kilometre. The flow conditions in the model were found satisfactory and resembled to those at the site. The model was, therefore, taken as proved. Details of the test conducted are available in Annexure – 4.1.

4.5   MODEL INVESTIGATIONS

4.5.1   STUDY –1 : UNDER EXISTING CONDITIONS (Without Bridge)

4.5.1.1   After proving of the model the river bed was dressed again according to the supplied river survey and fly levels of the flood plain. The arbitrary flood hydrograph having a peak of 10000 cumec was run in the model.

4.5.1.2   During the running of adopted hydrograph, it was seen that up to about 3000 cumec discharge the flow remained confined within the banks of the river, but for a discharge more than 3000 cumec, the water overflowed both the banks and spread over the flood plains. As the khadir on the both flanks had almost same levels, the flow soon reached to the flood dykes on either side. On increasing the discharge upto 6600 cumec and further, the main river flow in the upstream of the proposed bridge deviated from its original curved path and took a short-circuited route along the right flood dyke over the flood plains. Such a short-circuiting by the river made the flow oblique on to the bridge. The surface flow lines were observed at 3300, 6600 and 10000 cumec discharge respectively. The corresponding flow velocities at various critical points along the both dykes in the upstream and downstream of the bridge were observed.

4.5.1.3   At higher discharges it was observed that the existing flood dykes on both banks got overtopped at several places. Therefore, on the recommendation of the site engineers the height of both the dykes were raised adequately in the model so as to ensure no spilling anywhere over them. Thus the entire flow up to the maximum discharge remained completely confined within the dykes on both banks.

4.5.2   STUDY–2 : With Bridge 529.65 m long (11 spans of 48.15 m)

4.5.2.1   A 529.65 m long railway bridge having 11 spans with pier spacing @ 48.15 m c/c was initially tested in the model on the basis of Lacey's waterway for the maximum discharge of 10,000 cumec. The bridge with the approach embankments was constructed as per supplied

alignment drawing of proposed track. The left abutment of the bridge was positioned at a distance of 25.0 m from the left high bank line.

4.5.2.2   After incorporating the above proposal in the model, the river bed in the model was again dressed as per the supplied survey data. The adopted hydrograph was run in the model and the surface flow lines were observed at the maximum discharge of 10000 cumec. These flow lines along with the velocities of flow were observed at various critical points along the flood dykes in the upstream and downstream of the bridge. In the upstream of the bridge, the raised water level were observed due to the afflux caused after the construction of bridge and the railway embankment. At the discharge of 3300, 6600 and 10,000 cumec the flow velocities across the proposed bridge were also recorded in the centre of each bay.

4.5.2.3   The study of flow lines at the maximum discharge in the Study – 1 & 2, it could be seen that the direction of flow approaching the bridge has been changing after the construction of approach embankment. Thus, in the upstream of the proposed bridge site, the river instead of flowing between the river banks earlier was converging along the approach embankment and pass eventually through the bridge only. This was obviously due to the construction of railway embankment and a bridge in the path of the river flow. However, the obliquity of flow in the bridge bays was high which indicated the need of river training work especially on the right bank. Accordingly, it was decided that a guide bund suitably slanting away from the bridge be provided on the right bank in the upstream which would smoothly guide the flow into the bridge. Moreover, to take care of the flow obliquity on to the left bank too, it was also felt to construct a left guide bund that would deflect the flow further towards bridge bays.

4.5.3   STUDY–3 :

(i) With Bridge 529.65 m long (11 spans of 48.15 m)

(ii) Elliptical Guide Bunds with circular head on the upstream

4.5.3.1   As mentioned in the preceding paragraph, an elliptical guide bund of u/s projected length 270 m conforming to part of an ellipse $\frac{x^2}{300^2}+\frac{y^2}{150^2}=1$ followed by curved head of radius 225.0 m and sweep angle 45^0 was constructed in the model on the right bank to guide the flow smoothly towards the bridge. Also, as the flow in the upstream was highly oblique to the proposed bridge alignment, therefore, for ensuring non separation of the flow from the guide bund and having the flow closely following the profile of the right guide bund, the right guide bund was rotated in the plan to 30^0 anti-clock wise. On left bank, to deflect the flow towards the bridge bays and also to render the approaching flow to be streamlined for passing through the bridge, an elliptical guide bund conforming to part of an ellipse $\frac{x^2}{400^2}+\frac{y^2}{200^2}=1$ followed by curved head of radius 100.0 m and sweep angle 45^0 was provided in the upstream of the bridge. In the downstream, the projected length of each of the guide

bund was kept as 128.6 m with curved tail of R = 100.0 m sweep angle θ = 45°.

4.5.3.2   The above proposal was incorporated in the model and its bec re-laid as per the supplied survey of the year 2008. The adc hydrograph was run in the model and the surface flow lines observed at the design discharge 10000 cumec. These flow along with the velocities of flow were recorded at various c points along the flood dykes. At the discharge of 10000 cumec maximum velocities observed along the left and right guide b were 2.80 m/s and 2.99 m/s respectively. No measurable ve was observed anywhere along the approach embankment.

4.5.3.3   At the discharge of 3300, 6600 and 10000 cumec the velocities discharge distribution across the bridge bays were observed. A design discharge 10,000 cumec the maximum velocity of the order of 3.18 m/s with corresponding discharge intensity of 35.69 cumec/n was observed in the 9th bay from the right abutment of the bridge.

4.5.3.4   A study of the above results indicated that after introduction of guide bund on each bank of the river, the flow along them was quite smooth and closely followed their profiles. The left guide bund effectively diverted the flow through the bridge. This diverted stream following the profile of the left guide bund merged with the main oblique flow in the upstream of the bridge and thus helped activate the rightmost bridge bays. At the end of the curved head of right guide bund somewhat mild rotational flow was observed due to the abrupt difference of water levels on the opposite faces of the guide bund. This indicated the requirement of an increase in the length of the curved head with greater curvature and sweep angle. At the design discharge of 10,000 cumec, almost no flow was observed near the end of the curved head of the left guide bund. Therefore, on grounds of economy it was decided to curtail the curved length of the left guide bund by means of reducing the sweep angle suitably.

4.5.4   **STUDY–4 :**

(i) With Bridge 529.65 m long (11 spans of 48.15 m)

(ii) Modified Elliptical Guide Bunds on both flanks

4.5.4.1   In this study, the upstream elliptical guide bund on the right bank was kept almost same as in Study-3 but the curved head was modified to have greater curvature and sweep angle. Thus, as compared to Study-3, in the present study the radius of curved head 'R' was reduced from 225 to 80 m while the angle of sweep was increased from 45° to 90°. Moreover, as mentioned above, the length of the curved head of left elliptical guide bund was curtailed by about 50 m. Thus on the left bank a guide bund conforming to part of an ellipse $\dfrac{x^2}{350^2} + \dfrac{y^2}{175^2} = 1$ followed by a circular head of radius 'R' = 100 m and sweep angle 30° was provided in the model to effectively divert the approaching oblique flow towards right and to pass through the bridge bays. In the downstream of the bridge,

however, both the guide bunds were retained to be the same as provided in Study-3.

4.5.4.2   With the incorporation of above modifications in the layout of the guide bunds, the river bed of the model was re-laid as per the supplied river survey. The arbitrary flood hydrograph was run in the model and the surface flow lines were observed at the 10000 cumec discharge.. It was found that the flow conditions in the present study were quite smooth and stream lined as compared to that in Study-3. No cross flow was observed along the approach embankment. Based on the afflux observations on the model, the design H.F.L. at the design discharge 10,000 cumec has been observed as 199.7 m.

4.5.4.3   At the discharge of 3300, 6600 and 10,000 cumec the discharge intensities and percentage discharge distribution across the bridge bays were observed. A study of these observations showed that with the above modification in the layout of the guide bunds, the discharge distribution across the bridge bays has improved over the corresponding results as observed in Study-3. The discharge intensity in the end bays of the bridge increase to some extent. The maximum concentration of discharge was seen in the 10th bay from the right abutment where the maximum discharge intensity of 37.38 cumec/m was recorded at the design discharge 10,000 cumec.

4.6   DISCUSSIONS

4.6.1   It was seen during the study that the height of existing flood dykes is not adequate at few places as at higher discharges the flood water started to overflow dykes at these points. As such the dykes on either bank should be sufficiently raised above the water levels for the maximum river discharge 10,000 cumec. The water levels observed along the raised dykes may be referred for planning raising the dykes.

4.6.2   The flow in the river remained well confined within the channel only upto the discharge of about 3300 cumec. At higher discharges the flow started to spread over the flood plains and reached flood dykes on each bank. At a discharge of more than 6600 cumec, the flow instead of following the curved loop of the main deep channel, rather took a short-circuited path. Thus, due to deviation in the path of approaching flow at higher discharges, the flow in the upstream of the bridge became highly oblique to the bridge. In order to effectively divert and guide this oblique flow towards the bridge, elliptical guide bunds had to be provided on either bank.

4.6.3   At the higher discharges as the flow spreads over the flood plains, the river width is governed by the flood dykes on both banks. Therefore, in order to ensure the flow to conform well to the profile of the right guide bund as well as to improve the intensity of flow in the rightmost spans, a splay of 30⁰ in the anticlockwise direction was given in the upstream right guide bund.

4.6.4   Lacey's method was adopted as a guide to determine the bridge waterway. Trials with different bridge spans were carried out and eventually 11 nos. of spans @ 48.15 m c/c spacing of piers along with the elliptical guide bunds have been found to be the optimum

4.6.5   The photographs of model running for various proposals, as discussed above are attached under Figure 4.1.

4.7   CONCLUSIONS

The studies conducted on the physical model as described in the above paragraph revealed that :

4.7.1   A bridge of 529.65m length comprising of 11 equal spans of length 48.15m each is suitable for construction at the proposed location.

4.7.2   For obtaining the satisfactorily flow condition through the bridge, guide bunds on both the sides of the bridge have been found necessary and accordingly proposed to be constructed along with the bridge.

4.7.3   The existing flood dykes will not be adequate at certain location to hold the design discharge of 10,000 cumec. Therefore, the flood dykes shall be required to be raised suitably as per the water levels observed along the dykes at the design discharge under the final configuration of bridge with both the guide bund in place.

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Figure 4.1
(4 Sheets)
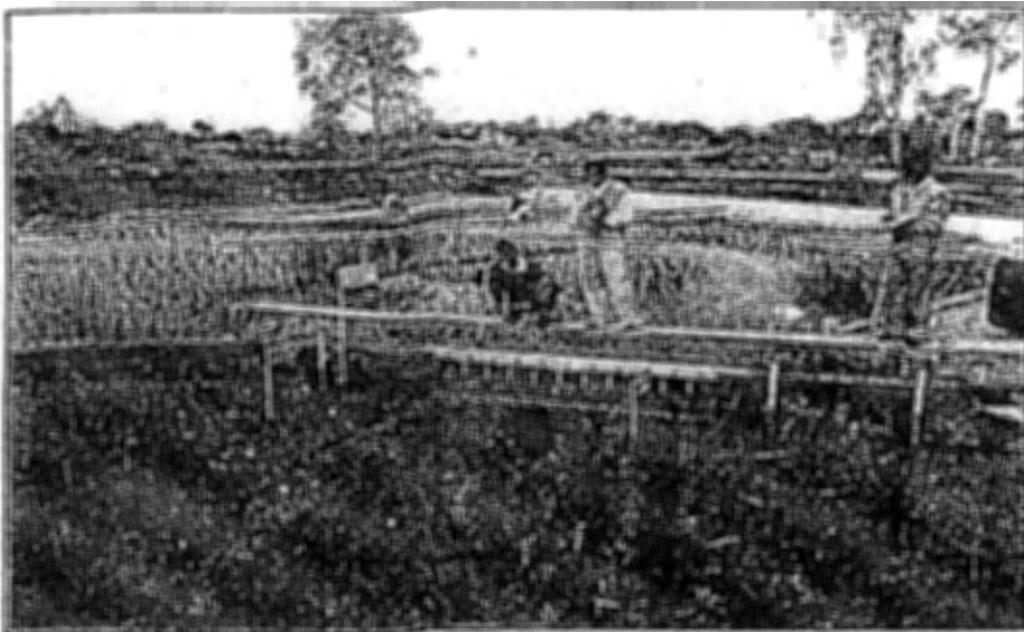
Study 2 – Bridge proposal with 11 spans of 48.15 m at a discharge of 3300 cumec
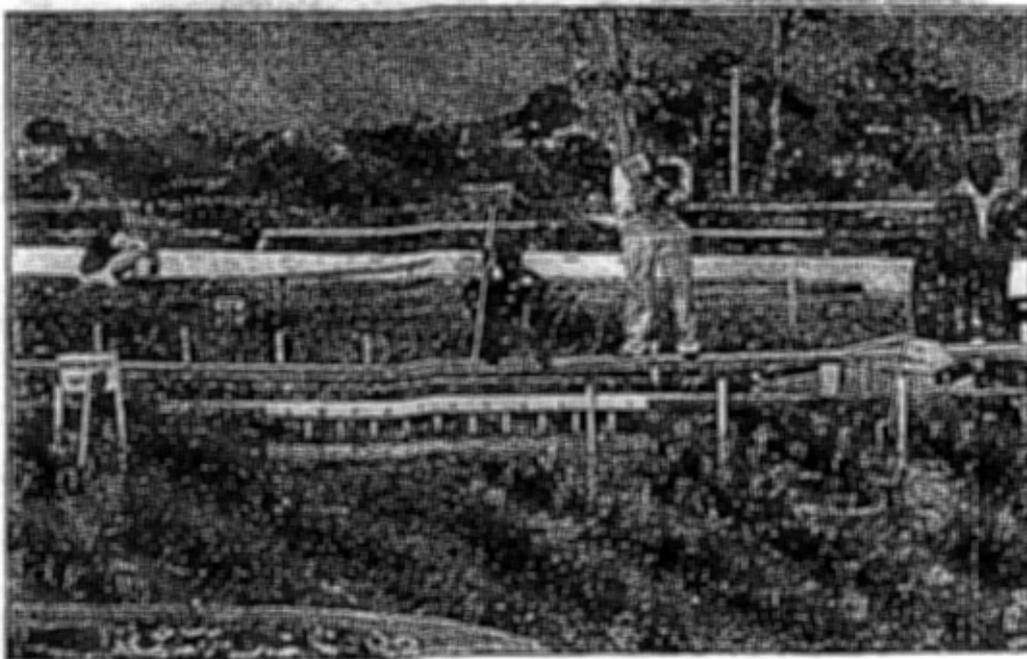
Study 2 – Bridge proposal with 11 spans of 48.15 m at a discharge of 6600 cumec
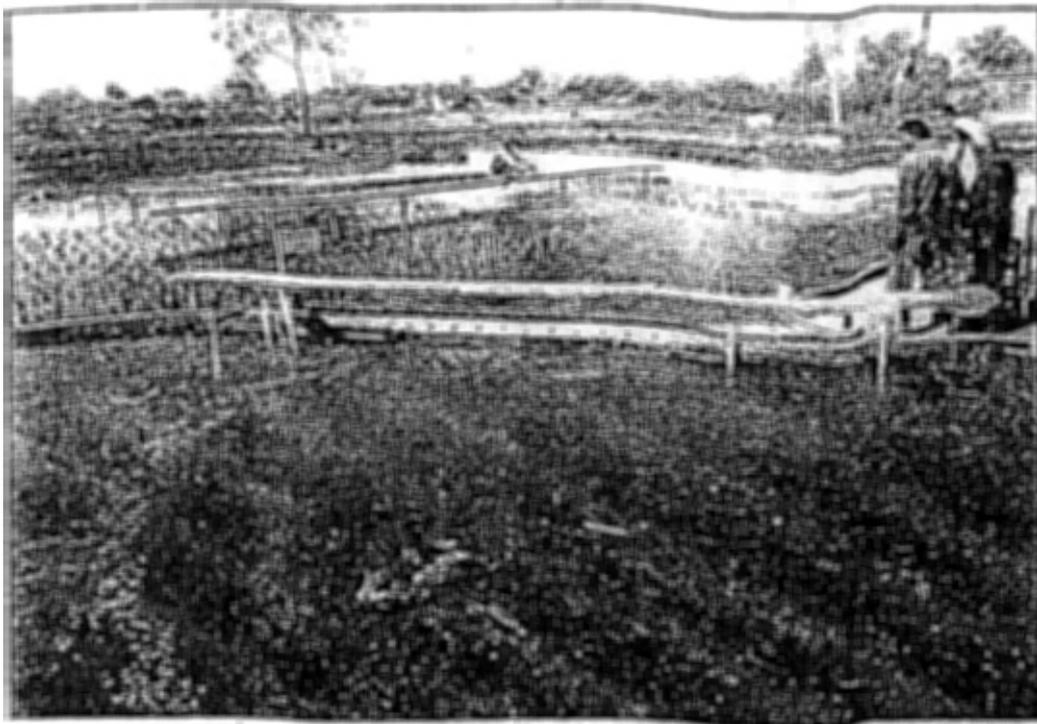
Study 2 - Bridge proposal with 11 spans of 48.15 m at a discharge of 10000 cumec

Study 3 - Bridge proposal with 11 spans of 48.15 m and elliptical Guide bund on both banks at a discharge of 3300 cumec

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Study 3 - Bridge proposal with 11 spans of 48.15 m and elliptical Guide bund on both banks at a discharge of 6600 cumec

Study 3 - Bridge proposal with 11 spans of 48.15 m and elliptical Guide bund on both banks at a discharge of 10000 cumec

3
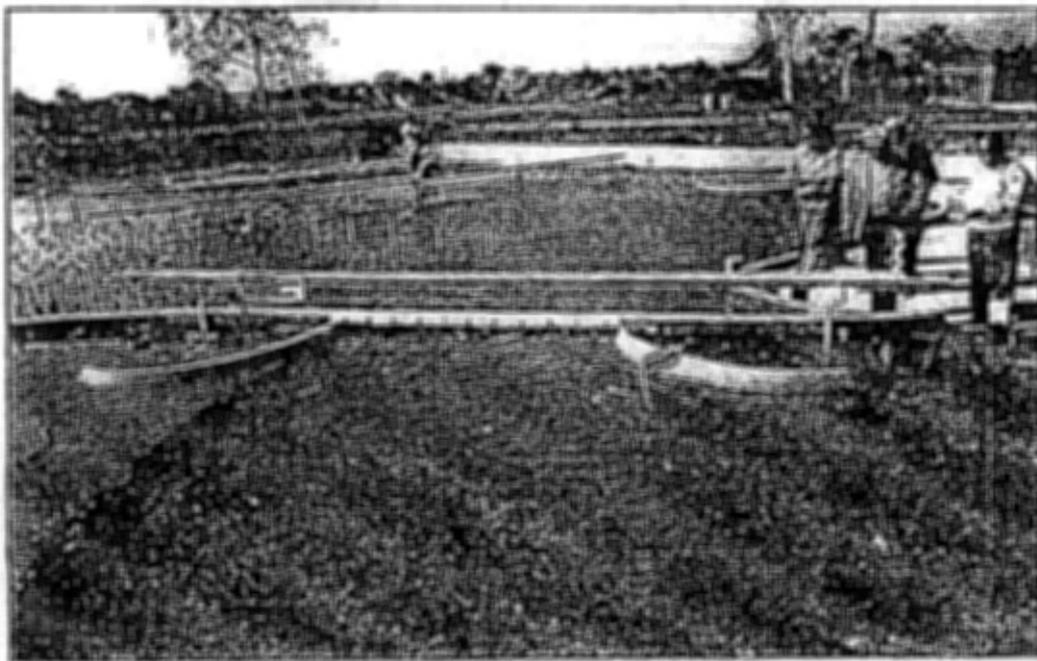
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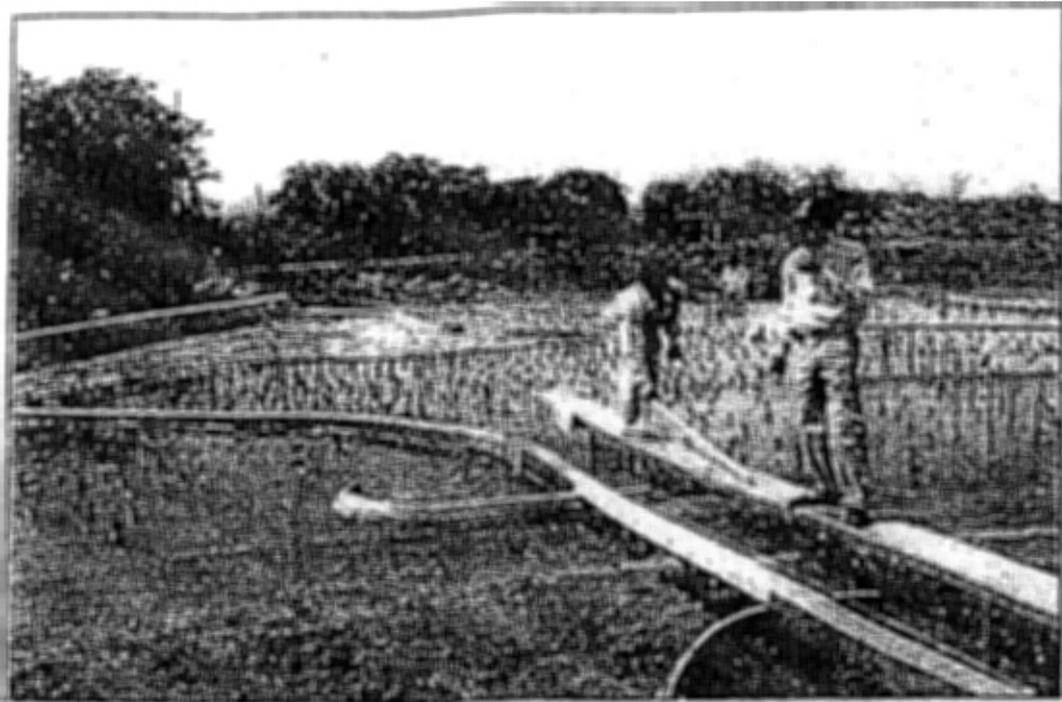
Study 4 - Bridge proposal with 11 spans of 48.15 m and elliptical Guide bund on both banks at a discharge of 6000 cumec

Study 4 - Bridge proposal with 11 spans of 48.15 m and elliptical Guide bund on both banks at a discharge of 10000 cumec

65
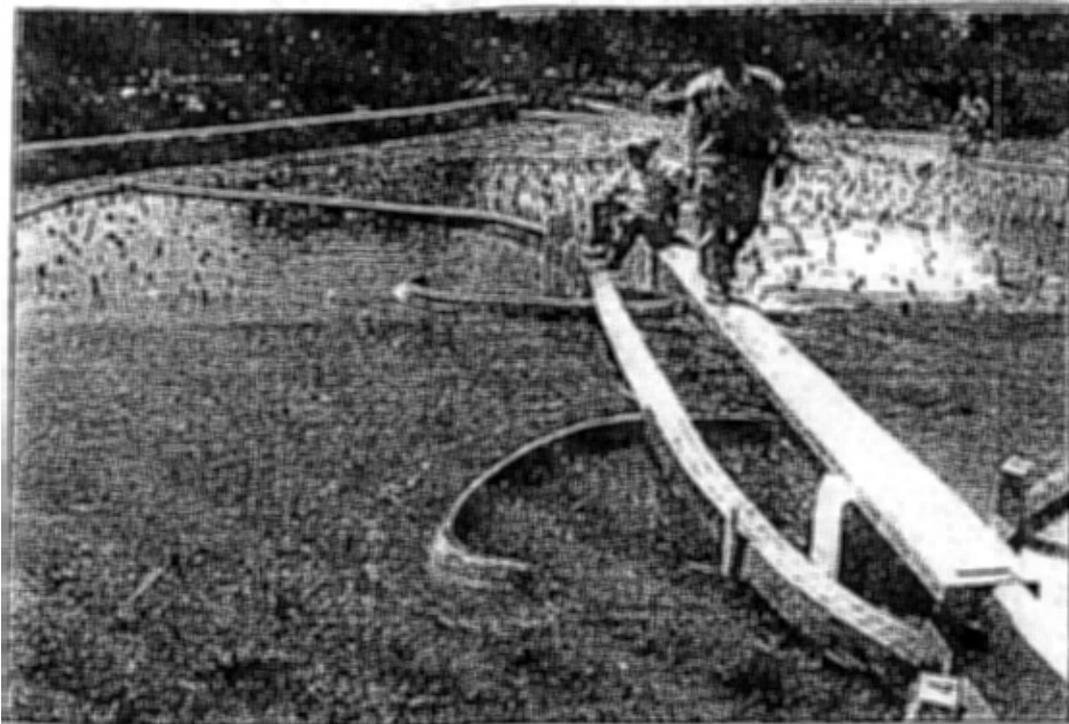
SECTION - V
SUMMARY & RECOMMENDATIONS

Section – V

Summary & Recommendations

5.1   **BRIDGE SITE**

5.1.1   The proposed bridge site is over river Yamuna between Delhi and Faridabad located at about 16.0 km. downstream of the Okhla Barrage. In the stretch downstream of the Okhla Barrage, the river Yamuna flows in a wide khadir width confined within the flood dykes (having av. Top at RL 197-198m) maintained by Upper Yamuna Division of UP Irrigation Department. Within the confines of these dykes, the river flows in narrow water channel(s) during the lean season as almost entire flow is retained at Okhla Barrage and diverted to irrigation channels. However, during the flood season, most of the gates are opened at the barrage resulting in substantial flow in the downstream reaches touching flood dykes on both the banks. The proposed DFC alignment is crossing the river between flood dykes in serpentine pattern, however, following a straight alignment between the proposed locations of the abutments. The proposed bridge is being sited covering adequate river width enabling to pass the design discharge and also accommodates the flow which exists for most of the time during non flood season. During the field survey, the river khadir on the left and right bank of flow was found to be varying from RL 196.1m to RL 197.5m. The water level was observed at RL 191.46 m during the month of survey i.e. May' 08 which indicates the position of water level in river during the non flood season.

5.1.2   As stated, during the high flood the discharge in the river is normally found inundating the entire khadir width within the confines of the flood dykes existing on both the banks. The water spread at high discharge is directly governed by the discharge released in the river from the Okhla Barrage. For the proposed bridge the design discharge has been estimated as 10,000 cumec. At that discharge, the estimated design flood level is RL 199.5 m which is about 2m higher than the general top level of the flood dykes. In order to decide the required bridge length, number of spans, location of abutments on both the banks along with the required river training works, if any, the hydraulic model study has been carried out. The detailed computations of the hydraulic parameters have already been covered under Section-III and subsequently, the details of the hydraulic model study conducted at IRI, Roorkee has been covered under Section-IV. The outcome of the said model study and recommendations thereof are given in the succeeding paras.

5.2   **OUTCOME OF THE HYDRAULIC MODEL STUDY**

5.2.1   As already explained under preceding Sections, based on the Lacey's waterway, the estimated bridge length was tested on the model under varying flow conditions with and without the training measures. The span length of 48.15m C/C of piers has been

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considered by RITES based on the clear span of 45.7m as intimated by DFCCIL vide minutes of meeting held on 21.07.08 forwarded vide letter dated 29.07.08 (Copy enclosed as **Appendix 5.1** at the end of the section). Accordingly following options were put on the model for testing

1. 529.65 m (11 spans of 48.15m) without Guide Bunds

   - Study No.2 on the model

2. 529.65 m (11 spans of 48.15m) with Guide Bunds

   - Study No.3 on the model

3. 529.65 m (11 spans of 48.15m) with modified Guide Bunds

   - Study No.4 on the model

After various experiments on the model, the performance of bridge length of 529.65 m (11 spans of 48.15m) with modified Guide Bunds as tested under third alternative was found to be most appropriate for the proposed location of bridge. The proposed chainages of the left abutment works out to be at Km. 47/729.65 and that of right abutment works out be at Km. 47200. The chainages are referred with respect to the chainages as followed by the alignment survey team

5.2.2   **Guide Bund**

5.2.2.1   Guide bunds are artificial embankments meant for streamlining and guiding the river flow past a bridge, without causing damage to the bridge and its approaches. They are placed in the direction of flow both upstream and downstream of the abutment, on one or both the banks, as required. With straight/curved shanks of suitable lengths, they end in heads of adequate curvature, both in upstream & downstream. Properly designed guide bunds at a bridge serve a two-fold purpose. Firstly, they protect the approach embankments of the bridge from attack and secondly, they control the river and channelise the flow more or less axially through the bridge. In designing guide bunds, their shape in plan is a vital decision which governs the flow conditions due to its placement. The flow conditions after placing alternative shapes and size of the guide bunds can only be detected on the model and accordingly, the best suited layout of the guide bund is finalised which results in most satisfactory flow conditions.

5.2.2.2   While running of the model for the proposed bridge length without guide bund, substantial oblique flow was observed across the bridge crossing. Such flow conditions necessitated the need to train the river on both the sides of the bridge in order to streamline the flow through the bridge and also to provide protection to the bridge abutment and the approach embankment. It was, therefore, decided to test the model by providing the guide bunds on both sides of the bridge. Accordingly, two alternative layouts of the elliptical guide bunds were tested on the model at various stages which were as under.

Alt-1. Elliptical Left Guide Bund (Study No. 3 on the model)

Upstream: Part of an ellipse $\dfrac{x^2}{400^2}+\dfrac{y^2}{200^2}=1$ followed by curved head of radius 100.0 m and sweep angle 45^0 was provided in the upstream of the bridge.

Downstream: projected length of 128.6 m with curved tail of R 100.0 m and sweep angle $\theta = 45^0$.

Alt-1. Elliptical Right Guide Bund (Study No. 3 on the model)

Upstream: The upstream projected length 270 m conforming to part of an ellipse $\dfrac{x^2}{300^2}+\dfrac{y^2}{150^2}=1$ followed by curved head of radius 225.0 m and sweep angle 45^0.

Downstream: projected length of 128.6 m with curved tail of R 100.0 m and sweep angle $\theta = 45^0$.

The right guide bund was rotated in the plan to 30^0 anti-clock wise.

Alt-2. Elliptical Left Guide Bund (Study No. 4 on the model)

Upstream: Part of an ellipse $\dfrac{x^2}{350^2}+\dfrac{y^2}{175^2}=1$ followed by a circular head of radius 'R' = 100 m and sweep angle 30^0.

Downstream: projected length of 128.6 m with curved tail of R 100.0 m and sweep angle $\theta = 45^0$.

Alt-2. Elliptical Right Guide Bund (Study No. 4 on the model)

Upstream: The upstream projected length 270 m conforming to part of an ellipse $\dfrac{x^2}{300^2}+\dfrac{y^2}{150^2}=1$ followed by curved head of radius 80.0 m and sweep angle 90^0.

Downstream: projected length of 128.6 m with curved tail of R 100.0 m and sweep angle $\theta = 45^0$.

The right guide bund was rotated in the plan to 30^0 anti-clock wise.

The performance of the guide bund placed as per layout under second alternative (under Study No. 4 on the model) was found to be most suitable. During model running with this alternative, the velocities (v in m/s) and water levels (W.L. in m) observed along the guide bunds were as under.

WATER LEVELS (m)

VELOCITIES (m/s)
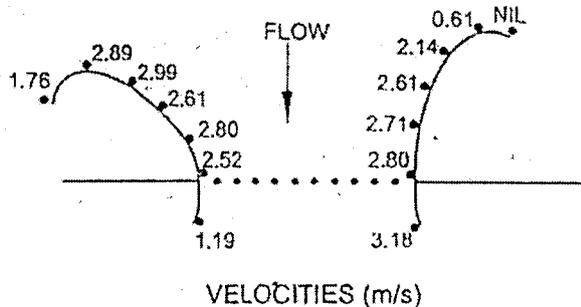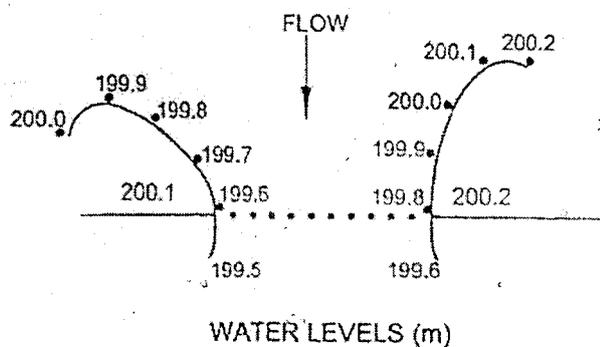
5.3 RECOMMENDATIONS

As per the hydraulic computations carried out under Section-III and results of the model studies conducted subsequently, for various alternatives, the following recommendations are made.

5.3.1 Bridge Length

A bridge length of 529.65 m (11 spans of 48.15m) with Guide Bunds on both the banks has been found to be most appropriate for the proposed location of bridge. The proposed chainages of the left abutment works out to be at Km. 47/729.65 and that of right abutment works out be at Km. 47200.. The position of abutments and configuration of bridge and guide bunds are shown in **Figure 5.1 & 5.2**. These figures in drawing form are also placed under Drawing No. **RITES/RCED/Y-Delhi/BR & GB (Sheet No.1)** and Drawing No. **RITES/RCED/Y-Delhi/GB (Sheet No.1A)**.

5.3.2 Hydraulic Parameters

The hydraulic parameters are given below which can be used for deciding the vertical profile and design of bridge structure, river training & protection measures and approach embankment.

5.3.2.1   Hydraulic Design Parameters

i)   Design discharge (Q) $= 10,000$ cumec

ii)   Computed Highest Flood Level (HFL) $=$ RL 199.50 m
      for design discharge

iii) Flood Slopes $= 1$ in 5300

5.3.2.2   Hydraulic Parameters obtained from Model Studies

i)   Max. Velocity through bridge span $= 3.57$ m/sec.

ii)   Max. discharge intensity (q) $= 37.38$ cumec/m

iii) Max. Water Level in Bridge Spans $=$ RL 199.80 m
      (Design HFL)

iv)   Max. Water Level along Right Approaches $=$ RL 200.1 m

v)   Max. Water Level along Left Approaches $=$ RL 200.2 m

vi)   Afflux $= 0.30$ m

5.3.3   Flood Dykes

The existing flood dykes will not be adequate at certain location to hold the design discharge of 10,000 cumec. Therefore, the flood dykes shall be required to be raised suitably as per the water levels observed along the dykes at the design discharge under the final configuration of bridge with both the guide bund in place as furnished under Table 5.1.

******

TABLE- 5.1
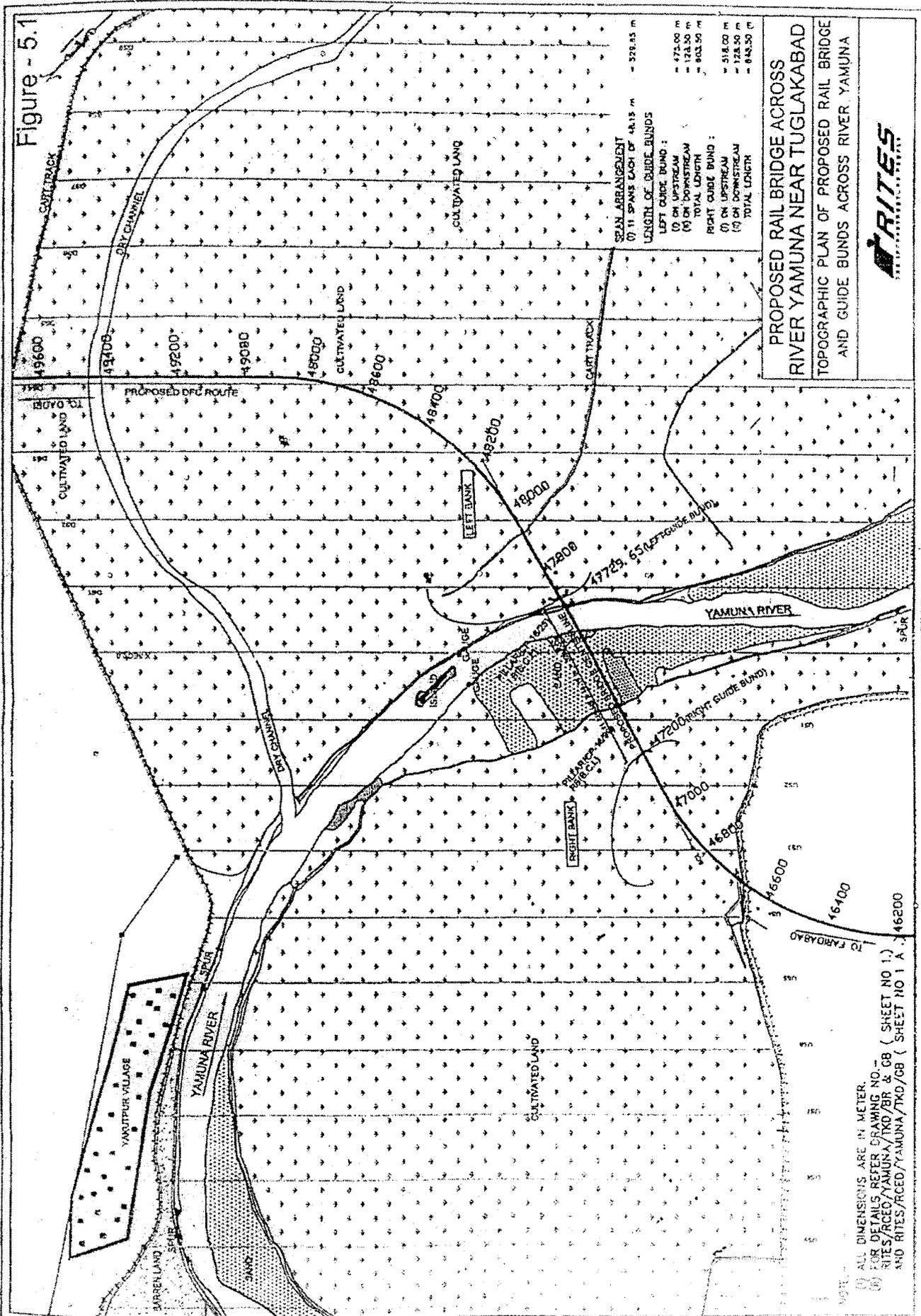(1 Sheet)

OBSERVED WATER LEVELS ALONG DYKE

(For Study – 4 At Design Discharge Of 10000 Cumec)

X-SEC NO.	W.L. ALONG DYKES	
	RIGHT SIDE	LEFT SIDE
U/S-32	201.5	201.9
U/S-30	201.5	201.7
U/S-28	201.5	201.7
U/S-26	201.4	201.7
U/S-24	201.4	201.5
U/S-22	201.3	201.4
U/S-20	201.3	201.1
U/S-18	201.2	200.8
U/S-16	201.1	200.8
U/S-14	200.7	200.7
U/S-12	200.7	200.7
U/S-10	200.6	200.6
U/S-8	200.5	200.6
U/S-6	200.2	200.5
U/S-4	200.2	200.5
U/S-2	199.5	200.5
B.C.L.	199.5	200.4
D/S-2	199.4	200.3
D/S-4	199.4	200.3
D/S-6	199.3	198.8
D/S-8	199.3	198.9
D/S-10	199.2	199.0

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Figure - 5.1

PROPOSED RAIL BRIDGE ACROSS RIVER YAMUNA NEAR TUGLAKABAD

TOPOGRAPHIC PLAN OF PROPOSED RAIL BRIDGE AND GUIDE BUNDS ACROSS RIVER YAMUNA

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Figure - 5.2

PROPOSED RAIL BRIDGE ACROSS
RIVER YAMUNA NEAR TUGLAKABAD

LAYOUT OF PROPOSED GUIDE BUNDS

RITES

Annexure 4.1

(FOR OFFICIAL USE ONLY)

RESEARCH REPORT NO. 80-RR(H_1-4)

MODEL STUDY FOR SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA)
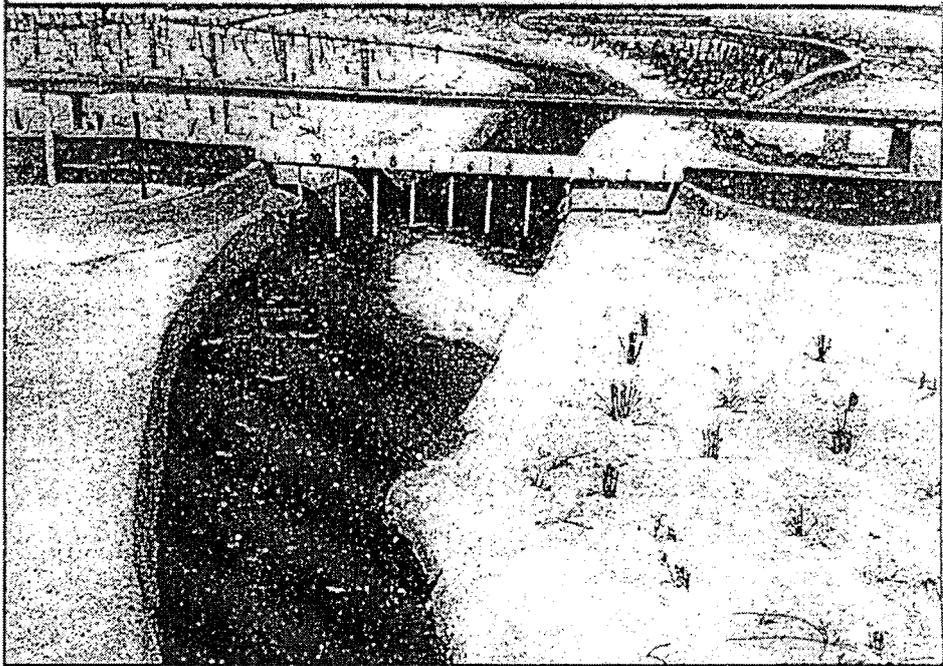
IRRIGATION RESEARCH INSTITUTE

ROORKEE – 247 667 (INDIA)

PRAMOD KUMAR BHARGAVA
CHIEF ENGINEER AND DIRECTOR

ROORKEE

APRIL 2009

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SYNOPSIS

Indian Railways plan to construct Eastern and Western Freight Corridors under Dedicated Freight Corridor project which is a very prestigious and time bound project of Indian Railways. A Railway bridge has been proposed on river Yamuna near Tughlakabad (Haryana) lies on. A physical model study of this railway bridge has been referred to the I.R.I. for fixation of waterway, exact location of abutments and suitable river training measures. Model studies were conducted on vertically exaggerated physical model built to 1:250 horizontal scale and 1:30 vertical scale with various proposals of bridge length and guide banks. Finally a 520.65 m long bridge with 11 spans of the bridge with pier spacing of 48.15 m c/o along with the elliptical guide bunds on both flanks as shown in Drg.-11 has been recommended for a design discharge of 10,000 cumec.

KEY WORDS : Railway Bridge, Guide Bund, Approach Embankment

SUBJECT : Fixation of waterway and river training works for the proposed bridge

PROJECT : Railway Bridge across river Yamuna near Tughlakabad (Haryana)

Approved by	Recommended by	Submitted by
(Y. N. GOEL) Superintending Engineer	(Y. N. Goel) Research Officer	(Puneet Kumal Mall) Asstt. Research Officer

1.0 INTRODUCTION

1.1 The Dedicated Freight Corridor Project is a dream project being undertaken by Indian Railways. The Project envisages construction of two freight corridors namely Western Freight Corridor and Eastern Freight Corridor covering 3300 route kilometers and aims at providing exclusive railway tracks for the freight trains to ensure free and faster movement of freight resulting in reduction of transit time and cost of transportation. It would lead to accelerated development of trade and industries and would ensure faster development of the nation.

1.2 The river Yamuna flows as a tortuous stream from South-East to North-West direction at Tughlakabad near Delhi-Haryana border. Though the deep channel of the river is meandering and well defined but during high floods the river overflows both banks and the flow spreads over the entire flood plains between the existing flood dykes. The river, therefore, was short listed from various small and big rivers for a model study.

2.0 THE PROBLEM

The General Manager (Civil), RITES BHAWAN, No. 1, Sector-29, Gurgaon (Haryana) vide his office letter no. RITES/RI/RCED/DFC/MS/2008, dated: 10.01.08 referred the problem to the Irrigation Research Institute, Roorkee whereby a physical model study for construction of a railway bridge across river Yamuna near Delhi-Haryana border at Tughlakabad (Haryana) was desired to be conducted in order to determination of optimum length of bridge, its orientation, location of abutments and river training works for the bridge at the proposed location.

3.0 THE DATA

For conducting the present model studies the following data/drawings were supplied by the sponsor vide letter dated : 24.01.08, dated : 25.06.08, and dated : 11.12.08.

(i) Topographic survey/contour plan (1:10000) of the river of year 2008 in the reach between 12 km upstream to 5 km downstream of the bridge.

(ii) River cross sections (1:2500) in the above study reach at 200, 400 m interval.

(iii) Guide bund area of south and north bank of river Yamuna.

(iv) The design discharge of river, 10,000 cumec.

(v) H. F. L. at design discharge = 199.5 m.

(vi) River bed slope = 1 in 5300.

(vii) Satellite imageries.

(viii) Terms of reference for the study: To determine length of the proposed bridge, positions of the abutments and to suggest suitable river training measures.

(ix) Gauge-Discharge curve of the river at B.C.L.

4.0 GAUGE-DISCHARGE CURVE AND HYDROGRAPH

4.1 Gauge-discharge (G-Q) curve of the river Yamuna at the centre line of the bridge (B. C. L.) was supplied by the sponsor. From this G-D data the stage-discharge curves at the bridge axis, in the upstream of B.C.L. at km 1.4, 3.8 and 5.8 were developed (Drg.-4) for proving of the model and conducting onward experiments.

4.2 In the absence of any supplied flood hydrograph of the river, an arbitrary single peak flood hydrograph having flood peak of 10,000 cumec as shown in Drg.-3(b) was prepared for the purpose of testing each proposal of the study under simulated flood conditions.

5.0 THE MODEL

5.1 As per the survey drawings/data supplied by the sponsors a distorted or vertically exaggerated physical model with mobile bed and rigid banks was built on the following scales:

Horizontal   1:250

Vertical   1:30

Discharge   1:41080

5.2   For the purpose of conducting model study, the supplied entire river : each from 12 km upstream to 5 km downstream of the proposed bridge was represented in the model. All existing pucca works such as flood dykes on both banks as well as cultivated area and forestation etc. were also represented as per the drawings supplied by the field engineers in the model.

5.3   The river bed in the model was laid (dressed) in locally available sand and was made to conform to the supplied river survey of the year 2008. The discharge fed into the model was measured with a sharp crested weir arrangement provided at the head of the model. During the running of model, the surface water levels and flow velocities were measured with the help of a scale graduated according to the vertical scale of the model and current meter respectively. The surface flow lines were observed by making use of suitable floats.

6.0   PROVING OF THE MODEL

6.1   After incorporating all existing and required features in the model, the river bed was made to conform to the supplied river survey of the year 2008 (Drg.-2). The fine clay was used in laying the river bed in the model to make the river bed least erodible as per site conditions reported by the sponsors. The ground levels of the flood plains on both sides of the river were laid according to the supplied fly levels.

6.2   After preparing the model as per survey plan and details supplied by the sponsors (Drg.-2), the arbitrary flood hydrograph having a maximum peak of 10,000 cumec (Drg.-3(b)) was run in the model. Various flood stages ranging from 1000 cumec to the peak flood of 10,000 cumec were run in the model and

water levels were recorded at B.C.L. and at 1.4 Km., 3.8 Km. & 5.8 Km. upstream sections maintaining corresponding water levels at 2.0 Km. downstream section. These water levels were found to be in close proximity to the theoretical water levels computed at these sections with the help of the supplied gauge discharge curve using slope effect of 1 in 5300 i.e. 0.189 m per kilometer (Drg.-4). The running of the model was witnessed by the sponsors and they were of the opinion that the flow conditions in the model resembled to those at the site. The model was, therefore, taken as proved.

7.0   MODEL INVESTIGATIONS

7.1   STUDY – 1 : UNDER EXISTING CONDITIONS (river survey of post floods 2008)

7.1.1 'After proving of the model the river bed was dressed again according to the supplied river survey and fly levels of the flood plain. The arbitrary flood hydrograph having a peak of 10000 cumec (Drg.3(B)) was run in the model.

7.1.2 During the running of adopted hydrograph it was seen that up to about 3000 cumec discharge the flow remained confined within the banks of the river, but for a discharge more than 3000 cumec, the water got overflowed both the banks and spread over the flood plains. As the khadir on the both flanks had almost same levels, the flow soon reached to the flood dykes on either side. On increasing the discharge further upto 6600 cumec, the main river flow in the upstream of the proposed bridge deviated from its original curved path and took a short-circuited route along the right flood dyke over the flood plains. Such a short-circuiting by the river made the flow oblique on to the bridge as shown in the Drg.-6. The surface flow lines were observed at 3300, 6600 and 10000 cumec discharge and are shown in Drg.- 5, 6 and 7 respectively. The corresponding flow velocities at various critical points along the both dykes in the upstream and downstream of the bridge are also shown in these drawings.

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7.1.3 At higher discharges it was observed that the existing flood dykes on both banks got overtopped at several places. Therefore, on the recommendation of the site engineers the height of both the dykes were raised adequately in the model so as to ensure no spilling anywhere over them. Thus the entire flow up to the maximum discharge remained completely confined within the dykes on both banks.

7.2   STUDY-2 :

(i) Post monsoon river topographic survey of the year 2008.

(ii) 529.65 m long proposed railway bridge having 11 spans

(with pier spacing of 48.15 m c/c)

7.2.1 As per intimation from the sponsors, a 529.65 m long railway bridge having 11 spans with pier spacing @ 48.15 m c/c was initially tested in the model on the basis of Lacey's waterway for the maximum discharge of 10,000 cumec. The bridge with the approach embankments was constructed as per supplied alignment drawing of proposed track as shown in Drg.-8. The left abutment of the bridge was positioned at a distance of 25.0 m from the left high bank line as per discussions with the sponsors.

7.2.2 After incorporating the above proposal in the model, the river bed in the model was again dressed as per the supplied survey data. The adopted hydrograph was run in the model and the surface flow lines were observed at the maximum discharge of 10000 cumec. These flow lines along with the velocities of flow at various critical points along the flood dykes in the upstream and downstream of the bridge are shown in Drg.- 8. In the upstream of the bridge, the raised water level due to the afflux caused after the construction of bridge and the railway track are also shown in Drg.- 8. At the discharge of 3300, 6600 and 10,000 cumec the flow velocities across the proposed bridge recorded in the centre of each bay are given in Table - 1.

7.2.3 The study of flow lines at the maximum discharge in the Study – 1 & 2, it could be seen that the direction of flow approaching the bridge has been conspicuously changed after the construction of approach embankment. Thus, in the upstream of the proposed bridge site, the river instead of flowing across the river banks earlier was converged along the approach embankment and pass eventually through the bridge only. This was obviously due to the construction of railway embankment and a bridge in the path of the river flow. However, the obliquity of flow in the bridge bays was high which indicated the need of river training work especially on the right bank. In this regard, as per the discussion between the I. R. I. officers and the field engineers, it was decided that a guide band suitably slanting away from the bridge be provided on the right bank in the upstream which would smoothly guide the flow in to the bridge. Moreover, to take care of the flow obliquity on to the left bank too, it was also felt to construct a left guide bund that would deflect the flow further towards bridge bays.

7.3 STUDY 3 :

(i) 529.65 m long proposed railway bridge having 11 spans of length 48.15 m each along with railway track.

(ii) Elliptical guide bunds with circular head on the upstream (Drg.- 9).

7.3.1 As mentioned in the preceding paragraph, an elliptical guide bund of u/s projected length 270 m conforming to part of an ellipse $\dfrac{x^2}{300^2}+\dfrac{y^2}{150^2}=1$ followed by curved head of radius 225.0 m and sweep angle 45^0 was constructed in the model on the right bank to guide the flow smoothly towards the bridge. Also, as the flow in the upstream was highly oblique (para 7.2.3) to the proposed bridge alignment, therefore, for ensuring non separation of the flow from the guide bund and having the flow closely following the profile of the right guide bund, the right guide bund was rotated in the plan to 30^0 anti-clock wise as shown in Drg.-9. On left bank, to deflect the flow towards the bridge bays and also to render the approaching flow to be streamlined for passing through the bridge, an elliptical

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guide bund (Drg.-9) conforming to part of an ellipse $\frac{x^2}{400^2} + \frac{y^2}{200^2} = 1$ followed by curved head of radius 100.0 m and sweep angle 45^0 was provided in the upstream of the bridge. In the downstream, the projected length of each of the guide bund was kept as 128.6 m with curved tail of R = 100.0 m and sweep angle $\theta = 45^0$.

7.3.2 The above proposal was incorporated in the model and its bed was re-laid as before as per the supplied survey of the year 2008. The adopted hydrograph was run in the model and the surface flow lines were observed at the design discharge 10000 cumec. These flow lines along with the velocities of flow recorded at various critical points along the flood dykes are shown in Drg.-9. At the discharge of 10000 cumec, the maximum velocities observed along the left and right guide bunds are 2.80 m/s and 2.99 m/s respectively. No measurable velocity was observed anywhere along the approach embankment.

7.3.3 At the discharge of 3300, 6600 and 10000 cumec the observed velocities and discharge distribution across the bridge bays are given in the Table-2. These observations show that at the design discharge 10,000 cumec the maximum velocity of the order of 3.18 m/s with corresponding discharge intensity of 35.69 cumec/m was observed in the 9th bay from the right abutment of the bridge.

7.3.4 A study of the above results indicated that after introduction of guide bund on each bank of the river, the flow along them was quite smooth and closely followed their profiles. The left guide bund effectively diverted the flow through the bridge. This diverted stream following the profile of the left guide bund merged with the main oblique flow in the upstream of the bridge and thus helped activate the rightmost bridge bays. At the end of the curved head of right guide bund somewhat mild rotational flow was observed due to the abrupt difference of water levels on the opposite faces of the guide bund. This indicated the requirement of an increase in the length of the curved head with greater

curvature and sweep angle. At the design discharge of 10,000 cumec, almost no flow was observed near the end of the curved head of the left guide bund. Therefore, on grounds of economy it was decided to curtail the curved length of the left guide bund by means of reducing the sweep angle suitably.

7.4   STUDY 4 :

(i)   529.65 m long proposed railway bridge having 11 spans of length 48.15 m each along with railway track.

(ii)   Modified elliptical guide bunds on both flanks as shown in Drg.-11.

7.4.1 As described in paragraph 6.3.4 above, the upstream elliptical guide bund on the right bank was kept almost same as in Study-3 but the curved head was modified to have greater curvature and sweep angle. Thus, as compared to Study-3, in the present study the radius of curved head 'R' was reduced from 225 to 80 m while the angle of sweep was increased from 45^0 to 90^0. Moreover, as mentioned above in the paragraph 6.3.4, the length of the curved head of left elliptical guide bund was curtailed by about 50 m. Thus on the left bank a guide bund conforming to part of an ellipse $\dfrac{x^2}{350^2}+\dfrac{y^2}{175^2}=1$ followed by a circular head of radius 'R' = 100 m and sweep angle 30^0 was provided in the model to effectively divert the approaching oblique flow towards right and to pass through the bridge bays. In the downstream of the bridge, however, both the guide bunds were retained to be the same as provided in Study-3.

7.4.2 With the incorporation of above modifications in the layout of the guide bunds, the river bed of the model was relaid as before as per the supplied river survey (Drg.-2). The arbitrary flood hydrograph (Drg.-3(b)) was run in the model and the surface flow lines were observed at the 10000 cumec discharge (Drg.-10). The velocities observed at the critical point along the flood dykes and along the guide bunds have also been shown in this drawing. It was found that the flow conditions in the present study were quite smooth and stream lined as compared

to that in Study-3. No cross flow was observed along the approach embankment. Based on the afflux observations on the model, the design H.F.L. at the design discharge 10,000 cumec has been observed as 199.7 m as shown in Drg.-10.

7.4.3 At the discharge of 3300, 6600 and 10,000 cumec the observed discharge intensities and percentage discharge distribution across the bridge bays are given in Table-3. A study of this table showed that with the above modification in the layout of the guide bunds, the discharge distribution across the bridge bays has been improved over the corresponding results as observed in Study-3. The discharge intensity in the end bays of the bridge increase to some extent. The maximum concentration of discharge was seen in the 10th bay from the right abutment where the maximum discharge intensity of 37.38 cumec/m bay width was recorded at the design discharge 10,000 cumec.

8.0 DISCUSSIONS AND CONCLUSIONS

8.1 It was seen during the study that the height of existing flood dykes is not adequate at few places. Consequently, at higher discharges the flood water started to overflow dykes at these points. As such the dykes on either flank should be sufficiently raised above the water levels which have been shown in Drg.-11 for the maximum river discharge 10,000 cumec.

8.2. The flow in the river remained well confined within the channel only upto the discharge of about 3300 cumec. At higher discharges the flow started to spread over the flood plains and reached flood dykes on each bank. At a discharge of more than 6600 cumec, the flow instead of following the curved loop of the main deep channel, rather took a short-circuited path as shown in Drg.-6. Thus, due to deviation in the path of approaching flow at higher discharges, the flow in the upstream of the bridge became highly oblique on to the bridge. In order to effectively divert and guide this oblique flow towards the bridge, elliptical guide bunds as shown in Drg.11 had to be provided on either bank.

8.3   At the higher discharges as the flow spreads over the flood plains, the river width is governed by the flood dykes on both flanks. Therefore, in order to ensure the flow to conform well to the profile of the right guide bund as well as to improve the intensity of flow in the rightmost spans, a splay of 30^0 in the anticlockwise direction was given in the upstream right guide bund as shown in Drg.11.

8.4   Lacey's method was adopted as a guide to determine the bridge waterway. Trials with different bridge spans were carried out and eventually 11 nos. of spans @ 48.15 m c/c spacing of piers along with the elliptical guide bunds as shown in Drg.11 have been found to be the optimum.

8.5   To safe guard the guide bunds as well as the approach embankment, it is desirable that the construction of a guide bund is completed within one working season.

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TABLE-1
OBSERVED VELOCITIES, DISCHARGE INTENSITIES, PERCENTAGE DISCHARGE DISTRIBUTION ACROSS THE B.C.L.

STUDY-2 : BRIDGE LENGTH=529.65 m i.e. 11 SPANS EACH OF 48.15m LENGTH (WITHOUT GUIDE BUND)

Bay No. from right	Q=3,300 cumec			Q=6,600 cumec			Q=10,000 cumec		
	Velocity (m/sec)	% Discharge	Intensity (cumec/m)	Velocity (m/sec)	% Discharge	Intensity (cumec/m)	Velocity (m/sec)	% Discharge	Intensity (cumec/m)
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.43	0.60	0.433	2.14	3.44	4.98	2.61	4.04	8.85
3	0.52	0.70	0.523	2.04	3.28	4.75	2.52	4.18	9.16
4	0.81	5.56	4.022	1.76	7.37	10.65	2.61	9.81	21.30
5	1.08	6.02	4.343	2.23	9.33	13.49	2.89	11.51	25.20
6	1.47	10.22	7.390	3.28	14.78	21.37	3.18	13.36	29.27
7	1.76	13.46	9.728	2.61	12.61	18.22	2.71	11.99	26.26
8	1.95	17.63	12.743	3.28	15.84	22.90	2.80	13.01	28.49
9	2.14	23.82	17.214	2.80	14.42	20.85	2.89	13.74	30.10
10	1.86	21.99	15.899	3.18	18.43	26.64	3.57	17.37	38.05
11	0.00	0.00	0.00	0.52	0.50	0.72	1.28	0.99	2.17

11

TABLE-2
OBSERVED VELOCITIES, DISCHARGE INTENSITIES,
PERCENTAGE DISCHARGE DISTRIBUTION ACROSS THE B.C.L.

STUDY-3 : BRIDGE LENGTH=529.65 m i.e. 11 SPANS EACH OF 48.15m LENGTH,
ELLIPTICAL LEFT AND RIGHT GUIDE BUND

Bay No. from right	Q=3,300 cumec			Q=6,600 cumec			Q=10,000 cumec		
	Velocity (m/sec)	% Discharge	Intensity (cumec/m)	Velocity (m/sec)	% Discharge	Intensity (cumec/m)	Velocity (m/sec)	% Discharge	Intensity (cumec/m)
1	0.89	1.03	0.74	2.04	2.59	3.74	2.24	2.35	5.14
2	0.99	1.15	0.83	2.89	4.08	5.89	2.89	4.04	8.85
3	0.99	1.15	0.83	3.09	4.36	6.30	3.09	4.32	9.46
4	1.28	7.40	5.35	2.52	8.53	12.33	1.95	7.27	15.92
5	1.47	7.65	5.53	2.89	10.59	15.32	2.89	12.79	28.01
6	1.86	9.68	7.00	2.80	10.27	14.84	1.86	8.66	18.98
7	2.42	14.00	10.12	3.28	13.88	20.06	3.18	14.81	32.45
8	2.89	18.39	13.39	3.09	13.94	20.16	3.09	15.11	33.11
9	2.99	20.75	15.00	3.18	16.14	23.34	3.18	16.29	35.69
10	2.71	18.80	13.60	2.42	13.65	19.74	2.61	12.46	27.30
11	0.00	0.00	0.00	2.33	1.97	2.85	2.33	1.90	4.16

TABLE-3
OBSERVED VELOCITIES, DISCHARGE INTENSITIES, PERCENTAGE DISCHARGE DISTRIBUTION ACROSS THE B.C.L.

STUDY-4 : BRIDGE LENGTH=529.65 m i.e. 11 SPANS EACH OF 48.15m LENGTH, ELLIPTICAL LEFT AND RIGHT GUIDE BUND

Bay No from right	Q=3,300 cumec			Q=6,600 cumec			Q=10,000 cumec		
	Velocity (m/sec)	% Discharge	Intensity (cumec/m)	Velocity (m/sec)	% Discharge	Intensity (cumec/m)	Velocity (m/sec)	% Discharge	Intensity (cumec/m)
1	0.61	0.81	0.58	1.57	1.62	2.34	3.18	3.97	8.70
2	0.99	1.31	0.95	2.33	2.40	3.47	3.18	3.97	8.70
3	0.80	1.06	0.77	2.33	3.20	4.62	3.57	4.46	9.77
4	0.80	4.77	3.45	2.04	8.39	12.14	2.33	8.24	18.06
5	0.89	5.31	3.84	2.23	10.70	15.48	3.28	12.97	28.41
6	1.38	8.23	5.95	2.33	11.19	16.17	2.71	10.72	23.47
7	1.66	11.00	7.95	2.23	10.70	15.48	2.61	9.23	20.23
8	1.95	15.51	11.21	2.42	14.11	20.40	3.09	12.22	26.77
9	2.42	23.26	16.81	2.52	17.28	24.99	3.09	14.79	32.40
10	2.71	28.74	20.77	2.80	19.20	27.76	3.28	17.07	37.38
11	0.00	0.00	0.00	1.76	1.21	1.75	2.52	2.36	5.17

13

8.9

TABLE-4
OBSERVED WATER LEVELS ALONG DYKE
(FOR STUDY - 4 AT DESIGN DISCHARGE OF 10,000 CUMEC.)

X-SEC NO.	W.L. ALONG DYKES	
	RIGHT SIDE	LEFT SIDE
U/S-32	201.5	201.9
U/S-30	201.5	201.7
U/S-28	201.5	201.7
U/S-26	201.4	201.7
U/S-24	201.4	201.5
U/S-22	201.3	201.4
U/S-20	201.3	201.1
U/S-18	201.2	200.8
U/S-16	201.1	200.8
U/S-14	200.7	200.7
U/S-12	200.7	200.7
U/S-10	200.6	200.6
U/S-8	200.5	200.6
U/S-6	200.2	200.5
U/S-4	200.2	200.5
U/S-2	199.5	200.5
B.C.L.	199.5	200.4
D/S-2	199.4	200.3
D/S-4	199.4	200.3
D/S-6	199.3	198.8
D/S-8	199.3	198.9
D/S-10	199.2	199.0

90

TABLE-5
OBSERVED VELOCITIES, DISCHARGE INTENSITIES,
PERCENTAGE DISCHARGE DISTRIBUTION ACROSS THE B.C.L.

STUDY-5 : BRIDGE LENGTH=481.50 m i.e. 10 SPANS EACH OF 48.15m LENGTH,
ELLIPTICAL LEFT AND RIGHT GUIDE BUND

Bay No. from Right	Q = 10000 cumec		
	Velocity (m/s)	% Discharge	Intensity (cumec/m)
1	2.61	2.12	4.65
2	3.37	3.66	8.01
3	3.66	10.59	23.20
4	3.76	12.24	26.81
5	3.95	14.29	31.29
6	3.37	12.80	28.03
7	3.47	13.18	28.87
8	3.47	14.44	31.62
9	3.47	13.80	30.25
10	3.18	2.88	6.29

T-C

15
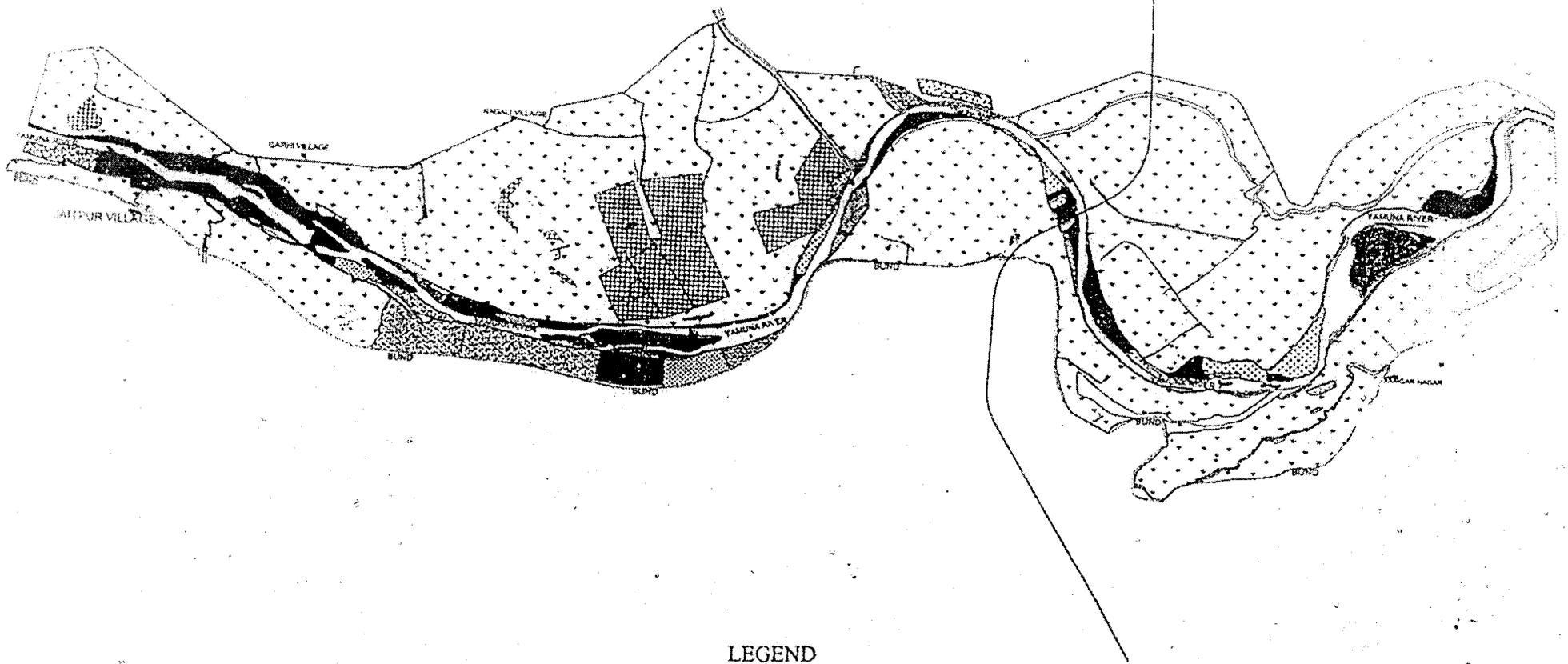
LEGEND

1	Water Line	
2	Road	
3	Bridges	
4	High Bank	
5	Barren Land	
6	B C L	
7	Agricultural Land	
8	Forest	

I. R. I. ROORKEE	
SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD(HARYANA)	
INDEX MAP OF THE SITE	
DRAWN	A.R.O.-2
CHECKED	R.O. H-1

DRG. 1(80-H₁-04)
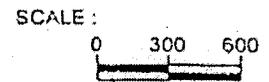
I. R. I. ROORKEE

SITING RAILWAY BRIDGE ACROSS
RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA)

SURVEY AS LAID

| DRAWN | A.R.O.-2 |
| CHECKED | R.O. H-1 |

DRG. 2(79-H₁-06)

93

YAKUTPUR VILLAGE

PROPOSED
B.C.L.

BUND

YAMUNA RIVER

LEGEND

——————— RIVER BANKS

——0—— CONTOURS

——————— EXISTING BUND

— · — · — PROPOSED B.C.L.

SCALE :

0   300   600

RIVER BED SURVEY OF THE YEAR 2008

I. R. I. ROORKEE	
SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA)	
SURVEY AS LAID	
DRAWN	A.R.O.-2
CHECKED	R.O. H-1
DRG. 2(80-H₁-04)	

94

(a) THEORETICAL GAUGE DISCHARGE CURVE
AT 1.4 Km. U/S OF PROPOSED BRIDGE AXIS

$G = 185.92 \, Q^{0.0078}$

MAX. PEAK DISCHARGE
$Q = 10000$ CUMEC

6600 CUMEC

3300 CUMEC

TIME IN HOURS
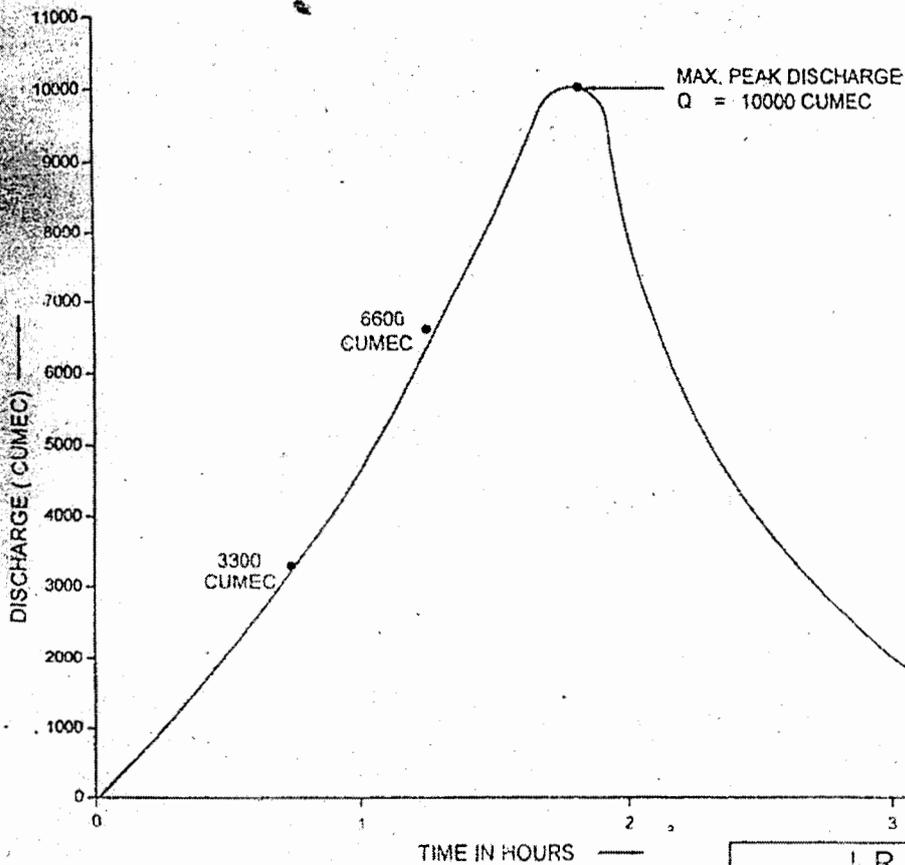
(b) ARBITRARY FLOOD HYDROGRAPH

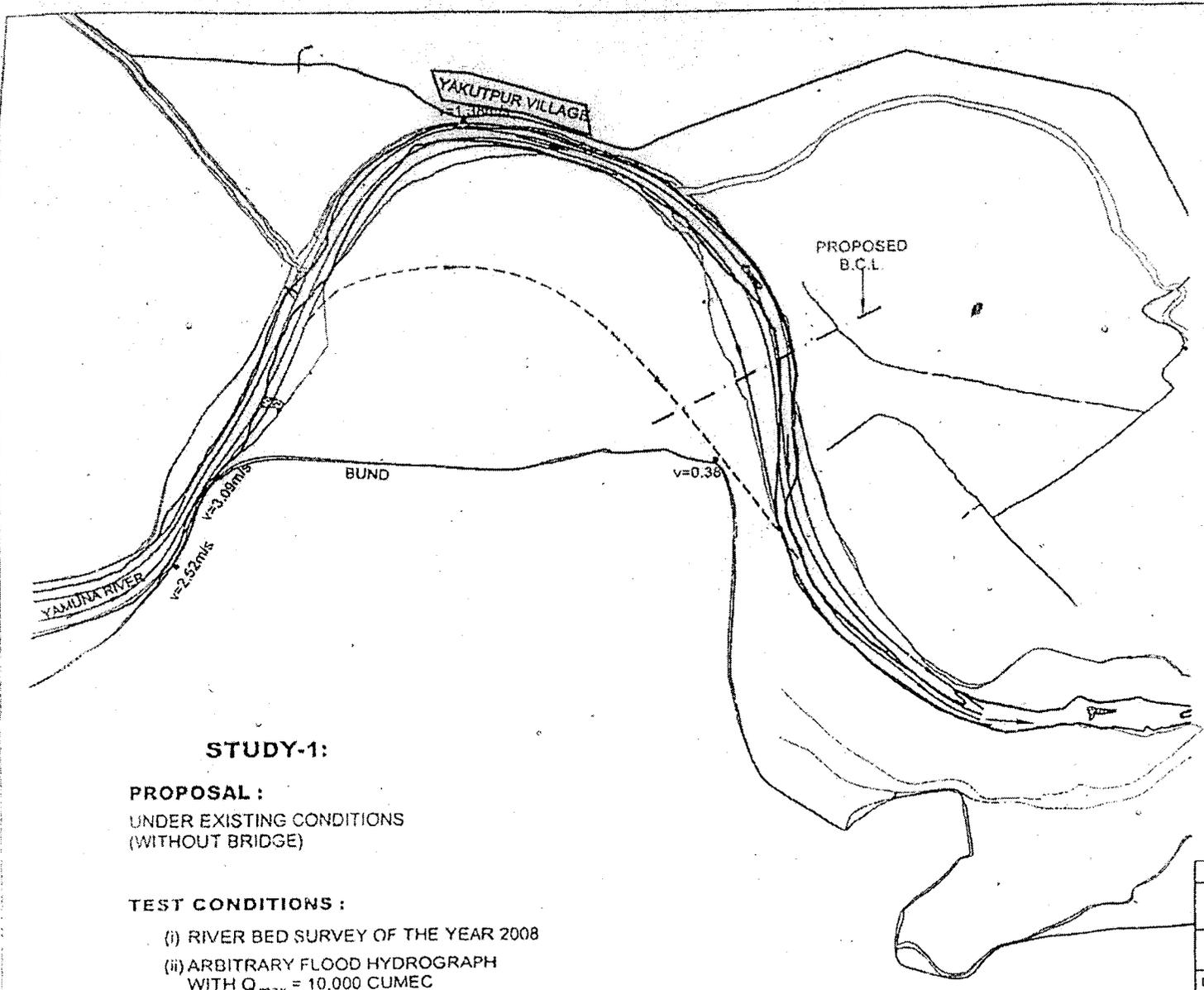| I. R. I. ROORKEE	
SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA)	
STAGE DISCHARGE CURVE & ARBITRARY FLOOD HYDROGRAPH	
DRAWN	A.R.O.-2
CHECKED	R.O. H-1

DRG. 3(80-H₂-04)

19

95

X-SEC AT Km. 5.80 U/S

X-SEC AT Km. 1.40 U/S

X-SEC AT Km. 3.80 U/S

X-SEC AT BCL
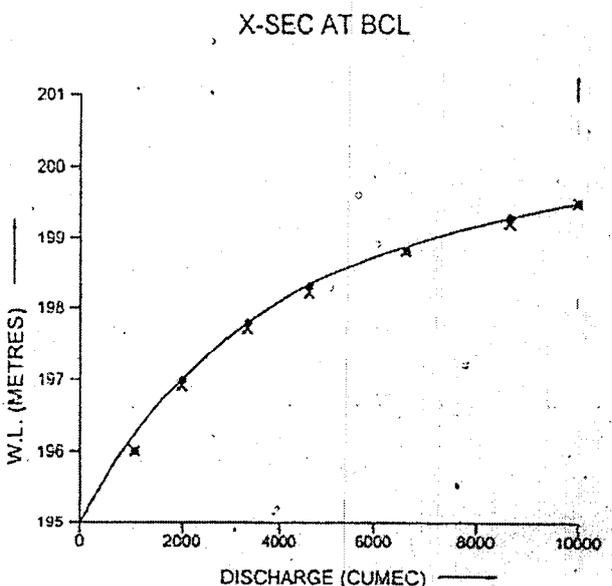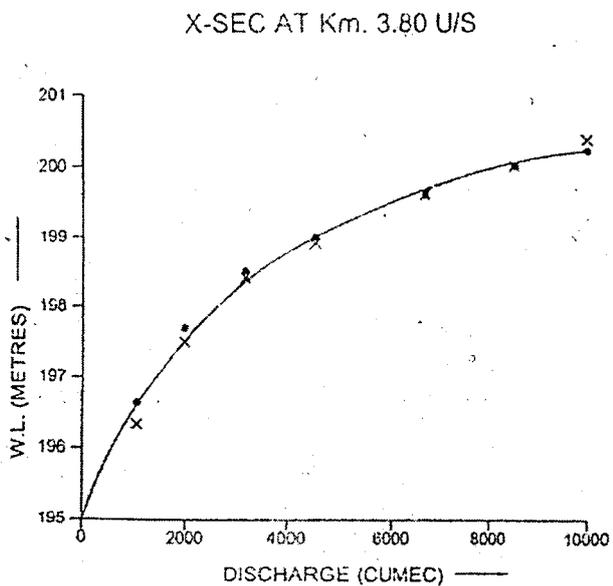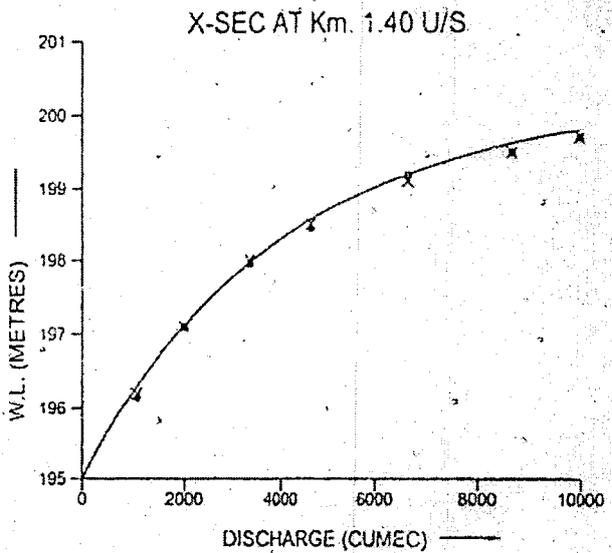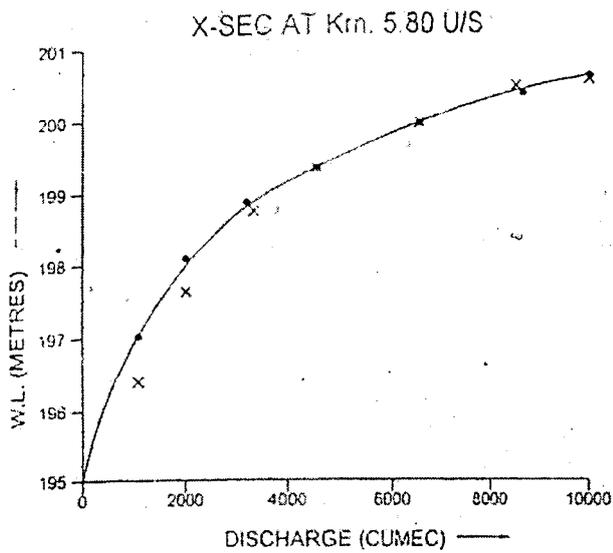
LEGEND :-
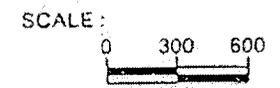1. THEORETICAL CURVE
2. OBSERVED W.L.   ×   ×   ×

I. R. I. ROORKEE	
SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD(HARYANA)	
PROVING OF MODEL	
DRAWN	A.R.O.2
CHECKED	R.O. H-1

DRG. 4(80-H₁-04)

20

96

LEGEND

— RIVER BANKS

— FLOW LINES

— EXISTING BUND

— · — PROPOSED B.C.L.

PROPOSED
B.C.L.

YAKUTPUR VILLAGE

BUND

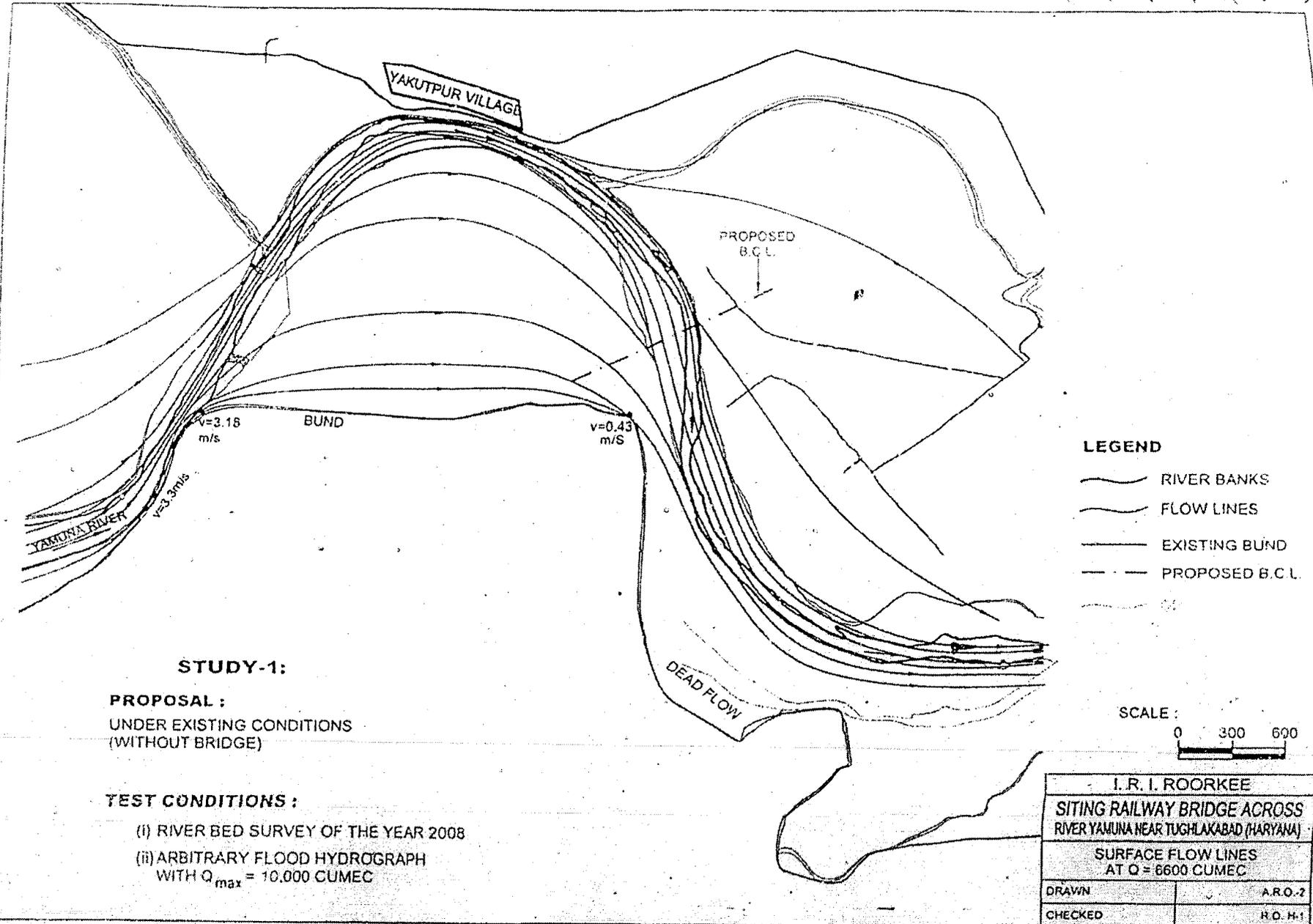v=0.38

v=3.09m/s

v=2.52m/s

YAMUNA RIVER

STUDY-1:

PROPOSAL :

UNDER EXISTING CONDITIONS
(WITHOUT BRIDGE)

TEST CONDITIONS :

(i) RIVER BED SURVEY OF THE YEAR 2008

(ii) ARBITRARY FLOOD HYDROGRAPH
WITH Q_{max} = 10,000 CUMEC

SCALE :

0   300   600

I. R. I. ROORKEE	
SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA)	
SURFACE FLOW LINES AT Q = 3300 CUMEC	
DRAWN	A.R.O.-2
CHECKED	R.Q. H-1

DRG. 5(80-H₁-04)

21

T.C
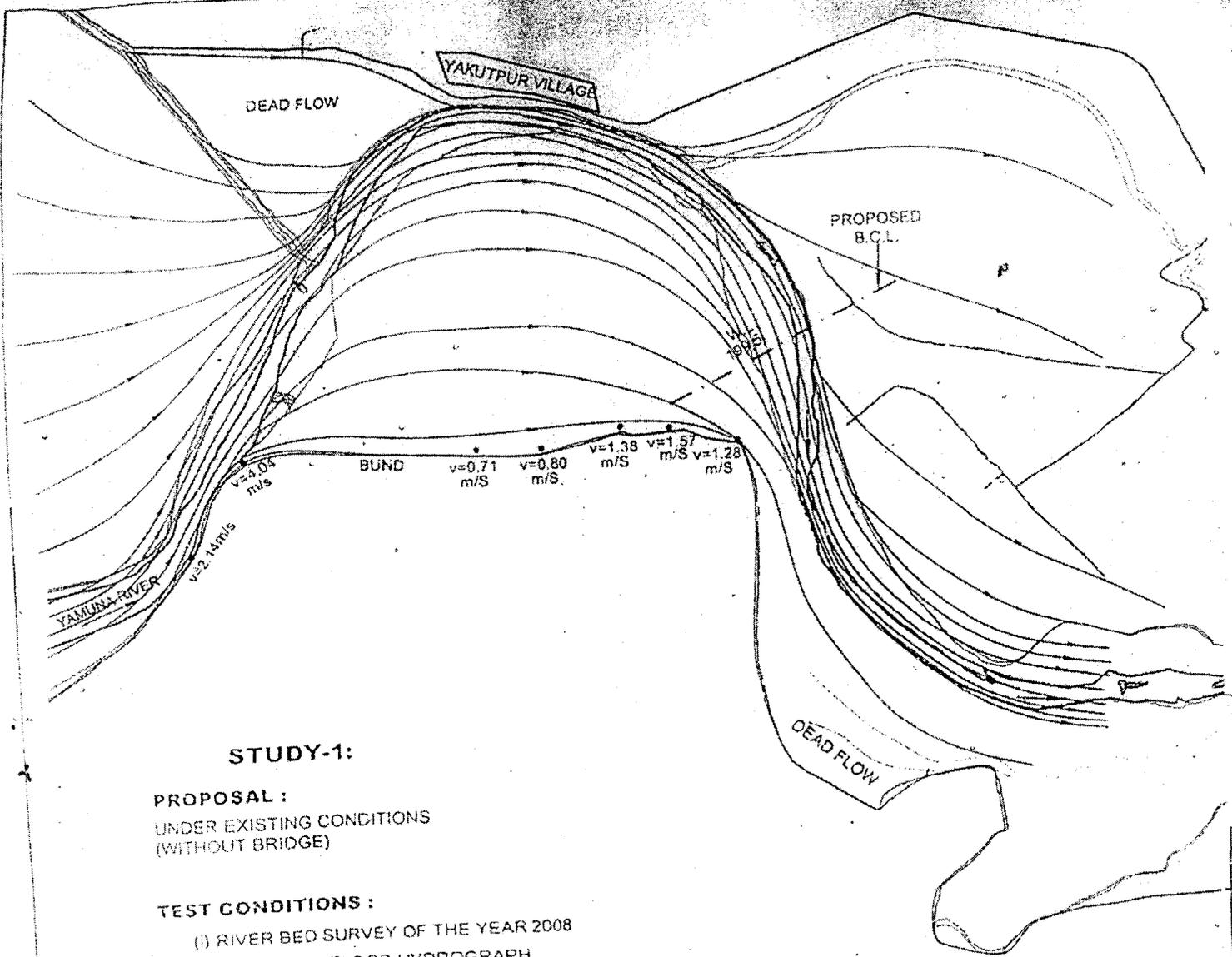
STUDY-1:

PROPOSAL :

UNDER EXISTING CONDITIONS
(WITHOUT BRIDGE)

TEST CONDITIONS :

(i) RIVER BED SURVEY OF THE YEAR 2008

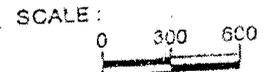(ii) ARBITRARY FLOOD HYDROGRAPH
WITH Q_{max} = 10,000 CUMEC

LEGEND

— RIVER BANKS

— FLOW LINES

— EXISTING BUND

—·—· PROPOSED B.C.L.

SCALE :

0   300   600

| I. R. I. ROORKEE |
| SITING RAILWAY BRIDGE ACROSS |
| RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA) |
| SURFACE FLOW LINES |
| AT Q = 6600 CUMEC |

| DRAWN | | A.R.O.-2 |
| CHECKED | | R.O. H-1 |

DRG. 6(80-H-04)

YAKUTPUR VILLAGE

PROPOSED B.C.L.

v=3.18 m/s   BUND   v=0.43 m/S

v=3.3m/s

YAMUNA RIVER

DEAD FLOW

22

DEAD FLOW

YAKUTPUR VILLAGE

PROPOSED B.C.L.

v=4.04 m/s

v=2.14 m/s

YAMUNA RIVER

BUND

v=0.71 m/S

v=0.80 m/S

v=1.38 m/S

v=1.57 m/S

v=1.28 m/S

DEAD FLOW

LEGEND

RIVER BANKS

FLOW LINES

EXISTING BUND

PROPOSED B.C.L.

SCALE:

0 300 600

STUDY-1:

PROPOSAL :

UNDER EXISTING CONDITIONS
(WITHOUT BRIDGE)
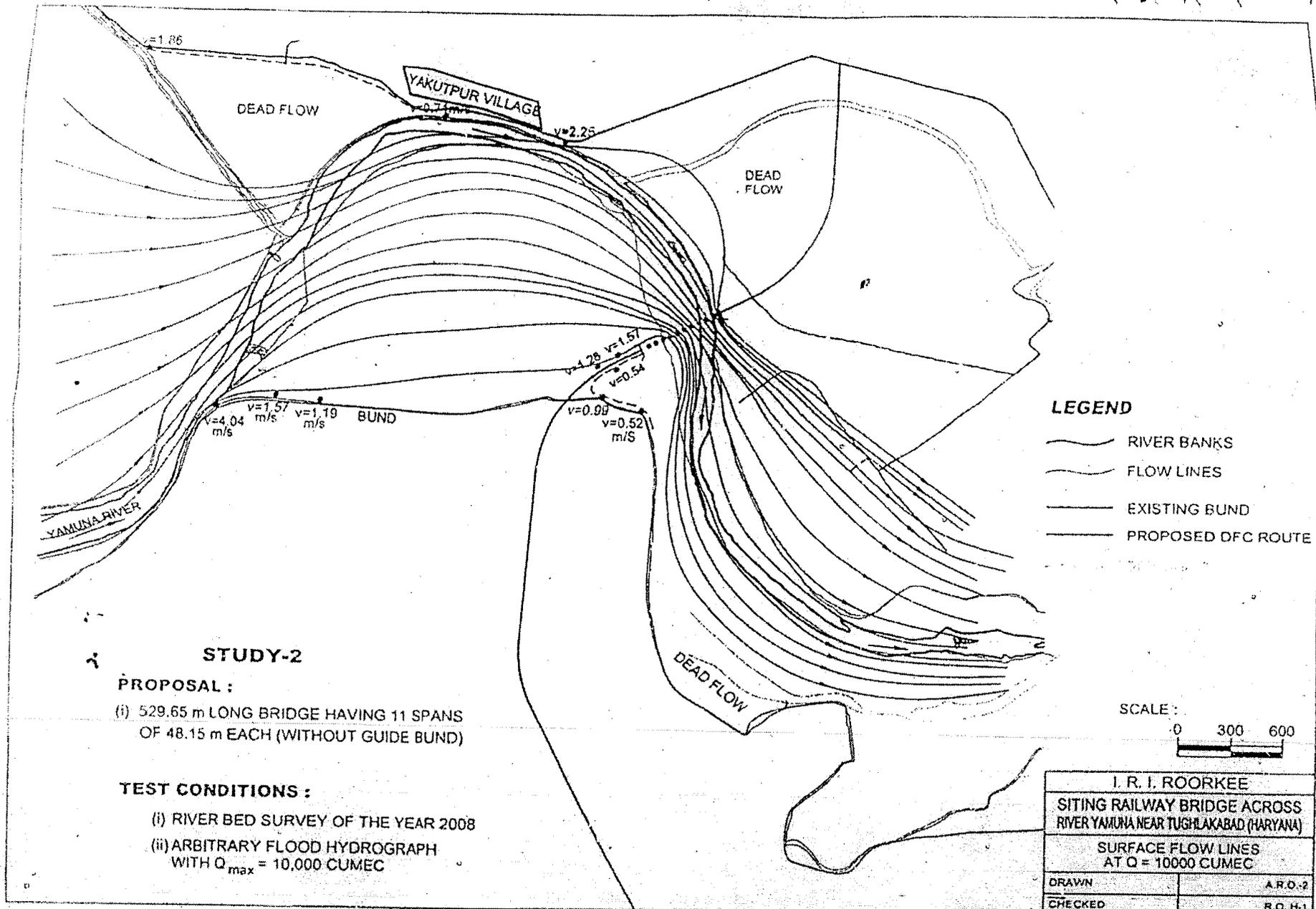
TEST CONDITIONS :

(i) RIVER BED SURVEY OF THE YEAR 2008

(ii) ARBITRARY FLOOD HYDROGRAPH
WITH Q_{max} = 10,000 CUMEC

I. R. I. ROORKEE	
SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA)	
SURFACE FLOW LINES AT Q = 10000 CUMEC	
DRAWN	A.R.O.-2
CHECKED	R.O. H-1

DRG. 7(60-H-04)

23

T. C

LEGEND

　　　　〜〜〜　RIVER BANKS

　　　　〜〜〜　FLOW LINES

　　　　———　EXISTING BUND

　　　　———　PROPOSED DFC ROUTE

DEAD FLOW

DEAD FLOW

DEAD FLOW

YAKUTPUR VILLAGE

v=1.86

v=0.71 m/s

v=2.26

v=1.57

v=1.28

v=0.54

v=1.57 m/s

v=1.19 m/s

BUND

v=4.04 m/s

v=0.99

v=0.52 m/s

YAMUNA RIVER

STUDY-2

PROPOSAL :
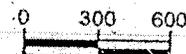
(i) 529.65 m LONG BRIDGE HAVING 11 SPANS
OF 48.15 m EACH (WITHOUT GUIDE BUND)

TEST CONDITIONS :

(i) RIVER BED SURVEY OF THE YEAR 2008

(ii) ARBITRARY FLOOD HYDROGRAPH
WITH Q_{max} = 10,000 CUMEC
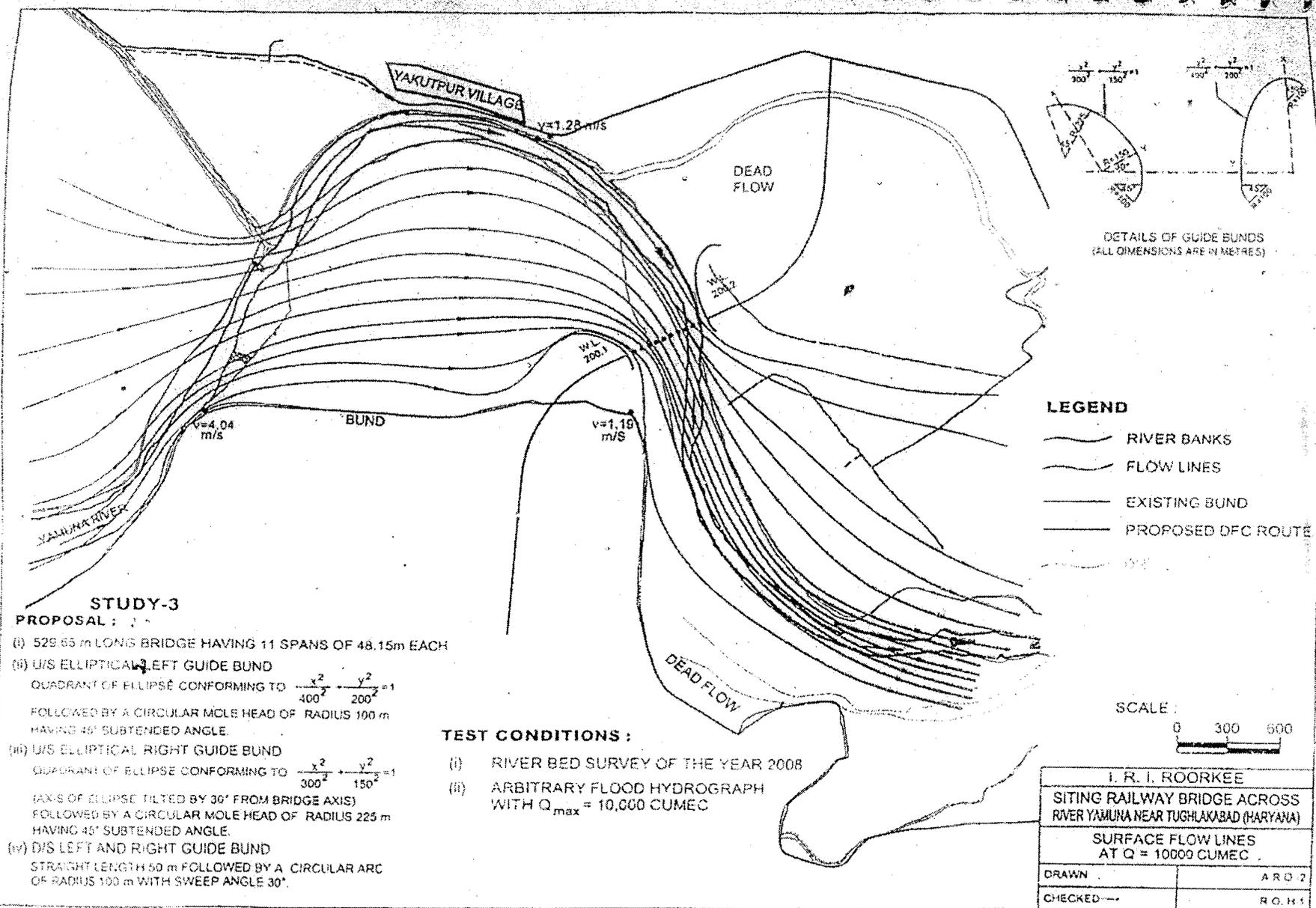
SCALE :

0　　300　　600

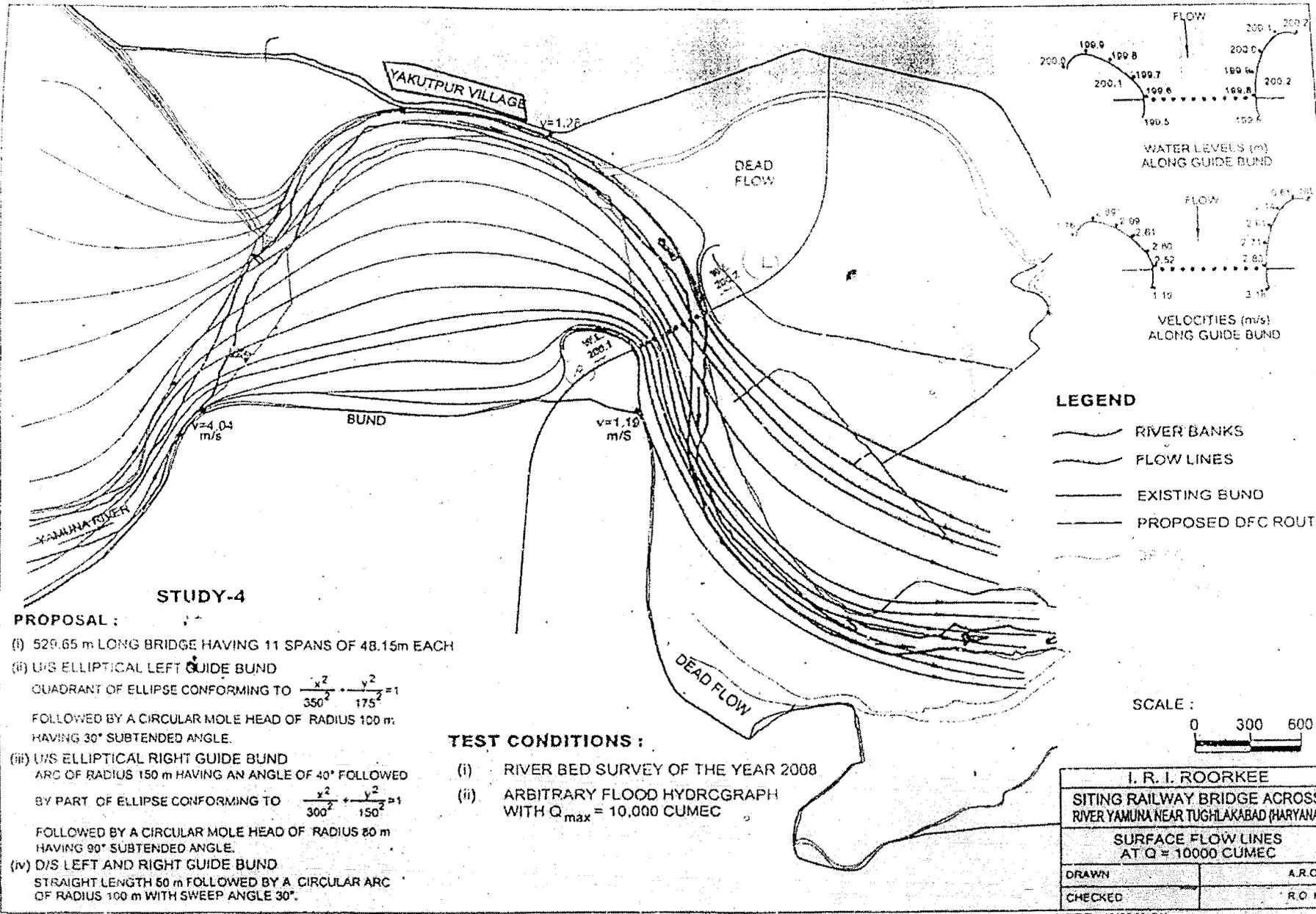| I. R. I. ROORKEE	
SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA)	
SURFACE FLOW LINES AT Q = 10000 CUMEC	
DRAWN	A.R.O.-2
CHECKED	R.O. H-1
DRG. 8(80-H₁-04)	

DETAILS OF GUIDE BUNDS
(ALL DIMENSIONS ARE IN METRES)

LEGEND

	RIVER BANKS
	FLOW LINES
	EXISTING BUND
	PROPOSED DFC ROUTE

STUDY-3

PROPOSAL :

(i) 529.65 m LONG BRIDGE HAVING 11 SPANS OF 48.15m EACH

(ii) U/S ELLIPTICAL LEFT GUIDE BUND

QUADRANT OF ELLIPSE CONFORMING TO $\frac{x^2}{400^2} + \frac{y^2}{200^2} = 1$

FOLLOWED BY A CIRCULAR MOLE HEAD OF RADIUS 100 m
HAVING 45° SUBTENDED ANGLE.

(iii) U/S ELLIPTICAL RIGHT GUIDE BUND

QUADRANT OF ELLIPSE CONFORMING TO $\frac{x^2}{300^2} + \frac{y^2}{150^2} = 1$

(AXIS OF ELLIPSE TILTED BY 30° FROM BRIDGE AXIS)
FOLLOWED BY A CIRCULAR MOLE HEAD OF RADIUS 225 m
HAVING 45° SUBTENDED ANGLE.

(iv) D/S LEFT AND RIGHT GUIDE BUND

STRAIGHT LENGTH 50 m FOLLOWED BY A CIRCULAR ARC
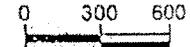OF RADIUS 100 m WITH SWEEP ANGLE 30°.

TEST CONDITIONS :

(i) RIVER BED SURVEY OF THE YEAR 2008

(ii) ARBITRARY FLOOD HYDROGRAPH
WITH Q_{max} = 10,000 CUMEC

SCALE :

0   300   600

I. R. I. ROORKEE	
SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA)	
SURFACE FLOW LINES AT Q = 10000 CUMEC	
DRAWN	A R D 2
CHECKED	R G H 1

DRG. 9(80-H₁-04)

FLOW

200.0 199.9 199.8 200.1 200.2
200.1 199.7 200.0
199.6 199.8
190.5 199.6 199.6

WATER LEVELS (m)
ALONG GUIDE BUND

FLOW

2.99 2.61 2.80 2.80
2.52
1.19 3.15

VELOCITIES (m/s)
ALONG GUIDE BUND

YAKUTPUR VILLAGE

v=1.26

DEAD FLOW

BUND

v=4.04 m/s

v=1.19 m/S

YAMUNA RIVER

DEAD FLOW

LEGEND

~~~ RIVER BANKS

~~~ FLOW LINES

—— EXISTING BUND

– – – PROPOSED DFC ROUTE

STUDY-4

PROPOSAL :

(i) 529.65 m LONG BRIDGE HAVING 11 SPANS OF 48.15m EACH

(ii) U/S ELLIPTICAL LEFT GUIDE BUND

QUADRANT OF ELLIPSE CONFORMING TO $\frac{x^2}{350^2} + \frac{y^2}{175^2} = 1$

FOLLOWED BY A CIRCULAR MOLE HEAD OF RADIUS 100 m.
HAVING 30° SUBTENDED ANGLE.

(iii) U/S ELLIPTICAL RIGHT GUIDE BUND
ARC OF RADIUS 150 m HAVING AN ANGLE OF 40° FOLLOWED

BY PART OF ELLIPSE CONFORMING TO $\frac{x^2}{300^2} + \frac{y^2}{150^2} = 1$

FOLLOWED BY A CIRCULAR MOLE HEAD OF RADIUS 80 m
HAVING 90° SUBTENDED ANGLE.

(iv) D/S LEFT AND RIGHT GUIDE BUND
STRAIGHT LENGTH 50 m FOLLOWED BY A CIRCULAR ARC
OF RADIUS 100 m WITH SWEEP ANGLE 30°.

TEST CONDITIONS :

(i) RIVER BED SURVEY OF THE YEAR 2008

(ii) ARBITRARY FLOOD HYDROGRAPH
WITH Q_{max} = 10,000 CUMEC

SCALE :

0   300   600

I. R. I. ROORKEE	
SITING RAILWAY BRIDGE ACROSS RIVER YAMUNA NEAR TUGHLAKABAD (HARYANA)	
SURFACE FLOW LINES AT Q = 10000 CUMEC	
DRAWN	A.R.O.-2
CHECKED	R.O H-1

DRG. 10(60-H-04)

₹5
NCT OF DELHI COURT FEE
DLCT2017673D2424K
20-APR-2024

ADVOCATES' WELFARE FUND STAMP
1100083
TWENTYFIVE RUPEES

VAKALATNAMA - अभिभाषक पत्र

In the Court of - न्यायालय *National Green Tribunal Principal Bench New Delhi*

Suit/Appesl/Revision/Misc/Execution No. *O.A. No. 641* Of 20*23*

Suman Chauhan & Ors.

Versus - विरुद्ध

State of Uttar Pradesh & Ors.

VAKALATNAMA OF- अभिभाषक पत्र ओर से *Respondent No. 8*

In the Case Noted above, I/We- उपरोक्त प्रकरण में, हम/मैं *Mr. Y.P. Sharma, Dy. Chief* **EACH OF SARV SRI- प्रत्येक की ओर से** *Project Manager, DFCCIL Noida Unit aged about 58 Years having an office at CAN Noida unit DFCCIL Complex Sector 145 Noida Noida 201310*

Shri./ श्री *SATYENDER CHAHAR, CHETAN SINGH* Advocate/ अधिवक्ता
P-3311-B-2007   PH/5202/2020

Is hereby appointed as counsel to appear, plead and act on behalf of the undersigned, in any manner, he think it proper, either himself or through any other Advocate and in particular to do the following, namely to receive any process of court (Including any notice from any appellate or revisional court), to file any applications, petitionsor pleadings, to file, produce or receive back any documents, to withdraw or compromise the proceedings, to refer any matter to arbitration, to deposit or withdraw any money, to execute any decree or order, to certify payment and/or receive any moneys due under such decree or order, to file appeal, revision, review or other necessary proceeding against any judgment, order or decree passed therein.

The undersigned shall be bound by all whatsoever may be done in the aforesaid case (including any appeal or revision there from) for and on behalf of the undersigned by any of the said counsels. The counsel will not be responsible in any manner or condition whatsoever may be. Counsel will have an right not to do the aforesaid acts, if payment of fee is not made to him, or for any other reason he thinks fit and proper.

को अपना अधिवक्ता नियुक्त किया जाता है, कि अधोहस्ताक्षरकर्ता की ओर से वे स्वयं अथवा किसी अन्य अधिवक्ता के माध्यम सेण जिस प्रकार भी वह उचित समझें, व किसी भी प्रकार से उपस्थित हों, अभिवचन व प्रतिवाद करें, और विशेषतः निम्न कार्य करें, जैसे कि न्यायालय की कोई भी आदेशिका-सूचना प्राप्त करें (किसी अपील अथवा पुनरीक्षण न्यायाल की सूचना सहित), कोई विषय को माध्यस्थम् को निर्दिष्ट करें, कोई धन जमा करें अथवा वापिस ले, किसी आज्ञप्ति अथवा आदेश को निष्पादन कराये, ऐसी आज्ञप्ति अथवा आदेश के अन्तर्गत किसी देय धन की संदाय (अदायगी) को प्रमाणित करें और/अथवा प्राप्त करें, इससे पारित किसी निर्णय, आदेश तथा आज्ञप्ति के विरुद्ध अपील, पुनरीक्षण, रिव्यू या अन्य आवश्यक कार्यवाही करें ।

उपरोक्त प्रकरण में (उसकी किसी अपील अथवा पुनरीक्षण सहित) उपरोक्त, अधिवक्ता द्वारा अधोहस्ताक्षरकर्ता की ओर से जो कुछ भी किया जायेगा, अधोहस्ताक्षरकर्ता उस सबके लिये, जो कुछ भी हो, बाध्य रहेगा/रहेंगे । अधिवक्ता किसी भी प्रकार से अथवा किसी भी अवस्था में, जो कोई भी हो, उत्तरदायी नहीं होंगे । अधिवक्ता को अधिकार होगा कि वह उपरोक्त कार्य न करें यांद उसे फास अदा न की गई हो अथवा अन्य किसी कारणवश वह उचित समझे ।

Signature- हस्ताक्षर

Name- नाम *Y.P. Sharma*

Date- तिथि *22-04-2024*

Attesting Withness- अनुप्रमाणक साक्षी

Signature- हस्ताक्षर

Name in full & adress - पूर्ण नाम एवं पता

Date- तिथि

Accepted- स्वीकृत/

Accepted in the strength of the Signature of the attesting witness- अनुप्रमाणक साक्षी के हस्ताक्षर के आधार पर स्वीकृत ।

Mr. AMAYA M. NAIR ADV.

Mr. Satyender Chahar Adv.

NISHANT KAMTAVALA, ADV हस्ताक्षर

Ms. Sangeeta gulati Adv.

नाम अधिवक्ता *CHETAN SINGH*
पंजीकरण संख्या *PH/5202/2020*
पता *103, SOUTH PARK APARTMT KALKAJI, DELHI-110019*

Suresh Srivastava <suresh.srivastava@aureuslaw.com>

Service-OA No. 641/2023 titled as Suman Chauhan & Ors Vs State of Uttar Pradesh & Ors.

1 message

Suresh Srivastava <suresh.srivastava@aureuslaw.com>   Tue, Apr 30, 2024 at 6:43 PM
To: "manoj@synergyinfracon.com" <manoj@synergyinfracon.com>, csup@nic.in, ceodelhi.djb@nic.in, ceifed@gmail.com, csdelhi@nic.in, "fciwrd@gmail.com" <fciwrd@gmail.com>, "ceo@noidaauthorityonline.com" <ceo@noidaauthorityonline.com>, eincididuplu-up@nic.in, dmgbn@nic.in
Cc: Praveen Singh <adpraveensingh@gmail.com>, Satyender Chahar <satyender.chahar@aureuslaw.com>, Chetan Singh <chetan.singh@aureuslaw.com>

Sir,
Please find enclosed herewith the Reply to the application on behalf of the Respondent No. 8 (DFCCIL).
Kindly acknowledge the receipt of the same.

Best regards,

Suresh

unnamed

Suresh Kumar Srivastava | Head of Administration (Litigation)
M: +91 9818269100
L: +91 11 41080803/04/05
103, South Park Apartments, Kalkaji, opposite K1 Block, Chittaranjan Park, New Delhi, Delhi 110019 *(Kindly note the change in our address and update your records accordingly)*
E: suresh.srivastava@aureuslaw.com
www.aureuslaw.com

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2 attachments

image001.jpg
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