INLAND WATERWAYS AUTHORITY OF INDIA

Ministry of Shipping, Government of India

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT REPORT, ENVIRONMENTAL MANAGEMENT PLAN AND RESETTLEMENT ACTION PLAN FOR "CAPACITY AUGMENTATION OF NATIONAL WATERWAY.1" BETWEEN HALDIA AND ALLAHABAD

(JAL MARG VIKAS PROJECT)

(DRAFT)

CONSOLIDATED ENVIRONMENTAL IMPACT ASSESSMENT REPORT

FOR

NATIONAL WATERWAYS-1

MAY, 2016

EQMS India Pvt. Ltd.

Since 1998

In JV with

IRG Systems South Asia Pvt. Ltd.

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Table of Contents

List of Tables

List of Figures

List of Annexure

Abbreviations	
µg/m^3	Microgram per cubic metre
A	Ampere
AAQ	Ambient Air Quality
AD	Amphibian Dredger
amsl	above men sea level
APHA	American Public Health Association
AWPCPL	Allahabad Waste Processing Company Pvt. Ltd
BCM	Billion Cubic Microns
BDU	Below Detection Unit
BDU	Best Designated Unit
BHDs	Backhoe Dredgers
BHU	Banaras Hindu University
BOD	Biochemical Oxygen Demand
BOQ	Bill of Quantity
BTKM	Billion Tonne Kilometres
BUIDCO	Bihar Urban infrastructure development Corporation Ltd.
BWE	Ballast Water Exchange
BWMP	Ballast Water Management Plan
BWP	Ballast Water Performance
CBWTF	Common Bio Medical Waste Treatment Facility
CEC	Cation Exchange Capacity
CERs	Critical Environmental Resources
CGWA	Central Ground Water Authority
CGWB	Central Ground Water Board
CIFRI	Central Inland Fisheries Research Institute
CIWTC	Central Inland Water Corporation Limited
cm	centimetre
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
Cr	Crore
CRZ	Coastal Regulation Zone
CSD	Cutter Section Dredgers
CTE	Consent to Establish
CTO	Consent to Operate
cum	cubic metre
dBs	Decibels
DEAC	District Environmental Impact Assessment Committee
DEIAA	District Environmental Impact Assessment Authority
DEM	Digital Elevation Model
DFO	District Forests Officer
DFR	Detailed Feasibility Report
DG	Diesel Generators
DGPS	Differential Global Positioning System

DO	Dissolved Oxygen
DWT	Dry Weight Tonnage
DWT	Dead Weight Tonnage
E	East
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMoP	Environmental Monitoring Plan
EMP	Environment Management Plan
EPC	Engineering Procurement Contractor
ESAs	Ecologically Sensitive Areas
ESC	Environment and Social Cell
ESS	Electrical Sub stations
FBP	Farakka Barrage Project
GHG	Green House Gases
GIS	Geographical Information Systems
gm	Gram
GoI	Government of India
GPS	Global Positioning System
GRB	Ganga River Basin
GW	Ground Water
ha	Hectare
HAD	Haldia Development Authority
HC	Horizontal Clearance
HDC	Haldia Dock Complex
HDPE	High Density Poly Ethylene
HFL	Highest Flood Level
hpa	Hectopascal
HPC	Name of a Consultant
hrs	hours
HSD	Hydraulic Surface Dredger
IARI	Indian Agricultural Research Institute
IBA	Important Bird Areas
IESWM	Institute of Environmental Studies & Wetland Management
IITs	Indian Institute of Technology
IMD	India Meteorological Department
IMDG-code	International Maritime Dangerous Goods Code
IMO	International Maritime Organization
INTACH	Indian National Trust for Art and Cultural Heritage
IRS	Indian Remote Sensing Satellite
IS	Indian Standards Published by Bureau of Indian Standards
ISRO	Indian Space Research Organization
IUCN	International Union for Conservation of Nature
IWAI	Inland Waterways Authority of India
IWC	International Whaling Commission
IWT	Inland Waterway Transport
JNNURM	Jawaharlal Nehru National Urban Renewal Mission

kgs	Kilograms
KLD	Kilolitre per Day
km	kilometre
KMC	Kolkata Municipal Corporation
kmph	Kilometre per Hour
KoPT	Kolkatta Port Trust
KoPT	Kolkata Port Trust
KW	Kilo watt
LAD	Least Available Draft
LC	Level Crossing
Leq	Equivalent continuous sound pressure level in dB
LPG	Liquid Petroleum Gas
m	Metre
MARPOL	International Convention for the Prevention of Pollution from Ships
meq	Milli equivalent
mg/l	Milligram per litre
mg/l	Milligram per litre
□ill^3	Microgram per cubic metre
mL	Millilitre
MLD	Millions of Litres Per Day
mmhos/cm	Mili mho/ centimetre
MoEF&CC	Ministry of Environment & Forests & Climate Change
mpn/100 ml	Most Probable Number/100 millilitre
MSIHC	Manufacture Storage import of Hazardous Chemicals
MSW	Municipal Solid Waste
MSW	Municipal solid Waste
MT	Metric Tonnes
MTPA	Million Tonne Per Annum
N	North
NAAQS	National Ambient Air Quality Standards
NABL	National Accreditation Board for Testing and Calibration Laboratories
NCAER	National Council of Applied Economic Research
NGBRA	National Ganga Basin River Authority
NGO	Non-Government Organization
NH	National Highway
NMCG	National Mission for Clean Ganga
NOC	No Objection Certificate
Nox	Oxides of Nitrogen
NRCD	National River Conservation Directorate
NTPC	National Transport Policy Committee
NTU	Nephelometric Turbidity Unit
NW	National Waterways
NW	North West
ºC	Degree Celsius
PCC	Portland Cement Concrete
PCCF	Principle Chief Conservator of Forests

PIANC	World Association for Waterborne Transport Infrastructure
PM	Particulate Matter
PMC	Patna Municipal Corporation
PMU	Project Management Unit
ppb	parts per billion
ppm	parts per million
PPP	Public Private Partnership
PWD	Public Works Department
QA/QC	Quality Assurance/Quality Check
RCC	Reinforced Cement Concrete
RET	Rare Endangered and Threatened Species
RIS	River Information System
RITES	Name of Govt. Consultancy Organisation
ROB	Rail Over Bridge
RO-RO	Roll on and Roll Over
RWH	Rain Water Harvesting
S	South
SAV	Submerged Aquatic Vegetation
SC	Schedule Caste
SE	South East
SEAC	State Expert Appraisal Committee
SEIAA	State Environmental Impact Assessment Authority
SH	State Highway
SO2	Sulphur Dioxide
SPCB	State Pollution Control Board
Sq.km	Square kilometre
ST	Schedule Tribe
STP	Sewage Treatment Plant
SW	Surface Water
SWDS	Solid Waste Disposal Site
TDS	Total Dissolved Solids
TKM	Tonne Kilometres
TPD	Tonnes per Day
TPP	Thermal Power Plant
TSDF	Treatment Storage and Disposal Facilities
TSHDs	Trailer Suction Hopper Dredger
UNDP	United Nations Development Programme
UP	Uttar Pradesh
USA	United States of America
USDA	United States Department of Agriculture
USEPA	United State Environment Protection Authority
VBREC	Vikramshila Biodiversity Research and Education Centre
VC	Vertical Clearance
VMC	Varanasi Municipal Corporation
W	West
WB CZMA	West Bengal Coastal Zone Management Authority

WDSC	Whale and Dolphin Conservation Society
WHC	Water Holding Capacity
WNW	West North West
WWF	World Wide Fund for NGO

Disclaimer:

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

The cargo movement through waterway is considered one of the cheapest mode of transportation internationally which is very low in India compared to the international scenario. To augment the capacity of waterways transportation in India, Govt. of India has constituted Inland Waterways Authority of India (IWAI) in 1985. IWAI has identified 5 river stretches as National priority and notified these stretches as National Waterways 1 to 5. Amongst the five notified waterways, the national waterways on Ganga (NW-1 between Haldia to Allahabad) is the longest waterways and is of prime importance considering its locational advantages. IWAI since long has been maintaining the least available depth (LAD) of 3m between Haldia and Farakka (560km), 2.5m in Farakka – Barh (400km), 2m between Barh – Ghazipur (290km) and 1.2 to 1.5m in Ghazipur – Allahabad (370km). Even currently this waterway (NW-1) is being used for various cargo movements, as well as tourists. Already good amount of cargo movement is taking place between Haldia and Farakka (e.g. 3 million metric tonne of imported coal from Haldia to NTPC plant near Farakka is being transported since October 2013 through 20 barges of 2000 dwt capacity each). Considering such a large potential and demands, IWAI has initiated the project of "Capacity Augmentation of National Waterway-1" between Haldia and Allahabad named as "Jal Marg Vikas Project". However, considering the available LAD and cargo demand scenario, IWAI is focusing on the stretch between Haldia to Varanasi at present.

The capacity augmentation of this magnitude under this project warrants additional infrastructural components such as river terminals of appropriate cargo handling capacity, provision of navigation aids; river information system; RO-RO jetties; bank protection / slope protection works; river training works; inland vessels; survey vessels, survey equipment and dredging facilities which are required to be developed in a phased and programmatic manner. Certain facilities are already planned such as multi-mode terminal at Ramnagar (Varanasi), Sahibganj and Haldia and new navigation lock at Farakka. Other developments are under finalization stages. Environmental and Social impact assessment studies have been carried out separately for each of already identified above four facilities, maintenance dredging and barge operation activities. A consolidated environmental impact assessment report is prepared for various above components and likely other developments proposed under feasibility report of Jal Marg Vikas Project being funded by World Bank. The following summarises the outcome of above studies.

2.0 Project Need and Location

Inland Waterway Transport (IWT) offers a comparatively low cost and environmentally sound alternative to road and rail transportation especially for bulk and containerized cargo. Infrastructure requirements of IWT in comparison to road and rail transport are also relatively low, although some investments are essential such as in port/terminal facilities, connecting road/rail infrastructure, navigation aid and maintenance dredging facilities. While cargo movement through other modes of transportation are often confronted with congestion and capacity problems, IWT offers a relatively congestion free and reliable mode of transport along with availability of unmatched capacity expansion due to its large untapped potential.

Till the middle of 20th century, IWT was being used as an important mode of transport in various parts of India but gradually it got confined to unorganized sector except in few states namely Goa, Assam, West Bengal, Kerala and Maharashtra primarily due to focus shift in transportation through rail and road modes. However, IWT use has shown increasing trend since 2003-2004 and touched 70 Million tonnes mark by 2011-2012 compared to only 32.48 Million tonnes in 2003-2004 which is just 0.34% of total inland cargo movements of about 1000 btkm. IWAI has set the target of increasing IWT share up to 2% of total inland cargo by 2025. The main commodities carried by IWT (which are also true with NW-1) include building materials (34%), metals\ores (19%) and coal\coke (17%). On demand side in the case of NW-1 (Allahabad – Haldia) alone 10 thermal power plants are located along Ganga river in UP & Bihar stretch and 11 more are expected to become operational soon. The total requirement of coal for these power plants will be nearly 70 million tonnes per year, 14 MT of which will have to be imported. In addition to this, there are seven fertilizer plans along NW-1. These are also estimated to generate an additional of 0.765 million ton of cargo requirement per year. Further, there is also large prospect of container movements for national as well as international trade. IWT and NW-1 in particular would play a very vital role when high quality ports/terminals and waterway connections are made available to facilitate the cargo movement in a cost effective and environmental friendly manner catering to the needs of high transportation movements due to enhanced industrial activities as compared to rail and/or road modes.

Project area under Jal Marg Vikas Project includes entire reach of the River Ganga from Haldia to Allahabad including the areas proposed for development of project related facilities & infrastructure, i.e. terminal sites, lock site, Ro-Ro jetty sites and sites for other planned development. Stretch from Allahabad to Haldia covers four states namely Jharkhand, Bihar, Uttar Pradesh & West Bengal. Map showing location of NW-1 stretch from Haldia to Allahabad is shown in **Figure 1** below.

Figure 1: Location Map of NW-1

3.0 Project Description

Proposed Project-Jal Marg Vikas aims at improvement of navigation in entire stretch of 1620 km. of NW-1 (Haldia to Allahabad). NW-1 is the Ganga - Bhagirathi - Hooghly river system. NW-1 is being fed by various tributaries at different locations. Major tributaries to NW-1 between Haldia to Allahabad are Tons, Gomti, Ghagra, Son, Gandak, Punpun and Kosi. The following interventions have been proposed and planned under the Jal Marg Vikas Project.

- Maintenance dredging to provide LAD in waterway/channel and the terminal facility
- Improved Navigation Infrastructure & Navigation Aids
  - Construction of 10 Ro-Ro jetties & ferry passenger jetties. Locations of these jetties are yet to be identified.
  - Construction of 6 terminals: Site identification and planning for 3 terminals sites at Sahibganj, Varanasi and Haldia is completed. 2 more potential sites for development of terminals are identified at Ghazipur and Kalughat. These two sites are still under consideration for finalization and planning of design at initial stage only. One more terminal site along NW-1 is being identified.
  - Construction of one Navigation Lock at Farakka, West Bengal.
  - Provision for tow barges, inland vessels, survey vessels including rescue boats and survey equipment. Development of low draught cargos.
  - Development of navigation aids along NW-1 for facilitation of day & night time navigation.
- Development of efficient River Information System with all hardware & software.

- Provision for bank protection / slope protection and river training works for critical locations.

The project also envisages the creation and improvement of integration opportunities with other surface transport modes such as roads and railways, so as to improve the overall efficiency of the logistics chain by linking the waterways through various well equipped terminals and jetties.

Cargo being transported in NW-1 includes cement, fly ash, iron ore, iron ore fines, coal, steel shed, tyres, iron fines, iron ingots, Galvanized steel plain sheets, stone chips, furnace oil, high Speed diesel, lube oil, boulders, pulses, aluminium block, sand, chips, ship block, food grains, Manganese ore, Petroleum, Coke, Cooking coal, Rock Phosphate, Timber, Peas, Slag oil, and Non-cooking coal. Traffic projections for the planned infrastructure site are given at **Table 1.** The terminals cargo handling capacity are being designed considering these traffic projections.

Table 1: Traffic Forecast for Planned Navigational Infrastructural Facilities

S. No.	Infrastructural Facility	Projected Cargo-2015 (MTPA)	Projected Cargo-2030 (MTPA)	Projected Cargo-2045 (MTPA)
1	Sahibganj Terminal	2.24	4.39	9.00
2	Varanasi Terminal (with current land)	0.54	1.22	1.22
3	Haldia Terminal	4.07 MTPA (1.57 other cargo & 2.5 MTPA coal transhipment)		

Source: HOWE Engineering Projects (India) Pvt.Ltd. (Design Consultant)

There are various challenges for Jal Marg Vikas Project development which includes typical characteristics alluvial river Ganga his braiding, meandering large water fluctuations between summer and monsoon months and annual silt loads of 1600 million tonnes. The maintenance dredging requirements, planned infrastructures facilities, and other facilities are planned keeping these challenges and transportation requirements in consideration. The salient features of the Jal Marg Vikas Project with the details of planned and proposed developments are given at **Table 2.**

Table 2: Salient Features of Jal Marg Vikas Project

Salient Features	Capacity/Quantity/Nos.
Facilities Planned	• 3 terminal sites (Sahibganj, Varanasi & Haldia) • 1 new Navigation lock- Farakka • River bank protection works at planned terminal sites and along Feeder canal
Facilities under Planning Stage	• 3 additional terminal sites • 10 ro-ro jetties • Barge repair and maintenance facility • River training works

<table>
<tr><td></td><td>• River bank protection works at the proposed civil intervention sites</td></tr>
<tr><td>Designed capacity of Terminals</td><td>
<table>
<tr><td>Infrastructural Facility</td><td>Projected Cargo-2015 (MTPA)</td><td>Projected Cargo-2030 (MTPA)</td><td>Projected Cargo-2045 (MTPA)</td></tr>
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<tr><td>Haldia Terminal</td><td colspan="3">4.07 MTPA (1.57 other cargo & 2.5 MTPA coal transhipment)</td></tr>
</table>
</td></tr>
<tr><td>Navigation Channel</td><td>Width-64m
LAD-3 m from Haldia to Barh, 2.5 m from Barh to Buxar and 2.2 m from Buxar to Varanasi at present</td></tr>
<tr><td>Design Vessel Specifications</td><td>Vessels of maximum length 110 m, beam 11.4 m, draught 2.5 m-2.8 m and air draught of 9 m will ply in the waterway</td></tr>
<tr><td>Size of Vessels</td><td>1500-2000 dWT</td></tr>
<tr><td>River Slope</td><td>Haldia to Farakka-1 in 11000
Farakka downstream-1 in 18000
Farakka to Allahabad-1 in 17,000</td></tr>
<tr><td>Maintenance Dredging</td><td>Navigation Channel-15,765,596 cum/year*</td></tr>
<tr><td>Type of Dredgers</td><td>CSD, Agitation dredgers/plough dredgers and back hoe dredgers</td></tr>
<tr><td>Dredge disposal</td><td>Preferably off-shore, onshore only if sediments are found to be contaminated</td></tr>
</table>

* quantities are tentative and subject to change with revision in planning

3.1 Project Implementation Schedule, Cost and Implementation Responsibilities

The project being of large spatial extent, will be developed in phases. The implementation period of 3 years is anticipated for completion of phase 1 components of the Jal Marg Vikas Project (6 terminal sites, maintenance dredging, vessel management system, shore protection works and river training works). Overall cost of the Jal Marg Vikas Project will depend on finalization of various components proposed under the project. However, fund allotted by World Bank to GOI for development of Jal Marg Vikas is about 650 million USD (~4200 Cr). The Project Director and officer of the rank of Vice Chairman of IWAI will be in charge of the implementation programme who will be assisted by Project Management Unit and Regional Directors.

4.0 Environmental Impact Assessment Process

This project is classified as Category 'A' operations under the world bank environmental screening procedures specified under its operation policy 4.01. The project triggers 7 of the World Bank safeguard policy[1] and requires comprehensive environmental assessment. This project does not require any environmental impact assessment as per the existing

[1]The world bank safeguard policies triggered are environmental assessment (OP/BP 4.01), Natural Habitats (OP/BP 4.04), Forests (OP/BP 4.36), Involuntary resettlement (OP/BP 4.12), Indigenous people (OP/BP 4.10), Physical Cultural Resources (OP/BP 4.11) and Project on International Waterways (OP/BP 7.5)

provisions of Indian Laws. The environmental impact assessment was carried out by a consortium led by EQMS India Pvt. Ltd. Initially a basin level critical environmental resource study was carried out to identify “NOGO” and “Restricted areas”. The baseline survey planning was carried out considering the output of this study as well. In addition to assessing the air, water, noise soil quality and biological environment (aquatic and terrestrial ecological aspects), sampling and testing of riverbed sediments at different locations in the entire stretch of NW-1 was also carried out. The baseline survey was carried out between: 15thSeptember, 2015 to 28thFebruary 2016 for different period and frequency at different locations covering the entire stretch of NW-1, finalised intervention areas, likely intervention areas, likely maintenance dredging areas, existing select RO-RO jetty locations, existing passenger select ferry locations and environmental sensitive areas. Being a liner project, the 500m radius on either side of the bank is considered as core influence zone, 2 Km radius as extended influence area. The terminal site will have influence area beyond 2 km. As per Indian standard practice, influence area is considered as 10 km along the NW-1 stretch and intervention areas for study purposes. The studies were carried out in tandem with preparation of detailed engineering feasibility report. Initially separate environmental impact assessment was carried out for each terminal / lock, maintenance dredging and barge operations. This was followed by carrying out environmental impact assessment for all components in the form of consolidated environmental impact assessment report. The formal informal consultation was undertaken as part of impact assessment process. The impact assessment covers all three stages of the project viz. design, construction and operation stages. The impacts are identified from all components and activities of the project on physical, biological (terrestrial and aquatic ecology) and socio – economic environment. Environmental management and monitoring programme are suggested to minimize the identified impacts and sustain the benefits. Institutional Mechanism is also proposed for effective implementation of environmental management and monitoring plan.

5.0 Project, Legal and Administrative Framework

The project has been evaluated for applicability of all National, State Laws, Rules and Regulations. The Acts, rules and guidelines applicable for the project are critically analysed to list out the permits/NOC required to be obtained by IWAI/contractor prior and during the development of the project. Environmental legislations applicable for the project are (i) Environmental Protection Act, 1986 (ii) EIA Notification, 2006 as amended till date (iii) Forest Conservation Act, 1980 (iv) Wildlife Life Protection Act, 1972 (v) CRZ Notification, 2011 (vi) Air (Prevention and Control) of Pollution Act 1981/1987 (vii) Water (Prevention and Control of Pollution) Act, 1974/1988 (viii) Hazardous and Other Wastes (Management &Transboundary Movement) Rules, 2016 (ix) Other waste management & safety rules, regulations and guidelines; Construction and Demolition Waste Management Rules 2016,

E-Waste Management Rules, 2016; Plastic Waste Management Rules, 2016; The Battery Management and Handling Rules, 2001;Ancient Monument and Archaeological Site and Remains Act, 1958.

Environmental clearance will be obtained for any project component wherever found applicable. The environmental clearance under minor mineral category of EIA notification 2006 shall be taken by the contractors as applicable before borrowing the earth and for setting up new quarry site. Consent to establish under Air and Water Acts for setting up batching plant, hot mix plant, DG sets, soak pit & septic tank/STP shall be obtained by the contractor before setting up these facilities from State Pollution Control Boards. No diversion of forest land is involved in the project, however; cutting of trees will be carried out for construction of terminals and other interventions and permission will be required from concerned authorities or forests departments as per law of respective states. Waste/used oil is the only hazardous waste likely to be generated during construction and operation stage which shall be managed as per Hazardous & Other Waste Management Rules, 2016. Other waste related regulations shall also be followed depending on nature of waste generation during construction and operation stages as defined above.

Permission under CRZ Notification, 2011 is required for establishing Haldia Terminal from West Bengal Coastal Zone Management Authority. The process for this permission has already been initiated. Permission for movement of vessel through Kashi Turtle sanctuary & Vikramshila Gangetic Dolphin Sanctuary located under Wild Life Protection Act, 1972[2]. Process has already been initiated for obtaining these permissions. There are nine archaeological sites located within 300m area of river bank on NW-1. No construction activities are proposed closed to these sites. Permissions shall be obtained from archaeological department if any construction is planned in near future within 300 m of these sites.

Additional international conventions/treaties applicable for the project have been analysed. India being signatory of IMO, is obliged to follow the environmental and safety guidelines prescribed under various conventions. Some of the regulation and guidelines applicable to vessels plying in Indian inland waterways as per IWAI includes (i) Prevention of Collision on National Waterways Regulations, 2002 (ii) National Waterways, Safety of Navigation and Shipping Regulations, 2002 (iii) The National Waterway-1 Act, 1982 (iv) New Inland Vessel Act, 2015 & Rules Under IV Act (v) Relevant other International Environmental Convention

6.0 Key safeguard documents

A detailed description of project baseline environmental conditions, identified positive and negative environmental impacts, the mitigation measures to eliminate or minimize the adverse impacts and enhance the positive impacts, detailed environmental management

[2] As per notification, restriction are imposed for fishing (larvae of Hilsha & during breeding & spawning season) only in Hislha Sanctuary

plan including institutional responsibilities, implementation schedule, environmental budget, arrangement for monitoring and evaluation and grievance redressal mechanism are provided in the consolidated environmental impact assessment report for NW-1 and environmental impact assessment report of Ramnagar (Varanasi terminal), Sahibganj terminal, Farakka Lock, and Haldia terminal. The other supplementary documents prepared under this project are i) Basin Level Critical Environmental Resource Assessment report; ii) Consolidated rehabilitation action plan for NW-1, iii) Rehabilitation action plan for Sahibganj, iv) EIA Report for maintenance dredging and barge operations

7.0 Public Consultation and Disclosure

Stakeholder's view and perception was assessed through informal and formal public consultation meetings. The different stakeholders viz. Govt. officials, NGOs, Village Panchayats (Village Administration), people (male, female) were contacted and consulted during the course of the study. Stakeholders were informed about the project components and likely environmental impacts before seeking their views. In each consultation all efforts were made to have adequate participation from women as well. Consultations has been carried out for the project in two stages. First stage consultation was undertaken during impact assessment process to identify the concerns of people which were duly addressed through appropriate mitigation measures. Second stage consultation was undertaken after preparation of EIA report so as to assess the adequacy and acceptability of the proposed mitigation measures and management plan. Public consultations ensured involvement of public, NGO, experts in the project's pre-planning stage itself and addressal of their concerns and expectation from the project.

The community members, Government officials and NGO members voiced that the proposed project will contribute in social and economic development of the region. The proposed project shall contribute to increase employment opportunities for the local people during and after project implementation. The communities welcomed the project and all were in favour of the project. However, some of the fishermen and land holders have raised some concerns about the fishing activities/yield and the compensation to be given. Major issues highlighted during consultation were adequate compensation against the land, loss of livelihood, provision of alternate employment, river water pollution, fish yield and disruption of fishing activities. Each of the issues raised by stakeholders were analysed for practical and scientific basis, and evolving appropriate mitigation, management and monitoring plan, depending on its importance and practicality.

An executive summary of consolidated EA report is available for public view in local language (Hindi and Bengali) versions at IWAI website. EIA report for entire Jal Marg Vikas Project and its executive summary is also disclosed at IWAI website and as per provisions of World Bank disclosure policies.

8.0 Alternative Analysis

Analysis of alternatives is an analytical comparison of the operational effectiveness, costs and environmental and social risks of proposed development options. This helps to analyse the options critically in relation to its impacts on all physical, social and biological environments. For this project, alternative analysis has been made for three considerations, i.e. strategic, planning and technology consideration. The summary of these analysis is presented below:

8.1 Strategic Consideration

A comparison is made for “With” & “Without” project scenario for the physical, social and biological environments and status of cargo transport scenario. “With Project Scenario” is considered better for all physical, biological, social environmental and cargo transport scenario compared to “Without Project Scenario”. With Project Scenario will improve the freight transportation efficiency, reduce the GHG emissions, fuel requirement, air emissions, land acquisition, and tree cutting for maintaining and expanding cargo movement requirement. However, impacts are anticipated more on water and aquatic ecology in “With Project” scenario compared to rail and road for which mitigation and management plans are prepared to minimize the impacts.

8.2 Planning Consideration:

This involves the consideration of options for location of the proposed interventions, suitability of intervention sites, design of the project layout and dredging extent. Locations are selected for proposed civil interventions (terminals/jetties) on the basis of potential of freight/cargo movement in the area and its connectivity with other modes of transport (Rail and Road). 10such locations were selected for development of 6 terminals and 1 navigational lock. One of the probable locations at Bhagalpur was ruled out due to presence of Vikramshila Gangetic Dolphin Sanctuary and based on “NO GO” areas identified in Basin Level Critical Resources Assessment study. Two sites at Varanasi and Sahibganj were identified few years back where land acquisition process was either completed or is near completion and thus were not included in the locational alternative analysis. However, acceptability of these sites from environmental aspects were assessed which were found acceptable. The terminal sites at Haldia, proposed to be located on Government Land (Kolkata Port Trust Land) which is already being used for shipping and industrial purposes, were considered acceptable from environmental and social aspects. The location of navigational lock at Farakka is already existing and navigation lock parallel to existing lock is proposed. Remaining seven sites were analysed from environmental, social, design considerations. Based on alternative analysis three terminal sites at Ghazipur, Tribeni (Kalyani), Kalughat near Doraiganj were considered as preferred sites for these interventions. The other three terminal sites at Barh, Kahalgaon & Balia were not

considered feasible due to (i) various environmental consideration including proximity to Vikramshila Dolphin sanctuary and Important Bird Areas, (ii) design issues such as unstable river, presence of navigational hazards and high sedimentation rate (iii) social issues concerning acquisition of land and (iv) connectivity.

Further alternative analysis was carried out for probable two sites at each of the above identified three terminal locations and Farakka lock, based on environmental, social and design consideration. As per this analysis, the preferred sites for these intervention locations were considered for design and environmental impact assessment.

At the time of impact assessment terminal designs were ready for Varanasi, Sahibganj, and Haldia terminals only. Considering technical feasibility, multiple layout options were available only for Sahibganj terminal & Farakka lock. These layout options were analysed for identification of most suitable design options. In case of Sahibganj terminal, Alternative 1 involves construction of U shaped jetty (25 m), aligned parallel to the River bank and connected to bank by approach trestle of 50 m and alternative 2 involves construction of jetty at the river bank aligned parallel to it. Both the alternatives were compared on multiple criteria, i.e. operational considerations, navigational aspects, ease of construction & maintenance, flexibility of expansion, construction cost and environmental considerations. Both the alternative layouts have certain advantages as well as disadvantages. It could be observed that in terms of available required depth round the year without need of dredging and marginal cost difference between two alternatives and environmental consideration Alternative-I is found preferred alternative for development of IWT Terminal at Sahibganj. In case of Farakka lock, alternative 1 involves construction of lock parallel to the existing lock and in alternative 2, lock will be constructed D/S of the existing lock. Considering the design, requirement of land, length of embankment, availability of depth, dredging requirement etc. It is found that the alternative 1 is better than alternative 2.

To maintain the river navigability, maintenance dredging is required to be planned so as to maintain the length and width of the channel and maintain LAD near the berths/jetty. IWAI proposed either maintaining 3m LAD throughout the NW-1 stretch or maintained different LAD in different stretches (3 m Haldia to Barh, 2.5 m from Barh to Buxar and 2.2 m from Buxar to Varanasi). Width[3] of 64 m will be maintained throughout the navigation channel. Alternative analysis was carried out for both these options considering environmental (dredge quality, impact on aquatic ecology and water quality), social (cultural and aesthetic value, employment and socio-economic consideration) and technical feasibility (dredge quantity, navigation feasibility, economic aspects, dredgers and other infrastructure

[3] The channel width is proposed to limit to 45m in phase I which will further reduce the maintenance dredging requirements.
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requirements). As per analysis option of maintaining different LAD at different stretch was found most preferred option.

8.3 Technological Consideration:

The technological aspects were analysed in terms of dredging technology. Five type of dredgers namely cutter suction dredgers (CSD), hopper dredgers, grab/bucket dredgers and back-hoe dredgers were analysed. These were analysed based on safety, accuracy, turbidity, spills and noise criteria as well as operational feasibility. The CSD was considered as most preferred option due to least associated environmental Impact and operational feasibility. As per experience of KoPT and IWT CSD has proved to be the best option and is considered for maintenance dredging planning and environmental impact assessment.

9.0 Salient Environmental Features of NW-1

The salient features of environmental resources within influence area (10 Km) of NW-1, are presented at Table 3. Topography of the whole of NW-1 (Allahabad to Haldia) falls within a relatively flat terrain of the Indo-Gangetic plain. The elevation within the influence area of the NW-1 stretch, ranges between 1 m amsl (meter above sea level) and 321 m amsl. Highest elevation levels were observed at Sahibganj area (Jharkhand) due to presence of small hillocks. Land use within influence area of the NW-1 is majorly dominated by agricultural land. About 78.9 % of the land is under cultivation; about 7.18% land is under settlement, 7.21% of the land is under water bodies, about 3.59% land is under vegetation, 2.82% land is under dry river bed and rest of the land falls under other uses.

Table 3: Salient Environmental Features along NW-1 Alignment

S. No.	Environmental Features	Within 500 m influence area around NW-1	Within 2 km Influence area around NW-1	Within 10 km influence area around NW-1
1	**Ecological Environment**			
A	Presence of National Park/Biosphere Reserves, Tiger reserve etc.	None	None	None
	Presence of Wildlife Sanctuary	Yes Kashi Turtle Sanctuary at Varanasi Vikramshila Dolphin Sanctuary Kahalgaon to Sultanganj Hilsa Sanctuary stretch in west Bengal	None	Yes Udhwa lake sanctuary in Jharkhand (about 9 km away from NW-1
B	Reserved /Protected Forests	None	None	Yes (Bethuadahari RF, Bahadurpur RF & RF near Rajmahal Hills)
C	Wetland of state and national interest	None	None	Yes (Udhwa Bird sanctuary)

D	Migratory route for wild terrestrial animals	None	None	None
E	Presence of Schedule-I Terrestrial Fauna	None	Yes Migratory birds near Farakka Barrage and surrounding	Yes Migratory birds at important birds' areas
F	Presence of Schedule-I Aquatic Fauna	Yes Dolphin, and Turtle	None	None
G	Important Bird Area	Vikramshila sanctuary area	Yes Danapur Cantonment area Mokamatal Kurseala river course and diyara flood plain. Farakka Barrage and surround area	Yes Udhwa lake sanctuary
H	Seismicity	NW-1 falls in Zone-III (moderate risk) and zone IV (high damage risk zone) as per Seismic Zonal Map of India		
B.	**Social Environment**			
I	Physical Setting	Rural, Industrial and Urban		
J	Densely populated area	Allahabad, Sirsa, Mirzapur, Chunar, Varanasi, Zamania, Ghazipur, Gahmar, Buxar, Ballia, Chappra, Patna, Barh, Bihat, Munger, Bhgalpur, Kahalgaon, Sahibganj, Farakka, Berhampore, Katwa, Kalna, Kolkata and Haldia are densely populated areas.		
K	Physical Sensitive Receptors	Yes Ghats at Varanasi, Patna, Temples, Schools, College and Hospital. Details are provided at section 4.7		
L	Archaeological Monuments	Yes There are 9 archaeological sites located within 300 m area of the NW-1 and these are Kardmeshwar Mahadeva Mandir, Ramnagar fort, archaeological excavation site, Varanasi, Manmahal and observatory, St. John's Church, Temple of Gour Chandra and Krishnachandra at Chatra (Gaur Chandra Ghat), Hazardwari Palace, Singhi Dalan and Jami Masjid Details provided in section 4.7, Chapter-4 of EIA report.		

10.0 Anticipated Environmental Impacts and Mitigation Measures

Environmental impacts have been assessed considering present environmental setting of the project area, nature, and extent of the proposed activities. Suitable qualitative and quantitative approach was followed for identification of likely impact on each value components of environment for design construction and operation stage. The impacts were analysed under three broad categories namely (i) Impacts due to dredging operations (ii) Impacts due to barge operations (iii) Impacts due to civil interventions. Additionally, impact was analysed for climate change and riparian issues. Impacts due to land acquisition are covered under separate Social impact assessment and Rehabilitation Action Plan report and not included under this summary.

Maintenance dredging & dredge disposal will be carried out during the operational phase of the project to maintain continued navigability throughout the year from Haldia to Varanasi in NW-1. Dredging of 15.76 million cubic meter will be undertaken from Haldia to Varanasi to maintain LAD of 3 m till Barh, 2.5 m till Buxar & 2.2 m till Varanasi. Impacts of the dredging are analysed for Physical Environment: on water quality and land, Ecological Environment: on aquatic ecology and avi-fauna (6 Important bird areas, VGDS, Kashi turtle sanctuary & Hilsa sanctuary), and Socio-Economic Environment: cultural (Ghats at Patna & Varanasi), archaeological (9 nos.) and livelihood of fishing community

IWT mode though is safest and most environmental friendly mode of transportation, may have impact valued environmental components. Barge movement may impact the water quality, river bank & bank structures, air quality, noise level, aquatic ecology, health & safety, livelihood of fishermen and socio-cultural aspects.

The civil interventions will have largely construction and operation related impacts. Impacts are summarised based on the impact assessment carried out for Varanasi, Sahibganj and Haldia terminals and Farakka navigational lock. The impacts identified for these four sites are likely to be the similar for other interventions sites barring few site specific issues related to tree cutting, land acquisition, muck disposal and construction material sourcing.

The impacts are summarised below for valued environmental components in two groups i) impacts due to dredging and barge operations and ii) impacts due to civil interventions. The baseline conditions are summarised under first group itself. The impacts on climate change and riparian issues are summarised following these two groups impacts.

10.1 Impacts due to maintenance dredging and barge operations

10.1.1 Impact on land and water quality

A. Baseline conditions

Soil and River Bed Sediment Quality: Soil quality monitoring is carried out along NW-1 and within the critical impact zones considered for planned civil interventions as per CPCB guidelines. Soil type is study area is dominated by alluvial soil. Soil texture varies from sandy clay to clayey loam type and soils are marginally acidic to slightly alkaline with pH ranging from 6.62-7.86. Electrical Conductivity ranges between 135.4 & 360.5 µmhos/cm. Soils in the study area are moderately fertile.

The concentration of heavy metal & pesticides in river bed sediments was found low in concentration at each sampling location and are within acceptable limit for off-shore disposal as per “Criteria for Off-Shore Dumping of Dredged Material”, USA except for cadmium which is slightly above the prescribed limit in UP stretch. Cadmium levels can be high due to industrial effluent discharge in this section.

Ground and Surface Water Quality: Ground water quality monitoring is carried out along NW-1 and within the critical impact zones considered for planned civil interventions as per

CPCB guidelines. TDS, Total Hardness and chloride values at Haldia and Sahibganj, Howrah and Kolkata are slightly above the desirable limit but are within the permissible limits specified of IS: 10500. Fe and Zn were detected in water samples but in lower concentration. Arsenic was detected in samples collected from Bhagalpur and Munger but in lower concentration.

River water quality monitoring is carried out along NW-1 and u/s & d/s of planned civil interventions as per CPCB guidelines. River water qualities meets BDU Class 'D' Criteria of CPCB barring few parameters pH & DO which meets class 'A' criteria, i.e. for propagation of Wild life and fisheries

B. **Impact on water quality & land due to dredging operations:**

Impacts: Impact of dredging on water quality are increase in turbidity; reduced light transmittance; reduced DO; changes in salinity, temperature, pH & concentration of nutrients and release of heavy metals/chemicals. As per a study, DO level comes down suddenly by 2 to 2.5 mg/l for maximum of 2 minutes only at the dredge plume arrival point which is regained within 3-4 minutes as plume passes. As per baseline study, river bed sediments are non-toxic except in Allahabad to Buxar stretch where Cadmium level is found marginally higher compared to US standard for off-shore sediment disposal. However, this higher level is unlikely to have toxic effect on aquatic life considering the sensitivity level to cadmium exposure (short terms at LC_{50} level) to aquatic life as per Canadian Guidelines[4]. Pesticides are present in traces but much below the safe limit for off-shore disposal. Turbidity of water also increases substantially close to dredging point but it reduces with distance and almost get normalise at a distance of 700 m from dredging point. Coarser sediments settle much faster and at shorter distance. Presence of iron in sediments enhances settling of fine sediments as it acts as coagulant. Land disposal of sediments is anticipated only when sediments are contaminated and in case of Haldia terminal dredging. When the dredged material is disposed on land in form of slurry, excess water drains back to the water body which can affect the water quality.

Key Mitigation Measures: Key mitigation involves reduction in dredging quantity by studying thalweg profiles, bandalling and usage of low draught vessels. Sediment loss can be minimized by wise selection of dredger depending on strata and depth and CSD are proposed accordingly. Selection of size of cutter head and other technical specifications can further be reducing dredged sediment loss.

C. **Impact on water quality due to barge operations:**

[4]As per Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment, 2014

Impacts: Vessels generate garbage, oily waste, sewage, bilge water & ballast water which can affect the water quality of the river. Usage of antifouling paints may also impact the water quality as the paints may contains toxins. Settling of the dust of the material transported on river surface again can impact the river water quality. Ship accidents/collision may lead to spillage of the commodities transported including oil which may impact the water quality of the river.

Key Mitigation Measures: Management of wastewater, oily waste, bilge water, noxious waste (if any), air emissions & garbage from vessels as per MARPOL can prevent the water quality pollution. All maintenance & repair works shall be carried out at designated locations only. Only toxin free paints should be used for anti-fouling purpose. Experienced crew should be hired to minimize the accident occurrence. Information of available LAD in form of electronic charts shall be made available to navigators and intimation of navigational hazards in form of cautionary signage shall be displayed at required locations to minimize the accidents and spillage of material in river. Oil carrying ships (>5000 dwT) shall be double hulled as prevention against oil spills.

D. Impact on river bank & river bank structures due to barge operations:

Impacts: Wave generated due to vessel movement may lead to bank erosion. Impacts are anticipated to be minimal except at Feeder canal which is narrow and have erodible banks.

Key Mitigation Measures: Restricting speed of vessels in narrow stretches & along sharp bends may minimize the erosion. Bank protection and bend straightening works can protect banks from erosion.

10.1.2 Impact on Air Quality and Noise Level

A. Baseline conditions

Meteorology: The predominant wind direction in all IMD stations located along NW-1 is from North and Northwest direction in winters and South and Southeast direction during rest of the season. The wind speed in the area ranges between 1.9 kmph (Patna) and 8.7 kmph (Kolkata). December and January constitutes winter months with daily mean minimum temperature of around 9.1^{o}C at Patna and daily mean maximum temperature of around 26.9^{o}C at Kolkata. April and May are the hottest months with daily mean minimum temperature of 24^{o}C at Malda and daily mean maximum temperature of 40.4^{o}C at Varanasi. Relative humidity ranges between 25 & 84%. The annual rainfall in the project area ranges between 1000.3 mm (Varanasi) and 1728.5 mm (Kolkata).

Air Quality: Ambient air quality monitoring ($PM_{2.5}$, PM_{10}, SO_2, NO_2 and CO) was carried out along NW-1 and within the critical impact zones considered for planned civil interventions as

per CPCB guidelines. PM_{10} level varies from 39 to 145 µg/m^3. PM_{10} levels are within 100 µg/m^3 at all the locations except Varanasi (near bridge), Patna and Howrah. $PM_{2.5}$ levels ranges from 16 to 58µg/m^3 and are within the CPCB limit of 60 µg/m^3. Level of SO_2& NOx ranges from 4.4 to 35.6µg/m^3 and 9.0 to 48µg/m^3 respectively and are within the prescribed limits of NAAQs, 2009. CO is detected at Haldia, Howrah, Patna and Varanasi only. The 8hrs CO level at these locations ranges from 0.18 to 1.2 mg/m^3 and are within limits of NAAQs, 2009.

Noise Quality: Noise level monitoring is carried out along NW-1 and within the critical impact zones considered for planned civil interventions as per CPCB guidelines. Ambient noise levels at all monitored locations are found within the prescribed Standards of CPCB as per land use except at Kashi turtle sanctuary because of anthropogenic activities like worship, bathing etc.

B. **Impact on Air Quality due to dredging and Barge movement**:

Impacts: Barges also generate the emissions but generation of emissions by barges is far less as compared to road and rail for transportation of same quantity of cargo for same distance. Thus impacts on air quality are anticipated to be positive. As per analysis there is reduction in emission generation of all the pollutants. Comparative analysis of emissions due to three different modes is given below in **Table 4.**

Table 4: Comparative Analysis for Air Pollutants by Different Modes

Mode of Transportation	Emission Load(Tonne/day)				
	NOx	SO2	CO	PM	HC
Railway (Diesel Engines)	7.78	3.50	2.91	1.36	1.36
Road	27.38	3.59	10.79	4.40	7.59
IWT (For inland vessels)	6.39	0.98	2.70	0.49	1.23

Source: Analysis done using emission factors[5]

Key Mitigation Measures: Material generating dust shall be transported in covered conditions. Regular maintenance of vessels engine and propellers may significantly cut down air emissions. Adaptation of cleaner fuels like LNG can be explored.

C. Impact on Noise Levels due to dredging and Barge movement:

Impact on noise quality w.r.t air due to barge movement will be negligible and will be far less when compared to road & railways. Intermittent noise of high level may be generated only when hooters are used as warning during navigation. Noise levels w.r.t air generated due to dredging operations at source will vary from 80-90 dB(A). Noise levels reduces to 70 dB(A)

[5] The Environmental Effects of Freight, Organization for Economic Co-operation and Development, Paris and Air Quality Monitoring Research Association of India "Air Quality Monitoring Project-India Clean Air Programme (ICAP), CPCB/MoEF & EPA emission factors for rail locomotives, commercial

at distance of 100 m, 64 dB(A) at distance of 200 m and to 56 dB(A) at distance of 500 m from source. Dredging will be carried out within the navigation channel only thus the impacts of the dredging noise on the nearby settlements are insignificant only. Also dredging operations will not be carried out after 10:00 pm. Several measures are proposed to manage the noise environment of the area.

Apart from noise levels w.r.t air, high level underwater noise is generated due to dredging & barge movement. This noise has impact majorly on aquatic flora and fauna and underwater noise impacts are discussed in detail in section impact on aquatic ecology

Key Mitigation Measures: Regulation of the dredging operations between 6:00 am to 10:00 pm only, dredgers should be regularly serviced and maintain to prevent noise generation due to friction, dredgers should be fitted with noise masking equipment to reduce the noise levels, barges should use hooters as and when required, i.e. for safety of fishermen and other ships. Noise from dredgers can be reduced at source (dredger) by isolation of exhaust system, by keeping engine room doors shut and by shielding.

10.1.3 Impact on terrestrial and aquatic ecology

A. Baseline Conditions

Critical Environment Resources (CERs): Wild life sanctuaries namely Kashi Turtle Sanctuary (Varanasi, U.P.), and Vikramshila Gangetic Dolphin Sanctuary (Bihar) lies within the NW-1 stretch. Hilsa Sanctuary notified under Fisheries Act with the aim of increasing productivity of Hilsa fishes are located at 4 locations in West Bengal Stretch. Apart from this there are 6 nos. of important bird areas including Udhwa bird sanctuary located within influence area (10 km) of the NW-1 stretch. RET species like Gangetic dolphin (Schedule-1) and fresh water turtle species are present in the river stretch of the NW-1.

Terrestrial Flora: There is no major forests area present along the NW-1. The riparian flora consists of commonly found trees, shrub and herb species. No rare and endangered plant species observed in the riparian area of the NW-1.

Terrestrial Fauna: As no major forest area is present along the NW-1 stretch the terrestrial fauna is restricted to commonly found terrestrial faunal species. No Schedule-I terrestrial mammals species observed along the NW-1 stretch. However, 6 IBA located within influence area of NW-1 are the major wintering site for many of migratory water birds. Some of the rarer/endangered/vulnerable avifauna has been reported in these IBA's.

Aquatic Flora & Fauna: The aquatic floral and faunal diversity of NW-1 stretch comprise phytoplankton, zooplankton, zoo-benthos, fish and higher vertebrates. Phytoplankton is represented by Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, Xanthophyceae and Rhodophyceae groups. Dominance of Bacillariophyceae members

followed by Chrophyceae and Cyanophyceae was observed in NW-1 stretch. Zooplankton comprises of Protozoans, Rotifers and Crustaceans. Phytoplankton and zooplankton diversity is little higher in Farakka to Haldia stretch in comparison of Allahabad to Farakka stretch. Macro benthos and Macro-invertebrates constitute Annelida, Arthropoda insects and Mollusca. Fish in the NW-1 stretch is represented by total of 106 species. The higher aquatic vertebrates present in NW-1 stretch (Allahabad to Haldia area are Gangetic dolphin (*Platanistagangeticagangetica*) which is categorized as endangered species (Schedule-I) and few endangered and vulnerable species of fresh water turtle.

B. **Impact on Aquatic Ecology due to maintenance dredging:**

Impact: Impact of dredging on aquatic ecology are change in diversity of benthic habitat, impact on behavioural response & tissue injury of aquatic organism due to increased noise levels, blocking of fish gills due to increased sediments, intake of toxic pollutants by aquatic fauna as released during dredging, smothering of benthic flora & fauna due to dredge disposal and loss of SAV due to increased depth due to dredging. Noise generation from CSD is 160-180 d(B) and behavioural disturbance criteria for dolphins, turtles, fishes (>2 gm) & fishes (<2 gm) from any continuous noise exposures are 177 dB, 150 dB, 186 dB & 183 dB respectively. In addition, no dredging operations are proposed within or in vicinity of Kashi Turtle Sanctuary and Vikramshila Dolphin Sanctuary that minimise the possibility of the impact of dredging on such vital sensitive organisms. Thus the dredging operations noise will not lead to any significant impact on aquatic organisms.

Key Mitigation Measures: Restricting dredging in biological sensitive locations like VGDS & Kashi turtle sanctuary; and during breeding &spawning season of fishes and migratory bird season may minimize the impact on aquatic fauna significantly. Reduction in dredging noise through regular servicing & maintenance of dredgers and usage of bubble curtains can significantly reduce underwater noise. Usage of bubble curtains can reduce underwater noise to app. 10 dB.

C. Impact on aquatic ecology due to barge operations:

Impact: Impact of barge movement on aquatic ecology can be due to speeding vessels, spillage of material transported (oil majorly) and generation of high level underwater noise. Vessels if moving in high speed can collide with aquatic organisms leading to mortality and injury to aquatic organisms. Spillage of material transported can impact the habitat of the aquatic species. Oil spills are most significant among all spills as oil can form a layer breaking contact between water & air and reducing DO level, block gills and skin pores of aquatic organisms leading to mortality. Barge of size 1500-2000 dWT are expected to move in the waterways which generate noise levels of 110-180 dB as per speed. Speed is

however restricted in sanctuary area to 5 kmph and noise levels will be maximum 140 dB. Tolerance level for behavioural response of turtles and fishes are 150 dB & 177 dB. Thus impact of vessel movement on dolphins and turtles is not anticipated. However underwater noise modelling, considering noise generation of 160 dB is carried out and it is found that noise levels will attenuate to 150 dB at distance of 4.6 m from vessel. Another impact on aquatic species is masking of biological important sounds. Echoclation clicks of dolphins have dominant energy around 65 kHz and are beyond the man made frequency range thus impact is not significant. However, communication signals lie in same frequency range as of man-made noise and can be masked but they are naturally masked many times by the natural noise environment of water.

Key Mitigation Measures: Restricting speed of vessels in sanctuary area can maintain noise levels lower than 140 dB which are lower than tolerance levels of turtle and dolphins thus minimizing impact of noise on turtles and dolphins. Vessels shall be fitted with propeller guards and dolphin deflectors to minimize dolphin accidents.

D. Impact on Avifauna due to maintenance dredging:

Impact: Impact on avifauna is anticipated due to disturbance of the habitat due to dredging & disposal of dredged material on banks/shallow waters and increased ambient noise levels due to dredging operations. Noise level of 85 dB(A) are generated during dredging which dissipates within 500 m distance making impact localized.

Key Mitigation Measures: Restricting dredging operations during day time (6:00 am-10:00 pm) & during migratory season of birds near locations of IBAs will minimize the disturbance to resting avifauna during night time. Regular maintenance and servicing and usage of noise mufflers with dredgers can significantly reduce noise levels. Isolation of exhaust system and by keeping engine room doors shut and by shielding dredging noise can be reduced further. Onshore disposal, if required shall be undertaken only on TSDF.

10.1.4 Impact on Socio economic and cultural aspects

A. Baseline Conditions

NW-1 traverses through four states: Uttar Pradesh, Bihar, Jharkhand, and West Bengal. There are various densely populated areas located along NW-1 such as Allahabad, Farakka, Sahibganj, Berhampur etc. As per the Census, 2011, population of the major cities & towns along NW-1 is 1,28,75,343 (67,82,150 male & 60,93,193 females) and the total numbers of Households are 2562165, population between 0-6-year age is recorded as 13,08,682. Being project of such large spatial extent, NW-1 interfaces with various archaeological, social and cultural sensitive and important locations. There are 9 archaeological important sites along NW-1 but no activity at present is proposed to be

undertaken within 300 m of these sites. Ghats at Patna and Varanasi are another socially important features which will be impacted due to project. However, measures are proposed to minimize such impacts. There are several festivals such as Kumbh at Allahabad (Jan-Feb), Ganga Mahotsav at Varanasi (Oct-Nov), Dhrupad Mela at Tulsi Ghat of Varanasi (Feb to March), Chatt at Bihar & Jharkhand (Oct-Nov) and Ganga Sagar Mela at Sagar (January) are being celebrated at NW-1. Due to barge operation and dredging activities there could be interference in these celebrations. Mitigation measures are proposed to be undertaken to minimize such impacts.

B. Impacts on Socio-economy due to maintenance dredging:

Impact: Impact of Dredging & disposal of dredged material are anticipated on cultural &archaeological important locations and on livelihood of fishing community. Dredging operations may impact socio-economy by disrupting fishing & boat movement, generating high noise levels near dredging location, increased river water pollution, unpleasant view and increased air pollutants. These impacts are however short term and localized as will be restricted to dredging locations only. Dredging activity also pose threat to health & safety of the workers and other waterway users.

Key Mitigation Measures: Dredging will be restricted in biological & social sensitive location and at time of occurrence of fest/festival at ghats, during breeding & spawning season of fishes and during migratory bird season can minimize the impact on socio-economy. Timely intimation to fishermen about dredging operation and location can minimize the disturbance to fishermen. As enhancement fishermen can be provided with trainings by institutions like CIFRI to learn better fishing practices and available aids for fishing which will help them to enhance their livelihood. Measures for accident risks during dredging and arrangement of all first-aid should be available at dredging locations all the time.

C. **Impact on Socio-economy due to barge operations**:

Vessel movement are subjected to various threats of accidents related to natural disasters like flood or cyclonic and operational hazards like Collison, fires and spillages. However, these accidents can be reduced by taking the below proposed mitigation measures

Key Mitigation Measures: Provision of night time navigation system, maintenance dredging, adequate and efficient river information system, vessel tracking system, Electronic Charts Display Information System - ECDIS, and Automatic Information System – AIS can minimize the accidents. Most of these measures are already under implementation by IWAI in some stretches of the NW-1 and there is proposal of extending these facilities to entire

NW-1. All safety regulations as per SOLAS should be followed to maintain safety during navigation and minimize accidents.

Enhancement Measures: Support for promoting fish productivity through setting up or supporting existing fish nurseries. Also providing training and awareness support through reputed institutes or experts like CIFRI for better fishing techniques and Provision of supporting Studies for conservation of Dolphin and other sensitive studies shall be made.

10.2 Impact & Mitigation Due to Civil Interventions

Impacts due to civil interventions are expected to occur during the design, construction and operation stage of the project. Impacts due to civil interventions during different phases are discussed below

Impact during design phase:

Activities to be carried out during design phase which can impact the physical, biological and social environment are site clearance & preparation, acquisition of land & change in land use land cover. Major impacts anticipate are Removal of vegetation & tree cutting, Unpleasant view, Increased GHG emissions due to operation of construction vehicle/machinery & removal of trees, Impact on regular day to day activities in area of development due to shifting of utilities, Impact due to change in land use, Impact on drainage, Loss of households, land and assets and Loss of income source and impact on quality of life

Key Mitigation Measures

Tree cutting should be minimized by efficient planning of the interventions. Permission from forest department is essential prior to cutting of trees besides, compensatory plantation to be carried out as per respective state forest policy. Restoration and rehabilitation of locations occupied or used for construction purposes immediately after the given task(s) is over. Dedicated approach roads and improvement of haul roads should be considered to minimize the traffic congestion and air emissions. Traffic management should be undertaken to avoid peak hours. Utility shifting should be carried out during or prior construction phase but without disrupting service to public. Necessary permissions from the area development authorities and local bodies should be obtained prior development of proposed interventions. Natural drainage pattern should be maintained by provision of adequate drainage. Compensation should be given to affected households as per R & R Act, 2013.

Impact during construction phase

Activities to be carried out during design phase which can impact the physical, biological and social environment are construction activities, material transportation and operation of machinery & construction equipment. Major impacts due to these activities are Loss of top

soil, Soil contamination due to spillage of material, Bank Erosion/bed scouring, Surface water contamination due to increased run-off from construction site, High noise levels and disturbance to nearby habitation, Traffic jams, wear & tear of existing roads, increased accidents and air pollution, Unpleasant view due to construction activities, construction material storage and waste storage, Health & safety of Workers and people in nearby areas, Quality of Life, Mortality, disturbance to habitat and change in behavioural response and Tree cutting & vegetation removal

Key Mitigation Measures

The top soil shall be preserved and used for landscaping purpose and shall be given to farmers in nearby areas, if asked by them. Clean up operations shall be taken up immediately after spillage of any material. Debris and excavated earth should be disposed-off as per defined plan. Provision should be made for Septic tank & soak pit/STP, maintenance waste collection and treatment before reuse. Concreted floor for storage of fuel and oils shall be proposed. Excavated earth shall be reutilized to the extent possible in the construction activity and balance will be used for road construction or disposed for designated places like mines in case of Sahibganj. Bank/scour protection works required at planned and under planning civil intervention locations. Adequate shore & scour protection measures should be taken at Sahibganj terminal, Varanasi terminal and Farakka Lock site. Provision of acoustic enclosures for DG sets to reduce noise levels. Noise causing activities should not be carried out close to settlement areas and during night hours. Haulage roads/approach roads to be used should be maintained regularly. Restoration and rehabilitation of the areas occupied or used for construction purpose immediately after use is over. Preparation and implementation of emergency preparedness and response plan and contingency plan by contractor. Implementation of proposed environment management plant to minimize the environmental pollution and stress on existing infrastructure resources. Management of surface run-off to prevent from mixing with contaminant, provision of storm water management system, provision of sediment traps, oil interceptors with storm water drains in parking areas. Impact of piling & construction dredging should be managed by adoption of vibratory piling and usage of bubble curtains to disperse the fauna and reduce the noise level.

Impact during operation phase at intervention sites

Activities to be carried out during design phase which can impact the physical, biological and social environment are barge mooring & berthing, operational activities at terminal site and discharge of waste/waste water from intervention sites. Major impacts anticipate are Increased GHG emissions near the terminal/jetty locations due to increased material transportation and dredgers operation, Increased pollutant emissions near the terminal/jetty locations due to increased material transportation and dredgers operation, Generation of

employment, Infrastructural development, Increased run-off from site, Increased noise levels and disturbance to nearby residents & Polluted water quality

Key Mitigation Measures

Development of thick green belt area and avenue plantation at all proposed intervention sites. Provision of sprinklers and dust suppressors at terminal sites for dust suppression should be made at site. Employment should be given to local people preferably. Skill development trainings can be undertaken for locals to train them for jobs. Storm water drainage should be collected and reuse for dust supersession. Sewage should be treated in STP constructed at site and treated water should be used for dust suppression and horticulture.

10.3 Impact on Climate Change

IWT mode is most efficient and environmental friendly mode of transportation, involving least CO_2 generation when compared to rail & road. Analysis is made to estimate the CO2 emissions from different mode of transportation for transportation of same quantum of cargo for similar distance. It is estimated that to carry freight of app 19000 metric tonne from Haldia to Varanasi, CO_2 emissions of 770.95 TPD, 234.46 TDP, 220.67 TPD & 159.71 TPD will be generated from road, railway diesel, railway electric and IWT mode respectively. Thus positive impacts are anticipated on the climate due to reduction of GHG emissions.

10.4 Impact on Indo-Bangladesh Water Sharing Treaty (Riparian Treaty)

The impact on Indo-Bangladesh water sharing treaty was analysed in terms of water flow to Bangladesh and impact on aquatic ecology and sedimentation load due to NW-1. This impact was analysed nil since no water storage or diversion structure is proposed under Jal Marg Vikas Project. Aquatic life is already fragmented due to Farakka barrage and no change is expected due to Jal Marg Vikas Project as its route diverts to feeder canal through navigation channel (Farakka navigation lock) at Farakka.

10.5 Cumulative Impact Assessment

Cumulative Impact Assessment (CIA) of NW-1 from Allahabad to Farakka has been carried out for (a) analyzing the potential impacts and risks of proposed, indirect & induced developments in the context of water flow, water availability and water quality, considering human activities and natural environmental and social external drivers on the chosen Critical Environmental Resources (CERs) over time, and (b) proposing concrete measures to avoid, reduce, or mitigate such cumulative impacts and risk to the extent possible in the influence area (10 km) on both sides of the NW-1. At first Cumulative opinions of various stakeholders which are directly & indirectly impacted due to proposed development, and extensive review of the consolidated EIA report & basin critical resources

study of the proposed project has been carried out to identify the CERs. Further, overlay mapping and GIS have been extensive used for identifying the spatial distribution of CERs. Also indicators have been identified which can determine status/conditions of CERs. Baseline study has been conducted to assess the existing condition or status of the identified CERs based on these indicators in the study area. Further CERs under stress have been identified and are termed as hotspots. Also nature of the impacts due to proposed/planned & anticipated development on these hotspots has been assessed. It has been found that cumulative impacts due to proposed development of NW-1 on the hotspots will not be significant. Further, impacts triggered due to induced & indirect development can be mitigated & monitored due to construction & operation stage of the project.

11.0 Environmental Management Plan

The Environmental Management Plan (EMP) is a plan of actions for avoidance, mitigation and management of the negative impacts of the project and enhancement of positive impacts. The detailed intervention and activity specific plans for Maintenance dredging, barge operations, civil interventions are given at Chapter 7 in EIA Report. EMP includes the environmental monitoring plan (specifying the parameters, frequency and responsibilities of monitoring), institutional framework, reporting requirements, auditing requirements, training awareness and capacity building programme, grievance redress mechanism and environmental budget.

Institutional Framework of IWAI: IWAI has set up a project management unit which is staffed with Environmental and Social specialists. These specialists would work as an environment and social cell (ESC) within PMU. It is proposed that each field unit will have one designated officer responsible for environment and social aspects who will also coordinate with ESC. The responsibility of ESC will be (i) review and inspect implementation of the EMP; (ii) implementation of the environmental capacity building and awareness programme; (iii) coordinating with field units(iv) Reviewing and ensuring effective implementation of EMP and regulatory compliance by contractor, and IWAI and (v) managing the environmental reporting, and audit process. Contractor will be responsible for implementation of Environmental Management Plan and ensuring health and safety of the construction workers at site during pre-construction & construction phase of the project

Reporting Requirements: Contractor would be required to submit monthly and six monthly reports containing the status of environment, health & safety at site to PMC (Project management consultant) & PMU of IWAI. PMC will be responsible for construction supervision and ensuring effective implementation of EMP by the contractor. PMC shall report to PMU monthly about the performance and effectiveness of the EMP implemented by contractor on site and coordinate with filed units and PMU for necessary corrective actions as may be required. IWAI will also organise an independent Environment Audit

which will be submitted to Bank within 3 months of completion of the second and fourth year of implementation period.

Training & Capacity Building Programme: IWAI has already taken actions to augment the capacity of project management unit (PMU). A capacity building and training programme has been prepared which includes training of staff of Environmental and Social cell of PMU, contractor's staff (labours & engineers), PMC staff and IWAI staff on environmental management, regulatory compliance and safety aspects.

Environmental Budget: Adequate environmental budget provision has been made for the implementation of the EMP. The overall budget is INR 49.91 Crore. A detailed breakup is given in **Table 5**.

Table 5: Environmental Budget

S.No.	Description	Amount
1.	**DESIGN AND CONSTRUCTION STAGE**	**Rs in INR**
	Technical Support of preparation of guidelines, bio-diversity conservation plan for turtle and dolphin sanctuary and performance indicators	90,00,000
	Compensatory tree plantation (7000 trees) Additional tree plantation for GHG sink (18000)	15000000
	Measures to Reduce GHGs by Green buildings certification & additional tree plantation under plantation head	90,00,000
	Storm-water and wastewater management/ Construction of soak pits/ clean drinking & domestic water facility/ STP construction, Zero Discharge management	44000000
	Provision of trainings and PPE to workers	1,72,00,000
	Health check-up camps for construction workers	3,20,00,000
	Enhancement Measures Institutional Support for Vikramshila Wild Life Sanctuary through reputed institutions Support Fish productivity enhancement through fish nursery development and training fishermen Bath shelter for women along NW-1 for maintaining privacy from vessel movement Support for cleanliness at Ghats and improvement of Ghats	12,60,00,000
	Environmental Monitoring in the construction phase: Terrestrial and Aquatic Fauna, Ambient Air Quality, Surface Water Quality, Drinking Water Quality, Noise & Vibration, Soil Quality, Erosion & Siltation and River Bed Sediment	58080000
	Drainage Congestion and disposal of accumulated water/ Erosion & Sedimentation/ Reduction in dredging requirement Land/ Soil/ Noise/ Air Quality -Dust Management during construction Appointment of Safety Officers, Safety signage, fire-fighting measures & water ambulance etc.	Covered in project design and engineering cost
	SUB TOTAL (Design & Construction stage)	**310280000**
2.	**OPERATION STAGE**	

S.No.	Description	Amount
	Monitoring of performance indicators viz. Terrestrial and Aquatic Fauna including surveillance audit, Ambient Air Quality, Surface Water Quality, Ground Water /Drinking Water Quality, Noise & Vibration, Soil Quality, River Bed Sediments, Soil Erosion & Siltation, Integrity of embankments	59040000
	Emergency Preparedness: Accident Response: Ambulance equipped with requisite emergency medical aid facility, First Aid Facility, Fire-fighting Equipment, Safety Trainings, Mock Drills etc.	6,79,00,000
	Waste Water Management (STP Operation, rainwater harvesting management and maintenance)	2,16,00000
	Storm Water Management System & Waste Management System, Erosion Control and landscaping, Reduction in GHGs	To be part of OM cost
	SUB TOTAL (Operation stage)	**1,48,540,000 Or say 14.85 Cr**
3.	**ESTABLISHMENT & TRAINING and MANAGEMENT SYSTEM)**	**1,65,00,000**
4.	**SUB TOTAL (Construction + Operation + Establishment)**	**47,53,20,000 Or say 47.53 Cr**
5.	**CONTINGENCIES @ 5 % on total Environmental Costs**	**2,37,66,000 2.38 Cr**
6.	**GRAND TOTAL (in Rs)**	**499086000 Or say 49.91 Cr**

12.0 Conclusion & Recommendations

The development of project “Jal Marg Vikas” is beneficial for the economic development of country and environment due to expected model shift of cargo movement from rail and road to IWT. With the effective implementation of the proposed mitigation measures and environment management plan, anticipated negative impacts of project can be minimised and benefits further enhanced. The project will overall bring development in the area.

It is recommended that IWAI should provide desired resources for implementation of EMPs and ensure that EMPS are effectively implemented. It must institutionalize the system of period monitoring against the defined performance indicators and establish the system of half yearly reporting. It should also develop its own EHS guidelines and protocols for managing all the projects uniformly from environment health and safety prospective. System should be self-responding in nature for initiating timely corrective and preventive action if any required for the protection of environment.

CHAPTER 1. INTRODUCTION

1.1. Project Background

The cargo movement through waterway is considered one of the cheapest mode of transportation internationally which is very low in India compared to the international scenario. To augment the capacity of waterways transportation in India, Govt. of India has constituted Inland Waterways Authority of India (IWAI) through IWAI Act in 1985. Since then IWAI, with the empowerment under above mentioned Act, has identified potential waterways and has further undertaken the task to develop, maintain and regulate the waterways for navigation. IWAI has also declared following five waterways as the national priority:

- NW-1 -The Ganga (Haldia to Allahabad-1620 km)
- NW-2- The Brahmaputra (Dhubri to Sadiya-891 km)
- NW-3 The West Coast Canal (Kottampuram to Kollam with Udyogmandal and Champakara canals- 205 km)
- NW-4- The Kakinda-Puducherry stretch of Canals with Godavari & Krishna Rivers (1078 km)
- NW-5-The East Coast Canal with Brahami Rivet and Mahanadi Delta (588 km)

Amongst the above five waterways, the national waterways on Ganga (NW-1 between Haldia to Allahabad) is the longest waterways (1620 km) and is of prime importance considering its locational advantages. IWAI since long has been maintaining the least available depth (LAD) of 3m between Haldia and Farakka (560km), 2.5m in Farakka – Barh (400km), 2m between Barh – Ghazipur (290km) and 1.2 to 1.5m in Ghazipur – Allahabad (370km). Even currently this waterway (NW-1) is being used for various cargo movements, as well as tourists. Already good amount of cargo movement is taking place between Haldia and Farakka (e.g. 3 million metric tonne of imported coal from Haldia to NTPC plant is being transported since October 2013 through 20 barges of 2000 dwt capacity each). Considering such a large potential and demands, IWAI has initiated the project of “Capacity Augmentation of National Waterway-1” between Haldia and Allahabad named as “Jal Marg Vikas Project”. The capacity building of this magnitude under this project warrant’s number of additional infrastructural components (such as construction of terminals for cargo handlings, provision of navigation aids, river information systems) which are required to be developed in a phased manner. The locational overview of NW-1 is shown at **Figure 1.1**.

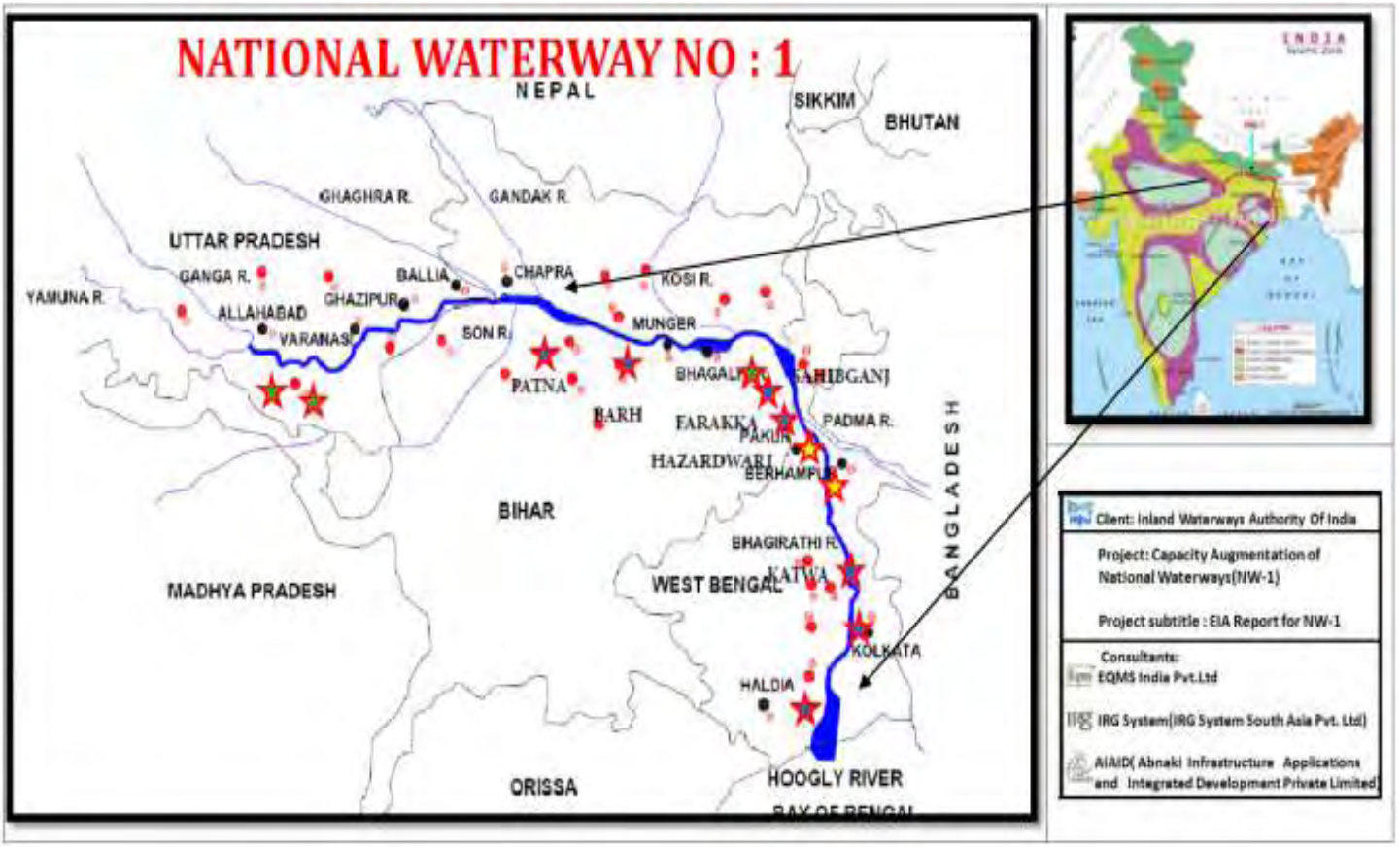


Figure 1.1 : Location Map of NW-1

1.2. Need of Jal Marg Vikas Project – NW-1

Inland Waterway Transport (IWT) offers a comparatively low cost and environmentally sound alternative to road and rail transportation especially for bulk and containerized cargo. Infrastructure requirements of IWT in comparison to road and rail transport are also relatively low, although some investments are essential such as in port/terminal facilities, connecting road/rail infrastructure, navigation aid and dredging facilities etc. While cargo movement through other modes of transportation are often confronted with congestion and capacity problems, IWT offers a relatively congestion free and reliable mode of transport along with availability of unmatched capacity expansion due to its large untapped potential.

Till the middle of 20th century, IWT was being used as an important mode of transport in various parts of India but gradually it got confined to unorganized sector except in few states namely Goa, Assam, West Bengal, Kerala and Mumbai primarily due to focus shift in transportation through rail and road modes. However, IWT use had picked and showed increasing trend since 2003-2004 and touched 70 Million tonnes mark by2011-2012 compared to only 32.48 Million tonnes in 2003-2004 which is just 0.34% of total inland cargo movements of about 1000 btkm. IWAI has set the target of increasing IWT share up to 2% of total inland cargo by 2025. The main commodities carried by IWT (which are also true with NW-1) include building materials (34%), metals\ores (19%) and

coal\coke (17%). On demand side in the case of NW-1 (Allahabad – Haldia) alone 10 thermal power plants are located along Ganga river in UP & Bihar stretch and 11 more are expected to become operational soon. The total requirement of coal for these power plants will be nearly 70 million tonnes per year, 14 MT of which will have to be imported. In addition to this, there are seven fertilizer plans along NW-1. These are also estimated to generate an additional of 0.765 million ton of cargo requirement per year. Further, there is also large prospect of container movements for national as well as international trade. It is therefore obvious that IWT and NW-1 in particular would play a very vital role when high quality ports/terminals and waterway connections are made available to facilitate the cargo movement in a cost effective and environmental friendly manner catering to the needs of high transportation movements due to enhanced industrial activities as compared to rail and/or road modes.

Economic Advantage: The economic advantages of this mode compared to other surface modes have been emphasized by a number of high-powered Committees including the National Transport Policy Committee (NTPC) (GOI, 1980), the Steering Committee on Transport Planning (GOI, 1987) and a number of reports and studies (NCAER, 1974, UNDP, 1993, Rao and Kumar, 1996). Some of these studies also pointed out the potential role of connectivity that this mode could perform besides cargo movements, like providing access and connectivity to far- flung areas and the maintenance of ecological balance. The cost advantages include:

- **Low capital Cost**-Cost of development of inland waterways is estimated to be a mere 5-10 percent of the cost of developing an equivalent 4-lane highway or railway. Cost for transportation of cargo through various modes is given in **Table 1.1** below in reference to the "Report of the Inter–Ministerial Committee to Identify New Areas of Private Investment in the Inland Waterways Transport (IWT) Sector" Planning Commission, (Transport Division)

Table 1.1 : Cost of Transportation Through Different Modes

Mode	VOC/Freight (Rs/Km)	Taxes	Total Rs/TKm
Railway*	1.36	3.71%	1.41
Highways**	2.50	3.09%	2.58
IWT	1.06	Nil	1.06
Source: Railways-Ministry of Railways, Road-TTSS, IWT-IWAI * Service Tax on rail Transport is 12.36% abatement is 70%			
**Service Tax on Road Transport is 12.36% abatement is 75%			

- **Low maintenance cost** -Cost of maintenance of inland waterway is about 20 percent of that of roads.
- **Low Operation Costs** – This is also least costs mode of transportation. According to Ministry of Railways, the freight costs by IWT are estimated as 1.06 Rs/ tkm compared to 1.41 Rs / tkm by railways and Rs 2.58 Rs/ tkm by highways**.**
- **Large Cargo Potential** – There is large cargo potential generation from areas along and close to NW-1 but the transportation facilities are insufficient. The potential can be judge from few of the following need:

- NW-1passes through Kolkata which is having connectivity with other states/cities and country through road and railway. Such place offers an appropriate location for development of cargo. Cargo generated at Kolkata or brought in to Kolkata from nearby areas through road/railway can be further transported to other destinations through NW-1 at lower cost
- U.P. & Bihar is large agricultural belt and have high potential of producing wheat. This wheat transportation can be undertaken through NW-1 to other parts of the country
- There are about 9 existing Thermal Power Plant (TPP) around NW-1 and 15 TPP under construction having total power generation potential of 21820 MW. Total coal requirement of these projects is 94.78 million tons per annum. Out of which imported coal requirement is 21.4 million tons per annum. At present on 3 million MTPA of coal is being transported to Farakka STPS. Coal is transported to these existing TPP through railways and all existing TPPs have their own railway siding. Imported coal is brought at Paradeep and Haldia ports. Further adequate depth is not available at Haldia port so 70% of coal is received at Paradeep port only. From these ports, coal is transported to destined locations through railways. However due to constrain capacity of railways, these power plants regularly face shortage. Pressure on railways will further increase after development of the 15 more TPP. NW-1 thus will serve as mode for transportation of coal to above listed TPPs will reduce burden on railways and reduce the gap in demand and supply of the coal.
- Jharkhand is one of the major coal producing state of India and is endowed with app. 80 billion tons of coal of all categories. App. 70 MT of coal is transported to various part of the country from Jharkhand. Coal transportation from Jharkhand can be taken through NW-1 through destined locations
- TPPs located around NW-1 will generate fly-ash which serves as raw material for cement plants and road construction. Fly-ash thus can be transported through NW-1. Assuming 25% of ash content in coal, it is estimated app. 24 million tone of fly-ash will be generated per annum.
- Large quantity of cargo of construction material, fertilizers, coal, minerals and chemicals, project cargo, food & food stuff, containers and vehicles are transported across NW-1 through road & railway. These commodities if transported through NW-1 can significantly cut down the emissions and transportation cost.
- Planning of IFFCO to use NW-1 for transportation of fertilizers produced at Paradeep plant to U.P. & Bihar

Environmental Need: Potential for Fuel Efficiency and GHG Emission: As per an estimate, 1 horse power can carry 4,000-kilogram load in water compared to 150

kilograms and 500-kilogram load by road and rail respectively. In one study[6] it is estimated that 1 litre of fuel can move 105 ton-km by inland water transport whereas the same amount of fuel can move only 85 ton-km by rail and 24 ton-km by road. By air, it is even less. Similarly, if we compare transportation of liquid cargo, the water transport can carry up to 827 Km (514 Miles) in one gallon of fuel against 95 KM (59 miles) and 523 Km (325 Miles) by road and rail transport[7] respectively. The higher energy efficiency of IWT compared to road haulage contributes to less fossil fuel consumption and therefore to less emission of CO_2, NO_x, SO_X and PM. In cases where IWT can provide alternatives for road haulage operations it can contribute to a reduction of polluting matters. The only disadvantage to IWT may be due to associated environmental impacts on aquatic life but the same is manageable with appropriate mitigation measures.

Similar to NW-1, IWAI has declared other river systems as national waterways. IWAI has planned to interlink these waterways so as to facilitate transportation of material from one waterway to another. However, all the waterways declared cannot be linked but as per study of RITES, it is possible to link four waterways out of 6 declared waterways. NW-1 can be connected to NW-2 and NW-6 using protocol route through Bangladesh. Similarly, NW5 that extends up to Paradeep Port can also be joined in the National Waterway grid through backwaters of Hooghly and Hijily tidal canal. Connectivity would further increase the area of influence of each designated waterway system. Proposed National Waterways Grid involves overall rivers length of 3220 km (excluding Indo-Bangladesh Protocol Route). Grid is likely to serves 11 states namely; Uttar Pradesh, Bihar, Jharkhand, West Bengal, Assam, Meghalaya, Arunachal Pradesh, Tripura, Mizoram, Manipur and Odisha serving 108 civil districts. Interlinking of waterways and formation of grids is however not component of this project but a proper navigable waterway is requirement for execution of such large programme. Water way development programme onNW-1 named as “Jal Marg Vikas Project” will help in execution of national waterway grid formation project.

1.3. Overview of NW-1

IWAI under Jal Marg Vikas Project – NW-1 proposes to improve the capacity of entire stretch and continue to maintain the waterways of entire stretch between Haldia to Allahabad. However, considering the available LAD and cargo demand scenario, IWAI is

[6] As per *German Federal Waterways and Shipping Administration,* http://www.efficiency-from germany.info/ENEFF/Navigation/EN/Energyefficiency/Transport/InlandWaterways/inland-waterways.html

[7] Tennessee Tombigbee Waterway, http://business.tenntom.org/why-use-the-waterway/shipping-comparisons

focusing on the stretch between Haldia to Varanasi at present. The capacity augmentation project primarily proposes development of the following infrastructural facilities:

- Construction of terminals of appropriate cargo handling capacity and Equipment for facilitating integration with other modes of transportation. Three terminal sites and one lock site have already been identified namely terminals at Haldia, Sahibganj& Varanasi and new lock site at Farakka. Tribeni and Ghazipur are identified potential sites for terminal development. One more site is to be finalized for development of terminal
- Provision of all types of navigation aids for day and night navigation.
- River information system with all hardware and software
- Provision of RO-RO Jetties
- Provision for bank protection / slope protection
- Provision of river training works for critical locations
- Provision for tow barges, inland vessels, survey vessels including rescue boats and survey equipment
- Dredging facilities for maintenance of waterways
- Barge Maintenance & Repair Facility

Some of the above facilities are finalised and some are in the process of identification and design.

1.4. Objective of EIA study

The implementation and development infrastructure facilities as mentioned above under this project will cause various associated environmental & social impacts. The objective of this study primarily focuses on identification, assessment and quantification of the all significant impacts and their mitigation to bring them within acceptable threshold associated with all stages of project implementation namely- design, construction and operation phases of project implementation. The likely impacts are first identified for all project implementation activities with respect to physio-chemical, ecological and social environments. Institutional mechanism is also proposed to make the implementation effective to ensure that there are no significant impacts left by incorporating the requisite EMP and EMoP. Attempts have been made to identify impacts for potential activities and measures suggested to be incorporated in the design as feasible. These measures will be further updated once design aspects are fully finalised.

Since the project is being developed with support and funding from the World Bank, the EIA study framework adopted is in accordance with the operational policies of World Bank, as well as the requirements defined under Environmental Impact Assessment Guidance Manual on Ports and Harbours and Guidelines (MoEF&CC), for carrying out such EIA study.

1.5. Extent and Limitation of EIA Study

The Environmental Assessment was done in tandem with the preparation of Feasibility Report of the proposed project design. Design details and detailed layout plans of various proposed infrastructural facilities and civil interventions associated with NW-1 implementation are not yet finalized for all the components. Therefore, the EIA is based on up-to-date project details provided by the engineering consultant during the preparation of the report[8], primary field investigations / assessment, secondary data collated from different Gov. Departments (centre as well as of four states as UP, Bihar, Jharkhand and W. Bengal). The secondary data/information was collated from agencies such as Inland Waterways Authority of India, State Pollution Control Board, Indian Meteorological Department, Public Works Department, Public Health & Engineering Department, District Collectorate, Irrigation Department, Statistic Department, District Fisheries Department, Mining Department, Ganga Pump Canal Nahar Pariyojna Office, Forest Department, published journals\books besides various local bodies. Summary table of secondary data sources concerning different aspects is tabled in the end of this chapter. Inputs from the extensive public consultation (as described in the report) were also taken into consideration. Professional judgement and subjective interpretation of facts and observations has been applied for the preparation of the EIA Report, since the entire project is under various stages of development. As the project is under design phase thus the figures presented for planned and proposed facilities are tentative and are subject to change with the changes proposed to be undertaken by Design Consultant of the project

1.6. EIA Contents

The EIA report is presented in 8 chapters following this introduction chapter.

Chapter 1: Introduction: This chapter describes project framework, objective and background including the need of the project.

Chapter 2: Policy, Legal and Administrative Framework: This chapter deals with the identification & listing of applicable legislations and applicable administrative framework. It also provides screening of applicable operational policies of World Bank and other international practices and guidelines.

Chapter 3: Description of Project: This chapter describes the various project components incorporated in the overall project framework. It also provides details the alternatives analysed before final selection of the most appropriate option having minimal environmental and social impact implications.

Chapter 4: Description of Environment (Environmental profile and baseline of the project and study area): This provides background information based on primary and secondary information for physical, biological, social and cultural resources of project and study areas.

Chapter 5: Anticipated Environmental Impacts and Mitigation Measures: Here first the anticipated potential impact for each environmental and cultural resource are first identified and then quantified. For each potential impact the mitigation measures are

[8] The engineering details may change at detailed project report preparation stage. In the situation of change of the design, the EIA and EMP reports will be updated accordingly.

delineated in order to mitigate the impacts up to the threshold of acceptable residual levels.

Chapter 6: Environmental Management Plan and Grievances Redress Mechanism: This chapter provide the details on the management plans and the institutional mechanism required along with resources required for effective implementation of the proposed mitigation measures and the monitoring framework essential during construction as well as operation period. It also highlights the institutional mechanism as well as capacity building needs for the implementation.

Chapter 7: Information Disclosure, Consultation, and Participation: This chapter highlights the process followed for the public consultation carried out with the various stakeholders namely public, NGO, Government bodies, prominent local bodies upfront of the project implementation initiatives. It also highlights the information generated during this process for incorporating in the final version of the report

Chapter 8: Conclusions and Recommendations: This chapter provide the summary of findings and concluding remarks.

1.7. Methodology

This project is classified as Category 'A' operations under the world bank environmental screening procedures specified under its operation policy 4.01. The project triggers 7 of the World Bank safeguard policy[9] and requires comprehensive environmental assessment. This project does not require any environmental impact assessment as per the existing provisions of Indian Laws. Initially a basin level critical environmental resource study was carried out to identify "NOGO" and "Restricted areas". Input of this study was used for this environmental assessment.

The EIA study was carried out using reconnaissance survey, review of previous studies, field visits, consultation with stakeholders & NGOs, review of existing data and primary data collection. The methodology was evolved considering the defined terms of reference of IWAI for the study. Extensive use of geographic information system is made to analyse the land use, drainage pattern, elevation profile and identify the environmental features of the study area. Topo-sheets as available and Google maps were used for the above. Since it is having strong interface with aquatic ecology, larger emphasis was given for primary data collection with regard to zooplanktons, phytoplankton, fishes and aquatic fauna. Establish sampling, and observation techniques were applied for this assessment.

The scope of the EIA extends well beyond the vicinity of the NW-1. The area considered for collection of data and assessment of impacts is termed as study area for this study purpose. Study area for this project is divided into 500 m, 2 km and 10 km for different parameters depending on their sensitivity and availability. Details of the study area are given below:

[9]The world bank safeguard policies triggered are environmental assessment (OP/BP 4.01), Natural Habitats (OP/BP 4.04), Forests (OP/BP 4.36), Involuntary resettlement (OP/BP 4.12), Indigenous people (OP/BP 4.10), Physical Cultural Resources (OP/BP 4.11) and Project on International Waterways (OP/BP 7.5)

500 m radius: This zone is considered as core impact zone as this zone is likely to have maximum interface with project development. All the parameters of environmental, socio-economy and cultural importance are studied within this zone.

2 km radius: This zone is considered as immediate buffer zone as this will interface with project development but not to the extent of 500m zone. All the parameters of environmental, socio-economy and cultural importance are studied within this zone also.

10 km radius: This zone is considered as extended buffer zone. Parameters studied under this zone include environmental sensitive locations as notified by GoI, land use change, socio-economy, and geology, seismicity& drainage pattern.

Since project is based on river, alternative analysis is undertaken for with and without project, technological aspects and sitting of interventions. Alternate analysis of the sites has been undertaken for selection of sites and infrastructure like roads, railway etc. for proposed interventions under this project. Analysis was carried out considering physical, biological and socio-economic impacts and technical and financial feasibility. Analysis of alternatives has also been considered at planning level of the each proposed interventions. The established practices (like trend analysis, expert assessment, stakeholders' perception and concerns, resource availability) were followed to identify potential impact associated with the proposed project activities. Appropriate tools and techniques (like use of Air Quality and Noise prediction models) were used to identify and predict the magnitude of the impacts. Suitable mitigation measures are suggested based on the intensity of the impacts identified for offshore and onshore activities both. The Environmental Management and Monitoring plan with institutional requirements is also prepared to ensure effective implementation of the mitigation measures proposed.

1.8. Data Collection

The objective of data collection was to provide a database of existing conditions, to be used for predicting the likely changes that are expected and for monitoring such changes. The first step was to undertake a project scoping exercise, identify the parameters to be considered, and outline the activities for collecting data on identified parameters. Sources of data were identified. Relevant available data pertaining to physical, biological (terrestrial and aquatic), and socio-economic aspects of the environment was collected from various secondary sources supported by primary data collection.

Primary data was also collected with focus on sensitive receptors like religious places, habitat areas, noise, air quality, water quality (ground and surface water both), soil, biodiversity (terrestrial and aquatic both). The air quality data was collected as per latest National Ambient Air Quality standards. The Ambient air quality monitoring stations were selected over the study area to get representative data of the area. Similarly, ambient noise level was monitored for day and night near sensitive locations, residential, and project areas. The water quality of surface and ground were monitored in the study area to get representative water quality information. River bed samples were also tested to assess the contamination level of river bad materials. The primary data was collected between September, 2015 & February, 2016

1.9. Public Consultation

Local knowledge about the ecosystem and problems associated with such a development project including sourcing of construction material and men river interface were carefully assessed and used in impact assessment and for developing mitigation plans. Consultations were held focusing on air quality, noise effect, water supply, drainage, aquatic and terrestrial flora and fauna, physical cultural resource of importance, environmental sensitive ecosystems or areas that may be affected by the project. Formal institutional level public consultation and opportunistic informal meetings involving local villagers and those who are likely to be affected due to the proposed projects were organized to determine potential environmental and socio-economic impacts. Interactions were also made with NGOs and concerned government officials. Consultation was carried out in two stage: Stage I during EIA report Preparation and stage II post EIA report preparation. A detailed description of the public consultation is presented in Chapter 7.

1.10. References

Secondary data for areas along NW-1 was also referred to authenticate & validate the primary information collected. The list of information sources, nature of data collected, purpose of data use and other reference are presented at **Table 1.2.**

Table 1.2 : Summary of Secondary Data with Sources

Source organisation	Report/source Name	Type of data
CPCB &MOEF&CC	CPCB Gazette notification dated 18.11.2009 on AAQ, Noise Notification, and BDU criteria	AAQ Standards BDU Criteria Standards Noise Standards
	Water Quality Assessment River Ganga 2013	Water Quality of NW-1 stretch
MOEF & CC	Endangered Species Brochure, 2009	Endangered Species
Indian Meteorological department	Climatological Normal 1961-1990	Met Data
	First order seismic micro zonation IMD	Seismicity and seismic map and Cyclone Hazard Prone Map
MOEF & CC	Jharkhand Wetland Atlas, Prepared by Space Applications Centre (ISRO), Ahmedabad and Institute of Environmental Studies & Wetland Management (IESWM), Kolkata)	Wetland information
MOEF & CC	Information on Wetlands	Wetland information
Central Ground Water Board	Ground Water Boucher of Project Districts	Geology, Ground water related information
Botanical Survey of India	Red Data Book of Indian Plants	RET species
Zoological Survey of India	Red data book on Indian Animal	RET species
IUCN (International Union for	Gland, Switzerland: International Union	RET species

Source organisation	Report/source Name	Type of data
Conservation of Nature) 1980	for Conservation of Nature. IUCN (International Union for Conservation of Nature) 1980.*World Conservation Strategy: Regional strategies for international river basins and seas*.	
IWC (International Whaling Commission) 2000	Report of the standing sub-committee on small cetaceans. *Journal of Cetacean Research and Management* 1 (Supplement),	Cetacean fauna
Mohan, R. S. L. and Kunhi, K. V. M. 1996.	Fish oil as alternative to river dolphin, *PlatanistaGangetica*(Lebeck) oil for fishing catfish *Clupisomagarua*in the River Gangetic, India. *Journal of the Bombay Natural History* Society 93, 86-88.	Oil impact on Aquatic fauna
Gland, Switzerland: IUCN.Perrin, W.F. 1999.	Selected examples of small cetaceans at risk. Pp. 296-310 in: *Conservation and Management of Marine Mammals* (eds. J.R. Twiss, Jr. and R.R. Reeves) Smithsonian Institution Press, Washington, DC.	Aquatic fauna
NGBRA (Indian Institutes of Technology)	GRB EMP: Ganga River Basin Environment Management Plan	Flora& Fauna
NGBRA (IIT Consortium)	Main Plan Document by Consortium of 7 Indian Institute of Technology's (IITs)	Ganga basin
NGBRA (Indian Institutes of Technology)	Status of Higher aquatic vertebrates in Ganga river (Ganga River Basin Management Plan) By Consortium of India's IIT Institutes	Higher aquatic vertebrates
NGBRA	Hilsa an assessment of in lower ganga basin (Ganga River Basin Management Plan) By Consortium of India's IIT Institutes	Fish
NGBRA (Indian Institutes of Technology)	Status of fish and fisheries in Ganga river (Ganga River Basin Management Plan) By Consortium of India's IIT Institutes	Fish
NGBRA	River Ganga at a Glance: Identification of Issues and Priority Actions for Restoration	Waterways quality
NGBRA (IIT Consortium)	Main Plan Document by Consortium of 7 Indian Institute of Technology's (IITs)	Ganga basin
Publication of BHU university	Flora of BHU	Flora

Source organisation	Report/source Name	Type of data
Kashi Turtle Sanctuary	Management Plan of Kashi turtle sanctuary	Turtle
Kalpavirksha	India's Notified Ecologically Sensitive Areas (ESAs)	Sensitive ecosystem
Chaudhary, S. K., Smith, B.D., Dye, S., Dye, S. And Prakash, S. 2006.	Conservation and Biomonitoring in the Vikramshila Gangetic Dolphin Sanctuary, Bihar, India. *Oryx,* 40 (2), 189-197	Dolphin
Quaritich.Braulik, G. 2000.	Entrapment of Indus dolphins (*Platanista minor*) in irrigation canals: incidence, implications and solutions. *International Whaling Commission, Scientific Committee Document* SC/52/SM9, Cambridge, UK.	Dolphin
Harison, R. J. 1972.	Reproduction and reproductive organs in *Platanistaindi* and *Platanista Gangetica. Invest Cetacea*.	Dolphin
Hua, Y., Zhao, Q., & Zhang G. 1989.The habitat and behaviour of Lipotesvexillifer. In W. F. Perrin, R. L. Jr. Brownell, K. Zhou & J. Liu (Eds.)	*Biology and conservation of the river dolphins* Occasional Paper of the IUCN Species Survival Commission (No.3., pp. 92-98).	Conservation Dolphin
Kannan, K. Sinha, R.K., Tanabe, S., Ichihashi, H. and Tatsukawa, R. 1993	Heavy metals and organochlorine residues in Gangetic Dolphin from India. Marine *Pollution Bulletin* Vol. 26 No. 3 pp 159-162 pergamon press U.K.	Heavy metal impact on Dolphin
Kannan, K., Tanabe, S., and Tatsukawa, R. And Sinha R.K. 1994.	Biodegradation capacity and residue pattern of organochlorines in Gangetic Dolphins from India. *Toxicological and Environmental Chemistry*.	Dolphin toxicology
Kasuya, T. 1972.	Some information on the growth of the Gangetic Dolphin with a comment on the Indus dolphin. *The Scientific Reports of the Whales Research Institute*	Morphology of dolphin
Mohan, R. S. L. and Kunhi, K. V. M. 1996.	Fish oil as alternative to river dolphin, *Platanista Gangetica* (Lebeck) oil for fishing catfish *Clupisomagarua*in the River Gangetic, India. *Journal of the Bombay Natural History* Society 93, 86-88.	Oil impact on Aquatic fauna
KK Vass, S K Mandal, S Samanta, V R Suresh and P K Katiha, (CIFRI)	The Environment and Fishery status of River Ganges	Fish

Source organisation	Report/source Name	Type of data
Srivastava, P. And M.P. Singh, M.P. (2013)	Phenology and Biodiversity of Riparian Plant Species of Ganga River Bank at Bharwari (Kaushambi), U.P., India. Indian J.Sci.Res. 4(1)	Flora
Sahibganj Forest Division	Forest Working Plan of Sahibganj Forest Division	Flora and Fauna
Kalpavirksha	India's Notified Ecologically Sensitive Areas (ESAs)	Sensitive ecosystem
R.J. Rao Conservation Biology Lab School of Studies in Zoology Jiwaji University, Gwalior	The Diversity, Ecology and Conservation Management of Freshwater turtles in Ganges River System	Ecology & Turtles
Agriculture Department	Agriculture plans	Cropping pattern
Census of India, Govt. Of India	Census of India 2011	Census data
Census of India, Govt. Of India	District Statistics Hand Book & Village Profile of the Project Districts	Basic Amenities
Kelkar, N., Krishnamurthy J., Choudhary, S., and Sutaria, D. 2010.	Coexistence of fisheries with River Dolphin Conservation. *Conservation Biology*, Vol. 24 (4): 1130-1140.	Dolphin conservation
WWF-Nepal. 2006	Conservation and Management of river dolphins in Asia. *Proceedings of the regional meeting on conservation and management of river dolphins*. 26-27 May, Kathmandu, Nepal.	Dolphin
Forest Division	Forest Working Plan of Kashi Forest Division, Farakka Division	Flora and Fauna
Guideline, Standard and recommendations as published by Environmental Committee of PIANC	• Initial Assessment of Environmental Effect of Navigation and Infrastructure Project (WG 143-2014) • Sustainable waterway within the context of Navigation and Flood Management (WG 107-2009) • Climate Change and Navigation (TG3-2008) • Dredging Management Practices for the Environment (WG 100-2009) • Dredging Material as a Resources (WG 104-2009) • Environmental Impact Assessments of Dredging and Disposal Operation (WG 10-2006) • Biological Assessment Guidance for Dredged Material (WG 8-2006) • Ecological and Engineering Guidelines for Wetland Restoration in relation to the Development, Operation and Maintenance of Navigational Infrastructure (WG 7-2003) • Management of Aquatic Disposal of dredged material (WG 1-1998)	

Source organisation	Report/source Name	Type of data
	• Dredged Material Management Guide 1997. • Guidelines for sustainable Inland Waterways and Navigation WG 6-2003 • Environmental guidelines for aquatic, nearshore and upland confined disposal facilities for contaminated dredged material WG 5-2002 • Dredging the environmental facts-where to find what you need to know? PIANC-IADC-WODA brochure-2001 • Environmental management framework for ports and related industries WG 4-1999 • Dredging: the fact WODA brochure-PIANC-IADC-CEDA-IAPH1999	

Chapter 2. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1. Introduction

India has well defined institutional and legislative framework. The legislation covers all components of environment viz. air, water, soil, terrestrial and aquatic flora and fauna, natural resources, and sensitive habitats. India is also signatory to various international conventions and protocols. The environmental legislations in India are framed to protect the valued environmental components and comply with its commitment to international community under various conventions and protocols. World Bank has also defined its Environmental and Social Safeguard Operational Policies. This assessment is about the applicability of above laws and regulations, conventions, protocols, and safeguards.

The applicability of legislation to the navigational channel (waterway) improvement, will be assessed under separate EIA being carried out for waterways and NW-1 as a whole.

2.1.1. *Overview of Indian Environmental Legislation and Administrative Framework*

The Government of India has framed various laws and regulations for protection and conservation of natural environment. The legislations are broadly divided under following categories.

- Environmental Protection
- Forests Conservation
- Wild Life Protection

The umbrella legislation under each of above category is highlighted below:

The Environment (Protection) Act 1986 was enacted with the objective of providing for the protection and improvement of the environment. It empowers the Central Government to establish authorities charged with the mandate of preventing environmental pollution in all its forms and to tackle specific environmental problems that are peculiar to different parts of the country. Various rules are framed under this Act for grant of environmental clearance for any developmental project, resources conservation and waste management.

The Forest Conservation Act 1980 was enacted to help conserve the country's forests. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of Central Government. To this end the Act lays down the pre-requisites for the diversion of forest land for non-forest purposes.

Wild Life (Protection) Act 1972 amended 2003 was enacted with the objective of effectively protecting the wild life of this country and to control poaching, smuggling and illegal trade in wildlife and its derivatives. It defines rules for the protection of wild life and ecologically important protected areas.

The MoEF&CC and the pollution control boards (CPCB - Central Pollution Control Board and SPCBs - State Pollution Control Boards) together form the regulatory and administrative core of the part. Other Ministries/Statutory Bodies/Departments responsible for ensuring environmental compliance and granting various clearances

includes state ministry /dept. of environment, regional offices of MoEF&CC and state forests/wildlife departments.

2.1.2. *Applicable Environmental Legislation*

As per the nature of the project, screening has been done to identify the legislations applicable to the project. Legislations applicable to the project are further divided into the legislations framed by Govt. of India and Regulations applicable for vessels plying in inland waterways framed by IWAI and Ministry of Shipping, GoI. Regulations of Govt. of India applicable to the project are given in **Table 2.1** and legislations framed for vessels plying in inland waterways framed by IWAI and Ministry of Shipping, GoI are given in **Table 2.2** below.

Table 2.1 : Summary of Environmental and Other Legislation with Applicability Screening

Name	Key Requirement	Applicability	Type of permit and stage of applicability	Administrative Authority and indicative time frame for grant of permission	Responsibility
Environmental Protection Legislations					
Environment Protection Act-1986 and Rules there under including EIA Notification 14th Sep 2006 and amendment till date	To protect and improve overall environment. Requires prior environmental clearance for new, modernization and expansion projects listed in schedule 1 of EIA Notification, 2006	Considered Not Applicable (EIA Notification 2006 does not classify terminals/jetties/ floating terminals on river or dredging in the river as a project requiring environmental clearance. The applicability of this legislation should be re-assessed periodically from the concerned authority during NW-1 project development and implementation stages to ensure conformity with changes in the regulations if any). Borrowing of earth for road construction as may be required, will require prior environment clearance under mining category.	Environment Clearance Construction stage for EC for borrowing earth as applicable	MoEF&CC & SEIAA/SEAC /DEAC/DEIAA	IWAI/EPC Contractor for obtaining environmental clearances as applicable. EPC contractor shall also be responsible for EMP implementation and compliance to environmental clearance conditions.

Air (Prevention and Control of Pollution) Act, 1981, 1987	An act to prevent and control Air pollution	Applicable. The applicability is due to emission from operation of construction equipment like batching plants, hot mix plants, DG sets, and similarly, during operation stage backup power generation, material handling related aspects.	Consent to Establish &Consent to Operate	SPCB	EPC contractor, for setting up each facility (terminal/ jetty/ floating terminals etc.), batching plant, hot-mix plant as prior to its establishment from SPCB CTO shall be taken by contractor for batching plant, hot-mix plant & quarry site as required prior to operation and it should be renewed before the expiry of permit. EPC contractor shall also obtain CTO for each proposed facility under the project before its handover.
Water Prevention and Control of Pollution) Act, 1974, 1988	An act to prevent and control water pollution.	Applicable. It is applicable for the projects having potential to generate effluent during any stage of the project. Effluents are expected to be generated during both the construction and operation phase of the project.	Consent to Establish & Consent to Operate	State Pollution Control Boards	CTE should be taken by contractor for disposal of sewage and construction of septic tank/soak pit prior to start of construction from SPCB CTE/CTO for each proposed facility under the project shall also be obtained by EPC contractor along with CTE / CTO under Air Act.

Noise Pollution (Regulation and Control Act) 2000 and amendment till date	Ambient Noise Standards for different areas and zones	Applicable due to generation of noise during construction and operation stage.	No permits issued under this act	SPCB & CPCB	EPC contractor and IWAI to ensure compliance to Ambient Noise Level Standards.
Hazardous & Other Wastes (Management and Transboundary Movement) Rules, 2016	Protection to general public against improper handling storage and disposal of hazardous waste. The rules prescribe the management requirement of hazardous wastes from its generation to final disposal.	Applicable. Project has potent to generate hazardous waste (Waste Oil) during both construction and operation phase.	Authorization for storage and handling hazardous waste	SPCB & MoEF& CC	EPC Contractor shall obtain authorization for handling, storage and disposal of hazardous waste (Waste Oil) along with CTE/CTO for air and water act.
MSIHC Rules, 1989	Usage and storage of hazardous material	Applicable only for storage of highly inflammable liquids like HSD/LPG	No specific permit is required, however precautions defined under the material safety datasheets shall be followed for use of hazardous substances listed under the schedules attached to this notification if any proposed to be used. Safety audit and other	Chief Controller of Explosives, MoEF&CC and DC	EPC contractor and IWAI

			requirements shall have to be complied if storage quantity exceeds the regulated threshold limit		
The Bio Medical Waste Management Rules, 2016	To control storage, transportation and disposal of Bio Medical Waste.	Applicable Applicable for the disposal of bio-medical waste from first aid centres and dispensaries	No specific permit is required. Just comply with the handling and disposal requirements of the rule	Disposal through authorized disposal agency	EPC contractor and IWAI
Construction and Demolition Waste Management Rules, 2016	To manage the construction and demolition waste	Applicable Applies to all those waste resulting from Construction, re-modelling, repair & demolition of any civil structure of individual or organization who generates construction and demolition waste such as building material, rubble, debris.	Approval required from local authorities, if waste generation is >20 tons in a day or 300 tons per project in month	Local Authorities. Segregation, management and disposal of waste as per rules.	EPC contractor and IWAI
E-Waste (Management) Rules, 2016	To manage the E-waste but not covering lead acid batteries and radio-active waste	Not Applicable as IWAI will not fall any of the categories. (Rule applies to every manufacturer, producer, consumer, bulk consumer, collection centres, dealers, e-retailer, refurbisher, dismantler and recycler involved in manufacture, sale, transfer, purchase, collection, storage and processing of e-waste or electrical and electronic equipment listed in Schedule I, including their components, consumables, parts and spares which make the product operational)	To obtain authorization from SPCB. Filing of return and maintenance of records in the forms given in the Rules	SPCB	Not Applicable

Plastic waste Management Rules, 2016	To manage the plastic waste generated	Applicable Rule applies to every waste generator, local body, Gram Panchayat, manufacturer, Importers and producer.	No authorization to be obtained. Waste management and minimization to be done. Fee to be paid to local bodies, if applicable	Local bodies	EPC contractor and IWAI
The Batteries (Management and Handling) Rules 2001	To regulate the disposal and recycling of lead acid batteries	Applicable Applicable for disposal of used lead acid battery if likely to be used in any equipment during construction and operation stage.	No specific registration required. Compulsion to buy and sale through registered vendor only.	MoEF&CC	EPC contractor and IWAI
Coastal Zone Management Act 2011	To regulate development activities within the 500m of high tide line in coastal zone and 100 m of tidal influence rivers.	Considered Applicable only for Haldia Terminal. However, it is proposed to be confirmed from concerned WB CZMA)	CRZ Clearance	West Bengal State Coastal Zone Management Authority and MoEF&CC	IWAI (IWAI has already started the process confirming and obtaining CRZ clearance for Haldia Terminal)
Forest Conservation and Wildlife Protection Legislation					
The Forest (Conservation) Act, 1980 and amendments The Forest (conservation) Rules 1981 and amendments till date	To protect forest by restricting conversion of forested areas into non-forested areas and deforestation	Not Applicable. No forest land is being diverted. However large no. of tree cutting is envisaged for which NOC from forest department as per applicable rules of the state. (it will be required in Up and West Bengal as per current rules of the states for cutting of the trees).	Forest Clearance / Permission for tree cutting.	Forest Department, MoEF&CC	NOC shall be obtained from forest department prior tree cutting in UP and West Bengal. Compensatory plantation shall be carried out in minimum ratio of 1:8. NOC shall be obtained by contractor.

Biological Diversity Act, 2002	Conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto	Not Applicable	No permit issued under this Act.	National Biodiversity Authority and State Biodiversity Board	Not Applicable
Wild Life Protection Act, 1972, 1993	To protect wildlife through notifying National Parks and Sanctuaries and buffer areas around these zones	Not Applicable as no development is being undertaken within the buffer zone of the eco-sensitive zone notified under this act. Necessary permission shall be obtained for virgin movement of vessel through these zone (Kashi Turtle Sanctuary and Vikramshila Dolphin sanctuary). Permission shall be taken for any intervention if planned at any stage within the buffer zone of eco-sensitive zones. No clearance is required under Hilsa Sanctuary as it is enacted only for fish productivity enhancement under Fisheries Act and not	Wild life clearance	Chief Conservator Wildlife, Wildlife Wing, Forest Department, MoEF&CC	Necessary permission shall be obtained for virgin movement of vessel through these zone (Kashi Turtle Sanctuary and Vikramshila Dolphin sanctuary). Permission shall be taken for any intervention if planned at any stage within the buffer zone of eco sensitive zones. (IWAI has already started process of obtaining permission for movement of vessel through these

		under this Act.			sanctuaries have already been started)
Safety and Other Related Legislations					
Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	Requirement of preparation of on-site and off-site Disaster Management Plans for accident-prone areas.	Not Applicable. The project does not involve handling of any hazardous chemical during both construction and operation phase which may lead to continuous, intermittent or repeated exposure to death, or injury.	No permits issued under this act	Central, State & District Crisis Group	Not Applicable
Public Liability and Insurance Act 1991	Protection from liability arising due to accidents from handling of hazardous chemicals.	Not Applicable. The project does not involve storage of any chemicals (HSD) beyond the threshold limit during construction and	No permits issued under this act. Owner of project shall take out insurance policies providing for contracts of insurance so as he is insured against liability to give relief, before handling any such hazardous material	Collector of the Area	Not applicable
Explosive Act 1884 & Explosive Rules, 2008	Safe transportation, storage and use of explosive material	Not Applicable as no explosive (as described in act & rules) shall be used in the construction and operation stage of the project.	Permission for storage and usage of explosive	Chief Controller of Explosives	Not applicable
Petroleum Rules, 2002	Use and Storage of Petroleum products	Applicable as storage of HSD/LPG or any other petroleum product may be required for the	License to store petroleum beyond prescribed	Chief Controller of Explosives/DC	EPC Contractor / IWAI

		project purpose	quantity.		
Central Motor Vehicle Act 1988 and amendment Central Motor Vehicle Rules, 1989 and amendments till date	To minimize the road accidents, penalizing the guilty, provision of compensation to victim and family and check vehicular air and noise pollution.	Applicable, for all the vehicles at site during construction & operation phase	No permit issued under this Act	Motor Vehicle Department (Licensing authority, registration authority &State Transport Authorities)	EPC Contractor to follow Rules for all the construction vehicles being used at site during construction purpose. IWAI shall follow the rules for all its vehicles at site during operation phase and should also monitor that loading & unloading vehicles also complied these rules
The Gas Cylinder Rules 2004	To regulate the storage of gas / possession of gas cylinder more than the exempted quantity	Applicable if contractor store more than the exempted quantity of gas cylinder.	License to store gas cylinder more than the regulated quantity	Chief Controller of explosives	Contractor
Ancient Monuments and Archaeological Sites and Remains Act, 1958	Conservation of cultural and historical remains found in India. According to this Act, area within the radii of	Applicable only if any intervention is planned within 300 m of archaeological protected sites falling along the NW-1	No objection certificate	Archaeological Dept. GoI, Indian Heritage Society and Indian National Trust for Art and Culture	Not applicable as yet as no intervention planned within 300m of these sites. However, it shall be applicable if any such intervention

	100m and 300m from the "protected Property" are designated as "protected area" and "controlled area" respectively. No development activity (including building, mining, excavating, blasting) is permitted in the "protected area" and development activities likely to damage the protected property is not permitted in the "controlled area" without prior permission of the Archaeological Survey of India (ASI).			Heritage (INTACH).	is planned in future within 300 m of such resource.
Merchant Shipping Act, 1958	To prevent marine pollution from ships	Considered Applicable as these cargos are also required to register in India under this act.	Registration Certificate	National Shipping Board	IWAI shall ensure that all the barges plying in the waterways

	beyond 5 km of the coastline and to make the transportation safe.				are complying with the rule as applicable
Guidelines for evaluation of proposals/requests for ground water abstraction for drinking and domestic purposes in Notified areas and Industry/Infrastructure project proposals in Non-notified areas, 2012	To regulate extraction of ground water for drinking and domestic purpose	Applicable if ground water is extracted for meeting drinking/domestic water needs of employees and visitors at proposed facility & vessels	No objection certificate	Central ground Water Authority/Board & MoEF&CC	Contractor/IWAI shall obtain NOC from CGWA/CGWB prior digging any bore well during construction & operation phase

Note: applicable social legislations are not listed here as these are covered under SIA and RAP reports being prepared separately.

Table 2.2 : Regulations Applicable on Vessels/Barges Plying in Inland Waterways

Name	Key Requirement	Applicability	Administrative Authority
Prevention of Collision on National Waterways Regulations, 2002	Regard to precautions required by the ordinary practice of Seamen and limitation of the vessel	Applicable for all the vessel plying in National Waterway	IWAI
National Waterways, Safety of Navigation and Shipping Regulations, 2002	Ensuring safety of navigation and shipping on the national waterways	Applicable for all the vessel plying in National Waterway	IWAI
The National Waterway-1 Act, 1982	Provision for regulation and development of that river for purpose of shipping and	Applicable for all the vessel plying in National Waterway	IWAI

	navigation on the NW-1 and for the matters connected therewith or incidental thereto		
New Inland Vessel Act, 2015 & Rules Under IV Act	Economical and safe transportation through inland waters	Applicable for all the vessel plying in National Waterway	IWAI

2.2. International Best Practices & Guidelines

2.2.1. *Operational Policies of World Bank*

The project is being developed with the financial aid from World Bank. World Bank has its operational policies which safeguards the different environment and social components. World Bank operational policies triggered for this project are listed in **Table 2.3**.

Table 2.3 : World Banks Operational Policies - Environmental & Social Safeguard

Name	Key Requirement	Applicability	Remarks
OP 4.01 Environmental Assessment	Ensures sustainability and environmental feasibility of the project. Projects are classified into A, B & C category depending on the nature and extent of the impact.	Triggers	Project classified as Category A considering nature of activities and impacts
OP 4.04 Natural habitats	Ensures conservation of natural habitats and discourages disturbance of nay natural habitat due to project development by recommending adoption of alternative method/route/approach or adopting management measures	Triggered	Triggered for Sahibganj & Varanasi Terminal Projects. No other project is in close vicinity of such endangered or protected environment
OP 4.36 Forests	Ensures that project activities donot disturbs/interfere with the forest, forest dwellers activities, fauna and flora of the forest. Prevents and discourages deforestation and impacts on rights of forest dependent people.	Triggers	No diversion of forest land is involved however large number of tree cutting is involved. Permission will be required for felling these trees from forest department.
OP 4.12 Involuntary Resettlement	Ensures minimal involuntary resettlement by considering feasible alternatives project design, assisting displaced people to improve their former	Triggers	Applicable for facilities which involves land acquisition like Sahibganj terminal, Varanasi terminal etc.

	living standard.		
OP 4.10 Indigenous people	Ensures protection of the dignity, right and cultural uniqueness of indigenous people and ensures they receive social and economic benefits	Triggers	No indigenous group of people will be affected directly by project, however ST population is residing within 10 km radius area of the Sahibganj terminal.
OP 4.11 Physical Cultural Resources	Ensures preservation of property of cultural and religious importance, heritage and property of natural importance and enhancement of cultural properties	Triggers	Applicable for Sahibganj terminal project as it involves shifting of one of the community temple which exists at the site. It may be applicable for other sites for civil interventions which are under planning and identification
OP 7.5 Projects on International Waterways	Projects on international waterways may affect the relations between the World Bank and its borrowers, and between riparian states. Therefore, the Bank attaches great importance to the riparian making appropriate agreements or arrangements for the entire waterway, or parts thereof, and stands ready to assist in this regard. A borrower must notify other riparian of planned projects that could affect water quality or quantity, sufficiently far in advance to allow them to review the plans and raise any concerns or objections	Triggered	NW-1 traverse through Farakka canal to Hoogly River and does not affect or change the water treaty between India and Bangladesh in any way. However due to movement of vessels in River Ganga in Farakka area which is part of international riparian treaty between India & Bangladesh, this policy is considered triggered with a view to give advance intimation of NW-1 plans of this area to Bangladesh

World Bank's operational policy 4.01 (OP 4.01) categorize the project into Category A, B & C on the basis of nature and extent of the impacts anticipated from the project. Scope of Environmental assessment studies depends on the category in which the project falls and is defined below.

Category A - Projects with significant environmental impacts and requiring a full Environmental Assessment (EA),

Category B - Projects with moderate environmental impacts and requiring a lesser level of environmental assessment,

Category C - Projects which require no environmental analysis.

Proposed Project involves augmentation of navigation capacity of NW-1 by developing various facilities like terminals, jetties, navigation aids etc. along the NW-1. Project is spread over app 1600 km and has impacts on various environment and social component. Components to be impacted due to project development are quality of life, livelihood, terrestrial and aquatic ecology, air quality, water quality, economy of the country, noise levels etc. Also it is anticipated impacts are both positive and negative but will be significant. Thus the project is classified as Category A and a detailed environment and social assessment study has been undertaken for the project.

2.2.2. *Relevant International Environmental Convention*

2.2.2.1 International Maritime Organization Conventions

India is member state of the International Maritime Organization (IMO). All the vessels plying in marine environment are bound to follow these conventions. These conventions are aimed at ensuring environmental protection and safety of seamen. These guidelines shall also be followed by vessels/barges plying in inland water bodies to the extent possible. IMO Conventions/ Protocols relevant to the project are given in **Annexure 2.1.** Conventions which majorly are in environmental context include MARPOL Convention 1973/78 & Ballast Water Management, 2004.

MARPOL Convention, 1973/78

The MARPOL Convention, an international convention is responsible for the preventing pollution of the marine environment by operational or accidental discharges from the ships. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years.

This international convention was adopted in 1973 at International Maritime Organization (IMO) and covered pollution by oil, chemicals, and harmful substances in packaged form, sewage and garbage. The Protocol of 1978 relating to the 1973 International Convention for the Prevention of Pollution from Ships (1978 MARPOL Protocol) was adopted at a Conference on Tanker Safety and Pollution Prevention in February 1978 held in response to a spate of tanker accidents in 1976-1977. Measures relating to tanker design and operation were also incorporated into a Protocol of 1978 relating to the 1974 Convention on the Safety of Life at Sea, 1974.

The MARPOL Convention includes regulations that are aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations – The convention currently includes six technical annexes delineate below:

Annex I: Regulations for the Prevention of Pollution by Oil

Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk

Annex III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form

Annex IV: Prevention of Pollution by Sewage from Ships

Annex V: Prevention of Pollution by Garbage from Ships

Annex VI: Prevention of Air Pollution from Ships (entry into force 19 May 2005)

Ballast Water Management, 2004

Under this heading, IMOs' setup "International Convention for the Control and Management of Ship's Ballast Water and Sediments, 2004" for preventing the introduction of unwanted organisms and pathogens from ship's ballast water and sediment discharges. This is aimed to arrest the potentially devastating effects of the spread of harmful aquatic organisms carried by ballast water. This convention will require all ships to implement a Ballast Water Management Plan (BWMP) and delineates the standards for the Ballast Water Exchange (BWE) and Ballast Water Performance (BWP) under BWMP.

2.2.2.2 United Nations Convention on the Law of the Sea, Montego Bay, (1982):

This Convention was adopted by India on 10th December 1982 at Montego Bay, Jamaica. Main objectives of the convention are:

- To set up a comprehensive new legal regime for the sea and oceans, as far as environmental provisions are concerned, to establish material rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment; and
- To establish basic environmental protection principals and rules on global and regional cooperation, technical assistance, monitoring, and environmental assessment, and adoption and enforcement of international rules and standards and national legislation with respect to all sources of marine pollution.

Thus the convention can be referred to understand the environmental protection principals and procedures to minimize the environmental pollution due to movement of vessels/barges and related operations

2.2.2.3 International Maritime Dangerous Goods Code (IMDG-code)

The IMDG code relates to methods of safe transport of dangerous cargoes and related activities. It sets out procedures for documentation, storage, segregation, packing, marking and labelling of dangerous goods. This convention can also be referred to understand the procedures followed by the vessels carrying the dangerous goods to ensure safety and avoid spillage and accidents.

2.3. Environmental Standards & Guidelines

Project involves various activities, which may interfere with various environmental components. Thus it is required to control those activities so as the concentration of pollutant in environment shall not exceeds its assimilation capacity. CPCB has issued some standards for disposal of effluents and quality of surface water body which should be referred and adhered to with regards to prescribed discharge standards at any point of time. India does not have any standard yet for disposal of dredged material, water quality in and around harbour/ports/terminals, thus standards issued by other renowned bodies are referred. Suggested list of standards are listed below and given in detail at **Annexure 2.2**.

- Standards for discharge of effluent in inland surface water bodies and Marine Coastal Areas (Source: G.S.R 422 (E) dated 19.05.1993 and G.S.R 801 (E) dated 31.12.1993 issued under the provisions of E (P) Act 1986)
- Classification of Surface water Bodies on basis of Quality (Source: Guidelines for Water Quality Management-CPCB, 2008)
- Water Quality Standards for Coastal Waters, SW-IV & V-Harbour and Navigation & controlled waste disposal (EIA Guidance Manual for Ports & Harbours, MoEF&CC, GoI)
- Standards for permissible level of water quality indicators (Source: Assessment of the Environmental Impact of Port Development, United Nations, New York, 1992)
- Permissible limit for off-shore dumping of dredged material (Source: Assessment of the Environmental Impact of Port Development, United Nations, New York, 1992)
- Criteria for harmful bottom sediments (Source: Assessment of the Environmental Impact of Port Development, United Nations, New York, 1992)
- Approximate Quantity of Suspended Sediments Generated by Dredging or Dumping Operations (Source: Assessment of the Environmental Impact of Port Development, United Nations, New York, 1992).

2.3.1. *Guideline, Standard and recommendations as published by Environmental Committee of PIANC*

PIANC- the World Association for Waterborne Transport Infrastructure is the forum which provides expert advice on cost-effective, reliable and sustainable infrastructures to facilitate the growth of waterborne transport. PIANC has published various guidelines for ensuring the sustainable development of waterborne transport. Some of the guidelines as applicable to the project are listed below. These guidelines can be referred to make the Inland water transportation system sustainable and environmental friendly.

- Dredging Management Practices for the Environment (WG 100-2009)
- Dredging Material as a Resources (WG 104-2009)
- Ecological and Engineering Guidelines for Wetland Restoration in relation to the Development, Operation and Maintenance of Navigational Infrastructure (WG 7-2003)
- Management of Aquatic Disposal of dredged material (WG 1-1998)
- Dredged Material Management Guide 1997.
- Guidelines for sustainable Inland Waterways and Navigation WG 6-2003

2.4. Key safeguard documents

A detailed description of project baseline environmental conditions, identified positive and negative environmental impacts, the mitigation measures to eliminate or minimize the adverse impacts and enhance the positive impacts, detailed environmental management plan including institutional responsibilities, implementation schedule, environmental budget, arrangement for monitoring and evaluation and grievance redressal mechanism are provided in the consolidated environmental impact

assessment report for NW-1 and environmental impact assessment report of Ramnagar (Varanasi terminal), Sahibganj terminal, Farakka Lock, Haldia terminal. The other supplementary documents prepared under this project are i) Basin Level Critical Environmental Resource Assessment report; ii) Consolidated rehabilitation action plan for NW-1, iii) Rehabilitation action plan for Sahibganj, iv) EIA Report for maintenance dredging and barge operations.

Chapter 3. PROJECT DESCRIPTION

3.1. Background

This chapter provides the base information of development proposed. The impact analysis is carried out considering the proposed project components. This chapter is presented in following three broad parts:

A: General Introduction to Jal Marg Vikas Project, Need, connectivity and River related information

B: Alternative Analysis

C: Development of Navigation Channel, Planned and proposed Project Components

Each of above section is elaborated in detail under respective section below.

A: **GENERAL INTRODUCTION TO JAL MARG VIKAS PROJECT, NEED, CONNECTIVITY AND RIVER RELATED INFORMATION**

3.2. Introduction- Jal Marg Vikas Project

NW-1 is natural waterway, extends from Haldia (Sagar) to Allahabad and spans 1620 km crossing the states of Bihar, Jharkhand, Uttar Pradesh & West Bengal. NW-1 is The Ganga - Bhagirathi - Hooghly river system between Haldia & Allahabad. It links the ocean gateway ports of Haldia and Kolkata to Bhagalpur, Patna, Ghazipur, Varanasi and Allahabad, their industrial hinterlands, and several industries located along the Ganga basin. Alignment of NW-1 is depicted in **Figure 3.1** below.

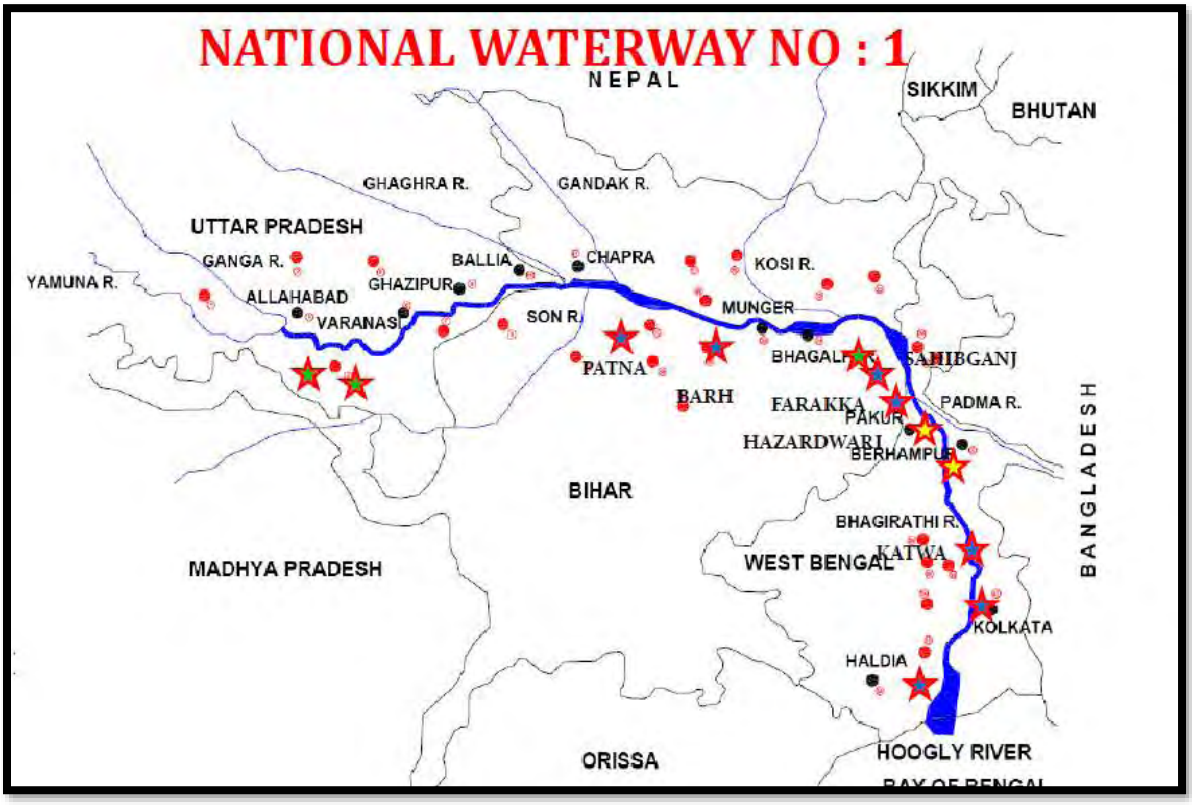


Figure 3.1 : Alignment of NW-1

NW-1 is being fed by various tributaries at different locations. Major tributaries to NW-1 between Haldia to Allahabad are Tons, Gomti, Ghagra, Son, Gandak, Punpun and Kosi. Jal Marg Vikas project is aimed at augmentation of navigation in the waterway by maintaining the LAD in the waterway throughout the year for navigation, development of the navigational infrastructure and navigation aids, river training works at critical location, equipment of the necessary barges/dredgers/boats for navigation purpose and development of efficient River information system. However, to optimize the project impacts and the cost, at present it is proposed to augment the stretch between Haldia and Varanasi only. Dredging operations for maintenance of LAD will be carried out between Haldia and Varanasi only.

3.3. Project Location

Project area includes entire reach of the River Ganga from Haldia to Allahabad including the areas proposed for development of project related facilities & infrastructure, i.e. terminal sites, lock site, Ro-Ro jetty sites and sites for other planned development. Stretch from Allahabad to Haldia covers four states namely Jharkhand, Bihar, Uttar Pradesh & West Bengal. Map showing location of NW-1 stretch from Haldia to Allahabad is depicted in **Figure 3.2**.

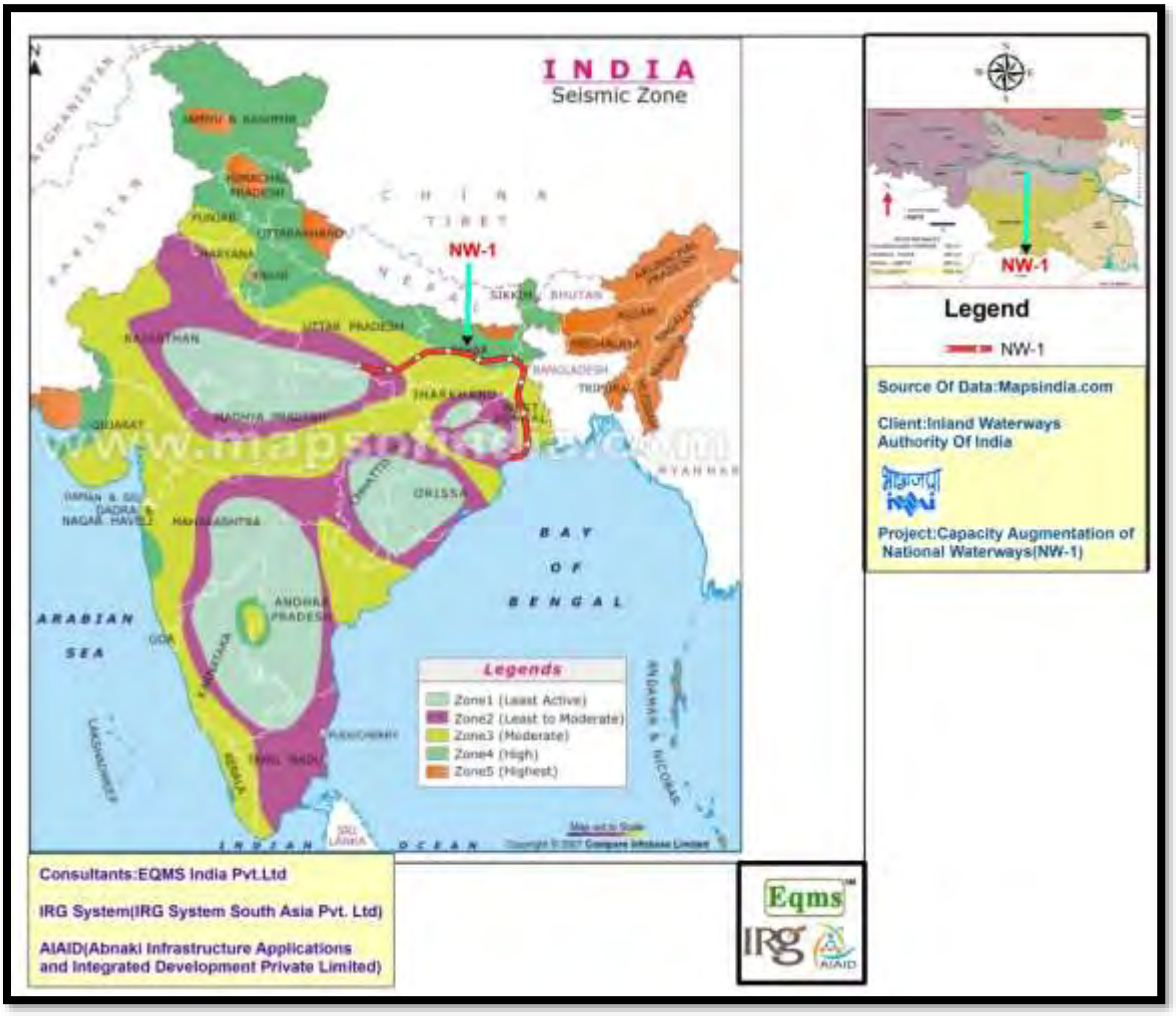


Figure 3.2 : Location Map of NW-1

3.3.1. *Rail and Road Connectivity to NW-1*

There is good rail and road connectivity at important places across NW-1 which enhances the utility of MW-1 for easy movement of material from one mode of transport to another. The connectivity details are provided at **Table 3.1.**

Table 3.1 : Road & Railway Infrastructure at Important Places Across NW-1

S. No.	Place	Road Connectivity	Railway Connectivity
1.	Allahabad (N)	NH 2, NH 27, NH 96	Delhi - Kolkata
2.	Allahabad (S)	NH 27, NH 76	Allahabad - Mirzapur
3.	Mirzapur (N)	SH 5, NH 2	
4.	Mirzapur (S)	NH 27	Mirzapur - Chunar
5.	Varanasi (N)	NH 29, NH 56, NH 233	Varanasi-Ghazipur

6.	Varanasi (S)	NH 2, NH 7	Mirzapur-Buxar
7.	Ghazipur (N)	NH 19	Ghazipur - Ballia
8.	Ghazipur (S)	NH 30, NH 97	Chunar-Buxar
9.	Ballia (N)	NH 19	Ballia - Chapra
10.	Buxar (S)	NH 30	
11.	Patna (N)	NH 77	Chapra - Begusarai
12.	Patna (S)	NH 30A,31,83 & 98	Patna - Jamalpur
13.	Bhagalpur (N)	NH 31, NH 106	Bhagalpur-Sahibganj
14.	Bhagalpur (S)	NH 80	Patna - Jamalpur
15.	Katihar (N)	NH 31, NH 131A	
16.	Sahibganj (S)	NH 80	Sahibganj-Farakka
17.	Farakka (E)	NH 81, NH 34	
18.	Farakka (W)	NH 80, NH 60	Farakka - Behrampur
19.	Behrampur	NH 34	Behrampur - Nabadwip
20.	Nabadwip	NH 34	Nabadwip - Raghunathpur
21.	Barrackpur	NH 34, NH 35	Barrackpur-Kolkata
22.	Kolkata	NH 34, NH 35	Kolkata - Bagnan
23.	Howra	NH 6, NH 2	
24.	Haldia (W)	NH 6, NH 41, NH 116B	Howra- Haldia
25.	Haldia (E)	NH 117	--

3.4. Size and Magnitude of the Project

Proposed Project-Jal Marg Vikas aims at improvement of navigation in entire stretch of NW-1 (Haldia to Allahabad). Length of the waterway is about 1620 km and traverses through 4 states namely Jharkhand, Uttar Pradesh, Bihar and West Bengal. Developments planned under the Jal Marg Vikas project includes

- Maintenance dredging to maintain the LAD in waterway/channel and the terminal facility
- Improved Navigation Infrastructure& Navigation Aids
  - Construction of 10 Nos. of Ro-Ro jetties & ferry passenger jetties. Location for these jetties is not yet identified.
  - Construction of 6 Nos. of terminals. Site identification and planning for 3 terminals sites at Sahibganj, Varanasi and Haldia is completed. 2 more potential sites for development of terminals are identified at Ghazipur and Kalughat. These two sites are still under consideration for finalization and planning is at initial stage only. One more terminal site is to be identified along NW-1.
  - Construction of Navigation Locks

- Provision for tow barges, inland vessels, survey vessels including rescue boats and survey equipment. Development of low draught cargos
- Development of navigation aids along NW-1 for facilitation of day & night time navigation

- Development of efficient River Information System with all hardware & software
- Provision for bank protection / slope protection and river training works for critical locations

3.4.1. *Existing and Anticipated Cargo at NW-1*

Cargo movement exists at present also in NW-1. 27,16,436 MT of cargo (15,11,961,380 TKM/1.512 BTKM) was transported via NW-1 during 2012-2013 (IWAI). Cargo transported include cement, fly ash, iron ore, iron ore fines, coal, steel shed, tyres, iron fines, iron ingots, Galvanized steel plain sheets, stone chips, furnace oil, high Speed diesel, lube oil, boulders, pulses, aluminium block, sand, chips, ship block, log, pulses, Manganese ore, Petroleum, Coke, Cooking coal, Rock Phosphate, Timber, Peas, Slag oil, and Non-cooking coal.

An Indo-Bangladesh Protocol on Inland Water Transit & Trade also exists between India and Bangladesh apart from intra country water transport. Under Indo-Bangladesh Protocol, inland vessels of one country can transit through the specified routes of the other country. The existing protocol routes are: Kolkata – Pandu-Kolkata, Kolkata-Karimganj–Kolkata, Rajshahi-Dhulian-Rajshahi, and Pandu-Karimganj-Pandu. For Inter-country trade, four ports of call have been designated in each country, namely; India – Haldia (West Bengal), Kolkata (West Bengal), Pandu (Assam), Karimganj (Assam) and Silghat (Assam) and Bangladesh-Narayanganj, Khulna, Mongla, Sirajganj and Ashuganj.

Cargo traffic and the commodities transported in NW-1 vary in different stretches. Cargo volume by rail & road mode along NW-1 stretch for year 2014 is given at **Table 3.2.**

Table 3.2 : Current Traffic Along NW-1 Stretch (2014)

Commodities	By Road (in tonne)	By Rail (in tonne)	Total Cargo (in tonne)
Coal	45258500	18723758	68222258
Construction Material	30171490	14429354	44760679
Consumer Goods	191811	0	191811
Container	2033280	0	2033280
Fertilizer	156900	1377741	1534641
Food and Food Stuff	1404369	484233	1888602
Gas and Petroleum	8400	217026	475976
Minerals and Chemicals	43950	575750	1953161
Project Cargo	186560	18250	228622
Vehicles	37100	100000	137100
Total Cargo (in tonnes)	79492360	35926112	121426130

Source: HPC&HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

As per projection study undertaken by survey and marketing consultant HPC for growth of traffic for planned project life of 30 years. Three scenarios are considered for forecasting, i.e. base case (in absence of Jal Marg Vikas Project), Medium Augmentation case (Jal Marg Vikas project with 3 m LAD upto Farakka, 2.5 m until Patna and 2 m upto Varanasi) and Full augmentation case (LAD of 3 m upto Patna and 2.5 m upto Varanasi). For the study purpose HPC has considered medium case augmentation. Since traffic will generate different for different stretches, the traffic projections is made for three different stretches, i.e. Haldia-Varanasi, Haldia-Patna & Patna-Varanasi. The traffic projection for these stretches as per medium case augmentation is given below in **Table 3.3, 3.4 & 3.5.**

Table 3.3 : Traffic Forecast for Stretch-1 (Haldia-Varanasi)

Cargo Type	Commodity	Forecast Medium Augmentation Case (tons)				
		Forecast MAC 2015 (t)	Forecast MAC 2020 (t)	Forecast MAC 2025 (t)	Forecast MAC 2035 (t)	Forecast MAC 2045 (t)
Dry Bulk	Stone chips	99,336	1,01,52,467	1,27,98,104	1,70,90,680	1,98,68,049
Dry Bulk	Coal	32,82,875	74,05,156	84,57,510	1,04,26,875	1,16,59,733
Dry Bulk	Iron ore	0	85,444	1,12,020	1,52,328	1,61,924
Dry Bulk	Limestone	0	3,889	4,932	6,925	8,050
Dry Bulk	Sand	0	1,38,070	1,74,090	2,32,932	2,70,785
Bagged	Food & Foodstuff	0	15,61,662	18,88,883	23,85,956	25,19,450
Bagged	Cement	0	8,27,552	12,13,633	20,34,856	25,62,950
Bagged	Fertilizer	0	60,061	66,117	75,037	80,216
Bagged	Plastic granules	0	9,383	12,270	18,713	24,250
Bagged	Textile	0	1,25,941	1,80,823	3,11,868	3,99,577
Neo-bulk	Logs & woods	63,151	86,976	1,08,042	1,45,196	1,82,878
Neo-bulk	Paper	0	3,745	5,282	8,320	10,480
Neo-bulk	Petroleum	2,62,460	5,15,815	6,61,925	9,25,784	10,70,067
Neo-bulk	Project cargo	0	3,79,560	4,43,000	5,67,556	7,14,850
Neo-bulk	Statues	0	1,07,208	1,21,296	1,37,339	1,37,339
Neo-bulk	Steel products	0	8,86,183	10,89,119	14,69,146	18,50,424
Ro-Ro	Vehicles	0	47,863	65,484	1,09,045	1,45,370
Container	General cargo	0	18,72,123	27,83,131	48,68,543	63,44,978
Total		37,07,822	2,42,69,096	3,01,85,663	4,09,67,100	4,80,11,367

Source: HPC & HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Table 3.4 : Traffic Forecast for Stretch-2 (Patna-Varanasi)

Cargo Type	Commodity	Forecast Medium Augmentation Case (tons)				
		Forecast MAC 2015 (t)	Forecast MAC 2020 (t)	Forecast MAC 2025 (t)	Forecast MAC 2035 (t)	Forecast MAC 2045 (t)
Dry bulk	Coal	0	2,51,993	2,46,256	2,68,992	2,71,067
Dry bulk	Sand stone	0	5,185	6,576	9,233	10,733
Dry bulk	Limestone	0	3,889	4,932	6,925	8,050
Bagged	Food & Foodstuff	0	3,32,723	4,35,396	5,94,442	6,28,316
Bagged	Textile	0	61,229	73,563	1,01,778	1,30,401
Bagged	Plastic granules	0	9,383	12,270	18,713	24,250
Bagged	Cement	0	8,13,646	11,93,886	20,03,696	25,23,702
Neo-Bulk	Paper	0	3,745	5,282	8,320	10,480
Neo-Bulk	Project cargo	0	2,02,152	2,24,605	2,77,894	3,50,014
Neo-bulk	Steel products	0	4,81,730	5,77,518	7,69,196	9,68,820
Neo-bulk	Statues	0	1,07,208	1,21,296	1,37,339	1,37,339
Ro-Ro	Vehicles	0	47,863	65,484	1,09,045	1,45,370
Container	General cargo	0	17,43,011	25,91,191	45,32,781	59,07,393
Total		0	38,11,763	53,12,000	85,69,361	1,08,44,869

Source: HPC & HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT

Table 3.5 : Traffic Forecast for Stretch-3 (Haldia-Patna)

Cargo Type	Commodity	Forecast Medium Augmentation Case (tons)				
		Forecast MAC 2015 (t)	Forecast MAC 2020 (t)	Forecast MAC 2025 (t)	Forecast MAC 2035 (t)	Forecast MAC 2045 (t)
Dry bulk	Stone chips	0	23,98,814	30,23,922	40,38,168	46,94,401
Dry bulk	Coal	32,82,875	69,39,211	79,69,586	98,53,827	1,10,56,473
Dry bulk	Iron ore	0	9,71,959	12,25,242	16,36,197	19,02,091
Dry bulk	Limestone	0	3,23,986	4,08,414	5,45,399	6,34,030
Dry bulk	Sand	0	68,652	84,513	1,12,091	1,41,182
Bagged	Food & Foodstuff	1,62,487	63,63,580	79,20,893	1,04,42,930	1,19,90,623
Bagged	Fertilizers	0	17,94,026	26,47,350	45,96,517	59,75,527
Bagged	Plastic granules	0	23,258	32,621	50,627	58,517

Bagged	Textile	0	2,22,364	3,02,610	4,71,792	5,99,523
Neo-Bulk	Logs and wood	0	6,47,972	8,16,828	10,90,798	12,68,061
Neo-bulk	Petroleum	2,62,460	14,63,318	18,43,599	24,76,593	28,74,916
Neo-Bulk	Project cargo	0	2,64,189	3,15,652	4,24,786	5,19,963
Neo-bulk	Steel products	0	9,39,231	11,52,032	15,42,578	19,02,495
Ro-Ro	Vehicles	0	25,886	30,543	41,522	53,199
Container	General cargo	0	2,17,457	2,95,933	4,65,037	5,85,405
Total		37,07,822	2,26,63,903	2,80,69,739	3,77,88,862	4,42,56,407

Source: HPC& HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT

Though above traffic projection indicated sufficient traffic cargo potential till 2045, however design consultant has considered different traffic forecasted the traffic again for the presently designed infrastructure facility. These terminals are designed on the basis of the traffic expected to be shifted at these sites from rail/road to IWT mode. Traffic projections for the planned infrastructure site are given below in **Table 3.6.**

Table 3.6 : Traffic Forecast for Planned Navigational Infrastructural Facilities

S. No.	Infrastructural Facility	Projected Cargo-2015 (MTPA)	Projected Cargo-2030 (MTPA)	Projected Cargo-2045 (MTPA)
1	Sahibganj Terminal	2.24	4.39	9.00
2	Varanasi Terminal (with current land)	0.54	1.22	1.22
3	Haldia Terminal	4.07 MTPA (1.57 other cargo & 2.5 MTPA coal transhipment)		

Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT

3.4.2. *Depth of Navigation Channel*

It is planned to maintain depth of 3 m all along the stretch from Haldia to Allahabad but to optimize the cost and minimize the environmental damage, it is planned to maintain depth of 3 m from Haldia to Barh, 2.5 m from Barh to Buxar and 2.2 m from Buxar to Varanasi at present[10]*.*

3.4.3. *Width of Navigation Channel*

It is planned to provide two-way cargo movements in the navigation channel and maintaining the width of channel between 60-120 m. However, at present it is planned to

[10]***Source of Data:(Detailed Feasibility Study for Jal Marg Vikas Project and Detailed Engineering for its Ancillary Works and Processes between Haldia to Allahabad by HOWE Engineering Projects (India) Pvt. Ltd).***

maintain the channel width[11] of 64 m and side slopes of 1:10 from section Haldia to Varanasi.[12]

3.4.4. *Size of the Vessel/Ships*

As per IWAI planning, vessels of maximum length 110 m, beam 11.4 m, draught 2.5 m-2.8 m and air draught of 9 m will ply in NW-1 waterway (***reference Detailed Feasibility Study for Jal Marg Vikas Project and Detailed Engineering for its Ancillary Works and Processes between Haldia to Allahabad prepared by HOWE Engineering Projects (India) Pvt. Ltd)***. However, the vessel size will vary in different stretched as per the available LAD and type and quantity of cargo to be transported. Vessels of size 1500-2000 DWT is expected to ply in the waterway. Study for cargo estimation is under process and size of the vessels will be finalized accordingly.

At present, planned vessels designed run on diesel, however IWAI is planning to switch to CNG for operating the vessels. Proposal and study for the feasibility of using CNG as fuel is under process. IWAI is interacting with various agencies for design of the high capacity vessels which can move in low draft so as to reduce the dredging requirement.

3.5. Challenges for Project Development

When it comes to the implementation of Jal Marg Vikas Project to ensure navigation in entire NW-1 throughout the year, various challenges come in picture. NW-1 is alluvial river with typical characteristic of braiding, meandering and large water level fluctuation between summer and monsoon months.

Wide variations in water level are observed ranging from 2.5 m at Farakka to 16.5 m at Allahabad. Current velocity varies between 0.2m/s during lean season to 4.0 m/s during flood season in the stretch between Allahabad to Farakka. Current velocity is 1.2 m/s in Feeder Canal & 1.7 m/s (max.) in Bhagirathi river stretch.

Ganga carries annual silt load of 1600 million tons. Fine silt leads to rapid shoal formation. It becomes difficult to maintain even 2 m depth during low water season throughout the stretch. The stretch between Haldia and Tribeni (196 km) is tidal and the Least Available Depth (LAD) of more than 3.0 m is maintained naturally therein. IWAI has to erect bandals and carry out dredging to maintain the LAD in upper stretches of Tribeni. Due to unavailability of adequate depth/width and navigational infrastructure facilities, navigation of the large cargos throughout the year is not possible. Major challenges for navigation in NW-1 are listed below

1. Highly braiding and meandering river
2. Large water level fluctuation
3. Unavailability of LAD for navigation throughout NW-1 and unreliable water depths
4. High silt load & shoal/bar/island formation leading to splitting of main channel
5. Growing of bars reducing the available depth
6. Lateral migration of the river and change in navigation line

[11] ***The width of the channel is being reduced to 45 m under phase I development. This will further reduce he dredging requirements. However, these details are under finalization stage.***

[12] ***Source of Data:(Detailed Feasibility Study for Jal Marg Vikas Project and Detailed Engineering for its Ancillary Works and Processes between Haldia to Allahabad by HOWE Engineering Projects (India) Pvt. Ltd).***

7. Existence of power line pylons at various locations
8. Existence of pontoon bridges. About 7 pontoon bridges are present between Buxar and Allahabad which are in use. Pontoon bridges are significant threat to navigation
9. Existence of Bagmari siphon in the Farakka feeder canal for irrigation purpose which generates eddy currents, reduces water level by 0.1-0.2 m in immediate vicinity of the structure and reduction in buoyancy of vessel due to presence of air bubbles in water column above this siphon leading to increase in vessel draught
10. Existence of critical bridges (bridges with Horizontal Clearance (HC)&Vertical Clearance (VC) less than 70 m & 9 m respectively). Details of the critical bridges are given below in **Table 3.7** below
11. Inadequate navigation infrastructure and aids like channel marking, inadequate fairway width, navigation lights, signals, RIS, lack of modern vessel based navigation aids, absence of effective waterway reporting & tracking system.

Table 3.7 : Details of Critical Bridges on NW-1

S. No.	Location	Chainage	Horizontal Clearance (HC)-m	Vertical Clearance (VC)-m
1	Pakur Bridge	525	49.07	12.15
2	Rajendra Setu- Semaria	853	40.00	10.00
3	Malaviya-Varanasi (Rajghat Bridge)	1308	101.50	6.56 (10.37-50%, 7.97-1-% & 7.18-1%)
4	Mirzapur	1398	30.50	2.52 (7.08-50%, 4.21-1-% & 3.22-1%)
5	Rabindra Setu/Howrah Bridge Howrah	157.8	--	9.0
6	Swami Vivekananda Setu	166.4	100	8.8
7	Bridge at Digha	990.5	20	--
8	Rajendra/Mokama Bridge, Hathida	--	--	10.6 -50%, 9.67-10% & 9.57-1%
9	Buxar Road Bridge	--	--	10.91-50%, 9.43-10% & 9.23-1%
10	Ghazipur Road Bridge	--	--	11.82-50%, 10.35%-10% & 10.12-1%

Source: IWAI &HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Apart from above bridge, some bridges at Varanasi, Balua, Hoogly and Munger are also navigational hazard. Available width of the navigation channel is reduced significantly due to presence of bridge piers of these bridges or due to their orientation w.r.t river flow or due to their location.

12. Some of the bends in the NW-1 are significant w.r.t. navigation. There are 10 significant bends in U.P. stretch, 1 bend at U/s of Farakka and 63 significant bends in West Bengal. Due to presence of these bends, additional channel width will be required. Details of the significant bends are given in **Table 3.8**.

Table 3.8 : Details of Navigationally Significant Bends in UP stretch of NW-1

S. No.	Stretch	No. of Bends
Uttar Pradesh-10		
1.	Saidpur-Varanasi	2
2.	Chunar-Mirzapur	2
3.	Rampur Ghat	5
4.	Sirsa-Allahabad	1
Jharkhand-1		
1.	U/s of Farakka Navigation Lock	1
West Bengal-63		
1.	Haldia Diamond Sand	1
2.	Diamond Sand – Howrah Bridge	5
3.	Howrah Bridge - Tribeni	3
4.	Tribeni - Balagarh	2
5.	Balagarh - Kalna	2
6.	Kalna - Samudragarh	3
7.	Samudragarh - Nabadrip	2
8.	Nabadrip – Patuli	6
9.	Patuli - Katwa	4
10.	Katwa - Plassey	7
11.	Plassey - Chunarigacha	5
12.	Chunarigacha - Behrampur	5
13.	Behrampur - Mahamuadpur	7
14.	Mahamuadpur - Nasipur	6
15.	Nasipur - Jangipur	3
16.	Jangipur – Farakka Lock	2

Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Project Jal Marg Vikas is aimed at minimizing the above mentioned challenges to ensure the navigation in the entire stretch during most of the time in year. Implementation of project will focus on maintaining the LAD for navigation in the desired stretches, improving existing navigation infrastructure, developing new infrastructure, improved navigation aids and navigation cargos.

3.6. River Morphology &Mobility

River Ganga is significantly mobile and changes flowing pattern in one season to another. Changes in river typology/morphology have been studies from last 10 years' satellite imagery by HPC. From the study it was found that, in the upper reaches, from Allahabad to Doriaganj, the river is meandering or sinuous with minor secondary

branches and several chutes. The river shows a clear change of planform typology at area around Patna younger. The change is from a meandering to an anabranching typology, with multiple channels. Change in planform is due to confluence of various tributaries namely Ghagra & Gandak in left bank and Son & Punpun in the right bank. The river typology changes again, downstream of Munge where the channel shows a sinuous channel with a certain degree of braiding. Bars are common in this area. Between Kahalgaon and Manihari the main channel clearly splits in two, with a certain degree of braiding in each channel. The contribution of the Kosi River takes place near Kahalgaon. From Manihari to Farakka there is one main sinuous channel and several sinuous secondary channels. Downstream stretches of Farakka to Farakka lock and Farakka lock to Jangipur lock is an artificial canal. Reaches downstream of Jangipur Lock show a meandering channel with different degrees of sinuosity, from tortuous to irregular meanders. From Jangipur Lock to Tribeni the presence of oxbow Lakes is common, and cut-offs meanders[13]. Detailed morphology of the river in different reaches is given in **Table 3.9**. Changes in the River morphology are depicted in the images given in **Figure 3.3** below.

Table 3.9 : Morphology of River (NW-1) in different reached

S. No.	Reach/Stretch	Chainage	Morphology
1.	Sagar Road – Haldia	(0-35)	Split channel with central islands
2.	Haldia – Diamond Sand	(35-60)	Split channel with central islands
3.	Diamon Sand –Howrah Bridge	(60-145)	Sinuous channel
4.	Howrah Bridge -Tribeni	(145-193)	Irregular meandering channel with some sporadic central bars
5.	Tribeni-Balagarh	(193-221)	Irregular meandering channel with split channels and bars. Oxbow lakes and cut-offs visible
6.	Balagarh-Kalna	(221-245)	Tortuous meandering channel showing split channels at bends. Oxbow lakes and cut-offs visible
7.	Kalna-Samudragarh	(245-263)	Irregular meandering channel showing some degree of split at a few locations. Oxbow lakes and cut-offs visible
8.	Samudragarh-Nabadweep	(263-280)	Tortuous meandering channel with bars at the near the inner bank of bends
9.	Nabadweep-Patuli	(280-322)	Tortuous meandering channel with chutes at bends and several split channels. Oxbow lakes and cut-offs visible

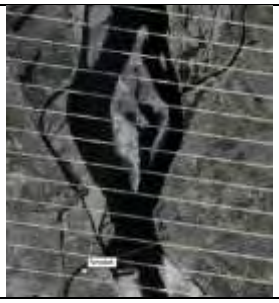
[13]***Source of Data:(Detailed Feasibility Study for Jal Marg Vikas Project and Detailed Engineering for its Ancillary Works and Processes between Haldia to Allahabad by HOWE Engineering Projects (India) Pvt. Ltd).***

10.	Patuli-Katwa	(322-345)	Tortuous meandering channel with localised bars and chutes at bends and some degree of split channels. Oxbow lakes and cut-offs visible
11.	Katwa-Palassey	(345-371)	Meandering single channel, wider at bends with some chutes. Cut-offs visible
12.	Palassey-Chaurigacha	(371-400)	Irregular meandering channel showing chutes at bends and split of channels at particular locations. Oxbow lakes and cut-offs visible
13.	Chauriga-Chaberhampur	(400-421)	Sinuous channel except for the approximately last 5 km of the reach. In that area the channel shows tortuous meanders and oxbow lakes. Cut-offs also visible
14.	Berhampur-Mohammadpur	(421-449)	Irregular meandering single channel. Oxbow lakes visible
15.	Mohammadpur- Nasirpur	(449-479)	Tortuous meandering single channel with central bars at certain locations. Oxbow lakes and abandoned meander channels visible
16.	Nasirpur-Jangipur Lock	(479-505)	Tortuous meandering single channel. Cut-off and abandoned meander channels visible
17.	Jangipur Lock-Farakka Lock	(505-544)	Artificial channel
18.	Farakka Lock- Rajmahal	(544-583)	Composite river with one main sinuous channel with bars and islands and several sinuous secondary channels. Several oxbow lakes can be seen
19.	Rajmahal-Manihari	(583-633)	Composite river with one main channel with bars and islands and several sinuous side channels
20.	Manihari-Karagola	(633-660)	Split river with sinuous channels with a certain degree of braiding that converts in a single main sinuous channel with several side channels

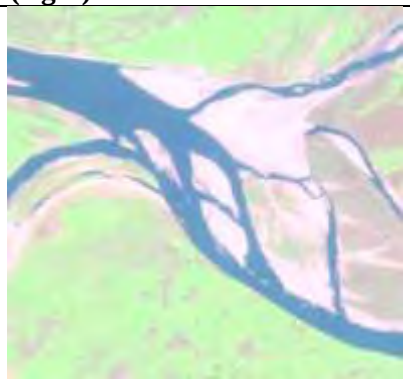
21.	Karagola-Kahalgaon	(660-690)	Split river with sinuous channels with a certain degree of braiding
22.	Kahalgaon-Bhagalpur	(690-715)	Sinuous channel with a certain degree of braiding showing bars and islands
23.	Bhagalpur - Sultanganj	(715-746)	Sinuous channel that shows some degree of braiding. The area shows clear oxbow lakes
24.	Sultanganj-Munger	(746-793)	Sinuous channel that shows some degree of braiding in a stretch of a few kilometres. It is a clear cut-off with the old bendy channel still showing some activity
25.	Munger-Mahendrapur	(793-820)	Anabranched river with channels with a certain degree of braiding showing bars, islands and side channels
26.	Mahendrapur-Semaria	(820-853)	Anabranched river with channels with a certain degree of braiding showing bars, islands and side channels
27.	Semaria-Barh	(853-891)	Anabranched river with channels with a certain degree of braiding showing bars, islands and side channels
28.	Barh-Mehnar	(891-925)	Anabranched river with channels with a certain degree of braiding showing bars, islands and side channels
29.	Mehnar-Patna	(925-955)	Anabranched river with channels with a certain degree of braiding showing bars and islands
30.	Patna-Doriganj	(955-1000)	Split sinuous channels with a high degree of anabranching
31.	Doriganj-Ballia	(1000-1063)	Meandering single channel, wider at bendswith some chutes and several sub parallel anabranches
32.	Ballia-Buxar	(1063-1124)	Sinuous single channel, wider at bends with some chutes and a sinuous side channel and certain degree of braiding
33.	Buxar-Ghazipur	(1124-1178)	Sinuous single channel, wider at bends with some chutes and a

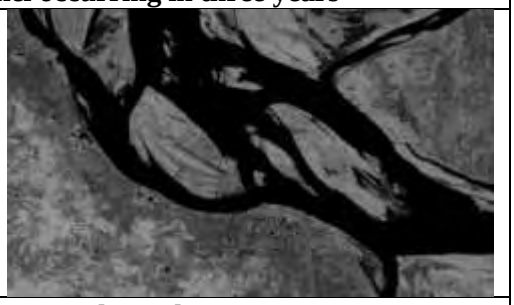
			sinuous side channel
34.	Ghazipur-Saidpur	(1178-1254)	Sinuous channel that shows some degree of braiding in a stretch of around 10 kilometres
35.	Saidpur-Varanasi	(1254-1311)	Meandering single channel, wider at bendswith some chutes and a side channel
36.	Varanasi-Chunar	(1311-1344)	Meandering single channel, wider at bendswith some chutes and a side channel
37.	Chunar-Mirzapur	(1344-1398)	Meandering single channel, wider at bendswith several chutes
38.	Mirzapur-Rampur Ghat	(1398-1419)	Sinuous channel that shows some degree of braiding in a stretch of a few kilometres
39.	Rampur Ghat-Sirsa	(1419-1506)	Meandering single channel, wider at bendswith some chutes and a sinuous side channel; stretches of few kilometres with split of channels less than 200 m wide
40.	Sirsa-Allahabad	(1506-1547)	Meandering single channel, wider at bendswith some chutes and a sinuous side channels.

Source: HOWE Engineering Projects (India) Pvt. Ltd. (Design Consultant)

Formation of a big island with two main channels upstream of Farakka Barrage. Images from 2011(left) and 2015 (right)

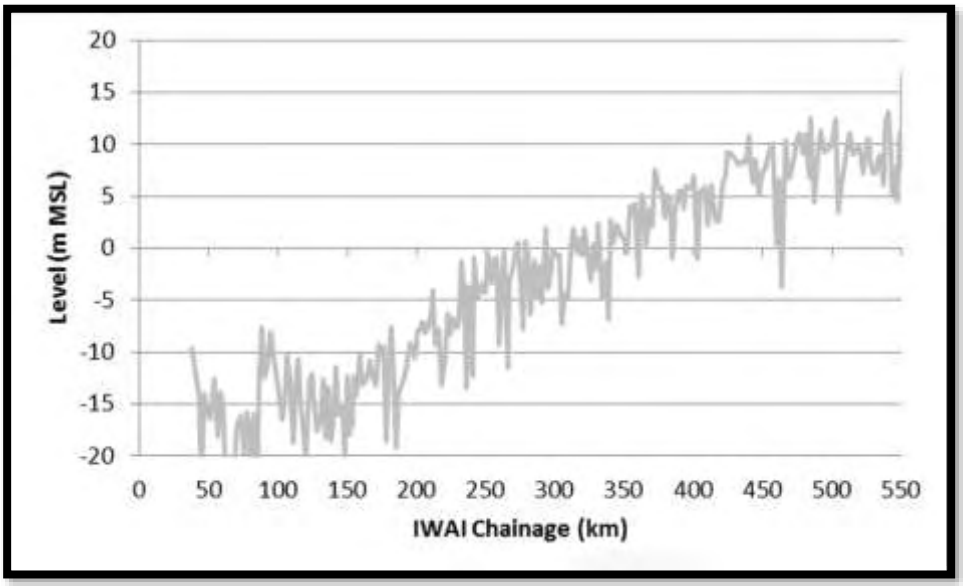
Example of the decay of a main channel occurring in three years	
	
Example of formation of a new channel	
	
Example of lateral migration of main channel	

Source: IWAI &HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 3.3 : Satellite Imagery of Different Years to Study Change in River Morphology

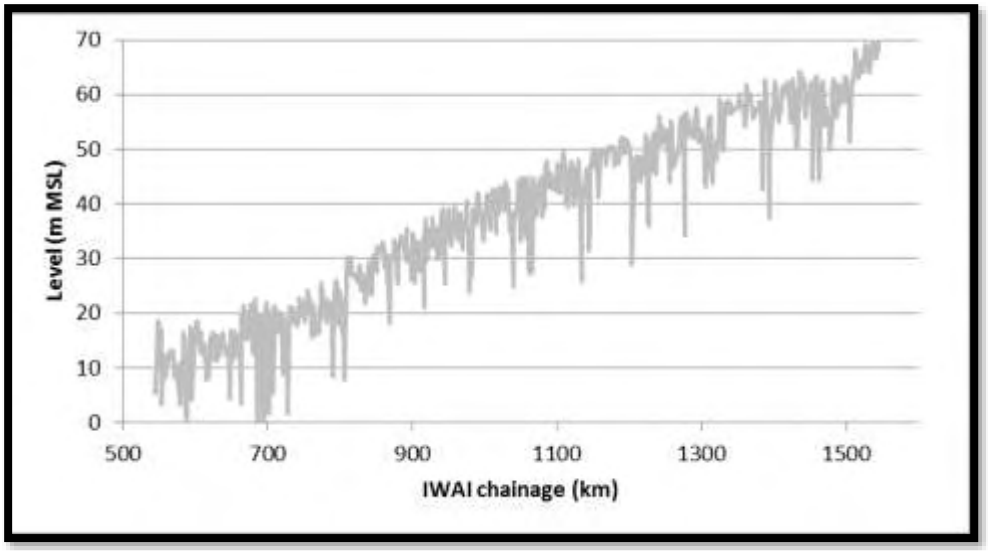
3.7. Bathymetry of NW-1 & River Slope

Bathymetric survey is carried out between Haldia to Allahabad. Longitudinal profile of the river bed between Haldia to Farakka and Farakka to Allahabad are given in **Figure 3.4 & 3.5.**



Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 3.4 : Longitudinal profile of river bed from Haldia to Farakka



Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 3.5 : Longitudinal profile of river bed from Farakka to Allahabad

From **Figure 3.5,** it is clear that between Chainage 50-150 km which is tidal stretch of river, river bed slope is flat. Then there is 250 km where river bed slope is 1 in 11,000 which flattens in the 50-100 km downstream of the Farakka lock to around 1 in 18,000. River slope from Farakka to Allahabad is 1 in 17,000. Longitudinal profile of river slope from Farakka to Allahabad is given in **Table 3.10** below.

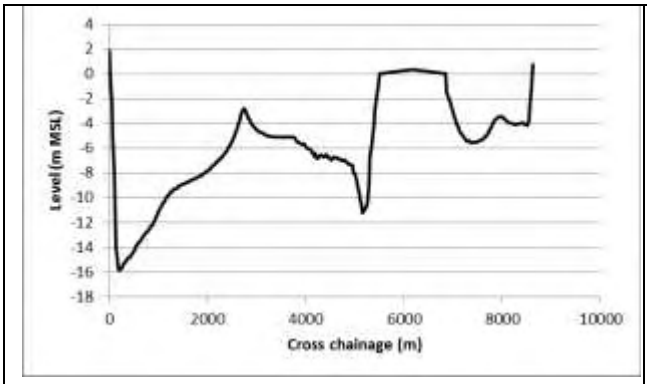
Table 3.10 : Longitudinal Profile of River Slope from Farakka to Allahabad

Reach	General slope for the 50 km reach	General slope for the 100 km each
550-600	1 in 10,000	1 in 32,000
600-650	Flat	
650-700	1 in 12,000	1 in 12,000
700-750	1 in 12,000	
750-800	1 in 12,000 (flat)	1 in 10,000
800-850	1 in 5,000	
850-900	1 in 350,000 (flat)	1 in 15,000
900-950	1 in 7,000	
950-1000	Flat	1 in 25,000
1000-1050	1 in 10,000	
1050-1100	1 in 18,000	1 in 15,000
1100-1150	1 in 14,000	
1150-1200	1 in 22,500	1 in 26,000
1200-1250	1 in 30,000	
1250-1300	Flat	1 in 15,000
1300-1350	1 in 7,000	
1350-1400	1 in 75,000	1 in 50,000

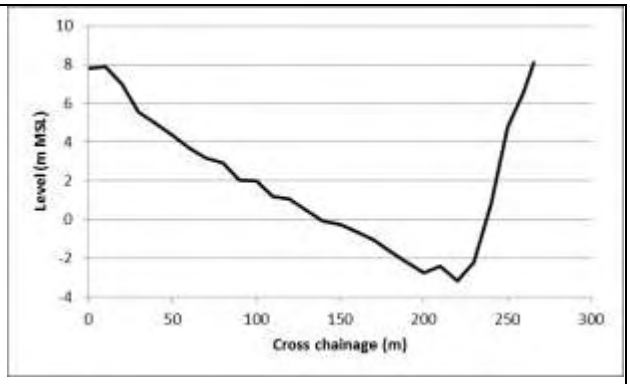
1400-1450	1 in 37,000	
1450-1500	Flat	1 in 12,000
1500-1550	1 in 5,000	

Source: IWAI &HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

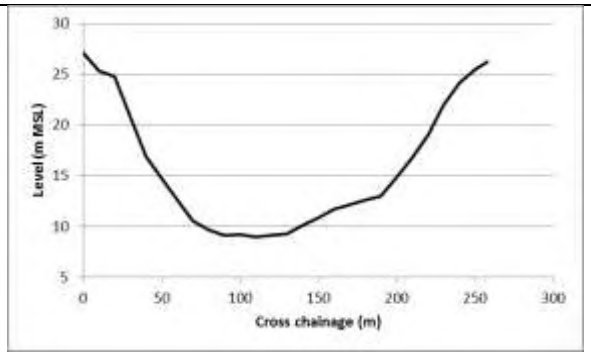
Cross section profile of the NW-1 at various location has also been studied by design consultant at various locations like Haldia, d/s Farakka lock, around island near Patna, Ghazipur, Varanasi, Allahabad & at meandering bend. Cross section profile of river is given at **Figure 3.6.**



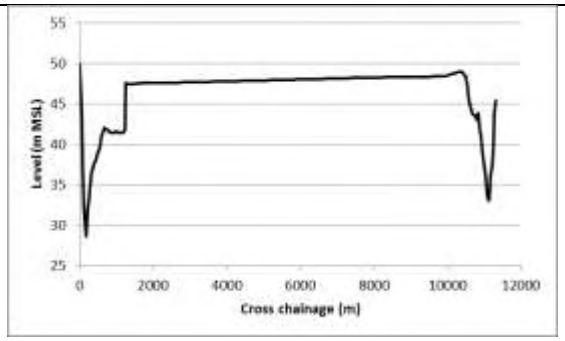
Cross section of river at Haldia



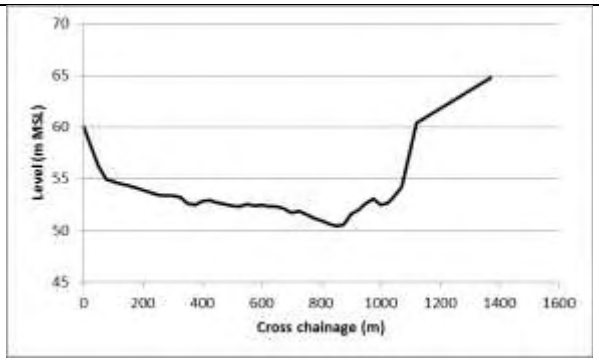
Cross section of river at meandering bed (ch-0326)

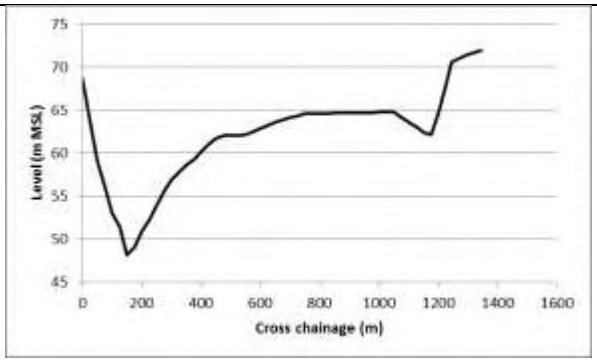


Cross section of canal d/s Farakka lock

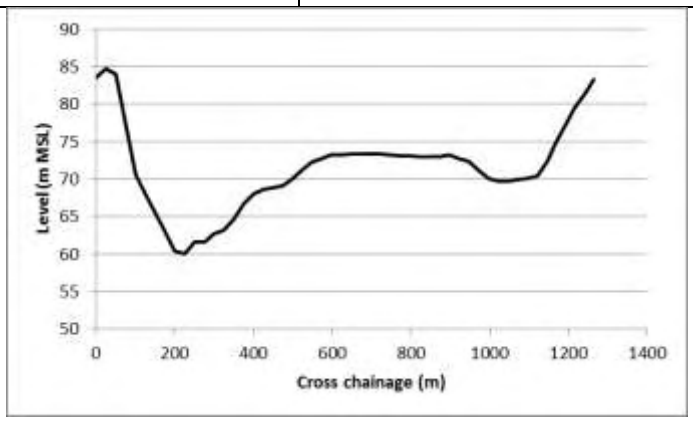


Cross section of river near large island at Patna





Cross section of river at Ghazipur	Cross section of river at Varanasi (deep)



Cross section of river at Allahabad

Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 3.6 : Cross-Sectional profile of river bed at Various Locations in NW-1

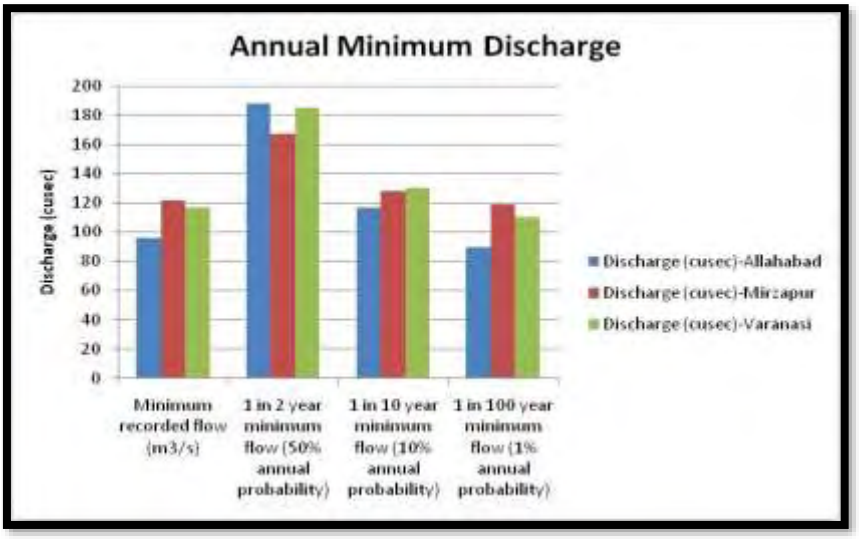
3.8. Available Flow in NW-1

The Ganga River is characterised by high flows during the monsoon season, approximately from July until October, and low flows during the rest of the year. Annual minimum discharges provided by IWAI at Allahabad, Mirzapur and Varanasi during the last 3 years are given below in **Table 3.11 & Figure 3.7.**

Table 3.11 : Annual minimum discharges obtained from statistical analysis

Parameter	Discharge (cusec)		
	Allahabad	**Mirzapur**	**Varanasi**
Minimum recorded flow (m3/s)	96	122	117
1 in 2-year minimum flow (50% annual probability)	188	167	185
1 in 10-year minimum flow (10% annual probability)	117	128	130
1 in 100-year minimum flow (1% annual probability)	90	119	110

Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)



Source: IWAI

Figure 3.7 : Annual minimum discharges obtained from statistical analysis

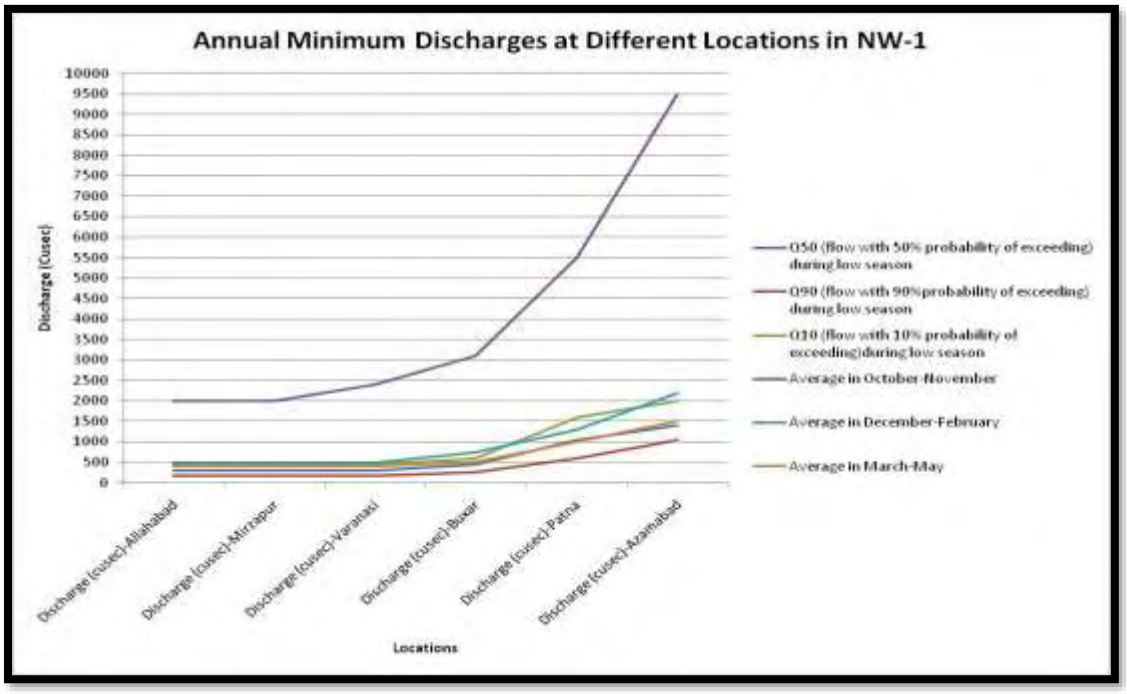
As per data available with IWAI, lowest flow recorded at Buxar was 225 cusec and lowest available flow at Patna 689 cusec. These flows are considerably lower than the average dry season flows. The design discharge for the feeder channel at Farakka is around 1,100 m^3/s.

As per the data available in the report "Status on River Ganga: State of the Environment and Water Quality" by the National River Conservation Directorate (2009), discharges with a probability of exceeding 50%, 10% and 90% of times at 6 stations namely Allahabad, Mirzapur, Varanasi, Buxar, Patna and Azamabad during low flow season are given in **Table 3.12 & Figure 3.8** below.

Table 3.12 : Annual Minimum Discharges at Different Locations in NW-1

Flow regime	Discharge (cusec)					
	Allahabad	Mirzapur	Varanasi	Buxar	Patna	Azamabad
Q50 (flow with 50% probability of exceeding) during low season	300	300	300	450	1050	1400
Q90 (flow with 90% probability of exceeding) during low season	175	175	175	250	600	1050
Q10 (flow with 10% probability of exceeding) during low season	450	450	450	600	1600	2000
Average in October-November	2000	2000	2400	3100	5500	9500
Average in December-February	500	500	500	750	1300	2200
Average in March-May	400	400	400	500	1000	1500

Source: National River Conservation Directorate



Source: National River Conservation Directorate

Figure 3.8 : Annual Minimum Discharges at Different Locations in NW-1

3.9. Sediment Load in NW-1

NW-1 comprises of the River Ganga and the tributaries system between Haldia and Allahabad. Rivers originating from the Himalaya region (Ganga, Ghaghara and Gandak) are characterized by a predominance of fine and very fine sand. The rivers draining from the Indian craton region (Tons, Son and Yamuna) bring much coarser sediments with higher contents of coarse and medium sand. Sediments are classified into suspended and bed load depending on the size of the particles. Sediments of diameter smaller than 125µm are transported in suspension and can be deposited during the low flow period. Sediment size decreases from Allahabad to Farakka. Sediment load at different locations and tributaries of NW-1is given below in **Table 3.13.**

Table 3.13 : Sediment Load at Different Locations and Tributaries of NW-1

Locations	**Sediment Load (MT/Year)**		
	From CWC (available online)	**From Abbas and Subramanian (1984)**	**From Jain and Sinha (2003)**
Ganges at			
Allahabad	-	228	-
Farakka	-	729	729
Kolkata	-	328	-
Gomati	-	6	6
Ghaghara	-	125	125

Son	22	50	-
Gandak	33	24	82
Kosi	73	-	193

Source: HOWE Engineering Projects (India) Pvt. Ltd. (Design Consultant)

3.10. Water Level of NW-1

NW-1 experiences high water level variations, i.e. of order of 10 m during high season. In general, water levels are at their highest in August-September and sharply decrease in October-November. In general, they continue to decrease during the whole low flow season, from December to May, and start to raise again in June-July. The variability of water levels during the dry season is lower than during the high season, with variations of the order of 2-3m. The period of the year in which the minimum water level can occur varies with location along the river. In the upstream reaches from Allahabad to Ghazipur the minimum water levels occur from April to July. Downstream of the three major tributaries, Ghagra, Son and Gandak that join the river near Patna, the minimum water levels can occur between February and June as a result of the influence of snow melt. Minimum & Maximum surface water levels at 7 gauging stations between Allahabad and Farakka for 3 annual probability of occurrence is given in **Table 3.14 & 3.15 & Figures 3.9 & 3.10** below

Table 3.14 : Minimum Water Levels for a Range of Annual Probabilities

Location	Minimum Water Level (m)		
	50%	10%	1%
Allahabad	71.45	70.72	70.38
Mirzapur	63.10	62.58	62.37
Varanasi	58.59	57.91	57.27
Ghazipur	52.45	51.69	51.27
Patna	40.88	40.27	39.56
Hathida	33.28	32.59	32.18
Kahalgaon	23.64	22.96	22.57

Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

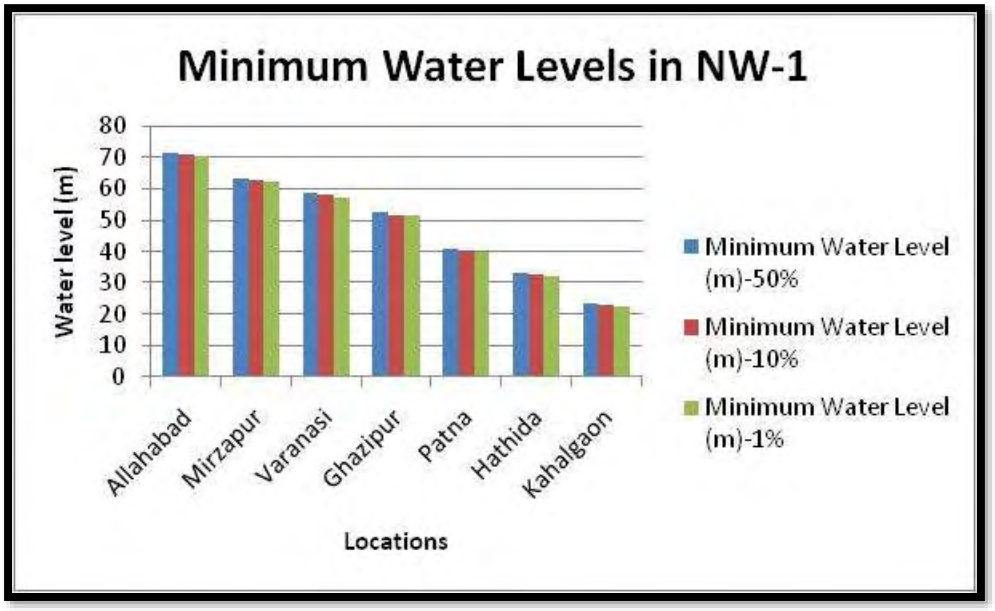


Figure 3.9 : Minimum Water Levels for a Range of Annual Probabilities

Table 3.15 : Maximum Water Levels for a Range of Annual Probabilities

Location	Maximum Water Level (m)		
	50%	10%	1%
Allahabad	82.36	85.67	87.22
Mirzapur	75.65	78.77	79.89
Varanasi	70.0	72.48	73.37
Ghazipur	62.88	64.78	65.18
Patna	49.36	50.44	50.91
Hathida	41.78	42.85	43.01
Kahalgaon	30.99	32.70	32.90

Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

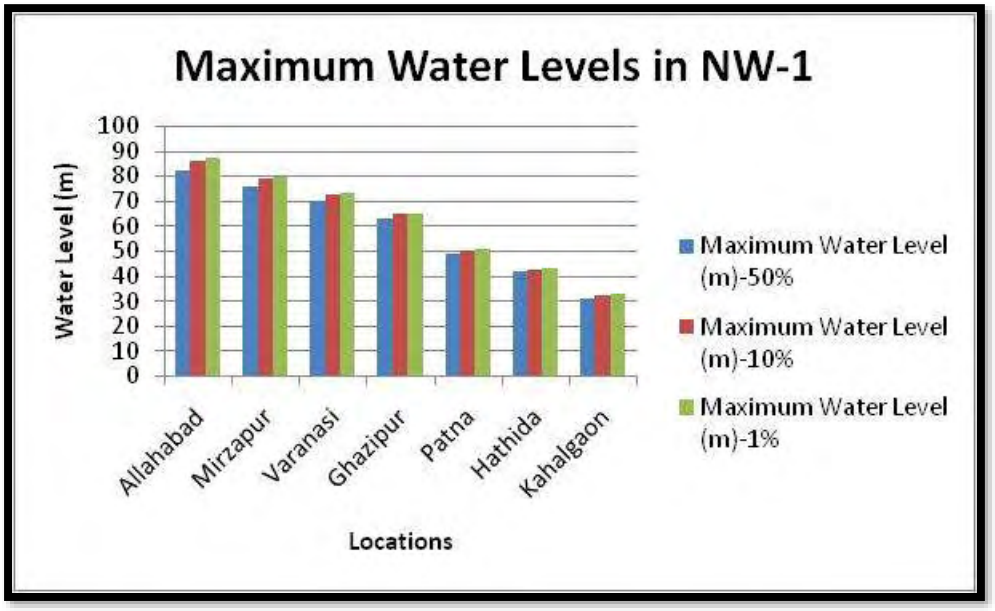


Figure 3.10 : Maximum Water Levels for a Range of Annual Probabilities

3.11. Tidal Variation in NW-1

Tides affect the Hugli River as far as Nabadwip, at Chainage 280km. According to the Admiralty Tide Tables (Indian Ocean 2015), there is an average spring tidal range of 4.8m at Haldia. The average spring tidal range on the NW-1 route reaches a peak at Diamond Harbour, of around 4.9m before diminishing with distance landward, such that it has reduced to about 4m in Kolkata, to 1.5 to 2.0m at Tribeni (IWAI 2012 NW-1 River Pilot), and effectively to zero at Nabadwip.

The tides are predominantly semi-diurnal, with two high waters, and two low waters occurring during any 24-hour period. The tidal conditions are largely governed by the (predictable) tidal cycles, but the river freshwater discharge influences the local conditions in the tidal stretch of the river significantly. In the tidal section of the waterway, in general terms, the water will continue to flow down-river on the ebb (falling tide). However, the flow direction is reversed to flow up-river on the flood (rising tide).

One of the important feature of tidal stretch of NW-1 is presence of tidal bore[14] which is significant risk to navigation. When a tidal bore forms in a river, the direction of flow of the water changes abruptly as the bore passes. There may be significant surges for some time after the passage of the bore wave. KoPT predicts the occurrence of the tidal bores for the year.

B: ALTERNATIVE ANALYSIS

3.12. Analysis of Alternatives

[14]A tidal bore (or bore) is tidal phenomenon that, in particular conditions, causes the flooding tide to propagate up an estuary as a distinct wave resulting in high energies on the river bed and in the water column and a rapid change in water level associated with passage of the wave. At low water, during spring tides, the flow of the flood current is checked by the shallow and restricted bed of the Hugli River and by the seaward flow of water from the upper reaches. These conditions can lead to the creation of a tidal bore. The Hugli River tidal bores are associated with periods of large tidal ranges

Analysis of alternatives is an analytical comparison of the operational effectiveness, costs and environmental and social risks of proposed development options. This helps to analyze the options critically in relation to its impacts on all physical, social and biological environment. For this project, alternative analysis has been made for three considerations, i.e. strategic, planning and technology consideration and they are briefed below

3.12.1. *Strategic Consideration*

This analysis enables us to justify that why and how much the project is viable. A comparison is made for "With" & "Without" project scenario for the physical, social and biological environments. This helped in assessment and comparison of the potential impacts on these environments in both the scenario. The scenario having minimal impact is recommended for selection. This has helped us to find the benefit of development of the project. Detailed analysis is given below in **Table 3.16.**

Table 3.16 : Alternative Analysis- "With & Without Project Scenario"

Environment	Without Project	With Project
Status of Transportation Infrastructure[15]	IR is oversaturated[16] in many sections. Ideally coal and iron ore are supposed to be trucked by road for short distances, mainly from mines to rail sidings only. However, at present larger volume of cargo is being transported via road due to insufficient capacity of IR. Road network is also not sufficient and adequately developed especially in minor towns/villages. Density of road network in India is high but the road quality suffers in terms of pavement thickness, distressed bridges etc. Thus to cater the freight transportation, there is high need of expansion & improvement of IR & road network.	IWT mode will facilitate shift of the freight from roads & IR leading to reduction in congestion on already congested IR & roads. This may reduce the need of expansion and will make the transportation safe and reliable. Infrastructure development for developing waterway involves comparatively lesser expenditure than required for developing IR & road network for transportation of equivalent amount of freight.

[15]Transportation network for freight and passenger is backbone of economy of every country. Transportation network should be robust, reliable, cost efficient, time efficient, energy efficient and environment friendly which can ensure intime delivery of goods with no or minimal emissions or pollution involved. Economy of India is world seventh largest in the world by nominal GDP. But various hurdles are in the way to achieve further higher economic growth and some are inadequate transportation network & infrastructure, poverty, unemployment etc. India's rail network is world's 4th longest and most heavily used system in the world and India's road network is 2nd largest road network in the world. But due to its high population, India's road & railway network is over utilized and insufficient to cater the freight transportation requirement of the country. Thus there is need of expansion of the road/ railway network or to find out alternate & efficient mode of transportation

[16]Oversaturation has implications for the quality of service of freight trains and severely restricts IR to meet customer expectation. Some of the section of IR has been working above their capacity, especially on eastern corridor line, i.e. Delhi-Howrah Currently this route face 140-150% of capacity utilization and rail route is considered congested, if its utilization is more than 80%. Speed of the freight trains remained stagnant from 25-29 kmph against design average speed of 60 kmph. Majorly nine commodities are transported trough trains such as coal (46%), iron ore (13%), cement (11%), fertilizers (5%), steel (5%), raw material for steel plants (5%) except iron ore, cement (11%), food grains (5%), petroleum products (4%) and container traffic (4%) and others (2%)

Physical Environment	**GHG Emissions:** In this scenario GHG emissions associated with freight transportation through rail/road mode will continue to generate, thereby increasing overall GHG emission load. Emission. GHG Emissions associated for movement of cargo estimated to be transported through NW-1 (calculated for maximum terminal capacity as planned in phase I) through from rail & road are 84 billion & 277 billion g/yr respectively. **Air Quality:** Air emissions will continue to result due to continued transportation of freight by road/rail. NOx; SOx; CO; PM & HC emissions associated for movement of cargo estimated to be transported through NW-1 (calculated for maximum terminal capacity as planned in phase I) through rail & road are 9.9, 2.8; 1.3, 1.28; 3.9, 1.06; 1.6, 0.5 & 2.77, 0.5 billion g/yr respectively. Also increasing freight transportation would require expansion of the road & railway network. Construction and operation of increased road/railway network will further add to the air emissions. Cutting of trees required for expansion of road/railway network will further deteriorate the air quality **Water Quality:** Due to construction of road/paved surfaces, run-off is likely to increase. This run-off may be contaminated with oil & grease. This run-off, if enter the water body may have impact on the aquatic flora	**GHG Emissions:** Reduction in overall GHG emissions as IWT involves minimal fuel consumption thus minimal GHG emissions when compared to road & rail. As per analysis carried out, it is estimated that CO_2 (potential GHG) emissions associated with IWT for freight transportation (calculated for maximum terminal capacity as planned in phase I) from Haldia to Varanasi is 58.4 billion g/yr. **Air Quality:** Reduction in overall air emissions as IWT involves minimal fuel consumption thus minimal emissions are anticipated. As per analysis carried out, it is estimated that NOx; SOx; CO; PM & HC emissions associated with IWT for freight transportation (calculated for maximum terminal capacity as planned in phase I) from Haldia to Varanasi is 2.3; 0.36; 0.99; 0.2 & 0.5 billion g/yr. However, air emissions in immediate vicinity of the terminals are likely to increase due to increased nos. of vehicular movement near the terminal areas. These air emissions can be managed or reduced by using clean fuels like CNG or low sulphur diesel in transportation vehicles, development of adequate road network to prevent congestion and provision of avenue plantation. Air pollutants will be generated during construction phase of IWT infrastructure facilities but those will be short term, temporary and far less than generated in construction of road/railways. **Water Quality:** Impact is anticipated both during construction & operation phase. Water quality will be impacted during construction phase due to increased contaminated run-off from construction site, pilling and

	& fauna. The run-off generation will increase with increased network of rail/road which may be required to cater the increasing freight transportation	dredging activities for construction of off-shore structures. Water quality may be impacted during operation phase due to plying of vessels, dredging operations, usage of antifouling paints, discharge of waste/sewage/bilge water by vessels. These impacts are manageable by taking proposed mitigation measures.
	Loss of agricultural land and top soil: No loss of agricultural land/top soil is anticipated in existing scenario, i.e. without project scenario. But there is continual expansion of railway and road network to meet the freight & passenger transportation requirement of the country, which requires acquisition of agricultural land and loss of top soil. Also soil is required for construction of roads which is majorly sourced from agricultural fields.	**Loss of agricultural land and top soil:** Land requirement is minimal and is required only for development of civil interventions like terminal, jetties, locks. Land requirement is far less than the land required for road & railway projects.
	Material Sourcing: Construction materials like asphalt, aggregates, soil, paints, steel, cement etc. will be required for repair and maintenance of existing road/railway and expansion of road/railway. Material requirement for construction of road/railway are fairly large as compared to waterway project	**Material Sourcing:** Construction material like aggregates, cement, sand, steel etc. will be required for construction of navigational facilities and river bank protection works. However, the material requirement is comparatively lesser than required for maintenance and expansion of road & railway network
Terrestrial & Aquatic ecology	**Terrestrial Ecology:** Terrestrial ecology will not be directly impacted in without project scenario. However, the very need of expansion of road & railway network to increase the freight transportation may involve cutting of large nos. of trees and/or impacting the forest areas affecting the terrestrial	**Terrestrial Ecology:** Impact on terrestrial flora is anticipated only if the land acquired for development of civil interventions supports vegetation. While selection of site, areas of ecological importance and protected areas are avoided.

	ecology. Also the existing road crosses various eco-sensitive zones & forest areas and expansion if such roads will have greater impact on terrestrial ecology. **Aquatic ecology** Road/railways running along NW-1 crosses river Ganga at various locations. Construction of bridges leads to deterioration of aquatic ecology due to reduction in flow. Expansion of these bridges & construction of new bridges will have significant impact on aquatic ecology	**Aquatic Ecology:** Development of off-shore structures, barge operations and dredging activities has significant impact on aquatic ecology which requires to be managed adequately to minimize the impact.
Socio-economic Environment	**Loss of Valuable Time and efforts**: In without project scenario, insufficient transportation system will persist. Delays in material transportation and gaps in need and supply will persist. Public at large will continue to waste time in waiting at traffic jams triggered at railway crossings and roads. **Pressure on land:** Expansion of road/railway network will involve loss of land and livelihood of the farmers. **Pressure on Existing Resources**: People tends to settle in the area which has good connectivity leading to congestion in the area and increased pressure on the existing resources of that area. **Movement safety:** Road transportation is highly vulnerable to accidents. Accidents involve loss of life, injuries and damage of road infrastructure. **Employment Opportunities:** Employment generation involved only for construction of new road/railway alignment and maintenance of road/rail networks	**Loss of Valuable Time and efforts:** Shift of freight to IWT mode will reduce the congestion on road/rails thereby reducing the congestion. Also IWT ensures timely delivery/transportation of the material due to systemized movement of the vessels. **Pressure on land:** Land acquisition may be required for development of the civil intervention facility but it will be comparatively lesser than rail/road projects **Pressure on Existing Resources**: Increased traffic movement and other activities are anticipated at location of civil interventions which may lead to increase in pressure of existing resources like road, water supply etc. of that area. **Movement safety:** IWT mode is safest mode of transportation. **Employment Opportunities:** Employment generation is anticipated at proposed civil interventions and large no. of indirect employment may generate due to the increased freight transportation

Conclusion for Strategic Alternative Analysis:

Analysing both the scenarios for above mentioned criteria it is concluded that "With Project Scenario" is beneficial for all physical, biological and social environment when compared to "Without Project Scenario". With Project Scenario will improve the freight transportation efficiency, reduce the GHG emissions, fuel requirement, air emissions, land acquisition, tree cutting and land requirement required for maintaining and expanding road/railway network. However significant impact are anticipated on water and aquatic ecology in "With Project" scenario for which mitigation and management plans are to be prepared to minimize the impact.

3.12.2. *Planning Consideration*

This involves the consideration of options involved in planning stage, i.e. location of the proposed interventions, suitability of site, design of the project layout and dredging extent. This enables to select the option having best planning/design with minimal implication on physical, biological & socio-economic environment. Detailed planning alternative analysis is discussed in sections below

3.12.2.1 Selection of Locations for Civil Interventions

Locations are selected for proposed civil interventions (terminals/jetties) on the basis of potential of freight/cargo generation of the area and its connectivity with other modes of transport (rail & road). Ten such locations were selected for development of 6 nos. of terminals and 1 no. of lock.

One of the probable location at Bhagalpur was ruled out due to presence of Vikramshila Gangetic Dolphin Sanctuary and based on "NO GO" areas identified in Basin Level Critical Resources Assessment study. Some sites like site at Varanasi and Sahibganj were already identified by IWAI for development of terminals and land acquisition process was initiated so no alternatives were considered for such sites. Also alternatives for sites located on Government owned lands like Haldia terminal (located within industrial area) are not considered due to its insignificant impacts on socio-economy and environment. However, acceptability of these sites from environmental aspects were assessed which were found acceptable. Also with location perspective, a lock is required to be constructed at Farakka only near the existing lock. Thus for construction of lock also the location is pre-decided as per requirement. Alternative analysis of locations was carried out for social, environment and engineering feasibility. Detailed location alternatives analysis is given below in **Table 3.17** below.

Table 3.17 : Location Alternative Analysis

S. No.	Development, Site & Location	Advantages	Disadvantages	Selection Status	Remarks	Site Map
1.	Terminal site at Varanasi, U.P.	**Environment Considerations:** • Very less tree cutting associated (8 khajur tree & 4-5 babool shrubs) **Social Considerations:** • Site is agricultural fallow land with no development • Site already acquired by IWAI • Site is accessible and is close to highways, roads & railway • Settlements located are at app. 500 m from site thus minimal impact due to project activities **Design Considerations:** • Availability of LAD required for berthing and movement of barges	**Environment Considerations:** • Varanasi turtle sanctuary located at app. 2.3 km downstream of the site in North direction **Social Considerations:** • Site not directly connected to any public paved road at present	Selected	No alternatives assessed as site already selected and land already acquired. Anticipated impact on turtles due to barge movement is analysed to be low as nos. of barge movement will be app. 1-2 per day with regulated speed of 5kmph.	

2.	Terminal site at Haldia, W.B.	**Environment Considerations:** • No/very less tree cutting involved • Area located within industrial area thus raw materials to be transported available in shorter distance **Social Considerations:** • Site located within industrial zone of Haldia Dock complex • No R & R as site belongs to Haldia Dock Complex • Site well connected with roads & railways **Design Considerations:** • No river bank protection is required as already carried out by Haldia Dock Complex • Site close to Haldia Dock Complex and can share the facilities	**Environment Considerations:** • Haldia was listed as critically polluted area by MoEF&CC but now moratorium on further development have been lifted on 17th September 2013. **Social Considerations:** • Haldia listed as notified zone by CGWB for extraction of water, however no ground water usage is proposed **Design Considerations:** • Requires significant maintenance dredging	Selected	No alternatives assessed as site located on Govt land and is within the industrial complex. Dredging can be minimized as per requirement of the freight transportation	

3.	Terminal site at Sahibganj, Jharkhand	**Environment Considerations:** • Location of stone quarries in nearby areas thus locally available material to be transported • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Sahibganj is one of major centre of the Jharkhand for sourcing building & construction material • Site is close to highway & railways, i.e. within 1-1.5 km **Design Considerations:** • Availability of sufficient depth for berthing & movement of ships at app. 75 m inside the river and thus minimum dredging is required	**Environment Considerations:** • Requires cutting of app. 600 trees (orchard) • Existence of dolphins in this stretch of River which is Schedule 1 species as per Wildlife Act, 1972 **Social Considerations:** • Involves R & R thus significant social impacts but site acquisition already initiated • Site is not connected to any paved road at present 7 approach road is required to be constructed **Design Considerations:** • River banks and bed are required to be protected from erosion & scouring	Selected	All the negative impacts listed are manageable with proposed environment & social management plans thus no major drawbacks associated with the site	

4.	Terminal site at Ghazipur, U.P (2 sites considered at Ghazipur)	**Environment Considerations:** • Sites are not part of or close to any eco-sensitive location **Social Considerations:** • Railway and agricultural land available for locating the terminal • Good connectivity • Availability of cargo	**Environment Considerations:** • Dredging may be required to carry out at one of the selected location **Design Considerations:** • River unstable and channel gets silted up	One site selected at Ghazipur	Analysis to be carried out for selection of one of the two sites considered. No major environment, social or design issue associated	 
5.	Terminal site at Ballia, U.P.	**Environment Considerations:** • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Site is close to road & rail which connects to other cities like Varanasi, Gorakhpur & Patna • App. 15 ha of agricultural land available at the identified location **Design Considerations:** • Stretch is easily navigable • Availability of	**Environment Considerations:** • Site highly prone to flooding • Problems of sedimentation & bank erosion and requirement of river training works **Social Considerations:** • Approach road will have required to be constructed for connecting the site • Provision of railway connectivity to the terminal site may be a problem • Involves land acquisition	Not Selected	Lot of site maintenance, river training work, dredging work are involved	

		sufficient cargo for transportation	**Design Considerations:** • River is unstable and show migration • High sedimentation due to confluence of secondary channel & tributaries near the site • Presence of migration sand bars • Potential of complex flows at confluence points of primary & secondary channel during medium & low flow			
6.	Terminal site at & near Doriaganj (Semaria), Bihar (2 sites considered at Doraiganj & Kalughat)	**Environment Considerations:** • Locally available raw material (sand) for transportation • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Area well connected by road & Railways to all major cities • Agricultural land available for setting up terminal facility **Design**	**Environment Considerations:** • Requires tree cutting **Social Considerations:** • May Involves land acquisition	One of the two sites considered is selected	No major environmental engineering and social issues associated with the site	 

		Considerations: • River channel is stable • No shoal formation and availability of LAD • Availability of sufficient cargo for transportation				
7.	Terminal site at Barh, Bihar	**Environment Considerations:** • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Site close to road & railways connecting site to the major cities • App 11.5 ha of agricultural land available **Design Considerations:** • Availability of sufficient cargo for transportation especially coal due to presence of TPP (NTPC)	**Environment Considerations:** • Large nos of tree cutting involved • Location of important bird areas (IBAs) in Barh **Social Considerations:** • Requires demolition of houses located within site and involves R & R **Design Considerations:** • Highly mobile river channel with secondary channel and large central shoal • Location of large pylon in the river obstructing the navigation	Not Selected	Stretch not feasible for navigation and large no. of tree cutting required	

8.	Terminal site at Kahalgaon, Bihar	**Social Considerations:** • Site close to road & railway network connecting site with rest of the city & other cities • App. 18 ha of agricultural land with no development available **Design Considerations:** • Relatively stable river channel • Availability of deeper river channel along opposite banks	**Environment Considerations:** • Few trees located at the site which may require to be cut • Bank erosion prominent • Site prone to flooding • Location near Vikramshila Dolphin Sanctuary **Social Considerations:** • Involves acquisition of land and R & R activities **Design Considerations:** • Presence of rocky outcrops in upstream of proposed site	Not Selected	High flooding risks and navigational hazards and near the Vikramshila Dolphin Sanctuary	
9.	Terminal site at Tribeni, W.B. (2 sites are considered)	**Environment Considerations:** • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Site well connected with road & railways • Availability of agricultural land **Design**	**Social Considerations:** • Involves land acquisition and R & R • Site is low lying and requires significant land filling and thus have associated impacts like borrowing of earth, loss of agricultural	One of the two sites considered is selected	One of the two sites is selected. No major environment, social and design constraint	

		Considerations: • River is stable in this stretch • Availability of sufficient cargo for transportation	soil etc. **Design Considerations:** • Some design constrains at both the sites			
10.	New Lock at Farakka	**Environment Considerations:** • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Land belongs to FBP and can be transferred thus no R & R involved • No major development at the site **Design Considerations:** • Lock is required at Farakka as existing lock is not properly functioning and is essential component of navigation channel of NW-1	**Environment Considerations:** • Inundation of existing land	One of the two sites considered is selected	Site is to be selected in Farakka as lock is essential component of navigation here. No major environmental, design and social constraints associated with Farakka site	

Conclusion for Location Alternative Analysis:

Out of the total 10 locations, 6 locations were finalized for construction of terminal and one location is finalized for development of lock. Varanasi, Sahibganj & Haldia terminal sites were pre-decided. Also location of lock was pre-decided, i.e. Farakka. There is requirement of navigation lock in that stretch due to large water level difference in river & feeder canal and existing lock does not work optimally. Environmental, social and biological impacts of development of terminal & lock on these locations are identified and accordingly mitigation and management plans are developed.

Remaining six sites were analysed from environmental, social, design considerations. Based on alternative analysis three terminal sites at Ghazipur, Tribeni, Kalughat near Doraiganj were considered as preferred sites for these interventions. The other three terminal sites at Barh, Kahalgaon & Balia were not considered feasible due to (i) various environmental considerations including proximity to Vikramshila Dolphin sanctuary and Important Bird Areas, (ii) design issues such as unstable river, presence of navigational hazards and high sedimentation rate (iii) social issues concerning acquisition of land and (iv) connectivity.

Further alternative analysis was carried out for probable two sites at each of the above identified three terminal locations and Farakka lock based on environmental, social and design consideration. As per this analysis the preferred sites for these intervention locations were considered for design and environmental impact assessment.

3.12.2.2 Selection of specific site at each selected location

One or more sites were analysed at each selected locations for setting up proposed terminal or lock facility. Sites were selected and analysed for environmental, social and design consideration and the analysis is given in **Table 3.18.**

Table 3.18 : Site Alternative Analysis

S. No.	Development, Site & Location	Advantages	Disadvantages	Selection Status	Remarks	Site Map
1a	Terminal site at Ghazipur, U.P.- Site 1	**Environment Considerations:** • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Site belongs to Indian railways and thus does not involve R & R • Site directly connected with existing IR and connects to NH through small paved road • Availability of the cargo traffic. NH-97 has large volume of traffic which can be diverted here	**Environment Considerations:** • Requires large quantity of dredging and thus high threat to aquatic ecosystem and issues of disposal of dredged sand **Social Considerations:** • Land available is only 3 ha which is insufficient for terminal development without any demolition and requires demolition of 20 houses to acquire 2 ha additional land **Design Considerations:** • Site located on secondary channel of River	Not selected	Dredging requirement is too high and it will have high associated cost and damage to aquatic environment	

			Ganga which is silted up and is dead channel			
1b	Terminal site at Ghazipur, U.P.- Site 2	**Environment Considerations:** • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Site is private agricultural land with no development on it • Good road & railway connectivity of site. **Design Considerations:** • Site is located on main channel of River Ganga • Availability of LAD of 2.5 m close to shoreline • Availability of the cargo traffic. NH-97 has large volume of traffic which can be diverted here	**Social Considerations:** • No paved road connecting the site and approach road is to be constructed • Involves land acquisition **Design Considerations:** • River is not stable at this location and River training works may require to be carried out	Selected	No major environmental and social impact anticipated with site and will also help in reducing the freight load from NH-97 thereby reducing GHGs and other air pollutants	

2a	Terminal site at Doriaganj (Semaria), Bihar	**Environment Considerations:** • Locally available raw material (sand) for transportation • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Area well connected by road & Railways to all major cities • App. 12 ha of agricultural land is available for development of terminal. Land does not support and development at present **Design Considerations:** • River channel is stable • No shoal formation and availability of LAD • Availability of sufficient cargo for transportation	**Environment Considerations:** • Requires tree cutting **Social Considerations:** • Involves land acquisition	Not Selected	Involves tree cutting and acquisition of agricultural land	

2b	Terminal at Kalugha, Sitabganj, Bihar	**Environment Considerations:** • Locally available raw material (sand) for transportation • No environmental sensitive location will be affected **Social Considerations:** • Availability of sufficient land • Site well connected by road & railway • Site is vacant and involves no development **Design Considerations:** • Availability of sufficient LAD • River section suitable for navigation	**Social Considerations:** • Involves acquisition of land	Selected	Site has no environmental, design & social issues associated	
3a	Terminal site at Tribeni, W.B.-Site 1	**Environment Considerations:** • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Site is close to	**Environment Considerations:** • Site is low lying area and requires filling **Social Considerations:** • Involves land acquisition and R	Selected	Availability of sufficient cargo, no major environmental issues, stable river channel with manageable river bank protection works makes site suitable for terminal	

		road & railways which will connect site to rest of the town and other cities • App 40 ha of agriculture/brick kiln land available **Design Considerations:** • River is stable in this stretch • Availability of sufficient cargo for transportation • Site is not part of or close to any eco-sensitive location	& R **Design Considerations:** • Site located on inside bend of the river and naturally deep water is available on opposite bank of the river • Requires maintenance dredging for maintaining berth pocket and approach channel to terminal		development	
3b	Terminal site at Tribeni, W.B.- Site 2	**Environment Considerations:** • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Availability of 10 ha of agricultural land for development of terminal with no development • Site is located	**Environment Considerations:** • River training works are not acceptable at the site due to built up nature of land • Site is low lying and requires significant land filling and thus has associated impacts like borrowing of earth, loss of	Not Selected	Disadvantages cannot be overcome through mitigation and management measures	

		close to railway and road connecting site to other cities • Internal road of city connects site to the highway **Design Considerations:** • Availability of sufficient cargo for transportation	agricultural soil etc. **Social Considerations:** • Site is located in thickly populated area • Traffic pressure on internal city road will increase significantly after development of terminal and its expansion will be problem due to location in thickly populated area **Design Considerations:** • Extension of railway line to the site is not easily feasible • Possible water intake is located within the site • A channel connecting to the main river at both ends is traversing the area & is probably a source of water for intake structure for			

			water supply to the town • Shallow water depth along the river bank and dredging will be required to maintain the approach channel			
4a	New Lock at Farakka Parallel to existing lock	**Environment Considerations:** • Site is not part of or close to any eco-sensitive location **Social Considerations:** • Land belongs to FBP and can be transferred thus no R & R involved • No major development at the site • Land required is 14.86 ha **Design Considerations:** • Length of extension of U/s channel is 190 m & D/s channel is 310 m • Dredging	**Social Considerations:** • Some farmers practice agriculture on the FBP land	Selected	No disadvantage associated with the site and is better w.r.t the second site selected for development of the lock	

		requirement of 0.5 lakhs cum in U/s approach channel and 0.8 lakhs cum in D/s approach channel to maintain LAD of 3 m • Length of FBP road to be realigned-675 m • Length of boundary wall to be constructed-1180				
4b	New Lock at Farakka D/S of existing lock	**Environment Considerations:** Site is not part of or close to any eco-sensitive location **Social Considerations:** • Land belongs to FBP and can be transferred thus no R & R involved • No major development at the site	**Environment Considerations:** **Social Considerations:** • Land required is 26.46 ha, large as compared to other option considered **Design Considerations:** • Length of extension of U/s channel is 575 m & D/s channel is 460 m • Dredging requirement of 1.5 lakhs cum in U/s approach	Not Selected	No major environment or engineering issues associated but parallel site is better in all respect to this site	

			channel and 1.5 lakhs cum in D/s approach channel to maintain LAD of 3 m • Length of FBP road to be realigned-980 m • Length of boundary wall to be constructed-1672			

Conclusion for Site Alternative Analysis:

Alternative sites were selected in case of 4 selected locations for development of terminals and lock, i.e. terminal site at Gazipur, Tribeni and at/near Doraiganj and lock site at Farakka. Considering environmental, social and environmental implications of development of terminal, suitable sites are selected.

3.12.2.3 Design Planning

After selection of site for development of the terminals, alternatives are selected for layout design and alignment of proposed roads and railways for connecting the site. Design planning helps to optimize the project cost during construction as well as during operation phase. Such alternatives are considered at few locations as per the requirement of locations. Details of the same are given in sections below. Alternative layout designs and location of road/rail alignment to provide connectivity is assessed in case of Sahibganj terminal & Farakka lock only. No major issues are associated with the Varanasi & Haldia site so no alternatives were considered

A. Alternative layout Designs at Sahibganj Site

Two layout designs were considered for development of the terminal at Sahibganj site. Alternative 1 involves construction of U shaped jetty (25 m), aligned parallel to the River bank and connected to bank by approach trestle of 50 m and alternative 2 involves construction of jetty at the river bank aligned parallel to it. Both the alternatives were compared on multiple criteria, i.e. operational considerations, navigational aspects, ease of construction & maintenance, flexibility of expansion, construction cost and environmental consideration. Detailed multi-criteria analysis for both the alternatives considered is given below in **Table 3.19.**

Table 3.19 : Alternative Layout Analysis of Sahibganj Terminal

S. No.	Criteria Description	Anternative-1	Alternative-2
1.	Dredging at Jetty	As the berth is located in deep water and connected to shoreline by approach trestle, there is no requirement to carry out the dredging.	As the berth is located on river bank itself where shallow water is available, there is requirement to carry out the dredging.
2.	Dredging in approach channel, turning circle and maneuvering area	As there are some pockets in approach channel, turning circle and maneuvering area where water available is less than the required draft of design vessel, dredging is required to be carried out.	Same as Alternative-1 but the dredging quantity is worked out to be more in this alternative.
3.	Scope for Expansion	As sufficient river front is available, there is enough scope for expansion in Alternative-1.	Same as Alternative-1
4.	Degree of Operation	As the cargo is proposed to be handled by combination of dumpers, pay loaders and barge loaders in Phase-1, the degree of operation is good in this alternative.	Same as Alternative-1

5.	Ease of Construction	As Alternative-1 involves construction of jetty along with 50 m long approach trestle, the construction can be carried out easily by well-established methods.	As Alternative-2 involves construction of jetty at river bank only, the construction can be done easily in relatively short time as compared to Alternative-1.
6.	Cost of Construction	The cost of construction for Alternative-1 works out to be marginally higher in comparison to Alternative-2.	The costs of construction for Alternative-2 is marginally lower than Altenrative-1.
7.	Environmental Consideration	Reduced dredging requirement will have lesser need for disposal of dredged material and also will have lesser disturbance to river system and aquatic life.	Larger dredging will have comparatively larger disturbance to river system and aquatic life.
8.	Layout		

Based on multi criteria matrix presented above, both the alternative layouts have certain advantages as well as disadvantages. It could be observed that in terms of available required depth round the year without need of dredging and marginal cost difference between two alternatives, and environmental consideration Alternative-I is preferred alternative for development of IWT Terminal at Sahibganj in Jharkhand.

B. **Alternative Layout Design of Farakka Lock**

Two Options for locating the new navigation lock have been considered. In Option - I, the new lock will be located parallel to the existing lock and in Option - II, it will be located D/S of the existing lock. Sufficient distance between the two locks has been kept in Option 1 so that there is no danger to the structure of existing navigation lock. Detail comparison of Option-I and Option II is provided in **Table 3.20.**

Table 3.20 : Alternate Site Analysis (Option-I & Option-II)

S. No.	Parameter	Option-I	Option-II	Remarks
1	Land Required (ha)	14.86	26.46	Land required in Option-II is almost two times
2	Length of extension of U/S Approach Channel (m)	190	575	• Length is almost three times in Option-II as compared to Option-I. • While Option-I involves construction of only the left Bank of the channel and protection works on left bank only, Option-II involves construction of both the banks of the channel and bank protection works on both the banks. This means additional cost in Option-II.
3	Assuming water depth	0.05	0.15	Quantity of excavation in Option-II is almost three times than that in Option-

	of the channel as 3-m, approximate quantity of dredging in excavation for U/S Approach Channel (million mm^3)			I.
4	Length of extension of D/S Approach Channel (m)	310	460	• Length is 150-m more in Option-II. • While Option–I involve construction of only the left bank of the channel and protection works of left bank only, Option-II involves construction of both the banks of the Channel and bank protection works on both the banks. This means additional cost in Option-II
5	Assuming water depth of the channel as 3-m, approximate quantity of earth work in excavation for D/S Approach Channel	0.08	0.15	Quantity of excavation in Option-II is almost double than that in Option-I.
6	Length of FBP Inspection Road to be realigned (m)	675	980	Length of the road to be realigned is almost 50% more in Option-II. It means requirement of additional land as well as additional cost.
7	Length of Boundary Wall to be constructed (m)	1180	1672	Length of the boundary wall in Option-II is about 500-m more than the length in Option-I. It means requirement of additional land as well as additional cost.
8	Layout Design	 Option-1		 Option-2

In view of advantages of Option, I over Option II as listed above, the Option I (locating new Lock parallel to the existing lock) is recommended. Dredging requirement for option I is almost half the requirement in option II. Length of extension of U/s & D/s approach channel is almost three times in option II as compared to option I. 675 m of existing FBP road will

required to be realigned in option I whereas 980 m will be required in option II. Thus it is anticipated disturbance in case of option II is more than that in option I. Thus it is recommended to adopt the option I. Present EIA study has been carried out considering the impact of considered option I only.

C. **Alternative Approach Road Alignments: Sahibganj Terminal**

At present site is not connected with any paved road. It is proposed to develop a four lane approach road to connect the site to NH-80. Two alignments are considered for development of the six lane road. Both the alignment's start & end points are at the same location and both alignments will cross the LC-54 of existing Railway line. On LC-54, it is proposed to provide the ROB to ensure smooth movement of vehicles. Comparative analysis of both the alignments is given below in **Table 3.21**

Table 3.21 : Alternative Road Alignment Analysis for Sahibganj Terminal

S. No.	Criteria Description	Anternative-1	Alternative-2
1.	Environmental Consideration	Cutting of trees	Cutting of trees
2.	Social Consideration	This alignment involves widening of the rural road and large nos. of households will be impacted. Movement of large no of trucks will cause increased noise level in village area.	Large land acquisition but lesser displacement & dislocation.
3.	Design Consideration	Length of this alignment is 1 km. Brownfield alignment and involves improvement of rural road.	Length of this alignment is 1.5 km. Greenfield alignment.
4.	Alignment		

Based on alternative analysis, it is concluded that environmental & social impacts on both the alignments are equal as both alignment involves tree cutting, land acquisition and displacement & dislocation of pucca structures. However, considering the design, alternative 1 is found to be more feasible.

D. **Alternative Railway Siding Alignments Considered for Sahibganj Site**

It is proposed to develop railway connectivity for terminal site with existing Railway Line. Three options are considered for giving the connectivity to the terminal site and are given below.

- 1st Option-Near Sahibganj railway Station
- 2nd Option-From Level Crossing Gate No. 53 or 54 at Sakrigali Railway Station
- 3rd Option-From loop line at Sakrigali Railway Station

All the three options are analyzed for environmental, social and design consideration and detailed analysis is given below in **Table 3.22.**

Table 3.22 : Alternative Railway Siding Alignment Analysis for Sahibganj Terminal

S. No.	Criteria Description	Anternative-1	Alternative-2	Alternative 3
1.	Description	Railway track is proposed to take-off near Sahibganj Railway Station and following existing main line leading to the entrance of the terminal	Two sub-options as Options 2A & 2B are identified where the railway track from Level Crossing Gate No. 53 & 54 shall take-off and following the curve leading to the entrance of the terminal	Railway track is proposed to take-off from loop line at Sakrigali station and following a U-turn leading to the entrance of the terminal
2.	Environmental Consideration	Involves tree cutting	Involves tree cutting	Involves tree cutting
3.	Social Consideration	Involves land acquisition, disturbance to pucca structures and R & R	Involves land acquisition, disturbance to pucca structures and R & R	Involves land acquisition, disturbance to pucca structures and R & R
4.	Design Consideration	This option is not found to be feasible as no railway land is available near Sahibganj Station to have additional track and also length of track works out to be on higher side.	Both these sub-options have not been found to be feasible in view of the high level difference between the track and terminal area exceeding the permissible gradient and curve limits under the Railway rules.	Found feasible considering the length of track, permissible gradient, degree of curve and cost involved
5.	Alignment			

Based on alternative analysis, it is found that only alternative 3 is technically feasible. Social & environmental implications of all the three alignments are same.

3.12.2.4 Maintenance of LAD

Dredging is required to be carried out so as to maintain the length and width of the channel and maintain LAD near the berths/jetty. IWAI proposed either maintaining 3m LAD throughout the NW-1 stretch or maintained different LAD in different stretches (3 m Haldia to Barh, 2.5 m from Barh to Buxar and 2.2 m from Buxar to Varanasi). Alternative analysis was carried out for both these options considering environmental (dredge quality, impact on aquatic ecology and water quality), social (cultural and aesthetic value, employment and socio-economic consideration) and technical feasibility (dredge quantity, navigation

feasibility, economic aspects, dredgers and other infrastructure requirements). Both the options have their pros and cons and are discussed at **Table 3.23.**

Table 3.23 : Alternative Analysis for Dredging Quantity

Considerations	Option 1 (3 m LAD in entire NW-1) In CUM	Option 2 (LAD of 3 m Haldia to Barh (Bihar), 2.5 m from Barh to Buxar and 2.2 m from Buxar to Varanasi) In CUM	Remarks
Dredging Quantity in Dry Season	31,079,576	1,57,60,596	Option 2 is app. 50% of option 1 hence less environmental, social and economic impacts associated with option 2
Navigation	In entire NW-1	Possible from Haldia to Varanasi during dry season	Option 1 provides better navigation facilities
Cost	High	Comparatively lower	Cost in option 1 is app. double the cost in option 2 due to doubling of quantity
Dredgers and other infrastructure requirement	32-33 (if dredgers work for 10 hours in month of 25 days in double shift)	16 (if dredgers work for 10 hours in month of 25 days in double shift)	Requirement of dredgers and dredging infrastructure is almost double in option 1 as compared to option 2
Disturbance to social, cultural and aesthetic value	Comparatively more than option 2	Comparatively less than option 1	Option 1 will have more disturbance as it covers the larger stretch
Disturbance to aquatic flora & fauna	Comparatively more than option 2	Comparatively less than option1	Option 1 will have more disturbance as it covers the larger stretch
Employment	More	Less	Since the dredging is to be undertaken at larger stretch in option 1, employment to larger nos. of people will be provided in option 1.

As per above analysis option of maintaining different LAD at different stretch was found most preferred option.

3.12.3. *Technology Consideration*

This enables to select the technology best suited for the site specific environment and having minimal implication of environment, social and biological component of environment. Technological consideration for selection of type of dredgers is made as maintenance dredging is one of the crucial activities of operational phase which will be continued for app. 8 month every year.

3.12.3.1 Selection of Dredger

Selection of dredgers is important as selection of dredger has environmental implications such as effect of production rate on the project duration, the levels of turbidity and suspended sediment concentrations generated relative to background levels, the proportion of total sediment lost to the environment and the degree of contamination in the sediment.

Typically, CSDs have least effect on turbidity at the dredging site and TSFDs produce similar low turbidity when used without overflow. Grab dredgers and TSGDs when used with overflow, produce significantly high turbidity throughout the water column near the dredging site than do CSDs. However, reverse is true for placement site. CSDs and TSHDs fluidise the sediments by mixing them with water than the mechanical dredgers do. Fluidized sediments by CSDs and TSHDs causes discharged material to cover larger area when unconfined. Comparative analysis of types of dredger and their relative performance related to environmental aspects is given below in **Table 3.24** & **3.25**.

Table 3.24 : Comparative Analysis of Dredgers and Their Relative Performance Related to Environmental Aspects

	Safety	Accuracy	Turbidity	Mixing	Spill	Dilution	Noise
Suction dredger	+	-	+	-	-	0	+
CSDs	+	+	0/+	0/+	0	0	+
TSHD	+/0	-	-/0	-	0	-	+
Bucket Ladder Dredger	-	+	-/0	0/+	+	+	-
Backhoe Dredger	-	+	-/0	+	+	+	+
Grab Dredger	-	-	-/0	0	+	+	+

+ is better than average, 0 is average and – is below average

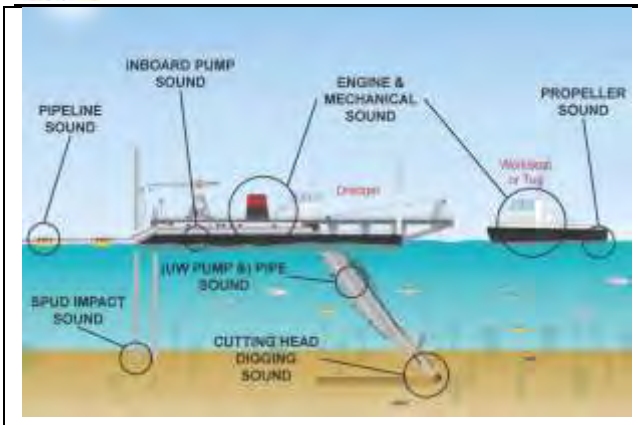
Table 3.25 : Comparative Analysis of Different Type of Dredgers Related to Environmental Aspects

Attributes	CSD	Hopper Dredgers	Grab/Bucket Dredger	Back hoe Dredger
Type	Hydraulic	Hydraulic	Mechanical	Mechanical
Strata	All type-soil, sandy, silty and	Silty and gravel	Silty, gravel, mud and soft rock	Clay & Gravel

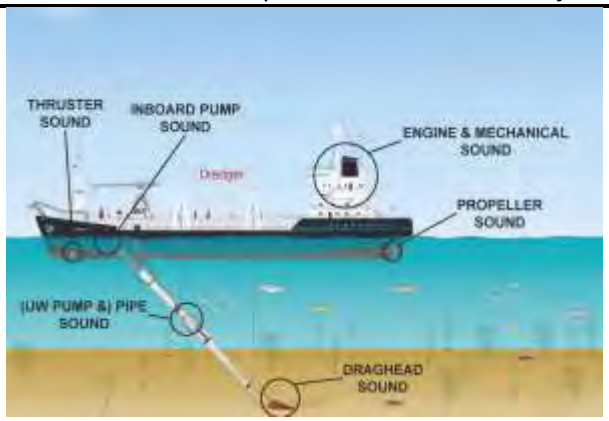
	rocky			
Usage	Inland waters	Coastal areas	Coastal waters and inland waters	Shallow waters and confined places
Underwater Noise levels at 1 m- underwater at 1 µPa2m2	172-185 d B	186-188 dB	Less	186-188 dB
Ambient Air Noise Level dB(A)	100-115dB (A)	100-112dB (A)	115dB (A)	110-118 dB(A)
Suspended Sediment Generation during dredging (kg/cum)[17]- Annexure 3.1	Ordinary 4,000 PS1/- 2.2 – 4.5 Ordinary 2,000 PS-0.1 – 0.3	2.4-5.2	0.4-5	--
Suspended Sediment Generation during placement of dredged material (kg/cum)[18]- Annexure 3.1	Ordinary 4,000 PS1/- 1.2 – 1.4 Ordinary 2,000 PS-NA	12-203	NA	--
Schematic diagram showing noise sources	**Figure 3.11**			

[17] *Assessment of the Environmental Impact of Port Development, United Nations, New York, 1992*

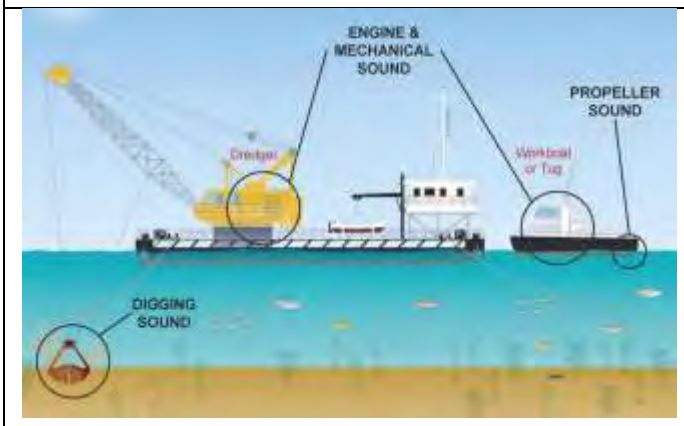
[18] *Assessment of the Environmental Impact of Port Development, United Nations, New York, 1992*



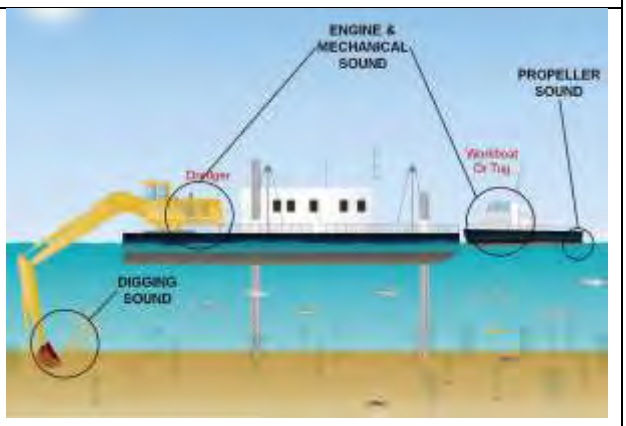
Cutter Section Dredger



TSHD



Grab Dredger



Back Hoe Dredger

Figure 3.11 : Diagrammatic Presentation of Different Type of Dredgers Showing Different Noise Source

Conclusion for Selection of Dredgers

The CSD was considered as most preferred option due to least associated environmental Impact and operational feasibility. As per experience of KoPT[19] and IWT CSD has proved to be the best option and is considered for maintenance dredging planning and environmental impact assessment. Technical brief of the CSDs is given in **Annexure 3.2.**

C: DEVELOPMENT OF NAVIGATION CHANNEL, PLANNED AND PROPOSED PROJECT COMPONENTS

The developmental activities include maintenance of Navigational Channel (Least Available Depth for Navigation), Barge operations, and Physical interventions (Such as construction of Terminals, Navigation Lock, River training structures, RO-Ro Jetties). Details of these interventions are described below.

3.13. Least Available Depth for Navigation in NW-1

For navigation purpose, it is essential that minimum depth of the water is maintained in the river all the time of navigation. IWAI is currently maintaining LAD for managing the

[19] KOPT is using CSD dregeres. According to KoPT it is impractical to use trailer suction hopper dredger (TSFDs) for shallow draught dredging. TSFD is practically a barge mounted and in no way a viable option for inland waterways due to high cost, larger sailing distance and shallow waters.

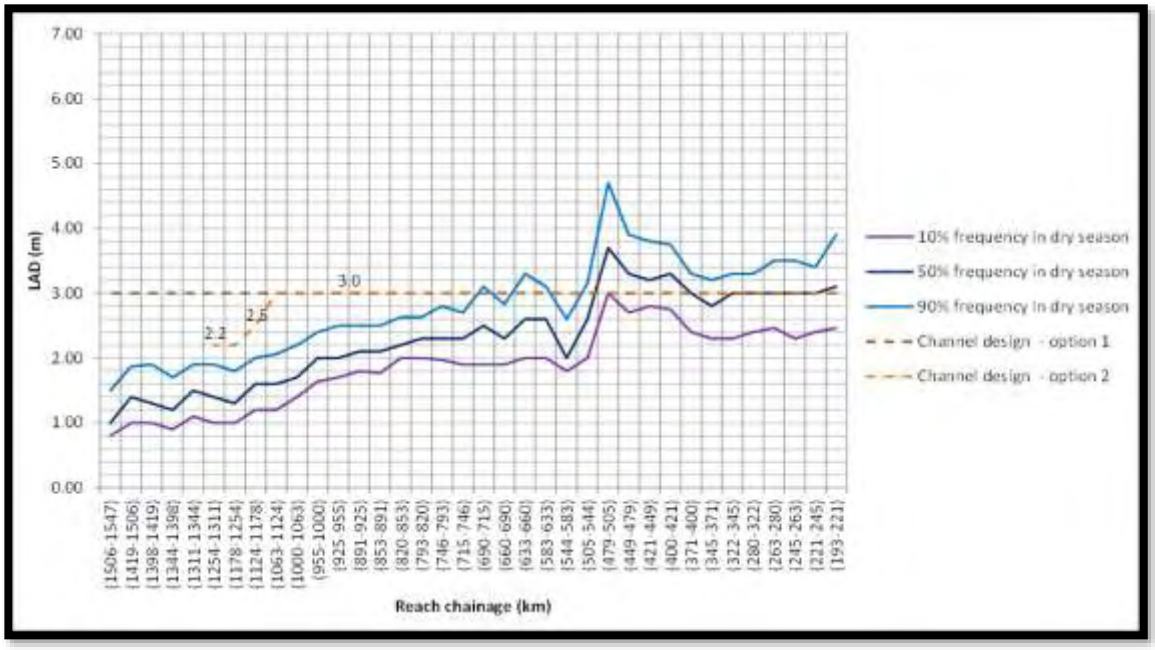
navigation in NW-1 through dredging and bandalling. Depths[20] maintained by IWAI in different stretches currently is given below

- Haldia (Sagar) - Farakka (560 km)-2.8-3.0 m
- Farakka - Barh (400 km)-2.1-2.5 m
- Barh - Ghazipur (290 km)-1.6-2 m
- Ghazipur – Chunar/Allahabad (124 km)-1.2-1.5m
- Chuna-Allahabad (246 km)-No maintenance

However, “Jal Vikas Marg” Project aims at maintenance of LAD to 3 m in entire NW-1. But to optimize the cost, deployment of dredgers, manage man-power and minimize environmental impacts, IWAI is focussing on different depths in different stretches at present.

- Haldia to Farakka (544 km)-3 m
- Farakka to Barh (347 km)-3 m
- Barh to Buxar (233 km)-2.5 m
- Buxar to Varanasi (187 km)-2.2 m

Varanasi to Allahabad (236 km)- no maintenance The above consideration also takes into account assessment of 10%, 50% and 90% frequency of occurrence of LAD during the dry season (Nov-June) for 2010-2015 carried out by design consultant which is shown at Figure **3.12**.



Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 3.12 : LAD Along the waterway for the 10, 50 & 90% frequency value

3.14. Maintenance Dredging in NW-1

[20] As per the surveys carried out by IWAI, depths available in NW-1 naturally are as follows:.

- Haldia to Tribeni (196 km)- LAD of 3m- throughout the year
- Tribeni to Farakka (364 km)- LAD of 2.5 m – 320 days
- Farakka to Ghazipur (690 km)- LAD of 2 m- 200 days
- Ghazipur to Allahabad (370 km)-LAD of 1.5 m-170 days

Dredging is required to be carried out so as to maintain the length and width of the channel and maintain LAD near the berths/jetty. At present dredging of 0.7 million cum is being undertaken by IWAI between Farakka to Barh & Barh to Patna. However, for year I maintenance dredging is planned as per required minimum LAD. Two options are opted for LAD. Option 1: 3m LAD thought NW-1(Haldia to Allahabad), Option 2: varied LAD between different sections between Haldia to Varanasi i.e. 3 m LAD from Haldia to Barh, 2.5 m from Barh to Buxar, 2.2 m from Buxar to Varanasi, and naturally available LAD between Varanasi to Allahabad (no dredging between Varanasi to Allahabad). Dredging quantity is estimated for achieving both the options in different sections. Dredging quantity is calculated for channel width of 64 m, and 1:10 side slope. Estimated dredging quantity will be as low as 50% in average flow conditions in option 2 compared to option1. Reach wise detail of the tentative dredging quantity in both the options is given in **Table 3.26** and summary of the tentative dredging quantity in different stretches is given in **Table 3.27.** For purpose of environmental impact assessment study, preferred option 2 is being considered. However, impacts of both option 1 & 2 are assessed in the impact assessment chapter.

Table 3.26 : Reach Wise Detail of Dredging Quantity (Option1 & option 2)

S. No.	Start	End	Option 1		Option 2	
			Average Flow (December) cum	Average Flow (Dry) cum	Average Flow (December) cum	Average Flow (Dry) cum
1.	Haldia	Tribeni	--	--	--	--
2.	Tribeni	Balagarh	208,500	208,500	208,500	208,500
3.	Balagarh	Kalna	193,002	193,002	193,002	193,002
4.	Kalna	Samudragarh	140,031	140,031	140,031	140,031
5.	Samudragarh	Nabadwip	51,855	51,855	51,855	51,855
6.	Nabadwip	Patuli	168,416	168,416	168,416	168,416
7.	Patuli	Katwa	133,483	133,483	133,483	133,483
8.	Katwa	Plassey	306,265	306,265	306,265	306,265
9.	Plassey	Chumarigacha	115,304	115,304	115,304	115,304
10.	Chumarigacha	Berhampore	76,121	76,121	76,121	76,121
11.	Berhampore	Mahammadpur	104,598	104,598	104,598	104,598
12.	Mahammadpur	Nasipur	148,823	148,823	148,823	148,823
13.	Nasipur	Jangipur	8,009	8,009	8,009	8,009
14.	Jangipur	Farrakka	8,185	8,185	8,185	8,185
15.	Farrakka	Rajmahal	84,676	174,321	84,676	174,321
16.	Rajmahal	Manihari	114,824	332,797	114,824	332,797
17.	Manihari	Karagola	430,541	945,924	430,541	945,924
18.	Karagola	Kahalgaon	193,914	685,960	193,914	685,960
19.	Kahalgaon	Bhagalpur	73,621	346,174	73,621	346,174
20.	Bhagalpur	Sultanganj	74,578	335,109	74,578	335,109
21.	Sultanganj	Munger	320,194	636,630	320,194	636,630
22.	Munger	Mahendrapur	183,846	364,106	183,846	364,106
23.	Mahendrapur	Semaria	487,580	702,489	487,580	702,489
24.	Semaria	Barh	641,884	1,094,622	641,884	1,094,622
25.	Barh	Mehnar	852,786	1,128,642	585,661	811,907

26.	Mehnar	Patna	1,566,955	2,060,893	1,072,193	1,475,192
27.	Patna	Doriganj	877,707	1,345,685	510,806	880,303
28.	Doriganj	Ballia	1,635,429	2,826,940	1,041,072	1,896,619
29.	Ballia	Buxar	284,847	826,628	112,731	485,201
30.	Buxar	Ghazipur	433,521	1,282,515	88,582	456,523
31.	Ghazipur	Saidpur	989,081	1,934,918	395,416	924,991
32.	Saidpur	Varanasi	1,717,726	2,575,922	930,815	1,549,137
33.	Varanasi	Chunar	1,163,500	1,436,199	5,000	5,000
34.	Chunar	Mirzapur	2,085,582	2,991,955	--	--
35.	Mirzapur	Rampur Ghat	1,173,041	1,589,645	--	--
36.	Rampur Ghat	Sirsa	357,143	830,872	--	--
37.	Sirsa	Allahabad	2,144,355	2,968,038	--	--

Source: HOWE Engineering Projects (India) Pvt. Ltd. (Design Consultant) India

Note: No dredging is at present planned to be undertaken between Varanasi & Allahabad stretch of NW-1.

Table 3.27 : Dredging Volumes in different Stretches for Maintaining LAD

Stretch	**Stretch Length (km)**	**Average Annual Dredge Volume (cum)**		
		Present Day 2013-2014	**LAD of 3 m**	**LAD of 3 m from Farakka to Barh, 2.5 to Buxar & 2.2 m to Varanasi**
Haldia to Farakka	544	--	1,662,592	1,662,592
Farakka to Barh	347	3,70,000	5,618,132	5,618,132
Barh to Patna	64	3,30,000	3,189,534	2,287,099
Patna to Buxar	169	--	4,999,253	3,262,123
Buxar to Varanasi	187	--	5,793,355	2,930,650
Varanasi to Allahabad	236	--	9,816,710	n/a
Total	1547	7,00,000	31,079,576	1,57,60,596

Source: HOWE Engineering Projects (India) Pvt. Ltd. (Design Consultant) India

Apart from dredging requirement for maintain LAD in navigation channel, maintenance dredging is required to be carried out at proposed Haldia Terminal. To provide 24X7 accesses to Haldia terminal, it is required to carry out dredging of 0.10-0.20 million cum/year at the Haldia terminal. Some maintenance dredging will also be required to be carried out at other proposed development sites like Sahibganj but that is not significant and thus not quantified here. To carry out these dredging operations, various equipment like cutting section dredgers, along with plough dredgers, agitation dredgers and Backhoe Dredgers are proposed to be used.

Requirement of Dredgers for Maintaining LAD in Navigation Channels: Maximum capacity of one dredger in one month is to dredge 50,000 cum of sand if there are 25 working days in month of 8 hours each. If dredger works at its maximum capacity for 6 months, then dredging volume per dredger of 3,00,000 cum can be achieved. Average volume to be dredged to maintain LAD in navigation channel as per option 2 is 1,57,60,596 cum/year thus it would require 53 dredgers working at their maximum capacity for 6 months. To optimize the nos.of dredgers, it is proposed to extend daily operation hours from 8 to 10 hrs so as nos. of dredgers required will be 43. If dredger works for 10 hrs in a day for 8 months, then dredgers required will be 32 nos. only. If dredgers work this way in 2 shifts,

then no. of dredgers required will be 16 only. However excess dredging may be required when water levels are lower than average water levels during dry season. Dredging should be supplemented by bandalling works so as to increase effectiveness of dredging and reducing requirement of dredging.

Type of Dredgers:

CSD (cutter section dredgers) is proposed to be used for Jal Marg Vikas Project along with the agitation (plough dredger) dredgers and Backhoe Dredgers (BHDs). The dredging plant will require support vessels, including bunkering, survey, accommodation and tugs. Plough/agitation dredgers could be used to dredge shallow waters or removing high spots (dredge cut <0.5 m). Channel width is 64 m and CSDs used by IWAI have swing width of 35-40 m thus two CSDs can be deployed in pairs leaving the off-set to prevent overlap to dredge the channel. Dredging depth varies from 0.5-3 m, means about 1-4 cuts will be required to achieve the required depth (dredge cut <0.5 m).

Water levels start reducing from mid-October and dredging operation would be required to be started during this period. Plough/agitation dredgers can be used in initial period to dredge shallow waters/ high spots. When depth reduces significantly by November CSDs will be used for dredging. Dredging operations will continue from mid-October to June. During monsoon season, i.e. July-mid October repair & maintenance of dredgers can be taken up.

Dredge Disposal:

Disposal of dredged material through CSDs will be done through pipeline into the free stream of the river in a way to avoid material working its way back to dredged channel. This can be achieved by disposing in faster flowing water, downstream and to the side of the working dredgers and disposal of material into secondary channels or redundant channels. Material dredged by BHD will need to be placed in a barge and disposed of away from the channel as the reach of the BHD is unlikely to be sufficient enough to reach the faster flow for dispersion of the material. Therefore, it is required to find potential disposal sites for this material.

3.15. Physical Intervention

3.15.1. *Navigation Aids*

3.15.1.1 Existing Navigation Aids on NW-1

- Temporary channel marks for day navigation maintained between Tribeni and Allahabad all-round the year.
- Night navigation aids were maintained between Tribeni and Varanasi (1187km) with country boats/ MS poles fitted with navigational lights and beacons
- DGPS stations at Bhagalpur, Patna and Swaroopganj.
- 12 Nos. survey vessels. Thalweg surveys conducted fortnightly during low water period and on monthly basis in flood season
- 77 Cargo vessels deployed in operations between Haldia & Kolkata
- 3 nos. cargo vessels on voyage charter basis and 3 nos. cargo vessels on bare boat charter basis on NW-1, NW-2 and Indo-Bangladesh Protocol route
- Eight Cutter Suction Dredgers (CSD) one Hydraulic Surface Dredger (HSD) and one Amphibian Dredger (AD) for maintain LAD in NW-1
- River Information System Development for Haldia to Farakka stretch which is 545 km in length. The project has 7 base stations, 2 control stations and has 30 vessel

stations. Project costs app. INR 26.3 Cr. River information system is a form of vessel traffic management system using combination of modern technologies like automatic identification system, Radar, Meteorological & hydrological equipment and software information technology related services designed to optimize traffic and transport processes in inland navigation. The system enhances swift electronic data transfer between mobile vessels and shore stations through advance and real time exchange of information. RIS aims to streamline the exchange of information between various stakeholders of Inland Water Transport. The system facilitates exchange of real time information like, wind speed, fog conditions, danger areas, depth information, route details between operators and vessel masters. This system will enhance the inland navigation safety in ports and rivers and optimize the resource management of the waterborne transport chain which will enhance the efficiency of inland navigation and help in providing traffic and transport information to the operators for an efficient & optimal navigation on Ganga. This immensely helps in optimization of navigation and minimizes collision risks in the waterway thus benefitting the users greatly.

3.15.1.2 Planned/Proposed Navigation Aids on NW-1 under Jal Marg Vikas Project

It is planned to develop navigation aids all along the NW-1 so as to ensure better navigation both during day and night. Navigation aids to be provided includes the following as per IWAI planning

- Upgrade the physical aids to navigation like channel marks, navigation lights, and signals between Haldia to Farakka
- Install comprehensive physical aids to navigation including navigation lights between Farakka and Allahabad
- Extending the NW-1 River Information System (RIS) to cover Farakka to Allahabad section also. Farakka to Allahabad stretch is further divided into Farakka to Patna and Patna to Varanasi stretch. Work on Farakka to Patna has already been started which is 410 km in length and the section Patna to Varanasi which measures 356 km is under tendering process. Farakka to Patna stretch will comprise of 6 base stations and 1 control station and cost for this stretch will cost INR 15.89 Cr. Patna to Varanasi stretch will comprise of 4 base stations and 1 control station and will cost INR 14.56 Cr.
- Communicating the key navigation data to users in real time e.g. detailed LAD, water levels, flow speeds, visibility, vessel congestion, operational status (one way/two traffic) etc.

Other planned development to build better understanding of the waterway performance and sharing knowledge with the waterway users are detailed below.

- Target and prioritise immediate/short-term physical intervention measures based on feedback and reports of experience from waterway users.
- Collect comprehensive data on all navigation incidents, and near-misses. Analyse these data, and take appropriate actions to prevent similar occurrences in the future.
- Collect detailed waterway performance data e.g. vessel congestion bottlenecks, incident hotspots, and effectiveness of dredging/bandalling activities. Continuously monitor and analyse the performance to identify and prioritise waterway management activities, and report to users.
- Publish detailed navigational guidance information for key navigation challenges and bottlenecks.

- Update and upgrade the pilotage information available in the NW-1 River Pilot (particularly for middle and upper sections of the waterway)
- Introduce immediate- to short-term skills training programme for IWT vessel masters and crews
- Establish and enforce minimum competency levels and qualifications for all IWT commercial masters and crews.
- Establish a long-term training and apprentice scheme/system for all IWT commercial users.
- Build engagement with local waterway users (fishermen, ferrymen and sand miners). Establish an information feedback mechanism with these users.
- Raise awareness of risks (to all waterway users) and opportunities associated with additional IWT traffic on the waterway.

3.15.2. *Navigations Infrastructure*

3.15.2.1 Existing Navigation Infrastructure

Navigation infrastructure existing at NW-1 which facilitates the cargo transportation are listed below

- Low & High level jetties at Patna
- GR jetty in Kolkata
- Fixed Jetty at Farakka & Pakur
- Floating terminals at Haldia, BISN & Botanical Garden in Kolkata, Tribeni, Shantipur, Swaroopganj, Katwa, Hazardwari, d/s Farakka, u/s Farakka, Manglahaat (Rajmahal), Samdaghat (sahebganj), Bateshwarsthan, Bhagalpur, Munger, Semaria, Buxar, Ghazipur, Ramnagar (Varanasi) and Allahabad.

Details of the location, Chainage, capacity, area, facilities of these above mentioned existing facilities in NW-1 are given below in **Table 3.28**. Map showing location of the existing developments in NW-1 is given in **Figure 3.13** below. Photographs of some of existing facilities along NW-1 are given in **Figure 3.14.**

Table 3.28 : Details of Existing Infrastructure in NW-1

A. Floating Terminals										
Sl. No.	**Name of terminal with chainage (In km)**	**Land area (in Sq. m)**	**Size of berth, water front (In metre)**	**No. of Pontoon Barge & Gangway**	**Cargo Handling equipment**	**Storage area**	**Link approach road**	**Security (in each shift)**	**Water/ Lighting facility**	**Remarks**
1	Allahabad (Ch. 1535)	8.759 Hectare Land	35 m berth & 300 WF	01 Pontoon Barge 01 Pontoon Gangway	Nil	To be stored on Pontoon and open space of IWAI's land 5000 Sq. m	Pucca Rasta (Concreted road)500 m and metalled road 2 kmconnected with NH 76	01 no. armed 01 no.unarmed	Drinking Water facility available	Generator could be provided for lighting if required
2	Ramnagar (Varanasi) (Ch. 1315)	5.586 Hectare Land	35 m berth & 300 WF	01 Pontoon Barge 01 Pontoon Gangway	Nil	To be stored on Pontoon and open space of IWAI's land 2000 Sq. m	Land acquisition in process for approach road of about 700m connecting with NH 07	01 no. armed 01 no. unarmed	-	Being developed under Jal Marg Vikas Project
3	Ghazipur (Ch. 1177 Km) / Rajghat (Varanasi)	-	35 m berth	01 Pontoon Barge 01 Pontoon Gangway	Nil	To be stored on Pontoon. Private land could be made available if required	Kachcha Rasta(Earthen Road) 100m and Pucca road 100 m connected with NH 19	-	Drinking Water facility available	Generator could be provided for lighting if required
4	Buxar (Ch. 1124 Km)	-	35 m berth	01 Pontoon Barge 01 Pontoon Gangway	Nil	To be stored on Pontoon. Private land could be made available if required	KachchaRasta100m and Pucca road 400 m connected with NH 84	-	Drinking Water facility available and Street Lights available as provided by Local Administration	
4	Semaria (Ch. 850 Km)	-	35 m berth	01 Pontoon Barge 01 Pontoon Gangway	Crane on Pontoon available	To be stored on Pontoon. Private land could be made available if required	Kachcha Rasta 200m and Pucca road 300 m connected with NH 31	-	Drinking Water facility available	
5	Munger (Ch.793Km.)	3.40 Acre Land	35 m berth	01 Pontoon Barge 01 Pontoon Gangway	Nil	To be stored on Pontoon and open space of IWAI's land 1000 Sq. m	Pucca Rasta 100 m and metalled road 5 km connected with NH 80	01 no. armed 01 no. unarmed	Drinking Water facility available and Street Lights available provided by Local Administration	Generator could be provided for lighting whenever required
6	Bhagalpur (Ch715Km.)	3.86 Acre Land	35 m berth	01 Pontoon Barge 01 Pontoon Gangway	Nil	To be stored on Pontoon and open space of IWAI's land 1000 Sq. m	Pucca Rasta 300 m and metalled road 2 km connected with NH 80	01 no. armed 02 nos unarmed	Drinking Water Sodium Vapour Lamps (Full Illumination)	DGPS Station is operational and being utilized since 2010.

7	Bateshwarsthan (Ch. 683Km.)	-	35 m berth	01 Pontoon Barge 01 Pontoon Gangway	Nil	To be stored on Pontoon.	Kachcha Rasta 200m and Pucca road 5km connected with NH 80	-	Drinking Water facility available	Generator could be provided for lighting whenever required
8	Samdaghat (Sahebganj) (Ch.617Km.)	-	35 m berth	01 Pontoon Barge 01 Pontoon Gangway	Crane on pontoon	To be stored on Pontoon. Private land could be made available if required	Kachcha Rasta300m and Pucca road 1km connected with NH 80	-	Drinking Water facility available	Generator could be provided for lighting whenever required
9	Manglahat (Rajmahal) (Ch. 588Km.)	-	35 m berth	01 Pontoon Barge 01 Pontoon Gangway	Nil	To be stored on Pontoon. Private land could be made available if required	Kachcha Rasta 100m and connected with NH 80	-	Drinking Water facility available	Generator could be provided for lighting whenever required
10	U/s Farakka (Ch. 545.0)	4800	35 m berth	01 Pontoon 01 Bamboo Gangway	NIL	To be stored on Pontoon & land of FBP	100 m	01 nos. armed 03 no. unarmed	Drinking Water Sodium Vapour Lamps	Land belongs to FBP being used by IWAI.
11	D/s Farakka (Ch. 542.0)	-	35 m berth	01 Pontoon 01 Bamboo Gangway	NIL	To be stored on Pontoon.	Along the road	NIL	Street Lights provided by Local Administration	Land not available pontoon placed on water front
12	Hazardwari (Ch. 439.0)	-	35 m berth	01 Pontoon 01 Bamboo Gangway	NIL	To be stored on Pontoon.	100 m	NIL	Street Lights provided by Local Administration	Land not available pontoon placed on water front
13	Katwa (Ch. 334.50)	-	35 m berth	01 Pontoon 01 Bamboo Gangway	NIL	To be stored on Pontoon.	1.5 km	NIL	NIL	Land not available pontoon placed on water front
14	Swaroopganj (Ch. 280)	2337	35 m berth	01 Pontoon 01 Bamboo Gangway	NIL	One Godown of size 4.5 x 5 m and Open space 290 m^2	500 m	01 nos. armed 03 no. unarmed	Drinking Water Sodium Vapour Lamps	Land taken from KoPT on lease basis
15	Shantipur (Ch. 241.0)	8000	35 m berth & 100 WF	01 Pontoon 06 Modular Pontoons Gangway	NIL	To be stored on Pontoon and open space of IWAI's land 2000 Sq. m	3 km	03 nos. unarmed	NIL	Land belongs to State Govt. of W.B. being used by IWAI.
16	Tribeni (Ch. 196.0)	-	35 m berth	01 Pontoon 01 Bamboo Gangway	NIL	To be stored on Pontoon	Along the road	01 nos. armed 02 no. unarmed	NIL	Land not available pontoon placed on water front
17	BISN Jetty & G.R. Jetty-1 (Ch. 135.0)	30409.64	70 m berth & 100 WF	03 Pontoons 01 Steel Gangway	NIL	Open Space area 6000 m^2	1 km	01 nos. armed 03 no. unarmed	Sodium Vapour Lamps (Full Illumination)	Land taken from KoPT on lease basis
18	Botanical Garden Jetty (Ch. 134.5)	996	35 m berth & 50 m WF	01 Pontoon 01 Steel Gangway	NIL	To be stored on Pontoon	150 m	03 nos. unarmed	Sodium Vapour Lamps (Full Illumination)	Land belongs to KoPT being used by IWAI.
19	Haldia (Ch. 35.0)	10930	70 m berth & 200 m WF	04 Pontoons 01 Gangway	NIL	One Godown of size 12 x 30 m and Open space 1630 m^2	3.5 km via HDC	01 nos. armed 03 no. unarmed	Drinking Water Sodium Vapour Lamps	Land taken from Haldia Dock Complex (HDC) on lease basis.
B. Fixed RCC Jetties										

Sl No	Name of terminal with chainage (In km)	Land area (in Sq. m)	Size of berth, water front (In mtr.)	No of Pontoon Barge & Gangway	Cargo Handling equipment	Storage area	Link approach road	Security	Water/ Lighting facility	Remarks
1	G.R.Jetty-2 (Ch. 134.5)	14,557	70 m berth	-	-	One Transit shed of size 25 x 46 m and Open space 4000 m^2	500 m.	01 nos. armed 03 no. unarmed	Drinking Water Sodium Vapour Lamps (Full Illumination)	Land taken from KoPT on long term lease basis. RCC Jetty completed and being operational since Nov., 2013.
2	Farakka RCC Jetty (Ch. 542 km)	-	115 m berth	-	-	-	Along the road	-	Drinking Water Sodium Vapour Lamps	Owned by FBP this can be used by the common users.
3	Pakur RCC Jetty (Ch. 522 km)	-	60 m berth	-	-	-	1 km	-	-	Owned by FBP this can be used by the common users.
4	Patna (Gaighat) (Ch. 955Km.)	2.93 Acre	46.0 m berth 100 m WF	Nil	Shore Crane-2 with capacity of 01 - 20 tonnes subject to radius	45m x 14m Transit shed and open space of IWAI's land 1000 Sq. m	Pucca Rasta 500 m and metalled road 2 km connected with NH 30	01 no. armed 03 no.unarmed	Drinking Water Sodium Vapour Lamps (Full Illumination)	Permanent High level Jetty and DGPS Station is operational and being utilised since 2012.

(Source: Howe Engineering -Detailed Feasibility Report)

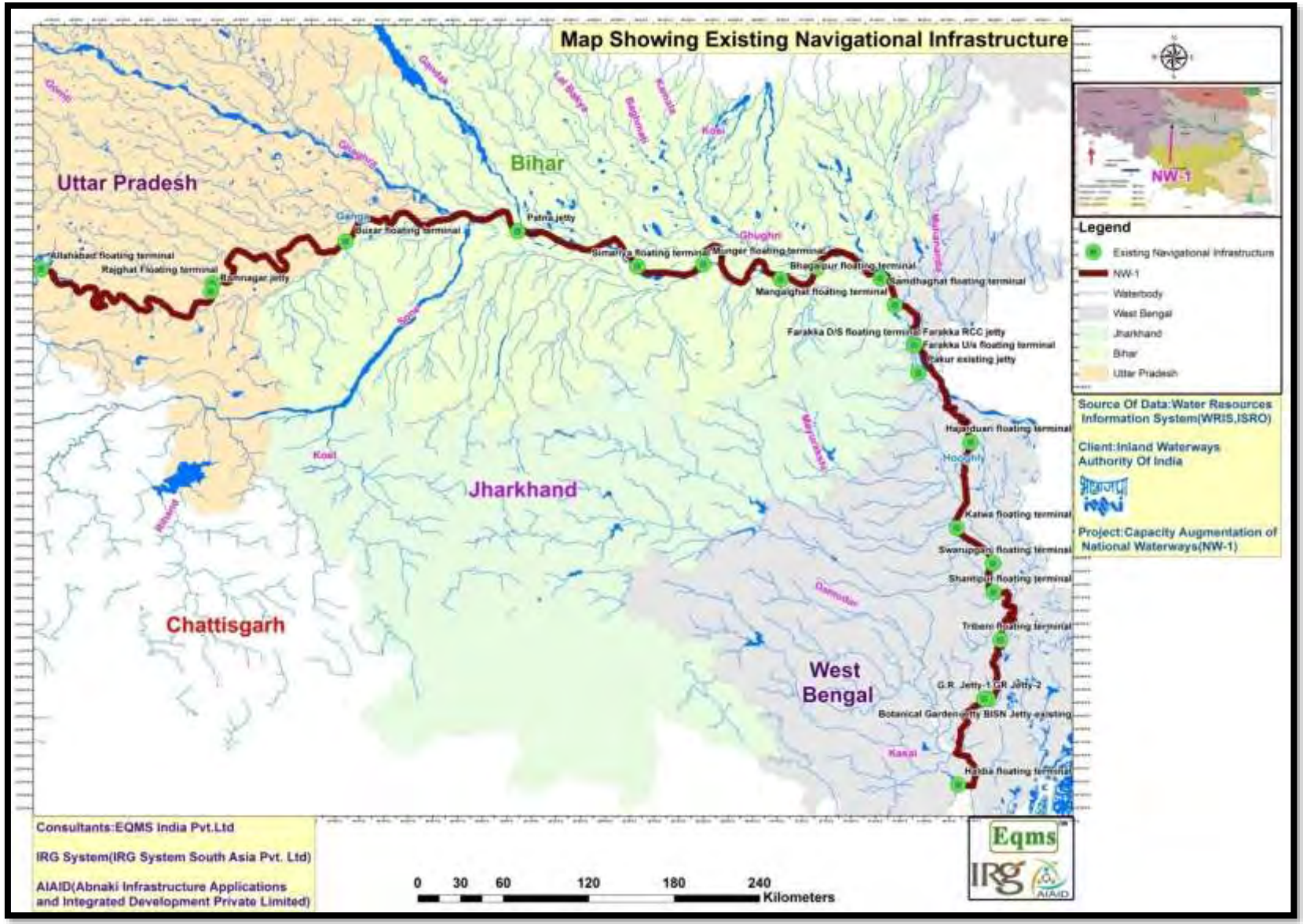


Figure 3.13 : Existing Navigation Infrastructure Facilities in NW-1

	
Mangal Haat, Jhakhand	Pakur Jetty
	
Farakka Lock	Existing Patna Terminal

Figure 3.14 : Photographs of Existing Infrastructure along NW-1

3.15.2.2 Planned/Proposed Infrastructure on NW-1 under Jal Marg Vikas Project

Jal Marg Vikas project involves development of various components for capacity augmentation of NW-1. Some of these components are already planned and being implemented, some are at initial stage of planning and some are yet to be planned. Details of all such components is given below

Planned Infrastructure

1. Terminal sites at Haldia, Sahibganj & Varanasi
2. New Lock at Farakka
3. Bank Protection and River Training Works at existing and planned civil interventions
4. Maintenance dredging for maintenance of waterways and proposed civil interventions/navigation infrastructure

Infrastructure Facilities at Initial Planning Stage

1. Terminals at Ghazipur and Tribeni (Kalyani)

Facilities yet to be planned

1. One similar terminal site
2. 10 Nos. Ro-Ro Jetty and Passenger Ferry Jetties
3. Development of low draught cargo
4. River Training Works at Critical Locations like bends and civil interventions under planning
5. Bank/slope & scour protection works

6. Equipment of tow barges, inland vessels, survey vessels including rescue boats and survey equipment
7. Barge maintenance and repair facility

Location of existing and proposed navigation infrastructure facilities for NW-1 under Jal Marg Vikas Project are shown at **Figure 3.15.**

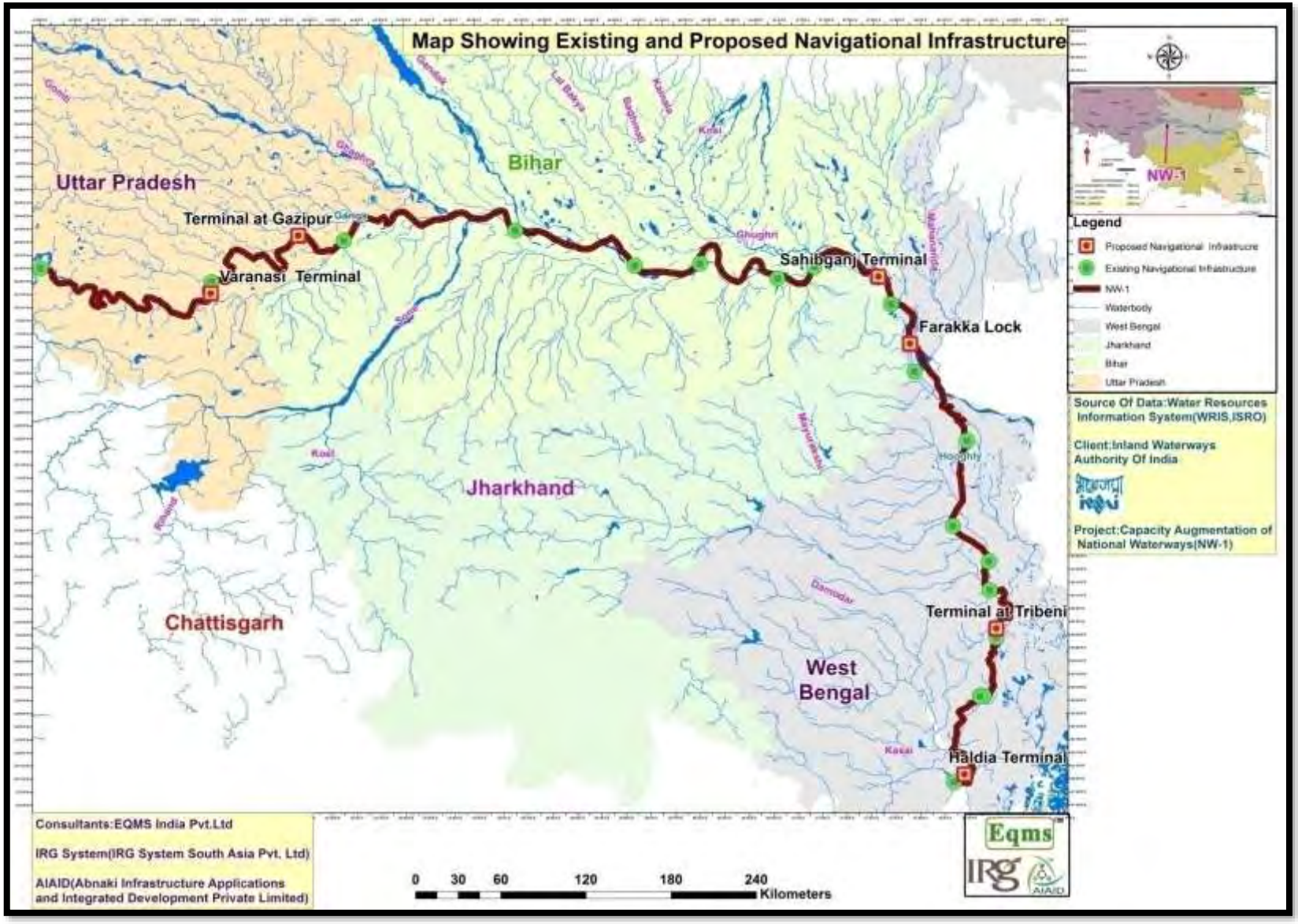


Figure 3.15 : Planned Navigation Infrastructure Facilities in NW-1 Under Jal Marg Vikas project

3.15.2.2.1 Terminal at Haldia

Haldia inland water terminal at River Hooghly (NW-1) is proposed to be located at River Hooghly at Industrial Zone of Haldia dock Complex near Durga Chak (J.L. No-135, Barmurchak-138 & Jagat Chak J.L. No-140), Haldia, District Purbi Medinipur, West Bengal. River Hooghly flows in South direction of the terminal site. Map showing location of Terminal at Haldia is given in **Figure 3.16.**

Figure 3.16 : Location Map of Haldia Terminal

Total area of terminal site is 61.0 acres. The identified land belongs to Haldia Dock Complex. Site is low lying area with elevation ranging from 4-9 m amsl. Photographs of the site are given in **Figure 3.17**. It is required to fill the site to achieve finished level of 7 m, i.e. 2.54 m above HFL. Soil required for filling is 3.3 lakhs cum. At present site is well connected with 7 m wide paved road (Haldia-Macheda Road) connecting the site with NH-41 as well as Haldia town. The NH-41 (Haldia-Kolaghat road) is located towards west direction at about 6.0 km from the site.

Figure 3.17 : Photographs of Haldia Terminal Site

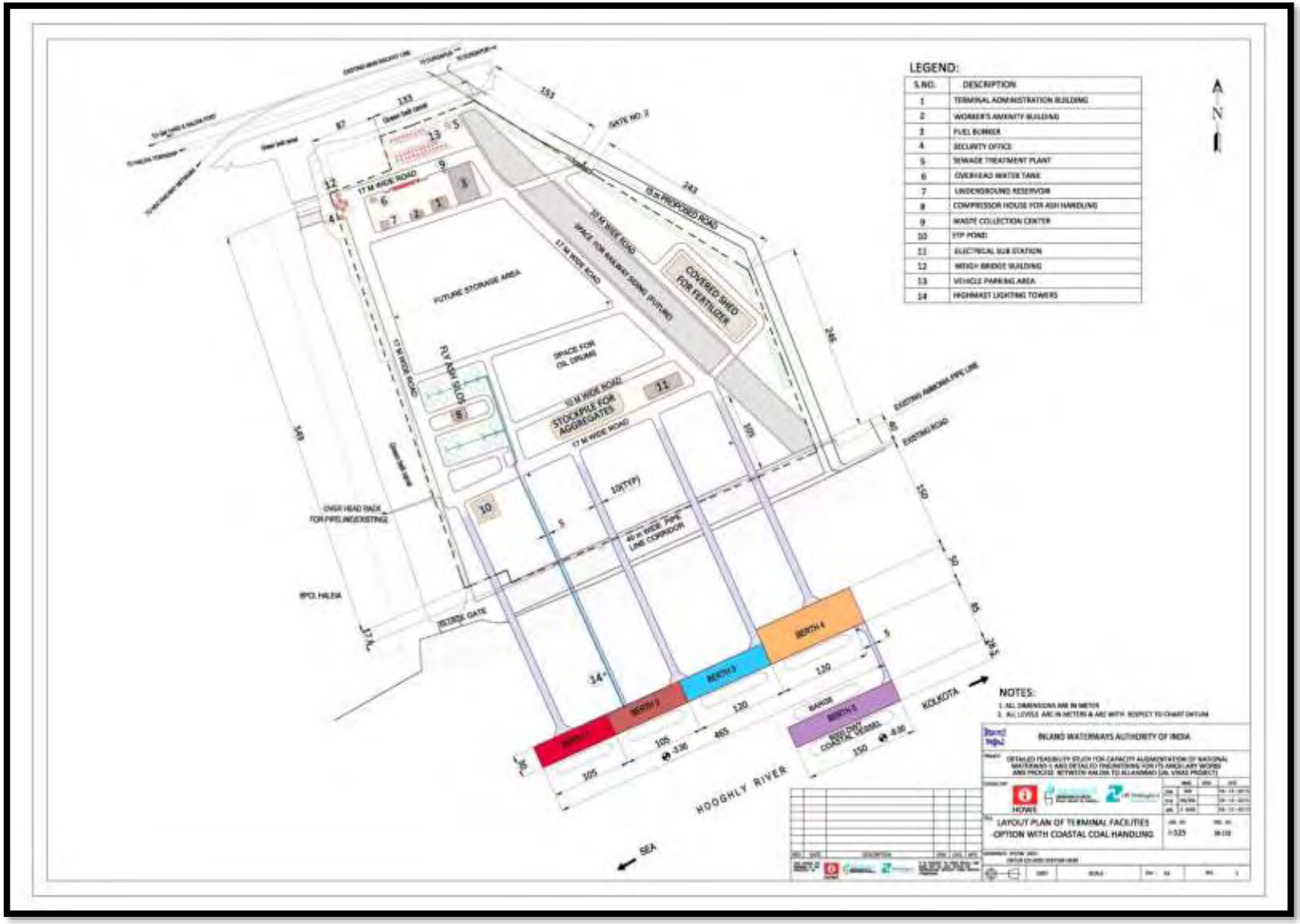
Terminal facility is designed to handle 4.07 MTPA of cargo. Out of 4.07 MTPA of cargo, 1.57 MTPA of cargo comprises of fly ash, fertilizer, stone aggregate, edible oil & POL. These materials will be stored, loaded, unloaded and transported from the terminal site. In addition to this transhipment of 2.5 MTPA of coal is involved. It is proposed to develop administrative building, worker's amenity building, fuel bunkers, security office, overhead water tank, STP, underground water reservoir, compressor house for ash handing etc. The proposed terminal project will be developed in phases, i.e. phase 1A & 1 B. Phase 1 A will comprises of all the proposed developments except berth proposed for transhipment of coal and 8 nos. of fly ash storage silos and its conveyors out of proposed 16 nos. of silos and stockyard development area (future storage). Salient features of the project are given at **Table 3.29** and layout plan of the terminal site at Haldia is given in **Figure 3.18.**

Table 3.29 : Salient Features of the Haldia Terminal

S. No.	Salient Feature	Capacity/Quantity/Nos.
1.	Location	Haldia Industrial Complex area, Haldia, District Purbi Medinipur, West Bengal.
2.	Geographical Coordinates	22°03'38.34"N & 88°08'29.49"E
3.	Capacity of Cargo Handling	4.07 million MTPA 1.57 MTPA for Stone aggregates, fertilizers, Fly ash and edible oil & POL and 2.5 MTPA for coal transhipment
4.	Connectivity	Site connected to NH-41 through 7 m wide road along western boundary of site. Nearest railway station is Durgachak Railway Station at 600 m in NE direction. Railway connectivity is not proposed.
5.	Topography of terminal site	Site is almost flat in topography and elevation ranges of 4-9 m amsl. Site requires levelling and filling (3.3 lakhs cum) to achieve finished level of 7 m
6.	Facilities Proposed for HaldiaTerminal (Phase 1A & 1 B)	• Storage sheds (future storage area will be developed in phase 1B) • 8 Nos. of Silos in phase 1A & 8 nos. of silos in phase 1B for flyash storage and pipeline conveyor system • Unloading & Loading Areas • Internal Roads • Berths (5 Nos.) (berth for coal transhipment in phase 1 B) • Water area & approach channel • Administration Building • Workers Amenity Building • Fuel bunker • Security office • Weigh bridge building • Lighting Towers • Railway siding (future development) • Other associated facilities like sewerage system, STP, dump pond, drainage system, RWH pond, fire-fighting facilities, communication system, water supply, ESS & power supply.
7.	Facilities to be shifted	Existing underground ammonia pipeline of Tata chemicals further towards the bank (above ground) and Existing Road to Mitsubishi Plant in South to Eastern Boundary of the site
8.	Shore Protection Works	The existing river bank protection works is adequate
9.	LAD (Least Available Draft)	3 m for barge vessels (4 nos. berths) and 8 m for large vessel (coal transhipment berth)
10.	Extension of Off-shore structure in River	Offshore structure | Extension of off-shore | Length of approach trestle | Length of Berth | Width of Berth

			structure (berth + approach trestle) inside the river	inside river		
		2 Nos of berths for barges	200	170	30	105
		1 Nos of berths for barges	200	170	30	120
		1 No of berth for barges/Berth No. 4	200	150	50	120
		1 No of berth for coal transhipment attached to Berth No. 4	313.5	85 + 50 m (length of berth no. 4)	28.5	150
		* length of 4 nos. approach trestle at terminal site is 145 m				
11.	HFL of the River	4.46 m amsl				
12.	Finished level of site	7 m				
13.	Top level of berth & approach trestle	14 m				
14.	Dredging During Construction Phase	7 lakhs cum				
15.	Material Transportation System	Trucks, Pay loaders, Barge loaders, mobile harbour cranes &gantry cranes. Flyash will be transported by trucks and loaded to the silos pneumatically by pumps and then it will be loaded to barge by pipe conveyor system. 16 Nos. silos of 1200 Tonne capacity will be provided for ash storage				
16.	Maintenance Dredging during operation phase	8.5 lakhs cum/year				
17.	Water Requirement-construction phase	90 KLD				
18.	Water Requirement-operation phase	70 KLD 20 KLD-Raw water requirement and 50 KLD potable water requirement				
19.	Power Requirement	Connected load-5500 KW Demand Load-2400 KW				
20.	Storm Water System	Open Storm water drains of total length 6 km Stock yard, parking area & roads –dump pond Buildings- Rain water storage sump				
21.	STP Capacity-Operation Phase	30 KLD				
22.	Dust Suppression Methods	Fly Ash-Dust extraction system on top of silos Aggregate & fertilizers stockyards- Swivelling plain water sprinklers for abatement of aggregate dust generation along the length of the stockpile.				

Source: Site visit &HOWE Engineering Projects (India) Pvt. Ltd. (Design Consultant) India



Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 3.18 : Layout of Haldia Terminal Site

3.15.2.2.2 Terminal at Sahibganj

Sahibganj terminal will be developed along River Ganga, Village Samdha Nala & Rampura, Tehsil & District Sahibganj, Jharkhand. Map showing location of Terminal at Sahibganj is given in **Figure 3.19.**

Figure 3.19 : Location Map of Sahibganj Terminal Site

The total land required for the proposed project is estimated to be 78.91 ha (195 acres) including land for rail and road connectivity, land for resettlement colony and the construction of an ROB. Total estimated land for phase I is approximately 18 ha. Land is currently under residential and agricultural use, orchards (mango trees) and settlements. Land is undulating with level variation of 30-56 m amsl. Photographs of the site are given in **Figure 3.20**. At present site is not connected with any paved road. Nearest highway to the site is NH-80 (Sahibganj-Rajmahal road) located at 1.0 km from site in Southern direction. PWD is to construct a road to connect the terminal site with NH-80.

Figure 3.20 : Photographs of Sahibganj Terminal Site

Terminal will be developed in phases. Phase 1 of terminal is designed for handling cargo of 2.24 million MT per annum. Ultimate cargo handling from the terminal is estimated to be 9.00 million MT per annum. Salient features of project are given at **Table 3.30** and layout plan of the terminal site at Sahibganj for phase I is given in **Figure 3.21** below.

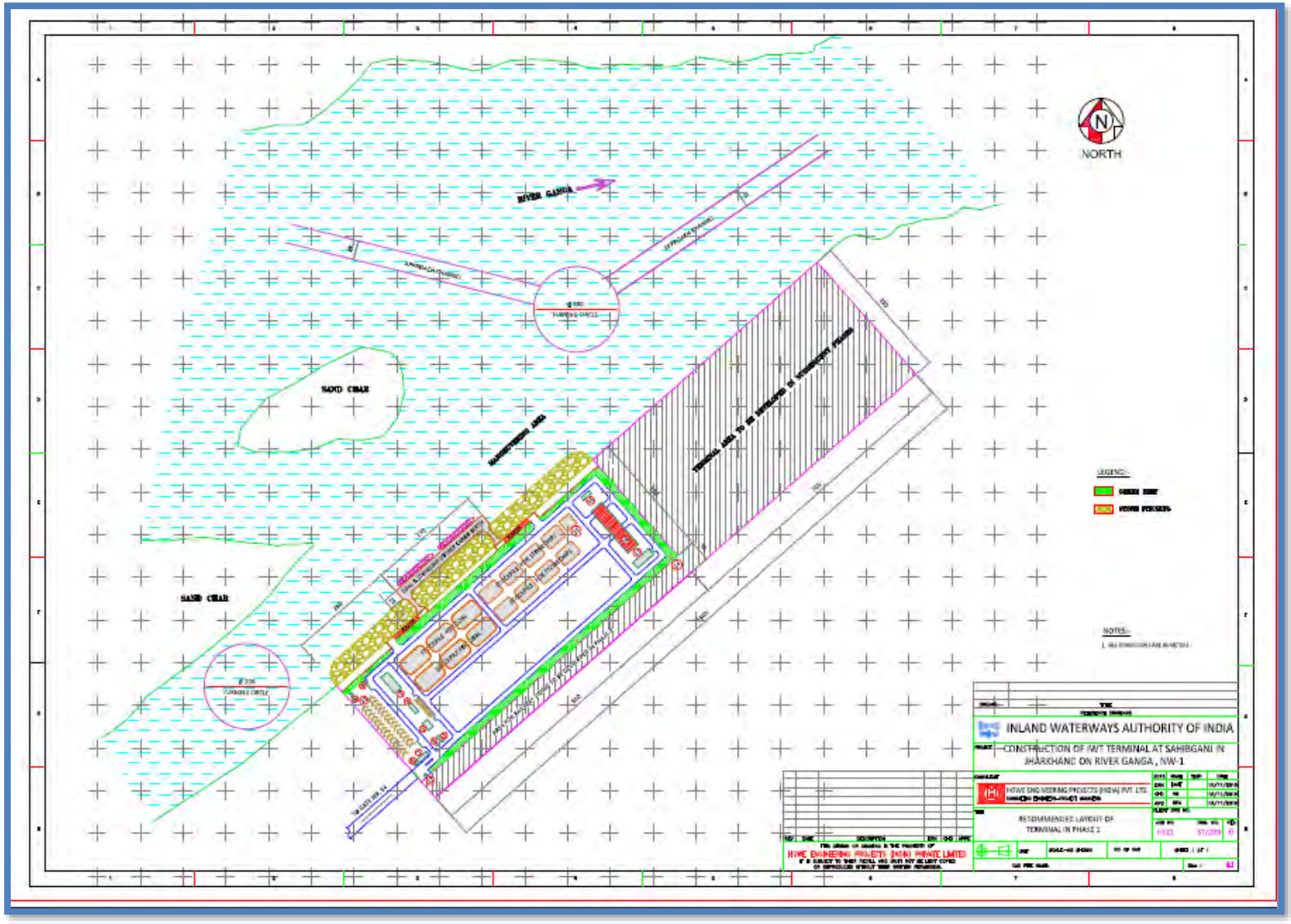
Table 3.30 : Salient Features of the Sahibganj Terminal

S. No.	Salient Feature	Capacity/Quantity/Nos.
1.	Location	River Ganga, Village Samdha Nala & Rampura, Tehsil & District Sahibganj, Jharkhand
2.	Geographical coordinates	25°15'0.73"N & 25°15'0.73"N
3.	Cargo Handling Capacity	Phase I-2.24 million MTPA Phase II-4.39 million MTPA Phase III-9.00 million MTPA
4.	Nature of Cargo to be	Coal, stone chips, food grains, cement, fertilizers &

	handled	sugar
5.	Connectivity	Approach road to be constructed by PWD to connect to NH-80 and Railway connectivity to be developed to link the existing railway line Nearest Railway Station: Sakrigali Railway Station (1.1 km, S) & Sahibganj Railway Station (6 km, W) Nearest Airport: Patna Airport (270 km, NW) Ferry Service: Sahibganj Ghat to Manihari Ghat
6.	Topography of terminal site	Undulating with level variation of 30 m-56 m
7.	On-shore Facilities Proposed for Phase I	• Stockyard for coal (6 stock piles-1.12 ha), for stone chips (8 stock piles-0.875 ha) & 1 covered shed (0.416 ha) • Unloading & Loading Areas • Internal Roads (12 m wide & 3.6 km length) • Administration Building • Workers Amenity Building • Lighting Towers • Other associated facilities like sewerage system, STP, drainage system, fire-fighting facilities, communication system, water supply & power supply (ESS) • Boundary wall of 2.4 m high • Green belt- 15-20 m (2.9 ha) To be developed by PWD/Railways: • Approach Road (1 km connecting to NH-80 crossing LC-54) • Railway Connectivity (through Sagrakali Railway Station) with provision of ROB over LC-54 for approach road to be developed
8.	Off-shore Facilities Proposed for Phase I	• Jetty (1 No.) & Berth (2 Nos.) • Water area & approach channel • Turning Circle (2 Nos. at starting & end of channel) • Shore protection (1.5 km along River Bank, 800 m in Phase I & 700 m in phase II)
9.	Extension of Off-shore structure (jetty & Berths) in River	75 m (50 m-approach trestle & 25 m jetty) length & 270 m width.
10.	Shore Protection Works	Retaining wall and stone pitching (30-50 kg) along the length of bank (1.5 km total, 800 m in phase I & 700 m in phase II) and 40 m apron inside the River.
11.	LAD	1-2.5 m near shoreline 7-11 m at distance of 50 m
12.	Water level fluctuation of River near Terminal Site	10 m
13.	HFL of Site	30.91 m amsl
14.	Finished Level of Site	37 m amsl
15.	Top level of Berth & Jetty	33.5 m
16.	Earthwork Phase I	Cut: 14.25 lakhs cum Fill: 2.15 lakhs cum Muck for disposal: 12.1 lakhs cum
17.	Dredging During Construction Phase	1.5 lakhs cum
18.	Material Transportation System	In Phase-1 of terminal, it is proposed to provide hopper at the coal and stone chips stockyard and the cargo shall be carried through conveyor system to the berth where it shall be discharged to the vessels through barge loader

19.	Maintenance Dredging during operation phase	30,000 cum in lean season
20.	River Water Requirement for dust suppression and horticulture	Phase 1: 162 KLD Phase II: 210 KLD Phase III: 350 KLD
21.	Municipal supply water for domestic purpose (staff & vessels)	Phase 1: 46.5 KLD Phase II: 65 KLD Phase III: 90 KLD
22.	Power Requirement	Phase 1: 588 KW Phase II: 2535 KW Phase III: 1897 KW
23.	Storm Water System	Storm water drain of length 3.05 km Stock yard, parking area & roads –dump pond Buildings- Rain water storage sump
24.	Sewage Generation & STP	Phase 1: 30 KLD Phase II: 36 KLD Phase III: 40 KLD STP: 40 KLD capacity
25.	Dust Suppression Methods	**Barge Loaders-** Plain water fine spray with medium pressure standard hydraulic system using raw water **Coal Stock Yard-**Swivelling plain water sprinklers for abatement of coal dust generation along the length of the stockpile.
26.	Vehicle Parking Area	1 ha
27.	Solid Waste Generation & management	Solid waste to be generated from terminal facility will include majorly the food waste and the garden waste. This waste can be disposed through the local agency in the area responsible for waste handling. Dustbins shall be provided at the site for collection of the waste. Used oils from DG sets/transformers/pumps etc. may also generate at the site. Used/Waste oil will be stored in HDPE containers at the site in isolated location and will be sold to authorized vendors

Source: Site visit &HOWE Engineering Projects (India) Pvt. Ltd. (Design Consultant) India



Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 3.21 : Layout of Sahibganj Terminal Site

3.15.2.2.3 Terminal at Varanasi(Ramnagar)

A multimodal terminal is proposed to be developed at Ramnagar, on river Ganga in Varanasi district in Uttar Pradesh. Map showing location of Terminal at Varanasi is given in **Figure 3.22**

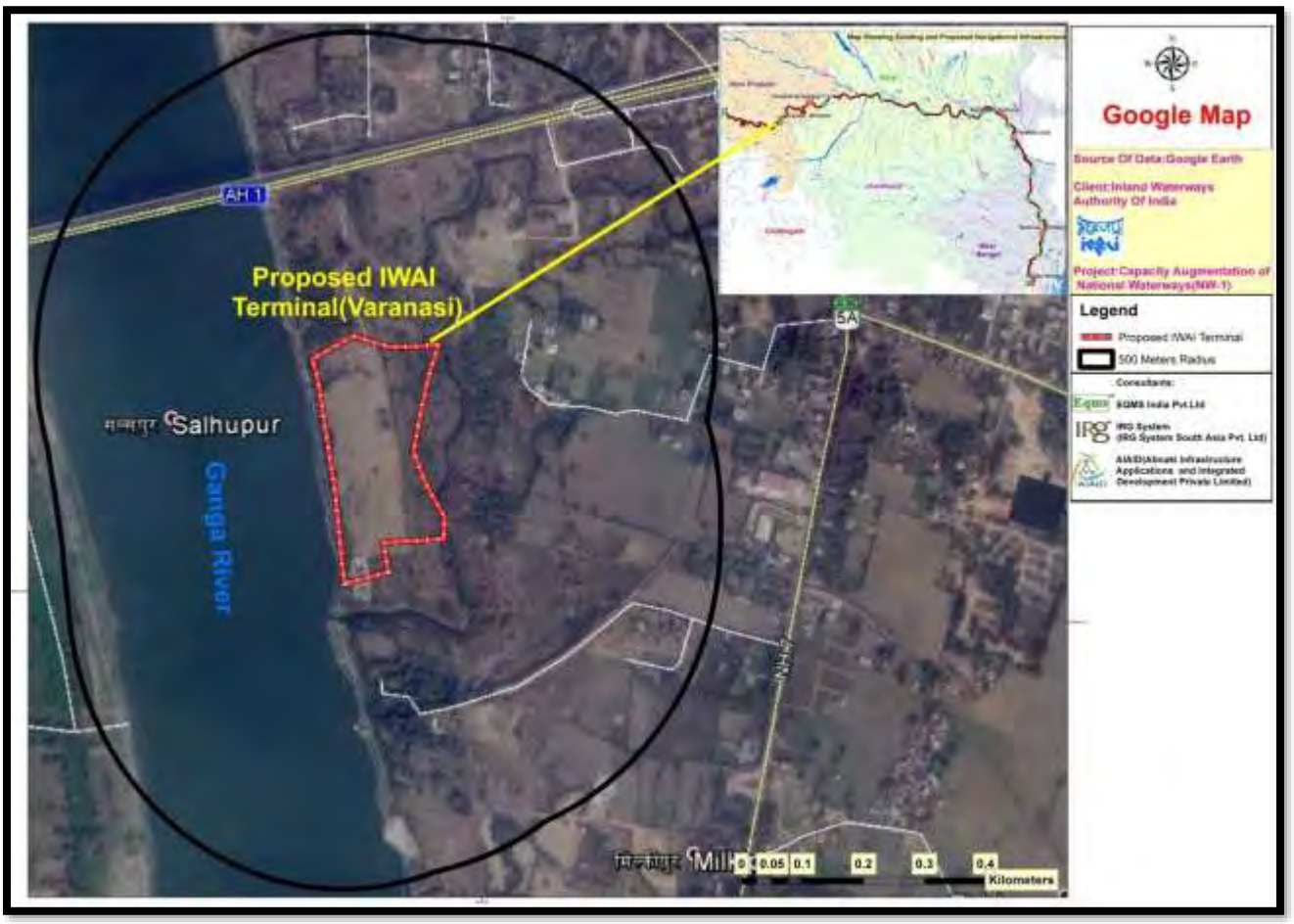


Figure 3.22 : Location of Varanasi Terminal Site

Area of 5.586 ha has been acquired for development of the terminal by IWAI. Identified site is open agricultural land. However, no agriculture activity is being carried out at site at present. The proposed terminal project site falls in Ramnagar Municipal Board of Varanasi district. Photographs of the Varanasi terminal site are given in **Figure 3.23**

Figure 3.23 : Photographs of Varanasi Terminal Site

Terminal will be developed in phases and at present phase 1A of terminal is designed. In phase 1 A, terminal shall handle about 0.54 MT per year which is expected to grow to 1.22 MTPA by 2038.Salient features of the development of phase 1A of the Varanasi terminal are listed in **Table 3.31**and **l**ayout plan of the terminal site at Varanasi for phase I is given in **Figure 3.24** below.

Table 3.31 : Salient Features of Varanasi Terminal

S. No.	Salient Feature	Capacity/Quantity/Nos.
1.	**Location**	River Ganga, Ramnagar, Varanasi, U.P.
2.	**Project site Geographical Coordinates**	25°15'7.90"N & 83° 1'55.45"E
3.	**Project Area**	5.685 ha
4.	**Type of Land**	Private Agricultural Land (12 small Khajur (Date) trees and 8 babool shrubs) but no agricultural activity is being undertaken
5.	**Site Surroundings**	River Ganga (abuts site, West) Gurha Nallah (Abuts, East & South)
6.	**Accessibility & Connectivity**	No pucca public road to access site. Site accessible through katcha village road and it connects site to NH-7. Approach road of 700 m is planned to connect the site with NH-7 for which additional area of 0.592 ha will be acquired. Nearest Railway Station – Jeonathpur (4.0 km, SE) Nearest Airport - Lal Bahadur Shastri Airport (30 km, NW)
7.	**Facilities Proposed**	• 2 Nos. berths (100 m length & 36 m width each) so as 2 vessels of 80 m each can be berthed at one time. • 2 mobile cranes for loading & unloading • Open area at site for storage of transportation material (Edible oil tank storage area) • Passenger jetty (floating pontoons-20 m X 10 m) & gangway (1.2 m wide) • Stone pitching upstream & downstream river bank (35 m length downstream & 117 m length upstream) • Area for DGPS • 12 m wide internal roads-365 m & 22 m wide internal road-650 m • Approach road to NH-7 • ESS (400 sq m) building & power back-up • Soak pit & septic tanks-wastewater management system • Workers amenity building (30 sqm) • Water supply system

<table>
<tr><td></td><td></td><td>• Storm water drainage system
• Earthing & lighting protection system for all conducting materials
• Lighting system
• Green area</td></tr>
<tr><td>8.</td><td>Cargo to be handled</td><td>Coal (imported & domestic), cement, fertilizers, wheat & crude edible oil</td></tr>
<tr><td>9.</td><td>Plying vessel</td><td>
<table>
<tr><th>Multimodal jetty</th><th>DWT</th><th>LOA (m)</th><th>Beam (m)</th><th>Loaded Draft (m)</th></tr>
<tr><td>Maximum Ship Size</td><td>2000</td><td>80</td><td>11</td><td>3.5</td></tr>
<tr><td>Minimum Ship Size</td><td>200</td><td>18</td><td>5</td><td>1.0</td></tr>
</table>
</td></tr>
<tr><td>10.</td><td>LAD at jetty</td><td>+3.5 m</td></tr>
<tr><td>11.</td><td>Eco-sensitivity</td><td>Kashi Turtle Sanctuary at 2.3 km in North direction (downstream)

No national park, reserved/protected forest, reserves, zoological parks, migratory bird route, protected wetland under Ramsar convention etc. are present within the 10 km radius area</td></tr>
<tr><td>12.</td><td>Water Supply System</td><td>Municipal Corporation, Varanasi</td></tr>
<tr><td>13.</td><td>Power Requirement</td><td>State grid (Purvanchal Vidyut Vitran Nigam Ltd).</td></tr>
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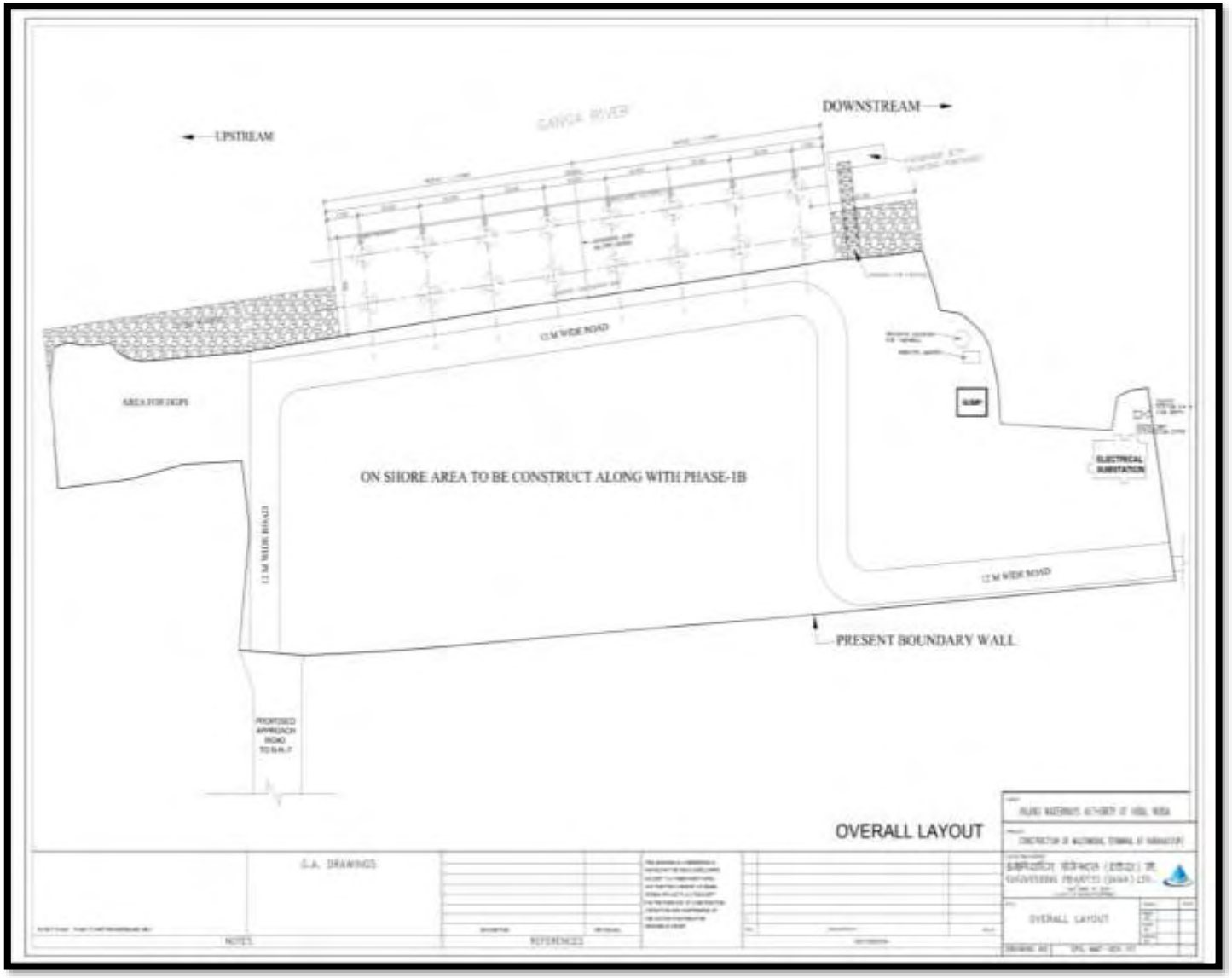


Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 3.24 : Layout of Varanasi Terminal Site

3.15.2.2.4 Lock at Farakka

A new lock is proposed to be developed in Farakka on the Feeder Canal of Farakka Barrage adjacent to the existing lock at Farakka in Murshidabad district of West Bengal. New lock will be further West to the existing lock and will share its right bank with the left bank of the existing lock. Site is located in village Goraipada, Grampanchayat Bewa, Farakka in Murshidabad district of West Bengal. The Ganga River is flowing about 1.2 km East of the proposed lock gate site. Map showing location of Lock at Farakka is given in **Figure 3.25**

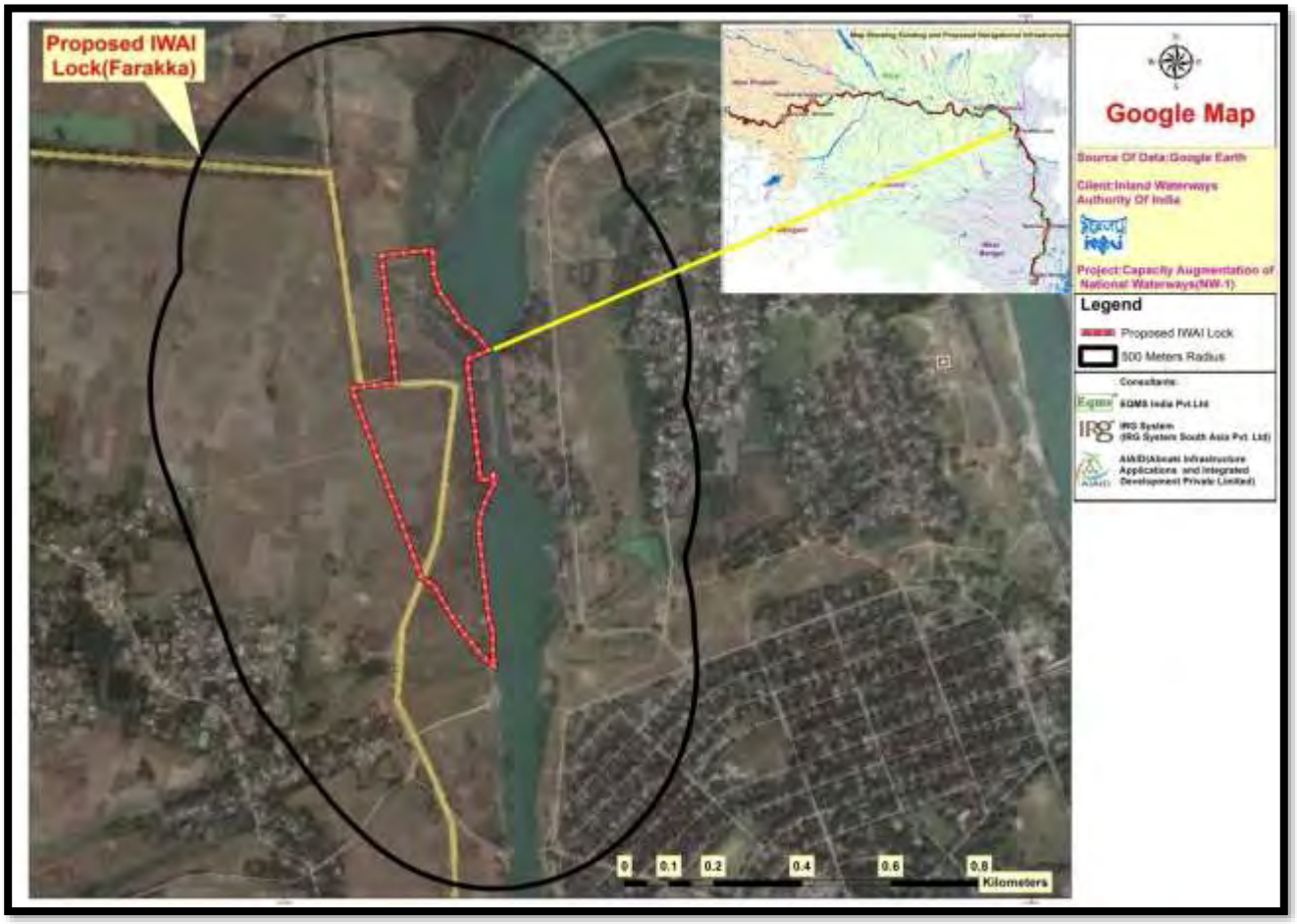


Figure 3.25 : Location Map of Farakka Lock

The proposed project would be set up in the 14.86 ha transferred land of Farakka Barrage Project (FBP) and the land revenue area demarked by Beoa Mouza`s,JL No. 31, Sheet No.3. As per the topographic survey carried out at site by IWAI, ground levels vary from RL+13 to RL+29 m which indicate the site is almost flat with gentle slope. The lock gate site is well connected with road & rail. This road at presently passes through the site and thus will be realigned to Western boundary of the proposed lock gate site. This road connects the NH-80 is located about 1.6 km West of the proposed Lock gate site and is connected. Photographs of the Varanasi terminal site are given in **Figure 3.26.**

Existing lock of Farakka is not working at optimal efficiency and it takes 2-3 hours to complete one operation there by reducing the possible nos. of ships which can cross through and ultimately the freight transportation efficiency. Renovation of the existing lock would keep the lock in non-operational condition for entire period, i.e. 6-31 months (WAPCOS, IWAI and FBP) thereby stopping the movement of barges/vessels in most of this period. Although this upper estimate could be reduced if parallel working is

assumed. To overcome this problem and to ensure uninterrupted and efficient movement of vessels/barges in NW-1, IWAI has proposed to construct a new lock at Farakka parallel to existing lock.

Figure 3.26 : Photographs of Farakka Lock Site

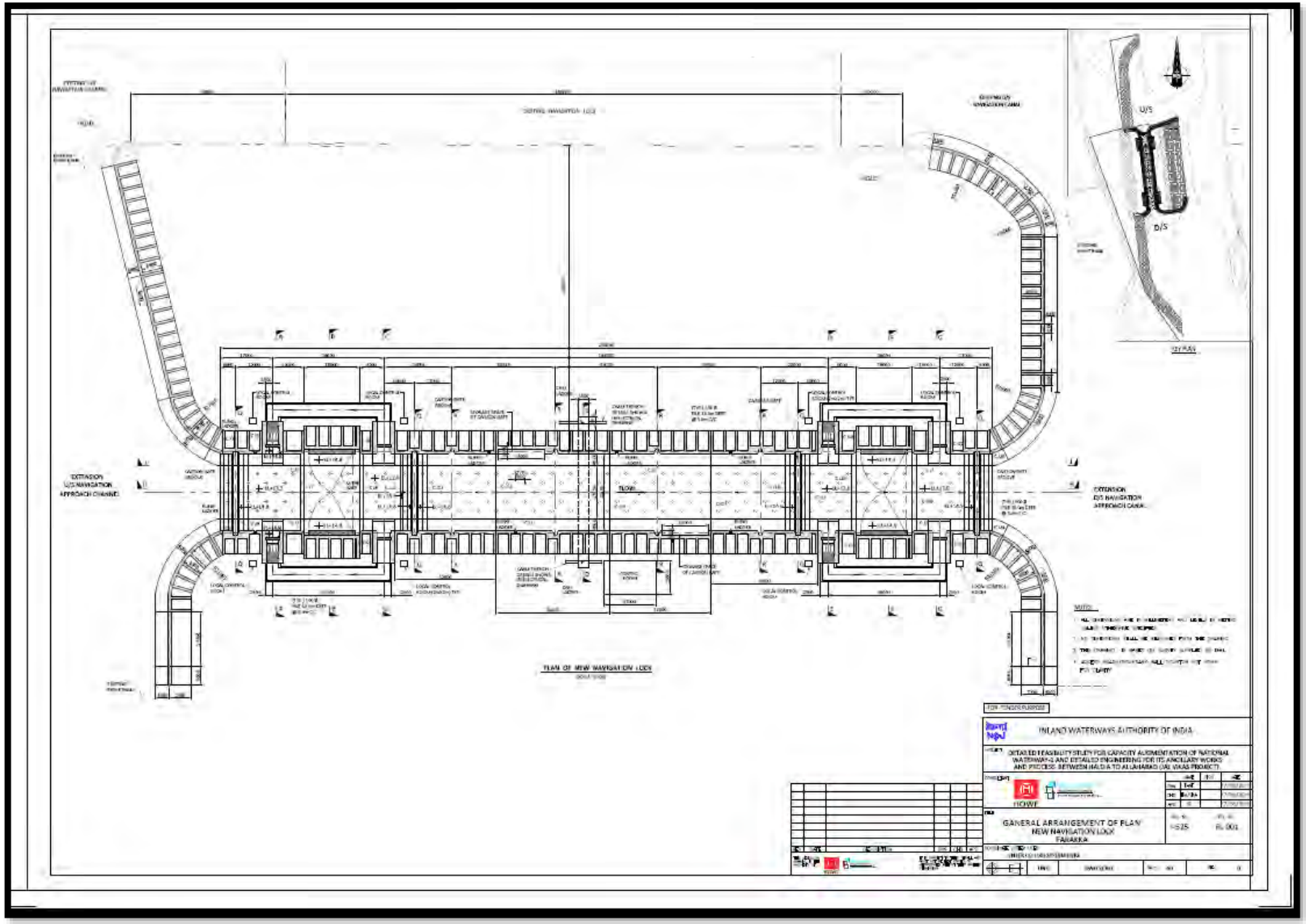
The new lock like the existing lock will facilitate the movement of vessels/barges from main River Ganga upstream to River Bhagirathi-Hooghly downstream through feeder canal negotiating the significant difference in water level existing in main River Ganga and feeder canal. Water level in the River Ganga and feeder canal varies according to the flow in River Ganga & the feeder canal. New lock is required as the existing lock is not functioning adequately and obstructs the movement of the vessels. The length and width (size) of the proposed lock is similar to the existing lock. Length & width of new lock will be 179.0 m & 25.148 m respectively. Lock is designed to handle four vessels of size 85 m (length) X 12 m, (width) so as two vessels are moored lengthwise and two sidewise like existing lock. The salient features of the existing lock site are given in **Table 3.32** and layout plan of the lock site at Farakka for phase I is given in **Figure 3.27.**

Table 3.32 : Salient Features of New Lock

S. No.	Parameters	Value
1	Location	Feeder Canal, village Goraipada, Grampanchayat Bewa, Farakka in Murshidabad district of West Bengal.
2	Geographical Coordinates	24°48'32.38"N to 24°49'02.23"N & 87°54' 05.63"E to 87°54' 17.18"E.
3	Land Required	14.86 ha
4	Topography	RL+13 to RL+29m
5	Finished Level of Site	28.44 m
6	High Water Level U/S High Water Level D/S	RL + 26.30 m RL +24.38 m
7	Length of Lock	179 m
8	Width of Lock	25.148 m
9	Av. Depth of Lock	13.10 m

10	Capacity of Lock to handle no. of vessels of size 85 m (length) X 12 m (width)	four vessels of size 85 m (length) X 12 m, (width) so as two vessels are moored lengthwise and two sidewise like existing lock
11	Seismic Risk Design Consideration	Site lies in Zone III and design is calculated as per IS:1893:2002
12	Length of extension of U/S Approach Channel (m)	190
13	Length of extension of D/S Approach Channel (m)	310
14	Dredging required in upstream and downstream of approach channel to achieve water depth of 3 m	0.05 + 0.08 = 0.13
15	Counter Fort Retaining wall • Top wall level • Bottom wall level • Slope	 28.44 m 12.8-14.8 m 1V:370 H
16	Slope of Excavation along River Bank	1.5 H :1 V
17	Inlet & Outlet water Structures	4 Nos. feeder culverts (2 U/s & 2 D/s) of length 60 m each.
18	Base Slab Thickness	1.2 m
19	Main Units other than the lock	• Mitre Gates- 2 sets (two leaves per set) • Radial Valve Gates- 4 sets (2 for U/S and 2 for D/S) • Mooring Bits (Floating)- 8 sets (4 sets per bank) • Caisson Gates/Stoplogs- 2 Nos (Used for U/S or D/S) • Bulkhead Gates- 4 sets (2 sets for U/S or D/S) • Control Rooms for remote control-1 each for U/S or D/S
20	Length of FBP Inspection Road to be realigned (m)	675
21	Length of Boundary Wall to be constructed (m)	1180
22	Scour Protection • River Bank Slopes U/s & D/s of approach channel • Guide wall	 2 layers of back pitching with PCC blocks of size 1 X 1 X 0.6 m and 6 m wide launching apron consisting of two layers of concrete blocks of size 1.5 X 1.5 X 0.9 m Tied to existing lock and cut-offs to a depth of 5 m
23	Flood Protection	Filling site to 28.44 m + RL, i.e. above HFL, strengthening of existing levees and banks to prevent erosion & flooding
24	Other facilities	Water supply system, soak pit & septic tanks, storm water drainage system, green belt (1 ha & 900 trees) and office building
25	Water Requirement	Construction Phase-16.5 KLD Operation Phase-6.5 KLD for domestic, 7.3 KLD for dust suppression & 2.7 KLD for horticulture
26	Power Requirement	557 KW
	Green Area	10000 m^2 (1000 m X 10 m). 900 trees to be planted

Source: HOWE Engineering Projects (India) Pvt. Ltd. (Design Consultant) India



Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Figure 3.27 : Layout of Farakka Lock Site

3.15.2.2.5 Bank Protection and River Training Works

Erosion of banks is natural phenomenon in the alluvial rivers. However, erosion is aggravated due to construction of any structure like bridge, terminal and jetty on the river. Thus river training works includes the engineering works carried out in river to prevent the erosion of the banks, control and guide the river. It is proposed to carry out bank protection works in the areas where civil interventions are planned to be carried out and details of the same are given at **Table 3.33**. Bank protection additionally also be carried out at other interventions yet to be finalised.

Table 3.33 : Bank Protection Works as per Current Planning

S. No.	Location	App. Length (km)
1.	Varanasi	0.35
2.	Sahibganj	1.1
3.	Farakka Navigation Lock	0.75
4.	Three new terminal	2.5
5.	Farakka Feeder Canal	39
6.	Barge Repair and maintenance facility	2
7.	Existing Terminals & Jetties	4.6

Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

Bends are navigational hazard which requires straitening. Crucial bends likely to be considered for straightening are Bend near Mirzapur, bend near Patauli & Agradwip, bend near Sanudragrah, bend near Chumariagacha, bend near Digibaraj and sharp bend just u/s of Farakka navigation lock. These task will be taken up after detailed study on a later date.

3.15.2.2.6 Terminal at Tribeni -Kalyani (Tentative Location)

It is planned to develop terminal at Tribeni. Planning is at initial stage and site selection & finalization is undergoing at present. Two locations are considered for development of terminal. First site is located on left bank of River Hoogly upstream of Road Bridge on SH-6 at Tribeni, west Bengal. Site is well connected with road & railways. Kalyani Samanta is nearest railway station. App. 40 ha of agricultural land is identified for development of terminal at this site. Some brick kilns also exist at the site. One more site is considered for development of the terminal. Site is located on the right bank of the River downstream of the road bridge at SH-6. This site is located near the thickly populated area. Out of both the options alternative 1, i.e. site located upstream if SH-6 is considered for development of terminal. Google map showing the site considered for development of terminal at Tribeni is given in **Figure 3.28.**

Figure 3.28 : Google Map Showing Proposed Terminal Site at Tribeni

3.15.2.2.7 Terminal at Ghazipur (Tentative Location)

It is planned to develop terminal at Ghazipur, U.P. Planning is at initial stage for this terminal. Site identification and alternative site analysis are undergoing at present. Two sites have been identified at present for development of project. Out of the two sites, preferable site is located at Village Chaukiya, Ghazipur. This site is located on left bank of River Ganga (main channel) and downstream of NH-97. The site is agricultural land with no development or facilities or settlements on it. Area of the site identified is app. 22 ha. Site is well connected with road & railway. Depth of the channel is more than 2.5 m close to the shoreline. However, approach road will be required to be constructed for connecting the terminal site to NH-19. Google map showing the site considered for development of terminal at Ghazipur is given in **Figure 3.29.**

Figure 3.29 : Google Map Showing Proposed Terminal Site at Ghazipur

3.15.2.2.8 Barge Maintenance & Repair Facility

Barge maintenance and repair facility is essential component of Jal Marg Vikas Project. At present no location has been finalized for the purpose but this development is under planning. Barge maintenance and repair facility will comprise of the following

- Slipway: It is a ramp, which helps in moving the barge/ship to and fro from water to land. Slipway will be provided in deeper water conditions so as design vessels can be taken in docking conditions.
- Winch House: It should be provided in straight-line to mail slipway. It is generally a single room like structure and should have adequate space for winch and electrical equipment
- Repair bay for large & small vessels: Repair bay for vessels should be inclined so as the vessels can slide towards the river on its own after repair under control of winch.
- Transfer bays: To transfer small vessels between slipway and repair bay
- Winches and trolleys. Winches should be provided at winch house and at transfer bay. Trolleys should be provided to receive the vessels on main slipway.
- Workshops and buildings with all basic utilities like water, electricity, storm water management system and waste management system.

3.16. Material Handling, Transportation and Storage

Material handling including transportation, storage, loading and unloading will be involved at terminals and jetty sites. Material handling at some planned site is manual, i.e. is through pay loaders, barge loaders, dumpers, trucks and at some sites is mechanical through

conveyor belts and pneumatically depending on type and quantum of cargo to be transported. Considering the environmental effect, it is strongly suggested to adopt mechanical mode of material handling only for loading & unloading of barges and pneumatic transportation of the fly ash to minimize dust generation.

3.17. Construction material Sourcing

Construction materials required majorly for the project development are bricks, steel, cement, timbers, sand etc. It is preferred that construction material will be sourced from nearby areas preferably. Details for construction material sourcing for the planned infrastructure under Jal Marg Vikas Project are given as a reference in **Table 3.34** below.

Table 3.34 : Construction Material Sourcing for already Planned Interventions

S. No.	Location	Construction Material Sourcing
1	Haldia Terminal	Stone chips- Pakur quarry in Jharkhand (370 km from site) Sand- Villages Kasthakbali and Barsundra (20 km) and Damodar River (100 km)
2	Farakka Lock	Stone and aggregates- Rajmahal hills (Sahibganj) at app.100 km from site
3	Sahibganj Terminal	Stone and aggregates- Rajmahal hills (Sahibganj) near the site
4	Varanasi Terminal	Stone and aggregates- Sirsa, Mirzapur at app. 45 km from site

3.18. Waste Disposal

It is likely that waste and sewage will be generated due to anticipated human activities at major intervention locations (terminal, locks & jetties). Details of waste generation and its management is given below

3.18.1. *Sewage & Effluent*

It is likely that sewage will be generated at the locations where interventions are proposed only. For management of sewage measures like provision of mobile toilet with anaerobic digester, provision of toilets with septic tank & soak pits are proposed during construction phase. It is proposed that soak pits should be provided in the locations away from river. During operation phase sewage should be managed by provision of well-developed sewage collection system and the collected sewage should be treated in STP (if sewage generation >5-10 KLD) and should be disposed in septic tank/soak pit if <5-10 KLD.

No vessels will be allowed to discharge its waste in river during navigation or berthing. Vessels should follow MARPOL guidelines for management of sewage.

3.18.2. *Solid Waste*

Solid waste will be generated due to project activities at the locations where interventions are expected majorly. Expected solid waste to be generated from the site is mainly municipal in nature. Some quantity of hazardous waste in form of used oil from operation of DG sets, cleaning operations etc. is expected to be generated from the intervention sites.

No vessels will be allowed to discharge its waste in river during navigation or berthing. Vessels should follow MARPOL guidelines for management of solid waste. No maintenance or repair work of ships/vessels and related facilities shall be undertaken at the proposed intervention sites. Site will be identified for development of workshops/maintenance hubs.

Adequate waste management system shall be designed for such sites for prevention of soil and water pollution.

3.19. Dust Suppression

Activities like vehicular movement, material loading, unloading from trucks, material loading and unloading from barge, storage of material etc. will generate the dust during the operation phase of the project. Materials like coal, fly ash, stone aggregates, stone chips, sand etc. are likely to generate more dust as compared to other commodities like fertilizers, oil, textiles etc. Adequate dust suppression measures shall be undertaken depending on the potential of dust generation. Dust suppression measures include development of green belt, provision of dust sprinklers, mechanical transportation system for loading/unloading of barges, pneumatically transportation of fly ash, and transportation of material in covered vehicles and storage of material under covered sheds. Such provisions are already incorporated under the planned navigation infrastructures (terminals at Varanasi, Sahibganj & Haldia) such as material loading/unloading through mechanical conveyor system at Sahibganj, provision of pneumatic transportation system at Haldia for fly ash, provision of water sprinklers, green belt and transportation of material in covered conditions in all the terminal sites. Similar provision will be made for remaining proposed facilities under planning stage.

3.20. Green Belt

Project development includes various intervention measures which will lead to change in land use, removal of vegetation etc. But the interventions are planned in a way so as to maintain the aesthetic value of the area by providing the adequate greens and also wherever tree cutting is associated necessary and additional compensatory plantation works are proposed. At all the proposed interventions, it will be ensured that adequate peripheral green belts and organized greens are provided. Details of the green area and trees proposed at the identified intervention locations are given in **Table 3.35** below.

Table 3.35 : Green Area and Tree Details for the Planned Intervention Sites

S. No.	Location	Green Area (Acres)	Nos. of trees
1	Haldia Terminal	3 acres (1.214 ha) 10 m wide tree belt all along the periphery and avenue tree plantation along roads	1200
2	Farakka Lock	2.47 acres (1 ha) 10 m wide tree belt all along the periphery and avenue tree plantation along roads	900
3	Sahibganj Terminal	7.166 acres (2.9 ha) 15-20 m wide tree belt all along the periphery and avenue tree plantation along roads	3500 (1000 as compensatory plantation & 2500 additional)

3.21. Accident Prevention

Associated hazards which may lead to accidents are fires, earthquakes, collision of vessels/barges/ships, floods, cyclones, spillage of material etc. These hazards are proposed to be managed by planning the proposed interventions considering these hazards. This planning will help in minimizing the chances of occurrence of accidents and impact of these hazards on developed infrastructure, human population and surroundings. Some of the stretches prone to the accident along the NW-1 are listed below

- **Haldia to Howrah:** Tidal section of Hugli estuary/river shared with ocean-going vessel traffic, that is subject at times to strong tidal conditions, strong seasonal winds and occasionally adverse wave conditions
- **Howrah to Nabadwip:** Tidal section of the Hugli river, shared with local commercial traffic. Subject to strong tidal conditions at times
- **Nabadwip to Jangipur:** Non-tidal section of natural river (Bhagirathi River). This section of the waterway is challenging to navigate due to sequences of sharp river bends.
- **Section of Farakka Feeder Canal Around Bagmari Syphon:** This siphon is significant navigation hazard

River information system developed and being developed by IWAI will help the vessels to judge the tides, tide level, meteorological condition, LAD, traffic and other vital information required for navigating safely and will help in prevention of accidents and collisions.

3.22. Project Cost

Overall cost of the Jal Marg Vikas Project will depend on finalization of various components proposed under the project. However, fund allotted by World Bank to GOI for development of Jal Marg Vikas is about 650 million USD (~4200 Cr). Tentative capital cost for each component planned or under planning stage of Jal Marg Vikas Project is given below in **Table 3.36** below. Cost considered for the terminals include land cost, development and cost of R & R (if applicable)

Table 3.36 : Component Wise Tentative Project Cost of Components (Planned & Under Planning) of Jal Marg Vikas Project

S. No.	Capital Cost	Project Cost-Phase-1 (in Millions INR)
1.	Varanasi Terminal	2567
2.	Sahibganj Terminal	5773
3.	Haldia Terminal	7496
4.	Terminal-4*(Tribeni Terminal)	4500
5.	Terminal-5*	4500
6.	Terminal-6* (Ghazipur terminal)	2500
7.	New Farakka Navigational Lock	3735
8.	Dredging	6844
9.	Shore Protection Work	10000
10.	River Training Works	500
11.	Vessel Management System	500
12.	Disaster Management System	1400
Total		50,315

Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)

**** Site yet to be finalized. Thus cost estimated is lump sum development cost***

3.23. Project Schedule

The NW-1 project activities will be developed in phases. The phase I development is likely to starting in mid-2016 and expected to be completed in 5years period by 2019. The project life is considered as 30 years. Time required for construction of the various planned infrastructure in Phase-I is given below in **Table 3.37** below.

Table 3.37 : Implementation Time for Planned Interventions under Jal Marg Vikas Project (Phase-1)

Component	Construction Time from Start (months)
Start	Mid 2016
Varanasi Terminal	26
Sahibganj Terminal	30
Haldia Terminal	30
Terminal-4* (Tribeni Terminal)	30
Terminal-5*	30
Terminal-6 * (Ghazipur terminal)	30
Farakka Navigation Lock	30
NW-1 Dredging	8
Shore Protection Works	18
River Training Works	24
Vessel Management System	12
Disaster Management System	12
Project Life Considered	30
End Date	Year 2045

Source: HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD. (DESIGN CONSULTANT)