PKS FLOODKON JV

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No. PFJV/FKNL/038 Date: 28/04/2023

To

The Project Director (JMVP)
Inland Waterways Authority of India,
A-13, Sector – 1,
Noida – 201301, India

Subject: Submission of vetted copy of Detailed Project Report (DPR) for the work of renovation/ modernization of existing navigation lock at Farakka.

Ref: Contract agreement dated 11.01.2022

Dear Sir,

Please find enclosed herewith the copy of the draft DPR for Preparation of Detailed Project Report (DPR) for the work of renovation/ modernization of existing navigation lock at Farakka.

This draft DPR has been duly vetted and proof checked by IIT Kharagpur and is being submitted for your kind perusal.

Yours Sincerely,

28/04/2023
(Mr. A K Bajaj)
Team Leader

Department of Civil Engineering
Indian Institute of Technology Kharagpur
West Bengal 721 302

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Date: 26.03.2023
IIT/CE/FKK-Con/2022-23/01

Dr Harinarayan Tiwari
Managing Director
M/S PKS Floodkon JV
4B, Mahalaxmi Square, 2nd Floor
Vasundhara, Ghaziabad
Uttar Pradesh - 201012

Kind attention: Dr. Subash Rai, M/s PKS Floodkon JV

Sub: Proof Checking and Vetting of Detailed Project Report for Renovation of Navigation Lock at Farakka

Work sanction order: PFJV/FKNL/WO/05 Dated 06/02/2023.

Sir,

With reference to the aforesaid work order, I am to state that all the observations pointed out by the undersigned have now been taken into account in the Draft DPR for the project. I consider the DPR to be thoroughly vetted by me and may be used for further official work, as required for the project.

Thank you.

Yours faithfully,

DSen

(Dhrubajyoti Sen)
Professor, Department of Civil Engineering

सत्यमेव जयते
Ministry of Shipping
Government of India

INLAND WATERWAYS AUTHORITY OF INDIA

भाअजप्रा
IWAI

CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION/MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

Checked and vetted

Draft DPR

D J Sen 26 April 2023
(Dhrubajyoti Sen)
Professor, Department of Civil Engineering
Indian Institute of Technology Kharagpur

April 2023

Submitted By:
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DOCUMENT/REPORT CONTROL FORM

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ABBREVATIONS

AC	Air Conditioning
ADAS	Automatic Data Acquisition System
B/W	Between
BH	Bore Hole
BS	British Standard
C	Cohesion
CCTV	Closed Circuit Television
CD	Consolidated Drained Test
cm	Centimeter
CU	Consolidated Undrained Test
CWC	Central Water Commission
D	Disturbed Sample
D/S	Downstream
Dmax	Maximum Scour depth
Ds	Size of PCC Block
DS	Direct Shear Test
DWT	Dead Weight Tonnage
e	Eccentricity
EIA	Environmental Impact Assessment
EL	Elevation
EMP	Environmental Management & Monitoring Plan
EPC	Engineering Procurement Construction
FBP	Farakka Barrage Project
FOS	Factor of Safety
H	Horizontal
HFL	High Flood Level
Hz	Horizontal
IACS	International Association of Classification Societies
IRC	Indian Road Congress
IS	Indian Standard
IWAI	Inland Waterways Authority of India
IWT	Inland Water Transport
KN	Kilo Newton
kN/m^3	Kilo Newton per meter cube
KNm	Kilo Newton meter
Kpa	Kilo Pascal
kV	Kilovolts
kW	Kilowatt
Lab	Laboratory
LL	Liquid Limit
LWL	Low Water Level
m	Meter

m/s	Meter per Second
Max	Maximum
Min	Minimum
mm	Millimetre
MWL	Maximum Water level
Nos.	Numbers
NW-1	National Waterways 1
P	Standard Penetration Test
PCC	Plain Cement Concrete
PL	Plastic Limit
RCC	Reinforced Cement Concrete
SBC	Safe Bearing Capacity
SD	Scour Depth
S.F	Skin Friction
SQRT	Square root
T	Ton
U	Undisturbed sample
U/S	Upstream
UC	Unconfined Compression Test
UU	Unconsolidated Undrained Triaxial Test
V	Volts
WL	Water Level
X.C.G	X- Direction Centre of Gravity
Y.C.G	Y- Direction Centre of Gravity
α	Angle of earth face of wall with vertical
αh	Seismic Horizontal Coefficient
αv	Seismic Vertical Coefficient
δ	Angle of friction between wall and earth face
Φ	Angle of Repose
μ	Coefficient of friction

EXECUTIVE SUMMARY

1. INTRODUCTION

The Ganga Bhagirathi Hooghly River system from Haldia to Allahabad has been declared as National Waterway No. 1 in 1986 and since then various developmental activities on this waterway are under progress.

Inland Waterways Authority of India has appointed PKS FLOODKON JV through their letter of award for consultancy services bearing no. IWAI/NW-1/WB/AG/Study-Exist.Nav.Lock/2020-21/321 dated 08.12.2021 to undertake the study entitled "Preparation of Detailed Project Report (DPR) for the work of renovation / modernization of existing navigation lock at Farakka" under the Jal Marg Vikas Project (JMVP).

Since the commissioning of navigation lock in the year 1987, no major repairs of hydraulic and electro-mechanical components have been carried out. As a result, mitre gates, radial valve gates, bulkheads, floating caissons and other mechanical components including electro-mechanical operating system are in dilapidated condition. The navigation lock is an important part of NW-1 and renovation of the navigation lock will helps to achieve overall goals of JMVP and improve the navigability of NW-1 through: (i) fairway development by providing an assured depth of 2.2m to 3.0m throughout the corridor for at least three hundred thirty (330) days in a year to make it navigable for comparatively larger vessels of 1,500-2,000 DWT and (ii) civil structures, logistics and communications interventions required that includes multimodal terminals, jetties, navigational locks, barrages, channel marking systems etc.

2. THE PROJECT AREA

The site is located at Farakka in Murshidabad district of West Bengal. The mean wind speed at the project site is found to be in the range of 1.38 to 2.60 m/s. The maximum temperature at site is 44^0C and minimum temperature at site is 6^oC.

Topographic survey for the lock site has been carried out. The ground levels at the site, broadly, vary from RL +13.00 to RL +29.00 m. The information on water levels U/S of the existing navigation lock has been extracted from the Operation / Maintenance Manual for the existing Lock and data supplied by the IWAI.

The highest flood level and the minimum water level U/S are 26.3m and 18.288m respectively. Similarly, water levels in the D/S channel vary between 24.38m and 18. 288m.

The geotechnical investigation report of the DPR of new navigation lock as well as the geotechnical investigation report prepared by the EPC contractor during execution of the new navigation lock has been considered. As the existing geotechnical reports of the new navigation lock are in the area lying in the immediate vicinity of the existing navigation lock on the opposite bank of the approach channel the past geotechnical investigation report has been considered in the design of foundations for casino gate parking bay of the existing navigation lock.

3. COMPONENT OF THE EXISTING NAVIGATION LOCK

Lock Chamber and Approach Structures

The lock chamber base slab and retaining walls is of reinforced concrete. The length of the lock is 250m and mitre to mitre length of lock is 179.8 m with the clear width between the two banks is 25.148m. The depth of the lock varies from 12.89m at U/S to 10.89m at D/S.

Filling Emptying System

The lock is filled using filling culverts running on either side of the upstream mitre gates, with inlets on each side of the lock head structure, and outlets in the walls inside the chamber and downstream of the upstream mitre gates. Similarly, the lock is emptied using emptying culverts running on either side of the downstream mitre gates, with inlets inside of the lock chamber on each side of the lock, and outlets in the walls outside the downstream mitre gates

Mitre Gate

In the existing navigation lock, there are two mitre gates. Mitre Gates is one at upstream and another at downstream of the lock to facilitate the opening and closing operation. Mitre gates are double leaf hinged type which is most commonly used.

Radial Gates

Four (4) Nos. Radial gates are there, 2 Nos. at U/Sand 2 Nos. at d/s, one each on both side of lock for filling and emptying of the lock chamber to facilitate navigation of inland water transport vessels.

Caisson gate

Two-no of caisson gate are to be used when mitre gates need servicing – maintenance/ repair/ replacement. There are a total of 5 grooves for installation of caisson gates with 2 grooves for each pair of mitre gate and one in the middle section of the lock.

Bulkhead gate

For repair of Radial gates, there are Eight (8) bulkhead gates one at inlet and one at outlet for all feeder culverts. There are four sets of bulkhead gates of three different lengths namely Type 'A', 'B' and 'C'

Mooring Arrangement

Conventional moorings systems viz. floating and fixed bollards have been used in the existing navigational lock. There are Bollards – eight (8) numbers floating type (four (4) on each bank) and fourteen (14) numbers fixed type (seven (7) on each bank).

Control room and wiring

Central control room is located on the east bank of the navigation lock and 4 local control room is located in the upstream and downstream of the existing lock. The local control rooms are located in the upstream and downstream of the existing lock with one each on left and right bank close to the mitre gate leafs. Electrical power of 400/440v is supplied from central control room to local control room near the upstream and downstream mitre gate.

4. CONDITION SURVEY

Condition survey has been carried out in order to assess the overall health of the existing navigation lock.

Underwater visual inspection (VI) of the lock chamber including the side walls and base slab, lock gates (mitre and radial gates) using Remotely Operated Vehicle. To carry out above water and Underwater non-destructive tests of the concrete walls of Lock using Ultrasonic Pulse velocity (UPV) technology. And to carry out Underwater non-destructive tests of the steel gates walls (mitre gates) of lock using Ultrasonic Thickness Gauging (UTG) technology.

Area of inspection of the condition survey Tests are East and West side wall, Base Slab, Mitre Gate East Side Gate 1 and 2, Mitre Gate West Side Gate 1 and 2, Radial Gates, Caisson Gate, Bulkhead Gate. Based on the condition survey, the functional condition index has been generated on the scale of 0 to 100. If a structure is designed and constructed properly, it has an initial condition index of 100. The functional condition index never quite reaches 0.

5. RENOVATION AND MODERNIZATION OF CIVIL COMPONENTS

The lock structure base slab, side walls, approach structure and filling emptying system has been proposed to retrofit the existing lock structure. Jacketing with high strength concrete on the base slab has been recommended. Jacketing is the process of strengthening weak RCC structure

The base slab shall be jacketed with high strength concrete of grade M40 with a thickness of 100mm. The top surface shall be thoroughly cleaned before the fresh concrete is applied. Wherever there are damages in the base slab, the loose concrete shall be removed before the high strength concrete layer is provided. Wherever embedded parts are to replaced/repaired, high strength concrete of grade M60 should use for proper connection and joint strength with concrete and embedded parts.

A reinforced concrete counterfort retaining wall has been proposed at the sides of the parking bay for caisson gates. The top of the wall has been kept at El. 28.44m. The stability analysis of retaining wall has been carried out considering the backfill soil as saturated and cohesion-less. The retaining wall has been designed for the worst combinations of dead load, static earth pressure, dynamic increment in earth pressure and earthquake forces. The Floating moorings conventional systems and magnetic moorings have been considered.

The wooden as well as AN 800 E 3.0 grade rubber fenders with stainless steel plates or SM 800 grade M2 which can withstand extreme climate as well as alternate wetting and drying are proposed to be used. Control Building will be with full view in the front of the control room. Control building comprises of Diesel Generator set, Metering panels, electrical panels and Transformer on the Ground floor. Operating cum programming station, server station, PLC panels, CCTV Terminals, monitoring control system for field instruments and the rest room for the operator are located at the third floor. A viewing gallery shall be provided in the control room building for operation of the existing lock as well as for visitors. It is proposed to have a viewing gallery on the 2nd floor by using external supporting column around the existing control room building.

Existing navigation lock currently has 4 local control rooms, two each on the upstream and downstream of the navigation lock (one each on the left and right bank) for operation of the gates. The control rooms are in a dilapidated condition; therefore, it is proposed that the local control rooms shall be reconstructed as per standard IS code. There is G+1 building on the upstream left bank which is functional which can be used after repair and renovation work for lock purposes.

The corroded/damaged part of the Steel Lattice Cable Bridge shall be repaired. A vertical access ladders with round safety tunnel shall be provided with the steel cable bridge for regular maintenance of the electrical cables and steel structure.

Bank Protection is required to prevent soil erosion along the river bank. PCC block of size 1m x 1m x 0.6m are provided in two layers along the slope of the river bank graded to a slope of 1.5H:1V. For free drainage of pore water from the saturated soil beneath, PCC blocks are proposed to be laid over a graded filter. To prevent the sliding and failure of the revetment on slope, a PCC toe wall has been provided. Launching apron comprising of PCC blocks of size 1.5m x 1.5m x 0.9m in a width of 6m in two layers has been proposed in front of the toe wall. A graded filter media should also be provided below the launching apron.

6. SAFETY ASPECTS OF EXISTING LOCK

Ensure the safety of existing lock and new navigation lock, monitoring instruments shall be installed for monitoring during the renovation/modernization and operation of the existing and new navigation lock. The proposed monitoring instruments to be installed are Piezometers – 15 Nos, Settlement gauges – 09 Nos, and Inclinometers – 09 Nos.

7. ENOVATION AND MODERNIZATION OF HYDROMECHANICAL COMPONENTS

Both existing mitre gate and operating mechanism proposed to be replaced with a hydraulic system with axial-piston pumps and cylinders for quick operation speeds and durable components. The replacement of the current rope operating system with an alternative involving a hydraulic system with axial-piston pumps and cylinders would enable overload protection and incorporate gate holding properties.

All the radial gates proposed to replace with Modern Hydraulic power packs units are envisaged to use axial pumps with hydraulic cylinders. The hydraulic system shall include hydraulic power units using variable displacement, axial-piston pumps, manifolds, stainless steel reservoirs, hydraulic cylinders, piping etc. as well as safety and instrumentation system.

The existing operating mechanism needs to be replaced with a new individual fixed Winch type hoist (of suitable capacity) for each bulkhead gate along with dogging arrangement. The replacement of the current operating system to an alternative involving a fixed Monorail hoist will allow for regular maintenance of the radial gates and filling/emptying system. The control system shall be PLC based.

The new caisson gates have been proposed for replacement / repair / maintenance of Mitre Gate. Gates. The new caisson gates shall comprise of deck, bulkheads, face plates so that various tanks and chambers can be arranged for ballasting and de-ballasting required for sinking and raising operations of the gate.

8. ELECTRICAL AND CONTROL SYSTEM

The main power requirement for electrical load shall be on account of operation of Mitre Gates, Radial Gates, Submersible Pump Motors, Capstan Motors etc. Other infrastructure such as general lighting, power for auxiliary services like Automatic Data acquisition system (ADAS) etc. will also need electric power. Power will also be needed for air- conditioning & lighting of control room building. A PLC system shall read the inputs, perform all system logic, conduct online diagnostics, sequencing control and control the outputs. A processor based central control system is envisaged to control and monitor the Lock operations in the New Navigation Lock so as to carry out the operation in an integrated mode from “Control Room”. For communication EPABX system of 3 PNT Line 12 Hybrid Extension is proposed for this project.

9. OTHER INFRASTRUCTURAL WORKS

RETIRING ROOMS

Retiring rooms have been proposed for the chief lock officer, lock officer and other lock operating staff of the navigation locks. 2 units of CPWD Type IV for officers and 4 units of CPWD Type III for staff have been proposed as retiring rooms. The plinth area shall be fixed as per the New Plinth Area Norms 2012 of CPWD.

BOUNDARY WALL

The existing boundary wall of existing lock may be demolished during the renovation and modernization of existing lock after the completion of renovation and modernization activity, the existing boundary wall shall be repaired. Existing navigation lock shall have an entry gate and security room at the entry gate., internal road shall be constructed and repaired from entry gate to control room and run all around the Lock area and connect to existing the external road through the entry gate.

INTERNAL ROAD

Flexible pavement types Internal Road of 5-meter width has been proposed for movement of vehicle in the lock area.

TOILET BLOCK

A public toilet of capacity of 2 Water Closet (flush toilet) for women and men and 4 urinals for men has been proposed in the lock area.

WATER SUPPLY AND SEWERAGE DISPOSAL

110KL/day of raw water and 9KL/day of potable water are required at construction stage assuming strength of 200 personnel. This does not account for water required at the labor camp which is to be arranged by the contractor outside the lock area. The amount of sewage/waste water generated in the Lock compound is approximately 2000Liters/day. It is, therefore, proposed to provide a small sewage treatment plant of 2.5 KLD, located near the D/S end of the lock. The treated effluent will meet the standards set by the state pollution control board and can be used for horticultural activities within the lock compound. The existing storm water drainage system shall be shall be repaired.

WASTE COLLECTION SYSTEM

In the lock area suitable waste collection system for solid waste shall be provided. Waste collection system includes suitable location of dumping area and permanent dustbin at suitable locations.

FIRE FIGHTING SYSTEM

A firefighting system capable of controlling and extinguishing fires has been proposed. In control room, it is proposed to install dry powder type fire extinguishers with inbuilt pressure gauge.

RAINWATER HARVESTING SYSTEM

Rainwater harvesting system for retiring rooms and other existing building has proposed. Rainwater harvesting system shall be designed for peak rainfall intensity.

10.MODEL STUDIES

The Mathematical/Physical model studies for the whole structure to access the filling/emptying time of the lock chamber, sedimentation in the hydraulic system, check for air entrapment in the hydraulic system, waves, currents and turbulence generation in the lock chamber. The speed of the flow inside the culverts, head losses and cavitation, particularly in bends and inter-independent interaction of various elements such as, speed of the opening of the valves with the locking duration, mooring forces, will be made during detailed designs and modification to those, if required, will be made at that stage.

11. DEWATERING ARRANGEMENT

Renovation and modernization of existing navigation lock requires the lock chamber to be dry. A coffer dam shall be constructed in the upstream and downstream of existing navigation lock to keep the working space in dry condition. Dewatering arrangement is required to pump out the water between the coffer dams. Additionally, seepage water from the coffer dams and natural ground surface is also required to be pumped out. Further water accumulated during the rainy season is to be pumped out to keep the working area in dry condition.

12. DISPOSAL OF CONSTRUCTION DEBRIS & SCRAPS OF HYDROMECHANICAL & ELECTRICAL COMPONENTS

Renovation and modernization work of the existing navigation lock shall generate construction debris from the base slab, side walls, guide walls, approach structures, filling emptying structures, control room buildings, cable trays, etc. The total quantity of construction debris likely to be generated is around 1200 cum, which will be used for back filling, site grading and construction of road embankments.

Scraps from the various hydromechanical and electrical component shall be safely handover to IWAI as per IWAI instructions.

A suitable waste management plan shall be carried out at the construction phase to keep the lock area clean and environment friendly after the completion of renovation and modernization of the existing lock.

13. LAND DETAILS

The proposed renovation and modernization of the existing lock shall not require additional land and even the new parking bays at upstream and downstream of the lock has been proposed within the existing boundary of the lock area and the ownership of the land vests with the IWAI.

14. TENDER DOCUMENTS

The Engineering, Procurement and Construction (EPC) contract documents for Construction of Navigational Lock have been prepared. They comprise of three volumes, Volume I - Bidding Documents, Volume II - Technical Specification and Drawings and Volume III - Bill of Quantities (BOQ).

15. ENVIRONMENTAL IMPACT ASSESSEMENT (EIA) & ENVIRONMENT MANAGEMENT AND MONITORING (EMP)

Project involves renovation and modernization the existing lock at Farakka, District Murshidabad, West Bengal. The existing navigation lock is currently managed by the IWAI and the proposed renovation and modernization activities shall not require any additional land. Even the land required for the caisson gate new parking bay is within the ambit of IWAI.

Baseline study has been carried out at the project site to study the existing condition of environmental at site. On the basis of the baseline data and associated project activities, impact of the project activities on social and environmental parameters were analyzed and mitigation measures and management plans are proposed for mitigating the anticipated negative impacts of the project.

16. LOCK ADMINISTRATION AND MANAGEMENT

It is proposed that the Navigational Lock shall be controlled and managed by the IWAI personnel. It is estimated that 28 persons will be required for the operation, maintenance and management of the lock.

17. IMPLEMENTATION SCHEDULE

The important activities to be carried out include Mobilization and Detailed Design, Site Development, Renovation/Modernization of Civil work, Renovation/Modernization of Hydromechanical work, Electrical lighting and miscellaneous works. The construction of the lock can be completed within a time frame of 20 months. Subsequently 3 months will be required for rectification of any defects and handing over of the complex by the EPC Contractor to the IWAI.

18. COST ESTIMATES

Capital Cost

The cost estimates of civil works have been prepared based on CPWD Schedule of Rates (SOR) 2021 and Market Rates for various items of work not available in CPWD SOR prevailing in the region. The costs of monitoring equipment, electro-hydraulic system is based on the quotations received from manufacturers, wherever applicable and also in-house data, and include manufacture, supply, installation, testing and commissioning. The price level used for the estimates is as of the third quarter of 2022.

1 INTRODUCTION

1.1 Project Background

An efficient transport sector is vital for development of the economy of any country. In a large country like India, efficient transportation becomes pivotal to stimulate a competitive business environment. The Indian transport system comprises various types, viz. Railways, Roadways, Inland Waterways, Coastal Shipping and Airways.

Inland Water Transport (IWT) is a fuel efficient and cost-effective mode of transport having the potential to supplement the overburdened rail and congested roads. For this, however, it is necessary that IWT is developed with public funding at least to a threshold level, after which point it is expected that the private sector would see the transport method as a viable alternative and make further investment as required.

The Inland Waterways Authority of India (IWAI), an autonomous organization under the Ministry of Shipping (MoS), Govt. of India was constituted in October 1986 for development and regulation of the inland waterways of the country. Waterways which have been declared as National Waterways (NWs) are developed, maintained and regulated by IWAI for shipping and navigation.

The Ganga – Bhagirathi – Hooghly River system from Haldia to Allahabad has been declared as National Waterway No. 1 in 1986 and since then various developmental activities on this waterway are under progress.

Inland Waterways Authority of India has appointed PKS FLOODKON JV through their letter of award for consultancy services bearing no. IWAI/NW-1/WB/AG/Study-Exist.Nav.Lock/2020-21/321 dated 08.12.2021 to undertake the study entitled

"Preparation of Detailed Project Report (DPR) for the work of renovation / modernization of existing navigation lock at Farakka" under the Jal Marg Vikas Project (JMVP).

1.2 Need of Renovation and Modernization of Navigation Lock at Farakka

A barrage has been constructed across river Ganga at Farakka to divert the water from Ganga to Bhagirathi through a feeder canal. The navigable route through the main Ganga River up-stream to the river Bhagirathi downstream is facilitated by the navigation lock at Farakka. The Feeder Canal of Farakka Barrage and the navigation lock becomes the link between the main Ganga and Bhagirathi.

Farakka Barrage Project (FBP) was commissioned in the year 1975 with the primary objective of improving the navigation facilities of river Hooghly and maintaining Kolkata Port. As part of FBP, a navigation lock was constructed and commissioned in the year 1987 at Farakka (in Murshidabad district of West Bengal) to facilitate movement of inland vessels on National Waterway-1 (NW-1) through Feeder Canal. The navigation lock along with all ancillary assets was taken over by the Inland Waterways Authority of India from FBP Authority in April 2018.

The navigation lock has: (a) an internal length of 179.8m and a width of 25.14m and consists of two (2) sets of mitre gates on upstream (u/s) and downstream (d/s) side (two (2) leaves per set, each hinged about a vertical axis); (b) two (2) floating caisson type stop log gates; (c) four (4) sets of radial valve gates with maintenance bulkheads; (d) eight (8) sets of mooring bits; and (e) a control tower for remote control operation.

Since the commissioning of navigation lock in the year 1987, no major repairs of hydraulic and electro-mechanical components have been carried out. As a result, mitre gates, radial valve gates, bulkheads, floating caissons and other mechanical components including electro-mechanical operating system are in dilapidated condition. Although the lock is operational and the vessels regularly pass through it in a month, its functioning has been inefficient and has encountered frequent breakdowns resulting in massive delays in vessels passage. Also, the movement of inland vessels on NW-1 carrying project cargo including Over Dimensional Cargo (ODC) has increased significantly / manifold in the last few years and inefficient functioning of the lock has become an impediment in smooth and efficient navigation on NW-1. At present, mitre gates and radial valve gates are operated through electro-mechanical system which is located near each gate as a result of which, it takes long time in operating these gates.

The navigation lock is an important part of NW-1 and renovation of the navigation lock will helps to achieve overall goals of JMVP and improve the navigability of NW-1 through: (i) fairway development by providing an assured depth of 2.2m to 3.0m throughout the corridor for at least three hundred thirty (330) days in a year to make it navigable for comparatively larger vessels of 1,500-2,000 DWT and (ii) civil structures, logistics and communications interventions required that includes multimodal terminals, jetties, navigational locks, barrages, channel marking systems etc.

1.3 Objective as per ToR

The major objective of the consultancy is to Preparation of Detailed Project Report (DPR) with the objective to

I. Renovate and modernize the existing navigation lock at Farakka to the latest technology based on the best practices followed worldwide; and

II. Synchronization of the operation of existing navigation lock with the new navigation lock being developed to ensure optimum utilization of both the locks, at the same time, for safe navigation & passage of vessels.

1.4 Organization of report

The DPR report comprises of following chapters:

Chapter 1 deals with the introduction and need of the project.

Chapter 2 deals with the project location, study area and layout of the existing navigation lock.

Chapter 3 deals with the various component of the existing navigation lock.

Chapter 4 deals with the condition survey and condition index as per performance indicators.

Chapter 5 deals with the renovation and modernization of civil components of the existing navigation lock.

Chapter 6 deals with the safety aspects of both the existing and new navigation lock during the renovation and modernization of the existing navigation lock.

Chapter 7 deals with the renovation and modernization of hydromechanical components of the existing navigation lock

Chapter 8 deals with the renovation and modernization of electrical and control system of the existing navigation lock.

Chapter 9 deals with the renovation and modernization of other infrastructure facilities of the existing navigation lock.

Chapter 10 deals with modelling studies.

Chapter 11 deals with dewatering plan of the area.

Chapter 12 deals with the dismantling/decommissioning of deteriorated components of the existing navigation lock.

Chapter 13 deals with the details of the land required for the project.

Chapter 14 deals with the environmental impact assessment and environmental management plan.

Chapter 15 deals with the tender documents for project execution in EPC mode.

Chapter 16 deals with the details of required manpower for lock operation and administration.

Chapter 17 deals with the implementation schedule of the renovation and modernization project execution.

Chapter 18 deals with cost estimation of the project.

2 PROJECT AREA

2.1 General

Farakka Barrage Project with headquarters at Farakka in Murshidabad district of West Bengal is a subordinate office under the Union Ministry of Water Resources, River Development & Ganga Rejuvenation. The Farakka Barrage Project Authority was set up in 1961 with the mandate to execute and thereafter operate and maintain the Farakka Barrage Project Complex comprising of Farakka Barrage, Jangipur Barrage, Feeder Canal, Navigation Lock and associated structures. The Barrage comprises of 112 nos. of Gates and 11 Nos. Head Regulator Gates for diversion of approximately 40,000 cusec (1035 cumec) of discharge into the Feeder Canal. The project construction commenced in 1961 and the project was commissioned and dedicated to the Nation in May 1975.

Main objective of the Farakka Barrage Project complex is to divert adequate quantity of Ganga waters to Bhagirathi-Hoogly River system through 38.38 km long feeder canal for preservation and maintenance of Kolkata Port by improving the regime and navigability of the Bhagirathi-Hoogly River system. The Hoogly-Bhagirathi River system, the Feeder Canal and the Navigation Lock at Farakka form part of the Haldia-Allahabad Inland Waterway (National Waterway 1). The Feeder Canal also supplies water to 2100 MW Farakka Super Thermal Power Project of NTPC Ltd. at Farakka and WBPDC Sagardighi (1600MW). The northern end of the Farakka Feeder Canal links to the river Ganga via a head regulator just U/S of the Farakka Barrage. For most of its length the canal is approximately 180m wide. A narrower section of navigation canal/channel approximately 60m wide connects the main Feeder Canal to the existing Farakka navigation lock and further to the main Ganga River U/S of the Barrage.

2.2 Project Site Location

The Site is located at Farakka in Murshidabad district of West Bengal. An index map of the project area is shown in Figure 2.1 whereas Figure 2.2 and Figure 2.3 shows the various project components. Index plan of Farakka navigation lock is shown in Drawing No. ENL001.

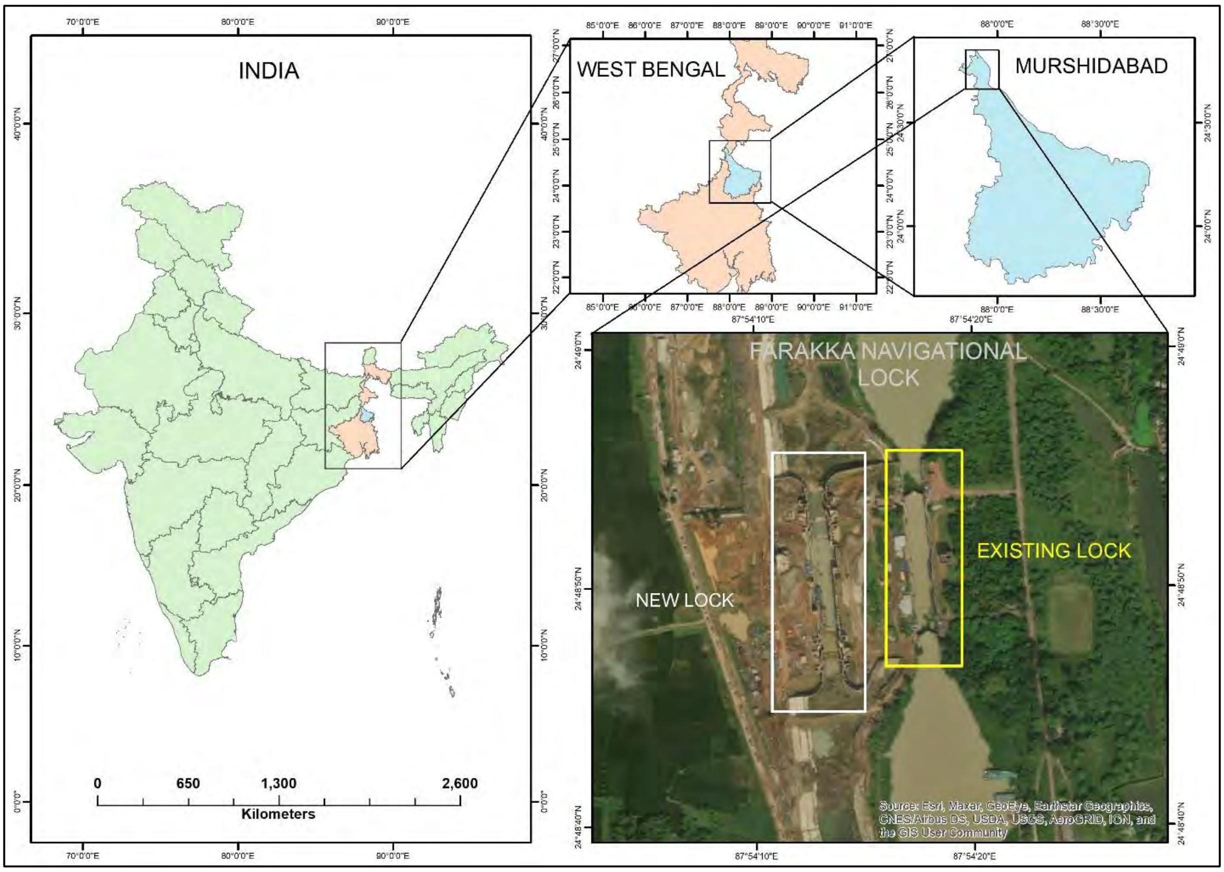


Figure 2.1 Index map of the project area with existing and new lock

Figure 2.2 Plan Map of Farakka Barrage and Navigation Lock

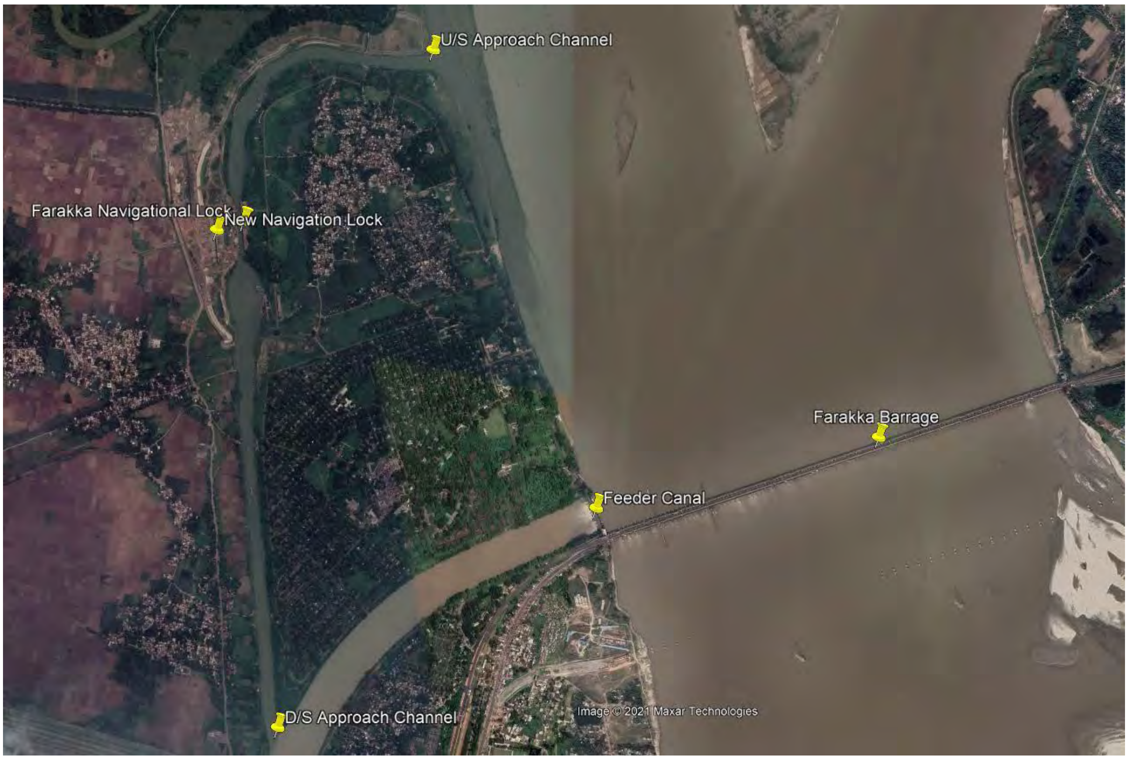


Figure 2.3 Close up view of Farakka Barrage, Feeder Canal and Locks

2.3 Existing Navigation Lock

The existing navigation lock is 179.8m long and 25.145m wide. It comprises of Mitre Gates, Radial Gates, Bollards, Caisson Gates/Stoplogs and Bulkhead Gates. Layout of the existing navigation lock is given in Figure 2.4 and Drawing No. ENL003. The salient features of the existing lock are given in Table 2.1.

Table 2.1 Salient Features of Existing Navigation Lock

S. No.	Parameter	Details
1	Number of Locks	One (1)
2	Length of lock	179.8m (b/w Mitre Gates) 250m (b/w Caisson Gates)
3	Width of lock	25.148m
4	Average depth of lock	12.89m at u/s to 10.89m at d/s
5	Major Structural Components	· Base Slab, Retaining Walls & Guide Walls · Filling / emptying Culverts including gate chambers · Bollards – eight (8) numbers floating type (four (4) on each bank) and fourteen (14) numbers fixed type (seven (7) on each bank) · 1 Central Control Room and 4 local control room
6	Major Hydromechanical Components	· Mitre Gates – two (2) sets 1 on U/S and 1 on D/S end, having two (2) leaves per set, · Caisson Gates/Stoplogs - 2 numbers (one (1) for u/s & one (1) for d/s) · Radial Gates – four (4) numbers (two (2) for u/s & two (2) for d/s) · Bulkhead Gates – eight (8) numbers (four (4) numbers for u/s and d/s each)

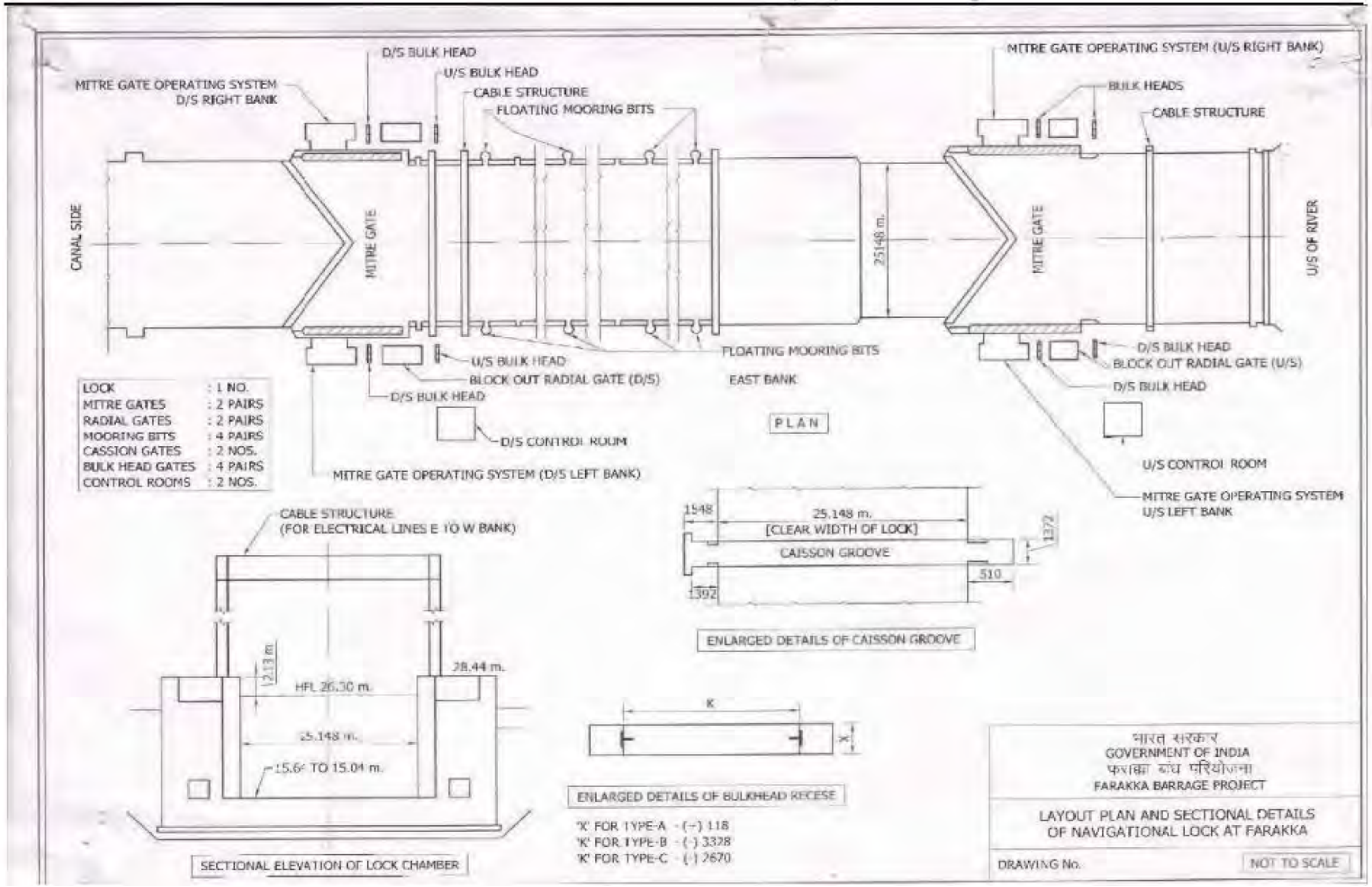


Figure 2.4 Layout of the existing navigation lock

2.4 Metrological Data

2.4.1 Rainfall

Gridded rainfall data has been collected from India Meteorological Department (IMD) for the project location between latitude and longitude of 24.75^o N, 88^o E and 24.75^o N, 87.75^o E. The data has been collected for a duration of 41 years from year 1980-2021. Average annual rainfall is around 1470 mm and the maximum rainfall occurs in the month of July which is of the order of 350 mm. The average monthly rainfall data from 1980-2021 is presented in Table 2.2 and plotted in Figure 2.5.

Table 2.2 Rainfall (mm) Data for the Project Site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	6.9	2.8	11.6	8.3	185.6	299.3	506.4	703.8	346.0	90.7	0.0	0.0	2161.2
1981	33.4	11.4	6.1	130.4	193.5	123.1	488.5	262.3	286.3	0.0	2.8	35.2	1572.7
1982	1.0	4.7	40.1	11.9	52.9	216.7	200.5	316.0	117.3	55.4	37.9	0.5	1054.7
1983	11.9	0.9	23.9	33.1	88.5	134.4	331.8	180.3	367.2	126.3	0.0	29.0	1326.9
1984	45.9	25.4	4.3	8.1	128.2	375.0	388.5	234.6	227.0	114.7	0.0	1.4	1552.8
1985	4.2	1.9	3.4	11.9	174.3	170.2	406.7	209.5	281.7	162.1	0.0	3.7	1429.4
1986	0.6	7.8	0.1	58.2	90.8	152.9	284.8	109.2	261.8	227.4	3.3	6.2	1202.9
1987	0.2	3.8	25.7	61.3	94.1	174.4	581.0	751.3	357.4	50.3	6.4	3.9	2109.4
1988	0.3	15.2	29.1	29.1	99.6	260.8	287.7	399.9	171.6	69.6	33.0	2.7	1398.3
1989	0.7	16.0	0.4	0.0	189.4	155.4	341.2	193.3	433.6	60.9	0.0	12.1	1402.8
1990	0.0	28 .4	20.2	20.0	196.1	162.1	514.9	251.6	257.3	145.0	0.9	0.0	1596.2
1991	6.2	5.7	9.1	13.1	116.2	327.4	391.8	204.6	472.4	60.7	0.0	68.6	1675.6
1992	0.0	14.3	1.5	4.7	84.1	161.9	458.5	237.2	200.2	75.1	9.0	0.6	1246.6
1993	21.0	1.8	21.7	67.7	71.1	340.6	236.2	385.2	396.9	67.0	37.4	0.0	1646.3
1994	21.9	20.6	0.0	13.2	27.4	240.6	171.9	200.3	150.3	131.9	0.0	0.0	977.9
1995	3.1	7.9	0.5	1.9	48.2	186.4	278.8	322.9	1020.3	9.1	58.8	8.1	1945.7
1996	10.3	10.4	0.4	15.1	29.6	248.0	303.0	513.7	277.9	70.0	0.0	0.0	1478.1
1997	23.3	9.4	8.3	77.9	109.5	242.3	387.5	510.3	270.1	29.8	14.2	32.8	1715.2
1998	7.6	11.1	61.9	45.7	141.5	143.7	568.1	359.1	324.4	226.2	20.5	0.0	1909.7
1999	0.0	0.0	0.4	5.7	108.3	308.1	489.5	566.6	541.6	172.9	0.6	0.0	2193.3
2000	4.1	36.2	26.6	111.4	181.5	327.5	264.9	176.1	635.2	25.9	0.0	0.0	1789.2
2001	0.3	0.0	1.5	16.9	185.7	272.8	221.8	230.6	259.7	209.9	0.0	0.0	1399.0
2002	10.9	0.6	2.9	88.1	104.1	195.5	259.3	358.2	329.9	54.8	9.3	0.0	1413.3
2003	1.0	52.7	30.8	14.5	136.8	309.7	194.3	176.1	210.7	258.5	0.0	2.0	1386.8

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	19.0	0.0	2.0	44.7	62.7	346.7	332.7	215.2	130.7	485.9	0.0	0.0	1639.4
2005	15.6	3.8	52.1	17.2	96.6	87.1	571.4	329.9	163.3	154.8	0.0	0.0	1491.7
2006	0.0	0.0	4.3	67.6	99.1	204.3	239.8	247.3	488.2	67.8	11.3	0.5	1429.9
2007	0.0	42.7	44.2	0.4	85.8	275.2	549.3	235.7	272.2	51.5	0.9	0.0	1557.6
2008	43.3	1.9	5.0	21.0	40.1	392.8	416.3	292.5	216.9	34.6	0.0	0.0	1464.1
2009	0.8	5.3	0.9	0.2	227.4	73.4	298.9	463.4	157.5	276.7	2.4	0.0	1506.8
2010	0.0	1.8	0.1	30.9	168.8	187.4	151.1	113.8	239.4	106.3	9.6	9.5	1018.5
2011	0.0	0.5	0.1	9.0	43.0	79.0	473.0	308.2	323.8	18.6	0.3	0.0	1255.2
2012	6.6	0.1	1.4	70.1	26.6	128.1	299.3	160.7	164.3	88.4	39.2	0.0	984.6
2013	0.1	14.3	1.0	32.6	134.2	320.9	118.1	381.8	169.3	309.5	2.9	0.0	1484.5
2014	0.3	55.0	1.4	11.5	168.3	236.5	382.0	251.2	217.0	29.6	0.0	0.0	1352.6
2015	18.9	2.9	35.7	97.5	137.2	269.9	452.5	322.6	221.6	32.0	3.0	0.0	1593.5
2016	14.9	0.0	4.0	16.6	78.2	130.8	358.4	163.9	338.9	46.7	0.0	0.0	1152.2
2017	2.1	0.0	7.6	69.5	101.2	87.9	311.4	413.4	165.6	111.8	0.2	8.9	1279.4
2018	0.0	13.2	24.6	143.2	142.5	91.3	199.6	157.4	115.3	69.0	0.0	13.5	969.4
2019	0.0	33.0	2.1	65.4	113.1	65.9	333.7	148.5	269.4	174.4	0.0	1.3	1206.6
2020	9.2	13.2	55.7	74.3	170.9	329.4	263.0	197.1	272.7	89.2	0.1	0.0	1474.5
2021	0.0	0.0	1.9	6.9	356.1	252.0	233.3	272.9	112.5	83.6	0.0	6.3	1325.2
Average	**8.2**	**11.3**	**13.7**	**38.7**	**121.1**	**216.3**	**346.2**	**298.3**	**291.3**	**112.5**	**7.2**	**5.9**	**1470.7**

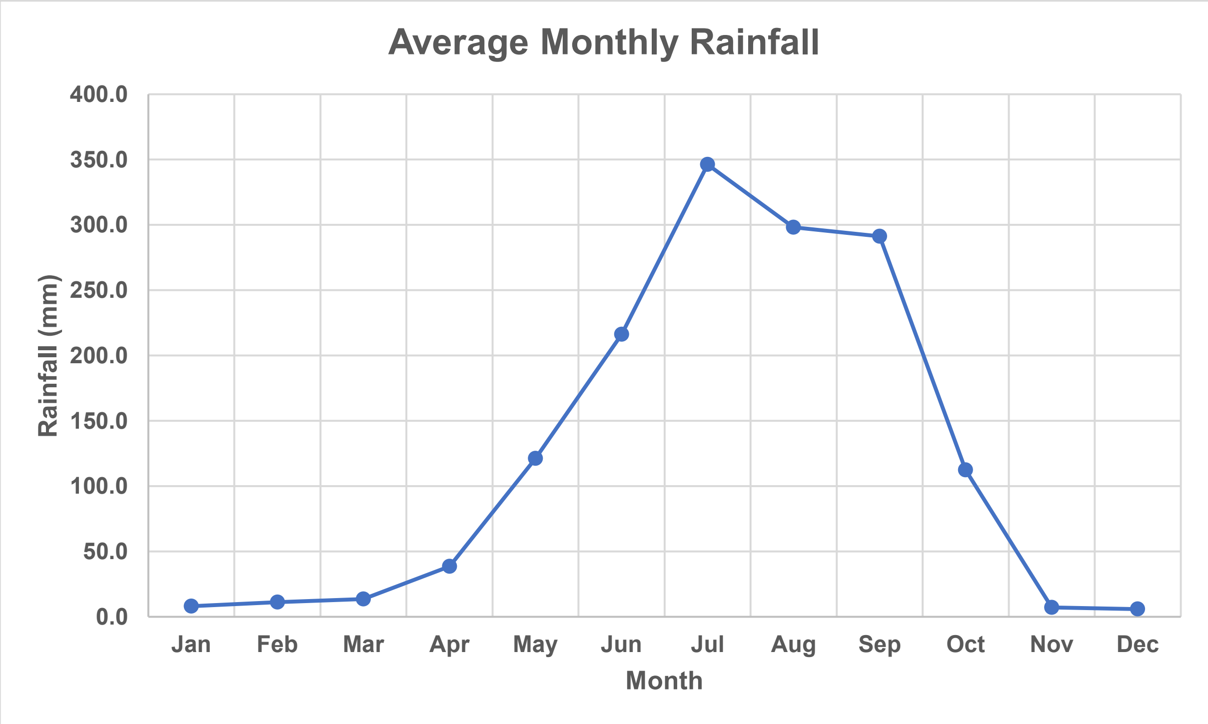


Figure 2.5 Average monthly rainfall distribution

2.4.2 Wind

Wind speed data at 2m above ground has been collected from NASA POWER LARC for the project location. The data has been collected for a duration of 40 years from year 1981-2021. Average annual wind speed at the project location is around 2m/s. The maximum wind speed occurs in the month of June i.e., 2.60 m/s. The average wind speed varies from 1.38 m/s to 2.60 m/s throughout the year. The average monthly wind speed from 1981-2021 is presented in Table 2.3 and plotted in Figure 2.6.

Table 2.3 Wind speed (m/s) for the project site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	1.57	1.85	1.91	2.25	2.41	2.91	2.76	2.24	1.65	1.27	1.54	1.59	2.00
1982	1.60	1.95	1.90	2.03	1.98	2.66	2.51	2.92	1.95	1.30	1.42	1.61	1.98
1983	1.59	2.02	2.47	2.66	2.27	3.27	2.90	3.00	2.41	1.76	1.45	1.59	2.28
1984	1.77	2.18	2.11	2.05	2.55	3.11	2.52	2.56	1.77	1.48	1.52	1.52	2.09
1985	1.73	1.74	2.24	2.47	2.50	2.66	2.69	2.53	1.87	1.68	1.65	1.66	2.12
1986	1.92	2.25	2.28	2.14	1.91	3.27	2.74	2.25	2.28	1.28	1.08	1.36	2.06
1987	1.54	1.55	1.62	2.27	1.91	2.69	2.45	2.17	1.93	1.38	1.70	1.66	1.91
1988	1.80	1.71	2.10	1.93	2.58	3.30	2.49	2.53	1.84	1.84	1.85	1.64	2.14
1989	1.87	2.62	2.38	2.43	2.95	3.23	2.24	2.63	2.32	1.45	1.45	1.57	2.26
1990	1.64	1.70	1.64	2.10	2.57	3.47	2.34	2.18	2.17	1.95	1.58	1.43	2.06
1991	1.62	2.00	1.84	2.00	2.47	2.70	2.94	2.70	1.88	1.44	1.32	1.51	2.04
1992	1.29	1.73	3.20	2.50	2.12	2.52	2.71	2.75	2.35	1.50	1.55	1.36	2.13
1993	1.81	1.54	2.52	2.23	2.57	3.55	3.33	2.71	2.38	1.20	1.42	1.57	2.24
1994	1.77	1.92	2.16	2.09	2.41	3.48	3.20	2.92	2.44	1.66	1.50	1.62	2.27
1995	2.05	2.00	2.75	2.07	2.53	3.40	2.77	2.56	2.61	1.32	1.71	1.62	2.28
1996	1.95	1.99	2.50	2.01	2.38	3.02	2.64	2.30	1.62	1.73	1.63	1.66	2.12
1997	1.79	2.00	2.20	1.90	2.09	3.17	2.49	2.40	1.79	1.16	1.40	1.65	2.00
1998	1.65	2.01	2.39	1.97	2.41	2.84	2.55	1.89	1.76	1.35	1.45	1.38	1.97
1999	1.55	1.87	2.25	1.83	2.16	2.50	2.30	2.41	2.25	1.56	0.98	1.19	1.91
2000	1.47	1.80	1.67	2.18	2.42	2.52	2.70	2.16	2.09	1.18	1.12	1.21	1.88
2001	1.54	1.39	1.90	1.90	2.59	3.06	2.98	2.06	1.51	1.30	1.10	1.17	1.88
2002	1.43	1.80	1.52	2.11	2.50	2.45	2.26	2.56	1.91	1.19	1.26	1.06	1.84
2003	1.48	1.62	1.76	1.95	2.05	3.00	2.56	2.43	2.01	1.49	1.12	1.42	1.91
2004	1.46	1.52	1.73	2.05	2.27	2.53	2.62	2.55	2.34	1.52	1.00	1.15	1.90
2005	1.36	2.12	1.89	1.56	2.15	2.82	2.56	2.02	1.58	1.70	1.02	1.29	1.84
2006	1.27	1.23	1.77	1.68	2.30	2.12	2.60	2.41	2.21	1.03	1.29	1.34	1.77

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2007	1.44	1.68	1.77	2.05	1.88	2.70	2.91	1.91	2.08	1.25	1.56	1.35	1.88
2008	1.55	1.38	1.51	1.69	1.81	2.90	2.20	2.17	1.63	1.30	1.20	1.12	1.70
2009	1.29	1.89	1.62	1.81	2.34	2.31	2.60	2.07	1.87	1.53	1.32	1.15	1.81
2010	1.63	1.70	2.03	2.01	2.39	2.43	2.65	2.05	1.71	1.59	1.30	1.41	1.91
2011	1.58	1.77	2.06	1.66	2.04	2.99	2.36	2.37	2.45	1.06	1.11	1.25	1.89
2012	1.64	2.08	1.92	2.19	2.12	2.69	2.27	1.62	1.94	2.05	2.18	2.29	2.08
2013	2.69	3.18	2.45	2.19	2.17	1.88	2.39	1.92	1.62	1.61	1.48	1.34	2.07
2014	1.94	2.22	2.16	1.88	2.44	1.95	2.49	2.22	1.69	1.14	1.30	1.72	1.93
2015	2.03	1.65	2.66	2.02	2.51	3.16	2.38	2.11	1.52	1.08	0.95	1.22	1.95
2016	1.45	1.70	2.26	2.56	2.24	2.53	2.75	2.48	1.52	1.18	1.28	1.63	1.97
2017	1.75	1.73	1.89	2.27	2.30	2.77	2.66	2.02	1.66	1.62	1.31	1.40	1.95
2018	1.60	1.54	1.70	2.02	2.39	2.23	2.72	1.91	1.82	1.22	1.21	1.57	1.83
2019	1.65	1.88	2.10	1.85	2.50	2.73	2.78	2.28	1.92	1.35	1.48	1.71	2.02
2020	1.61	1.56	1.86	1.93	2.31	2.45	2.30	2.27	1.62	1.05	1.43	1.17	1.80
2021	1.27	1.35	1.88	1.73	2.23	2.59	2.41	1.99	1.82	1.61	1.23	1.39	1.80
Average	**1.65**	**1.84**	**2.06**	**2.05**	**2.31**	**2.79**	**2.60**	**2.32**	**1.95**	**1.42**	**1.38**	**1.45**	**1.99**

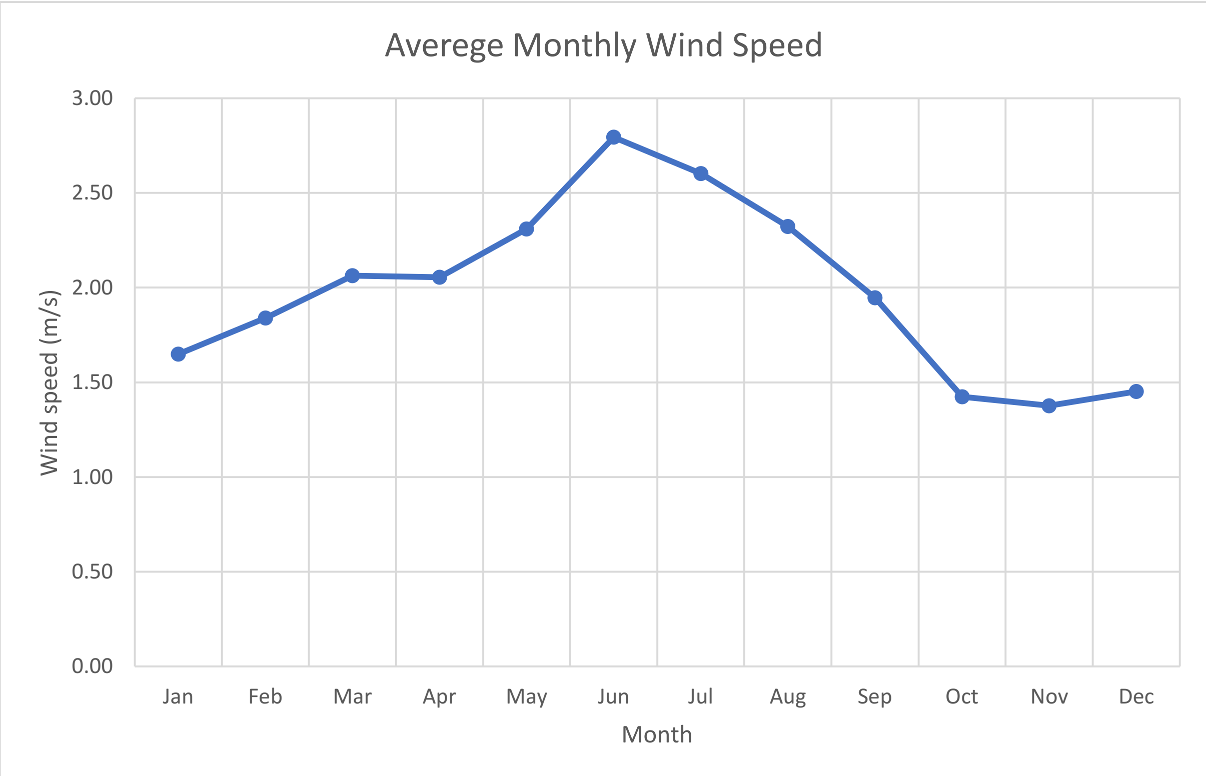


Figure 2.6 Average monthly wind speed distribition

2.4.3 Temperature

Temperature data has been collected from NASA POWER LARC for the project location. The data has been collected for a duration of 40 years from year 1981-2021. Average annual maximum and minimum temperature at the project location is around 44° C and 6° C respectively. The average maximum and minimum temperature vary from 27.8° C to 43.1° C and 6.6° C to 25.9° C respectively. The maximum and minimum average monthly temperature from 1981-2021 is presented in Table 2.4 and Table 2.5 respectively and plotted in Figure 2.7.

Table 2.4 Maximum Temperature(°C) at the project site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	28.8	35.9	37.1	39.7	41.2	41.6	34.8	33.6	33.8	31.6	30.7	29.1	41.6
1982	30.4	31.7	37.3	40.2	43.0	40.6	40.6	34.6	35.1	36.1	33.1	29.0	43.0
1983	31.0	34.2	40.2	42.9	43.9	46.8	41.7	38.0	36.0	36.0	32.6	29.4	46.8
1984	28.2	32.4	41.5	44.5	43.8	42.1	35.3	35.6	32.4	33.4	31.8	30.3	44.5
1985	31.0	33.7	41.2	44.9	44.0	43.1	37.9	37.6	37.0	36.1	32.2	28.9	44.9
1986	30.5	34.3	43.7	43.7	41.1	43.6	37.8	36.8	36.4	30.8	29.3	27.9	43.7
1987	29.0	35.3	39.9	42.2	43.0	43.1	38.1	34.6	33.7	35.0	34.4	30.1	43.1
1988	29.8	34.7	40.0	43.9	46.3	42.3	37.9	37.6	37.8	37.0	34.5	31.0	46.3
1989	29.0	35.7	40.1	44.2	45.6	41.6	39.1	38.9	39.2	36.4	33.8	31.0	45.6
1990	34.2	32.8	39.5	44.0	42.3	41.9	36.0	36.7	37.3	32.8	35.2	30.1	44.0
1991	31.1	36.9	40.1	43.0	45.8	41.7	39.1	38.7	35.8	32.9	32.5	29.1	45.8
1992	31.1	32.5	42.0	44.9	44.4	42.8	42.7	40.4	39.8	37.2	36.0	29.3	44.9
1993	29.8	36.3	38.5	42.0	44.2	41.6	38.7	37.5	37.8	36.7	33.3	30.8	44.2
1994	31.2	34.4	41.2	42.9	45.4	43.8	38.0	38.9	37.6	37.3	34.5	30.3	45.4
1995	29.1	35.0	41.6	44.8	45.6	43.4	36.7	36.8	36.7	36.0	34.6	28.8	45.6
1996	28.5	34.3	41.5	44.2	45.8	43.3	38.5	36.0	37.6	36.7	35.8	30.3	45.8
1997	28.7	33.6	38.4	40.2	44.2	43.7	34.6	34.6	33.0	31.3	31.1	28.6	44.2
1998	28.0	32.7	36.5	41.2	43.6	45.6	34.6	32.6	33.4	32.8	29.0	25.0	45.6
1999	27.0	34.4	39.7	46.1	43.9	40.9	33.8	32.9	31.9	30.9	30.2	25.4	46.1
2000	28.3	30.1	37.7	43.1	40.1	36.2	35.3	33.2	32.8	32.3	30.1	26.8	43.1
2001	28.6	34.2	39.2	45.0	40.3	37.2	34.5	33.9	32.7	31.7	30.0	24.9	45.0
2002	28.1	33.4	38.4	40.5	44.1	38.4	35.8	33.8	32.8	32.3	28.5	26.3	44.1
2003	27.5	31.6	36.7	41.7	42.5	41.4	35.2	34.4	33.3	31.2	29.2	26.6	42.5
2004	27.3	34.7	41.2	43.8	43.7	38.7	33.2	32.7	32.4	30.8	27.5	25.2	43.8
2005	25.2	34.4	39.2	41.2	43.2	44.7	36.9	34.2	33.5	31.1	27.3	24.4	44.7
2006	25.3	36.5	39.7	42.4	41.1	38.5	34.0	34.2	33.7	32.9	29.5	27.8	42.4

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2007	28.8	31.5	39.8	42.0	42.9	42.8	34.6	34.8	32.8	32.6	28.6	24.8	42.9
2008	27.0	30.2	39.3	42.4	41.7	37.4	33.8	35.0	33.2	32.3	29.7	27.7	42.4
2009	29.3	34.7	37.9	42.3	42.6	42.5	36.8	34.4	33.0	32.4	29.3	25.5	42.6
2010	25.7	31.9	41.9	44.3	43.5	41.4	34.7	35.2	33.2	32.3	31.0	27.7	44.3
2011	27.6	33.4	40.3	39.6	39.3	39.7	34.3	34.7	32.7	31.7	27.8	27.0	40.3
2012	26.2	34.6	39.7	42.2	44.9	44.7	36.6	33.8	33.7	32.0	28.8	26.6	44.9
2013	28.2	34.4	39.5	43.4	43.7	36.6	34.1	33.8	33.3	31.2	28.6	25.7	43.7
2014	27.0	30.6	41.2	43.7	45.1	40.9	35.1	33.7	34.2	32.6	30.4	28.0	45.1
2015	29.0	34.7	39.0	39.4	43.4	43.4	35.4	33.8	33.9	33.4	30.6	30.5	43.4
2016	28.7	36.4	39.7	45.0	43.3	42.6	36.1	34.6	32.4	32.8	30.1	27.5	45.0
2017	30.6	35.3	40.5	41.4	39.9	41.3	33.7	33.3	33.7	32.6	29.3	26.6	41.4
2018	24.6	32.7	37.7	39.8	39.1	39.6	34.7	34.2	33.0	33.2	32.8	28.2	39.8
2019	28.6	34.0	39.7	43.2	43.5	40.8	35.8	35.1	33.1	31.2	28.7	25.3	43.5
2020	25.2	29.6	37.0	39.3	40.8	36.1	33.5	34.8	33.3	32.7	29.8	25.6	40.8
2021	26.7	34.9	40.1	42.5	40.2	36.8	34.1	34.2	33.1	32.4	27.2	26.5	42.5
Average	**28.5**	**33.8**	**39.6**	**42.6**	**43.1**	**41.3**	**36.2**	**35.2**	**34.4**	**33.3**	**30.9**	**27.8**	**43.9**

Table 2.5 Minumum Temperature(^{0}C) at the project site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	8.3	9.5	13.9	16.6	23.7	24.8	25.1	25.4	23.5	16.2	11.5	7.7	7.7
1982	7.4	8.9	11.9	19.1	21.9	25.8	25.6	25.2	20.9	19.0	9.8	8.9	7.4
1983	7.3	6.5	14.1	19.4	24.4	27.7	26.3	25.5	24.6	15.8	13.7	7.0	6.5
1984	7.3	7.9	12.1	20.4	22.3	25.6	24.9	25.3	20.1	16.8	11.5	6.5	6.5
1985	8.9	9.3	14.9	20.9	25.0	27.6	25.0	25.3	24.0	17.2	10.5	8.4	8.4
1986	7.0	10.4	14.9	20.6	19.4	25.1	24.4	24.7	22.8	15.7	12.4	7.0	7.0
1987	6.0	11.7	14.9	20.7	21.3	26.1	25.7	24.8	23.2	16.6	9.8	9.1	6.0
1988	7.7	9.5	14.2	17.9	25.0	24.7	26.2	25.2	23.6	19.8	13.5	10.1	7.7
1989	5.4	9.9	11.8	16.3	22.4	26.0	23.5	24.7	24.5	17.1	13.5	7.6	5.4
1990	7.3	10.0	13.0	16.2	25.1	26.1	25.4	25.0	24.3	15.5	11.4	8.6	7.3
1991	7.3	11.5	15.4	19.8	26.2	24.1	26.5	25.9	22.9	17.0	11.1	7.0	7.0
1992	5.9	9.4	13.0	19.8	22.5	25.5	26.0	25.1	22.3	16.5	13.2	9.8	5.9
1993	5.9	9.5	14.3	18.4	25.4	26.2	26.0	24.9	24.5	16.7	11.8	9.5	5.9
1994	7.7	10.8	13.3	21.3	24.0	26.4	26.1	25.9	20.4	17.7	13.7	7.1	7.1
1995	6.6	9.9	13.7	18.7	25.7	26.4	25.8	25.3	23.9	16.9	10.0	8.7	6.6
1996	7.2	7.7	15.6	16.4	22.7	26.6	25.4	24.7	24.3	17.8	10.9	8.2	7.2
1997	7.4	8.0	14.3	18.5	20.6	25.5	25.2	25.1	20.7	16.6	14.6	7.4	7.4
1998	6.0	8.9	11.8	19.0	24.3	27.1	25.8	25.5	23.8	15.7	11.1	7.3	6.0
1999	6.4	8.2	12.8	18.9	24.8	26.0	25.5	23.9	23.6	18.7	10.1	8.4	6.4
2000	5.1	8.1	11.6	18.1	23.7	25.3	25.2	24.8	21.9	15.8	13.3	8.9	5.1
2001	5.6	8.6	14.3	19.6	24.3	25.3	25.7	25.3	23.9	19.0	11.3	7.6	5.6
2002	6.9	7.2	14.1	18.3	23.2	25.7	25.6	24.8	23.0	15.3	13.3	9.0	6.9
2003	4.9	11.1	10.6	19.3	22.0	26.3	25.1	25.8	24.2	18.5	10.9	8.0	4.9

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2004	6.7	8.0	12.3	21.5	21.3	26.2	25.1	25.5	22.8	16.2	13.7	5.9	5.9
2005	7.7	7.9	16.3	17.9	23.2	26.6	25.0	25.2	24.0	18.9	12.9	7.1	7.1
2006	6.3	11.6	15.0	19.9	24.1	25.5	25.2	24.6	23.7	17.1	10.3	8.5	6.3
2007	6.8	11.2	12.9	20.8	24.1	26.2	24.5	24.7	23.6	17.3	12.9	6.6	6.6
2008	7.3	6.3	14.8	19.0	25.3	24.7	25.5	25.0	23.4	16.6	11.4	10.4	6.3
2009	8.1	10.2	13.2	19.9	23.8	26.2	26.1	25.0	23.5	15.7	10.0	6.7	6.7
2010	6.4	7.9	15.2	21.3	24.7	26.0	25.1	25.0	21.9	17.1	13.1	6.9	6.4
2011	6.0	10.7	11.5	18.8	22.8	26.2	25.0	24.6	23.2	15.7	12.8	7.0	6.0
2012	6.2	7.2	13.7	21.6	24.5	27.0	25.9	25.4	21.9	14.0	9.1	4.7	4.7
2013	2.5	9.1	13.7	19.6	23.9	25.7	26.1	25.1	23.9	17.2	11.8	7.6	2.5
2014	6.1	8.8	14.1	19.8	24.7	26.2	25.8	25.4	23.3	17.1	11.3	6.6	6.1
2015	6.8	8.0	13.6	20.4	24.5	25.1	25.1	24.9	22.7	18.7	16.7	8.0	6.8
2016	6.7	10.1	18.5	21.0	25.1	26.4	24.8	24.6	24.7	19.1	11.7	8.8	6.7
2017	5.0	11.0	13.1	19.0	23.3	26.5	25.4	24.9	25.1	18.2	10.2	8.3	5.0
2018	5.2	11.2	15.0	21.1	22.6	25.6	26.2	25.2	22.2	17.7	13.9	6.7	5.2
2019	7.4	9.0	11.2	20.3	22.6	26.4	25.5	25.5	23.1	17.9	14.0	4.5	4.5
2020	6.1	7.2	14.3	18.7	22.4	25.6	25.6	25.4	24.5	18.3	10.8	6.2	6.1
2021	6.3	6.9	15.7	19.0	23.4	25.0	25.1	24.9	24.2	16.0	11.9	5.3	5.3
Average	**6.6**	**9.1**	**13.8**	**19.3**	**23.6**	**25.9**	**25.4**	**25.1**	**23.2**	**17.1**	**12.0**	**7.6**	**6.2**

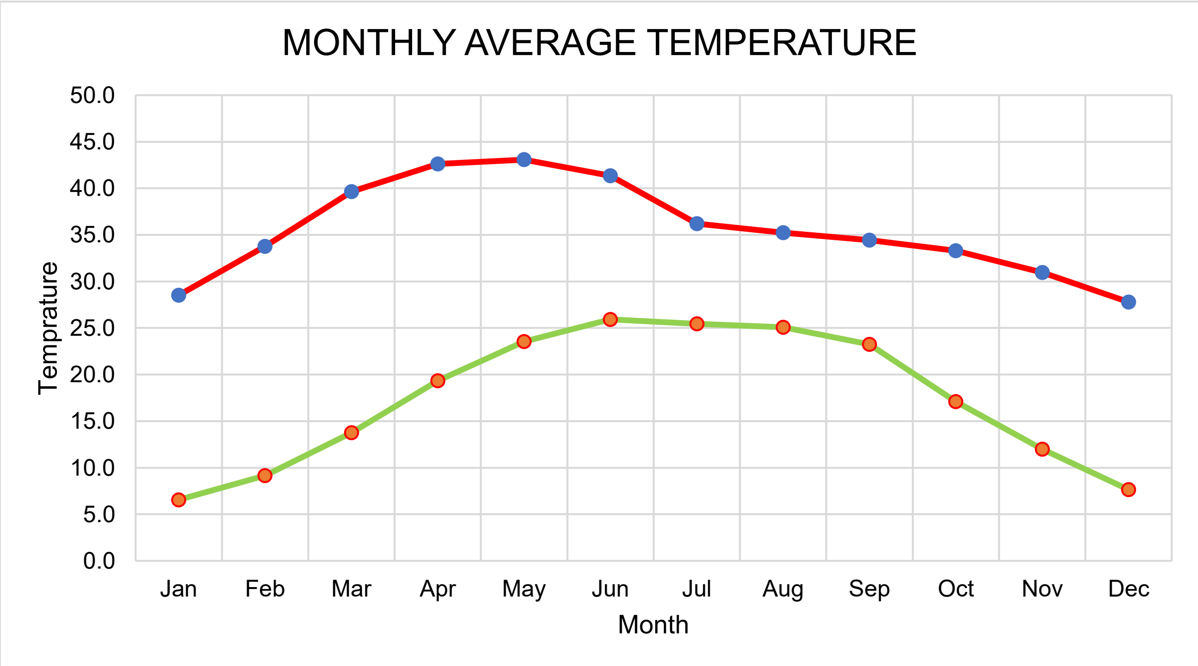


Figure 2.7 Monthly Average Temperature Variation at Project Site

2.5 Topographic Information

Topographic survey has been conducted for the site. The ground levels at the site, broadly, vary from RL +13.00 to RL +29.00 m. The survey plan along with contours is shown in the Figure 2.8. The detailed topographic survey is presented in the Drawing No. ENL002.

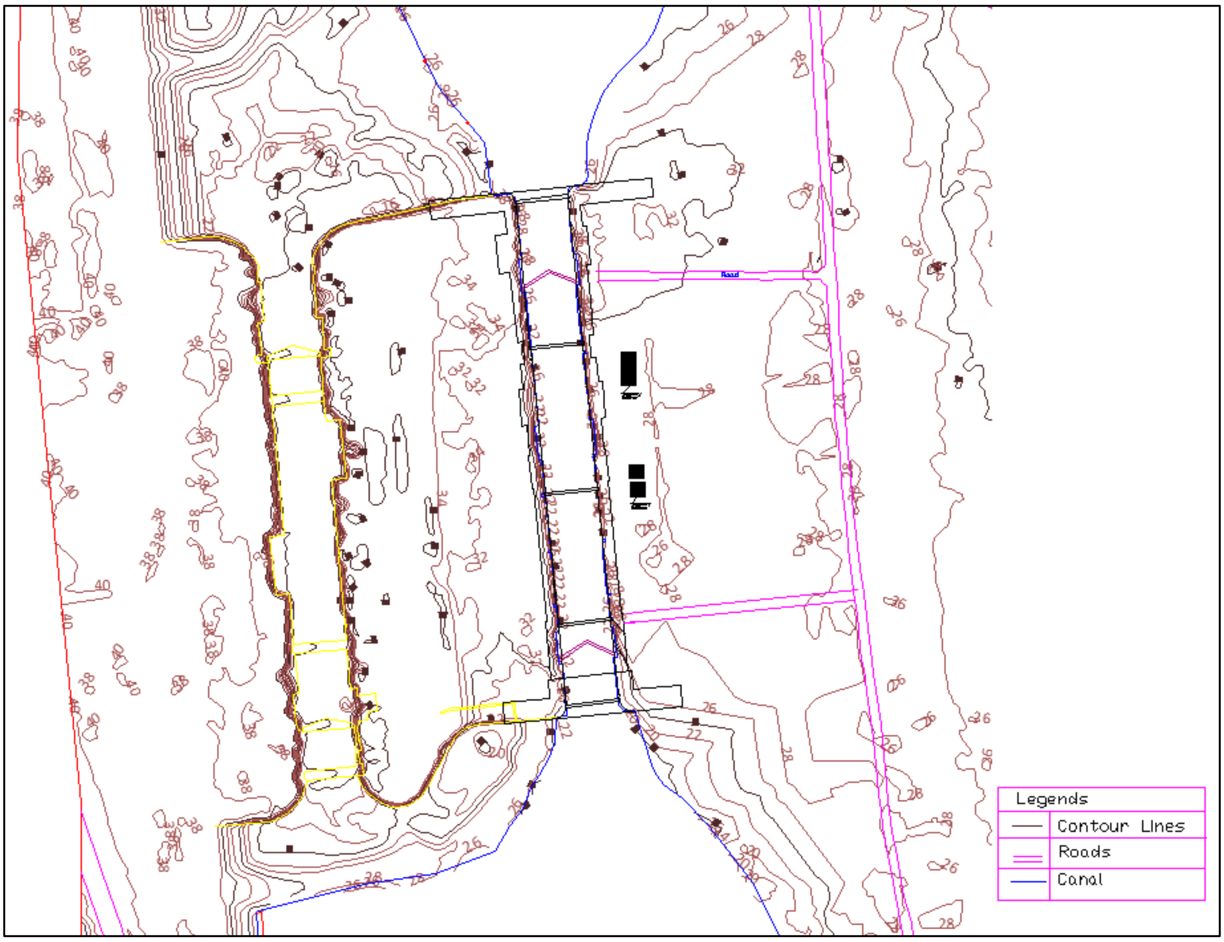


Figure 2.8 Topographical plan of the navigation locks

2.6 Hydrological Information

The water levels U/S and D/S of the existing navigation lock as mentioned in the Operation Maintenance Manual for the existing Lock are given in Table 2.6.

Table 2.6 Water Level at navigation lock

High Water Level U/S	RL +26.30 m
Low Water Level U/S	RL +18.288 m
High Water Level D/S	RL +24.38 m
Low Water Level D/S	RL +18.288 m

2.7 Geotechnical Data

As per the condition survey, the renovation and modernization work of existing navigation lock shall not require any major foundation to be constructed. However, new parking bay for the caisson gates storage is proposed on the left bank one each on the upstream and downstream of the existing navigation lock. The geotechnical investigation report of the DPR of new navigation lock as well as the geotechnical investigation report prepared by the EPC contractor during execution of the new navigation lock has been considered. As the existing geotechnical reports of the new navigation lock are in the area lying in the immediate vicinity of the existing navigation lock on the opposite bank of the approach channel the past geotechnical investigation report has been considered in the design of foundations for caisson gate parking bay of the existing navigation lock. As per the geotechnical report of the DPR on new navigation lock, borehole BH-2 and BH-10 are the nearest to the new parking bay area for caisson gate and located on the right bank of the existing lock chamber, these boreholes can represent the soil and geotechnical properties required for the design of parking bay of existing navigation lock. The location of borehole BH-2 and BH-10 are shown in the Figure 2.9 and the layer details and generalized soil profile as per DPR of new Farraka navigation lock are shown in Figure 2.10. From the interpreted soil profile as per the DPR soil layers has been identified and given in Table 2.7:

Table 2.7 Generalized soil profile as per DPR of Farraka navigation lock

BH-2		**BH-10**	
RL (m)	**Geotechnical Description**	**RL (m)**	**Geotechnical Description**
22.8 to 18.3	Fill	26 to 18.5	Stiff silty clay
18.3 to 4.3	Stiff silty clay	18.5 to 8	Stiff to very stiff silty clay
4.3 to (-2.6)	Stiff to hard stiff silty clay	8 to (-1)	Stiff to hard stiff silty clay
(-2.6) to (-9.2)	Decomposed laterite rock	(-1) to (-4.5)	Decomposed laterite rock

From Table 2.7, it can be inferred that at foundation level (about 14 m amsl) is of stiff to very stiff silty clay. The above interpretation of geotechnical report of the DPR of new navigation lock has been also cross checked with geotechnical report at the time of execution of the new navigation lock. As per the EPC geotechnical report borehole NBH-2 and NBH-12 which are located on the right bank at symmetrical location (Figure 2.11) where the proposed parking bay is located. Generalized soil profile of the NBH-2 and 12 is given in Figure 2.12:

Table 2.8 Generalized soil profile as per EPC of Farraka navigation lock

Generalized sub-surface soil model for U/s & D/s Slope protection	
RL (m)	**Geotechnical Description**
28.44 to 16.5	Stiff silty clay
16.5 to 10	Stiff silty clay
10 to (-3)	Very stiff silty clay
(-3) to (-20)	Weathered Rock (Intermediate Geo-Material)

From both the geotechnical reports (DPR and Execution) it can be inferred that at the foundation level stiff to very stiff silty clay is observed. Therefore, in further calculation the properties of stiff to very stiff silty clay has been used.

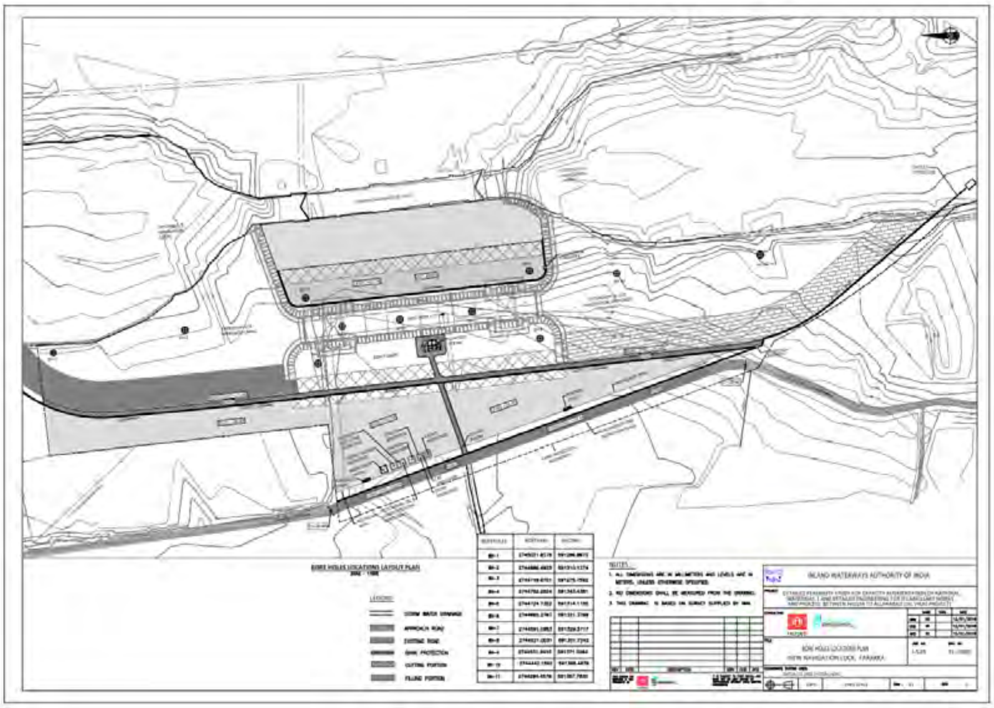


Figure 2.9 Boreholes location for the new navigation lock

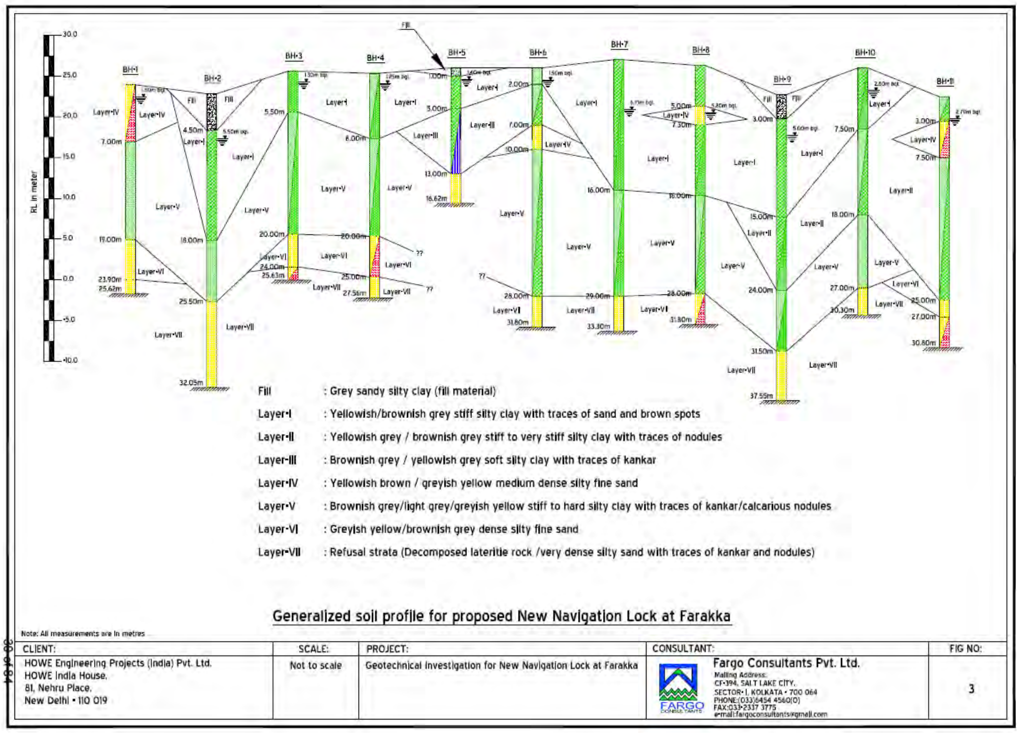


Figure 2.10 Generalize soil profile as per the DPR of the new navigation lock

Figure 2.11 Location of boreholes

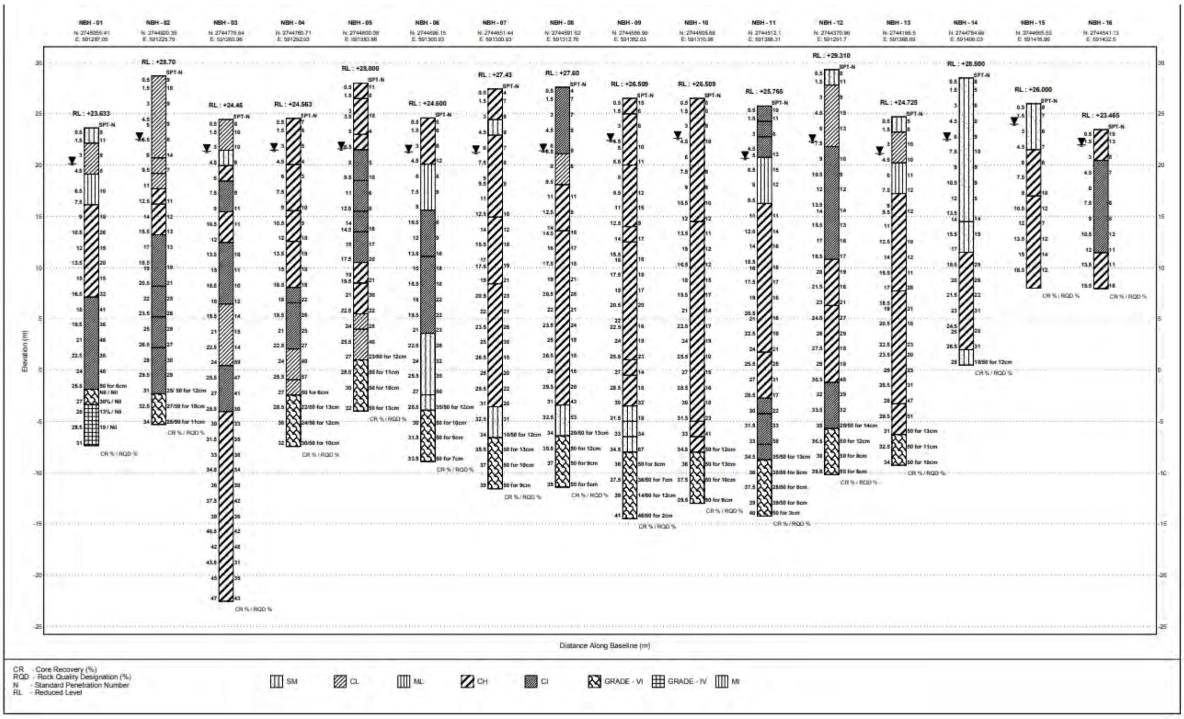


Figure 2.12 Generalize soil profile as per the EPC contractor of the new navigation lock

3 COMPONENTS OF EXISTING NAVIGATION LOCK

Existing navigation lock consist of the following main components:

- Lock Chamber and approach structures
- Filling Emptying Arrangement
- Main Operating gates, i.e., mitre gate, radial gate, bulkhead gate and caisson gate
- Mooring Arrangement

3.1 Lock Chamber and Approach Structures

The lock chamber base slab and retaining walls is of reinforced concrete. The length of the lock is 250m and mitre to mitre length of lock is 179.8 m with the clear width between the two banks is 25.148m. The depth of the lock varies from 12.89m at u/s to 10.89m at d/s. There are overhead structures for electrical cables to west bank from control rooms near u/s and d/s mitre gate. There are rung ladders on both side (east and west bank) for getting down inside lock. The dimension of the lock and other features are shown in Figure 3.1.

The lock chamber is primarily of unreinforced mass concrete, although reinforcement is used where necessary. The chamber structure is fitted with recesses for the mitre gates, caisson stop lock gates and floating bollards. The chamber is fitted with provisions of mooring hooks, ladders and wooden fenders rubbing strips.

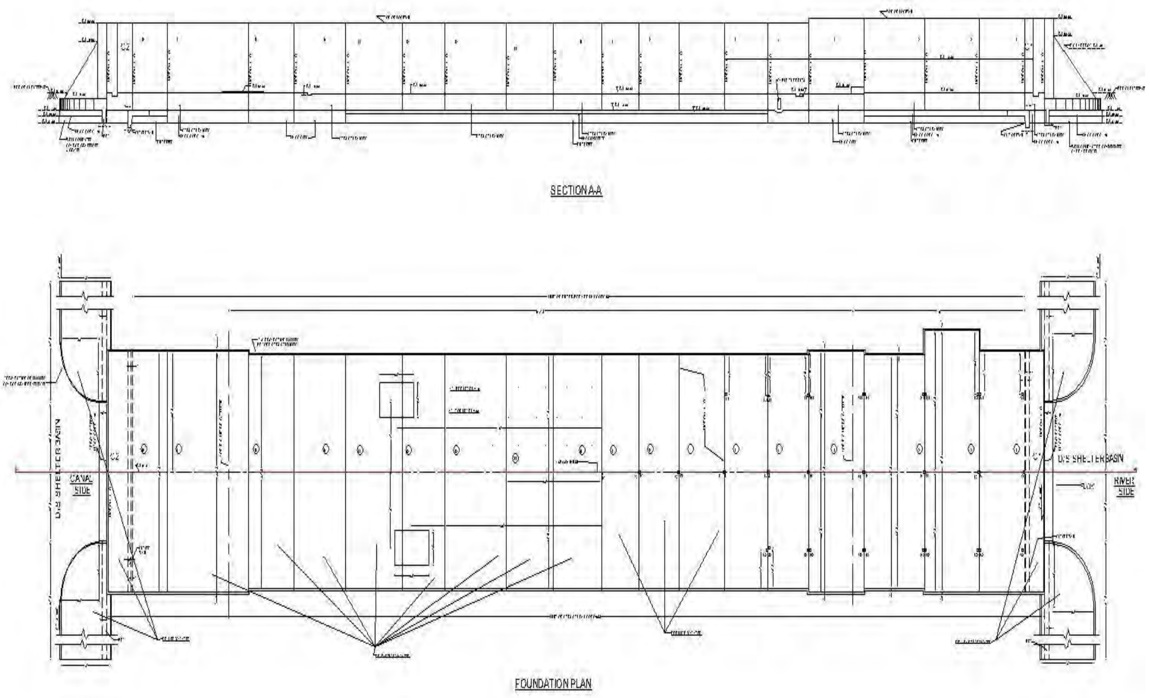


Figure 3.1 Plan and section of the existing lock

The Lock head structures forming the entrances to the lock are also mass concrete structures and are integrated with the lock chamber structure. These are shaped to provide robust rounded bull nose approach structure, and are also fitted with wooden fender rubbing strips as shown in Figure 3.2.

The chamber walls incorporate the culverts of the lock filling and emptying system, with inlets and outlets at each end of the lock chamber and the lock head structures as shown in Figure 3.3. The lock floor is also constructed of reinforced concrete. The lock chamber counterfort type retaining walls are made up of concrete mix of 1:3:6 and 1:4:8 whereas the base slab and cut-off are made up of concrete mix of 1:3:6.

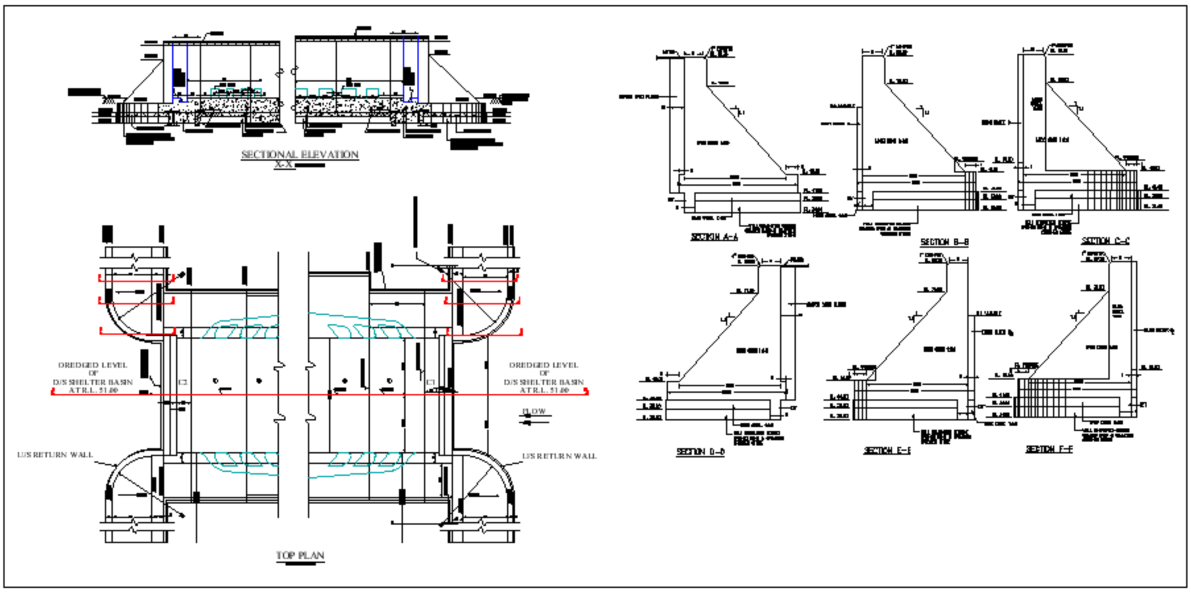


Figure 3.2 Approach structure of the existing navigation lock

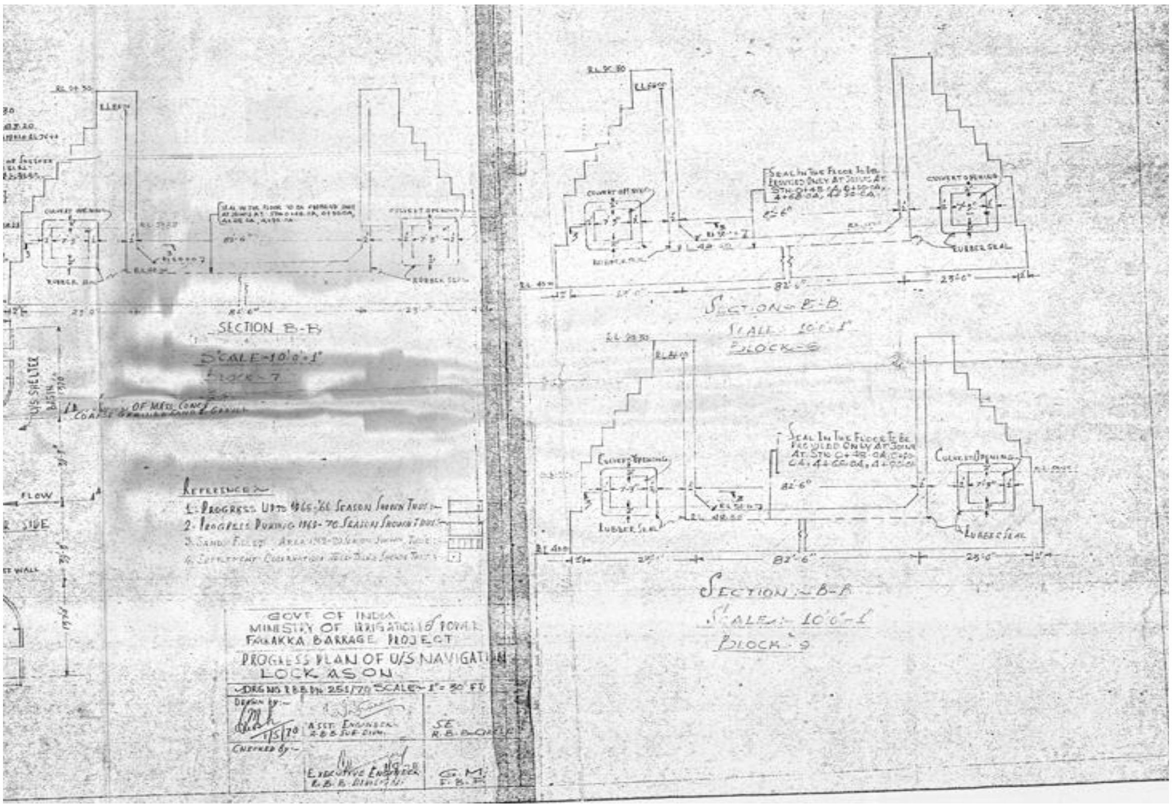


Figure 3.3 sectional view of side wall and base slab of the existing navigation lock

3.2 Filling Emptying System

The lock is filled using filling culverts running on either side of the upstream mitre gates, with inlets on each side of the lock head structure, and outlets in the walls inside the chamber and downstream of the upstream mitre gates. Similarly, the lock is emptied using emptying culverts running on either side of the downstream mitre gates, with inlets inside of the lock chamber on each side of the lock, and outlets in the walls outside the downstream mitre gates. The details of the existing inlet outlet arrangement are shown in Figure 3.4.

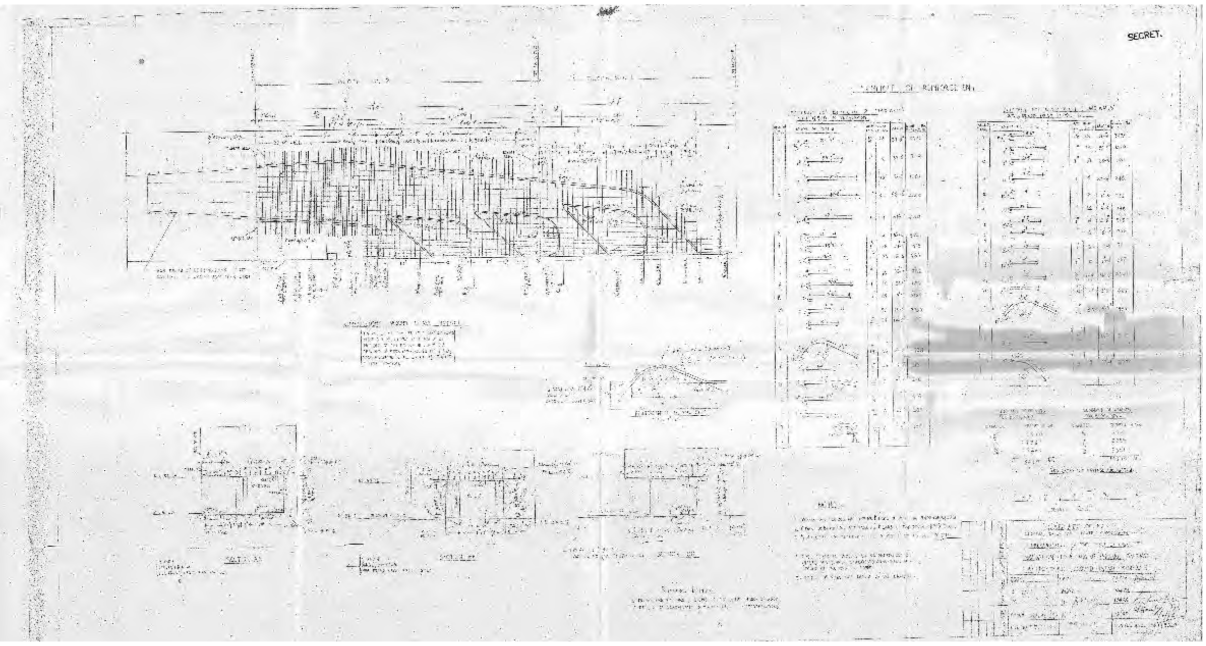


Figure 3.4 sectional view of side wall and base slab of the existing navigation lock

3.3 Mitre Gate

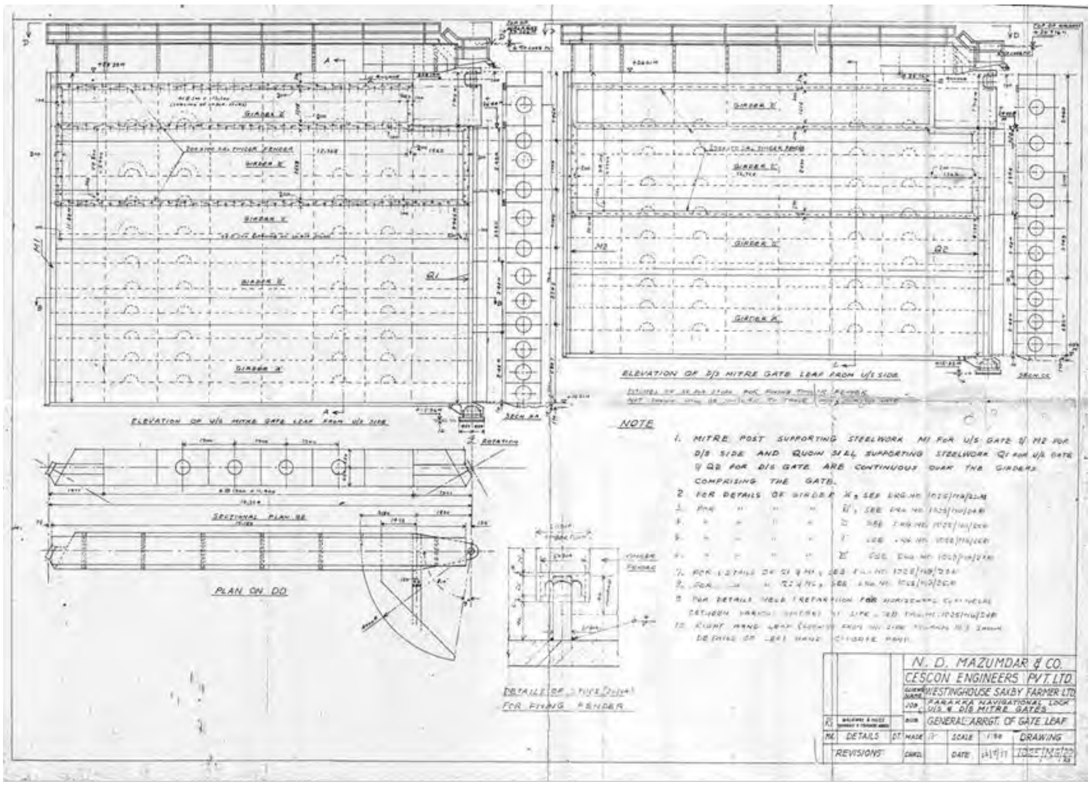
In the existing navigation lock, there are two mitre gates. Mitre Gates is one at upstream and another at downstream of the lock to facilitate the opening and closing operation. Mitre gates are double leaf hinged type which is most commonly used. The Mitre gate is hinged about the vertical axis. Each mitre gate comprises of mainly:

- Pair of mitre gate leaf with hinges, pintles.
- Bottom seals and timbal mitering face.
- Quoin seal
- Sector arm at top of gate leaf with pulleys and wire ropes to hoisting drums rotated by gear boxes (primary and secondary) driven by electric motor of 1 hp controlled by remote or local control boards
- Electromagnetic brake
- Manual operation for hoisting system with hand breaks

As per the manual only one pair of gates are operated at a time, other pair of gates remains closed. Before operation of lock, water level in lock and canal level are equalized by operating radial valve gates. The Mitre gates are designed for the differential water head considering maximum water level i.e., 26.3 m on the U/S side and minimum water level on D/S since lock is required to be emptied for maintenance. Details of the existing mitre gate is given in Table 3.1 and shown in Figure 3.5.

Table 3.1 Details of the mitre gate

Mitre Gate Leaf Length	15.354
Mitre Gate Top Width	1.300
Mitre Gate Height (U/S)	11.880
Mitre Gate Height (D/S)	10.110
Mitre Gate Bottom Level (U/S)	15.545
Mitre Gate Bottom Level (D/S)	15.240
Mitre Gate Weight	90 Ton (U/S) to 85 ton (D/S)
Mitre Gate Angle from U/S wall at Full Closure	60 Degree



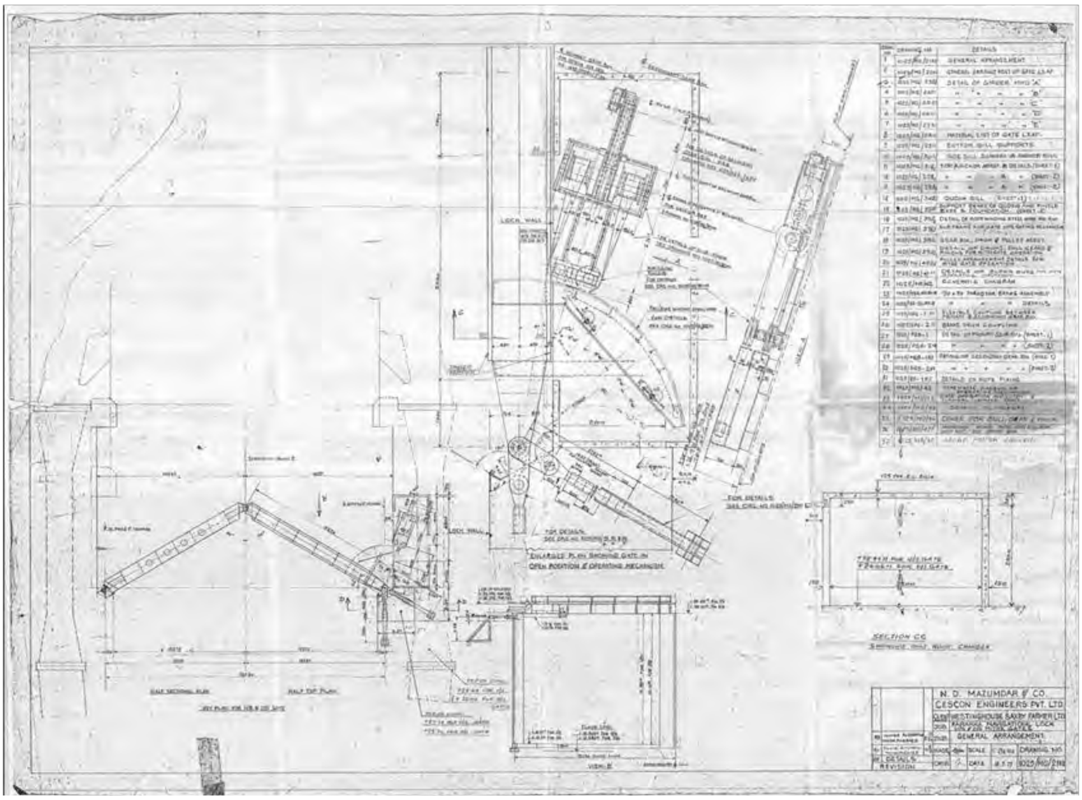


Figure 3.5 Plan and section of the existing mitre gate

3.4 Radial Gates

Four (4) Nos. Radial gates are there, 2 Nos. at U/Sand 2 Nos. at d/s, one each on both side of lock for filling and emptying of the lock chamber to facilitate navigation of inland water transport vessels. The radial gates shall consist of curved skin plate supported on vertical stiffeners which in turn rest on horizontal girders. The horizontal girders are supported by radial arms emanating from the trunnion hubs located at the axis of the skin plate cylinder. The arms transmit the water thrust to yoke girder.

Radial gates serve the purpose of filling and emptying of the lock chamber and comprises of mainly

- Radial gates steel structure with seals and trunnions pins jointed arm connecting gates and bull wheel rope drum (rope to bull wheel) driven through gear boxes (primary and secondary) connected to 1 H.P motor controlled by remote control board or local control
- Limit switch governing radial gates limit to 45°29'
- Manual operation handles for turning bull wheel

Radial valves are usually in closed position for maintain desired water level and only one pair either u/s and d/s as required are opened for operation of mitre gates and closed when water level has been equalized. Sectional view of the existing radial gate is shown in Figure 3.6.

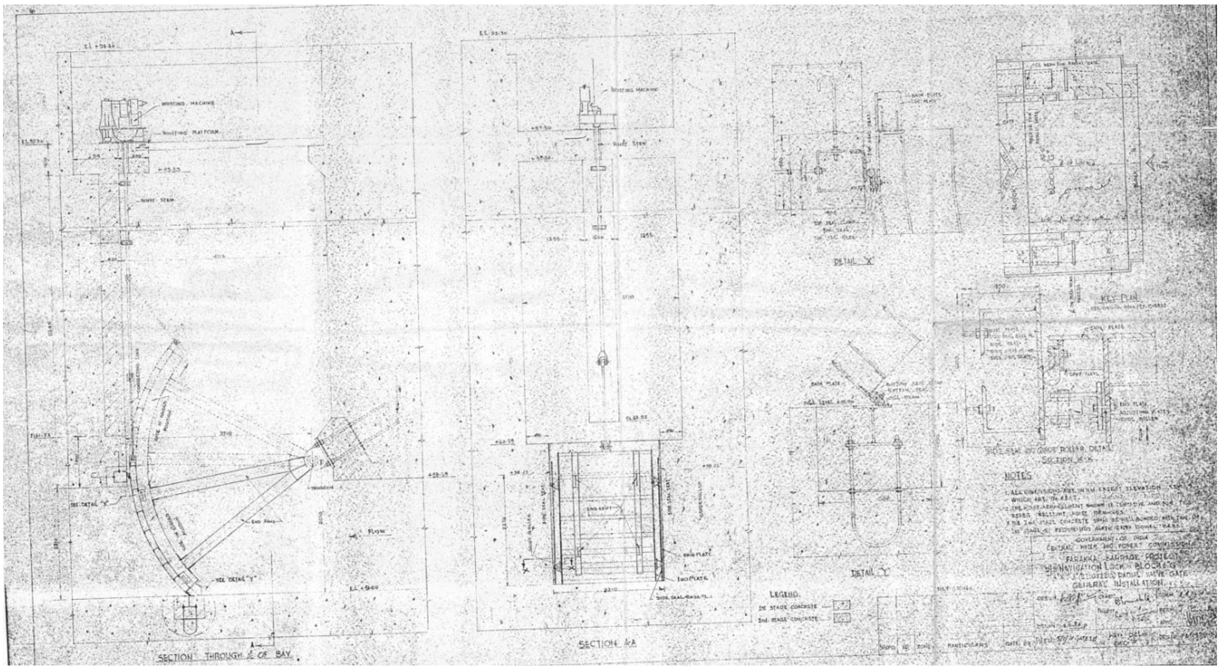


Figure 3.6 Sectional view of the existing radial gate

3.5 Caisson gate

Two-no of caisson gate are to be used when mitre gates need servicing – maintenance/ repair/ replacement. There are a total of 5 grooves for installation of caisson gates with 2 grooves for each pair of mitre gate and one in the middle section of the lock. Gates can be installed vertically at both end of the lock for stopping water flow from U/S and D/S of lock chamber only when Mitre gates are required to be attended for repairs. The plan and section of the existing caisson gate is shown in Figure 3.7. Main components of the caisson gates are:

- Caisson floating body
- Cast iron permanent ballasts at bottom
- Wooden fendering at both ends and koolat bottom (3 side)
- Scuttle tank 4 nos. inside caisson box
- Trimming tanks 2 no inside the caisson box all connected to motor driven pump sets and pipe line.

- Manhole on top deck to ladder to caisson box
- Heel indicators on top to check uprightness
- Mooring ropes

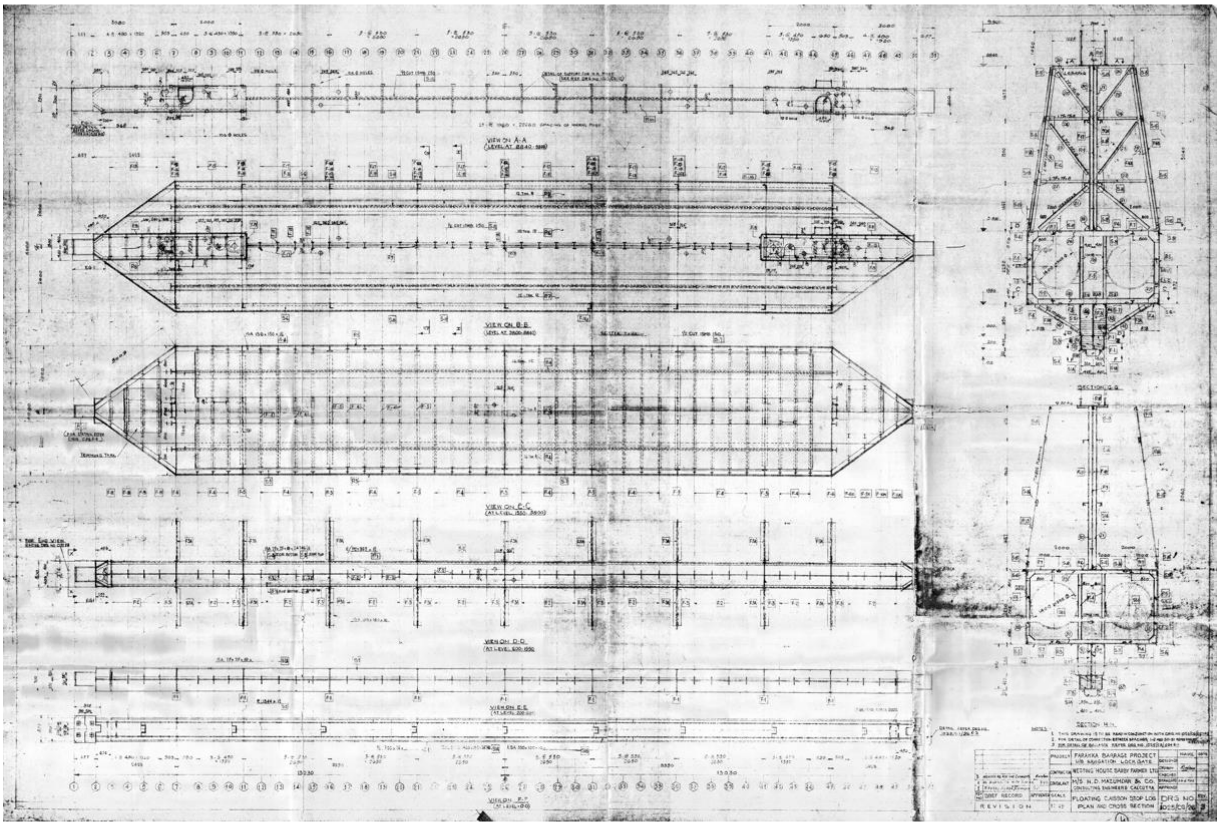


Figure 3.7 Plan and section of the existing caisson gate

3.6 Bulkhead gate

For repair of Radial gates, there are Eight (8) bulkhead gates one at inlet and one at outlet for all feeder culverts. There are four sets of bulkhead gates of three different lengths namely Type 'A', 'B' and 'C'. Type 'A' and 'B' are for upstream radial gates and Type 'C' is for downstream radial gates. Main components of the bulkhead gates are:

(a) Side rollers with pin and bearing

(b) Side and bottom rubber seals with seal on lock pockets

(c) Valve in bulkhead gate body

(d) Lifting beams

Plan and section of the existing bulkhead gate of the navigation lock is shown in Figure 3.8.

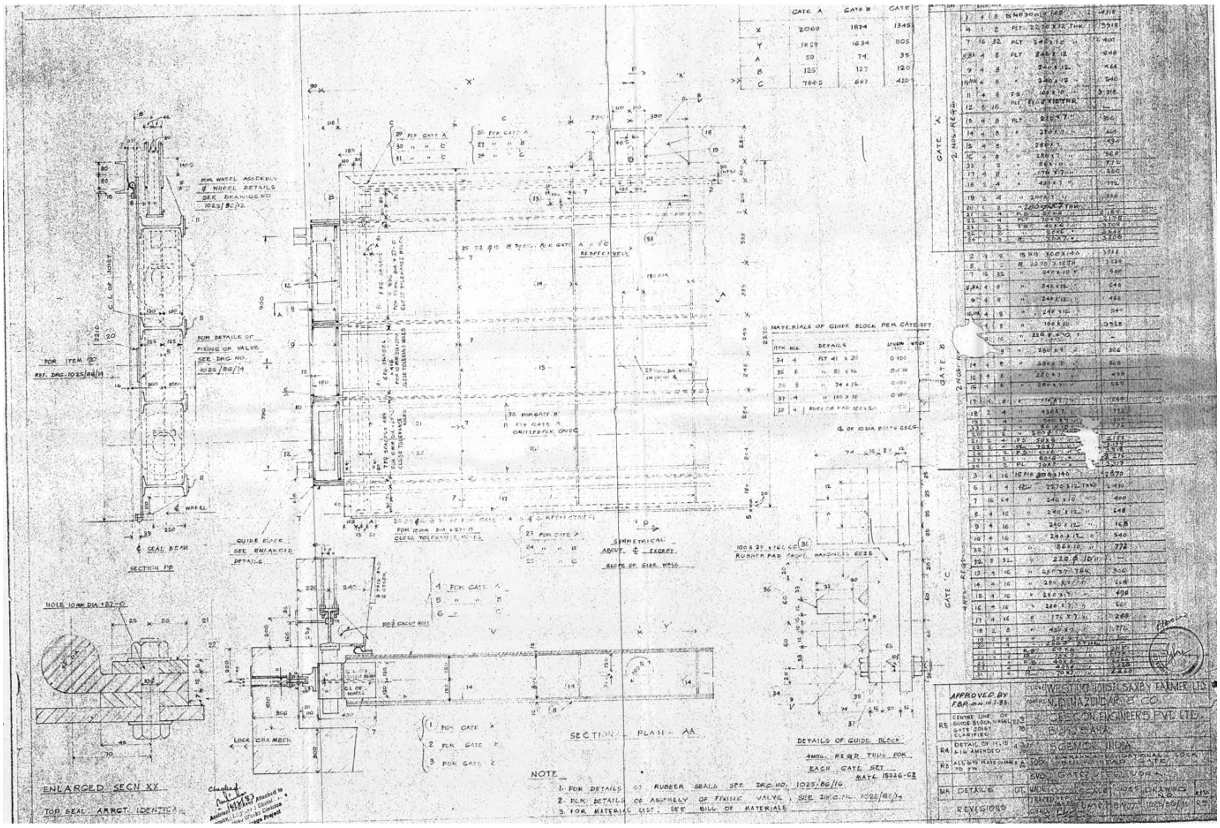


Figure 3.8 Plan and section of existing bulkhead gate

3.7 Mooring Arrangement

Conventional moorings systems viz. floating and fixed bollards have been used in the existing navigational lock. There are Bollards – eight (8) numbers floating type (four (4) on each bank) and fourteen (14) numbers fixed type (seven (7) on each bank). The floating type bollard comprises of a water tight floating body with bit on top and side rollers for sliding up & down the pocket wall lifting hock. The plan and section of the existing mooring equipment is shown in Figure 3.9

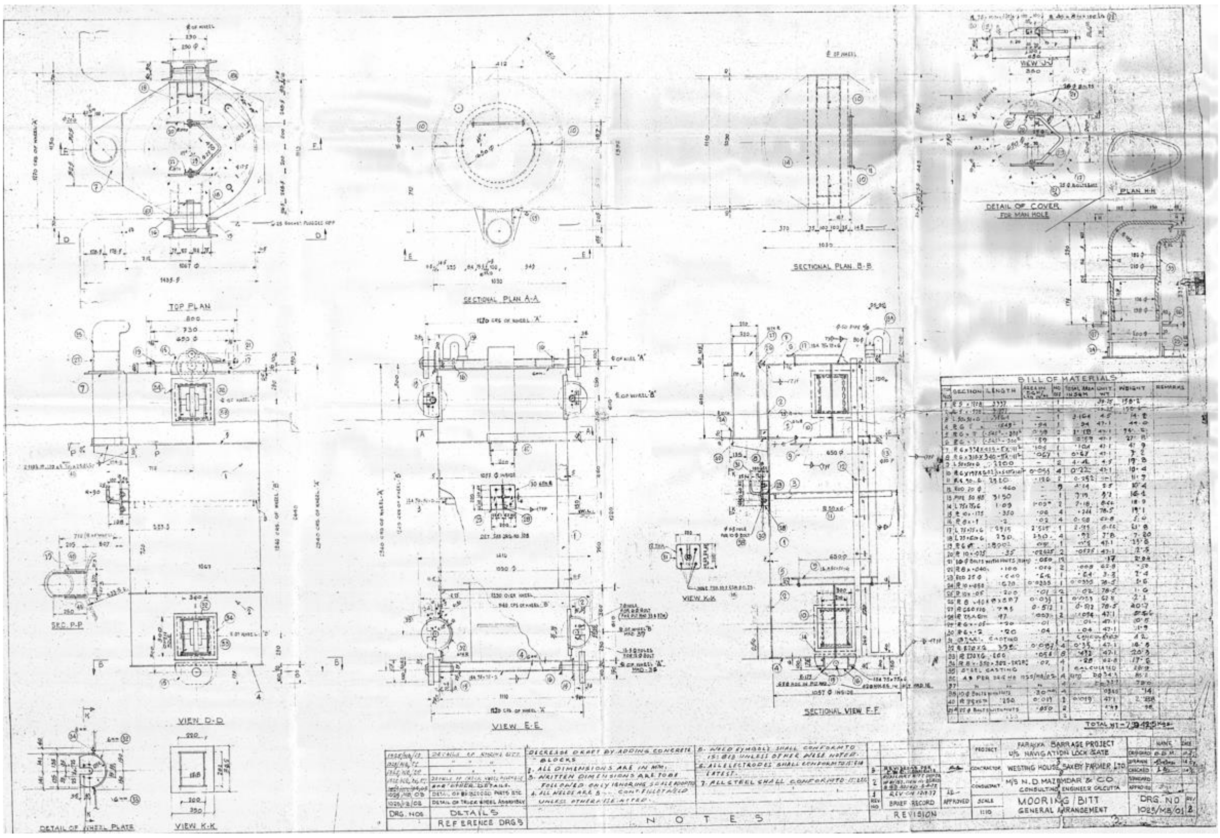


Figure 3.9 Plan and section of the existing mooring equipment

3.8 Control room and wiring

Central control room is located on the east bank of the navigation lock and 4 local control rooms is located in the upstream and downstream of the existing lock on either side near the mitre gate leafs. Electrical power of 400/440v is supplied from central control room to local control room near the upstream and downstream mitre gate. The power requirement is to drive the hoist motors of the mitre and radial gate through control boards. Location and wiring layout of the existing electrical cable network is shown in Figure 3.10.

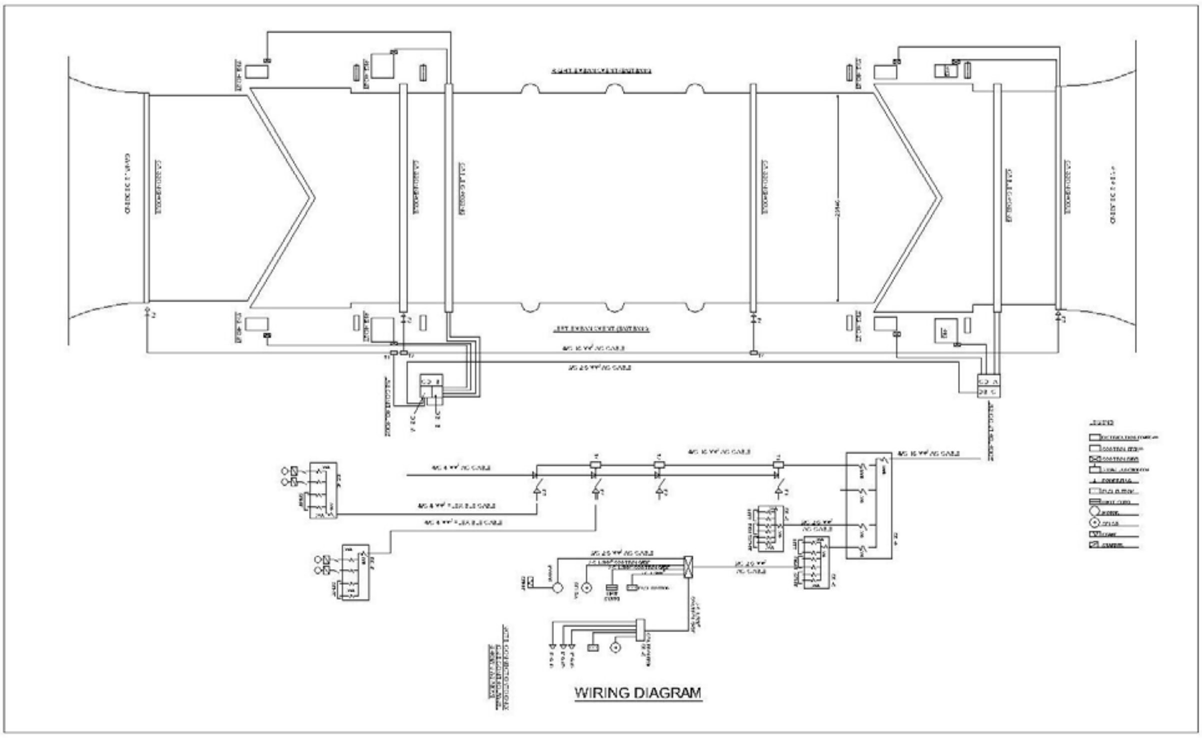


Figure 3.10 Existing electrical wiring network of the navigation lock

3.9 Time of Operation of the Lock

The complete set of operations of gates with movement of vessels was observed and the current time taken for each component was noted and compared with the new navigation lock. The total time for one operation is currently around 68 minutes for average water levels which is much higher as compared to 38 minutes designed in new lock. As per the Manual on Design of Locks, Intake and discharging systems, Netherlands, the optimum time should be about 30-45 minutes. It is necessary to bring down the time of operation of the existing lock to bring it to international standards.

The details of the time taken in the existing and under construction lock is given in Table 3.2 and 3.3 respectively.

Table 3.2 Time taken in movement of Vessels through Existing Navigation Lock (Operation Time)

Vessel movement U/s to D/s		Vessel movement D/s to U/s following the U/s to D/s movement	
Normal Scenario, average water level both U/s and D/s (water level in lock equal to D/s level and D/s Mitre gate considered open)		Normal Scenario, average water level both U/s and D/s (water level in lock equal to D/s level and D/s Mitre gate considered open)	
Activity	**Time (min)**	**Activity**	**Time (min)**
D/s Mitre gate closing	10	Travel time	5
U/s radial gate opening	4	D/s Mitre gate closing & U/s radial gate opening	10
Lock Filling up to WL in U/s channel	7	Lock Filling upto WL in U/s channel	7
Opening U/s Mitre gate & U/s radial gate closing	10	Opening U/s Mitre gate & U/s radial gate closing	10
Travel time (into the lock)	5	Travel time	5
U/s Mitre gate closing & D/s radial gate opening	10	Total	37
Lock Emptying to WL in D/s channel	7		
Opening D/s Mitre gate & D/s radial gate closing	10		
Travel time (out of lock)	5		
Total	68		

Table 3.3 Time taken in movement of Vessels through New Navigation Lock (Operation Time)

Vessel movement U/s to D/s		Vessel movement D/s to U/s following the U/s to D/s movement	
Normal Scenario, average water level both U/s and D/s (water level in lock equal to D/s level and D/s Mitre gate considered open)		Normal Scenario, average water level both U/s and D/s (water level in lock equal to D/s level and D/s Mitre gate considered open)	
Activity	**Time (min)**	**Activity**	**Time (min)**
D/s Mitre gate closing	5	Travel time	5
U/s radial gate opening	2	D/s Mitre gate closing & U/s radial gate opening	5
Lock Filling upto WL in U/s channel	3	Lock Filling upto WL in U/s channel	3

Opening U/s Mitre gate & U/s radial gate closing	5
Travel time (into the lock)	5
Activity	Time (min)
U/s Mitre gate closing & D/s radial gate opening	5
Lock Emptying to WL in D/s channel	3
Opening D/s Mitre gate & D/s radail gate closing	5
Travel time (out of lock)	5
Total	38

Opening U/s Mitre gate & U/s radial gate closing	5
Travel time	5
Activity	Time (min)
Total	23

4 CONDITION SURVEY

4.1 Structural Health Assessment

Structural Health Assessment (SHA) aims to assess the behaviour of structures, evaluate the performance of materials during the life cycle and give a diagnosis of the "state" of the constituent materials, of the different parts, and the structure as a whole. It refers to the process of implementing a damage detection and characterization strategy for various engineering structures. In an effective Structural management program, strategies for life extension, upgrade, and replacement strategies must be developed.

Any structure after its construction deteriorates due to loading or environmental impacts. Thus, there is a variation in the strength of the structure after it is built in place. If this variation is under a certain threshold limit, the structure is considered as damage-free; otherwise, the structure is considered as damaged, which, eventually may fail. Here, the damage is defined as changes to the material and/or geometric properties of a structural system, which adversely affects the system's performance.

The methods used are based on Visual Inspection and instrument-based Non-Destructive Testing (NDT). The instrument-based NDT includes Ultrasonic Test. Different parts influence the selection of the monitoring method used. Structural phenomena to be studied which include Inclinations, Crack detection and localization, Crack widths, Foundation settlements, Corrosion. The parameters causing these phenomena can be forces, stresses, displacements, rotations, vibrations, and strain or environmental parameters such as temperature, humidity, precipitation, wind etc.

The available SHA procedures for damage detection are classified into four levels as:

- ✓ Level 1- Determination if the damage is present in a structure,
- ✓ Level 2- Determination of the geometric location of the damage,
- ✓ Level 3- Assessment of severity of the damage and
- ✓ Level 4- Prediction of remaining (residual) life of the structure.

The condition survey and assessment will include the following components:

- Visual Inspection
- Non-Destructive Testing
- Ultrasonic Testing

4.1.1 Visual Inspection

Visual Inspection (VI), or visual testing (VT), is the oldest and most basic method of inspection. In its simplest form, visual inspection is the process of examining a component or piece of equipment using one's naked eye to look for flaws. Visual inspections are generally performed as a precursor to more advanced inspection techniques that are capable of detecting flaws beyond what the human eye can see, such as subsurface cracks. Optical aids such as illuminators, mirrors, borescopes, etc. can be used to enhance one's capability of visually inspecting equipment. Cameras, computer systems, and digital image analyzers can also be used to further the capabilities and benefits of visual inspection.

Remote Visual Inspection (RVI) is an advanced form of visual inspection that uses various types of video probes, video borescopes, remotely operated cameras, robotic crawlers, and other specialized tools in order to remotely examine components. In doing so, the risks associated with confined space entry are considerably reduced.

In recent years, Remotely Operated Vehicle, commonly known as ROV, have seen increased adoption and usage for remote visual inspections of underwater structures that are difficult to reach by traditional means. This proposed methodology for underwater inspection has various advantages over manual operations including the ability to inspect in dark and flooded areas, otherwise constricted and risky zones with unlimited endurance, enhanced stability, and reliable data acquisition with repeatability. The results can aid the authorities rapidly make key decisions concerning repair, maintenance, and safety of the structure.

4.1.2 Non-Destructive Testing: Ultrasonic Pulse Velocity Method

Non-destructive testing (NDT) methods are techniques used to obtain information about the properties or internal condition of an object without damaging the object. Non-destructive testing is a descriptive term used for the examination of materials and components in such way that allows materials to be examined without changing or destroying their usefulness.

The principal objectives of the non-destructive testing of concrete in situ are to assess one or more of the properties of structural concrete. The ultrasonic pulse velocity (UPV) method is used for non-destructive testing of plain, reinforced and prestressed concrete whether it is precast or cast in-situ as shown in Figure 4.1.

An ultrasonic pulse velocity (UPV) test is an in-situ, non-destructive test to check the quality of concrete. It is used to examine the homogeneity, quality, cracks, cavities, and defects in concrete. In this test, the strength and quality of concrete or rock is assessed by measuring the velocity of an ultrasonic pulse passing through a concrete structure. This test is conducted by passing a pulse of ultrasonic through concrete to be tested and measuring the time taken by pulse to get through the structure. Higher velocities indicate good quality and continuity of the material, while slower velocities may indicate concrete with many cracks or voids.

Figure 4.1 Sample image of conducting UPV tests above water

The ultrasonic pulse is generated by an electro acoustical transducer. When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves is developed which includes longitudinal (compressional), shear (Transverse) and surface (Rayleigh) waves. The receiving transducer detects the onset of the longitudinal waves, which is the fastest. Any damage to the concrete will also be measured and recorded. The field measurement data is representative of the current state of the structure.

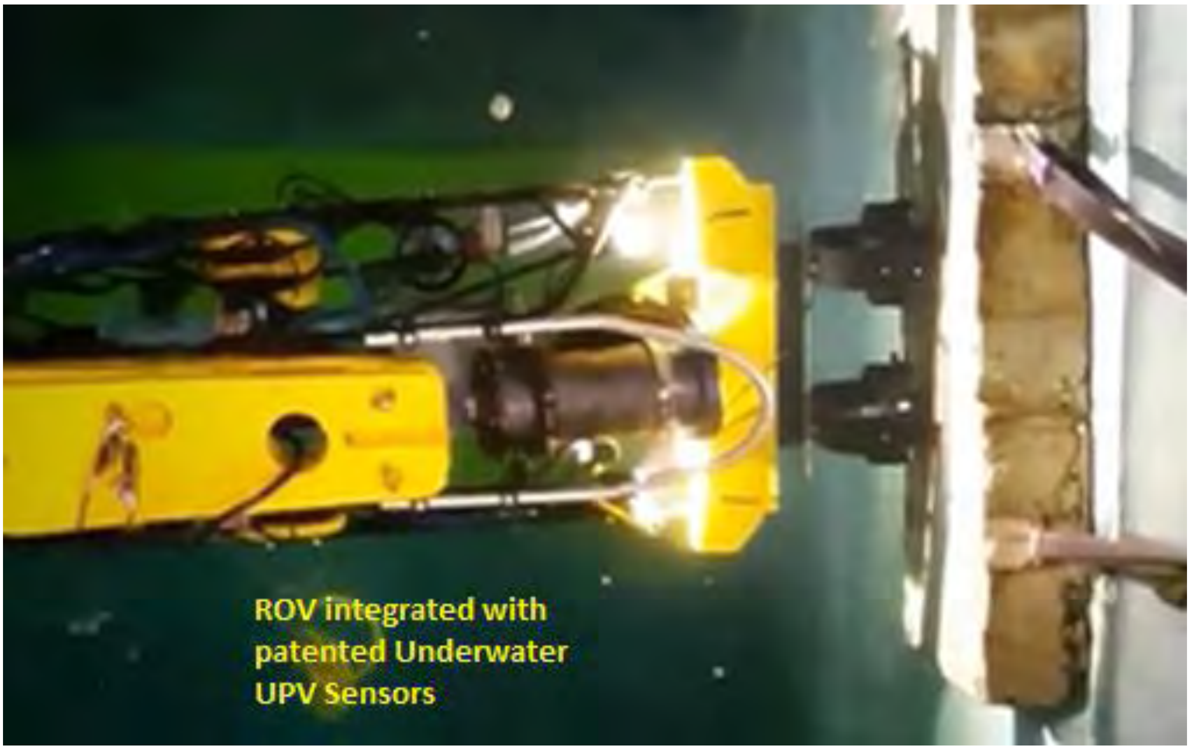


Figure 4.2 Sample image of conducting underwater UPV tests

Planys has built the World's first underwater UPV testing equipment and has conducted successful field trials for the same as shown in Figure 4.2. This helps disrupts the underwater NDT world and thus supports authorities in charge of billions of aging submerged assets worldwide take decisions on repair and maintenance.

4.1.3 Inspection for Corrosion

Appropriate tools to assist in measuring and defining corrosion damage include a depth micrometre (for pitting), feeler gages (for crevice corrosion), an ultrasonic thickness gage (for thinning), a ball peen or instrumented hammer (for corroded or loose rivets), a camera, a tape measure, and a means to collect water samples. When corrosion is observed, the type, extent, severity, and possible cause should be reported. If the corrosion is severe, the specific locations should be noted and the severity (amount of thinning, etc.) should be quantitatively determined. Common NDT methods that can be applied for inspecting structures for corrosion damage include Visual Testing inspection and Ultrasonic Testing inspection.

The extent of paint system failure and regions of localized discoloration of structural components should be recorded. In areas where paint failure has occurred, the surface should be visually examined for pitting. When pitting is present, it should be quantified using a probe type depth gauge following guidance specified in ASTM G46.

Ultrasonic inspection is useful when corrosion appears to have caused significant thickness loss in critical components and can be used to obtain a baseline reference for thickness. The thickness of a steel plate or part can be determined to an accuracy of ±0.01 cm (0.005 in.). The technique can be performed through a paint film or through surface corrosion with only a slight loss in accuracy. Ultrasonic transducers are available in a number of sizes. Ultrasonic inspection is useful in determining both general and localized thickness loss due to corrosion, even on curved skin plates. Ultrasonic inspection can be used when only one side of a component is accessible. The open surface can be scanned with the transducer to identify thickness variation over the surface and to determine where corrosion has occurred. Ultrasonic inspection to determine thickness is generally not reliable when pitting corrosion is prevalent, because the size and depth of the pitting impair the output signal of the transducer.

Underwater Ultrasonic Thickness Gauging (UTG) technology can be used to determine the thickness of the steel material submerged under water. UTG sensor is attached in the front side of the ROV and integrated with the ROV systems. The ROV will be lowered at the Gate locations where UT measurements are to be performed and accordingly the ROV would will take readings across the all the submerged portions of the gate structures.

4.2 Condition Survey

Based on the site reconnaissance and inputs from the condition survey team the following tests have been undertaken in order to assess the overall health of the navigational lock:

1. Underwater visual inspection (VI) of the lock chambers including the side walls and base slab, lock gates (mitre and radial gates) using Remotely Operated Vehicle.
2. To carry out above water and Underwater non-destructive tests of the concrete walls of Lock using Ultrasonic Pulse velocity (UPV) technology.
3. To carry out Underwater non-destructive tests of the steel gates walls (mitre gates) of lock using Ultrasonic Thickness Gauging (UTG) technology.

The area of inspection for condition survey is given in Table 4.1 and Figure 4.3

Table 4.1 Area of inspection of the condition survey Tests

Area of Inspection	1. East and West side wall
	2. Base Slab
	3. Mitre Gate East Side Gate 1 and 2
	4. Mitre Gate West Side Gate 1 and 2
	5. Radial Gates
	6. Caisson Gate
	7. Bulkhead Gate

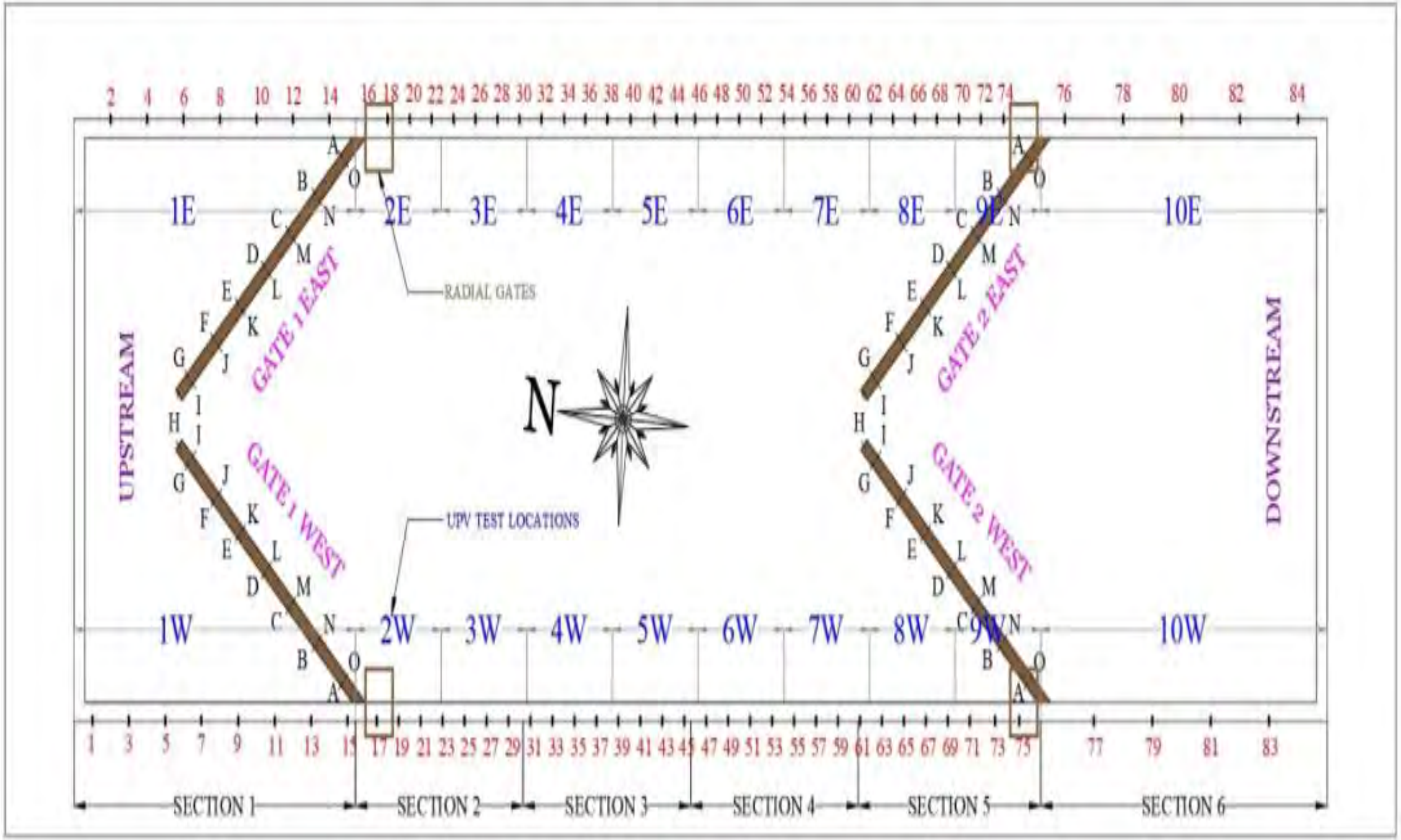


Figure 4.3 Location plan of the condition survey tests

The condition survey was conducted between 29th March to 12th April 2022 which included underwater visual inspections, above water and underwater Ultrasonic Pulse Velocity (UPV) test and underwater Ultrasonic Testing (UT) to determine the health of the navigational lock chamber concrete and the hydromechanical equipment / gates. Findings from the Condition Survey pertaining to deterioration in the structure, the functional condition index of the caisson gates, mitre gates, radial gates, bulkhead gates, and the lock chamber has been estimated.

4.3 Performance Indicators

The information gathered from condition survey and various type of inspection is used to calculate a condition index (CI). The Condition Index (CI) is a snapshot look at the condition of a part or component of the infrastructure. The field measurement data is representative of the current state of the structure. The condition index (CI) is a numerical measure used to rate the current state of the equipment / structure. The ratings are based primarily on physical deterioration as determined by distresses that can be seen or measured.

The Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program of the U.S. Army Corps of Engineers has developed a condition index which is a numerical scale, ranging from a low of 0 to a high of 100. The numbers indicate the relative need to perform REMR work because of deteriorating characteristics of the structure. Condition index provided by U.S. Army Corps of Engineers has been used to assess the present condition of the navigation lock and its various appurtenances. For management purposes, the CI scale is also calibrated to group structures into three basic categories or zones (Table 4.2).

The functional condition index is generated using expert analysis and judgement of field data. The experts take many factors into account as they evaluate the functional condition index like:

1. Its performance at normal and below-normal service conditions on a day-today basis.
2. Subjective Safety A series of critical measurements have been made on each gate to quantify the functional condition index. The functional condition index is quantified by

   Functional CI = $100(0.4)^{X/X_{max}}$

   where X_{max} is the limiting value of X.

Table 4.2 Condition index scale and zones

Zone	Condition Index (CI)	Condition Description	Recommended Action
1	85 to 100	Excellent: No noticeable defects. Some aging or wear may be visible	
	70 to 84	Good: Only minor deterioration or defects are evident	
2	55 to 69	Fair: Some deterioration or defects are evident, but function is not significantly affected	Economic analysis of repair alternatives is recommended to determine appropriate action
	40 to 54	Marginal: Moderate deterioration. Function is still adequate	
3	25 to 39	Poor: Serious deterioration in at least some portions of the structure. Function is inadequate	Detailed evaluation is required to determine the type of repair, rehabilitation or reconstruction. Safety evaluation recommended
	10 to 24	Very Poor: Extensive deterioration. Barely functional	
	0 to 9	Failed: No longer functions. General failure or complete failure of a major structural component	

According to the previous description of action zones, X_{max} is defined as the point at which the functional condition index is 40, that is, the dividing point between Zones 2 and 3.

Figure 4.4 illustrates the equation and zones from Table 5.1. If X is 0, that is, no distress, the condition index is 100.

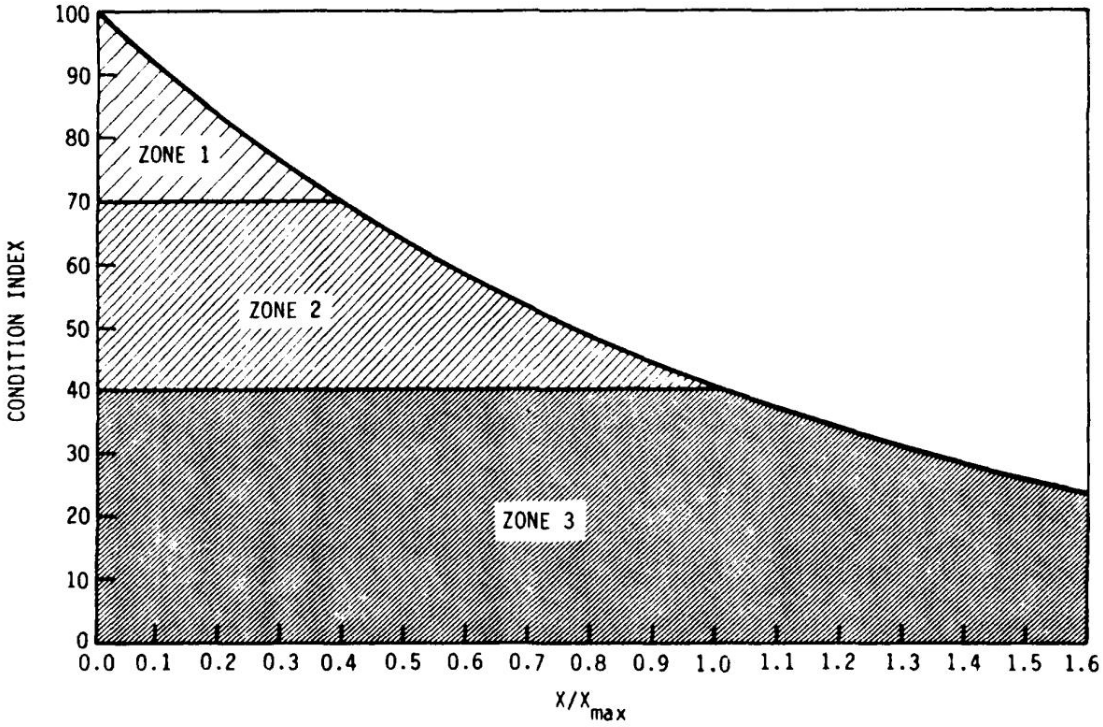


Figure 4.4 Functional condition index (CI) related to X/Xmax

Notes

- If a structure is designed and constructed properly, it has an initial condition index of 100.
- The functional condition index never quite reaches 0.
- The judgment for X_{max} is based on serviceability or subjective safety considerations. The mix and weight of serviceability versus safety are incorporated.

The functional condition index of Caisson Gates, Mitre Gates, Radial Gates, Bulkhead Gates, Navigation Lock Chamber, Mooring Equipment and Electrical equipment is discussed in subsequent Chapters.

5 RENOVATION AND MODERNIZATION OF CIVIL COMPONENTS

Followings are the major civil structures of the existing navigation lock:

- Lock chamber and approach : Retaining wall, Base slab, Inlet/Outlet arrangement and Parking Bay
- Mooring equipment : Floating (8) and Fixed (14) bollards
- Fender arrangement : 25 wooden fenders on each wall of dimension 6 in x 4 in and variable height.
- Electrical Cable Bridge : Over-ground steel-lattice cable bridge
- Control room building : A G+4-storey control room building
- Bank protection work : 100m U/S and 50m D/S

5.1 Lock Chamber and Approach

5.1.1 Retaining Wall, Base slab and Lock Approach

A reinforced concrete counterfort retaining wall is available at the sides of the Navigation lock. The retaining wall is dimensioned as counterfort retaining wall to take the earth pressure and earthquake forces etc. The top of wall is kept at El. 28.438m in the U/S and 26.056 in D/S The bottom elevation of wall varies from El. 15.545m to El. 15.240m. The lock chamber counterfort type side walls are made up of reinforced concrete with concrete mix of 1:3:6 and 1:4:8.

The sub-surface flow of water plays an important role for the stability of structure. The base slab gets destabilized due to uplift pressure and provision of sufficient floor thickness prevents this kind of failure. The base slab is 2.44 m thickness. The existing base slab and cut-off are made up of reinforced concrete with concrete mix of 1:3:6. The existing retaining wall is shown in Figure 5.1

Visual inspection and non-destructive testing of concrete both for the above water and under water portion has been carried out to assess the homogeneity and characteristics of concrete as well as health of the structure. The type of defects observed are cavity, honeycomb, surface deformation and debris (Figure 5.2 and Figure 5.3). Based on the visual inspection of walls and base slab, a total of 139 defects have been observed of which 18% fall in the category of major defects, whereas 47% are in moderate category and the remaining 35% are minor defects.

Based on the above water UPV test conducted at 40 locations on the lock walls, 45% fall in the category of doubtful, 12% in medium and 43% in good category. For underwater UPV test conducted at 475 locations, 26% fall in the category of doubtful, 48% in medium and only 26% in good category.

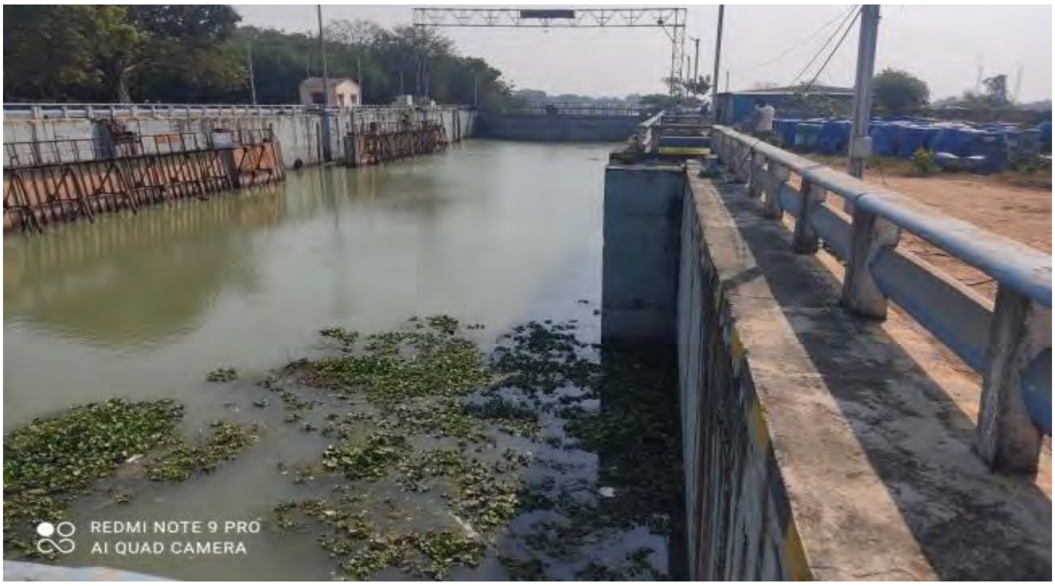


Figure 5.1 Retaining walls of existing navigation lock

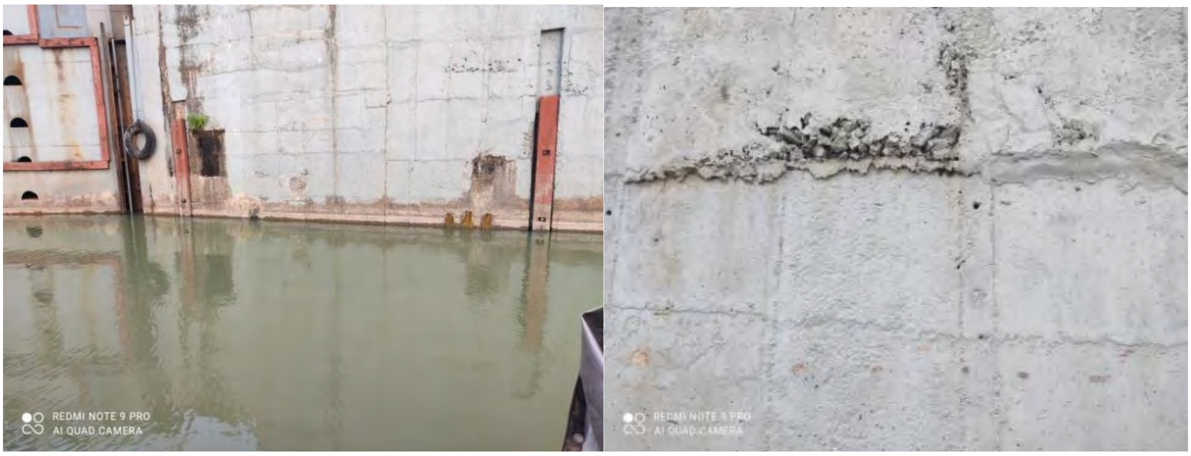


Figure 5.2 Honey Combing in Lock Walls

Figure 5.3 Lock Chamber side walls damaged

Base Slabs show siltation in the downstream portion as per depth measurement in the lock chamber (Figure 5.4). Heavy siltation and deposit near caissons is also visible and observed during depth measurements in nearby area in lock chamber. Vegetation can also be seen near caissons on the deposited silt.

Figure 5.4 Depth measurement in lock chamber for silt deposition over base slab

Guide Walls /Side Walls show patches of honey combing in concrete, cracks, and gaps in concrete. Presence of vegetation in adjacent portions is also visible. Details are shown in Figure5.5 and Figure 5.6.

Figure5.5 Guide Walls Damaged & Vegetation

Figure 5.6 Guide Walls Damaged – Honey Combing & Cracks

5.1.2 Inlet/Outlet arrangement

The project consists of four feeder culverts, two at U/S and two at D/S (one on each side). The water is carried through culvert system on both sides of the Lock for filling/emptying of the Lock. The Inlet /Outlet system comprises of inlet structures at one end and outlet structures at another end. The inlet is provided with multiple opening for efficient flow. The invert level of the inlet at culvert inlet is kept at EL. 15.545 m at U/S and D/S. The invert level at the entrance of the inlet is suitable to ensure sufficient depth of water above the inlet level of the tunnel for proper flow conditions. The top level of inlet is kept at EL. 17.755 m. The inlet is provided with a radial gate as main operating gate which is required to be opened / closed for Lock operations. On the upstream of the radial gate, an emergency gate is provided for inspection and maintenance of Radial gate and embedded parts. Outlet is provided with only bulkhead gate which can be operated for the maintenance of Radial gate at Inlet. The whole filling/emptying system can be isolated by operating the bulkhead gates at inlet and outlet.

The filling/emptying (f/e) appeared to operate at an adequate speed, and the lock levelling process (filling or emptying) took about 6.5 minutes including the time required for opening the radial gates. The hydraulic conditions created by the f/e system, i.e., currents and turbulence, appeared to provide acceptable conditions for vessels moored in the lock. However, detailed assessment must be carried out during the renovation and modernization of the lock.

5.1.3 Present status /Functional Condition Index

The structural health of side walls and base slab is fair and categorized in zone 2 with functional condition index falling in the range of 60 to 64 as per the condition survey Table 5.1. However, concrete has been affected with deterioration in homogeneity and honeycombing along with cracks and cavity formation.

Table 5.1 Functional condition index of the lock chamber and Approach structure

Lock Chamber and Approach Structure								
Items	**Critical Parameter**	**Defect based on Visual Inspection/ Estimation & Ultrasonic Pulse Velocity Testing (UPV)**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight * CI**	**Functional CI**	**Remarks**
Side Walls	Crack	Yes	1	63.25	25	15.811	63.46	Repair the wall surface
	Bar Exposure	Yes	1	90	25	22.5		
	Honeycombing	Yes	3	50.30	25	12.57		
	Quality	Yes	3	50.30	25	12.574		
Base slab	Crack	Yes	1	63.25	25	15.811	60.96	Repair the Base slab surface
	Bar Exposure	Yes	1	80	25	20		
	Honeycombing	Yes	3	50.30	25	12.57		
	Quality	Yes	3	50.30	25	12.574		

5.1.3.1 Design life with and without Renovation

As per IS:456, the design life of lock chamber and approach structure is 100 years but the residual life without renovation and replacement is of the order of 30 years. It is recommended to carry out major repairs in the side walls as well as the base slab. Major repairs in the approach wing walls, water conductor system, etc. are also necessitated. The working life of structure can be increased to around 50 years by renovation.

5.1.3.2 Renovation/Rehabilitating using State of the Renovation/Rehabilitating using State of the Art Technology Art Technology

The lock structure base slab, side walls, approach structure and filling emptying system has been proposed to retrofit the existing lock structure. Jacketing with high strength concrete on the base slab has been recommended. Jacketing is the process of strengthening weak RCC structure which have deteriorated over some time due to adverse atmospheric conditions or due to poor maintenance of the structure. High stretch concrete is used for jacketing the base slab portion. Rebars shall be used in the jacket wherever necessary. The base slab shall be jacketed with high strength concrete of grade M40 with a thickness of 100mm. The top suface shall be thoroughly cleaned before the fresh concrete is applied. Wherever there are damages in the base slab, the loose concrete shall be removed before the high strength concrete layer is provided.

The interface of hydromechanical components are civil components is through the embedded parts which are fixed in the civil structure with concrete grade higher than the general concrete grade of the structure. Wherever embedded parts are to replaced/repaired, high strength concrete of grade M60 should be used for proper connection and joint strength with concrete and embedded parts. Rebars shall be used wherever necessary.

For repairs on the retaining walls, guide walls and filling emptying system, epoxy grouting shall be used to treat the defects in the concrete. In general, epoxy grouts are recommended for:

- Very high early strength applications resulting in lowest downtime.
- Chemical and oil resistant and in some cases as a corrosion preventer.
- Vibration damping.
- Grouting reciprocating compressors.
- Applications requiring maximum bond to foundation and machine or baseplate resulting in a monolithic structure.
- Injection into cracks and deep penetrations for repairs to concrete.
- Ability to withstand high dynamic loading without failure.

The process of repair of concrete is explained below:

Removal of loose concrete

All the loose concrete shall be removed by manually operable chisel and mechanical hammer before commencement of the core of jacketing. The exposed surface shall be cleaned thoroughly with water jet to remove loose particle.

Alkaline rust converter

Apply single pack alkaline water-based rust converting primer which is designed for application on rusted steel surfaces to form a complex iron compound. The unique deoxygenating agent formed during application should convert the rust into corrosion resistant, insoluble and adherent layer by reacting with the oxygen present on the surface. Typical component be **Feovert or equivalent.** Application procedure is mention below.

- Remove loosely held rust using a hand wire brush gently, but leave behind the layer of rust directly attached to the underlying steel.
- Ensure removal of oil or greasy residues if any with strong detergent and wash with clean water. Allow it to dry.
- Apply the rust remover using a brush or spray.
- Apply minimum 1 coat. Preferably two coats when heavy rust is present.
- Curing time for each coat 6 – 8 hours.

Anti-Corrosive treatment

Providing and applying anti-corrosive treatment to the exposed corroded steel bars after proper cleaning using alkaline based Rust Remover after surface preparation. Epoxy phenolic reinforcement treatment instead of Zn rich epoxy system as the elongation property of epoxy phenolic is near to steel elongation. As protective, anti-corrosive coating to rebar in the construction of RCC structures exposed to aggressive corrosion, to enhance the durability. As anti-corrosive coating to exposed reinforcement bars in embedded concrete (after thorough de-rusting with wire brushes) in repair works. Typical component for anti-corrosive treatment is **IPNET-RB or equivalent.**

Epoxy injection grouting

Exposed concrete surface shall be provided with low viscosity injection grouting at a spacing of 300 mm c/c in staggered manner. Concrete elements shall be injected as per the following procedure

- Surface preparation
- Fixing of packers
- Sealing of cracks using
- Mixing of injection grout
- Grouting

Surface Preparation

For Areas where injection of visible cracks is required: Clean the concrete surface, 2cm on either side of the crack to ensure better bonding of sealing material used for crack sealing.

- Where the concrete is found to be weak immediately next to cracks, weak concrete shall be opened up completely.
- For wider cracks, opening of crack in the form of V-Groove, minimum 10mm wide and 10mm deep is ideal.
- For very fine cracks, Cutting V-Groove is not required.
- All loose traces of dust, grease oil, form release agent etc. must be thoroughly removed mechanically by scrapping, brushing, high pressure water jetting along the crack line.
- Holes of approximately 12mm dia. shall be drilled into the concrete without damaging the embedded reinforcement steel.
- Depth of the drilled holes shall be minimum 50mm to 75mm
- All the dust and loose particles that surrounds the cracks and the dust inside the drilled holes shall be flushed out with clean, dry, compressed air.
- If the concrete along the crack is loose, it should be routed out by cutting a small v-groove and blowing out the dust and loose particles by air pressure.
- For Areas where concrete mass is porous: The holes shall be drilled on the entire surface of the porous concrete as mentioned above.

Fixing of packers

- Injection packers with non-return valve shall be fixed into the drilled holes for injecting grouts at a spacing of not more than 500mmc/c ideally.
- The spacing of the packers shall depend upon the severity of concrete deterioration and shall be ideally decided depending upon the site conditions and the test results if conducted.
- The packers shall be inserted into the drilled holes and fixed in position using non-sag, two component epoxy putty.
- The epoxy putty shall be allowed to cure for couple of hours before the start of injection grout.

Sealing of Cracks

- The opened crack line shall be sealed with epoxy putty, to avoid oozing of the injection grout from between the packers.
- Two component epoxy putty shall be mixed suitably with a slow speed around 300rpm until uniform consistency is achieved.
- The material shall be pressed into the opened-up cracks and levelled at the top in line with the concrete surface using steel trowel.
- The epoxy putty shall be allowed to cure for couple of hours before the start of injection grout.

Mixing of Injection Grout

- Properly Stir each component of epoxy resin separately.
- Combine the base and hardener in a suitably sized container.

- Mix the material using slow speed drill mixing paddle at 300 to 400rpm min for 3 minutes until homogeneous mix is achieved.
- Scrap the sides of the container to ensure full reaction.

Injection Grouting

- The prepared surface should be air dry before the application starts with moisture level ≦4%.
- The mixed grout shall be injected using a suitable pressure grouting machine and within the pot life of the material.
- The injection pressure to be maintained shall be between 2.5kg/cm2 to 6kg/cm2.
- Pressure to be maintained at the site shall be gradually increase upward depending upon the site conditions
- The supply line shall be connected to the first packer.
- Pumping of the resin shall then commence.
- The injection process shall continue till the material starts coming out and the concrete stops taking material further.
- The pump pressure shall be maintained for at least 2-5 minutes, allowing the resin to stabilize into crack before the pump is disconnected.
- The injection pump shall be connected to the next immediate packer and the injection process is repeated again till all the packers are finally injected.
- For horizontal cracks: Injection shall start from the widest part and then continued till the last packer is injected.

- For Vertical Crack: Injection should start from the lowest port and continued upwards till the last packer is injected.
- The injected port shall be removed by cutting it at the lowest edge after 24 hrs. and the area shall them be sealed/levelled using epoxy putty.
- Do not apply the material when either the temperature 40℃ or humidity is >75% or both.
- The injection grout is self-curing

Provision of shear connector

Drill holes of 12mm diameter and 100 mm depth in concrete surface, clean the drilled holes and fix shear connectors in drilled holes using chemical grout (Hilti or equivalent) at spacing of 200 mm.

However, a detailed condition survey assessment shall be undertaken during the renovation and modernization phase in the dry condition to ascertain the health of the structure. The health assessment shall include NDT test of concrete, concrete block out test, reinforcement mapping, corrosion test, etc.

5.1.4 Caisson Gate Parking Bay

Existing caisson gates are currently parked in the lock chamber thereby encroaching upon the effective width of the existing navigation lock which can affect the movement of vessels. In order to avoid any hindrance to the navigation of vessels, dedicated parking bay has been proposed to be provided one each in the immediate upstream and downstream of the existing navigation lock along the left bank. The proposed location of the new parking bay is shown in Drawing No. ENL013.

5.1.4.1 Counterfort Retaining Wall for Parking Bay

A reinforced concrete counterfort retaining wall has been proposed at the sides of the parking bay. The retaining wall has been dimensioned as counterfort retaining wall to take the earth pressure and earthquake forces etc. The top of the wall has been kept at El. 28.44 m as the maximum water level is 26.3 m thus giving a free board of 2.14 m to account of the waves due to movement of vessels as well likely increase in maximum water level due to global warming impact and delay in opening of barrage gates in case of high flood in the river. The stability analysis of the structure has been carried out considering the maximum depth of the Retaining wall. The details are as given below:

Assumptions

For the stability analysis of retaining wall, the following assumptions have been made

- The backfill soil is saturated and the density of backfill soil is 18 kN/m^3. The density of reinforced concrete is 25 kN/m^3
- The backfill soil has been considered as cohesion-less.
- The surcharge of 1.2m has been considered on top of backfill. This is in accordance with IRC 6- 2000.
- Angle of repose of backfill soil considered is 25^o.
- Safe bearing capacity of foundation soil is 300 kN/m^2 (interpreted on results of geotechnical investigations).
- Density of reinforced cement concrete = 25 kN/m^3
- Cohesion of soil strata = 1.2 kpa
- Deepest section is considered for analysis.
- Grade of Concrete (Structural) = M 40

- Grade of Steel = Fe 500

Design Loads

The retaining wall has been designed for the following loads:

a) Dead load (self-weight of structure).

b) Static earth pressure.

c) Dynamic increment in earth pressure due to earthquake.

d) Earthquake forces (horizontal and vertical inertia forces).

Stability Check

Condition

Stability of the retaining wall is checked for the following condition:

- Lock is empty
- Maximum water level, U/S at H.F.L.
- Backfill soil is saturated

Stability is checked for the following conditions:

a) Overturning

Safety against overturning is checked about the point of rotation at the bottom end of toe of retaining wall in the horizontal direction.

$$Factor\ of\ safety\ (FOS) = \frac{Restoring\ Moments}{Overturing\ Moments}$$

b) Sliding

$$Factor\ of\ safety\ (FOS) = \frac{Resting\ Force}{Sliding\ Force}$$

c) Foundation base Pressure

$$Base\ Pressure = \frac{W}{b.L}[1 \pm \frac{6.e}{L}]$$

Where,

b: Foundation base width (m)

L: Foundation base length (m)

e: Eccentricity of load

W: Algebraic sum of the vertical forces

Factors of Safety

As per relevant IS codes, factor of safety must be more than those given in Table 5.2 below:

Table 5.2 Factors of Safety

Minimum Factor of Safety	Normal	Seismic
Sliding	1.5	1.2
Overturning	2.0	1.5
Base Pressure	< 300 kN/m2	< 300 kN/m2

Results

The results of stability analysis are given in Table 5.3. Detailed calculations are given in Annexure 2 and Annexure 3 and general arrangement of the parking bay is shown in Drawing No. ENL004.

Table 5.3 Results of Stability Analysis

Stability Check	FOS (Normal case)	FOS (Seismic case)	Remarks
Overturning	7.7	5.02	Safe
Sliding	2.01	1.34	Safe
Base Pressure	Max. 237.4 kN/m2	Max. 192.9 kN/m2	Safe
	Min. 96 kN/m2	Min. 78.2 kN/m2	Safe

All the construction work for the renovation and modernization of existing navigational lock will be completed on shore which includes the activities like excavation, concreting etc. Suitable arrangements are required to keep the existing navigation lock and working area free of water during construction.

5.1.5 Instrumentation

Water Level and water depth Monitoring

Fixed water level gauge boards exist at locations upstream and downstream of each of the sets of mitre gates, but these are in the ladder recesses and are not readily visible to the lock operators. Some of the gauge boards have been damaged and do not cover all operating water levels. (Figure 5.7). There is no existing instrumentation system for monitoring and recording water level in the upstream of the lock chamber, within the lock chamber and downstream of the lock chamber.

In order to achieve remote operation of lock gates, it is necessary to have digital water level recorders at suitable locations in the upstream of the lock chamber, within the lock chamber and downstream of the lock chamber to assess the head differences across the gates as well as depth to water level shall be monitored in real time at different location of lock chamber and upstream and downstream of the lock. Ultrasonic type/

Down looking Doppler radar sensor has been proposed for the measurement of water level and depth which shall indicate any deposition of silt in the navigation lock. The Ultrasonic sensor for water level measurement shall be fixed above the HWL whereas the radar sensor shall be placed below the LWL. The integrated system of both sensors shall give the real time water level and water depth in the navigation lock. Figure 5.8 provides a schematic of a down looking Doppler radar system. The water level and water depth data can be used for monitoring of the silt deposited on the lock bed, if any For Navigation lock operation, dynamic water level monitoring system shall be installed and real time water level difference data shall be relayed to the control room.

Figure 5.7 Fixed water level gauge in ladder recess

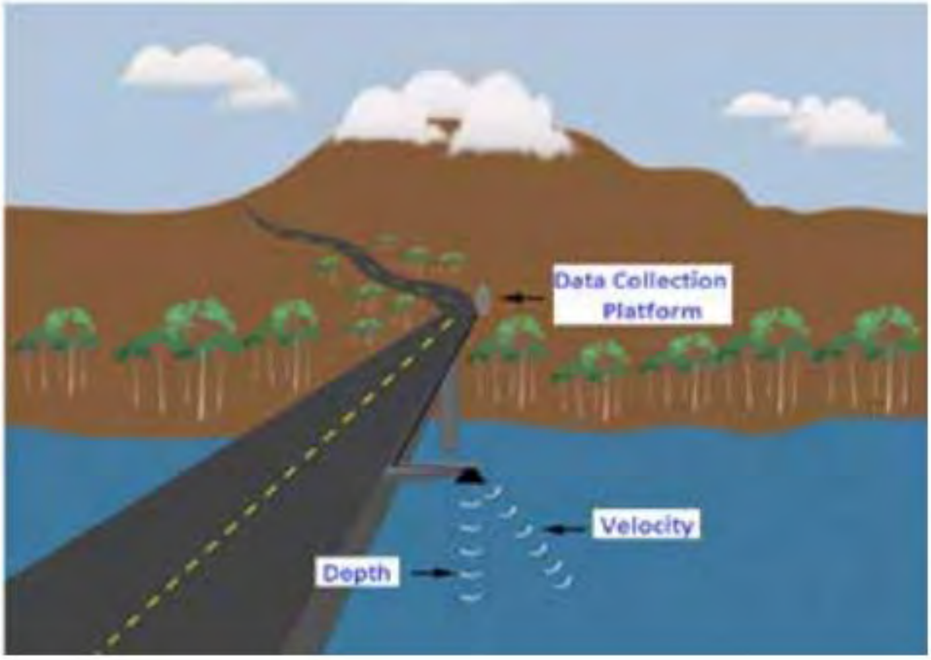


Figure 5.8 The schematic of Down-looking Doppler radar combined with ultrasonic depth of water

5.2 Mooring Equipment

Conventional moorings systems viz. floating and fixed bollards are in place in the navigational lock. There are Bollards – eight (8) numbers floating type (four (4) on each bank) and fourteen (14) numbers fixed type (seven (7) on each bank). During the condition survey it is observed that all the floating type of bollards are non-functional and 1 fixed type of bollard was damaged. Present condition of floating and fixed type bollard is shown in Figure 5.9 and Figure 5.10. Plan and section of the existing fixed bollards is shown in the Figure 3.9

Figure 5.9 Floating Type Bollards

Figure 5.10 Damaged Fixed Type Bollard

5.2.1 Present status /Functional Condition Index

The health of the Mooring Equipment is marginal in zone 2 with functional condition index falling in the range of 41-50 (Table 5.4). The floating bollards are rusted and almost all are non-functional while one of the fixed bollards are damaged and detached from the lock structure. It is suggested to replace damaged fixed and floating bollards.

Table 5.4 Functional condition index of Mooring equipment

Mooring Equipment								
Items	**Critical Parameter**	**Defect based on Visual Inspection/**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight * CI**	**Functional CI**	**Remarks**
Fixed Bollard	Crack	Yes	3	50.30	100	50.3	50.3	Replace the Fixed Bollard
Floating Bollard	Corrosion	Yes	2	63.25	50	31.6	41.6	Replace the Floating Bollard
	Movement	Yes	4	20	50	10		

5.2.2 Design life with and without Renovation

The design life of mooring equipment is 30-35 year and residual life without renovation and replacement is Nil. The working life of mooring equipment can be enhanced by 30-35 years by replacement and renovation. The replacement of the Mooring Equipment in the navigational lock structure will enhance the safety of the vessels during operations.

5.2.3 Rehabilitation measures for the Mooring Equipment

The Floating moorings conventional systems and magnetic moorings have been considered. The conventional system is adopted because of following advantages:

1. Magnetic moorings fail to work properly in silt conditions. Silt is likely in our case hence conventional floating moorings having been adopted.
2. Easy or no maintenance is required, unlike the magnetic moorings.
3. These are also economical.

The damaged floating and fixed bollards shall be replaced and working fixed bollard shall be repaired if needed.

General Arrangement of the mooring equipment is shown in Drawing No. ENL005.

5.2.4 Fender Arrangement

The existing fenders of wooden log and hanging tires as provided in the lock chamber (

Figure 5.11) are in very poor condition and require replacement. The replacement of the wooden and rubber tire fenders shall enhance the safety of the lock walls as well as vessels during the movement of the vessels through the lock. The wooden as well as AN 800 E 3.0 grade rubber fenders with stainless steel plates or SM 800 grade M2 which can withstand extreme climate as well as alternate wetting and drying are proposed to be used.

Figure 5.11 Existing wooden fender of the lock chamber

5.3 Control Room Building

A G+4-storey central control room building is on the left bank of the existing navigational lock. There are a total of four local control rooms; two local control room in the upstream and two on the downstream side. The local control room is placed on either side of the mitre gate leaf in the upstream and downstream of the navigation lock. The current status of the central control room is shown in Figure 5.12

Based on the UPV test conducted at 10 locations beams and columns, 10% fall in the category of doubtful, 20% in medium and 70% in good category.

Figure 5.12 Present condition of the control room buildings

5.3.1 Present status /Functional Condition Index

The structural health of the control room building is good and categorized in zone 1 as per the condition survey but it lacks the necessary operational facilities like lift, water supply, drinking water, water purifier, sanitation, etc. Also, the exterior look is very shabby as it has not been painted for many years. Local control room for the operation of gates at upstream and downstream is also in a dilapidated condition. It is proposed to repair, renovate as well as modernize the building with all the latest features as well as safety systems.

5.3.2 Design life with and without Renovation

The repair of the control room building will improve the usability and serviceability.

5.3.3 Renovation and Restructuring of the Control Room Building

The existing G+4-storied building will be used as master control room. The second and third floor should be fitted with full width glass view in the front of the control room so that the movement of the vessels in U/S and D/S direction in the approach channels and in the Lock can be viewed by the operator sitting in his chair. The control room building shall be provided with vitreous non-skid tiles in the flooring of the control room.

Control Room building shall comprise of the following:

- Switchgear room on the Ground Floor shall be housing Metering Panel of WBSEDCL, Transformers, Diesel Generator set, 11 kV HT Switchgear Panel, 415 V Power Control Center (PCC) and various distribution Boards etc.
- Two store rooms for spare parts (one for General Electric items and other for specialized components) shall be on the first floor.
- Operating cum programming station, server station, PLC panels, UPS and 32" LED Screen, CCTV Terminals, Third party control system for field instruments, conference room and various utilities rooms at second and third floor. The floors shall be equipped with Rest Room, Pantry and Toilet.
- The fourth floor shall be housing two numbers of Guest Rooms with attached toilet facility.
- The building shall be fitted with a lift.
- The building shall be fitted with firefighting systems.
- The building shall be fitted with rainwater harvesting systems.

The local control room buildings in the upstream and downstream end of the existing lock shall also be renovated with all the latest features as well as safety systems.

The existing control room does not have any viewing gallery for existing navigation lock. A viewing gallery shall be provided in the control room building for operation of the existing lock as well as for visitors. It is proposed to have a viewing gallery on the 2nd floor by using external supporting column around the existing control room building.

Local control room building

Existing navigation lock currently has 4 local control rooms, two each on the upstream and downstream of the navigation lock (one each on the left and right bank) for operation of the gates. The control rooms are in a dilapidated condition; therefore, it is proposed that the local control rooms shall be reconstructed as per standard IS code. There is G+1 building on the upstream left bank which is functional which can be used after repair and renovation work for lock purposes.

5.4 Electrical Cable Bridge and Cable Network Trench

As the electrical system and control room is situated on the left bank, the electrical cables are required to cross the existing lock to operate the various gates on the right bank. As per the design, there is an underground cable duct for movement of electrical cables. Also, there are two over-ground steel lattice cable bridges (one each at u/s ant d/s mitre gate) through which the electrical cables are supported and taken to the right bank (Figure 5.13). The electrical cable network is placed under the electrical cable trench (Figure 5.14). As per the earlier studies, the underground cable duct is non-functional. The current network of electrical cables utilizes the steel lattice bridges for supply of electricity to the units on the right bank.

Figure 5.13 Steel lattice type cable bridges

Figure 5.14 Electrical cable trench

5.4.1 Present status /Functional Condition Index

The existing electrical and control cable trench are in dilapidated condition and requires overhaul. The existing Steel Lattice Cable Bridge also requires repair. Functional conditional index of the electrical equipment varies from 32.5 to 63.25 (Table 5.5.) The repair of the cable shaft as well as cable bridge will improve the reliability and serviceability during operations of the vessels.

Table 5.5 Functional index of electrical equipment

Electrical Equipment								
Items	**Critical Parameter**	**Defect based on Visual Inspection**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight * CI**	**Functional CI**	**Remarks**
Underground Electrical Ducts	Access	Yes	4	20	50	10	32.5	Repair the Underground Electrical Ducts
	Civil Structure	Yes	3	50.30	50	22.5		
Steel Lattice Cable Bridge	Corrosion	Yes	2	63.25	100	63.25	63.25	Repair the Steel Lattice Cable Bridge

5.4.2 Repair and Rehabilitation of the Electrical Cable Bridge and Cable Network Trench

The corroded/damaged part of the Steel Lattice Cable Bridge shall be repaired. Welding, riveting etc. process of the damaged steel shall follow the relevant IS code such as IS 822. A vertical access ladders with round safety tunnel shall be provided with the steel cable bridge for regular maintenance of the electrical cables and steel structure. A typical vertical access ladder is shown in Figure 5.15. The vertical ladder shall be provided in a such way that it will not impact on the navigation or movement of ships

As per the drawing of the existing navigation lock the dimension of the underground electrical duct 4 ft X 6 ft which is sufficient for the cable passing but congested for movement of human for the maintenance work and the entry and exiting point of the lock has been severely damaged and blocked for access which requires major rehaul in the structure. Therefore, only electrical cable bridge shall be considered for renovation.

The existing dilapidated cable network trench shall be renovated and modernized.

Figure 5.15 A picture of vertical access ladders with round safety tunnel

5.5 Bank Protection Work

In the upstream and downstream of the lock, the existing bank protection works of stone pitching is covered with silt and damaged at few points. Bank Protection has been proposed in the upstream side from the lock approach till the River Information Station (observation station in the upstream) excluding the proposed parking bay area and in the downstream side it has been proposed from the lock approach till the boundary wall excluding the proposed parking bay area to prevent soil erosion along the river bank.

There are various types of bank protection works. Taking the nature of the structure it is required to project Revetment is proposed with launching apron and toe wall. Revetment comprises of stone pitching / lining with PCC block the river bank after grading to an appropriate slope depending on nature of soil in bank and bed of the river to absorb the erosive power of the flow. River bank protection is subjected to hydrodynamic drag and lift forces. These destabilizing forces are stabilized by the submerged weight of PCC blocks. Bank protection works in the form of PCC blocs of M15 grade has been proposed to maintain the aesthetic similarity with the existing bank protection works carried out in the new navigation lock.

The required size of blocks has been computed based on IS 14262:1995. PCC block of size 1m x 1m x 0.6m are provided in two layers.

Along the slope of the river bank graded to a slope of 1.5H:1V. For free drainage of pore water from the saturated soil beneath, PCC blocks are proposed to be laid over a graded filter of 250 mm thickness conforming to IS 8237:1985. A gap of 10mm is to left between adjacent PCC blocks. This gap is to be filled with free draining coarse sand. To prevent the sliding and failure of the revetment on slope, PCC toe wall has been provided. The maximum scour depth has been accessed based on the IS 14262:1995 and a launching apron is provided to take care of the maximum scour depth (1.5 times the calculated scour). Thickness of Launching apron is calculated based on the negative head created by velocity.

Launching apron comprises of PCC blocks of size 1.5m x 1.5m x 0.9m in a width of 6m in two layers in front of the toe wall. A graded filter media should also be provided below the launching apron. On the top of the bank, a 2m wide key has been provided to prevent erosion of the soil from rain. D/S end of the revetment will abut into the guide wall. The detailed calculations for computation of Bank protection works are given in Annexure-4. The details are shown in Drawing Nos ENL006.

6 SAFETY ASPECTS OF EXISTING LOCK

Renovation and modernization of the existing lock shall not require major excavation during the renovation work, thus there is no risk to the stability of side wall as well as there is no risk to the safety of new navigation lock. However, to ensure the safety of existing lock and new lock, monitoring instruments shall be installed for monitoring the safety and stability of the existing and new navigation lock during the renovation/ modernization and operation phase. The proposed monitoring instrument to be installed are following:

- Piezometers – 15 Nos
- Settlement gauges – 09 Nos
- Inclinometers – 09 Nos

Piezometers

Piezometers are sensors that are used to measure pore water pressure (piezometric level) in the ground. It is designed to measure pore water pressure in the soil, earth/rock fills, foundations and concrete structures. Proper evaluation of pore pressure helps in monitoring the behavior after construction and indicates potentially dangerous conditions that may adversely affect the stability of the structure, its foundation and appurtenant. There is various type of piezometers are available. Digital Ground Water Level Recorder type piezometer has been proposed for monitoring pore pressure. Figure 6.1 shows the schematic of general arrangement of piezometer.

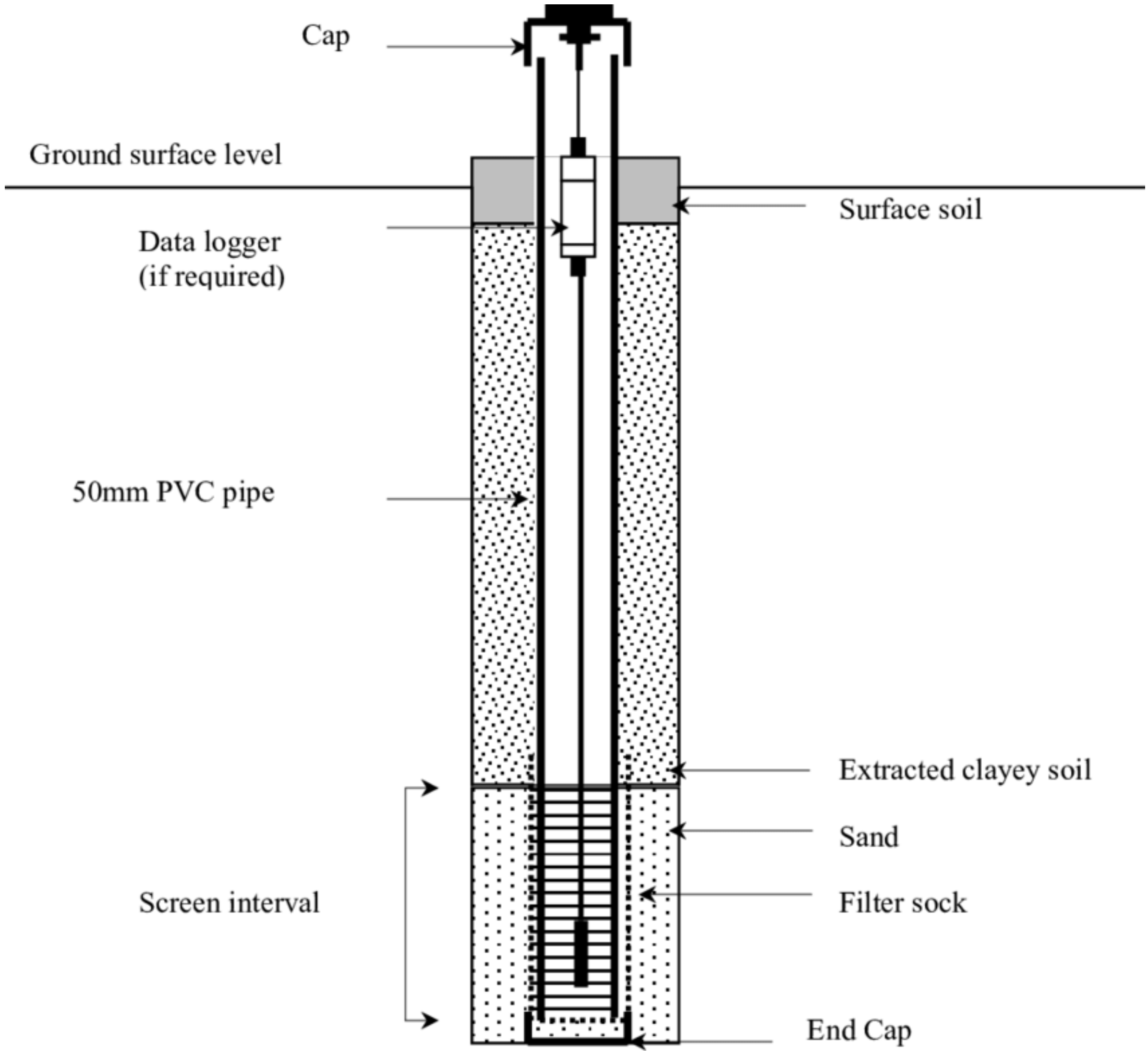


Figure 6.1 Schematic of piezometer

Settlement gauges

The settlement gauge is a pressure transducer with vibrating wire or capacitive technology, mounted on a plate with a protective cover. Depending on the requirement, the settlement system can be installed with just a single gauge or with multiple gauges. Figure 6.2 shows the schematic of general arrangement of settlement gauges.

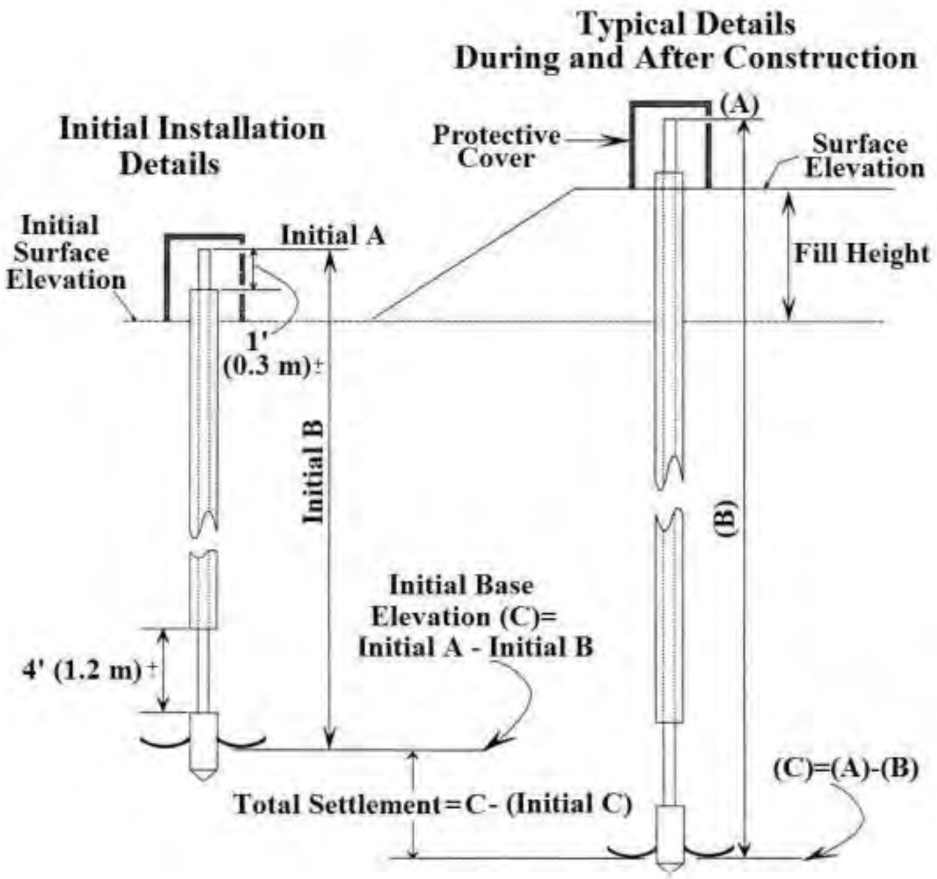


Figure 6.2 Schematic of Settlement gauges

Inclinometers

Inclinometer sensors are used to measure the slope gradient during activities like tunnelling, excavation and de-watering. Such activities affect the ground that supports the structure. Figure 6.3 shows the typical inclinometer probe, cable, and readout device.

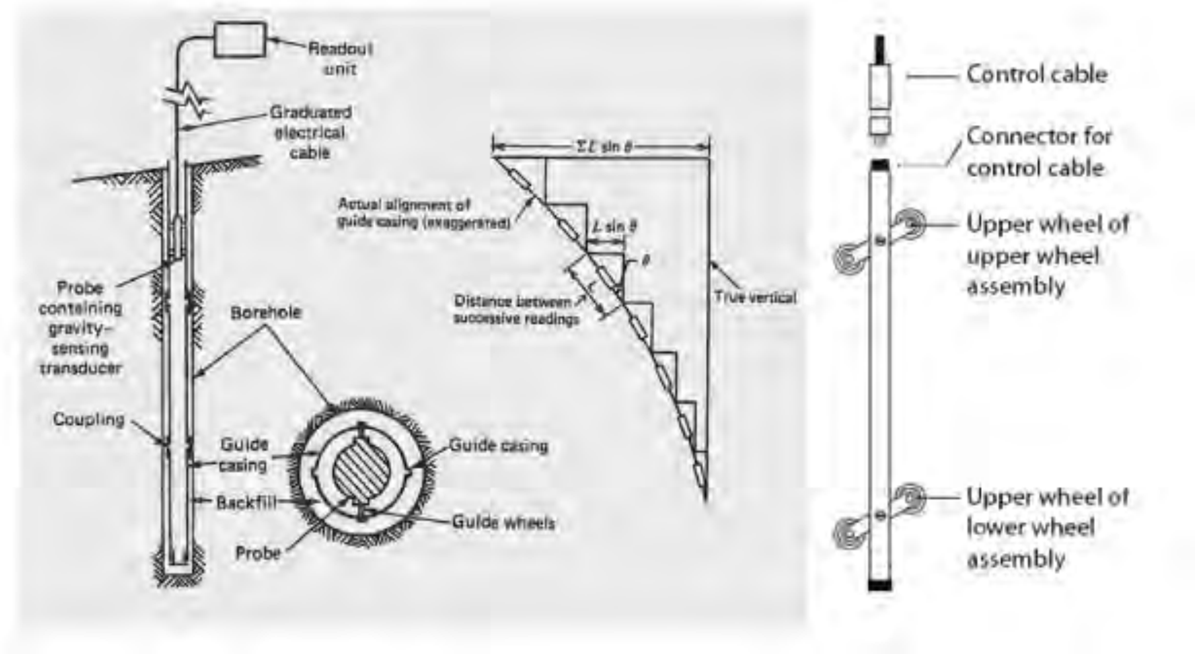


Figure 6.3 Schematic of inclinometer probe

These instruments will provide real time monitoring of the structural safety of the existing lock as well as the new lock. During renovation and modernization, if any settlement / inclination of the lock wall is observed, remedial measures to check the structural safety will be taken. During operation of the navigation locks, feed of the instruments will be available in the control room. The location of monitoring instruments is given in Drawing No. ENL 014.

During the construction of new navigation lock, monitoring instruments were installed at the vicinity of the existing and new navigation lock for safety of the existing navigation lock. The data of piezometers, inclinometers and settlements gauges has been received for the period of 15/11/2018 to 15/10/2019 from IWAI. The data indicates that there has been no major deflection observed around the existing navigation lock.

7 RENOVATION AND MODERNIZATION OF HYDROMECHANICAL COMPONENTS

7.1 General

A navigation lock requires closure gates at both ends of the lock so that the water level in the lock chamber can be varied to coincide with the upstream and downstream approach channels. The sequence of “locking” a vessel upstream is: (i) lower the water level in the lock to the downstream water level by opening the downstream radial gates; (ii) open the downstream mitre gate and move the vessel into the lock chamber; (iii) close the downstream mitre and radial gate and fill the lock chamber to the level of the upper pool by opening the upstream radial gate; and (iv) open the upstream mitre gate and move the vessel out of the lock.

Lockage of a vessel downstream involves (i) bring the water level in the lock to the upstream water level by opening the upstream radial gates; (ii) open the upstream mitre gate and move the vessel into the lock chamber; (iii) close the upstream mitre and radial gate and empty the lock chamber to the level of the lower pool by opening the downstream radial gate; and (iv) open the downstream mitre gate and move the vessel out of the lock.

The current operation time for the movement of vessels in the existing navigation lock is around double the time required for crossing a navigation lock as per international standards. Further, as per the condition survey, it has been observed that the existing gates along with the operating systems are in a dilapidated condition as well as outdated. In view of the above, it has been recommended to replace and modernize the hydromechanical components of the existing navigation lock.

7.2 Mitre Gates

During visual survey it was observed that the submerged portion of gates have significant leakages from bottom and front portion and structural components of these portion were found to be severally corroded (Figure 7.1). The wooden and rubber seals were found to be damaged and not effectively sealing openings/gaps between the structure and skin plates from both ends (b/w gates and b/w gate and corners (Figure 7.2). The embedded parts of gate groove could not be inspected due to restricted access and presence of water during the site visit however the condition of the visible areas is not inducing confidence and rusting in exposed parts can be seen.

Figure 7.1 Mitre Gates of Farakka Lock

Figure 7.2 Condition of Seals of Mitre Gate of Farakka Lock

The opening and closing of the gates were demonstrated to the team and the operation periods of the lock gates are noted as below.

Mitre Gate: Opening time: Appx. 10 minutes

Closing time: Appx. 10 minutes

These timings are quite high compared to the proposed Opening/Closing Time of 3-5 min for new lock's Mitre Gates and the operational capability and reliability of present mechanism is doubtful in future if the traffic across the Lock is further increased. During the operation of the gates, it was noted that top hinges of both gates are almost in the end period of their use and significant part of them is corroded with noise being observed for some period of operations from top bearings (Figure 7.3). It was noted that the greasing arrangement for the bearing is abandoned and has never been used. Hinges of one of the gates was damaged and subsequently replaced in 2020.

Figure 7.3 Top Bearing of Mitre Gates of Farakka Lock

The operating mechanism (Figure 7.4) of the mitre gates is found to be based on old technology principles and the components and consumables are in dire need of replacement. The rope dismantles from the guides during operation and has to be put back on guides manually. The double rope guided pulley mechanism is not dependable and can create operation hazard/bottlenecks easily. The opening and closing time of the gate cannot be speeded up with this operating system. There is no automatic supervisory control mechanism for mitre gate operation and human intervention/interpretation is required to assess the U/S and D/S water level at gate and to decide the right time for closing and opening operation.

Figure 7.4 Operating Mechanism of Mitre Gates of Farakka Lock

7.2.1 Present status /Functional Condition Index

The health of the gate leaf portion of the mitre gates above water is good whereas, for the underwater portion and area in the splash zone, the health is marginal in zone 2 with functional condition index falling in the range of 40-54 functional conditional index of critical parameter is given in

Table 7.1. The health of the operating mechanism of the mitre gates is poor in zone 3 with functional condition index falling in the range of 25-39.

Table 7.1 Functional conditional index of mitre gates

Upstream Mitre Gate (East Leaf)								
Items	**Critical Parameter**	**Defect based on Visual Inspection/ Estimation &Ultrasonic Thickness Testing (UT)**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight CI**	**Functional CI**	**Remarks**
Skin Plate, Girders and Stiffeners	Crack	Yes	4	40	50	20	50.65	Replace the underwater portion and 1.o m above the HFL in splash zone
	Corrosion	Yes	4	40	20	8		
	Strength (Thickness)	Yes	2	63.25	20	12.65		
	Dents	No	0	100	10	10		
Wooden and Rubber Seals	Leakage	Yes	4	20	100	20	20	Replace the wooden and rubber seals
Operating Mechanism	Noise/Vibration	Yes	3	30	25	7.5	30	Replace the operating system
	Maintenance Easiness	Yes	3	30	25	7.5		
	Operation	Yes	3	30	25	7.5		
	Synchronization	Yes	3	30	25	7.5		
Upstream Mitre Gate (West Leaf)								
Items	**Critical Parameter**	**Defect based on Visual Inspection/ Estimation & Ultrasonic Thickness Testing (UT)**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight * CI**	**Functional CI**	**Remarks**
Skin Plate, Girders and Stiffeners	Crack	Yes	4	40	50	20	48.06	Replace the underwater portion and 1.o m above the HFL in splash zone
	Corrosion	Yes	4	40	20	8		
	Strength (Thickness)	Yes	3	50.30	20	10.06		
	Dents	No	0	100	10	10		
Wooden and Rubber Seals	Leakage	Yes	4	20	100	20	20	Replace the wooden and rubber seals
Operating Mechanism	Noise/Vibration	Yes	3	30	25	7.5	30	Replace the operating system
	Maintenance Easiness	Yes	3	30	25	7.5		
	Operation	Yes	3	30	25	7.5		
	Synchronization	Yes	3	30	25	7.5		
Downstream Mitre Gate (East Leaf)								
Items	**Critical Parameter**	**Defect based on Visual Inspection/ Estimation & Ultrasonic Thickness Testing (UT)**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight * CI**	**Functional CI**	**Remarks**
Skin Plate, Girders and Stiffeners	Crack	Yes	4	40	50	20	50.65	Replace the underwater portion and 1.o m above the HFL in splash zone
	Corrosion	Yes	4	40	20	8		
	Strength (Thickness)	Yes	1	63.25	20	12.65		
	Dents	No	0	100	10	10		

Items	Critical Parameter	Defect based on Visual Inspection/ Estimation & Ultrasonic Thickness Testing (UT)	Count/ Severity	CI	Weightage (%)	Weight * CI	Functional CI	Remarks
Wooden and Rubber Seals	Leakage	Yes	4	20	100	20	20	Replace the wooden and rubber seals
Operating Mechanism	Noise/Vibration	Yes	3	30	25	7.5	30	Replace the operating system
	Maintenance Easiness	Yes	3	30	25	7.5		
	Operation	Yes	3	30	25	7.5		
	Synchronization	Yes	3	30	25	7.5		
Downstream Mitre Gate (West Leaf)								
Items	**Critical Parameter**	**Defect based on Visual Inspection/ Estimation & Ultrasonic Thickness Testing (UT)**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight * CI**	**Functional CI**	**Remarks**
Skin Plate, Girders and Stiffeners	Crack	Yes	4	40	50	20	50.65	Replace the underwater portion and 1.o m above the HFL in splash zone
	Corrosion	Yes	4	40	20	8		
	Strength (Thickness)	Yes	1	63.25	20	12.65		
	Dents	No	0	100	10	10		
Wooden and Rubber Seals	Leakage	Yes	4	20	100	20	20	Replace the wooden and rubber seals
Operating Mechanism	Noise/Vibration	Yes	3	30	25	7.5	30	Replace the operating system
	Maintenance Easiness	Yes	3	30	25	7.5		
	Operation	Yes	3	30	25	7.5		
	Synchronization	Yes	3	30	25	7.5		

7.2.2 Design life with and without Renovation

As per IS Code the design life of Mitre gate is 30-35 year and residual life without renovation and replacement is Nil. The working life of mitre gate can be enhanced up to 30-35 years by replacement and modernization. The gates shall be designed as per the following design life considering proper maintenance.

- Gate Structure – 30 years
- Electro Hydraulic components – 15 years

It is recommended to replace the mitre gates. Further the embedded parts along with the wooden and rubber seals also need replacement. The operating system is also outdated and the gate opening closing time is also very high. Overall, all the components of the mitre gates along with the operating system should be replaced.

7.2.3 State of the Art Technology

The existing operating mechanism needs to be replaced with a hydraulic system with axial-piston pumps and cylinders for quick operation speeds and durable components. The replacement of the current rope operating system with an alternative involving a hydraulic system with axial-piston pumps and cylinders would enable overload protection and incorporate gate holding properties.

General arrangement of the mitre gate is shown in Drawing No. ENL007-SH1, ENL007-SH2 and ENL007-SH3.

7.2.3.1 Range of Differential Water Levels

All the gates on upstream (river) side should be designed for the differential water head considering maximum water level i.e., 26.3 m on one side and other side empty. Similarly, the gates on downstream (canal) side should be designed for the differential water head considering maximum water level 24.38 m on one side and the other side empty.

7.2.3.2 Load considered for Structural Design

Gates shall be designed for the following loading conditions:

I. All static and dynamic hydraulic loads due to differential water levels mentioned above.

II. All loads due to dead weight and frictional forces.

III. Accidental impact from 3000 DWT fully loaded barge on Caisson and Mitre gate.

IV. Seismic / wind load as per IS:800

V. All temperature loads as per IS:800

VI. The stresses for the design shall be as per IS: 4622, IS:4623, IS:5620.

7.2.3.3 Structure and Scantling

The envelope plating and all structural members (primary & secondary) of mitre gates shall be designed as per Rules of any IACS member Classification Society. However, thickness of envelope plating and all primary structural members shall be 25% over Rule requirement. Scantling of all secondary members to be 15% over Rule requirement.

7.2.3.4 Design Method

The sizing of structural plating and stiffening of the gate shall be based on the above-mentioned loading criteria and hydrostatic pressure. The slenderness, buckling resistance and yielding of each plate panel, stiffener and beam members shall be assessed for finalizing the structural design. The rules and regulations of any IACS member of classification society will be followed in addition to BS-6349: Part 3. Maximum combined stresses shall be checked to be less than the allowable stresses given in BS-5400 Part 3 or any equivalent Indian Standards. A minimum load factor of 1.2 shall be used as per BS-5400 in conjunction with water levels mentioned above.

Structure

The gate shall be designed to a robustness sufficient to withstand all expected stresses associated with river navigation. The two leaves of the mitre gates shall butt against each other to form a V-shape in plan. The leaves of each leaf shall be constructed of welded steel box sections to obtain high rigidly and good torsional strength. The mitre angle shall be approximately 30 degrees.

The leaves of the mitre gates must be designed for impact of vessels passing through the open gates. Bearing and gasket design must ensure a smooth operation of the gate.

All welding seams of the gate shall be continuous and the size of fillet welds shall be approximately equal to the thickness of the thinnest member of the joint.

Gate Leaf

Each gate leaf shall comprise a skin plate with stiffeners, all of welded steel construction. The gate leaves shall be provided with circular water intake holes protected by screens on the downstream plate of each leaf so that the water within the leaves can follow water level variations. Any point that could trap water shall be drained. Any openings in the gate structure should be protected against ingress of floating debris.

Each gate leaf shall be protected in those areas where contact/impact/rubbing by passing vessels can occur. The leaves shall have easily removable vertical timber rubbing strakes in these areas.

In order to distribute the forces on the gate not only to the lower pivot thrust bearing and the upper bearing, but also to the lock walls the heel post shall comprise a system of adjustable, removable thrust bearings on the heel post.

The gates and their supports should have a mechanism to ensure that the forces on the gate are transmitted evenly to the walls and foundations.

A well-sized circular access shaft provided with a ladder shall enable inspection and maintenance inside the gate from the top of each gate leaf. On top of each gate leaf must be a catwalk, with hand railing, to enable crossing of the lock chamber by foot.

Both heelposts of the leaves forming a gate shall be provided with the following removable bearings:

- An upper spherical joint bearing
- A lower spherical joint thrust bearing as well as the removable thrust blocks and vertical seals.

The mitre post of one of the two leaves forming a single gate will also carry removable thrust blocks as well as the vertical seals. The mitre post of the opposite leaf will carry corresponding thrust blocks and the vertical sealing face.

The piston rod or strut of the servomotor must be connected to the gate leaf above the water level during normal operation.

Each guide wall must be provided with four stops, which shall be adjusted before being built in, to support the gate leaves in their fully open position. In addition, the gate leaves must be safely secured in the open position in case of flood release through a lock chamber, if flood release is planned to be done via the lock chamber.

Sill Bearings

The sill bearings shall comprise the pivots with spherical support surfaces and the ball sockets. The pivots shall be anchored to the concrete by supporting structures and shall be either of stainless steel or hard chromium plated steel. The ball sockets shall incorporate self-lube bushings. The sill bearings shall be protected against the ingress of abrasive matter.

Mitre Bearings

The mitre bearings shall be of welded or cast steel construction and of spherical design to eliminate undue edge pressures.

Collar Bearings

The collar bearings of the gate must be of adjustable type. Their fixing to the anchoring assemblies shall be spring loaded using disc springs. The pins of the collar bearings shall be of stainless steel. The bushings shall be of self-lubricating material.

Gate Seals

The gate seals shall be bolted to the skin plate with full-length stainless-steel clamps, with stainless steel nuts, washers, ferrules and bolts.

Material and properties of the gaskets shall be as specified in the General Technical Specifications. The gaskets shall have moulded corner pieces to provide a single continuous seal. The tensile strength of all shop splices shall not be less than 50% of the tensile strength of the unspoiled material. The seals on the heel posts of the gate leaves and on one mitre post shall be of music note type, or other shape activated by the upstream water pressure. The bottom seal shall be of trapezoidal rubber section and shall be bolted to the steel plates with full-length stainless-steel clamps, with stainless steel nuts, washers, ferrules and bolts. All gaskets must be easily adjustable in the closed gate position.

Parts Embedded in Concrete (Built-in Parts)

The design of the gates should suit the existing embedded parts. However, where required the gate frames shall be replaced in the lock chamber recesses. The frame shall consist of a sill beam, and side frames with a combined seal seat, and track for the leaf side guide. The frames shall be supported on metalwork embedded in second stage concrete. The seal seats/track surface shall be machined to the tolerance permitted in DIN 19704.

All parts shall be equipped with stud bolts and stiffeners. The stud bolts will be site welded to dowel plates, being encased into first stage concrete. All embedded parts as well as the dowel plates are parts of supply.

Dowel plates and stud bolts shall be arranged in such a manner, that all parts to be embedded in second stage concrete are adjustable and can be rigidly fixed. Reinforcement, anchor rods and other supporting mild steel parts must have a sufficient concrete cover. The minimum plate thickness of embedded parts shall be 12 mm. Stud bolts must have a minimum diameter of 16 mm. The required thread length shall be sufficient, to assure easy adjustments. The stud bolts shall be equipped with adjusting nuts.

Hydraulic Hoist

One hydraulic hoist shall operate one mitre gate leaf with the load being taken by the navigation lock pier at a hoist trunnion bolted to embedded metalwork in the pier wall. One hydraulic cylinder for each gate leaf shall operate the gate. Connections between the hoists and gate shall be by spherical bushings.

The servomotors and the controls must be designed to properly "open" and "close" the gate leaves. Provision shall be made to prevent pressure build-up in the hydraulic system when the gates are closed as a result of gate deflection caused by rising water pressure. When the gate leaves are opened and resting against the stops, the valves shall be closed to stop the gate leaves from moving on their own.

Hydraulic piping shall be run from the hoists back to a hydraulic cubicle, one for each mitre gate. Connections to the hoists shall be via steel reinforced high-pressure hydraulic hoses.

The hoists on both sides of the mitre gate leaves shall be synchronized to ensure smooth operation of the gate.

Oil Hydraulic Cylinder

The cylinder shall be designed in accordance with DIN 19704 and the General Technical Specifications.

All bolts, washers and nuts used in the hydraulic hoist equipment shall be of stainless steel.

Oil Hydraulic Unit

The oil hydraulic unit shall be designed in accordance with DIN 19704 and the General Technical Specifications.

The unit shall be provided with at least two motor driven pumps (one duty and one standby in alternating operation)) and one manual pump, each capable of operating the gate at a maximum normal operating pressure as given in DIN 19704.

The combined oil hydraulic unit shall be provided as one unit. The unit will be located in the LCR of the navigation lock piers.

The oil pumps shall be located on the top of the oil reservoir and be neatly arranged for easy maintenance and properly identified.

The unit shall be provided with all hydraulic and electric devices required including relief valves, limit switches, pressure gauges, high and low oil pressure alarm switches, other required alarm switches, and protective relays to guarantee reliable and safe operation of the unit. The first filling with hydraulic fluid shall be included.

Hydraulic Pressure Piping

The Contractor shall supply all necessary hydraulic piping between the oil hydraulic unit and the hydraulic hoist cylinders of the gates. Pipe hangers and necessary hardware shall be included.

Piping of stainless steel shall be used throughout the oil system.

Electrical and Control Equipment

The complete control system required to operate the navigation lock mitre gates has to be furnished under this Contract. The equipment must contain a programmable logic control (PLC), integrated in the LCB and shall be selected in accordance with the Electrical Equipment.

Control Equipment

The system shall include an operator workstation in the LCR's. Each gate control panel shall include at least the following:

1. Motor starting and/or valve control equipment
2. A LOCAL/REMOTE control selector switch. This switch shall be key-operated, with the key only being withdrawable when the switch is in the 'remote' position.
3. Push-buttons and indicating lamps for local control of the gates
4. Gate position indicators
5. Indicating lamps for indication of alarm conditions
6. Terminal interface to the control room
7. Controls, monitoring and alarms to be transmitted to the MCR
8. All terminal blocks and other equipment necessary to complete the control system.

Operation System

Each gate control panel shall be provided with an emergency stop push-button, which shall be hard-wired to over-ride al! other gate controls.

If a gate is selected for 'local' control at its control panel, all gate control shall be by means of push buttons on the LCB. 'Local' control will normally only be used for maintenance when the gate stoplogs are in place.

If one gate is selected for 'remote' control, gate control shall be through the MCB in the navigation lock control room in the Administration Building.

Main Control System (SCADA)

Contract Electrical Equipment includes all terminals specified in the General Technical Specifications. All equipment necessary for the connection to the equipment shall be provided and for the interchange of data to the SCADA system in the format nominated by the contractor for Electrical Equipment, shall comply with IEC 60870- 5-104.

Data interchange shall be in accordance with the Specification. It shall have sufficient spare capacity to permit future incorporation of all operational facilities specified for the Main Control Board (MCB) -including all control, alarm and indication- through the SCADA.

Gate Position Measurement

Each gate leaf shall be provided with limit switches and a position transducer.

7.3 Radial Gates

To facilitate equalization of water levels at opening and closing of lock, 4 Nos. of radial gates (2 Nos each at U/S and D/S end) are provided. These gates were manually operated for long duration. However; the mechanism was changed to electrically operated rope drum hoist. The radial gates of the Lock are found in reasonably good physical condition. Bare minimum maintenance has been performed on the radial gates due to non-functioning of bulkhead gates.

Some structural members are found to be corroded and misaligned. Due to misalignment in the trunnions, it has caused the gate structure to rub against the piers causing some damage to both. The seals of most of the gates are not functioning properly and are worn out due to normal use and have not been replaced since long time. Radial Gates of Farakka Lock and Lifting brackets and limb arms of radial Gates are shown in Figure 7.5.

Figure 7.5 Lifting brackets and limb arms of Radial Gates

The embedded parts of these gates could not be inspected due to lack of access and most of structure being underwater. The operation time of the radial gates as observed is given below:

Radial Gate: Opening time: Appx. 4 minutes

Closing time: Appx. 4 minutes

These durations are considered to be on higher side compared to the proposed Opening/Closing Time of 1 min for New Lock's radial gates. The operating mechanism of these gates is electrically operated rope drum hoist of old technology. Also, the operating equipment i.e., hoists, motors, ropes are found to be in poor condition and the system has not been properly maintained (Figure 7.6).

Figure 7.6 Operating System of Radial Gates

7.3.1 Present status /Functional Condition Index

The health of the radial gates skin plate is good in zone 1 with functional condition index falling in the range of 70-84 functional conditional index of critical parameter is given in Table 7.2. The health of the operating mechanism of the radial Gates is marginal in zone 2 with functional condition index falling in the range of 40-54. However, as there is some misalignment of trunnion assembly and improper operation of radial Gates, it is suggested to re-align and attend any other issues after isolating these radial Gates so that smooth and trouble-free operation of radial Gates can be ensured.

Table 7.2 Functional conditional index of radial gate

Radial Gates								
Items	**Critical Parameter**	**Defect based on Visual Inspection/ Estimation**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight * CI**	**Functional CI**	**Remarks**
Skin Plate	Crack	No	0	100	50	50	84.30	Repair the skin plate areas
	Corrosion	No	2	63.246	20	12.649		
	Strength (Thickness)	No	2	63.25	20	12.65		
	Dents	No	0	100	10	10		
Arms	Joint assembly	Yes	4	20	100	20	20	Repair the arms/joint assembly
Rubber Seals	Leakage	Yes	4	20	100	20	20	Replace the rubber seals
Operating Mechanism	Noise/Vibration	Yes	1	90	25	22.5	45	Replace the operating system
	Maintenance Easiness	Yes	3	30	25	7.5		
	Operation	Yes	3	30	25	7.5		
	Synchronization	Yes	3	30	25	7.5		

7.3.2 Design life with and without Renovation

As per IS:10210, the design life of Radial gate is 30-35 year and residual life without renovation and replacement is 10-15. The working life of structure can be enhanced by to 30-35 years after replacement and modernization. It is recommended to all the structural components of the radial gates along with the rubber seals and other embedded parts. The operating system is also outdated and time consuming. So, it is also recommended to completely replace the operating system with latest operating systems to bring down the operation time.

7.3.3 State of the Art Technology

Modern Hydraulic power packs units are envisaged to use axial pumps with hydraulic cylinders. The hydraulic system shall include hydraulic power units using variable displacement, axial-piston pumps, manifolds, stainless steel reservoirs, hydraulic cylinders, piping etc. as well as safety and instrumentation system. General arrangement of the radial gate is shown in the Drawing no. ENL008-SH1 and ENL008-SH2.

7.3.3.1 Design

The radial gates shall consist of curved skin plate as per IS:2060 steel quality cladded with corrosion resistant steel confirming to IS:1570 (Part-5) supported on suitably spaced vertical stiffeners which in turn rest on horizontal girders. The horizontal girders shall be supported by radial arms emanating from the Trunnion hubs located at the axis of the skin plate cylinder. The arms shall transmit the water thrust to yoke girder. Suitable sealing arrangement shall be fixed with the help of stainless-steel screws so as to ensure positive water pressure to prevent leakage.

7.3.3.2 Range of Differential Water Levels

The Radial gates should be designed for the differential water head considering maximum water level i.e., 26.3 m on U/S side and other side considering empty.

Gates for Filling and Emptying Culverts:

Mitre gates of Navigation lock are operated under balanced head condition achieved by gated filling and emptying culverts provided on each side of lock. The lock is filled using filling culverts running either side of the upstream mitre gates, with inlets on each side of the lock head structure, and outlets in the walls inside the chamber and downstream of the upstream mitre gates. These culverts are controlled using radial gates as described in the following sections. Similarly, the lock is emptied using emptying culverts running either side of the downstream mitre gates, with inlets inside the chamber and outlets in the· walls·, downstream of the downstream mitre gates.

Gate chamber at inlet of each Filling and Emptying culvert, are provided to accommodate Service and bulkhead gates. Sluice type radial gates operated by hydraulic hoist are proposed to control the flow in culverts. Fixed wheel type bulkhead gate operated by electrical wire rope hoist are provided on upstream as well as downstream side of service gates, to stop flow from river side into culvert, during repair and maintenance period. Similarly, a sluice type radial gates operated by hydraulic hoist, along with bulkheads are proposed at outlet to stop flow into culvert from downstream side.

Sluice Radial Gate

The radial gates shall consist of curved skin plate having uniform thickness supported on suitably spaced vertical stiffeners which are supported on horizontal girders. The horizontal girders shall be supported by parallel arms emanating from the trunnion hubs located at the axis of the skin plate cylinder. The arms shall transmit the water thrust through trunnion to the trunnion bracket which is supported directly on civil structure on upstream side. Suitable sealing arrangement on sides, bottom and top shall be provided. Twin sealing are required to be provided at top. One seal will be fixed on the gate (moving part) while another will be provided on concrete lintel at EL 18.555m so as to prevent water jet during partial operation. The seals shall be fixed with the help of stainless-steel screws so as to ensure positive water pressure between seal & gate leaf to bear tightly on the seal seats to prevent leakage.

The radial gates shall be provided with two horizontal girders. The framing adopted for the gate can be either vertical stiffeners supported on horizontal girders or horizontal stiffeners supported on vertical diaphragms resting on horizontal girders. In any case, vertical diaphragms shall be provided for ensuring rigidity of the gate. The skin plate shall be of uniform thickness and having smooth surface on upstream for effective sealing at top. The gate shall be sufficiently rigid so that the deflection at the top seal is within permissible structural limits to prevent any leakage from top seal. The gate shall be designed for various load conditions as per the provisions contained in IS:4623.

Radial gates are proposed to be operated by hydraulic hoist connected with the gate. Arrangement of hoist attachment and hoist suspension shall be such that hoist cylinder and all related parts are having sufficient clearance from the civil structures operating water level. Location of hydraulic hoist trunnion indicated in specification drawings is as per existing structure. Connection of hydraulic hoist stem on the downstream shall be made at the top most horizontal girder and shall be sufficiently rigid. Pins connecting hydraulic hoists with gate shall be of stainless steel and fitted with the type of bearing recommended/provided by hydraulic hoist manufacturer. Tolerances on hoist connecting pin shall suit the bearing.

The gate is not intended for partial opening for regulation of discharge, and will be either in fully open or closed condition.

Guide Rollers

Guide Rollers shall be provided to the sides of radial gate to limit the lateral motion or side sway of the gate to be not more than 6 mm in either direction by rolling contact. These shall travel on wall plate but the portion of wall plates on which they travel shall be made of structural steel. Roller shall be provided with plain Aluminum Bronze Bushings running on fixed steel pins. Suitable provision for greasing shall also be made. Design of guide rollers shall also be checked for the forces caused due to non-operation of one of the hydraulic cylinders. It has to be ensured that at least two guide rollers are in contact with wall plate when gate is fully raised.

Horizontal Girders & Stiffeners

The horizontal girders may be so spaced that the bending moments in the vertical stiffeners at the horizontal girders as a continuous beam are approximately equal. Minimum three girders are to be provided. The girders shall be designed considering the fixity at arms support. Girders shall be checked for shear at the points where they are supported by arms. The spacing and design of the bearing and intermediate stiffeners shall also be governed by relevant portion of IS:800.

Arms

The arms shall be designed as columns for the axial load and bending moment transmitted by the horizontal girders in accordance with the provisions contained in IS:800, taking into consideration the type of fixity to the girder.

The total compressive stress shall not exceed the permissible limits specified in IS:4623.

Arms shall be suitably braced in between the arms. The bracing shall be so spaced, that the slenderness ratio of the arms in both the Longitudinal and Transverse directions is nearly equal.

Trunnion Hubs

The arms of the gate shall be rigidly connected to the hubs to ensure full transfer of loads. The hubs shall be sufficiently long so as to allow arms of the gate to be fixed to the respective limbs of the hub without having to cut and shape the flanges of the arms. The limbs of the hubs shall on the apex of a cone with the base of the cone along with joints of the arms and the horizontal girders. The thickness of the webs and flanges of each of the limbs of the hub shall be greater to the extent so as to provide adequate space for the weld. Sufficient ribs and stiffeners shall be provided in between its webs and flanges to ensure rigidity of the trunnion hubs. The thickness of hub shall be 0.3 times of the diameter of the pin.

Trunnion Pins

The trunnion pins of Corrosion Resistant steel Gr.20Cr13 conforming to IS:1570 shall be supported at both ends on the trunnion brackets which are fixed to the support girders. The trunnion pins shall be designed for bending for the total load transferred through the trunnion hub. The load shall be taken as uniformly distributed over the length of the pin bearing against the hub. The pin shall be checked for shearing and bearing also for the same load. The provision for periodical greasing of the bearing shall be made on the outer surface. The trunnion shall be medium fit in the bearing lugs of the support and shall be locked against rotation.

Trunnion Bush/Bearings

The bearing should be self-lubricating, completely maintenance free during its lifetime. They should consist of bronze (DIN 1714-2.0975.03 – ASTM B271 C95500 or DIN 1709-2.0598.03 / ASTM B271 C86300) with solid deposits of special lubricants (white).

The lubricant should be free from graphite and molibdenium to avoid electrolysis. It should be distributed on the whole sliding surface, covering more than 25% of the area.

The sliding surface should be covered with a running in film containing the same lubricant (PTFE with about 0.02mm of thickness)

The baring should have high static and dynamic load capacity, consistent low coefficient of friction (< 0.10), without "stick-slip" and should be corrosion resistant and tolerant to dirt. Co-efficient of friction should be consistent over all load ranges and relationships to demonstrate this should be supplied. Mating material Shaft Properties Shaft should be Corrosion resistant and should have the following properties:

I. Minimum Shaft Hardness – 300 BHN
II. Shaft Surface Roughness – 0.2 to 0.8 microns.

Trunnion Brackets

The trunnion brackets shall be rigidly fixed to the embedded anchorage by bolts and shall transfer the total load from the trunnion to the Anchorages. The arms of the bracket shall be designed to transfer the load from each trunnion in bearing. The arms of the bracket shall also be designed to resist any bending which may be encountered by them due to the component of the load parallel to the base of the trunnion bracket. Ribs and stiffeners shall be provided on the trunnion bracket to ensure sufficient structural rigidity. The bearing stress and bending stress shall not exceed the values specified in Appendix 'A' of IS:4623.

Gate Anchorage System

The anchorage system shall be verified to withstand the applicable governing total water on the gate and transfer it to the gate chamber.

Design Criteria

Radial Gate for filling Culvert

The gate shall be designed for an unbalanced hydrostatic head corresponding to EL24.380 m (full reservoir level) and checked for H.F.L. 26.3 m, to suit the operating criteria. Sill of filling culvert Service Gates is at EL 15.545m. The gate & embedded parts shall be designed for Wet and Inaccessible condition as per provisions contained in IS: 4623. These gates shall be operated by single acting hydraulic hoist under flowing water conditions when the upstream water level is at Full reservoir level.

Radial Gate for Emptying Culvert

The gate and embedded parts shall be designed for an unbalanced hydrostatic head corresponding to water level in lock chamber 24.38 m, as per the design criteria specified in Annexure II. Sill of emptying culvert gates is at EL 15.545m. The gate & embedded parts shall be designed for Wet and Inaccessible condition as per provisions contained in IS: 4623.

Control System

The gate shall be operated through electro-hydraulic system to achieve opening and closing time preferably in 1 min. (max. 2 mins.) It is proposed to install the hydraulic power packs at both side of the lock near each radial gate. A remote-control operation of the gate is envisaged from central control and also local control from the room where hydraulic power packs will be located.

The hydraulic system shall include hydraulic power units using variable displacement, axial-piston pumps, manifolds, stainless steel reservoirs, hydraulic cylinders, piping etc. as well as safety and instrumentation system. The system components shall be designed as per IS:10210. The speed of the radial gate will be determined by the output flow of the pump controlled by an electrically operated valve. The control system shall be PLC based. Fiber optic technology is proposed as communication mode for the lock operating system. The preferred protocol for the control system shall be suitable for the operations and shall be selected by the manufacturer/supplier of the control system.

7.4 Bulkhead Gates

To isolate the existing radial gates for inspection and maintenance 8 Nos Bulkhead gates (2 Nos for each radial gate at its U/S and D/S) have been provided. These gates are critical to proper functioning of the Lock as they are necessary for maintenance and upkeep of radial gate and reduce the risk of failure. These are fixed wheel type vertical lift gates. Bulkhead Gates for Radial Gate Maintenance are shown in Figure 7.7. All gates were observed and also reported to be of different dimensions with not all of them being interchangeable. Most of the gates were kept outside in open atmosphere.

All structural members of the bulkheads were visually inspected and were found to be heavily corroded and beyond any chances of use in operation and not in a position of rehabilitation. The seals of all gates are in damaged conditions (Figure 7.7 and Figure 7.8). The filling valve arrangement of gates are also in dilapidated state with corrosion on all sides (Figure 7.9). The Wheels are jammed and not rotating freely, greasing system was not functioning and bearings need to be replaced. The lifting assembly is shown in Figure 7.10 .

Figure 7.7 Bulkhead Gates for Radial Gate Maintenance

Figure 7.8 Heavy corrosion in Bulkhead Gates

Figure 7.9 Deteriorated equalizing valve of Bulkhead Gates

Figure 7.10 Lifting Assembly of Bulkhead Gates

7.4.1 Present status /Functional Condition Index

As per the condition survey, the health of the bulkhead gates in general including skin plate and its supporting members is marginal in zone 2 with functional condition index falling in the range of 40-54 (Table 7.3). The Gates are pitted; rusted and heavily corroded. All filling valves of the bulkhead gates are also badly damaged and non-functional. All rollers are jammed along with rusted pins and bearings. These gates have not been operated since decades. The present lifting arrangement of bulkhead gates is totally inadequate and the condition of the operating mechanism of the bulkhead gates is in zone 3 (poor) with functional condition index falling in the range of 25-39.

Table 7.3 Functional conditional index of bulkhead gate

Bulkhead Gates								
Items	**Critical Parameter**	**Defect based on Visual Inspection/ Estimation**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight * CI**	**Functional CI**	**Remarks**
Skin Plate, Girder and Stiffner	Crack	No	3	40	50	20	44.06	Replace the skin plate areas
	Corrosion	No	4	20	20	4		
	Strength (Thickness)	No	3	50.30	20	10.06		
	Dents	No	0	100	10	10		
Equalizing Valve	Operation	Yes	4	20	100	20	20	Replace the Equalizing valve
Roller Assembly	Jammed	Yes	4	20	100	20	20	Replace the roller assembly
Operating Mechanism	Noise/Vibration	Could not be checked	NA	NA	NA	NA	30	Replace the operating system
	Maintenance Easiness	Yes	3	30	33	9.9		
	Operation	Yes	3	30	34	10.2		
	Synchronization	Yes	3	30	33	9.9		

7.4.2 Design life with and without Renovation

As per IS:10210, the design life of Radial gate is 30-35 year and residual life without renovation and replacement is Nil. The working life of structure shall be enhanced by 30-35 years by replacement and modernization. It is recommended to replace the skin plate and supporting steel members of the bulkhead gates. Further, besides the roller assembly and equalizing valve, embedded parts and rubber seals also need to be replaced. Almost the entire gate is unusable and difficult to repair. The critical embedded parts and its critical dimensions need to be checked and matched with the new bulkhead gates suggested to be provided. Overall, all the 8 Bulkhead gates need to be replaced.

7.4.3 State of the Art Technology

The existing operating mechanism needs to be replaced with a new individual fixed Winch type hoist (of suitable capacity) for each bulkhead gate along with dogging arrangement. The replacement of the current operating system to an alternative involving a fixed Monorail hoist will allow for regular maintenance of the radial gates and filling/emptying system. General arrangement of the bulkhead gate is shown in the Drawing No. ENL009-SH1 and ENL009-SH2.

7.4.3.1 Range of Differential Water Levels

The Bulk Head gates should be designed for the differential water head considering maximum water level i.e., 26.3 m on one side and other side considering empty.

7.4.3.2 Load considered for Structural Design

Gates shall be designed for the following loading conditions:

- All static and dynamic hydraulic loads due to differential water levels mentioned above.
- All loads due to dead weight and frictional forces.
- Seismic loads as given in the design criteria of civil works.
- Temperature loads as applicable.

7.4.3.3 Design Method

The sizing of structural plating and stiffening of the gate shall be based on the above-mentioned loading criteria and hydrostatic pressure. The slenderness, buckling resistance and yielding of each plate panel, stiffener and beam members shall be assessed for finalizing the structural design. The stresses for the design shall be as per IS: 9349.

Structure

Bulkhead gates that are intended for isolating each of the radial gates for inspection, maintenance and repairs. Eight bulkhead gates with sizes are provided in Table 7.4.

Table 7.4 Size and type of bulkhead gate

Location of Gate	Filling culvert		Emptying culvert		No. of Gates
	Width (m)	Height (m)	Height (m)	Width (m)	
Bulk Head Gate on U/S of upstream radial gates. Type A	3.658	2.21	-	-	2
Bulk Head Gate on D/S of upstream radial gates. Type B	3.268	2.21	-	-	2
Bulk Head Gate on upstream and downstream for D/S radial gates. Type C	-	-	2.210	2.205	(2+2) =4

For maintenance of sluice radial gate, fixed wheel type bulkhead gate of as indicated above are proposed just upstream of the intake service gates. The sill of the gate is located at EL 15.545m and top of opening at EL 17.755m. The gate shall have downstream skin plate and sealing. The gate is to be designed for a head corresponding to FRL 24.43m. The gate shall be capable of lowering in flowing water condition in case of any emergency. The gate shall generally be in fully open position and lowered only for inspection and maintenance of the radial gate. The gate shall generally be lifted or lowered under balance head condition. However, the gate shall also be designed to be self-closing under flowing water condition.

The gate shall be operated under balance head condition created by crack opening, by electrically operated monorail hoist of adequate capacity 10t.travelling over monorail supported over trestles. Provision of removable guide shall be made in trestles. When not in use the gate shall be stored on dogging beams on at EL 26.30m. To ensure that the gates are self-closing, they are so dimensioned that their self-weight is sufficient to effect positive closure. If necessary, ballast can also be added to them for this purpose.

7.4.3.4 Seals

Rubber seals shall be provided as per relevant IS codes and the sealing arrangement should be such as to make the gate watertight. Provision shall be made to pressurize the back of the top and side seals with water in order to obtain water tightness.

7.4.3.5 Guide Rollers

Guide rollers shall be provided at the sides of the gates both near the top and bottom. The guide rollers shall be effective in both longitudinal and transverse directions. Bottom guide roller shall be provided with shear screws and top roller shall be provided with non-shearing screw capable of withstanding the load arising due to tilting of the gate.

7.4.3.6 Track / Bearing Plates

It shall be provided on downstream side of the gate slot.

7.4.3.7 Seal Seat

Side seal seat face shall be in common plane without off sets or gaps at joints. The bottom seal seat shall be flush with adjoining concrete surface. The arrangements of fixing should be such to ensure water tightness.

7.4.3.8 Sill Girders

The bottom seal seat shall be provided on a suitable girder of structural steel to safety withstand the gate loads and impacts due to sudden closure of the gate.

7.4.3.9 Operating Mechanism

The bulkhead gate shall be operated by electrically operated rope drum hoists. Electric Wire Rope drum hoist for operation of bulkhead gates:

The wire rope shall be class 2 as per IS 6938/IS:3177, outdoor traveling type with electrically operated hoist of adequate capacity complete with pendent type Push Button Switch capable of operating from the floor at EL 28.44m. Suitable steel supporting structure shall be provided as shown on the specification drawing in such a way that the hoist shall be able to lift the bulkhead clear of the top of pier by at least 0.50 meter.

The capacities, travel distance and approximate speed of the hoist shall be as follows:

I.	Capacity of hoist	10 t. (tentative)
II.	Total lift	13.50 m (minimum)
III.	Hoisting speed	1 to 1.5 m/min.

Design criteria for hoist

The electric wire rope hoist shall be totally enclosed, outdoor type and suitably protected from outside weather, rain etc. Suitable arrangement shall be made for oiling/greasing the various bearings, components and hook etc. of the hoist.

The gear train and the control gears shall be housed in aluminum or any other suitable material covers. The runner wheels shall be of cast steel mounted on ball bearings. The hoist and long travel brakes shall be electromagnetic type designed and built to arrest & hold safely the full load capacity of the hoist at any desired position.

All gears shall be machine cut spur or helical type made from cast steel/carbon alloy steel and of very robust construction. The gears shall run in a totally enclosed oil bath gear box giving positive and constant splash lubrication to all the gear parts and bearings. The gears shall be easily accessible by removing few bolts from a light but strong gear box.

The diameter of the rope drum shall be at least 20 times the diameter of hoisting rope and length of drum shall be suitable for the total lift specified in these specifications. A minimum factor of safety of 'six' over normal breaking strength shall be allowed for the selection of rope size.

The bottom block shall be of a suitable type. The sheaves in the block shall be totally enclosed with proper cut to guide the ropes. These sheaves shall be supported on suitable heavy duty bush bearings. The lifting hook shall be of forged steel supported on ball/thrust bearings so that the load may swivel freely. The wire rope shall be made from special improved plough steel of 6 x 36 or 6 x 37 construction lang's lay fibre main core. Suitable limit switches shall be provided for controlling the extreme positions of gate. The motors shall be squirrel cage/ slipring type, totally enclosed fan cooled, high starting torque suitable for operating on 400/440 volts, 3 phase, 50 cycles/sec.

power supply with pendent type push buttons capable of operation from the top of pier. The power supply shall be made available from the suitably located plug receptacles.

Control equipment shall be heavy duty fully magnetic reversible controllers with definite time limiter and instantaneous over current, overload and under voltage protection or any other such suitable and reliable control arrangement.

The manufacturer shall be responsible for the supply of all the accessories and controls necessary for the satisfactory operation of the crane including current collectors, conductors and insulators etc.

All electrical equipment such as motors, conductors switch etc. shall be as per relevant Indian Standards.

The suitable permanent 220-volt lighting system shall be provided with500 watt highway lighting units to illuminate the area of the hoist under operation. The system shall be supplied from 400/440 volts crane power system through suitable circuit breaker.

Complete set of tools, wrenches and a suitable grease gun in a steel box, shall be provided along with the crane to cover all the ordinary maintenance of the hoist.

Hoist Supporting Structure

The hoist supporting structure shall be made of structural steel conforming to I.S: 2062 (Latest revision) and shall be designed to withstand the hoisting load, dead weight of hoist and it's all components as well as vibrations caused due to operation. Additional loading due to the operating mechanism (live as well as dead) of downstream stoplogs will also be combined. In addition, wind/ seismic load shall also be taken into account. Suitable anchorages for the hoist frame shall be provided to take the worst combination of all loads under which the gates and hoists are under operation.

Live load due to crowd shall be considered as 500 kg/sq.m other natural loading shall be as per IS: 875. Supporting columns shall be designed considering effective length of 2L whereas 'L' is the height of the column from the base to the meeting point of center of main beams and column sections. They shall be braced properly as per provisions of

IS: 800 an as indicated in specification drawings. Bracing in the hoist support columns in the gate portion should also be provided with guides for facilitating the drifting of gate above piers at EL 28.438m

Main beams for supporting the hoist machinery shall be designed as simply supported beams having provisions for thermal expansion on one end. They shall be designed all the load combinations for which the hoist may be subjected to. Permissible resultant deflection of hoist support beams and cross beams shall not exceed span/900, where span is the distance between supports. The main beam and cross beams shall be provided with intermediate and load bearing stiffeners at appropriate locations. In case box sections are proposed, diaphragms shall be provided. Overall design of the hoist support structure shall confirm to IS: 800

The structure shall be designed for each of the following combinations:

I. Dead loads plus live load, impact load, wind load @ 50 kg / sq. m and crowd load @ 500 kg/ sq. m on entire area of walkway.
II. Dead load with no hoisting load plus effect of storm wind load @ 150 kg/sq.m.
III. Breakdown torque of the motor shall be taken as 200% of normal torque or the actual breakdown torque as specified in the manufacturers catalogue, whichever is higher. The permissible stresses as specified in IS: 800-1984 for normal operation shall be increased by 33-1/3 %

7.5 Caisson Gates

Two set of caisson Gates were provided for use to isolate the mitre gate for their inspection and maintenance. The gates are of size 26.05 m (L) X 4.0 m (B) X 9.09 m (H). Gates are installed vertically at both end of the lock for stopping water flow from

U/S and D/S of lock chamber only when Mitre gates are required to be attended for repairs. However, due to the gate groove being not constructed properly during the initial stages, the gates were never lowered and hence have been abandoned with little to no care for their structural elements and operating mechanism. The existing caisson gates are shown in the Figure 7.11.

Figure 7.11 Cassion Gates for Mitre Gate Maintenance at Farakka Lock

7.5.1 Present status /Functional Condition Index

The health of the caisson gates is very poor in zone 3 with overall condition index falling in the range of 10-24. Functional conditional index of critical parameter is given in Table 7.5.

Table 7.5 Functional conditional index of the caisson gate

Caisson Gates								
Items	**Critical Parameter**	**Defect based on Visual Inspection/ Estimation**	**Count/ Severity**	**CI**	**Weightage (%)**	**Weight * CI**	**Functional CI**	**Remarks**
Skin Plate, Girder and Stiffener	Crack	No	4	20	50	10	24.00	Replace the skin plate areas
	Corrosion	No	4	10	20	2		
	Strength (Thickness)	No	4	40.00	20	8.00		
	Dents	No	3	40	10	4		
Equalizing System	Operation	Yes	4	20	100	20	20	Replace the Equalizing System
Seals	Leakage	Yes	4	20	100	20	20	Replace the Seals
Operating Mechanism	Noise/Vibration	Could not be checked	NA	NA	NA	NA	23.3	Replace the operating system
	Maintenance Easiness	Yes	3	30	33	9.9		
	Operation	Yes	3	20	34	6.8		
	Synchronizatior	Yes	3	20	33	6.6		

7.5.2 Design life with and without Renovation

The design life of Caisson gate is 30-35 year and residual life without renovation/modernization and replacement is Nil. The working life of the caisson gate after replacement and modernization should be enhanced by 30-35 years. It is recommended to replace both the caisson gates. The complete system of caisson gates and the operating system needs to be replaced. The gate groves and embedded parts of existing lock may be suitably modified to accommodate the new caisson gates.

7.5.3 State of the Art Technology

The new caisson gates shall comprise of deck, bulkheads, face plates so that various tanks and chambers can be arranged for ballasting and de-ballasting required for sinking and raising operations of the gate. General Arrangement of the caisson gate is shown in Drawing No. ENL010-SH1, ENL010-SH2, ENL010-SH3 and ENL010-SH4.

7.5.3.1 Range of Differential Water Levels

The caisson gates should be designed for the differential water head considering maximum water level i.e., 26.3 m on one side and other side empty.

7.5.3.2 Load considered for Structural Design

Gates shall be designed for the following loading conditions:

- All static and dynamic hydraulic loads due to differential water levels mentioned above.
- All loads due to dead weight and frictional forces.
- Accidental impact from 3000 DWT fully loaded barge on Caisson and Mitre gate.
- Seismic / wind load as per IS:800
- All temperature loads as per IS:800
- Loadings from small forklift trucks of 1 T capacity on the top deck of caisson gate.
- Induced pressure during de-ballasting operation of the caisson gate on the water ballast tank plate work and piping system.
- The stresses for the design shall be as per IS: 4622, IS:4623, IS:5620.

7.5.3.3 Structure and Scantling

The envelope plating and all structural members (primary & secondary) of Caisson gates shall be designed as per Rules of any IACS member Classification Society. However, thickness of envelope plating and all primary structural members shall be 25% over Rule requirement. Scantling of all secondary members to be 15% over Rule requirement.

7.5.3.4 Design Method

The sizing of structural plating and stiffening of the gate shall be based on the above-mentioned loading criteria and hydrostatic pressure. The slenderness, buckling resistance and yielding of each plate panel, stiffener and beam members shall be assessed for finalizing the structural design. The rules and regulations of any IACS member of classification society will have to be followed in addition to BS-6349: Part 3 . Maximum combined stresses shall be checked to be less than the allowable stresses given in BS-5400 Part 3 or any equivalent Indian Standards. A minimum load factor of 1.2 shall be used as per BS-5400 in conjunction with water levels mentioned above.

Structure

The entire gate shall be weld fabricated with shipbuilding quality steel plate as per IS: 3039 for skin plate and primary structural members. For secondary structural members IS:2062 quality steel shall be used.

It shall comprise of deck, bulkheads, face plates so that various tanks and chambers can be arranged for ballasting and de-ballasting required for sinking and raising operations of the gate.

The structural arrangement of the gate shall be such so that adequate strength and stiffness shall be achieved during sinking and raising operation under the specified load conditions.

The shape of the gate shall be designed in such a manner so that the structure can be floated at a required light ship draft with adequate stability for maneuvering and maintained sufficient stability during sinking and raising operation.

The profile of the keel should properly match with the contour of the lock floor. Proper sealing arrangements shall be provided with vertical and horizontal face of the lock chamber for the placement of the caisson gate in the grooves as shown in civil drawings. The meeting face shall be provided with rubber seal of suitable grade and shall be placed in an epoxy grout and fitted properly using bolts for tight tolerance.

Sill and side walls at gate grooves should be made of polished granite as per IS codes 14223 (Part-I) as mentioned in Design Criteria, keeping suitable provision in civil works in consultation with gate manufacturer.

The conceptual arrangement of tanks and chambers for water ballast and permanent ballast is shown in the General Arrangement of the caisson gate

Any modification/addition of tanks or chambers if required from stability point of view the same can be considered without changing the clear opening width of the lock based on which gate dimension has been planned.

Miscellaneous items / fittings and fixtures

- **Fixed Ballast** -Steel / concrete block

- **Loose Ballast** – Cast iron blocksThe requirements of the ballast for operation of the caisson gate shall be decided by the contractor while designing the caisson and stability of the gate.
- **Bollards** - At four corners of the top deck suitable beyond the operating platform tying up the gate with lock wall /shore structure.
- **Fair Leads / Mooring Bits** – Near the end of the top deck in four corners.
- **Fixed Hard Rails** – At each side of the top deck over full length in 3 tiers duly supported by galvanized steel stanchions. Handrails around bollards/ fairleads shall be removable type.
- **Vertical Ladders** – At both side in both ends up to the gate securing place.
- **Ring Plates** – Suitable ring plates shall be provided for handling the caisson when afloat.
- **Cathodic Protection** – Aluminum anodes shall be provided on the skin plate and inside tanks/chambers to achieve design life mentioned in design criteria.
- **Draft Marks –** shall be made from M.S. Roman numbers and welded on each side of the caisson near each stem and also printed in white denoting the draft in meters.

Control System

The sinking and raising operation of the gate shall be carried out through suitable valve arrangement without requiring any external assistance. The sequence of valve operations and the conditions of various tanks/chambers (full or empty) before starting the raising of lowering of the caisson shall be decided by the contractor depending on the design.

Each valve or cock shall have a separate control to operate from the top deck as well as from local. The valve controls shall be operated by electrical mode and manually from the top deck. All controls shall have suitable indicators showing the position of level for the valve or cock. Suitable piping arrangement shall be provided to connect these valves.

Capstan

Two (2) nos. electrically operated capstan including starters, cables, fuse sockets etc. shall be fitted with necessary foundation for positioning and shifting the caisson on both side of lock floor. The capacity of the capstan shall be adequate for the intended operation.

Submersible Pumps and Blowers

As an alternative arrangement for pumping due to any emergency, electric driven submersible pumps shall be provided in the tanks / chambers for emptying river water to achieve required buoyancy.

Blowers of required capacity shall be provided for proper ventilation of enclosed space with wirings, switch and socket.

Electricals

Control panel for operation of ballasting system, valves, etc. shall be attached to the handrail on the top deck. The panel shall be within a weather proof enclosure. Sufficient lights with watertight fittings suitable under water application with all the cables and gears etc. shall be provided below main deck. The cables shall be enclosed in watertight GI pipes.

Painting System

Before fabrication all surfaces shall be shot blasted to SA 2 ½ quality standard and primed immediately after blasting with one coat of approved shop primer. Thereafter the skin plate, tanks, frames, fittings shall be coated with anticorrosive and antifouling paint system to achieve minimum guarantee life to first maintenance of 15 years based on ISO 12944.

Testing for Air/Water Tightness

The entire caisson gate shall be tested for water or air tightness as the case may be separately for individual compartment and jointly as a complete gate. All water pipes and valve bodies shall be also tested in accordance with the manufacturer's specification and relevant IS codes.

Inclining Test

The metacentric height of the gate at lightship draft shall be calculated by means of an inclining test during commissioning.

Trials

A demonstration trial shall be carried out at the project site to prove that the gate along with the ballasting/de-ballasting system is in good condition and to familiarize the operation to the lock operators. The following trials will be carried out before acceptance:

I. The gate shall be placed and position in the landing face of the lock basin to be checked for perfect sealing of the gate. There should not be any leakage from the gate i.e., in between the lock face and caisson seals.
II. The above trial shall be shown for both the side of the caisson one after another.
III. Ballasting/de-ballasting time in 30 mins or less.
IV. Emergency lifting of the gate by using submersible pumps.

7.6 Codes & Standards:

The designs should conform to BIS standards. Latest editions of standards applicable at the time of detailed design shall be referred. Standard other than those stipulated, shall be acceptable after scrutiny provided, they ensure equal or higher quality than those specifications. The contractor shall submit for approval the detailed standards, which he proposes to use. Chronology and priority of applicable standard shall be as under:

- Bureau of Indian Standard (IS)
- International Organization for Standardization (ISO),
- American Society for Testing and Materials (ASTM),
- American Society of Mechanical Engineers (ASME),
- Deutsches Institute fur Normung (DIN),
- Technical Standards for Gate and Penstocks (Hydraulic Gate and Penstock Association: Japan)
- British Standard (BS),
- European Standard (EN)
- International Electrotechnical Commission (IEC)

If these specifications conflict any way with any of the above standards or codes, these specifications and drawings shall take precedence.

7.7 Special Conditions:

Earthquake Effect The gates & hoists and their components shall be designed for earthquake forces in accordance with IS: 1893. Seismic co-efficient (alpha-h) shall be taken as 0.12.

The allowable stresses specified in Annex. A of IS: 4622/5620 (latest revision) shall be increased by 33-1/3 %, subject to maximum of 85% of yield point stress of the material used.

The increase in allowable stresses in case of Bolts & nuts shall not exceed 25%. The permissible value of stresses in the welded connection shall be same as permitted for parent material.

7.8 Material Specification of Gates

Recommended Material for Gates & Hoists

Material for all the components for gates and hoists shall be as stated on respective specification drawings. All the materials shall be as per rules of any IACS member classification society. Following is the list for guidance (Table 7.6):

Table 7.6 Materials specification and guidance of all the components

A. Mitre & Caisson Gates:	
Skin plate & enveloping Plates	Ship building quality steel (IS:3039)
Secondary structural members	Hot Rolled Medium & High Tensile Structural Steel (IS:2062)
Seals	Rubber (IS:11855 & IS:15466)
Polished Building Stones Specifications	Granite (IS:14223 – Part I)
Seal Seats and fasteners	Stainless steel (IS:1570 Part V)

Bushings	Aluminium Bronze (IS:305, IS:318)
Guide Roller	Cast steel (IS:1030/IS:2014)
Guide Roller pin	Corrosion resistant steel (IS:1570 Part V)
Wheels	Cast steel / forged steel (IS:1030, IS:2004)
Wheel pin	Corrosion resistant steel (IS:1570 Part V)
Ballast	Cast Iron (IS:210) or concrete
Components of Hydraulic System	IS:10210 & DIN 19704
Valves	2% Ni-Cast Iron
Piping	G.I. (IS: 1239)

B Radial Gates			
Sl. No.	**Components / Articles**	**Recommended Material**	**B.I.S Specification/ Standard/ Make**
1	All structural members such as skin plate, stiffeners, horizontal girders, splice plates, arms, bracings, rest beam, yoke girders, load carrying anchor flats, trunnion brackets, hoist connection brackets, sill beam, wall plates, seal bases, track bases, seal seat bases, seal clamps, lifting lugs etc.	Structural steel	I.S: 2062
2	Trunnion Bearings	Self lubricating maintenance free bush bearing	Of reputed make ASTM B271 with solid lubricants
3	Trunnion pins, roller pins, lifting pins, Hoist support pin etc.	Corrosion resistant	I.S: 1570(V)/
		Steel, 20 Cr 13	AISI 420
		Stainless steel	
		04 Cr 18Ni.10	
4	Seal seats	Stainless steel	I.S: 1570(V)/
		04 Cr 18Ni.10	AISI -304
5	Guide rollers, trunnion hubs	Cast steel	I.S: 1030
6	Guide roller bearings	Aluminum Bronze bush	IS: 305
7	Seals	Natural or Synthetic rubber (Flurocarbon clad for sides and top seal)	IS: 11855
8	Screws / bolts & nuts for fixing seals	Stainless steel	I.S: 1570(V)

C. Vertical lift Gates			
Sl. No.	**Components / Articles**	**Recommended Material**	**B.I.S Specification**
1(a)	Skin plate of Service & Emergency gates,	Stainless steel	IS:1570 P(V), / AISI 316(L)
1(b)	Skin plate of stoplogs, stiffeners, horizontal / End vertical girders, end vertical stiffeners, Seal bases, track bases, seal seat bases, clamps, guides, diaphragms, anchor plates and anchorages, lifting lugs etc.	Structural steel	IS: 2062
2	Seal seat	Stainless steel 04Cr19Ni9	IS: 1570 (Pt.V)
3	Track plate	Corrosion resistant steel 20Cr13/30Cr13 (hardened to 50 BHN more than that of wheel rim).	--do--
3.a	Guide, face plates of embedded parts exposed to sea water.	Stainless steel 04Cr19Ni9	IS: 1570 (Pt.V)/ AISI 304
4	Wheel/ guide rollers	Corrosion resistant high alloy steel and nickel based casting.	IS:3444
5	Wheel pin/axle	Corrosion resistant steel	IS: 1570(Pt V)
6	Bearing	Self-lubricating bearings	Reputed make
7	Side Seals	Rubber seals (fluoro-carbon clad)	IS:11855 / IS:15466
8	Bottom seals	Wedge type rubber seal	--do--
9.	Screws / bolts & nuts for fixing seals	Stainless steel	I.S: 1570(v)
D.	**Rope Drum Hoists**		
Sl. No.	**Components / Articles**	**Recommended Material**	**B.I.S Specification**
1	Wire ropes	*6x36/ 6x37 construction galvanized improved plough steel	IS:2266
2	Sockets for wire ropes	Forged steel	IS: 2485
3	Rope drums	Cast steel	IS: 1030

		Structural steel	IS: 2062
4	Gears	Cast steel	IS: 1030
		Forged steel	IS:1875/IS: 2004
5	Pinions	___do____	_____do_____
6	Sheaves /pulleys & couplings	Cast steel	IS: 1030
7	Shafts	Forged steel	IS:2004
8	Bolts & nuts		IS: 1363
9	Keys & cotters		IS:2291/IS:2048/IS: 2292
10	Bearings		
	Bush bearing	Aluminum Bronze	IS: 305
		Self-lubricating bearings	Reputed make
		Standard	
	Ball/Roller bearing		Reputed make
11	Equalizer bars, turn buckles	Forged steel	IS:1987
12	Hoist supporting structure/ gantry girder	Structural steel	IS : 2062
13	Covers	Structural Steel	IS:2062
14	Plummer Blocks	Cast steel	Reputed makes

Notes:

a) Latest editions / revisions of all B.I.S. codes mentioned herein these technical specifications and or on the specification drawings, applicable at the time of detailed design shall be referred.

b) Decision regarding adopting particular equivalent standard/ make, shall be made by the IWAI and shall be binding on the contractor.

7.9 Painting

7.9.1 General

All paints, painting materials and accessories, required for the shop as well as field paintings shall be conducted by the contractor. Surface preparation and painting of all exposed and under water steel works shall be carried out as per the provisions of IS: 14177. However, during selection of paint IS: 14428 (Painting of structures in aggressive chemical environment- guidelines) shall also be considered. Paints, which are proposed by the contractor, must be got approved from the representative of the IWAI before its application. Paints shall be anti-corrosive and anti-fouling paint system to achieve minimum guarantee life to first maintenance of 15 years based on ISO-12944. The detailed analysis reports in respect of paint properties, chemical composition and performance requirements of the proposed paint shall be submitted by the contractor for examination and approval of the IWAI before the application of the paint. All paints shall be applied by skilled workers in a workman like manner in accordance with the provisions contained in I.S:14177 i.e., “Guide lines for painting system for Hydraulic Gates and Hoists”.

7.9.2 Embedded Parts in contact with concrete

All surfaces of embedded parts, which are in contact with concrete shall be cleaned as given in Para 4.2.1.4 of I.S: 14177, to meet the requirement of class D and shall be given a coating of Cement Latex to prevent rusting. Exposed machined surfaces of ferrous metal, which are to be in rolling and sliding contact shall not be painted but shall be coated with heavy gasoline soluble rust preventive compound. In all exposures, where metal will be partially embedded in concrete, it is good practice to extend the protective coating on the non- embedded portion a short distance into the area later to be embedded, thus eliminating problem at the junction point.

7.9.3 Surfaces not to be painted

The following surfaces are not to be painted unless or otherwise specified:

i. Machine finish or similar surfaces, however, such surfaces should be protected with a corrosion preventive compound.
ii. The surfaces, which are in contact with concrete.
iii. Stainless steel overlay surfaces.
iv. Surfaces in sliding contact.
v. Galvanized surfaces, brass and bronze surfaces.

vi. Aluminum alloy surfaces.
vii. Bare electrical conductors and insulating materials.
viii. Equipment name plates and instructions etc.

7.9.4 Tolerances

The tolerances for embedded parts and for components of the gates shall be as specified in relevant BIS codes mentioned in Table 7.7.

Table 7.7 List of BIS Standards for gates & hydro-mechanical equipment

Sl. No.	Code No.	Description
1	IS:4622	Fixed Wheel Gates Structural Design Recommendations
2	IS:4623	Recommendations for Structural Design of Radial Gates
3	IS:5620	Recommendations for Structural Design Criteria for Low Head Slide Gates
4	IS:807	Code of practice for design, manufacturer, erection and testing (structural portion) of cranes and hoists
5	IS:6938	Design of rope drum and chain hoists for hydraulic gates code of practice
6	IS:13591	Criteria for design of lifting beams
7	IS:10210	Criteria for design of hydraulic hoists for gates
8	IS:11855	Guidelines for design and use of different types of rubber seals for hydraulic gates
9	IS:7718	Recommendations for inspection, testing and maintenance of fixed wheel and slide gate

8 ELECTRICAL AND CONTROL SYSTEM

8.1 Electrical Power Supplies

Power comes onto the site via an 11kV substation inside the perimeter walls. The substation is outside of the scope of the survey, but looks in poor condition. It provides a 440 V 3-phase plus neutral supply via a single, overhead, 16 mm2 (according to the O and M manual) cable which emerges at the downstream mitre gate power distribution house. 80 kA, 415 V, HRC in-line fuse links are in position. The power is distributed around the site via covered trenches and or overhead lines. The existing setup of transformer, electric sub-station and electrical control room is shown in Figure 8.1, 8.2 and 8.3 respectively.

Figure 8.1 A 11 kV to 415 V Transformer

Figure 8.2 Electrical sub-station distribution board

Figure 8.3 Electrical Control Room

All electrical equipment inspected was barely serviceable and in a dangerous condition whereby three-phase electricity can be directly touched. There is an alternative power source in the form of a DG set which is in good shape.

8.1.1 Present status /Functional Condition Index

All electrical equipment inspected was barely serviceable and in a dangerous condition whereby three-phase electricity can be directly touched. There is an alternative power source in the form of a DG set which is in good shape. The existing power distribution system is past the end of its useful life. The following improvements are needed:

i) Refurbish the electrical sub-station at the boundary of the lock site adjacent to the road.

ii) Renew the main incoming power supply cable from the electrical substation.

iii) Evaluate the use of the under-lock electrical tunnel. If possible, decommission the cable bridges, which are difficult to maintain and are vulnerable to impact with passing vessels.

iv) Provide local distribution isolation panels adjacent to each mitre gate leaf as well as centralized operating point in the existing control building.

8.1.2 State of the Art Technology

The main power requirement for electrical load in the old Navigation Lock is on account of mitre gates, radial gates, Submersible Pump, Motors, etc. Other infrastructure such as general lighting, power for auxiliary services like Automatic Data Acquisition System (ADAS) etc. will also need their share of electric power. Power will also be needed for air- conditioning and lighting of control room building. The total power requirement shall be met through the existing dedicated power supply. Also, standby power source in the form of DG set of suitable capacity should be in place as alternative power source for smooth operations in case of power failures.

For operational power, all the installed loads like mitre gates, radial gates and Submersible Pump, Motors etc. will not be operating simultaneously and will not draw maximum power at the same time. Taking all such aspects and applying suitable diversity factors, the computation for estimated connected power and demand load calculations shall be carried out during the design phase, and given in draft DPR. All Electrical and controls equipment shall be designed for an ambient temperature of 45 ^{0}C.

Taking all such aspects and applying suitable diversity factors, the computation for estimated connected power and demand load calculations are shown in attached Table 8.1 and the summary of which is given in Table 8.2. Power single line diagram is shown in Drawing No. ENL011.

Table 8.1 Electrical power requirement

S. No.	Equipment	Connected Load (kW)	Utilization Factor (%)	Maximum Demand (kW)	DG Rating (kVA)	Total Capacitance Load	
1	LCP Mitre Gate-Leaf-1	75	0.90	68	68	68	
2	LCP Mitre Gate-Leaf-2	75	0.90	68	68	68	
3	LCP Mitre Gate-Leaf-3	75	0	0	0	0	
4	LCP Mitre Gate-Leaf-4	75	0	0	0	0	
5	LCP Radial Gate-1	22.5	0.90	20	20	20	
6	LCP Radial Gate-2	22.5	0.90	20	20	20	
7	LCP Radial Gate-3	22.5	0	0	0	0	
8	LCP Radial Gate-4	22.5	0	0	0	0	
9	Electric Actuated Valve for Caisson Gate	20.0	0	0	0	0	

10	Submersible Pump Motors (4x7.5kW)	30	0	0	0	0	
11	Capstan Load for Caisson Gate (2x5.5kW)	11	0	0	0	0	
12	MLDB (Lighting + High Mast Load)	123	1	123	59	123	
13	ACDB (For Welding Socket Load)	45	0	0	0	0	
14	Sewage Treatment Plant	1	1	1	0	1	
15	Battery Charger	5	0.8	4	4	4	
16	UPS load (2kVA @ 0.95 PF)	1.9	1	1.9	1.9	2	
	Total LT Load in kW	627		305	240	Capacitance Load	305
	Load in kVA at 0.95 PF for Transformer & 0.80 for DG			320	301	Multiplying factor	0.553
	Load at 120% Overload			385	361	(0.75 to 0.95)	
	TRANSFORMER & DG RATING SELECTED			400 kVA	400 kVA	Required Capacitance	169
						Capacitor Bank Selected	170 kVAR

8.1.2.1 Source of Power Supply

The existing source of Power at 11 kV is made available up to a DP (Double Pole) Structure within the Project boundary by West Bengal State Electricity Distribution Company Limited (WBSEDCL). Power at 11 kV received at the input of HT Switchgear is stepped down to 415 V through a transformer. This 415 V power shall be supplied to various LT Loads such as mitre gates, radial gates, Submersible Pump, Motors etc.

8.1.2.2 Utilization Voltages

The particulars of Power Supply are shown in Table 8.2 below:

Table 8.2 Power Supply

S. No.	Parameter	Value
1.	Voltage	11kV ± 10% & 415V ± 10%
2.	Phase	11kV (3 Phase 3 Wires) 415V (3 Phase 4 Wires)
3.	Frequency	50 Hz ± 3%
4.	Combined Voltage & Frequency Variation	10%
5.	Fault Level	26.3kA for 1 second at 11kV 50kA for 1 second at 415V

6.	System Earthing 415 V		Solidly Earthed
7.	Control Circuits		
(i)	Circuit Breaker Protection & Tripping		110 V DC, 2 Wire grounded
8.	Control System		
(i)	Server, PLC, FI (Intelligent) I/O VDU, Keyboard, Printer		240 V ± 10%, AC, 50 HZ ± 3%, 1 Ph, 2 Wire All equipment shall have internal close loop regulation & spike arrestors
(ii)	UPS System, Field instruments		240 V ± 10%, AC, 50 HZ ± 3%, 1 Ph, 2 Wire

8.1.2.3 Power Factor Correction

415V capacitor bank with Automatic Power Correction Panels shall be provided to achieve power factor of 0.95 lag on 415V bus respectively.

8.1.2.4 Distribution Transformer

11kV voltage is further stepped down to 415V through one number of distribution transformer. Transformer of rating 11kV/433V, 400KVA, indoor Dry type, having off circuit tapping of +/-10%, in steps of 2.5%, winding temperature detectors with scanner for temperature alarm and trip, door safety limit switch and accessories shall be provided

8.1.2.5 Motors

All Motors including and below 110 kW shall be 415V and all motors above 110 kW (if applicable) shall be 11kV. Motors shall be energy efficient (IE3) & squirrel cage induction type.

8.1.2.6 HT Power Distribution System

11kV HT Switchgear Panel shall be at Control Room Building Ground Floor as per. All relays in these HT Switchgear Panel shall have intelligent type Multifunction relays (Numerical relays) and meters shall be of digital type with RS 485 communication port facility both for relays and meters. Lamps shall be LED type. Busbars shall be high conductivity Aluminium alloy @ 1.0 Amps/mm^2 current density for HT Switchgear panel. 20% spare feeders of each type and rating shall be provided. The enclosure protection shall be IP54 minimum for indoor installation and IP55 minimum for outdoor installation. 11kV HT Switchgear Panel shall be provided with Vacuum Circuit Breaker (VCB) of suitable breaking capacities but not less than 26.3KA for 3 second.

8.1.2.7 LT Power Distribution System

One number of 415V Power Control Centre (PCC) is shall be at Control Room Building Ground Floor All relays in this LT Switchgear Panel shall have intelligent type Multifunction relays (Numerical relays) and meters shall be of digital type with RS 485 communication port facility both for relays and meters. Lamps shall be LED type. Busbars shall be high conductivity Aluminium alloy @ 1.0 Amps/mm^2 current density for PCC, ACDB and MLDB. Bus bar shall be of high conductivity electrolytic grade Copper @1.25 Amps/mm^2 current density for other distribution boards (like LDB, PDB, CDB etc.). PCC shall feed power at 415V to the various LT Loads such as Mitre Gates, Radial Gates, Submersible Pump Motors & Capstan Motors, ACDBs, MLDB/LDBs/CDBs, Distribution Boards (DBs) etc. The enclosure protection shall be IP54 minimum for indoor installation and IP55 minimum for outdoor installation. PCC shall be provided with Air Circuit Breaker (ACB) and moulded case circuit breaker (MCCB) of suitable breaking capacities but not less than 50KA for 1 second. The rupturing capacity of miniature circuit breaker (MCB) used in DB's/SB's/FP's for further distribution shall not be less than 10 KA. Industrial power sockets 240V 15A, minimum 2 Nos. shall be provided at each floor in Control Room Building, Local Control Panel Rooms (8 Nos.), Security Office etc. Welding socket 415V TPN and earth 63A, minimum 2 Nos. shall be provided at each floor in Control Room Building, Local Control Panel Rooms (8 Nos.), Security Office etc. shall also be provided.

8.1.2.8 Standby Power Supply

In case of power failures, DG set shall be provided for feeding 100% indoor lighting, 20% High Mast Load & Operation of Mitre & Radial gates. As per Table 8.1, one number 400 kVA DG set is proposed.

8.1.2.9 Emergency Power Supply

The power supply to the existing and new navigation lock shall be synchronised for use in case of power failure or emergency power requirement. This can act as an alternative source of power for both locks i.e., existing and new navigation lock.

8.1.2.10 Illumination

The illumination level in various areas to be maintained at the working plane are mentioned below in Table 8.3 and for other areas not mentioned herein it shall be based on National Electric Code.

Table 8.3 Illumination level for different areas of the navigation lock

Location	Average lux level	Type of Luminaire
Outdoor Area	30	2x400W HPSV twin lamp & 1x1000W Flood Light, weather proof, Heavy duty High Mast (30 m) in die cast Aluminium alloy housing
Boundary Wall	20	Single Arm Street light poles of 3.5m height above boundary wall with 30W LED luminaires @ 15m distance
Control Room Building (Ground Floor), DG & Transformer Room, & Local Control Panel Rooms	200	General Purpose Industrial compact batten suitable for 2x20 W LED Tube Light fitted with Aluminium heat sink
Control Room Building (First & Second Floor)	300	34Watt LED Panel with ultra-modern recess mounting luminaire suitable for

		Armstrong/grid/POP ceiling complete with separate electronic driver & high brightness Surface Mounted Device (SMD) LEDs
Control Room Building (Ground, First & Second Floor) & Local Control Panel rooms & at all entry / exit points etc.	10(Min.)	Battery operated emergency lighting unit consist of aesthetically designed rechargeable 5-Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type & 5V DC Li-ion charger with 1 hour battery backup.

Wherever required poles of suitable height with fittings shall also be installed for outdoor lighting of the buildings. One number of MLDB is proposed. MLDB shall receive power from respective PCC, which in turn shall feed various LDBs. 1:1 lighting transformer shall be placed at MLDB to maintain voltage drop within the permissible limits.

8.1.2.11 Cables

Power distribution at 11 kV shall be done through 11 kV (E), XLPE, stranded Aluminium conductor, armoured, overall FRLS PVC sheathed cable laid on cable trays, ducts, directly buried in ground and in trenches, etc. as per site requirement. LT power distribution to various Gates and services such as illumination, firefighting, air conditioning, water supply etc. shall be done through 1.1 kV grade XLPE insulated, stranded Aluminium conductor, armoured, overall FRLS PVC sheathed power cables. Laying of cables shall be done as per site requirement. Internal wiring shall be done in recessed PVC conduit or on surface with GI conduit and single core PVC insulated FRLS copper wire.

8.1.2.12 Cable Trays & Accessories

FRP type cable trays and its accessories shall be considered for the project. Thickness of the various components shall be as per the calculations and these calculations shall be submitted by EPC Contractor for client approval before starting the manufacturing.

8.1.2.13 Earthing & Lightning Protection

An efficient earthing and lightning protection system shall be designed to ensure protection of men and material in worst of the weather conditions. Suitable Lightning protection system shall be installed as per the guidelines of the IS/IEC 62305: 2010 (Superseding IS-2309: 1989).

All equipment of substation and various other services / equipment shall be earthed at two points. There shall be one earth grid formation using 75 x 8 mm GI strip and all equipment earthing shall be connected to this earth grid through Aluminium wire with PVC coating or GI strip as per the requirement. This grid shall be connected with number of pipe electrodes. However, the neutrals of transformers and DG sets shall be earthed separately. Each neutral shall be connected to 2 numbers separate pipe earth electrodes. Earthing system shall be designed in principle as per IS: 3043, however for chemical earthing IEEE: 80-2000 shall also be followed.

For lightning protection separate earth pits shall be provided. Exact number of earths pits shall be worked out after earthing and lightning protection calculation has been carried out measuring the soil resistivity at site.

Earth (chemical) pits shall be based on High Conductivity Technology. In this technology of chemical earthing, a compound of high electrical conductivity shall be filled up in the space around the ground electrode, so that the earth resistance value would decrease appreciably. Minimum Electrode size shall be as per the latest amendments of IS: 3043.

The high Conductive Compound shall be able to perform in any weather and soil Conditions and shall have following properties;

1. It shall have high electrical conductivity, which should remain constant and unaffected by changes in temperature & moisture.
2. It shall permanently remain embedded and should neither dissolve in and swept away by water.
3. It shall have an ability to absorb large amount of water and retain the same over a long period of time.
4. It shall decrease earth pit resistance with passage of time.
5. Solubility: Shall be partly miscible; so that it does not dissolve fully like common salt and thus increasing the Earth Pit Life.
6. The pH value shall be near neutral so that it does not pollute soil or water and also does not corrode earth electrode.
7. It shall be maintenance free Compound so that there shall be no need of extra water pouring at regular interval as in conventional earthing material, because it should retain the moisture.
8. Chemical Compound shall be thermally conductive, in order to maintain a constant Earth resistance in temperature range of -50 to +60 degree Celsius.
9. The Compound shall have relatively High conductivity so that it can create very low resistance even in rocky areas.
10. It shall have low earth resistance, carries high peak current repeatedly.
11. It shall have a Long and reliable life.
12. It shall be easily installed in any soil conditions.

8.1.2.14 Ventilation and Air Conditioning (AC) System

Control Room building at Ground Floor, WBSECL metering room, Battery room, Transformer and DG Room, all toilets and pantries shall be provided with exhaust fans for ventilation to ensure proper maintenance of temperature inside the panel room and removal of additional heat produced due to various switchgears. Split AC shall be used for Control Room building Ground Floor (Admin office and in-charge office), First & Second Floor and Local Control Panel rooms (As RIO Panels are located inside these rooms).

8.1.2.15 Battery and Battery Charger

One number dual Battery and Battery Charger with DC Distribution Board shall be provided for the control, protection, interlocks and indication of switchgear panels.

8.1.2.16 Closed Circuit Tele Vision (CCTV) System

To ensure surveillance of required locations as well as create secured record for post event analysis, CCTV system is proposed. The system shall provide an online display of video images on LED monitors located in Control Room. The PTZ (360^0) type cameras are installed at various locations like U/S & D/S approach channels, control room building & security room at entry gate. The core of the surveillance system shall be Network Video recorder (NVR) server. System shall also have operating systems, appropriate software, networking equipment and other essential components.

8.2 Control System

8.2.1 Instruments, Remote Control and power:

Complete set of remote-control system for the remote-control operation of all mitre and radial gates along-with Programmable Computerized Automatic Reservoir Monitoring and Control system is provided in the Main Control Room proposed on the left side, in addition to individual operation system provided at top of pier. The signaling system shall also be connected with the control room of new navigation lock for monitoring and control of the traffic. The Programmable lock monitoring and control system shall include all necessary instrumentation required for monitoring and control including water level measuring systems, gate position indication transducers, discharge measuring devices etc. The communication system shall be through a Multimode armoured Fiber Optic Cable.

The Contractor shall furnish complete Control & Instrumentation System for all the equipment as identified including redundant limit switches at the end position of each gate (total 4 Nos. for each gate), redundant electric position transmitter for each gate, local status indicators and position indicators, control etc. to ensure complete operability of the service gates mechanisms.

Remote operation of each gate shall be feasible from the graphical user interface (GUI) terminal mounted on the LCP. The Local Control Panel shall be with all required accessories including power supply system, instrumentation and power cables, earthing etc. and shall comply with all the requirements stipulated under the Specification and the Standards. The signal exchange list between FCN, RTUs, CCN and SCADA systems shall be finalized during detailed engineering stage and shall be subject to the approval of the IWAI.

All interconnecting cables including cabling between the Networks, Local Control Panels, RTUs, etc. shall be provided by contractor.

All cables and cabling including trays and supporting structure etc. beyond the Control Panels/RTU Panels up to drives (process) and also between the Control /RTU Panels and LT switch gear etc. shall be in the scope of supply by the bidder. Complete equipment lighting, earthing (underground and above ground) and Lightening Protection etc. for the entire System Electrical /Control equipment shall be under bidder’s scope of supply. All lighting fixtures and accessories shall be designed for 240V AC, 50 Hz supply with continuous operation for its life under atmospheric conditions existing at site.

The original installation came complete with a push-button operating system with desks in houses at each end of the lock, on the left-hand side. The electrical drawings indicate a sensible system based on direct-on-line starting of synchronous electric motors. Two control buildings exist, a central control building and a secondary control building at the upstream gates. These were built at the same time as the lock but it is not clear whether they were ever fully commissioned, or had originally been commissioned but have subsequently fallen into a state of dilapidation.

There are no working limit-switches for end of travel shut down and a series of stones are placed which are being used to indicate end of gate travel positions to the operators Figure 8.4 Temporary position indicator used to control gate opening.

Figure 8.4 Temporary position indicator used to control gate opening

The gates were originally fitted with a push-button control system complete with end of travel limit switches and safety devices. This system has completely failed and the gates are now operated by persons directly closing the respective motor starter contactors (by placing their hands into a live electrical control box and using a stick) while somebody else manually over-rides the brake (Figure 8.5). This practice is dangerous as it exposes people to potentially fatal voltages.

Figure 8.5 Local control system of u/s Mitre and Radial Gate

8.2.2 State of the Art Technology

The Control system shall be installed to ensure safe and reliable operation of Lock Gates and other facilities. PLC system shall read the inputs, perform all system logic, conduct online diagnostics, sequencing control and control the outputs. The processor based central control system is envisaged to control and monitor the Lock operations in the Navigation Lock so as to carry out the operation in an integrated mode from "Control Room". The Control Network shall be used for providing Automation functions, Opening and closing of Mitre and Radial Gates, monitoring and supervisory functions from Control Room. The core of the system shall consist of an Operating cum Programming Terminal and Server station (all the computers shall be latest version of the Industrial PCs - IPC as on the date of bidding) with printer and along with centralized real –time redundant PLC system (One online and the other in hot standby excluding I/O modules), sharing a RAID 6 (redundant array of independent disk) data storage system and a data network, with shared high-capacity data backup and off-site data archiving.

The control system would incorporate all safety interlocks to ensure complete safety to operating personnel and to avoid any damage to equipment due to malfunctioning. The control system shall generally be based on the following principles:

a. To start equipment in either of the two modes i.e., ‘Local’ or ‘Remote’
b. To trip off minimum equipment in the desired sequence during abnormal operating conditions, leaving all the other equipment running, which may safely be permitted to continue the operations
c. To annunciate the fault which has tripped equipment along-with the cause for tripping
d. To prevent restarting of the equipment until safe conditions have been restored
e. To retain maximum flexibility of operation consistent with safety
f. To prevent mal-operation of equipment on interruptions
g. To stop all the running equipment simultaneously by pressing Emergency Stop Push Button
h. To stop running equipment in the reverse order with time lag during normal stop.

The control network shall be real-time network, requiring long time continuous operation. During normal operations, the system cannot be shut off and it shall be possible to replace the components without shutting off the power. It shall be feasible to program the system online. Proper care shall be taken in data transfer so as to achieve quick response while transmitting control and management information. The response time should not be more than one millisecond. The network system shall have fault clearance functions, secure transmission of data through error checking routines on all data transmitted. The networks shall use open systems (universal protocol) technology, support multiple industrial standards, allow a combination of multiple communication agreements, and shall have the capability to join wider networks in future through the server. The analogue module system shall have provision to accept signals from other subsystems generating 4-20mA analogue signals. Proper conversion to standard units shall be done by control software. Redundancy (100% hot standby) is provided in the PLC's so that in case of failure of any of the processors, the hot stand by processor shall take over automatically. The changeover shall be smooth. Redundancy shall be provided for complete processor subsystem including CPU, memory, power supply.

Input/output units shall be capable of accepting discrete, analogue and digital input and output devices. If the number of slots for input and output modules in the controller rack is not sufficient, expansion units shall be connectable to the CPU by means of interface modules.

Each Input and Output module shall be electrically isolated from the controllers through opto-couplers or isolation transformers and shall withstand severe voltage transients without damage or adverse effect on the controller. Output modules shall incorporate self-contained damping networks and voltage limiting devices to prevent false triggering of outputs and to suppress line voltage spikes. PLC power supply units must have self-test facilities for detecting under voltage and also must be able to give alarm and switch over to UPS mode in case the output voltage is + 20% above the normal value.

A SCADA system shall be provided to control and monitor operation of the proposed

facility. The PLC control system is envisaged to control all navigation lock operations from the control room located on the first floor of the control room building.

(i) All the major equipment shall be controlled from the PLC and Remote I/O Panels (located in Local Control Panel rooms) such as

a) LCP Mitre Gate-(Leaf-1) PUSH BUTTONS OPEN / CLOSE
b) LCP Mitre Gate-(Leaf-2) PUSH BUTTONS OPEN / CLOSE
c) LCP Mitre Gate-(Leaf-3) PUSH BUTTONS OPEN / CLOSE
d) LCP Mitre Gate-(Leaf-4) PUSH BUTTONS OPEN / CLOSE
e) LCP Radial Gate-1 PUSH BUTTONS – UP/DOWN
f) LCP Radial Gate-2 PUSH BUTTONS – UP/DOWN
g) LCP Radial Gate-3 PUSH BUTTONS – UP/DOWN
h) LCP Radial Gate-4 PUSH BUTTONS – UP/DOWN
i) Submersible Pump Motors (4 Nos.) – PUSH BUTTONS START / STOP
j) Capstan Motors for Caisson Gate (2 Nos.) – PUSH BUTTONS START / STOP

The LCP stands for Local Control Panel.

(ii) The PLC and Remote I/O panels (at Local Control Rooms) shall also have provisions for various indications / status of various equipment such as

1. All Mitre Gates LED OPEN / CLOSE
2. All Radial Gates LED UP / DOWN
3. Submersible Pump Motors LED ON / OFF
4. Capstan Motors LED ON / OFF

The system shall consist of all the required panels, components, inter-connection cables, field sensors on all the equipment, junction boxes etc. to achieve the required functions.

Efficiency of System

The usual values of efficiencies adopted for the various elements of hoisting mechanism shall be adopted as given in Table 5 of I.S: 6938. The overall efficiency of the system, which is the product of individual efficiency of elements, shall then be worked out. The overall efficiency of the system shall be used in calculating the capacity of the electric motor. The ratio of overall running efficiency to the overall starting efficiency shall be less than the ratio of starting torque to running torque of motor.

Motors

The motor shall be totally enclosed fan cooled, high staring torque, squirrel cage with Soft Starter Motor control, 3(three) phase induction electric motor of rated capacity suitable for operation on 415 volts, 3 phase, 50 cycles / sec. A.C. power supply, 40% CDF, 150 starts/hr. and outdoor type duty conforming to I.S:12615:2019/ IEC:60034, with IE3 category, (IS:325 stands withdrawn). The motor shall be suitable for reversing frequent acceleration and mechanical braking. The break-down torque of the motor at rated voltage shall not be less than 2(two) times i.e., 200% of the rated torque. During this condition, for checking the components of hoist and the hoist supporting structure, the starting efficiency of the system shall be taken into account. The motors shall be so located that the bush, gears and terminals are easily accessible, for inspection and maintenance with proper ventilation. The motor chosen shall be of standard make easily available in the market. Motors especially designed for the purpose shall not be accepted. Torque limiters, if provided will not be considered while checking the hoisting components in break down torque conditions. In this condition, the value of actual break down torque as specified by the manufacturer will be considered.

Electro-Magnetic Brakes

The electro-magnetic brakes shall be of spring set, shoe type solenoid operated and of continuously rating. These shall be effective in both directions of travel and shall be capable of overcoming at least 150% of the full load torque exerted by the motor. The brake shall set automatically, when the current is cut off from the motor and shall be electrically released, when the current is applied to the motor. The brake shall be equipped with a hand operated release lever and a weather proof cover complete with heaters to prevent the condensation on moving parts. Hydraulically operated thruster brakes may also be used.

Limit Switches

General

The limit switches, after being tripped, shall automatically reset themselves with a reasonable distance traveled in opposite direction. This does not prevent the use of changeover type limit switches, where resetting is achieved by moving in opposite direction. These may be mechanically driven from the shaft.

Hoist Limit Switch

It is a device provided to cut off the current and to stop the motion of the hoist mechanism and to apply the brake, when the gate has risen to the pre-determined level. Limit switches shall be weather proof type. Inter-locking arrangements shall be provided to isolate the power supply when the hoist is being operated manually. Limit switches for intermediate position of travel and crack opening position shall also be provided. Adequate adjustment shall also be provided to compensate for rope elongation.

Control Equipment

The hoist mechanism shall be complete with one control panel with push buttons, which shall be suitably labeled as 'Raise', 'Stop' and 'Lower'. Lamps to indicate the condition of the control circuits and directions of motion may be provided.

The hoist shall be provided with all necessary relays, starters, heaters if required, fuses, limit switches, indicating lights complete with suitable wiring so that all the functions are carried out smoothly. All the controls shall be so inter-locked that the proper functioning of individual parts for the purpose is ensured. The wiring shall be as per relevant standards.

Inter-Locking & Earthing

All electrical equipment shall be provided with Off Position Inter-locking and earthing arrangement in terms of provisions contained in IS: 3043-1966.

Manual Operation

The manual operation shall be provided for emergency operations of all the gates in the event of power supply failure. An electric inter-lock shall be provided to prevent the operation due to restoration of power supply, when the manual operation is engaged. The manual operation should be designed in such a manner that the continuous effort per man does not exceed a crank force of 100 N with 400 mm of crank radius at a continuous rating of 24 rev/ min. The maximum number of persons shall not exceed 4(four). The manual operating mechanism shall preferably be parallel to the hoist.

8.2.3 Remote Input Output (RIO) Panels

RIO Panel is located in Local Control Room as shown in Drawing No. ENL 012 This RIO Panel shall receive input commands from Local Control Panels (LCPs) of Mitre Gates and Radial Gates and send the same data to PLC through fiber optic cable. Further from PLC the opening and closing operation of Mitre gates and Radial gates shall be controlled. It shall have communication interface with necessary signal/baud rate converters.

8.3 Communication System

There are no installed systems of communications at the lock complex and it appears that communications are primarily by voice.

8.3.1 Telephone System

EPABX system of 3 PNT Line 12 Hybrid Extension is proposed for this project.

8.3.2 Public Address (PA) System

No PA system is proposed for this project.

8.3.3 Signal System for Traffic Management

8.3.3.1 Existing Navigation Lock signal system

The existing navigation lock shall be equipped with a dedicated signal system for the operation and movement of vessels in and out of the lock. In the new navigation lock, a dedicated signal system has been installed for movement of vehicle in such way that during the filling of lock chamber the signal will red and when water level of inside the lock chamber is same as that in the approach channel and the mitre gate is completely open then the signal turns green and indicates ready for movement of vessels. Similar type of signal system has been proposed for the existing navigation lock for proper synchronization. Figure 8.6 shows the Schematic diagram of the dedicated signal system for the existing navigation lock.

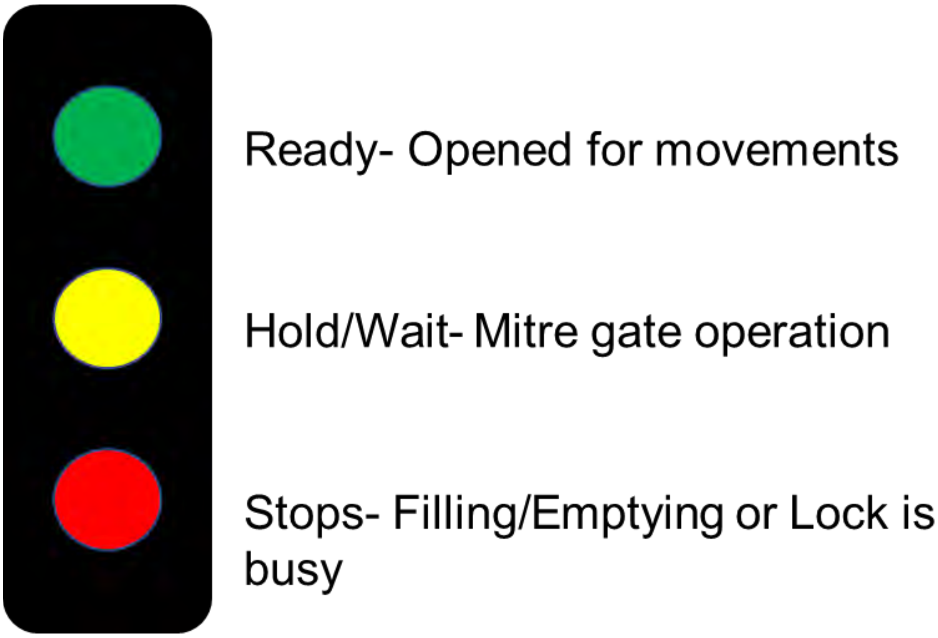


Figure 8.6 Schematic diagram of separate signal system of navigation lock

8.3.3.2 Integrated signal system for Synchronized Operation of Existing and New Navigation Lock System

Movement of ships and traffic in both of the navigation lock shall be managed from the control room building. Signal system shall be installed at the upstream and downstream of the lock for optimum operation of both locks. the individual signal system data may be used by decision making software/authority in control room for smooth and synchronised operation of new and existing navigation lock. Schematic diagram of signal system is shown in Figure 8.7. Red signal indicates the navigation lock of that side is busy and green signal shows the lock is available for use.

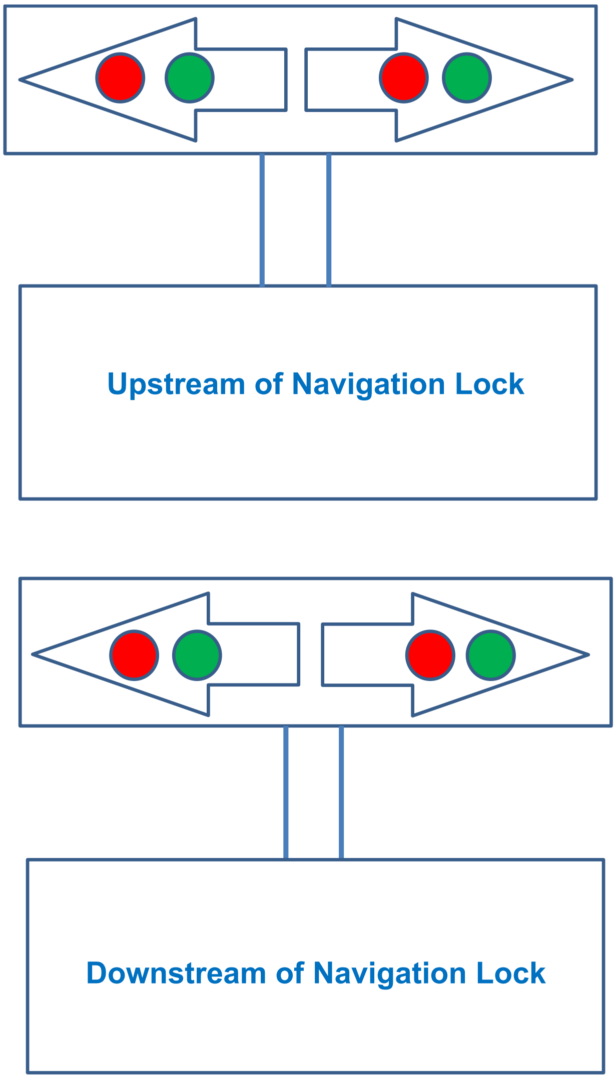


Figure 8.7 Schematic diagram of signal system of navigation lock

8.4 Synchronization of Existing and New Navigation Lock

Automated operation of the existing navigation lock has been proposed from the central control room of the existing navigation lock. Similar system of automated operation is also in place for the new navigation lock which is operated from the central control room of the new navigation lock. Synchronization in terms of operation of both the existing and new navigation lock have been proposed. The synchronized operation includes a combined system with an integrated signal system for providing signals to the vessels for movement accross the navigation lock, i.e. the vessel has to go thorugh the existing navigation lock or new navigation lock. The synchronization module should have real time inputs as well as visualization capabilities from both the existing and new navigation lock parameters and accordingly the decision of movement of vessel through existing or new navigation lock shall be made by the decision maker. The synchronization setup should be accessible from both the central control rooms. A schematic diagram for synchronization operation of the existing and new navigation lock is show in Figure 8.8.

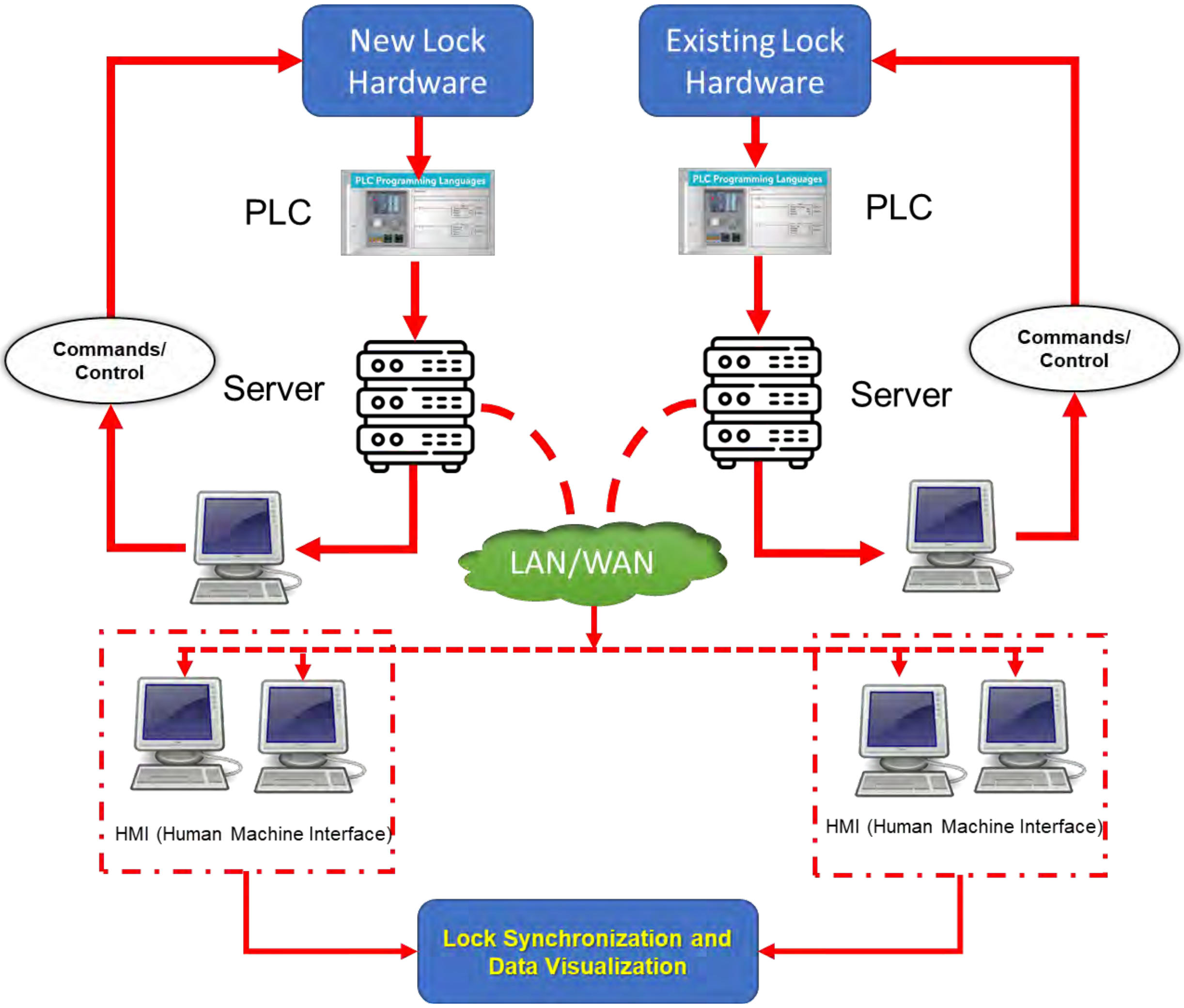


Figure 8.8 A Schematic Diagram for Synchronization Operation of The Existing and New Navigation Lock

9 OTHER INFRASTRUCTURAL COMPONENTS

9.1 Retiring Rooms

Retiring rooms have been proposed for the chief lock officer, lock officer and other lock operating staff of the navigation locks. 2 units of CPWD Type IV for officers and 4 units of CPWD Type III for staff have been proposed as retiring rooms. The plinth area shall be fixed as per the New Plinth Area Norms 2012 of CPWD.

The retiring rooms shall have the following amenities:

1. Kitchen
2. Kitchen sink
3. Ceramic glazed tiles
4. Built in cupboard with open shelves below cooking platform
5. Cooking platform standing
6. Wardrobes
7. Curtain rods with bracket
8. Storage tank
9. Ceiling Fans
10. Exhaust Fans

All other required amenities shall be provided as per the Revised Specifications & Scale of Amenities for General Pool Residential Accommodation (Type I to VI). The Location of the proposed retiring rooms is shown in Drawing No. ENL 013.

9.2 Boundary Wall/ Fencing

The existing boundary wall of existing lock may be demolished during the renovation and modernization of existing lock after the completion of renovation and modernization activity, the existing boundary wall shall be repaired. Existing navigation lock shall have an entry gate and security room at the entry gate.

9.3 Internal Roads

In the existing navigational lock, internal road shall be constructed and repaired from entry gate to control room and run all around the Lock area and connect to existing the external road through the entry gate. An internal road shall be connected with the new parking bay area of the navigation lock. For the existing navigation lock internal road of flexible pavements has been proposed. Turning space for heavy vehicle for the movement of machinery and equipment's should be provided at the end points. Details of Roads as planned have been provided in Table 9.1. Layout of the road is shown in Drawing No. ENL 013.

Table 9.1 Details of road in the lock area

Roads	Carriageway Width	Length
Internal	5m	700

9.3.1 Parking Area

There is no dedicated area for parking of vehicles at the control room building. Suitable covered parking arrangements for parking of 6 vehicles shall be constructed near the central control room building.

9.3.2 Security Check Post cum Security Office

Security office cum check post at upstream entry gate of existing navigation lock and a security check post at downstream entry gate has been proposed.

9.4 Water Supply

Water requirement during the construction phase is furnished in Table 9.2

Table 9.2 Details of Water Demand

SN	Facilities	Water demand (KLD)
1	For construction activities (considering water required for concreting and other activities)	110
2	200 Personnel deployed during construction @ 45 lpcd	9

Total water required for the construction activities is estimated as 110 kld and total potable water is estimated as 9kld.

Assuming staff of 25 persons deployed for operation and maintenance of the lock and another 20 people visiting the lock office, considering the water requirement @ 65 lpcd, during the operation stage potable water demand will be around 2.5 KL/day. For water requirement in horticultural activities, treated effluent from the proposed STP shall be used. The scheme for providing raw water and potable water development of Navigational Lock is described below.

The potable water required for personnel and users shall be drawn from tube wells through a submersible pump.

The potable water shall be stored in the tanks located on the top of control building.

9.5 Toilet Block

A public toilet of capacity of 2 Water Closet (flush toilet) for women and men and 4 urinals for men has been proposed in the lock area.

9.6 Sewerage System

The amount of sewage/waste water generated in the Lock compound is worked out to be approximately 2000 Liters/day. It is therefore proposed to provide a small sewage treatment plant of 2.5 KLD, located near the D/S end of the lock. It shall receive sewerage from the control room building and Guards room at the entry gate. The treated sewage shall be used for horticulture activities. The sludge from the treatment plant will be processed and converted into Biomass used as manure.

9.6.1 Waste Collection System

In the lock area suitable waste collection system for solid waste shall be provided. Waste collection system includes suitable location of dumping area and permanent dustbin at suitable locations.

9.7 Storm Water Drainage

9.7.1 Drainage System

The storm water drainage system is existing to drain the storm water. In the existing lock there is one main drainage system existing one in left bank. The left bank drainage system is working properly. Additionally, a right bank drainage line is under construction for collecting the drainage from the area in between the existing and new navigation lock. Existing drainage system shall be repaired and covered with removable perforated reinforced cement concrete covers which carry the storm water runoff to a collection chamber. The storm water from the control room building and other buildings shall also be connected to this drain through small collection chamber, and PVC pipes

The drainage network for both Lock compound is shown in Drawing No. ENL013.

9.7.2 Fire Fighting Facilities

The firefighting system should be capable of both controlling and extinguishing fires. In control room, it is proposed to install dry powder type fire extinguishers with inbuilt pressure gauge to indicate pressure.

9.8 Rainwater Harvesting System

Rainwater harvesting system for retiring rooms and other existing building has proposed. Rainwater harvesting system shall be designed for peak rainfall intensity. A typical rainwater harvesting system has been shown in Figure 9.1.

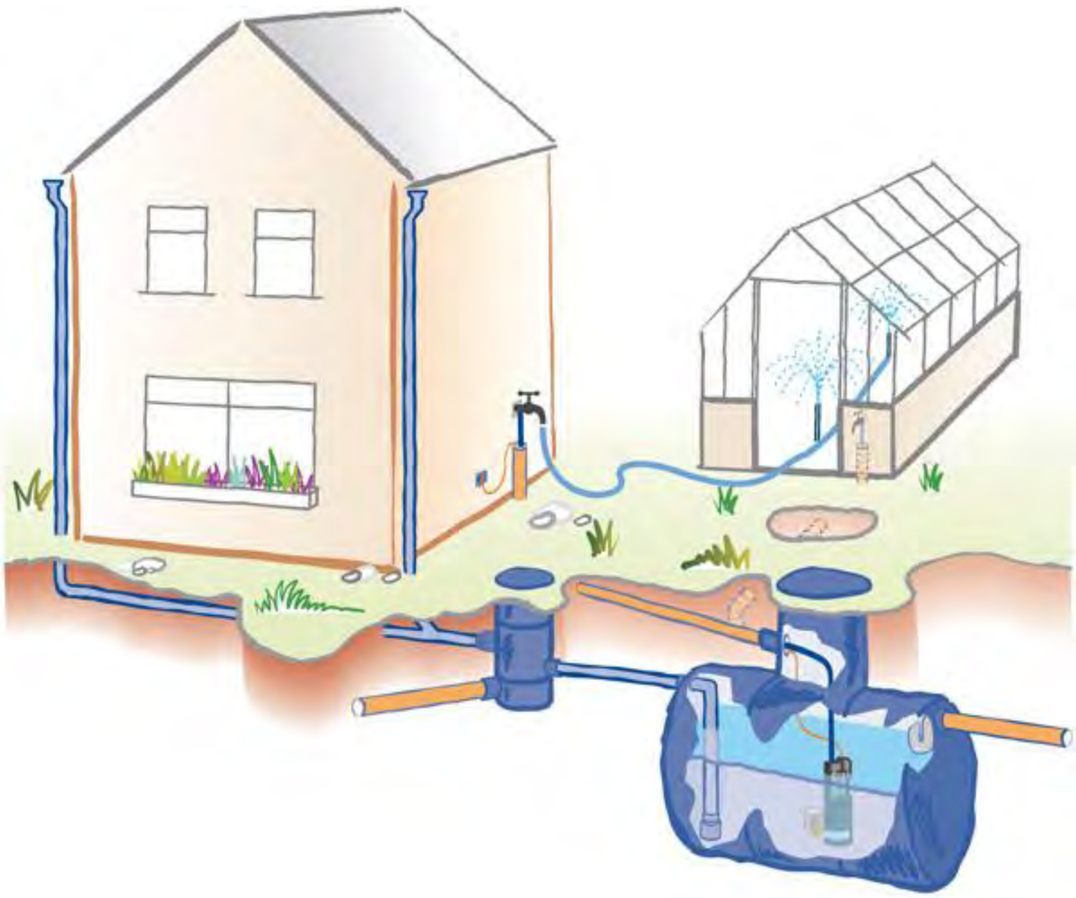


Figure 9.1 A typical rainwater harvesting system

10 MODEL STUDIES

A detailed mathematical model study at suitable scale (preferably between 1:1 to 1:10) should be carried out keeping in view the existing and new navigation lock systems as well as the lock approaches. The mathematical modelling shall study the hydraulic parameters such as the filling/emptying time of the lock chamber, sedimentation in the hydraulic system, check for air entrapment in the hydraulic system, waves, currents and turbulence generation in the lock chamber as well as include the simulation of gate operation and vessel movement. The speed of the flow inside the culverts, head losses and cavitation, particularly in bends and inter-independent interaction of various elements such as, speed of the opening of the valves with the locking duration, mooring forces, will be made during detailed designs and modification to those, if required, will be made at that stage.

11 DEWATERING ARRANGEMENT

Renovation and modernization of existing navigation lock requires the lock chamber to be dry. A coffer dam shall be constructed in the upstream and downstream of existing navigation lock to keep the working space in dry condition. Dewatering arrangement is required to pump out the water between the coffer dams. Additionally, seepage water from the coffer dams and natural ground surface is also required to be pumped out. Further water accumulated during the rainy season is to be pumped out to keep the working area in dry condition.

12 DISPOSAL OF CONSTRUCTION DEBRIS & SCRAP OF HYDROMECHANICAL AND ELECTRICAL COMPONENTS

12.1 Construction Debris

Existing component of the navigation lock shall be repaired, replaced, renovated and modernized. Replacement of any structure requires to remove the existing damaged components. Decommissioning of the dilapidated components shall be carried out. The dismantling and decommissioning should be conducted safely and also ensured that the process shall not impact the other structures.

Renovation and modernization work of the existing navigation lock shall generate construction debris from the base slab, side walls, guide walls, approach structures, filling emptying structures, control room buildings, cable trays, etc. The total quantity of construction debris likely to be generated is around 2000 cum, which will be used for back filling, site grading and construction of road embankments. The generated construction derbies shall be crushed up to the suitable size before the site grading.

The site is slightly undulating with level variation of RL + 13 to RL + 29 m. Also due to the construction of dedicated parking bay for caisson gates, minor cut & fill will be required at the site. The estimated cutting of earth is 10000 m^3 and filling of earth is 30000 m^3. Filling will be done to achieve the finished level of 28.438 m amsl level which is above highest water level of the existing lock, i.e., RL+26.30 m. This excavated soil will be utilized for back filling and leveling of undulated surface.

All the waste generated through dismantling and decommissioning shall be cleared by the Contractor. Proper waste management plan shall be adopted by the Contractor as per the Guidelines on Environmental Management of Construction & Demolition (C & D) Wastes by Central Pollution Control Board.

12.2 Scrap from Hydromechanical Components

12.2.1 Mooring equipment

Existing damaged fixed bollards shall be cut at the lowest portion and the concrete below the fixed bollards shall be cut out or excavated carefully. Waste shall be managed as per the waste management plan.

12.2.2 Mitre Gate including operating system

Mitre gates and its operating system require heavy machinery since the weight of these components are of the order of 85-95 ton. High-capacity crane shall be used to lift the mitre gates and its other components with additional safety. The scrap materials shall be safely handover to the IWAI as per the instructions of IWAI and the rest of the waste shall be managed as per the waste management plan.

12.2.3 Radial Gate including operating system

High RPM iron and concrete cutter shall be used to cut the damaged part of the radial gate. A proper lifting system shall be installed to lift the scraps from the culvert. The scrap materials shall be safely handover to the IWAI as per the instructions of IWAI and the rest of the waste shall be managed as per the waste management plan.

12.2.4 Caisson Gate

As the entire caisson gate shall be replaced and it being a standalone structure, it can be cut into suitable sections and lifted with a high-capacity crane. The scrap materials shall be safely handover to the IWAI as per the instructions of IWAI and the rest of the waste shall be managed as per the waste management plan.

12.2.5 Bulkhead Gate including the operating system

Bullhead gates are currently placed in the open surface so it shall not require an additional lifting system. High-speed iron cutter shall be used to cut the corroded parts of bulkhead gates. The scrap materials shall be safely handover to the IWAI as per the instructions of IWAI and the rest of the waste shall be managed as per the waste management plan.

12.3 Electrical Equipment

The existing electrical equipment's shall be replaced with modernize systems. The scrap materials shall be safely handover to the IWAI as per the instructions of IWAI and the rest of the waste shall be managed as per the waste management plan.

12.4 Debris Managements

All the waste generated during the recovery, shall be used for filling and levelling of lands. Before the filling and levelling of construction debris shall be crushed up to suitable size and further shall be used in filling process. A suitable waste management plan shall be carried out at the construction phase to keep the lock area clean and environment friendly after the completion of renovation and modernization of the existing lock.

13 LAND DETAILS

The proposed renovation and modernization of the existing lock shall not require additional land and even the new parking bays at upstream and downstream of the lock has been proposed within the existing boundary of the lock area and the ownership of the land vests with the IWAI.

14 TENDER DOCUMENTS

The Engineering, Procurement, and Construction (EPC) mode contract documents for the Construction of Navigational Lock are prepared and comprise the following:

Volume 1	:	Bidding Documents
Volume 2	:	Technical Specification and Drawings
Volume 3	:	Bill of Quantities (BOQ)

All the above-mentioned documents are being submitted separately.

15 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) AND ENVIRONMENT MANAGEMENT AND MONITORING PLAN (EMP)

Project involves renovation and modernization the existing lock at Farakka, District Murshidabad, West Bengal. The existing navigation lock is currently managed by the IWAI and the proposed renovation and modernization activities shall not require any additional land. Even the land required for the caisson gate new parking bay is within the ambit of IWAI.

Baseline study has been carried out at the project site to study the existing condition of environmental at site. On the basis of the baseline data and associated project activities, impact of the project activities on environmental parameters were analyzed and it is predicted that project will have impact (construction phase) on air, water, noise, soil, drainage, hydrology, ecology and socio-economy of the area. However, mitigation measures and management plans are proposed for mitigating the anticipated negative impacts of the project.

Environment management and monitoring plans are prepared to prevent/ control/abatement of pollution resulting from project activities in different stages. Environment management plan defines the institutional framework responsible for implementation of EMP, environment monitoring plan and environment management budget.

As per the EIA study, it is concluded that the project “Renovation and modernization of existing navigation lock gate at Farakka” is beneficial for the economic development of country as it will increase the efficiency of freight transportation through waterways and will also be beneficial for environment by shifting freight load from road/railway to waterways and cutting down carbon emissions. However, project development will have minor impacts on environmental parameters, mitigation measures and management plans are prepared to reduce anticipated negative impacts of project and to enhance the benefits. The project will overall bring development in the area. The total budgetary provision for the Environment Management and Monitoring Plan is approximately Rs. 0.87 crores. The detailed Environment Impact Assessment Report is attached as Annexure-5.

16 LOCK ADMINISTRATION AND MANAGEMENT

The existing navigational Lock, is controlled and managed by IWAI personnel. Estimates and details of Operators and manpower required for the operation and maintenance of the lock are follows:

Operation and Maintenance Personnel

Sl. No	Category	Nos.
1	Chief lock officer	1
2	Lock officer	3
3	Lock operator for control room	3
4	Technical Coordinator	1
5	Electrical Diploma engineer	3
6	Electrical ITI engineer	3
7	Mechanical Diploma engineer	3
8	Mechanical ITI engineer	3
9	IT engineer	1
10	Office staff (Clerk/Data Operator)	1
11	Supervisor	0
12	Auxiliary staff	
I	Gardener	0
II	Sweeper	0
III	Manpower (Operation)	6
	Total	**28**

16.1 Chief lock officer

Smooth operation of the both navigations lock it is suggested that one common chief lock officer for both navigation lock. Chief lock officer has minimum qualification of Bachelor degree in Electrical Engineering or Mechanical Engineer with total/overall experience of 20 years. Chief lock officer shall be overall in-charge of the general administration for both navigation lock. Role and responsibility of the chief officer shall be ensuring the smooth operation of navigation lock.

16.2 Lock officer

Three Lock officer are required to manage technical as well as administration of existing navigation lock for minimum of 24X7 hr. to achieve the minimum working hours, lock officer shall be work in three shifts with individual 8 hr working time. The minimum qualification of Bachelor degree in Electrical Engineering or Mechanical Engineer with total/overall experience of 20 years.

16.3 Lock operator for control room

Three no. of lock operator are required to operate the navigation lock in the control room. Control room required 3 operators to manage the lock operation with minimum of 24X7 hr. to achieve the minimum working hours, lock officer shall be work in three shifts with individual 8 hr working time. The minimum qualification of Bachelor degree in Electrical Engineering or Mechanical Engineer with total/overall experience of 15 years.

16.4 Technical Coordinator

The key expert shall be overall in charge of the technical team. The minimum no. of 8hrs is required with 6 days per week, hence one technical coordinator shall be required. The role and responsibility of technical coordinator shall be maintained proper inner electric supply through cable from transformer, electrical components and its repairing, Maintenance, health checking of all related electro-mechanical machineries for functioning in view of operation, identify and remove technical glitches occurring due to electro-mechanical faults. Technical coordinator shall have Minimum Qualification of Bachelor degree in Electrical Engineering or Mechanical Engineer with Experience of at least 15 years after graduation in which at least 10 years' relevant experience in operation and maintenance activities and software driven equipment Experience of managing team of technical personnel for O&M project.

16.5 Electrical Diploma engineer

Electrical Diploma engineer Shall assist Technical Coordinator in all duties and responsibilities assigned from time to time and shall be responsible for execution of all electrical and associated tasks assigned by the technical operators. The minimum no. of 24hrs is required with 7 days per week, hence 3 electrical diploma engineers shall be required in three different shifts. Minimum qualification of Diploma in Electrical Engineering with Total / overall experience of at least 12 years in which at least 8 years' relevant experience in operation and maintenance of civil and hydraulic structures in water or ports related projects.

16.6 Electrical ITI engineer

Shall assist Technical Coordinator in all duties and responsibilities assigned from time to time. shall be responsible to assist in execution of all electrical and associated tasks assigned by the technical coordinator. The minimum no. of 24hrs is required with 7 days per week, hence 3 electrical ITI engineers shall be required in three different shifts. Minimum qualification of Matriculation and ITI in electrical with Total/ overall experience of at least 8 years in which at least 5 years' relevant experience in operation and maintenance of civil and hydraulic structures in water or ports related projects.

16.7 Mechanical Diploma engineer

Mechanical Diploma engineer Shall assist Technical Coordinator in all duties and responsibilities assigned from time to time and shall be responsible for execution of all electrical and associated tasks assigned by the technical operators. The minimum no. of 24hrs is required with 7 days per week, hence 3 mechanical diploma engineers shall be required in three different shifts. Minimum of Diploma in Mechanical Engineering Total / overall experience of at least 12 years in which at least 8 years' relevant experience in operation and maintenance of civil and hydraulic structures in water or ports related projects.

16.8 Mechanical ITI engineer

Mechanical ITI engineer Shall assist Technical Coordinator in all duties and responsibilities assigned from time to time and shall be responsible for execution of all electrical and associated tasks assigned by the technical operators. The minimum no. of 24hrs is required with 7 days per week, hence 3 mechanical ITI engineers shall be required in three different shifts. Minimum of Matriculation and ITI in mechanical with Total / overall experience of at least 08 years in which at least 05 years' relevant experience in operation and maintenance of civil and hydraulic structures in water or ports related projects

16.9 IT engineer

IT engineer shall assist Technical Coordinator in all duties and responsibilities assigned from time to time and shall be responsible for execution of all IT and associated tasks. The minimum no. of 8hrs is required with 6 days per week, hence one IT engineer shall be required. Minimum qualification of Diploma in Information Technology with Total / overall experience of at least 12 years in which at least 8 years' relevant experience in operation and maintenance of civil structures in water or ports related projects.

16.10 Office staff (Clark/Data operator)

To support the technical and administration operation, 1 office staff is required. The minimum required qualification of senior secondary school/10+2 with computer skills.

16.11 Supervisor

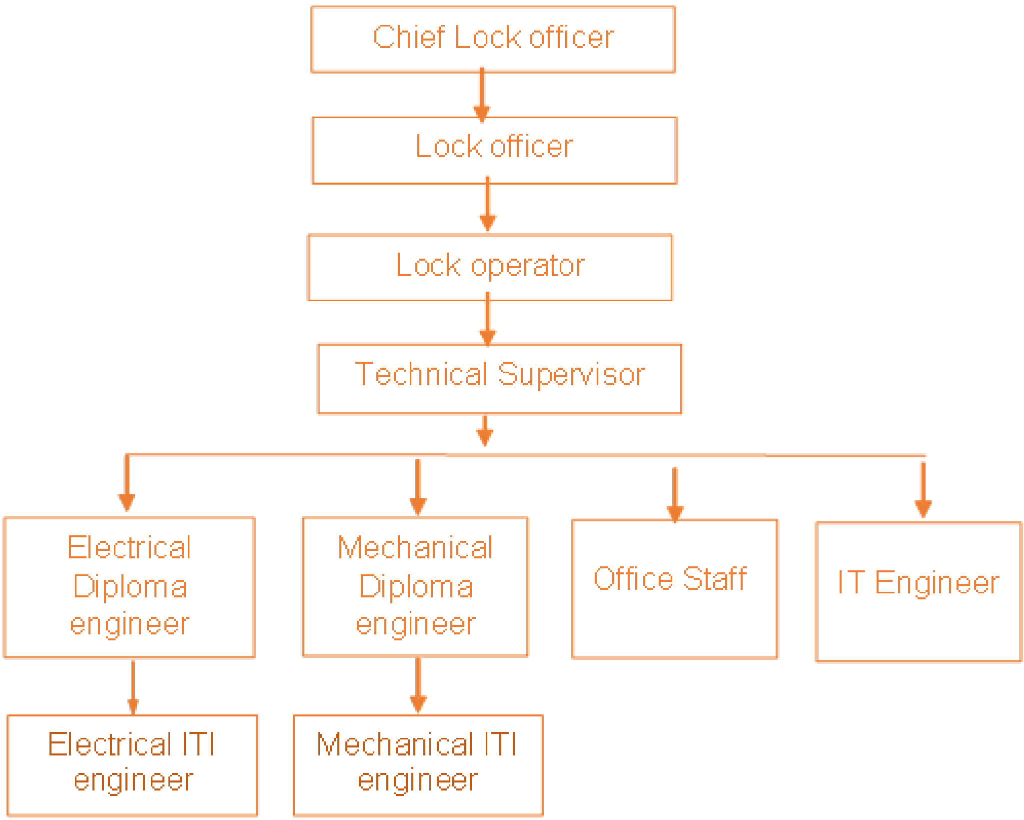
A supervisor is required for manage the auxiliary staffs and support the technical team whenever they required auxiliary staffs. Supervisor shall ensure the deployment of auxiliary staff at right place/position.

16.12 Auxiliary staff

Auxiliary staffs are required the daily works in the lock area. The details of the auxiliary work are given below:

1. Gardener - 0 No.
2. Sweeper - 0 No.
3. Manpower (Operation) - 6 No.

Since in the new navigation lock there are sufficient auxiliary staffs are proposed and enough to maintain both (new and existing navigation lock) therefore the minimum auxiliary staffs are proposed for the existing navigation lock.


Chief Lock officer
Lock officer
Lock operator
Technical Supervisor
Electrical Diploma engineer
Mechanical Diploma engineer
Office Staff
IT Engineer
Electrical ITI engineer
Mechanical ITI engineer

17 MAINTENANCE PLAN

A good maintenance program will protect the renovated and modernize navigation lock against deterioration, prolong its life, and greatly reduce the chance of failure. The Lock authorities and operating and maintenance personnel must be knowledgeable of the potential problems which can lead to failure of a navigation lock. Nearly all the components of navigation lock and its materials are susceptible to damage and deterioration if not well maintained.

17.1 Maintenance Plan

Timely maintenance assures that a navigation lock would remain in a good working condition and prevents more harmful conditions from developing.

17.2 Maintenance Priorities

Maintenance activities need to be prioritized.

17.2.1 Immediate Maintenance

The following conditions are critical and require immediate action by Lock authorities

1. Radial and Mitre gates being blocked and leakage from the gates
2. Any failure in operating system of any component of navigation lock
3. Electrical supply failure

17.2.2 Condition based Maintenance

The following maintenance should be completed as soon as possible after the defective condition is noted.

1. Removal of all vegetation and Shrub from the structural areas of navigation lock.

2. Repairs of any cracks in lock chamber
3. Repair of defective gates, valves, and other hydro-mechanical equipment.
4. Repair any concrete or metal components that have deteriorated.
5. Repair any damages bank protection work.
6. Repairs of any cracks/cavities/joints in masonry/concrete in culvert.

17.2.3 Routine Maintenance

1. Maintenance of Electrical & Hydro-Mechanical equipment and systems, e.g., servicing of mitre and radial gates, hoisting arrangements, bulkhead gates, lifting beam, and stand by generator.
2. Proper lighting at near mitre gates and in the local control room, etc.
3. Monitoring of leakage from the culverts and radial gates.
4. Monitoring of cracks in lock chamber and culverts.
5. Maintenance of all internal roads & access roads.
6. Operation of electrical and mechanical equipment and systems including gates.
7. To keep the gate slots, clear of silt/debris.
8. Maintenance/testing of monitoring equipment (instruments) and safety alarms.
9. Testing of security equipment
10. Testing of communication equipment.
11. Any other maintenance considered necessary.

17.3 Procedures for undertaking routine Maintenance

17.3.1 lock chamber, inlet and outlet culverts

Various issues that may need routine maintenance in **lock chamber, inlet and outlet culverts** may include but are not limited to:

1. Removal of vegetation growth from the surfaces of lock chamber, inlet and outlet culverts.
2. Monitoring of seepage from the mitre and radial gates.
3. Monitoring of cracks in lock chamber and inlet and outlet culverts.
4. Removal of leached deposits from wall of lock chamber and inlet and outlet culverts and general cleaning.
5. Minor repairs of routine nature.

For complicated problems advice of experienced engineers/ experts will need to be obtained.

17.3.2 Gates and Hoisting Equipment's

A satisfactory operation of a navigation lock envisages proper operation of its Gates & their Hoisting Equipment. If routine inspection of the Hydro-Mechanical Equipment shows the need for maintenance, the work should be completed as soon as possible.

17.3.3 Radial Gates

Radial gates are provided in the inlet and outlet of navigation lock. The aspects to be inspected and maintained periodically for ensuring proper operation of these gates are as under:

17.3.3.1 Rubber Seals

1. Seals shall be inspected for leakages. Locations of excessive leakages shall be recorded for taking remedial measures. Weeping or slight flow in localized area will not require immediate remedial measures. However,

measures like tightening of bolts are carried out. Further adjustment is carried out during annual maintenance.

2. If leakage is excessive & immediate repair is considered necessary, the seals should be repaired as soon as possible.

B. Trunnion block assembly and its anchorages

1. All the nuts and bolts of trunnion block assembly and its anchorages shall be checked for tightness.
2. Check all the welds for soundness and rectify defects.
3. Check whether the Yoke girder and thrust block is covered or not. If not, cover it with mild steel plates.
4. Cover the trunnion pin with anti- corrosive jelly.
5. Remove all dirt, grit etc. from trunnion assembly and lubricate trunnion bearings of the gate with suitable water resisting grease as recommended by bearing manufacturers.

C. Gate structure

1. Check all the welding for soundness and rectify defects.
2. Check welding between arms and horizontal girders as well as between latching bracket and skin plate with the help of magnifying glass for cracks/defects and rectify the defects.
3. Check all the nuts and bolts and tighten them. Replace damaged ones.
4. Check upstream face of skin plate for pitting, scaling and corrosion. Scaling may be filled with weld and grinded. Corroded surface shall be cleaned and painted

5. The guide roller pins shall be lubricated.

17.3.3.2 Embedded Parts

- All the sill beams and wall plates shall be inspected for crack, pitting etc. and defects shall be rectified.

17.3.3.3 General Maintenance

The maintenance of radial gates and hoist components should be done regularly. Proper record of inspection testing and maintenance should be kept by the officers in charge of the work.

- Defective welding should be chipped out and it should be re-welded duly following the relevant Codal Provision (IS: 10096, Part-3).
- Damaged nuts, bolts, rivets, screws etc. should be replaced.
- Any pitting should be filled up by welding and finished by grinding if necessary.
- The gate leaf, exposed embedded metal parts, hoists and hoist supporting structure etc., should be thoroughly cleaned and repainted when required keeping in view the original painting system adopted and as per the guidelines contained in IS: 14177.
- Trunnion bearing should be greased as and when required. Keeping trunnion bearings in perfect working condition is very important. All other bolted connections should also be checked up for proper tightness.
- Bolts and trunnion bearing housing should be tightened wherever required.
- The seals of the gate should be checked for wear and tear and deterioration. These should be adjusted/replaced as and when necessary.

- The wall plates, sill beams shall be checked and repaired if necessary.
- Wire ropes should be properly lubricated.
- Oil level in the worm reduction unit should be maintained by suitable replenishment. Oil seals should also be replaced if required. Lubrication of other parts of hoists such as chains, position indicators and limit switches should also be done.
- The stroke of the brake should be reset to compensate for lining wear. Worn out brake linings should be replaced in time.
- Flexible couplings should be adjusted if required.
- Repairs and replacements of all electrical relays and controls should be attended to.
- Maintenance of alternative sources of Power such as Diesel Generating sets and alternative drives wherever provided should be carried out.
- The list of essential spare parts to be kept available should be reviewed and updated periodically. The condition of spares should be checked periodically and protective coating given for use.
- Weld joints of major components should be checked thoroughly and defects if any should be rectified by re-welding and grinding.
- Maintenance of hand drive components such as lubrication of drive shaft, nut and bushes wherever provided should be done.
- In addition to the above, other defects noticed during pre-monsoon inspection shall also be rectified before onset of monsoon if the defects need immediate attention.

- Lubricant of worm gear reducer shall be drained and changed in alternate years before onset of monsoon.

17.4 Maintenance Schedule

17.4.1 Quarterly Maintenance

17.4.1.1 Reduction gears boxes

Teeth of all gears and pinions should be greased by smearing on the surfaces.

17.4.1.2 Electro Magnetic Brake

- Broke drum and liners should be cleaned. These components should be free from grease, oil etc.
- The spring and hinges of Electro Magnetic Brake should be lubricated.

17.4.1.3 Guide Rollers

- The guide roller bushes and pins shall be greased.
- Position Indicator
- Teeth of gears and pinions of position indicator shall be greased by smearing.
- All bushes of position indicator shall be greased.

17.4.1.4 Trunnion Assembly

- The Trunnion bushes should be greased by greasing gun till grease oozes out from the side.

17.4.2 Half yearly maintenance

17.4.2.1 Control Drive unit

- Oil level in worm gear reducer shall be checked and topped up if necessary. Maintenance works specified in quarterly maintenance shall also be carried out during the half yearly maintenance.

17.4.3 Yearly Maintenance

- all moving parts such as line shaft, brakes, motor bearings shall be lubricated with proper lubricant.
- Grease shall be applied to turn-buckle threads and pins and lifting bracket pins.
- Oil in worm gear reducer shall be replaced every alternate year
- The limit switches and other contractor shall be checked for proper functioning. The contact points shall be cleaned thoroughly.
- Check the compression in spring of Electro Magnetic Brake and the stroke of the brake should be reset if wear and tear of brake lining is found.
- Check the condition of wiring, switches, Electrical relay etc. For damage if any and for proper functioning and defects if noticed, may be rectified.
- Check the stand by diesel generating set if provided for its proper functioning. The diesel generating set should be kept in perfect working order
- In addition to the above, maintenance works specified in quarterly maintenance and half yearly maintenance shall also be carried out.
- Check the hand drive arrangement if provided and lubricate the components. Operate the gate by using hand drive arrangement to check proper functioning of the same.

17.4.4 Painting of Gates, Stoplog, Hoist/ Gantry and Steel Structures

Painting of Gates, Hoist / Gantry structure is essential to prevent rusting and corrosion since the gates/ steel structure are exposed to sun, rain and air. The gates/ structure shall be painted in alternate years and the painting should be completed preferable by end of May every year

Before painting, the surface must be perfectly cleaned by wire brushing and shall be free from moisture, dust, oil, grease, rust etc. If the surface shows cracks, it is advisable to scrap or burn the old film.

Painting schedule should be planned in such a way that 50% gates and hoists with allied components in a project are painted every year. The following paints are recommended for painting of gates and hoists.

Painting shall be carried out in accordance with latest Indian standards.

18 IMPLEMENTATION SCHEDULE

18.1 General

The main components for the Navigational Lock comprise the lock structure internal roads, Mitre gates, Radial gates, Bulkhead gates, Caisson gates, control room building, storm water drainage network, water supply system, sewerage disposal system including sewerage treatment plan, boundary wall, security room, lighting system, automatic control systems, monitoring system etc. In the existing lock system, some of above component are already exist however its required renovation.

18.2 Main Activities

Renovation and Modernization on existing navigation lock, following activity needs to be carried out.

18.2.1 Mobilization and Detailed Design

18.2.1.1 Survey Including Field Investigations and Condition Survey

In order to undertake the detailed design of the structure, the entire area of the lock compound including area in near vicinity has to be surveyed and field investigations have to be taken up. The activity is likely to take 3 months' period. The detailed condition survey of the existing navigation lock shall be also carried out.

18.2.1.2 Detailed Design

The detailed design for all the civil, mechanical and electrical components shall be carried out. The design work is to start from the very beginning and it is anticipated to complete all the design works in 4 months' time. All the designs should be authenticated and approved by IWAI in stages. All design and drawings should be vetted by any IIT.

18.2.2 Site Development

Temporary Buildings

For construction activities the temporary building should be developed after the survey of the area selected for temporary buildings has been done and existing road has been realigned. The grading at the location of temporary construction buildings can be taken up and rest of the site grading can be done only after the excavation work. The temporary building shall be so placed that they serve their purpose throughout the construction period. The activity can commence after one month of commencement of work and get completed within next one month.

Coffer Dam

The activity can commence after one month of commencement of work and get completed within 3 months.

Dismantling work

The existing civil structure and hydro-mechanical and electrical equipment which require replacement shall be dismantled before the replacement. This activity can commence after commencement of work and get completed within 4 months.

18.2.3 Renovation/Modernization of Civil work

18.2.3.1 Lock chamber

Detailed survey and condition survey of lock shall be carried out before renovation and modernization work which will completed in detailed design stage. After the approval from IWAI, renovation work will start and it requires 14 months' time to complete the renovation of the lock chamber.

18.2.3.2 Control Room Building

Existing control room building health is in good condition but it lacks basic facilities and amenities like full width glass view, vitreous non-skid tiles, lift, fire safety, etc. Time requires to complete the task is 13 months.

18.2.3.3 Electrical Cable Bridge

The existing cable bridge has been corroded and damaged it requires repair. The renovation work on the cable bridge with painting requires 6 months.

18.2.4 Renovation/Modernization of Hydromechanical work

18.2.4.1 Mitre Gate including operating system

The mitre gate along with the operating system shall be replaced whereby modern hydraulic power packs with axial pumps and hydraulic cylinders shall be used. Time required for renovation and modernization of the mitre gate is 14 months.

18.2.4.2 Radial Gate including operating system

The radial gate along with the operating system shall be replaced whereby modern hydraulic power packs with axial pumps and hydraulic cylinders shall be used. Time required for renovation and modernization of the radial gate is 14 months.

18.2.4.3 Caisson Gate including operating system

Existing caisson gates shall be replaced with new one and time required to construct the caisson gate is 14 months.

18.2.4.4 Bulkhead Gate including operating system

The bulkhead gate shall be replaced and dedicated operating system shall be provided. Time required for renovation and modernization of the bulkhead gate is 14 months.

18.2.5 Electrical and Control System

18.2.5.1 Electrical Power Supply

Electrical power supply system, the main incoming power supply cable and other electrical equipment shall be renovated and this will require 6 months to complete.

18.2.5.2 Control System

The existing control system is in a dilapidated condition. New Realtime PLC system shall be installed to safely control all the gates. 4 months shall be required to replace the existing control system with new PLC system.

18.2.5.3 Communication System

There are no installed systems of communications at the lock complex and new communication system shall be installed. Time required to complete the task is 4 month. During this period the signal system shall be installed to guide the moving vessels.

18.2.6 Other Infrastructural Works

Other infrastructure such as boundary wall, water supply system and sewerage system and storm water drainage are required to construct.

18.2.6.1 Retiring Rooms and Rainwater Harvesting System

Retiring rooms of CPWD Type III and Type IV shall be constructed and time required to complete the task including its proposed interiors is about 6 months.

18.2.6.2 Waste Management System and Toilet Block

Waste management system and toilet block will require 5 months to construct

18.2.6.3 Internal Roads and Parking Area

Internal connecting road for the all- individual control room from the main control room building including parking area and main gate will require 5-month time to complete.

18.2.6.4 Water Supply and Sewerage System

Existing water supply system and sewerage system is not efficient in existing scenario. Water supply network and sewerage system for the new water demand shall be construct and time required to complete this task is 5 months

18.2.6.5 Storm Water Drainage

The existing storm water drainage system shall be repaired which will require 4 month to complete.

18.2.6.6 Levelling and removal of coffer dam

Civil works shall make the surface undulating. For the testing and commissioning the lock system required to be removed the coffer dam in phases. Time required to levelling and removing the coffer dam is 2 month. During this period the scrap and waste generated from the renovation work shall be cleaned from the project site.

18.2.7 Testing and commissioning of Navigation Lock and Gates

Testing of renovated equipment shall be done in this stage whether all the equipment is working properly or not. Testing and commissioning requires 3 months and during this period all the equipment shall be in monitoring stage.

18.3 Implementation Schedule

Based on the above it could be seen that the Navigational Lock renovation and modernization could be completed within a time frame of 17 months. The next 3 months will be devoted to rectification of any defects and handing over of the complex. The project implementation schedule is shown in Table 17.1.

Table 18.1 Implementation schedule of the renovation and modernization work

ITEMS	Duration (Month)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Mobilization and Detailed design																					
Survey including field investigation and condition survey	3																				
Detailed Design and Vetting	4																				
Approval by IWAI	4																				
Renovation/Modernization of Civil work																					
Monitoring instruments	1																				
Site development	3																				
Dismantling work	4																				
Lock chamber	14																				
Control Room Building (including local control rooms)	13																				
Parking Bay for Caisson Gate	13																				
Bank Protection	6																				
Electrical Cable bridge	6																				
Renovation/Modernization of Hydromechanical Work																					
Mitre Gate including operating system	14																				
Radial Gate including operating system	14																				
Caisson Gate including operating system	14																				
Bulkhead Gate including operating system	14																				
Painting Schemes for Gate	5																				
Electrical and Control System																					
Electrical Power Supplies	6																				
Control System	4																				
Communication System	4																				
Signaling System	3																				
Other Infrastructural Works																					

Retiring Rooms and Rainwater Harvesting System	6																				
Waste Management System and Toilet Block	5																				
Internal Roads (Including parking area)	5																				
Water Supply and Sewerage System	5																				
Storm Water Drainage	4																				
Leveling and Removal of coffer dam	2																				
Testing and commissioning of Navigation Lock and Gates	3																				

19 COST ESTIMATES

19.1 Capital Cost Estimates

The Capital Cost Estimates have been prepared for the renovation and modernization of the existing of Navigational Lock at Farakka as per Layout provided in Drawing in the respective chapters. These are based on the project descriptions and drawings given under the relevant sections of the present report. The drawings were prepared after carrying out preliminary design of various components of the project. The quantities have been calculated from the drawings for cost estimation purpose. These will need to be developed, revised, and refined during the detailed design phase. The following are to be noted with respect to the cost estimates:

2. The cost estimates of civil works have been prepared based on CPWD Schedule of Rates (SOR) 2021 and Market Rates for various items of work not available in CPWD SOR prevailing in the region.
3. The costs of monitoring equipment, electro-hydraulic system is based on the quotations received from manufacturers, wherever applicable and also inhouse data, and include manufacture, supply, installation, testing and commissioning.
4. All costs towards overheads, labour, tools, machineries, and materials etc. are covered in the rates for individual items.
5. The price level used for the estimates is as of the third quarter of 2022.

The estimates given here do not include the cost of reengineering of sharp bend at U/S end of the approach channel, widening and dredging of approach channel. This item will be taken a separate DPR work. The capital cost estimates for the construction of

Navigational Lock is worked out to be Rs. 160.10 crores and summary are presented in Table 19.1 below.

Table 19.1 Cost summary of the project

Item No.	Description of Item	Amount (Rs.in Crores)
1	Earthwork including mobilization and demobilization	15.91
2	Bank Protection Works including mobilization and demobilization	17.03
3	Construction of Cast-in-situ piles including mobilization and demobilization	3.01
4	Renovation and Modernization of Existing Navigation Lock including mobilization and demobilization	14.62
5	Ancillaries for Navigational lock including mobilization and demobilization	12.58
6	Back filling / Grading including mobilization and demobilization	0.98
7	Gates including mobilization and demobilization	60.00
8	Electrical Equipments, Control Room Building and Fire Fighting System including mobilization and demobilization	7.02
9	Road Works including mobilization and demobilization	1.58
10	Retiring Rooms, Water supply , Drainage, Sewerage & Boundary Wall including mobilization and demobilization	2.15
11	Instrumentation and Miscellaneous including mobilization and demobilization	3.50
12	Cost of Environmental Mitigation measures including mobilization and demobilization	0.87
13	Cost of Electricity and Water Supply connections including mobilization and demobilization	5.00
14	Model Study	1.00
15	Dismantling of Concrete & Decommission of Hydromechanical & Electrical Components including mobilization and demobilization	3.00
	Total	**148.23**
17	Design fee including all kind of survey, investigations, etc. @ 3% on total	4.45
18	PMC Fee @ 2% on total	2.96
19	Contingencies @ 3% on total	4.45
	Grand Total (Exclusive of GST)	**160.09**
	SAY	**160.10**

The break-up of major components of the capital cost estimates for the Navigational Lock are furnished in Table 19.2 respectively.

Table 19.2 Detailed Capital Cost Estimates for Construction of Navigational Lock

Item No.	Description of Item	Qty	Unit	Rate (Rs)	Amount (Rs.in Crores)
1	**Earthwork including mobilization and demobilization**				
i	Earthwork including mobilization and demobilization and ready to use in Excavation including dressing of sides and levelling of bottoms, including getting out of excavated soil and disposing of excavated surplus soil within 5 kms.	10,000	cum	405.52	0.41
ii	Dewatering arrangements including mobilization and demobilization and ready to use during renovation and modernization.		Nos.	LS	8.00
iii	Additional cost for installation and removal of coffer dam including mobilization and demobilization and ready to use in the u/s and d/s of the existing navigation lock		Nos.	LS	7.50
	Sub Total for Earthwork including mobilization and demobilization				**15.91**
2	**Bank Protection Works including mobilization and demobilization**				
i	Providing and Laying in position PCC blocks of M15 grade of concrete for the Bank protection works	20,000	Cum	8,101.67	16.20
ii	Providing and laying Filter material (course sand (Zone III)) underneath PCC blocks in Bank Protection work, complete as per drawing and Technical Specification	5,000	Cum	1,650.00	0.83
	Sub Total for Bank Protection Works including mobilization and demobilization				17.03
3	**Cast-in-situ piles including mobilization and demobilization**				
i	Shift & set up piling plant & equipment at each pile location	13	No.	75,000	0.10
ii	Boring through all types of soil strata	195	m	5,250	2.05
iii	Cut & dress pile head to required lines & levels	13	No	8,250	0.21
iv	Supply & placing in position design mix cement concrete grade M40 in pile shaft by means of tremie or any other approved method using 20 mm MSA including cost of all labour and materials but excluding the cost of steel reinforcement.	124	Cum	9,200.62	0.11
v	Supplying corrosion resistant deformed bars grade Fe 500, cutting, bending, tying with 1.5 mm dia annealed binding wire & placing in position reinforcement cage including cleaning, straightening, tack/ lap/ butt welding with approved electrodes, etc. with all labour and materials complete for piles.	23.66	T	98,615.00	0.23
vi	Carrying out load test of pile including construction of test caps, accessories and dismantling same after test etc.	2	No.	15,00,000	0.30
	Sub Total for construction of Cast-in-situ piles including mobilization and demobilization including mobilization and				3.01

Item No.	Description of Item	Qty	Unit	Rate (Rs)	Amount (Rs.in Crores)
	demobilization				
4	**Renovation and Modernization of Existing Navigation Lock including mobilization and demobilization including mobilization and demobilization**				
4a	**Parking Bay Base Slab including mobilization and demobilization**				
i	Supply & place in position to lines & levels cast in-situ design & precast units mix cement concrete of grade M40 for Base slab including providing formwork shuttering, machine mixing, compacting, curing of concrete, centering, including providing pockets, openings, recesses, champhering where required and rendering if required to give a smooth and even surface in any shape etc. complete as directed with all labour and materials but excluding the cost of steel reinforcement.	702	Cum	11,203.56	0.79
ii	Supplying corrosion resistant deformed bars grade Fe 500, cutting, bending, tying with 1.5 mm dia annealed binding wire & placing in position reinforcement cage including cleaning, strengthening tack/ lap/ butt welding with approved electrodes, etc. with all labour and materials complete for Base slab	147	T	98,615.00	1.45
iii	PCC	57	cum	8,101.67	0.05
4b	**Parking Bay Counter fort Retaining wall including mobilization and demobilization**				
i	Supply & place in position for construction of counterfort retaining wall & precast units mix cement concrete of grade M40 for retaining walls including providing formwork shuttering, machine mixing, compacting, curing of concrete, centering, including providing pockets, openings, recesses, champhering where required and rendering if required to give a smooth and even surface in any shape etc. complete as directed with all labour and materials but excluding the cost of steel reinforcement.	130	cum	11,203.56	0.15
ii	Supplying corrosion resistant deformed bars grade Fe 500, cutting, bending, tying with 1.5 mm dia annealed binding wire & placing in position reinforcement cage including cleaning, strengthening tack/lap/butt welding with approved electrodes, etc. with all labour and materials complete for Counterfort Retaining Wall	20	T	98,615.00	0.19
4c	**Existing Base Slab including mobilization and demobilization**				
i	Supply & place in position for repair with high strength concrete of grade M40 for base slab including providing formwork shuttering, machine mixing, compacting, curing of concrete, centering, including providing pockets, openings, recesses, champhering where required and rendering if required to give a smooth and even surface in any shape etc. complete as directed with all labour and materials but excluding the cost of steel reinforcement.		Nos.	LS	3.00
ii	Supplying of rebar & placing in position reinforcement cage including cleaning, strengthening tack/lap/butt welding with approved electrodes, etc. with all labour and materials complete		Nos.	LS	0.50

Item No.	Description of Item	Qty	Unit	Rate (Rs)	Amount (Rs.in Crores)
4d	**Existing Retaining Walls, Guide Walls, Approach Structures and Filling Emptying System including mobilization and demobilization**				
i	Supply & place in position for repair with epoxy grout for Retaining Walls, Guide Walls, Approach Structures and Filling Emptying System including providing formwork shuttering, machine mixing, compacting, curing of concrete, centering, including providing pockets, openings, recesses, champhering where required and rendering if required to give a smooth and even surface in any shape etc. complete as directed with all labour and materials but excluding the cost of steel reinforcement.		Nos.	LS	5.00
ii	Supplying of rebar & placing in position reinforcement cage including cleaning, strengthening tack/lap/butt welding with approved electrodes, etc. with all labour and materials complete		Nos.	LS	0.50
4e	**Embeded Parts including mobilization and demobilization**				
i	Supply & place in position for repair with high strength concrete of grade M60 for embedded parts including providing formwork shuttering, machine mixing, compacting, curing of concrete, centering, including providing pockets, openings, recesses, champhering where required and rendering if required to give a smooth and even surface in any shape etc. complete as directed with all labour and materials but excluding the cost of steel reinforcement.		Nos.	LS	1.50
ii	Supplying of rebar & placing in position reinforcement cage including cleaning, strengthening tack/lap/butt welding with approved electrodes, etc. with all labour and materials complete		Nos.	LS	0.50
4f	**Electrical Steel Lattice Bridge (2 Nos) including mobilization and demobilization**		Nos.	LS	1.00
	Sub Total for Construction of Navigation Lock including mobilization and demobilization				14.62
5	**Ancillaries for Navigational lock including mobilization and demobilization**				
i	Providing and fixing cast steel bollards of 30 T capacity (Floating type 8 Nos. and Fixed type 14 Nos.) complete with base plate & H.T. anchor bolts of appropriate length, nuts washers, etc. including grouting with cement concrete M40 under base plate, filling the cavity with concrete grade M15, painting etc. complete.	9		2,25,000	0.20
ii	Design, supply, assemble and fix in position in the required lines and levels arch type AN 800 E 3.0 grade rubber fenders of Trellborg or SM 800 grade M2 of Bridgestone make or equivalent make of length 3m with stainless steel plates manufactured as per manufacturer's specifications as directed by the Engineer.	50	No.	20,25,000	10.13
iii	Supplying, fabricating, painting, welding, drilling, grouting & fixing in position etc. complete various miscellaneous items such as steel inserts, hand railing, coping fender, ladders, handhold, expansion joints, mooring rings, nut, bolts, washers, bituminous filler etc. in precast & in-situ concrete components in accordance with the drawings & as directed by the Engineer		Nos.	LS	2.25

Item No.	Description of Item	Qty	Unit	Rate (Rs)	Amount (Rs.in Crores)
	Sub Total for ancillaries for Navigational lock including mobilization and demobilization				12.58
6	**Back filling / Grading including mobilization and demobilization**				
i	Filling of excavated surplus soil in the backfill area and levelling the surface	35,000	Cum	279.35	0.98
	Sub Total for Filling including mobilization and demobilization				0.98
7	**Gates including mobilization and demobilization**				
i	Mitre Gates designing, fabricating, Supplying, painting, welding, drilling, grouting & fixing in position including testing and commissioning.	2	Nos.	LS	15.00
ii	Caisson Gates designing, fabricating, Supplying, painting, welding, drilling, grouting & fixing in position including testing and commissioning.	2	Nos.	LS	18.75
iii	Radial Gates designing, fabricating, Supplying, painting, welding, drilling, grouting & fixing in position including testing and commissioning.	4	Nos.	LS	3.75
iv	Bulk head Gates designing, fabricating, Supplying, painting, welding, drilling, grouting & fixing in position including testing and commissioning.	8	Nos.	LS	7.50
v	Hydraulic Hoists / operating mechanism for Mitre Gates including designing, fabricating, Supplying, painting, welding, drilling, grouting & fixing in position along with testing and commissioning.		Nos.	LS	6.00
vi	Hydraulic Hoists / operating mechanism for Radial Gates including designing, fabricating, Supplying, painting, welding, drilling, grouting & fixing in position along with testing and commissioning		Nos.	LS	4.50
vii	Operating mechanism for Bulk Head Gates including designing, fabricating, Supplying, painting, welding, drilling, grouting & fixing in position along with testing and commissioning.		Nos.	LS	0.60
viii	Filling/Emptying arrangement/operating mechanism for Caisson Gates including designing, fabricating, Supplying, painting, welding, drilling, grouting & fixing in position along with testing and commissioning.		Nos.	LS	0.15
ix	Computerised control/monitoring system for control of Mitre and Radial Gates in centralised control room.		Nos.	LS	3.75
	Sub Total for Gates including mobilization and demobilization				60.00
8	**Electrical Equipments, Control Room Building and Fire Fighting System including mobilization and demobilization**				
i	Including supplying, installation, testing and commissioning of Power Distribution System (HT, LT switch gears, Transformer, capacitor banks, distribution boards, battery and battery charger, & control room building safety equipment, surveillance camera system, traffic signalling system, integrated signal system for synchronised operation of existing and new navigation lock, etc.		Nos.	LS	0.66
ii	Including supplying, installation, testing and commissioning of		Nos.	LS	0.48

Item No.	Description of Item	Qty	Unit	Rate (Rs)	Amount (Rs.in Crores)
	D.G. Set				
iii	Including supplying, installation, testing and commissioning of illumination system (Indoor lighting/ outdoor Highmast)		Nos.	LS	0.96
iv	Repair and renovation of electrical cable duct and Including supplying, installation, testing and commissioning of Cables and cable trays with accessories.		Nos.	LS	0.60
v	Including supplying, installation, testing and commissioning of Earthing and Lightning protection		Nos.	LS	0.18
vi	Including supplying, installation, testing and commissioning of control equipments along with control cabling (PLC, CCTV, RIO and LED screens)		Nos.	LS	0.95
vii	Communication and IT		Nos.	LS	0.05
viii	Control Room Building (Central & Local (4 Nos) repair complete in respect to all civil and miscellaneous works including rainwater harvesting system		Nos.	LS	3.00
ix	Fire Fighting System		Nos.	LS	0.15
	Sub Total for Electrical Equipments, Control Room Building and Fire Fighting System including mobilization and demobilization				7.02
9	**Road works including mobilization and demobilization**				
i	Internal Approach Road including vehicle parking area	3,500	Sqm	4,500	1.58
	Sub Total for Road Works including mobilization and demobilization				1.58
10	**Retiring Rooms, Water supply, Drainage, Sewerage & Boundary Wall including mobilization and demobilization**				
i	Retiring Rooms with rainwater harvesting system		Nos.	LS	0.65
ii	Water Supply and Distribution		Nos.	LS	0.50
iii	Storm water Drainage		Nos.	LS	0.20
iv	Sewerage System with STP and Waste Collection System		Nos.	LS	0.60
v	Boundary Wall repair with 0.5m barbed wire fencing		Nos.	LS	0.20
	Sub Total for Water Supply, Drainage, Sewerage and Boundary Wall including mobilization and demobilization				2.15
11	**Instrumentation and Miscellaneous including mobilization and demobilization**				
i	Instrumentation for monitoring of dynamic water level monitoring and Silt monitoring		Nos.	LS	0.75
ii	Safety Instruments (Piezometers, Settlement gauges and inclinometers)		Nos.	LS	2.00
iii	Miscellaneous		Nos.	LS	0.75
	Sub Total for Instrumentation and Miscellaneous including mobilization and demobilization				3.50
12	**Cost of Environmental Mitigation measures including mobilization and demobilization**				0.87
13	**Cost of Electricity and Water Supply connections including**		Nos.	LS	5.00

Item No.	Description of Item	Qty	Unit	Rate (Rs)	Amount (Rs.in Crores)
	mobilization and demobilization				
14	**Model Study**		Nos.	LS	1.00
15	**Dismantling of Concrete & Decommission of Hydromechanical & Electrical Components and dismantling of local control rooms including mobilization and demobilization**		Nos.	LS	3.00
	Total				148.23
16	**Design fee including all kind of survey, investigations, etc. @ 3% on total**				4.45
17	**PMC Fee @ 2% on total**				2.96
18	**Contingencies @ 3% on total**				4.45
	Grand Total				160.09
	SAY				160.10

19.2 Operation and Maintenance Costs

Operation and Maintenance costs have been calculated under various heads, as described in the subsequent paras:

- 3% of Civil Works
- 1.5% of Mechanical, Electrical Works and Utilities

The summary of the annual operation and maintenance costs of the facilities for Existing Navigational Lock is presented in Table 19.3.

Table 19.3 Cost summary of the project

S. No.	Item	Qty.	Unit	Rate	Unit	Annual Cost (Rs. In Crores)
OPERATIONAL AND MAINTENANCE COST						
1.	Civil Works	160.0 (Say)	Rs. In crores	1.5%	% of Cost	2.40
2.	Mechanical, Electrical Works and Utilities	70	Rs. In crores	3%	% of Cost	2.10
TOTAL						4.50
3.	Insurance, Administration Expenses and Miscellaneous				LS	1.50
TOTAL ANNUAL MAINTENANCE AND OPERATIONAL COST						6.00

Annexure 1 – Geotechnical Investigation Report

GEOTECHNICAL INVESTIGATLON FOR NEW NAVIGATION LOCK AT FARAKKA FOR CAPACITY AUGMENTATION OF NATIONAL WATERWAY-L & DETAILED ENGINEERING FOR ITS ANCILLARY WORKS AND PROCESSES BETWEEN HALDIA TO ALLAHABAD (JAL MARG VIKAS PROJECT)

DRAFT FINAL REPORT
LOCATION: FARAKKA BARRAGE

Client :
HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD.
HOWE INDIA HOUSE,
81, NEHRU PLACE,
NEW DELHI – 110 019

FEBRUARY, 2016

FARGO CONSULTANTS PVT. LTD.
CF-394, SECTOR-I, SALT LAKE CITY
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TABLE OF CONTENTS

CHAPTER – I

1.0 INTRODUCTION

- Geotechnical Investigation for New Navigation Lock at Farakka for Capacity Augmentation of national Waterway-I & Detailed Engineering for its Ancillary Works and processes between Haldia to Allahabad (Jal Marg Vikas project) was entrusted to Fargo Consultants Pvt. Ltd., CF-394, Sector-I, Salt Lake City, Kolkata- 700 064 by HOWE Engineering Projects (India) Pvt. Ltd., HOWE India House, 81, Nehru Place, New Delhi – 110 019.

- The scope of the soil investigation work consisted of sinking nine (9) no. boreholes to a maximum depth of 33.00m. Soil borings included collection of undisturbed / disturbed soil samples and conducting Standard Penetration Tests.

- The formation at the site is to be reported for various layers present at their respective depths along with their thickness. As ground water table location influences the method of construction of foundation at a site, its location also needs to be found out.

- During sinking of boreholes soil samples both in disturbed and undisturbed conditions were to be collected for laboratory tests. The disturbed samples would be subjected to tests to obtain soil index properties. The undisturbed soil samples, however, would be used mainly for conducting tests to obtain bulk density, shear strength parameters as well as consolidation characteristics of the soil representing the strata.

CHAPTER - II

2.0 FIELD INVESTIGATION

2.1 SOIL BORING

- The details of field work like, location, borehole no., termination depth, static water level and the dates of commencement and completion are furnished below.

Borehole No.	Termination Depth (m)	RL (m)	*D.T.W. (m)	Commencement Date	Completion Date
BH-1	25.62	23.932	1.50	15.10.2015	16.10.2015
BH-2	36.05	22.836	5.50	19.01.2016	24.01.2016
BH-3	25.63	25.593	1.30	14.10.2015	15.10.2015
BH-4	27.56	25.338	1.25	13.10.2015	14.10.2015
BH-5	16.62	26.000	1.40	12.10.2015	13.10.2015
BH-6	31.80	26.000	1.50	11.10.2015	12.10.2015
BH-7	33.30	27.000	6.10	09.10.2015	11.10.2015
BH-8	31.80	26.321	5.80	08.10.2015	09.10.2015
BH-9	37.55	22.730	5.00	25.01.2016	31.01.2016
BH-10	30.30	26.000	2.80	06.10.2015	07.10.2015
BH-11	30.80	22.473	2.70	01.10.2015	07.10.2015
Note: **D.T.W. – Depth to water from borehole top RL – Borehole top estimated from survey contour drawing					

- The boreholes of 150mm diameter were explored with the help of auger and mud rotary circulation as per IS 1892 - 1979. Here the auger was turned in the bottom of the hole through auger pipes. Due to this the soil cuttings were held in the auger and were drawn to the surface by pulling the auger out of the hole each time the auger was filled. In continuation to auger boring mud rotary boring method was employed. In this method the boring was advanced by a cutter fixed to drill pipes, which were rotated by means of pipe wrenches. Bentonite was pushed simultaneously by a mechanical pump. The slurry flowing out of cutter bottom mixes up with the cut soil and flows up to the ground surface, and slurry tank after passing through setting pits and back to the slurry tank. The process was continuous and the same slurry can be used several times. The cutting tool was lowered slowly with the help of a double pulley system fixed on a tripod. This method of boring was followed upto the explored depth in each borehole.

- Seamless flush jointed steel casing of 150mm internal diameter was used to prevent any caving of boreholes and it was inserted simultaneously with the advancement of boring operation whenever required.

- The undisturbed samples were collected from the boreholes wherever possible, with the help of a thin walled sampler, as per the IS:2132-1986 "Code of practice for thin walled tube sampling of soils". The area ratio of the sampler was of the order of twelve percent and the inside clearance was around two percent. The sample tube about 450mm long and 100mm inner diameter, was coupled with the sampler with a drive head, vent holes and ball check valve to complete the sampling assembly. While sampling below the water table inside the borehole, the entrapped water has the opportunity to escape through this valve at the top. The sampling assembly was then lowered inside the boreholes by connecting a string of 'A' / 'AW' size drill rods to it. The assembly was driven to a predetermined depth with the help of jarring link. On completion of sampling operation, the sampler was first rotated (so that the soil would shear off on a horizontal plane at the cutting shoe edge) and then raised to the surface. The undisturbed sample was waxed at both ends with proper identification mark on the tube sampler. Undisturbed samples were not collected from hard cohesive soils.

- Standard Penetration Tests were conducted inside the boreholes at 3.0m intervals as per IS:2131-1981 "Method of Standard Penetration Tests for soils". The split spoon sampler used was of standard design and dimension. The spoon was advanced by driving with a drop hammer weighing 63.5 kg. falling freely through a height of 75cm. A record of the number of blows required to penetrate every 15cm. to a depth of 45cm. was kept. The number of blows required for the last 30cm penetration of the split spoon sampler was recorded as 'N' – value. On completion of the test, the sampler was lifted to the ground, opened and the specimen of the soil sample was stored in double polythene bags with the proper identification mark. The penetration number, 'N', has been shown against the corresponding depths in the field bore logs. The distributions of field 'N' values with RL at different locations are shown in the attached figures.

- Representative disturbed samples were collected regularly and wherever the stratum changed. These samples were taken from the cutting edge of the cutter and the split spoon samplers after standard penetration tests. These samples were labelled depth wise and used in the preparation of borehole log and for general identification and classification purposes.

- The first phase of the field investigation work commenced on 01st October 2015 and was completed on 16th October 2015. The second phase of the investigation commenced on 19th January 2016 and was completed on 31st January 2016. The depth of water level in the boreholes was determined 24 hours after the completion of boring so that the water in the boreholes could come to equilibrium with the water table. No artesian condition was encountered in any borehole.

2.2 FIELD PERMEABILITY TEST

- For determination of field permeability at the site Hvorslev's method (Time lag and Soil Permeability in Groundwater Observations, M. J. Hvorslev, 1951) was utilised. A borehole is sunk 150mm below existing groundwater level. A casing is introduced into the hole upto a certain length (L) above the bottom of the borehole to prevent cave in of the borehole. Water was filled in the casing and drop in water level was measured at fixed time intervals. The following equation was used for determination of permeability of the subsurface

$$k = \frac{d^2 \ln[(mL/D) + \sqrt{1 + (mL/D)^2}]}{8L(t_2 - t_1)} \times \ln(H_1/H_2)$$

Where,

k = permeability

d = Diameter of casing

D = Diameter of hole below casing

L = Length of open hole below below casing

m = $\sqrt{k_h/k_v}$ = 1 (Since uniform soil)

H_1 = Height of water above existing groundwater level at time t_1

H_2 = Height of water above existing groundwater level at time t_2

CHAPTER - III

3.0 LABORATORY TESTING

The following laboratory tests were carried out to ascertain the properties of the sub-soil.

- Grain size analysis

The particle size distribution of various soil samples collected from different subsoil deposits were determined by sieve analysis (dry method) or hydrometer analysis (wet method) or a combination of both, as was found necessary. From the test results, grain size distribution curves were generated to ascertain percentage of sand, silt, clay etc in each sample.

- Natural Moisture Content

The natural moisture content (N. M. C) or water content of the samples were obtained by oven drying a quantity of soil for at least 24 hours at 105^{0}C and recording their weights before and after drying.

- Atterberg Limits

The Atterberg limits of the soil samples were determined by adopting standard procedure. The liquid limit was determined with the help of Cassagrande's apparatus. The plastic limit was ascertained by rolling the soil samples into threads.

- Specific Gravity

The Specific Gravity of the soil samples were determined by adopting standard procedure. The soil sample was dried in oven dried for 24 hours and pulverished. The sample was then poured into a specific gravity bottle and topped up with distilled water. The specific gravity bottle was stirred and heated to eliminate air bubbles. The weight of the specific gravity bottle was recorded along with the temperature of the sample.

- Tri-axial Test (Unconfined Compression)

The tri-axial test unconfined compression test was carried as per IS Code. Three samples were tested and the average value was reported. For hard soils, undisturbed samples are not collected, the shear strength was estimated from correlations published in text books.

- One Dimensional Consolidation Test

The One dimensional consolidation test was carried as per IS Code. The sample was loaded upto 8kg/cm incrementally and then unloaded. The data was used to evaluate the m_v values. These values will be used for settlement calculations. For hard soils, undisturbed samples are not collected. The m_v values were determined from correlations published in "Manual for Estimating Soil Properties for Foundation Design" by F.H. Kulhawy and P.W. Mayne.

All these tests were conducted as per relevant I.S. Codes and the test results are tabulated in Tables enclosed herewith.

CHAPTER - IV

4.0 DISCUSSION AND RECOMMENDATION

4.1 The sub-soil formation in this area has been investigated by sinking nine (9) boreholes explored upto a depth of 33.30m below the existing ground level. The field investigation data and the results of laboratory test conducted on samples collected from the borehole indicate the presence of seven (7) layers. The details of layer like layer no., description of layer and the thickness of each layer as encountered in the borehole are furnished below.

Layer No.	Description	Layer Thickness (m)					
		BH-1	BH-2	BH-3	BH-4	BH-5	BH-6
Fill	Grey sandy silty clay (fill material)	-	4.50	-	-	1.00	-
I	Yellowish/brownish grey stiff silty clay with traces of sand and brown spots	-	13.50	5.50	8.00	4.00	2.00
II	Yellowish grey / brownish grey stiff to very stiff silty clay with traces of nodules	-	-	-	-	-	-
III	Brownish grey / yellowish grey soft silty clay with traces of kankar	-	-	-	-	8.00	5.00
IV	Yellowish brown / greyish yellow medium dense silty fine sand	7.00	-	-	-	-	3.00
V	Brownish grey/light grey/greyish yellow stiff to hard silty clay with traces of kankar/calcarious nodules	12.00	7.50	14.50	12.00	-	18.00
VI	Greyish yellow/brownish grey dense silty fine sand	4.90	-	4.00	5.00	-	-
VII	Refusal strata (Decomposed lateritie rock /very dense silty sand with traces of kankar and nodules)	1.72*	10.55*	1.63*	2.56*	3.62*	3.80*
* - Upto termination depth							

Layer No.	Description	Layer Thickness (m)				
		BH-7	BH-8	BH-9	BH-10	BH-11
Fill	Grey sandy silty clay (fill material)	-	-	3.00	-	-
I	Yellowish/brownish grey stiff silty clay silt with traces of sand and brown spots	16.00	5.00 & 8.70	12.00	7.50	-
II	Yellowish grey / brownish grey stiff to very stiff silty clay with traces of nodules	-	-	9.00	10.50	3.00 & 17.50
III	Brownish grey / yellowish grey soft silty clay with traces of kankar	-	-	-	-	-
IV	Yellowish brown / greyish yellow medium dense silty fine sand	-	2.30	-	-	4.50
V	Brownish grey/light grey/greyish yellow stiff to hard silty clay with traces of kankar/calcarious nodules	13.00	12.00	7.50	9.00	-
VI	Greyish yellow/brownish grey dense silty fine sand	-	-	-	-	2.00
VII	Refusal strata (Decomposed laterite rock /very dense silty sand with traces of kankar and nodules).	4.30*	3.80*	6.05*	3.30*	3.80*
* - Upto termination depth						

4.1.1 The ground water level was encountered at a depth of 1.25m to 6.1m below ground level in the borehole during the period of field work. The borehole location plan, graphical representation of field 'N' values with depth, is provided in Annexure A.

4.1.2 On close scrutiny of field test results, laboratory test results and based on experience and judgement, necessary soil parameters for the purpose of design of foundation are tabulated in the following table.

Layer No.	Description	Thickness (m)	Average of N-Value	Bulk Density (t/m^3)	Shear Strength Parameter
Fill	Grey sandy silty clay (fill material)	[illegible]	[illegible]	1.75#	[illegible]
I	Yellowish/brownish grey stiff silty clay silt with traces of sand and brown spots	16.00	9	1.872	c=2.7t/m
II	Yellowish grey / brownish grey stiff to very stiff silty clay with traces of nodules	[illegible]	18	1.883	c=7.8t/m
III	Brownish grey / yellowish grey soft silty clay with traces of kankar	[illegible]	3	1.70#	c=1.9t/m
IV	Yellowish brown / greyish yellow medium dense silty fine sand	[illegible]	17+	1.84#	[illegible]33.0#
V	Brownish grey/light grey/greyish yellow stiff to hard silty clay with traces of kankar/calcarious nodules	13.00	30	1.938	c=14.4t/m
VI	Greyish yellow/brownish grey dense silty fine sand	[illegible]	27+	1.90#	[illegible]34.0#
VII	Refusal strata (Decomposed lateritie rock /very dense silty sand with traces of kankar and nodules).	4.30*	43+	2.02#	[illegible]35.0#
* = Upto termination depth #=Suggested value + = Corrected N-value					

4.1.3 The pile load capacities of suggested piles are provided in the table below. The pile load capacities will require to be checked by conducting pile load test as per IS Code. The centre to centre distance between the piles should at least 3 times the diameter of pile. Sample calculations are provided in Annexure - A.

Pile Diameter (mm)	Pile Founding depth Below EGL (m)	Suggested Pile Vertical load Capacity (t)	Suggested Pile Uplift load Capacity (t)	Suggested Pile Lateral Load Capacity (Fixed head) (t)
500	18	38.0	22.5	2.1
500	20	43.0	27.0	2.1
500	22	49.0	31.0	2.1
500	24	54.0	35.0	2.1
500	26	59.0	39.5	2.1
550	18	43.0	25.0	2.5
550	20	48.0	30.0	2.5
550	22	54.0	34.5	2.5
550	24	60.0	39.0	2.5
550	26	66.0	43.5	2.5
600	18	48.0	28.0	3.0
600	20	54.0	33.0	3.0
600	22	60.0	38.0	3.0
600	24	67.0	43.0	3.0
600	26	73.0	48.0	3.0
Note: 1) Pile cut-off level is 1.5m below existing ground level (EGL). 2) Last layer is assumed to extend to a depth 10m below pile founding level				

Proper care shall also be taken during construction, particularly during excavation and casting of pile caps. The sides of excavation shall be protected against possible collapse or caving in. The bottom of excavation shall be checked against any heaving. The stagnating water from the excavated pit shall be conveniently drained out.

4.2 In-situ permeability test results are provided Annexure - B. Permeability for depth interval of 7.0m to 10.7m was observed to be 9.0×10^{-9} cm/s and for depth interval 17.0-20.0m was 7.3×10^{-8} cm/s.

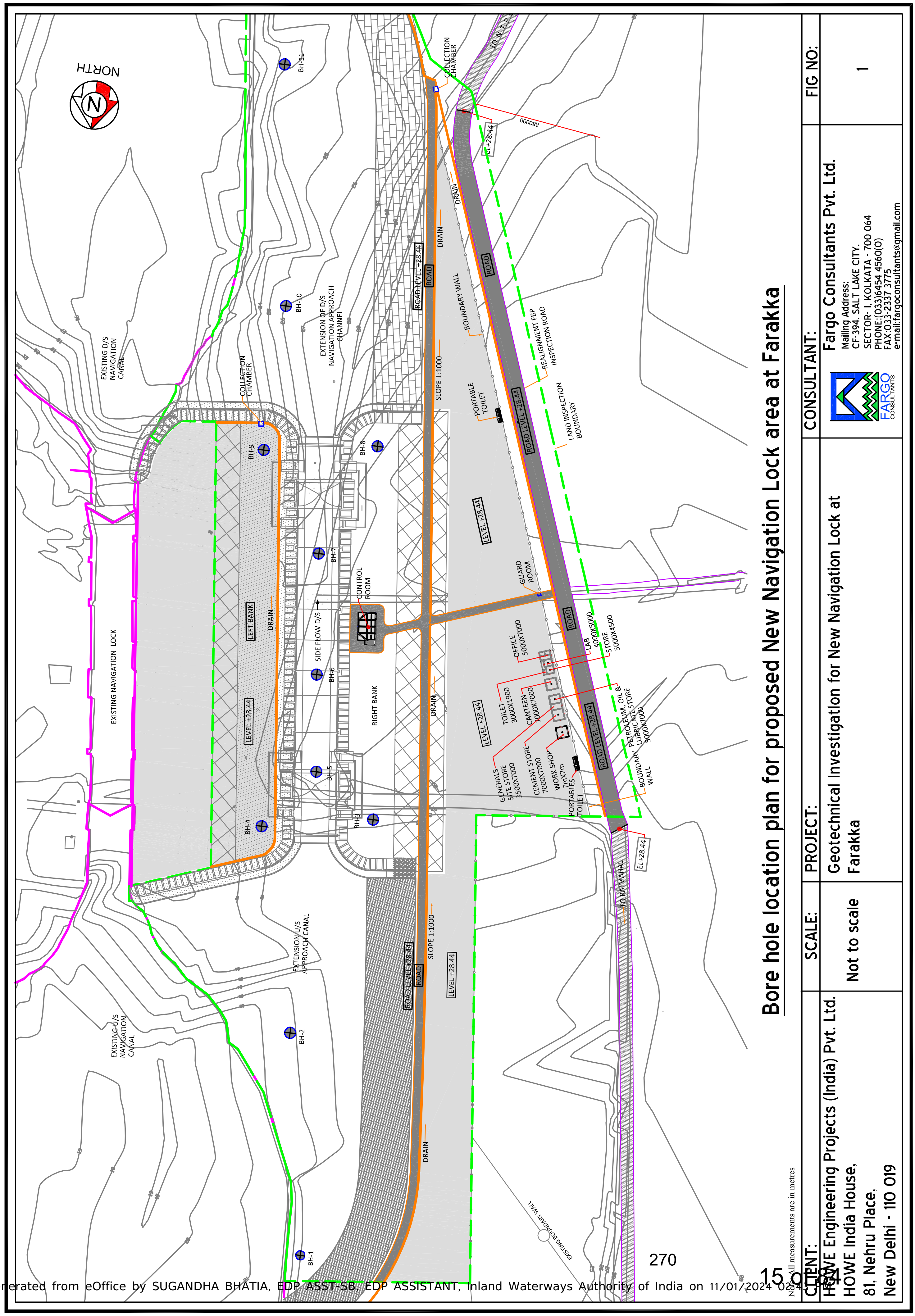
for **FARGO CONSULTANTS PVT. LTD.**

(P. BRAHMA)
B. Tech (Hons.), M.S. (USA), MIGS

ANNEXURE - A

Annexure 1

Sheet No.: A-1



GEOTECHNICAL INVESTIGATION REPORT

FOR

CONSTRUCTION OF NEW NAVIGATION LOCK AT FARAKKA, WEST BENGAL

L&T Construction

4 | 3 | 2 | 1

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DATE	REV.NO.	DESCRIPTION	CHECKED	APPROVED
19.04.17	A	ISSUED FOR APPROVAL	PTN	AVSN

REVISIONS

LARSEN & TOUBRO LIMITED

CLIENT: भाअजप्रा IWAI **INLAND WATERWAYS AUTHORITY OF INDIA**
(MINISTRY OF SHIPPING, GOVT. OF INDIA)

PROJECT: **CONSTRUCTION OF NEW NAVIGATION LOCK AT FARAKKA WEST BENGAL**

EPC CONTRACTOR: **L&T CONSTRUCTION**

JOB No.: **G-O16003**

	NAME	SIGN	DATE
DSGN	SKA	SKA	15.04.17
DRWN	–		–
CHKD	PTN		18.04.17
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TITLE:
GEOTECHNICAL INVESTIGATION REPORT

SCALE 1:1

PROJECTION

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4 | 3 | 2 | 1

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CONTENTS

REPORT ON GEOTECHNICAL INVESTIGATION FOR CONSTRUCTION OF NEW NAVIGATION LOCK AT FARAKKA, WEST BENGAL

1. INTRODUCTION

Inland Waterways Authority of India (IWAI) proposes to construct a new Navigational lock on National Waterway-1 at Farakka in West Bengal. A Navigation lock is a structure used with significant difference in water level. It is used for raising and lowering Boats, Ships and other watercraft between such stretches. A barrage was constructed across river Ganga at Farakka to divert the water from Ganga to Bhagirathi through a feeder canal. There is a significant difference in water level of upstream pond of the Barrage and feeder canal, depending upon the flow in river Ganga and the feeder canal. To negotiate this difference, navigation lock is required. The navigable route through the main Ganga River upstream to the River Bhagirathi downstream is facilitated by the old navigation lock at Farakka. The Feeder Canal of Farakka Barrage and the existing navigation lock becomes the link between the Main Ganga and Bhagirathi.

This report covers details of the soil investigation carried out at the proposed new navigational lock at Farakka, West Bengal.

2. SCOPE OF WORK

2.1 Field Investigation

Drilling of boreholes, through soil for investigation. Details of work carried out in bore hole as follows:

1. Conducting Standard Penetration tests
2. Collecting disturbed soil samples from boreholes
3. Collection of Water samples from boreholes

2.2 Laboratory Tests

***On Soil Samples*:**

1. Determination of moisture content.
2. Grain size distribution analysis
3. Atterberg limits
4. Specific gravity test
5. Triaxial test
6. Chemical analysis of soil and water samples

3. CODES AND STANDARD REFERENCES

The reference used for preparation of the geotechnical investigation report is described below,

IS: 1080	Code of practice for design and construction of shallow foundations on soils
IS: 1498	Classification and identification of Soils for engineering purposes
IS: 1888	Method of Load Test on soils
IS: 1892	Code of practice for Subsurface Investigation for Foundation
IS: 1904	Code of practice for design and construction of foundation in soils: General requirements
IS: 2131	Method of Standard Penetration Test for soils
IS: 2132	Code of practice for thin walled tube sampling
IS 2720	Method of test for soils
IS: 2809	Glossary of terms and symbols relating to Soil Engineering
IS: 2810	Glossary terms relating to soil dynamics
IS: 2950	Code of practice for design and construction of raft foundation
IS: 3025	Methods of sampling and testing (Physical and Chemical) for water used in industry
IS: 3043	Code of practice for Earthing
IS: 4078	Code of practice for indexing and storage of drill cores

IS: 4464	Code of practice for presentation of drilling information and core description in foundation investigation
IS: 4651	Code of practice for planning and design of ports and harbours: Part-I site investigation
IS: 6403	Code of practice for determination of allowable bearing capacity on shallow foundation
IS: 6935	Method for determination of water level in boreholes
IS: 8009	Code of practice for calculation of settlement of foundation subjected to symmetrical (Part I) vertical loads: Shallow foundations
IS: 8009	Code of practice for calculation of settlement of foundation subjected to symmetrical (Part II) vertical loads: Deep foundations
IS: 8763	Guide for Undisturbed Sampling of sands
IS: 9259	Specifications for Liquid Limit apparatus
IS: 9640	Specifications for Split Spoon Sampler
IS: 9669	Specifications for CBR mould and its accessories
IS: 10042	Code of practice for site investigation for foundation gravel boulder deposit
IS: 10074	Specification for compaction mould assembly for Light and Heavy compaction
IS: 10108	Code of practice for sampling by thin wall sampler with stationary piston
IS: 10589	Equipment for determination of subsurface sounding of soils
IS: 11229	Specifications for Shear Box testing of soils
IS: 15736	Geological exploration by geophysical method (Electrical resistivity) - Code of practice
IS: 4968	Part1- Method for surface sounding for soils- Dynamic Method using cone without bentonite slurry
IS: 4968	Part2- Method for surface sounding for soils- Dynamic Method using cone and bentonite slurry

IRC 78	Standard Specifications and Code of Practice for Road Bridges Section VII – Foundations and Substructure
SP 36	Part1 – Compendium of Indian standards on soil engineering: Laboratory testing
SP 36	Part2 – Compendium of Indian standards on soil engineering: Field testing
	Pile design and construction practice by Michael Tomlinson (Fifth Edition)
NAVFAC DM 7.01	Naval Facilities Engineering Command Design Manual 7.01

4. REGIONAL GEOLOGY OF THE SITE

The geological formation at the site is broadly classified into three parts viz.

a) Recent alluvium,

b) Pleistocene- recent older alluvium and lateritic clay and

c) Jurassic Rajmahal Trap.

Recent alluvium:

The “bagri” region of the district is occupied by recent alluvium. The soil is mainly composed of sands and clays brought by the rivers. All types of soils are fertile and produce all kinds of crops.

Pleistocene- recent older alluvium and lateritic clay:

A major part of the “rarh” region that is the western part of the river Bhagirathi is occupied by older alluvium and lateritic clay. It may be the continuation of the sub-Vindhyan region of lateritic clay and nodular limestone. The ‘kankar’ (the beds of limestone) are scattered at places in this western part.

Jurassic Rajmahal Trap:

The northern part of the district consists of basaltic lava which flowed with intercalated, carbonaceous shale and clays. The basalt is a black- coloured, fine-grained amygdaloidal rock. The amygdales are filled with chalcedony, calcite, zeolite and other secondary minerals.

GEOMORPHOLOGY

The area was divided into four surficial geomorphic plains a) Lateric upland, b) Older deltaic Plain, c) Younger Deltaic Plain and d) Bhagirathi Recent Surface.

The District Murshidabad lies generally within the Younger Deltaic Plain or Kandi Plain and the Bhagirathi Recent Surface. The river Bhagirathi, flowing from north to south through the district had divided the area into almost two equal halves, namely 'rarh' and 'bagri'. The tract to the west of the river is locally known as 'rarh' and the tract to the east as 'bagri'.

The east of Bhagirathi is low-lying and alluvial. The climate is humid and the land is liable to flood by the spill of the Bhagirathi and other rivers. The soil is amazingly fertile. On the western side, the relief is higher than the eastern part and the surface is undulating. The soil is hard clay. The climate is drier than in the eastern tract. Although the western tract or the 'rarh' is slightly high and undulating than the eastern tract 'bagri', the land is interspersed with numerous swamps and paleo-channels. The greatest elevation in the western boundary is near the border of the Birbhum district, i.e. Khargram, Burwan, Nabagram and Sagardighi block.

The Quaternary sediments have been classified as:

Geological time scale	Geomorphic subdivision	Morphological characteristics
Recent Pleistocene	Younger Deltaic Plain formation (YDP)	• River terrace sediments • Alluvial sediments with soil containing soft ferruginous nodules
	Older Deltaic Plain formation (OLD)	• Alluvial sediments with soil containing calcareous nodules
	Lateritic formation	• Hard lateritic and mottled clay with underlying alluvial sediments

The Young Deltaic Plain or Kandi Plain is a terrace like plain. This plain varies from 6 kilometres in the north to 38 kilometres in the south and the average slope is 0.6 meters per kilometres.

The Bhagirathi recent surface is confined into the present day channels and their immediate vicinity. The belt of terrace is 3-5 kilometres in width with slope 0.2 meters per kilometres.

Between Young Deltaic Plain and the Bhagirathi recent surface is composed of loose and completely unconsolidated sediments structures. The older landforms are exposed to erosion; therefore, the land forms of the younger ones are better preserved.

PHYSIOGRAPHIC DIVISION

Minor Physiographic division of Murshidabad district

Minor Physiographic division	Blocks
Strip of low lying land	Suti-I, Suti-II, Samsarganj and Farakka

SOIL

The ‘rarh’ region is substantially a continuation of the sub- Vindhyan region of lateritic clay and nodular ghuting. The soil is greyish or reddish mixed with lime and iron oxide and scattered nodular lime ghuting (kankar).

The ‘bagri’ region lying in the Bhagirathi recent surface has little soil development. The surface composed of loose and completely unconsolidated sediments exhibiting a variety of sedimentary structures. About 1-2 meters of thick brown mottled soil with soft and incipient ferruginous concretion develop on Younger Deltaic Plain.

Sandy loam soils, Domkal Block, Murshidabad District

Clay loam soil, Barwan Block, Murshidabad District

Soil Combination in Different Block of Murshidabad District:

Block	Predominant groups of soil	% total area	Other groups	% total area
Suti-I	Clay, Sandy loam	80	Loam, Clay loam	20
Suti-II	Sandy loam, Clay	80	Loam, Clay loam	20
Samsarganj	Clay loam, Clay	60	Sandy loam	40
Farakka	**Clay loam, Clay**	**85**	**Sandy loam, Loam, Silty loam**	**15**
Sagardighi	Clay loam, Clay	67	Sandy clay, Sandy clay loam	33

The northern part of the Murshidabad district (blocks Farakka, Suti-I, Suti-II and Samsarganj) consists of basaltic lava flows with intercalated carbonaceous shale and clays.

5. FIELD INVESTIGATION

5.1 Boreholes

Sixteen Boreholes of 150mm diameter in subsoil strata were bored / drilled at various locations as detailed in Table 1A. The detail of borehole layout is depicted in *Annexure I*.

i) Standard Penetration Tests were conducted in soil at regular intervals and 'N' values noted. The samples were collected from split spoon samplers.

ii) The collected soil samples were sent to laboratory for testing.

Details of boring with SPT values, and sampling are included in the respective Bore logs refer in *Annexure II*. Detailed soil profile is presented in *Annexure-III*.

Table 1A: Borehole Details of Farakka Site

Sl. No.	BH No.	Coordinates		Borehole depth (in m)	R.L (in m)	Water Depth below EGL (in m)
		Easting	Northing			
1	NBH - 01	591287.1	2745055.4	31	(+) 23.633	3.5
2	NBH - 02	591225.8	2744920.4	34	(+) 28.700	6.2
3	NBH - 03	591264.0	2744776.6	47	(+) 24.450	3.1
4	NBH - 04	591292.9	2744760.7	32	(+) 24.563	3.1
5	NBH - 05	591383.9	2744800.1	32	(+) 28.000	6.4
6	NBH - 06	591300.9	2744696.2	33.5	(+) 24.600	3.3
7	NBH - 07	591300.9	2744651.4	39	(+) 27.430	6.2
8	NBH - 08	591312.8	2744591.5	39	(+) 27.600	6.2
9	NBH - 09	591352.0	2744557.0	41	(+) 26.509	4.1
10	NBH - 10	591311.0	2744505.7	39.5	(+) 26.509	3.9
11	NBH - 11	591388.3	2744512.1	40	(+) 25.765	5.1
12	NBH - 12	591291.7	2744371.0	39.5	(+) 29.310	7.0
13	NBH - 13	591368.9	2744186.5	34	(+) 24.725	3.6
14	NBH - 14	591406.0	2744784.9	28	(+) 28.500	6.0
15	NBH - 15	591419.0	2744665.5	18	(+) 26.000	2.0
16	NBH - 16	591432.5	2744541.1	15.5	(+) 23.465	1.5

5.2 Trial pits

Three trial pits 3m x 3m were carried out in subsoil strata at road locations as detailed in Table 1B. The detail of trial pit layout is depicted in *Annexure I*.

Table 2B: Trial pit Details of Farakka Site

Sl. No.	Trial Pit No.	Coordinates		Depth (in m)	R.L (in m)	Water Depth below EGL (in m)
		Easting	Northing			
1	TP -7	2744627.6	591161.3	3	(+) 23.828	2.7
2	TP - 8	2744600.7	591255.5	3	(+) 24.670	2.9
3	TP - 9	2744419.2	591248.9	3	(+) 24.100	2.8

6. LABORATORY TESTS

6.1 Moisture content

Natural moisture content of the soil samples was determined from the collected disturbed and undisturbed samples using oven-drying method, as per IS 2720 (Part II). The test results are given in Annexure-IV.

6.2 Grain Size analysis

Grain size analysis by sieve was conducted on selected samples to determine the grain size distribution. Hydrometer tests were conducted to determine the percentage of clay and silt fractions in cohesive layers, as per IS: 2720 (Part IV). The test results and the graphs are presented in *Annexure IV*.

6.3 Atterberg's limit test

Atterberg's limit tests were conducted on the samples collected from the cohesive layer to determine the liquid and plastic limits, as per IS: 2720 (part V). The test results are presented in *Annexure IV*.

6.4 Specific gravity test

Specific gravity of the soil grains was determined using specific gravity bottles as per IS: 2720 (Part III) and the test results are presented in *Annexure IV*.

6.5 Triaxial test

Unconsolidated and Undrained Triaxial shear tests were conducted on the undisturbed samples collected from boreholes as per IS: 2720 (Part XI) to arrive at the shear strength parameter 'c' and 'ϕ' values. The test results are given in Annexure-IV.

6.6 Chemical analysis of soil & water samples:

Chemical analyses of soil samples were conducted on the samples collected from boreholes to determine the pH value, Chloride, Sulphate & Carbonate as per IS: 2720 part-23 & 26, and IS: 3025 Part-24, and chemical analyses of water samples were conducted on the samples collected from boreholes to determine the pH value, Chloride, Sulphate, Carbonate & Organic Matter as per IS: 3025 Part-11, 18, 23, 24 & 32, the test results are given refer in *Annexure V*.

7. SUBSURFACE CONDITIONS

7.1 Introduction

Sixteen numbers of boreholes were drilled at the proposed Navigation lock area for the assessment of subsoil conditions and design soil parameters. The existing ground levels at this location varies from RL. +23.465m to RL. +29.310m at the time of investigation. Water table is encountered at depths varying from 1.5m to 7m below existing ground levels at the time of investigation.

7.2 Stratigraphy

Based on the geotechnical investigation, the subsoil at the present project location can be categorised in to four major layers.

Layer I: Soft to Medium Stiff Silty Clay

The top layer exists as Soft to Medium Stiff Silty Clay with thickness ranging from 3m to 14m. The field SPT N values observed in this layer are ranging from 3 to 8.

Layer II: Stiff to Very Stiff Silty Clay

Stiff to Very Stiff Silty Clay layer exists below the top layer with thickness ranging from 11m to 31m. The field SPT N values observed in this layer are ranging from 9 to 31.

Layer III: Hard Silty Clay / Dense Silty Sand

The above layer is followed by either hard silty clay layer or dense silty sand layer with thickness ranging from 1.5m to 23m. The field SPT N values observed in this layer are ranging from 30 to 58.

Layer IV: Weathered Rock

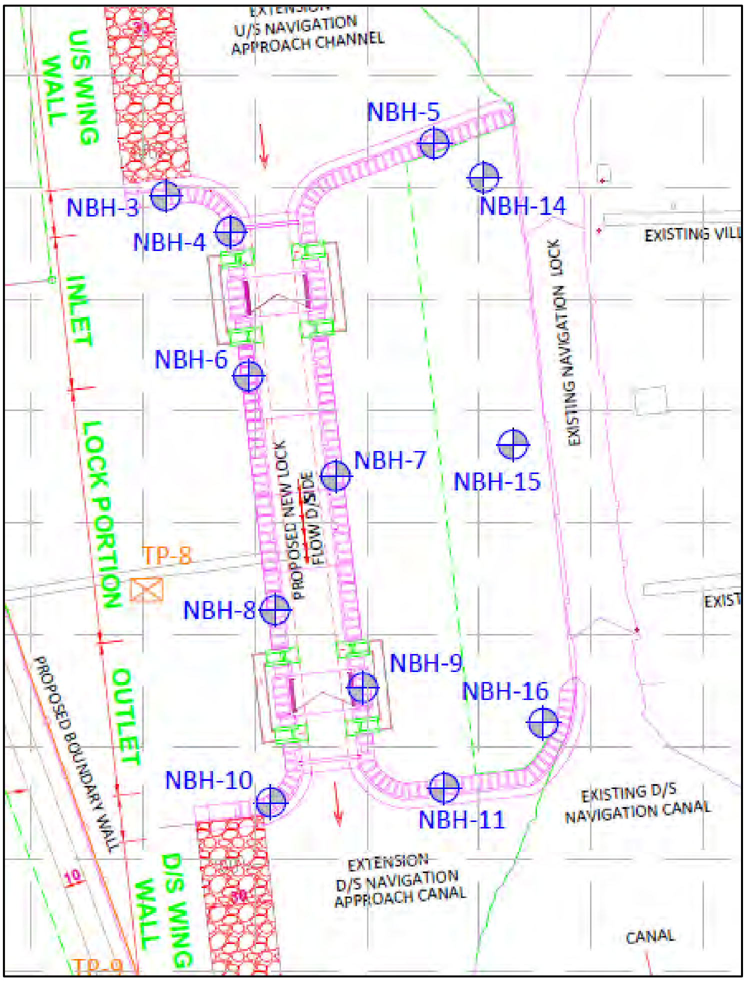
As per Cl.B-8 of IS 2911 (Part 1/Sec 2): 2010, strata with N ≥ 60 is classified as weathered rock and it can also be referred as Intermediate Geo-Material (IGM). This layer is encountered at 25.5m to 35m from existing ground levels and the layer is available up to borehole termination levels. The field SPT N values observed in this layer are ranging from 67 to >100.

7.3 Generalized Design Soil Parameters

The foundation recommendations for the lock structure is provided based on the individual elements viz., Inlet chamber, outlet chamber, central lock chamber, Guide wall for U/s & D/s portions.

Table 3: Detail of Structures & Reference boreholes for foundation recommendation

Sl.No	Structure	Reference Borehole
1	Raft – Lock portion	NBH - 06, NBH - 07, NBH - 08
2	Raft – Inlet	NBH - 04
3	Raft – Outlet	NBH - 09
4	U/s Wing wall	NBH - 03, NBH - 05
5	D/s Wing wall	NBH - 10, NBH - 11



Borehole location plan

Based on the bore logs, laboratory test data and established relations, generalized design soil parameters are recommended for use in engineering analysis of foundations for the site under consideration. The structure-wise generalized sub-surface soil models are presented below.

Table 4: Generalized sub-surface soil model for Raft – Lock Portion (NBH-06, NBH-07 and NBH-08)

Layer No.	Geotechnical Description	D (m)		H (m)	SPT-N''	C (kPa)	ϕ (°)	Es (kPa)
		From	To					
I	Medium Stiff Silty Clay	27.6	13.1	14.5	7	42	-	9000
II	Very Stiff silty Clay	13.1	-3.4	16.5	20	120	-	42000
III	Medium dense silty sand	-3.4	-6.4	3	22		33	50500
IV	Weathered Rock (Intermediate Geo-Material)	-6.4	-11.4	5	>100	1010	-	140000

Table 5: Generalized sub-surface soil model for Raft – Inlet Portion (NBH-04)

Layer No.	Geotechnical Description	D (m)		H (m)	SPT-N''	C (kPa)	ϕ (°)	Es (kPa)
		From	To					
I	Medium Stiff Silty Clay	24.56	12.6	11.96	6	36	-	7000
II	Very Stiff Silty Clay	12.6	0.6	12	22	132	-	45200
III	Hard Silty clay	0.6	-2.44	3.04	48	288	-	96000
IV	Weathered Rock (Intermediate Geo-Material)	-2.44	-7.44	5	>100	1240	-	140000

Table 6: Generalized sub-surface soil model for U/s Wing wall (NBH-05)

Layer No.	Geotechnical Description	D (m)		H (m)	SPT-N''	C (kPa)	ϕ (°)	Es (kPa)
		From	To					
I	Medium Stiff Silty Clay	28.00	13.5	14.5	8	48	-	12000
II	Very Stiff silty clay	13.5	1	12.5	24	144	-	48400
IV	Weathered Rock (Intermediate Geo-Material)	1	-4.0	5	>100	1005	-	140000

Table 7: Generalized sub-surface soil model for Raft outlet (NBH-09)

Layer No.	Geotechnical Description	D (m)		H (m)	SPT-N''	C (kPa)	ϕ (°)	Es (kPa)
		From	To					
I	Medium stiff silty clay	26.51	12.5	14	9	54	-	14000
II	Very Stiff silty clay	12.5	-3.5	16	18	108	-	37200
III	Medium dense Silty Sand	-3.5	-8	4.5	15	-	31	38000
IV	Weathered Rock (Intermediate Geo-Material)	-8	-12.5	4.5	>100	1160	-	140000

Table 8: Generalized sub-surface soil model for D/s Wing wall (NBH-10 & NBH-11)

Layer No.	Geotechnical Description	D (m)		H (m)	SPT-N''	C (kPa)	ϕ (°)	Es (kPa)
		From	To					
I	Medium stiff silty clay	26.51	8.5	18	9	54	-	14000
II	Stiff to Very Stiff silty clay	8.5	-6.5	15	16	96	-	32400
III	Hard Silty Clay	-6.5	-8.0	1.5	41	246	-	82000
IV	Weathered Rock (Intermediate Geo-Material)	-8.0	-13	5	>100	1250	-	140000

7.4 Bank Protection

Banks on both upstream and downstream side of the proposed lock shall be protected with the help of suitable slope protection measure. Reference borehole and generalized subsoil parameters for slope protection are given below.

Sl.No	Structure	Reference Borehole
1	Upstream slope protection	NBH - 01 & NBH - 02
2	Downstream slope protection	NBH - 12 & NBH - 13

Finished Ground Level is considered as (+) 28.44 m.

Table 9: Generalized sub-surface soil model for U/s & D/s Slope protection

Layer No.	Geotechnical Description	D (m)		H (m)	SPT-N''	C (kPa)	ϕ (°)	Unit weight (kN/m³)
		From	To					
I	Stiff silty clay	28.44	16.5	11.94	9	54	-	18
II	Stiff silty clay	16.5	10	6.5	12	72	-	18
III	Very stiff silty clay	10	-3	13	20	120	-	18
IV	Weathered Rock (Intermediate Geo-Material)	-3	-20	17	>100	1000	-	20

Slope protection with PCC Blocks of 0.4m thick with unit weight of 24 kN/m^3 is considered for the analysis.

Note: Legends used in above tables are as below;

D - Depth below finished ground level in meters

H - Thickness of the strata in meters

N'' - Average Corrected Standard Penetration Test value

C - Average cohesion in kN/m^2
('C' values are arrived as per NAVFAC DM 7.01)

ϕ - Angle of Internal Friction in deg.
('ϕ' values arrived based on Fig.1 of IS: 6403)

Es - Elastic Modulus of soil (kPa)
[Based on Shultz & Muhus (1998) for Sand and Mori (1965) for Clay]

8. DISCUSSION ON THE FOUNDATION SYSTEM

8.1 Open foundation

The foundation works for the project envisages construction includes Lock Structure including all associated facilities and control buildings. The Geotechnical recommendations for construction of the above structures were covered in this report.

The foundation recommendations for the lock structure is provided based on the individual elements viz., Inlet chamber, outlet chamber, central lock chamber, Guide wall for U/s & D/s portions.

8.1.1 Geotechnical Analysis

The foundations for any structure must generally satisfy two basic criteria. First, the substrata beneath the foundation must possess adequate bearing capacity to support the maximum loads with an appropriate factor of safety. Second, the expected settlements due to the compressibility of the underlying substrata must be within the tolerable limits.

8.1.2 Bearing Capacity Calculations

Bearing capacities are calculated for shear failure and settlement consideration point of view. For shallow foundations, the footing size, orientation and position relative to the ground surface have an influence on the bearing capacity. Based on IS: 6403 – 1981 the net ultimate bearing capacity for shear failure in soil strata is determined from the following relationship.

8.1.3 Shear Criteria

$$Q_{nult} = C * N_c * S_c * d_c + q * (N_q - 1) * S_q * d_q + 0.5 * B * \gamma * N_\gamma * S_\gamma * d_\gamma * W'$$

Where,

Q_{nult} = Net Ultimate Bearing Capacity (kN/m^2)

Q_{safe} = Net Safe Bearing Capacity (kN/m^2)

γ = Unit weight of soil (kN/m^3)

C = Cohesion (kN/m^2)

q	= Effective surcharge at the base level of foundation (kN/m^2)
B	= Width of footing (m)
L	= Length of footing (m)
D_f	= Depth of foundation (m)
N_c, N_q & N_γ	= Bearing capacity factors
S_c, S_q & S_γ	= Shape factors

Safe bearing capacity (SBC) is the maximum intensity of loading that the foundation will safely carry without the risk of shear failure of soil irrespective of any settlement that may occur. Safe bearing capacity can be obtained by dividing the Ultimate bearing capacity with suitable factor of safety (2.5).

$$\mathbf{Q_{safe} = Q_{ult} / 2.5}$$

8.1.4 Settlement Criteria

The intensity of loading that will cause a permissible settlement or specified settlement of the structure is termed as allowable bearing pressure. These foundation settlements are evaluated using IS: 8009 Part 1. Allowable Bearing Capacity (ABC) is the intensity of the loading which the foundation will carry without undergoing settlement in excess of the permissible value for the structure under consideration but not exceeding the net Safe bearing capacity (SBC).

The settlement in the over consolidated clay stratum is calculated based on the following elastic approach up to a depth of 1.5 times the width of foundation:

$$S_f = m_v . \Delta p . H = \Delta p . H / E_s$$

Where,

Δp	= pressure increment at center of soil layer (2:1 distribution)
H	= thickness of soil strata
E_s	= Elastic modulus of soil
m_v	= coefficient of volume compressibility = $1/E_s$

Main lock is supported using raft foundation at (+) 12.55m RL. Width of the raft varies from 37m to 42m at the central lock portion. Wing wall is of counterfort type retaining wall with base slab founding level varies from 6m below finished ground level to (+) 12.55m RL on one side and on the other side base of counterfort remains throughout at (+) 12.55m RL. Based on the above considerations, shallow foundation safe bearing capacities are estimated as given below.

Table 10: Shallow foundation safe bearing capacity for Raft

Reference Borehole	Depth of foundation below FGL (m)	Width of foundation (m)	Allowable Net Safe Bearing Capacity (kN/m^2) for 75 mm settlement
NBH - 08	16.0	37 to 42	270

Table 11: Shallow foundation safe bearing capacity for U/s Wing wall

Reference Borehole	Depth of foundation below FGL (m)	Width of foundation (m)	Allowable Net Safe Bearing Capacity (kN/m^2) for 50 mm settlement
NBH - 03	16.0	5	250
	6.0	5	120

Table 12: Shallow foundation safe bearing capacity for D/s Wing wall

Reference Borehole	Depth of foundation below FGL (m)	Width of foundation (m)	Allowable Net Safe Bearing Capacity (kN/m^2) for 50 mm settlement
NBH - 10	16.0	5	270
	6.0	5	120

Typical bearing capacity calculations are presented in *Annexure VI*.

8.2 Deep foundations

8.2.1 Axial Capacity

Considering the nature of soil, type of proposed structures and loads on the foundations, bored cast in situ pile foundations are recommended as suitable foundation system below raft. The details of estimating the pile capacities are described below.

8.2.2 Pile in Weathered Rock

The allowable axial load carrying capacity of the pile founded in weathered / soft rock is determined by calculating end bearing resistance and socket friction resistance as given below:

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4F_s} + \alpha c_{u2} \cdot \frac{\pi BL}{F_s}$$

C_{u1} = shear strength of rock below the base of the pile, in kN/m^2;

(See Fig. 3 of [IS: 2911 (Part 1/ Sec 2) - 2010])

N_c = bearing capacity factor taken as 9;

F_s = factor of safety usually taken as 3;

α = 0.9 (recommended value);

C_{u2} = average shear strength of rock in socketed length of pile, kN/m2;

(See Fig. 3 of [IS: 2911 (Part 1/ Sec 2) - 2010])

B = diameter of circular piles, in m; and

L = socket length of pile, in m.

Pile capacity summary for the lock structure is given below.

Table 13: Pile capacity for Raft – Lock Portion (NBH-07)

Diameter (m)	Length of Pile below cut-off level (m)	Safe Pile Capacity (kN)	
		Compression	Tension
0.90	23.55	6061	3524
	25.55	8723	6080
*Pile cut-off level at (+) 12.55m RL (i.e., Raft bottom level) has been considered.			

Table 14: Pile capacity for Raft – Inlet Portion (NBH-04)

Diameter (m)	Length of Pile below cut-off level (m)	Safe Pile Capacity (kN)	
		Compression	Tension
0.90	19.55	5222	4118
	21.55	6547	5364
*Pile cut-off level at (+) 12.55m RL (i.e., Raft bottom level) has been considered.			

Table 15: Pile capacity for Raft – Outlet Portion (NBH-09)

Diameter (m)	Length of Pile below cut-off level (m)	Safe Pile Capacity (kN)	
		Compression	Tension
0.90	24.55	5039	4142
	25.55	5443	4884
*Pile cut-off level at (+) 12.55m RL (i.e., Raft bottom level) has been considered.			

Typical pile capacity calculations are presented in *Annexure VII*.

9. AGGRESSIVENESS OF SOIL AND WATER TO FOUNDATION CONCRETE

The chemical analysis carried out on water samples collected in various boreholes shows that the pH value of water is in the range of 6.91 to 7.42, Sulphates in the range of 25 to 57 mg/l and chlorides in the range of 22 to 160 mg/l.

The chemical analysis carried out on soil samples collected in various bore holes shows that the pH value of soil is in the range of 6.86 to 8.12, Sulphates in the range of 10 to 172 mg/l and chlorides are in the range of 12 to 40 mg/l.

The soil / water are not aggressive to concrete and not corrosive to reinforcement steel. Since the chloride content is less than 500mg/l, the water shall be used for construction purpose.

10. SLOPE STABILITY ANALYSIS & RESULTS

Excavation will be carried out on the upstream and downstream side of the proposed lock structure to carry out the necessary slope protection works. The depth of excavation is 15.44m (i.e., from (+) 28.44m to (+) 13.00m) with a slope of 1V:1.5H with berms of 2m wide at every 5m height from excavation bottom level.

Slope stability analysis is carried out with the help of TALREN software. TALREN software is developed based on Simplified Bishop Method which is the most widely used method for circular failure. The Simplified Bishop Method uses the method of slices to discretize the soil mass and determine the FS (Factor of Safety). This method satisfies vertical force equilibrium for each slice and overall moment equilibrium about the center of the circular trial surface.

From the results, it is found that slope is stable against base failure with a minimum factor of safety of 1.5. Analysis results are enclosed in *Annexure-VIII*.

11. CALIFORNIA BEARING RATIO (CBR)

CBR tests are carried out for the purpose of road design. Results are enclosed in *Annexure-IV*. From the results, it is observed that CBR of existing subsoil at soaked condition is 4% and hence CBR of 4% shall be recommended for road design.

12. RECOMMENDATIONS

Based on the geotechnical exploration carried out along with corresponding field/laboratory test results, the recommendations may be summarized as follows.

12.1 Shallow Foundation Recommendation

Main lock is supported using raft foundation at (+) 12.55m RL. Width of the raft varies from 37m to 42m at the central lock portion. Wing wall is of counterfort type retaining wall with base slab founding level varies from 6m below finished ground level to (+) 12.55m RL on one side and on the other side base of counterfort remains throughout at (+) 12.55m RL. Based on the above considerations, shallow foundation recommendations are given below.

Table 16: Shallow foundation recommendation for Raft

Reference Borehole	Depth of foundation below FGL (m)	Width of foundation (m)	Recommended Allowable Net Safe Bearing Capacity (kN/m^2)
NBH - 08	16.0	37 to 42	140

Table 17: Shallow foundation recommendation for U/s Wing wall

Reference Borehole	Depth of foundation below FGL (m)	Width of foundation (m)	Recommended Allowable Net Safe Bearing Capacity (kN/m^2)
NBH - 03	16.0	5	180
	6.0	5	100

Table 18: Shallow foundation recommendation for D/s Wing wall

Reference Borehole	Depth of foundation below FGL (m)	Width of foundation (m)	Recommended Allowable Net Safe Bearing Capacity (kN/m^2)
NBH - 10	16.0	5	180
	6.0	5	100

- Water table is encountered at a depth varies from 1.5m to 7.0m below existing ground level. However, for design purposes the same is considered at Finished Ground level (FGL).

- Compound walls and other lightly loaded structures (with foundation loading intensity less than 50 kN/m^2) can be supported on open/ shallow foundations resting on virgin/ controlled compacted filled up soil.

Modulus of Subgrade Reaction (MOSR):

Main Lock foundation comprises of raft foundation. Modulus of subgrade reaction for raft shall be taken as 8000 kN/m^3. Typical calculation for MOSR is enclosed in *Annexure-VI*.

12.2 Deep Foundation Recommendation

For the main lock, pile foundation is proposed below raft to take uplift forces acting due to differential water pressure. Pile foundation recommendation for the mail lock portion is given below.

Table 19: Pile foundation recommendation for Raft – Lock Portion (NBH-07)

Diameter (m)	Length of Pile below cut-off level (m)	Recommended Pile Capacity (kN)	
		Compression	Tension
0.90	23.55	4500	2500
	25.55	6500	3500
*Pile cut-off level at (+) 12.55m RL (i.e., Raft bottom level) has been considered.			

Table 20: Pile foundation recommendation for Raft – Inlet Portion (NBH-04)

Diameter (m)	Length of Pile below cut-off level (m)	Recommended Pile Capacity (kN)	
		Compression	Tension
0.90	19.55	4500	2500
	21.55	5500	3500
*Pile cut-off level at (+) 12.55m RL (i.e., Raft bottom level) has been considered.			

Table 21: Pile foundation recommendation for Raft – Outlet Portion (NBH-09)

Diameter (m)	Length of Pile below cut-off level (m)	Recommended Pile Capacity (kN)	
		Compression	Tension
0.90	24.55	4500	2500
	25.55	5000	3500
*Pile cut-off level at (+) 12.55m RL (i.e., Raft bottom level) has been considered.			

12.3 Slope Protection Work

Excavation shall be done on the upstream and downstream of new navigation lock to carry out slope protection work. It is recommended to construct an excavated slope no steeper than 1V:1.5H with 2m wide berms at every 5m height from excavation bottom level.

12.4 CBR for Road Design

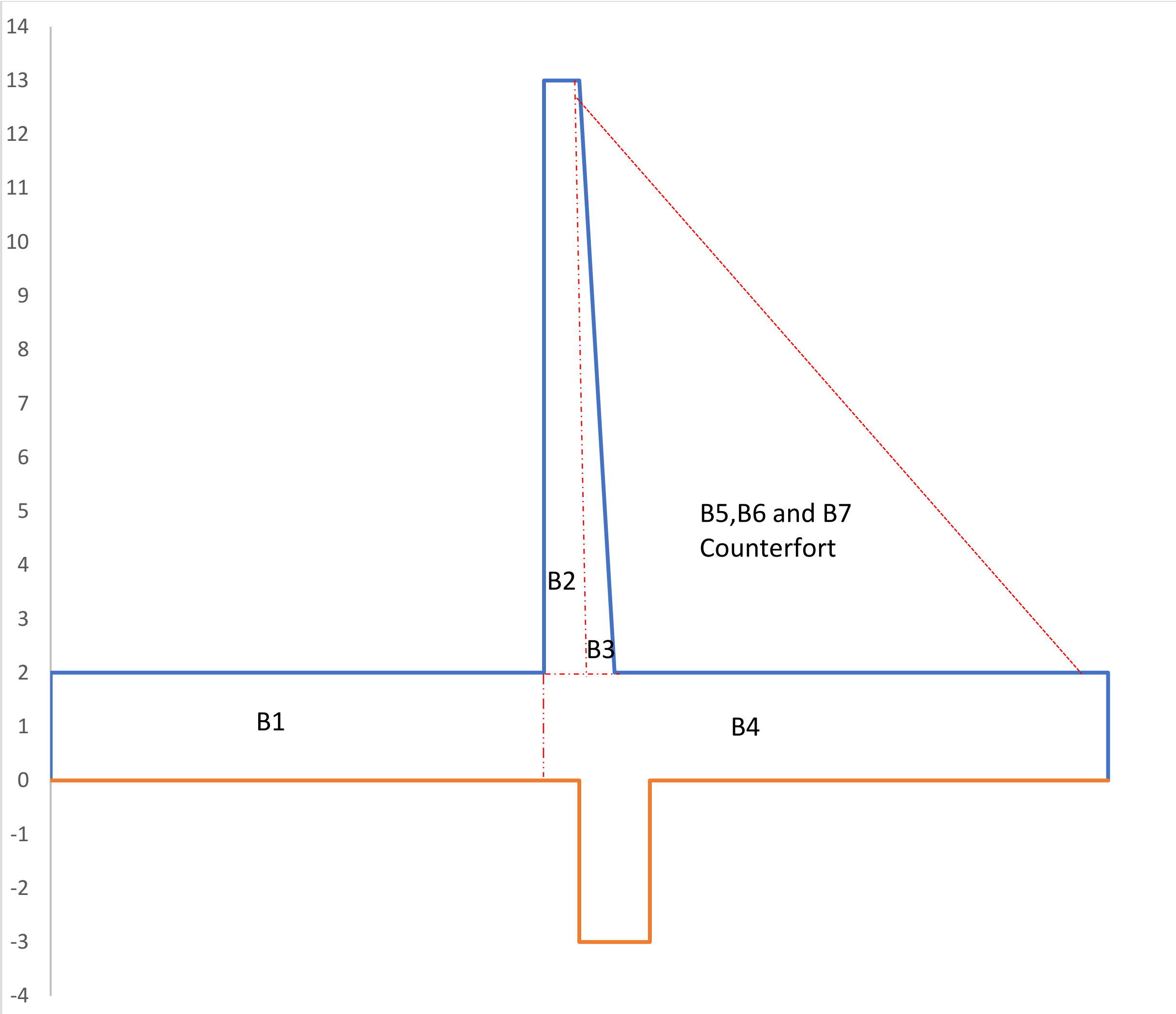
For the design of roads, it is recommended to consider the CBR of existing subsoil as 4%.

12.5 Chemical analysis results and recommendation

The chemical analysis of soil and water for pH, Chloride and sulphate contents are found to be within the acceptable limits. Since the chloride content is less than 500 mg/l, the water can be used for construction purpose.

Annexure 2 – Stability Analysis

Counter fort Retaining Wall Stability Analysis



Size

C/C distance of counterforts		=	3.00	m
Bottom thickness of retaining wall		=	1.00	m
Top thickness of retaining wall		=	0.50	m
Thickness of counterforts		=	0.25	m
Toe Length (X dimension)		=	7.00	m
Heel Length including Retaining Wall (X dimension)		=	8.00	m
Depth of footing		=	1.50	m
Depth of Shear Key		=	4.00	m
Height of retaining wall above footing		=	13.00	m
Height of Soil for front wall		=	13.00	m
Height of Water for front wall		=	10.00	m
Unit Wt. of concrete		=	25.00	kN/m^3
Unit Wt. of Water	Y_w	=	10.00	kN/m^3

Saturated Unit Wt. of Soil	γ_s	=	18.00	kN/m^3
Lateral seismic coefficient	αh	=	0.10	
Vertical seismic coefficient	αv	=	0.07	
Internal angle of friction of filling soil	Φ	=	25.00	degree
Internal angle of friction of base soil	Φ'	=	2.00	degree
Coefficient of friction between soil and concrete	μ	=	0.03	
FOS against overturning (Without earthquake case)		=	2.00	
FOS against overturning (With earthquake case)		=	1.50	
FOS against sliding (Without earthquake case)		=	1.50	
FOS against sliding (With earthquake case)		=	1.20	
Bearing Capacity of soil		=	300.00	kN/m^2
Cohesion			120.00	

Earth pressure Coefficient (Static & Dynamic)

α_h	=	Horizontal Seimic Coefficient.
α_v	=	Vertical seismic coefficient equal to $\alpha_h/2$
Φ	=	Angle of internal friction of soil
λ	=	$\tan^{-1}[(\alpha_h)/(1\pm\alpha_v)]$
α	=	Angle which earth face of the wall makes with the vertical
ζ	=	Slope of earth fill
δ	=	Angle of friction between the wall and earthfall
		(Wall friction angle, should be taken 2/3 of Φ IRC-78pp79)

Static earth pressure coefficient (Ka) and Dynamic earth pressure (Ca) coefficient has been estimated using the equation given below:

$$Ka = \frac{(1) * \cos^2(\Phi-\alpha)}{1 * \cos^2\alpha * \cos(\delta+\alpha)} \; X \left[\frac{1.00}{1 + \left\{\frac{\sin(\Phi+\delta)\sin(\Phi-\zeta)}{\cos(\alpha-\zeta)\cos(\delta+\alpha)}\right\}^{1/2}}\right]^{2.00}$$

$$Ca = \frac{(1\pm\alpha_v) * \cos^2(\Phi-\lambda-\alpha)}{\cos\lambda * \cos^2\alpha * \cos(\delta+\alpha+\lambda)} \; X \left[\frac{1.00}{1 + \left\{\frac{\sin(\Phi+\delta)\sin(\Phi-\zeta-\lambda)}{\cos(\alpha-\zeta)\cos(\delta+\alpha+\lambda)}\right\}^{1/2}}\right]^{2.00}$$

Static earth pressure for saturated condition

α_h = 0.00

α_v = 0.00

Φ = 25.00

λ = 0.00

α = 4.40

ζ = 0.00

δ = 16.67

$$Ka = \frac{(1) * \cos^2(\Phi - \alpha)}{1 * \cos^2\alpha * \cos(\delta + \alpha)} \times \left[\frac{1.00}{1 + \left\{\frac{\sin(\Phi + \delta)\sin(\Phi - \zeta)}{\cos(\alpha - \zeta)\cos(\delta + \alpha)}\right\}^{1/2}}\right]^{2.00}$$

The Static earth pressure coefficient in the saturated condition has been estimated as 0.39

Dynamic increment in earth pressure with earthquake condition

α_h	=	0.1
α_v	=	0.067
Φ	=	25.00
λ	=	5.36 and 6.12
α	=	4.40
ζ	=	0.00
δ	=	16.67

$$Ca = \frac{(1 \pm \alpha_v) * \cos^2(\Phi - \lambda - \alpha)}{\cos\lambda * \cos^2\alpha * \cos(\delta + \alpha + \lambda)} \times \left[\frac{1.00}{1 + \left\{\frac{\sin(\Phi + \delta)\sin(\Phi - \zeta - \lambda)}{\cos(\alpha - \zeta)\cos(\delta + \alpha + \lambda)}\right\}^{1/2}}\right]^{2.00}$$

Using the above parameter, the estimated value of coefficient of dynamic earth pressure of saturated soil is (Ca-Ka) = 0.12

Calculation of dead load

Weight of each block has been calculated for Static and Dynamic earth pressure force at different earthquake conditions and given below:

Component of the wall		Weight	
Block 1	=	1706.25	kN
Block 2	=	1056.25	kN
Block 3	=	1056.25	kN
Block 4	=	1950.00	kN
Block 5	=	264.06	kN
Block 6	=	264.06	kN
Block 7	=	264.06	kN
Total	**=**	**6560.94**	**kN**

Centre of gravity of each block has been calculated in each directions i.e., X,Y and Z is given below

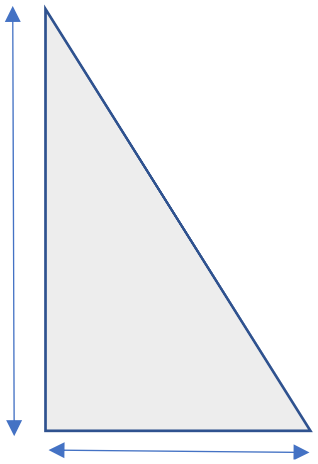
Block	**X(m)**	**Y(m)**	**Z(m)**
1	11.50	3.25	0.75
2	7.75	3.25	8.00
3	7.00	3.25	5.83
4	4.00	3.25	0.75
5	4.67	6.38	4.33
6	4.67	3.25	4.33
7	4.67	0.13	4.33

The weight of soil and water above the heel and toe of retaining wall

				X(CG)	
Weight of soil above heel	=	8745.75	kN	3.25	m
Weight of water above toe	=	4550.00	kN	11.50	m

Calculation of Earth pressure on wall

H=13 m



Earth Pressure = Ka*Y*H

Static and dynamic earth pressure with no earthquake condition

				Z(CG)
Static force	=	3440.38	kN	5.83
Dynamic force	=	0.00	kN	8.00

Static and dynamic earth pressure with earthquake condition (ah=100%, av=30%)

				Z(CG)
Static force	=	3440.38	kN	5.83
Dynamic force	=	1049.49	kN	8.00

Static and dynamic earth pressure with earthquake condition (ah=100%, av=-30%)

				Z(CG)
Static force	=	3440.38	kN	5.83
Dynamic force	=	1049.49	kN	8.00

Static and dynamic earth pressure with earthquake condition (ah=30%, av=100%)

				Z(CG)

Static force	=	3440.38	kN	5.83
Dynamic force	=	262.37	kN	8.00

Static and dynamic earth pressure with earthquake condition (ah=30%, av=-100%)

				Z(CG)
Static force	=	3440.38	kN	5.83
Dynamic force	=	262.37	kN	8.00

Stability check

Case 1: construction condition (Structure with backfill, no water and no earthquake)

Overturning moment

Component	Force(kN)	Lever arm(m)	Moment (kNm)
Static earth force	3440.38	5.83	20068.91
Total	**3440.38**		**20068.91**

Resisting Moment

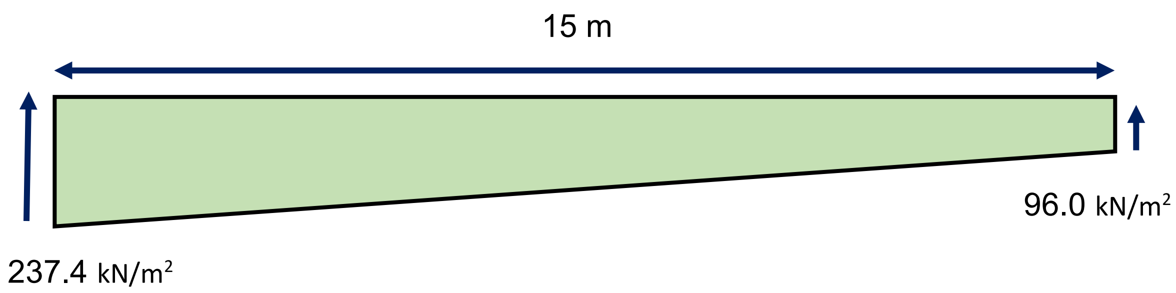
Component	Force(kN)	Lever arm(m)	Moment (kNm)
Block 1	1706.25	3.50	5971.88
Block 2	1056.25	7.25	7657.81
Block 3	1056.25	8.00	8450.00
Block 4	1950.00	11.00	21450.00
Block 5	264.06	10.33	2728.65
Block 6	264.06	10.33	2728.65
Block 7	264.06	10.33	2728.65
Weight of soil above heel	8745.75	11.75	102762.56

Total	**15306.69**		**154478.19**

Resisting force for sliding (Including Friction and Shear key)	=	6918.52	kN
Net Moment	=	134409.28	kNm
Factor of safety against overturning	=	**7.70**	**ok**
Factor of safety against Sliding	=	**2.01**	**ok**

Base pressure

Total Vertical Load	=	15306.7	kN
Area of foundation, A	=	97.5	m^2
Net Moment	=	134409.3	kNm
Eccentricity(e)	=	1.3	kN/m^2
q_{max}	=	237.4	kN/m^2
q_{min}	=	96.0	kN/m^2



Maximum base pressure is less than the safe bearing capacity of the foundation.

Case 2: construction condition (Structure with backfill, no water and earthquake condition (ah=100%, av=30%)

Overturning moment

Component	Force(kN)	Lever arm(m)	Moment (kNm)
Static earth force	3440.38	5.83	20068.91
Dynamic earth force	1049.49	8.00	8395.92
Block 1	170.63	0.75	127.97
Block 2	105.63	8.00	845.00
Block 3	105.63	5.83	616.15
Block 4	195.00	0.75	146.25
Block 5	26.41	4.33	114.43
Block 6	26.41	4.33	114.43
Block 7	26.41	4.33	114.43
Total	5145.97		30543.48

Resisting Moment (Deducting upward seismic inertia force)

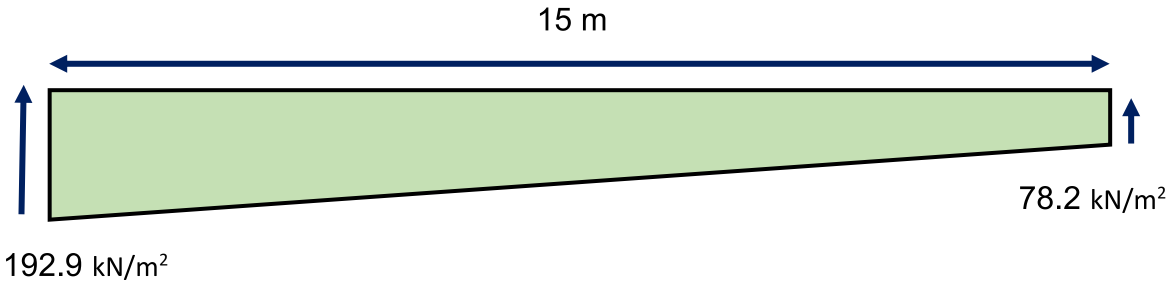
Component	Force(kN)	Lever arm(m)	Moment (kNm)
Block 1	1671.95	3.50	5851.84
Block 2	1035.02	7.25	7503.89
Block 3	1035.02	8.00	8280.16
Block 4	1910.81	11.00	21018.86
Block 5	258.75	10.33	2673.80
Block 6	258.75	10.33	2673.80

Block 7	258.75	10.33	2673.80
Weight of soil above heel	8745.75	11.75	102762.56
Total	**15174.81**		**153438.70**

Resisting force for sliding (Including Friction and Shear key)	=	6913.92	kN
Net Moment	=	122895.23	kNm
Factor of safety against overturning	=	5.02	**ok**
Factor of safety against Sliding	=	1.34	**ok**

Base pressure

Total Vertical Load	=	15174.8	kN
Area of foundation, A	=	97.5	m^2
Net Moment	=	122895.2	kNm
Eccentricity(e)	=	0.6	kN/m^2
q_{max}	=	192.9	kN/m^2
q_{min}	=	78.2	kN/m^2



Maximum base pressure is less than the safe bearing capacity of the foundation.

Case 3: construction condition (Structure with backfill, no water and earthquake condition (ah=100%, av=-30%)

Overturning moment

Component	Force(kN)	Lever arm(m)	Moment (kNm)
Static earth force	3440.38	5.83	20068.91
Dynamic earth force	1049.49	8.00	8395.92
Block 1	170.63	0.75	127.97
Block 2	105.63	8.00	845.00
Block 3	105.63	5.83	616.15
Block 4	195.00	0.75	146.25
Block 5	26.41	4.33	114.43
Block 6	26.41	4.33	114.43
Block 7	26.41	4.33	114.43
Total	5145.97		30543.48

Resisting Moment (Deducting upward seismic inertia force)

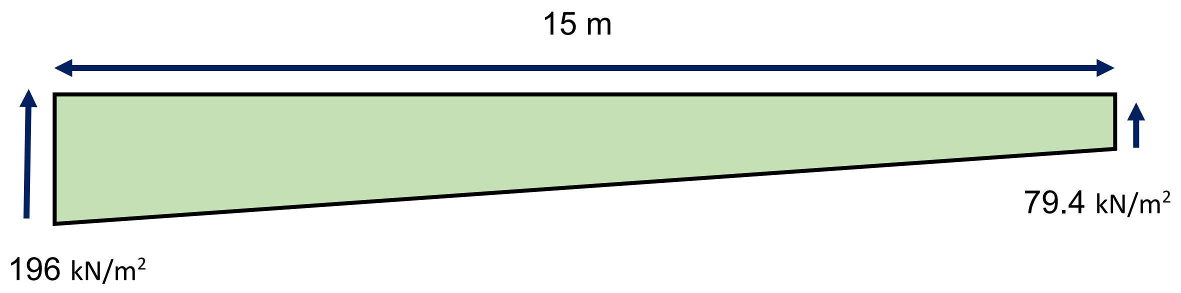
Component	Force(kN)	Lever arm(m)	Moment (kNm)
Block 1	1740.55	3.50	6091.91
Block 2	1077.48	7.25	7811.73
Block 3	1077.48	8.00	8619.85
Block 4	1989.20	11.00	21881.15
Block 5	269.37	10.33	2783.49
Block 6	269.37	10.33	2783.49
Block 7	269.37	10.33	2783.49

Weight of soil above heel	8745.75	11.75	102762.56
Total	**15438.56**		**155517.67**

Resisting force for sliding (Including Friction and Shear key)	=	6923.13	kN
Net Moment	=	124974.20	kNm
Factor of safety against overturning	=	5.09	**ok**
Factor of safety against Sliding	=	1.35	**ok**

Base pressure

Total Vertical Load	=	15438.6	kN
Area of foundation, A	=	97.5	m^2
Net Moment	=	124974.2	kNm
Eccentricity(e)	=	0.6	kN/m^2
q_{max}	=	196.0	kN/m^2
q_{min}	=	79.4	kN/m^2



Maximum base pressure is less than the safe bearing capacity of the foundation.

Case 4: construction condition (Structure with backfill, no water and earthquake condition (ah=30%, av=100%)

Overturning moment

Component	Force(kN)	Lever arm(m)	Moment (kNm)
Static earth force	3440.38	5.83	20068.91
Dynamic earth force	262.37	8.00	2098.98
Block 1	51.19	0.75	38.39
Block 2	31.69	8.00	253.50
Block 3	31.69	5.83	184.84
Block 4	58.50	0.75	43.88
Block 5	7.92	4.33	34.33
Block 6	7.92	4.33	34.33
Block 7	7.92	4.33	34.33
Total	3899.59		22791.48

Resisting Moment (Deducting upward seismic inertia force)

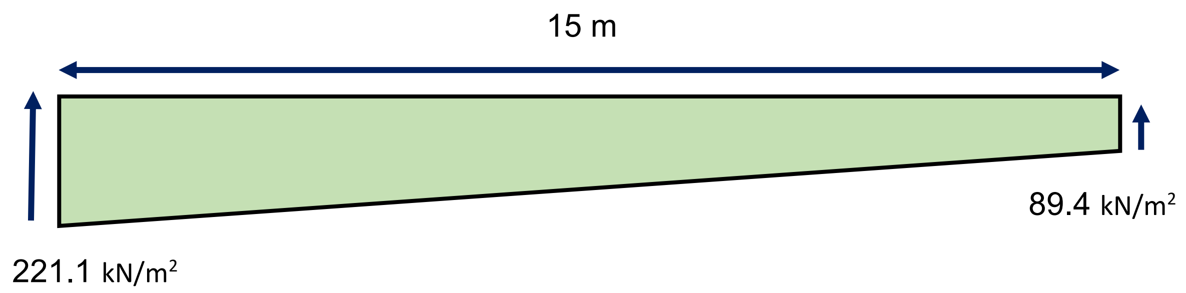
Component	Force(kN)	Lever arm(m)	Moment (kNm)
Block 1	1591.93	3.50	5571.76
Block 2	985.48	7.25	7144.74
Block 3	985.48	8.00	7883.85
Block 4	1819.35	11.00	20012.85
Block 5	246.37	10.33	2545.83
Block 6	246.37	10.33	2545.83
Block 7	246.37	10.33	2545.83

Weight of soil above heel	8745.75	11.75	102762.56
Total	**14867.10**		**151013.24**

Resisting force for sliding (Including Friction and Shear key)	=	6903.17	kN
Net Moment	=	128221.76	kNm
Factor of safety against overturning	=	6.63	**ok**
Factor of safety against Sliding	=	1.77	**ok**

Base Pressure

Total Vertical Load	=	14867.1	kN
Area of foundation, A	=	97.5	m^2
Net Moment	=	128221.8	kNm
Eccentricity(e)	=	1.1	kN/m^2
q_{max}	=	221.1	kN/m^2
q_{min}	=	89.4	kN/m^2



Maximum base pressure is less than the safe bearing capacity of the foundation.

Case 5: construction condition (Structure with backfill, no water and earthquake condition (ah=30%, av=-100%)

Overturning moment

Component	**Force(kN)**	**Lever arm(m)**	**Moment (kNm)**
Static earth force	3440.38	5.83	20068.91
Dynamic earth force	262.37	8.00	2098.98
Block 1	51.19	0.75	38.39
Block 2	31.69	8.00	253.50
Block 3	31.69	5.83	184.84
Block 4	58.50	0.75	43.88
Block 5	7.92	4.33	34.33
Block 6	7.92	4.33	34.33
Block 7	7.92	4.33	34.33
Total	**3899.59**		**22791.48**

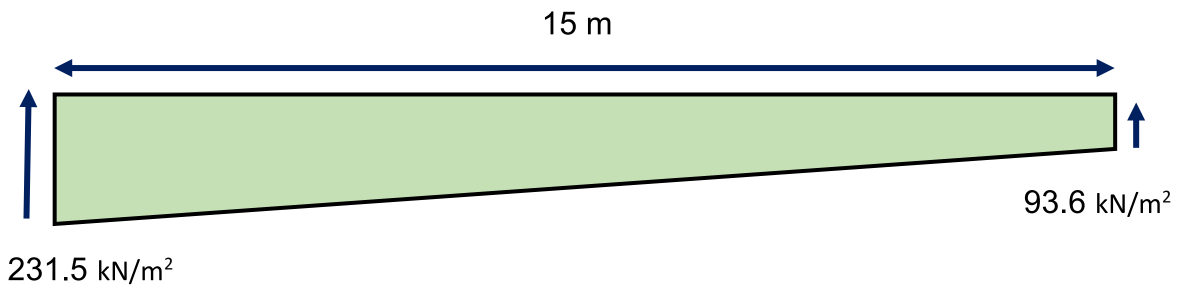
Resisting Moment (Deducting upward seismic inertia force)

Component	**Force(kN)**	**Lever arm(m)**	**Moment (kNm)**
Block 1	1820.57	3.50	6371.99
Block 2	1127.02	7.25	8170.89
Block 3	1127.02	8.00	9016.15
Block 4	2080.65	11.00	22887.15
Block 5	281.75	10.33	2911.47
Block 6	281.75	10.33	2911.47
Block 7	281.75	10.33	2911.47
Weight of soil above heel	8745.75	11.75	102762.56
Total	15746.27		157943.13

Resisting force for sliding (Including Friction and Shear key)	=	6933.87	kN
Net Moment	=	135151.65	kNm
Factor of safety against overturning	=	6.93	**ok**
Factor of safety against Sliding	=	1.78	**ok**

Base pressure

Total Vertical Load	=	15746.3	kN
Area of foundation, A	=	97.5	m^2
Net Moment	=	135151.7	kNm
Eccentricity(e)	=	1.1	kN/m^2
q_{max}	=	231.5	kN/m^2
q_{min}	=	93.6	kN/m^2



Maximum base pressure is less than the safe bearing capacity of the foundation.

Annexure 3

Bearing capacity based on Shear criteria

Ground water table location (Dw)	0
Unit weight of soil (y)	18
Submerged unit weight of soil (y')	8
Type of Footing	
Width of footing (B)	15
Length of footing (L)	30
Depth of footing from FGL (Df)	16
Angle of internal friction (ϕ)	0
Cohesion (C)	120
Bearing Capacity Factor (Nc)	5.14
Shape Factor (Sc)	1.1
Depth Factor (dc)	1.21
Inclination Factor (ic)	1
Factor of Safety (F.O.S)	2.5
Net ultimate bearing capacity (qnu)	820.9
Net safe bearing capacity (qns)	328.3
Effective overburden at founding level	288
Gross safe Bearing capacity (qgs)	616.3

Bearing capacity based on settlement criteria

Depth of Foundation	15
Unit Weight of soil	18
Width of the foundation	13
bearing pressure at founding level	300
Depth of influence Zone	55.5
Settlement Analysis	
Settlement in Soil Layer	H*▲p/Es
Layer 1	(+14.54 m to -3 m)
Type of Soil	Very Stiff Silty Clay
Thickness of layer (H)	17.54
Increase in pressure at H	
(At the Centre of the layer) At H/2	179.15
Average Corrected SPT (N)	20
Elastic modulus of soil (Es)	42000
Settlement of layer-1 (mm)	74.8
Total Settlement	74.8

Modulus of sub-grade reaction

Modulus of sub-grade reaction		
Average Existing Ground level	27	
Foundation Level	14.54	
Low water Level	18.3	
Unit weight of Soil	18	
Submurged unit weight of soil	8	
Effective Overburden pressure at raft founding level	186.68	(Depth up to Saturated Soil) X (Saturated unit Weight of Soil) + (Depth from Saturated Soil to submerged soil) X (Submerged unit Weight of Soil)
Net bearing pressure at foundation level	300	
Gross pressure at raft founding level	486.68	
Modulus of Subgrade Reaction (MOSR)	6506	Pressure/Settlement
Recommended MOSR value	6500	

Design of Pile for Tension in Base slab

Design Data

MWL U/S of lock	=	26.3	m
Average El at Ground	=	27	m
Lock Floor Level (Min)	=	11.6	m
Uplift Head (Max.)	=	14.7	m
Dia of pile	=	900	mm

Tension Carring capacity of Piles is given by the expression :

$$Q_u = \Sigma\ K_i P_{Di} \tan\delta_i A_{si} + \Sigma\ \alpha_i c_i A_{si}$$

Where

Qu	Skin friction Load carring capacity of Piles in KN.		
Ki	coefficient of earth pressure applicable for the ith layer = 1.0 (For driven piles in loose to dense sand)	=	1
Pdi	effective overburden pressure at pile ,in kN/m2		
δ i	Angle of wall friction between pile and soil for the ith layer		
Asi	Surface area of pile shaft in the ith layer,in m2.		
α i	adhesion factor for the ith layer depending on the consistency of soil = .3 (Fig 2, IS 2911 (Part 1/Sec 2) : 2010	=	0.3
Ci	Average cohesion for the ith layer, in kN/m2		

Surface area of pile shaft = 2.827 m2/mlength

Calculation for skin Friction

Soil Type		LEVEL	length (m)	Bulk density(KN/m3)	Pdi (KN/m2)	δ I (Degrees)	Ci (KN/m2)	Ki Pdi tan(di) Asi	αi Ci Asi
Layer - 2	Start	11.60	8.10	21	161.7	2	120	164.95	824.48
	Bottom	3.50			250.8				
Layer - 3	Top	3.50	4.90	21	250.8	2	120	134.38	498.76
	Bottom	-1.40			304.7				
Layer - 4	Top	-1.40	2.00	21	304.7	2	120	62.34	203.58
	Bottom	-3.40			326.7				
Total			**15.00**					**361.67**	**1526.81**

Uplift capacity of Pile

Total Frictional resistance of Pile	=	1888	KN
Self weight of pile	=	143	KN
Design Uplift capacity of pile (Qu)			
((0.7 * 1888.48 / 3) + 143.14)	=	672	KN

(Considering frictional resistance of 0.7 times the Total Frictional Resistance, and FOS as 3)

Uplift computations

crest level of barrage	=	15.85	m
height of spillway gate	=	6.4	m
ponding level	=	22.25	m
Considering free board	=	24	m
Invert of base slab	=	12	m
Uplift head	=	8.4	m
Uplift Pressure head	=	82	KN/m2
Weight of submerged slab(Considering 2m depth)	=	30	KN/m2
Providing piles @ 3m C/C Base Slab area supported by e	=	9	m2
Uplift coming on each Pile	=	471.636	KN

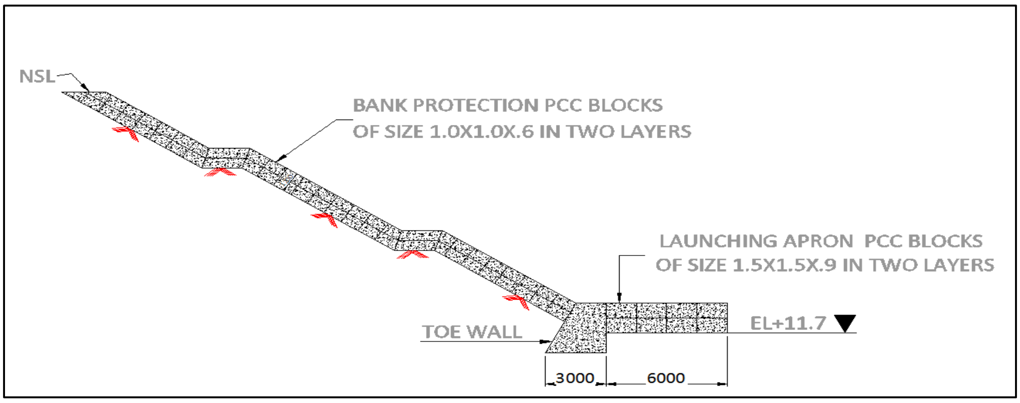
< Tension capacity of pile

Since Design uplift capacity is more than the tension coming on the Plie the size is adequate.

Annexure 4

Bank Protection Design

Design discharge(Q)	=	50000	cusec
	=	1415.842	cumec
Gravitational acceleration (g)	=	9.81	m/s2
HFL	=	26.3	m
LWL	=	18.288	m
avg area of cross section	=	350	m2
Stream velocity (V) assumed	=	4.05	m/sec
mean dia of river bed material(d)	=	0.3	mm
silt factor f = 1.76*sqrt(d)	=	0.964	
angle of sloping bank(7H:1V)(Theeta)	=	8.130	degrees
angle of repose of protection material(Phi)	=	30	degrees
K=sqrt(1-sin(theeta) ^2)/(sin(phi)^2)	=	1.98	
specific gravity of boulders Ss	=	2.4	
weight of PCC Block	=	44.969	Kg
Size of PCC Block $D_s = 0{\cdot}124\sqrt[3]{\frac{W}{S_s}}$	=	0.329	m
Thickness of pitching $T = \frac{V^2}{2g(S_s - 1)}$	=	0.596	m
provide thickness =2*T	=	1.2	m
Scour Depth below HFL D = 0.473*(Q/f)$^{1/3}$	=	5.376608	m
Max scour depth below HFL (Dmax)= 1.5*D	=	8.064911	m
width of launching appron = 1.5(Dmax-(HFL-LWL))	=	0.080425	m
Thickness of launching appron = 1.5*(2*T)	=	1.8	m



Typical Cross Section of Bank Protection

Annexure 5

Ministry of Shipping
Government of India

INLAND WATERWAYS AUTHORITY OF INDIA

CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION/MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

Draft EIA Report

March 2022

Submitted By:
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List of Abbreviations

AAQ	Ambient Air Quality
APHA	American Public Health Association
BDU	Best Designated Unit
BoD	Biological Oxygen Demand
BSI	Botanical Survey of India
BTKM	Billion Tonne Kilometers
BWE	Blast Water Exchange
BWMP	Ballast Water Management Plan
BWP	Ballast Water Performance
CGWB	Central Ground Water Board
CoD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health & Environmental Engineering Organization Ministry of Urban Development, Governmentof India
CRZ	Coastal Regulation Zone
CTE	Consent to Establish
CTO	Consent to Operate
DDT	Dichloro diphenyl trichloro ethane
DEM	Digital Elevation Model
DFO	Divisional Forest Officer
DG	Diesel Generating Set
DO	Dissolved Oxygen
EIA	Environmental Impact Assessment
EMoP	Environmental Monitoring Plan
EMP	Environmental Management Plan
EPC	Engineering Procurement Contractor
ESA	Ecological Sensitive Areas
ESIA	Environmental Social Impact Assessment
GIS	Geographical Information Systems
GoI	Government of India
GPS	Global Positioning System
GW	Ground Water
HFL	Highest Flood Level
IIT	Indian Institute of Technology
IMD	India Meteorological Department
IMDG	International Maritime Dangerous Goods
IMO	International Maritime Organization
INTACH	Indian National Trust for Art and Cultural Heritage
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
LAD	Least Available Depth
IWC	International Whaling Commission
IWT	Inland Waterway Transport
KLD	Kiloliter Per Day
KW	Kilo Watt

LAD	least available depth
LAD	Least Available Depth
MARPOL	International Convention for the Prevention of Pollution from Ships
MASL	Mean Above Sea Level
MoEF&CC	Ministry of Environment & Forests & Climate Change
MTPA	Million Tonne Per Annum
NCAER	National Council of Applied Economic Research
NGBRA	National Ganga Basin River Authority
NGO	Non-Government Organization
NH	National Highway
NOC	No Objection Certificate
NTPC	National Transport Policy Committee
NW	National Waterways
NW	North West
OP	Operational Policies of World Bank
PAF	Project Affected Family
PCCF	Principal Chief Conservator of Forests
PCM	Public Consultation Meeting
PIANC	World Association for Waterborne Transport Infrastructure
PLI Act 1991	Public Liability and Insurance Act 1991
PM	Particulate Matter
PMSS	Probable maximum storm surge (Associated with Cyclone)
PWD	Public Works Department
RET	Rare Endangered and Threatened Species
RoB	Rail Over Bridge
SC	Schedule Cast
SE	South East
SEAC	State Expert Appraisal Committee
SEIAA	State Environmental Impact Assessment Authority
SPCB	State Pollution Control Board
SRTM	Shuttle Radar Topography Mission
ST	Schedule Tribe
STP	Sewerage Treatment Plan
SW	South West
TIN	Triangulated Irregular Network
TKM	Tonne Kilometers
UNDP	United Nations Development Programme
ZSI	Zoological Survey of India

Executive Summary

1. Introduction

Inland waterways Authority of India (IWAI) has proposed to augment the navigation capacity of waterway NW-1 (Haldia to Allahabad) and continue to maintain the entire stretch. Under this project, IWAI has proposed to develop the infrastructure facility like Multimodal terminals, Navigation aids for day & night navigation, River information system with all hardware and software, Navigational locks, Ro-Ro jetties, Bank & slope protection, River training works, Equipments like tow barges, inland vessels, survey vessels including rescue boats & survey equipment and Dredging of the navigation channel, to augment the navigation capacity of the waterway.

Under this project, renovation and modernization of existing lock is proposed at Farakka adjacent to the new lock as one of the means of improving navigation in NW-1. Existing lock of Farakka located on Feeder canal 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, thereby stopping the movement of barges/vessels. During this period, the new lock at Farakka will ensure uninterrupted and efficient movement of vessels/barges in NW-1.The existing lock site is located at Farakka in Murshidabad District of West Bengal, on the Feeder Canal of Farakka Barrage.

1.1 Connectivity of Site:

The lock gate site is well connected with road & rail. The road presently passes through the site. This road connects the NH-80 which is located about 1.6 km West of the existing Lock gate site. The site is also well connected with rail network. Nearest railway station is Farakka Railway Station located about 2.6 km South of the site. Champagram railway station is located about 6 km East of the site.

River Ganges is navigable in this stretch and is being used to transport material from Haldia port to Farakka. At present NTPC Farakka is transporting imported coal from Haldia to plant site at Farakka by NW-1 and NTPC has a 7-year contract with Jindal ITF for coal transportation.

1.2 Existing Lock

Existing lock gate site is located at Farakka in Murshidabad District of West Bengal, on the Feeder Canal of Farakka Barrage. The Ganga River is flowing about 1.2 km East of the existing lock gate site. There are no environmentally sensitive components such as National Park, Wildlife Sanctuary, Elephant / Tiger Reserve and Wetland notified under Ramsar Convention, present within 10 Km radius of existing Lock gate site. The salient features of the existing lock site are given in **Table 1**

Table 1: **Salient Features of Existing Lock**

S. No.	Parameter	Details
1	Number of Locks	One (1)
2	Length of lock	179.8m (b/w Mitre Gates) 250m (b/w Caisson Gates)
3	Width of lock	25.148m
4	Average depth of lock	12.89m at u/s to 10.89m at d/s
5	Major Structural Components	· Base Slab, Retaining Walls & Guide Walls · Filling / emptying Culverts including gate chambers · Bollards – eight (8) nos floating type (four (4) on each bank) and fourteen (14) nos fixed type (seven (7) on each bank) · 1 Central Control Room and 2 local control room
6	Major Hydromechanical Components	· Mitre Gates – two (2) sets 1 on U/S and 1 on D/S end, having two (2) leaves per set, · Caisson Gates/Stoplogs - 2 nos (one (1) for u/s & one (1) for d/s) · Radial Gates – four (4) nos (two (2) for u/s & two (2) for d/s) · Bulkhead Gates – eight (8) nos (four (4) for u/s and d/s each)

1.3 Construction Material Sourcing

Construction material required such as bricks, cement, reinforcement, timber will be sourced from Sahibganj and nearby areas, which is app. 100 kms from site in NW direction.

Stone and aggregates will be sourced from the quarries located in Rajmahal hills of Sahibganj District. Site is slightly undulating and will require cutting and filling. Surplus earth from the site will be used for filling the slopes and embankments proposed to be provided.

1.4 Fire Protection and Emergency Measures

Fire-fighting system will be developed as per TAC Guidelines. Potable fire extinguishers will be provided in all the required areas. Fire alarm system will be provided at the site.

1.5 Green Belt Development

Green belt is present at the existing lock and during the renovation and modernization of the lock; the greenbelt will be retained. An additional 100 trees will be planted in the green belt area. This will help in improving the aesthetic value of the area and to prevent spread of dust beyond lock boundary.

1.6 Implementation Schedule of project

Time of renovation and modernization for the existing lock project at Farakka is estimated to be 20 months.

1.7 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 and legislations framed for vessels plying in inland waterways framed by IWAI and Ministry of Shipping, GoI are given in Table 2.

Table 2: List of the Permits/Clearances Required as per GoI Legislations

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 (However EIA Notification 2006 does not classify locks on river or dredging in the river as a project requiring environmental clearance. The applicability of this legislation shall be re-confirmed from the concerned authority). Borrowing of earth (if any) for road realignment and construction shall fall under mining category and would require prior environmental clearance.	Environment Clearance Operation stage for EC for borrowing earth	MoEF& CC & SEIAA/SEAC	EPC Contractor for obtaining environmental clearances as applicable. EPC contractor shall also be responsible for EMP implementation and compliance to environmental clearance conditions. Borrowing may not be required due to availability of surplus earth
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 during renovation phase.	Consent to Establish (CTE) & Consent to Operate (CTO)	SPCB	EPC contractor shall obtain CTE, for setting up lock, 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 lock site before its handover to IWAI.
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	Consent to Establish & Consent to Operate	State Pollution Control Boards	CTE should be taken by contractor for disposal of sewage and construction of

		any stage of the project. Effluents are expected to be generated during both the renovation phase of the project.			septic tank/soak pit prior to start of construction from SPCB CTE/CTO for lock site shall also be obtained by EPC contractor along with CTE / CTO under Water 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 renovation stage.	No permits issued under this act	SPCB & CPCB	EPC contractor and IWAI to ensure compliance to Ambient Noise Level Standards as per the rules.
Hazardous Wastes (Management Handling and Trans- boundary) Rules, 2008.	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 renovation 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. Safety audit and other requirements shall have to be complied if storage quantity exceeds the threshold limit	Chief Controller of Explosives, MoEFCC & DC	EPC contractor and IWAI
The Bio Medical Waste (Management and Handling rules) 1998	To control store, transport and disposal of Bio Medical Waste.	Not applicable	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
The Batteries (Management and Handling) Rules 2001	To regulate the disposal and recycling of lead acid batteries	Applicable for disposal of used lead acid battery if likely to be used in any equipment	No specific registration required. Compulsion to buy	MoEF&CC	EPC contractor and IWAI

		during renovation stage.	and sale through registered vendor only.		
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.	Not applicable as the project does not fall in coastal area	CRZ Clearance	State Coastal Zone Management Authority and MoEF&CC	Not Applicable
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 byrestricting conversion offorested areas into non- forested areas and deforestation	Not Applicable.No forest land is being diverted.However few no. of tree cutting may be undertaken but prior permission from forest department to be taken before any tree cutting	Forest Clearance / Permission fortree cutting.	Forest Department, MoEFCC	NOC shall be obtained from forest departmentprior tree cutting(if any). Compensatory plantation shall be carried out in ratio of 1:7. NOC for tree cutting shall be obtained by IWAI through 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	NA
Wild Life Protection Act, 1972& Wildlife Protection Rules, 1995	To protect wildlife through notifying National Parks and Sanctuaries and buffer areas around these zones	Not Applicable as no eco-sensitive zone notified under this act is lying within 10 kms area of the project site	Wild life clearance	Chief Wildlife Warden, of the State, State Govt. &, MoEFCC	Not applicable
Safety and Other Related Legislations					
Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	Requirement ofpreparation of on-site and off-siteDisaster Management Plansfor accident-proneareas.	Not Applicable.The project doesnot involvehandling of anyhazardous chemical duringboth renovation phase which maylead to continuous, intermittent orrepeated exposure to death,or injury.	No permits issued underthis act	Central, State& DistrictCrisis Group	Not Applicable
Public Liability and	Protection fromliability arising	Not Applicable.The project	No permits issued	Collector ofthe	Not applicable

Insurance Act 1991	dueto accidents fromhandling ofhazardous chemicals.	does not involvestorage of anychemicals (HSD)beyond the threshold limit during construction	underthis act. Owner of project shalltake out insurancepolicies providing for contracts of insurance so as he is insured against liability to give relief, before handling any such hazardous material	Area	
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 renovation 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	Not Applicable as no storage of HSD/LPG or any other petroleum product may be required for the project purpose more than the threshold limit	License to store petroleum beyond prescribed quantity.	Chief Controller of Explosives/D C	EPC Contractor / IWAI
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 renovation 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	Conservation of cultural and historical remains found in	Not Applicable as no notified ancient monument is located	No objection certificate	Archaeologic al Dept. GoI,	Not applicable

Remains Act, 1958	India. According to this Act, area within the radii of 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).	within 300 m of the project site.		Indian Heritage Society and Indian National Trust for Art and Culture Heritage (INTACH).	
Merchant Shipping Act, 1958	To prevent marine pollution from ships beyond 5 km of the coastline and to make the transportation safe.	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 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/Infra structure project proposals in non-notified areas, 2012	To regulate extraction of ground water for drinking and domestic purpose	Applicable if bore well is done for extracting water for meeting drinking/domestic water needs of lock & vessels	No objection certificate	Central ground Water Authority/Board & MoEFCC	Contractor/IWAI shall obtain NOC from CGWA/CGWB prior digging any bore well during renovation phase

1.8 Description of Environment

The baseline environmental data generation has been done for September, 2022. The study area within a 10 km radius around the proposed lock site has been considered as general impact zone and 2 Km radius as specific impact zone for EIA study. The study period and methodology for primary data collection is followed as per the monitoring plan approved by IWAI and World Bank in line with prescribed TOR by IWAI and the salient features are given in Table 3.

Table 3: Salient Environmental Features of Farakka Lock Site

S. No.	Environmental Features	Within 500 m area around existing Lock gate site	Within 2 km area around existing Lock gate site	Within 10 km area around existing Lock gate site
1	**Ecological Environment**			
A	Presence of Wildlife Sanctuary/ NationalPark/Biosphere Reserves	None	None	None
B	Reserved /ProtectedForests Wetland of state and/or of national/international importance	None	None	None
C	Migratory route for wild animals	None	None	None
D	Presence of Schedule-I Terrestrial Fauna	None	None	None
E	Presence of Schedule-I Aquatic Fauna	None	None	None
F	Tree cover	Few trees in the site. Mainly herbs and shrubs are present	Yes Typical roadside plantation	Yes Typical sparse vegetation road side plantation.
G	Major Industries	None	None	NTPC thermalPower -3.6 km SSW and Ambuja Cement Ltd.- 4.2 km SW
2.	**Physical Environment**			
H	Critically Polluted Area	None	None	None

I	Rail connectivity	None	None	Farraka railway Station -2.6 km towards South and Champagram Railway station-6km towards East
J	Defense Installation	None	None	None
K	Densely Populated Area	None	Farakka town	Many depicted in 10 km radius map
L	Topography	Almost flat with elevation ranging between 25-31 m amsl as per GIS mapping	Mainly flat with elevation ranges between 19-45 meters amsl as per GIS mapping	Mainly flat with elevation ranges between 17-56 meters amsl as per GIS mapping
M	Seismicity	Falls in Zone-II moderate risk zone	Falls in Zone-II moderate risk zone	Falls in Zone-II moderate risk zone
N	Surface Water Resources (Rivers)	Existing Lock	Ganga River - 1.2 km East of the Lock gate	Feeder Canal -2.3 km Farakka Barrage- 2.4 km towards Southeast
O	Groundwater Zone	Safe	Safe	Safe
P	Soil and Land-use	Clay loam Land use in 500m of site is under existing lock and agriculture. Land for the existing lock belongs to FBP.	Clay loam Land use in 2 km area of site is under road, existing lock, agriculture and village settlements.	Clay loam As per the land use analysis about 57.5% of the land is under agriculture, about 11.02% of the land is under water bodies, about 9.13% land is under vegetation, 8.30% land is under settlement and rest of the land is under other uses
3	**Social Environment**			
Q	Physical Setting None None	rural	rural	Urban & Rural
R	Physical Sensitive Receptors	None	Yes (Temples, School)	Yes (Temples, Schools, College, Hospital)
S	Archaeological Monuments	None	None	None

Meteorology: The predominant wind direction is from southeast and south direction. The average wind speed is 2 m/s for a period of 1981-2021. Average annual maximum and minimum temperature at the project location is 43.9 ^{0}C and 6.2 ^{0}C, respectively. The relative humidity varied from 40 to 77%. The annual rainfall is 1470.7 mm.

The predominant wind direction during winter and summer season is from East/South-east and North/Northwest direction respectively. During Monsoon season the wind flows from narrow range of East, South-east direction. The wind speed was mostly between 2.4 – 4.7 km/hr for all the months. The maximum humidity during rainy season is 77% and minimum was 73%. Daily mean minimum temperature of area is around 13.1°C and daily mean maximum temperature is around 11.8°C. The annual total rainfall is 1470.7 mm. Over 80% of the total annual rainfall is received during the monsoon period between May to September.

Air Quality: $PM_{2.5}$, PM_{10}, SO_2, NO_2 and carbon monoxide were monitored at one location near the navigation lock. Monitoring was done at upwind direction and downwind directions of the project. PM_{10} within study area varies from 64 to 67 µg/m^3. $PM_{2.5}$ levels vary from 34 to 35.4 µg/m^3. SO_2 ranges from 11.2 to 16.7 µg/m^3. The NO_2 level is found ranging from 31.8 to 41.3 µg/m^3. CO ranges from 2.13 to 2.24 µg/m^3 near the existing lock. The baseline air quality levels of all parameters are found to be within the National Ambient Air Quality Standards prescribed for residential and industrial area.

Noise Quality: Noise level monitoring was done in one location near the existing navigation lock. The baseline noise levels of all the locations were found to be well within the National Standards for residential area.

Water Quality: The Ganga water quality near Lock gate site is meeting the Class C of BDU Criteria of CPCB for its suitability for drinking water source after conventional treatment and disinfection. The Physico-chemical characteristics of the ground water samples were in good agreement with IS: 10500.TDS, all the parameters in all sample of ground water are well within the desirable limit. As regards heavy metals, only Fe and Zn were present but quite lower in concentration whereas the other heavy metals were in traces. Hence, the GW within the impact zone is neither contaminated nor high in any metallic contamination from any natural sources

Soil Quality: The texture of soil is sandy silty clay. The organic matter, potassium and phosphorus content of the soil are low-moderate. However, nitrogen content is high in the soil sample. The pH and conductivity of all the soil samples are within the acceptable range.

River Bed Sediments: The texture of soil is silty sand. The organic matter, potassium and phosphorus content of the soil are low-moderate. However, other heavy metals and metals are in low in concentration. The pH and conductivity of all the soil samplesare within the acceptable range.

Flora and Fauna: No reserved or protected forest is present within 2 kms radius area of project site. The vegetation within the 2 kms & 10 km radius area of the Lock gate is primarily of agriculture type. Taad and khajur trees are predominantly grown in the study area. Other trees are Simul, Neem, Amlaki, Tal, Bat, Asvattha, Delbergia, Sirish, Bans, Arjun, Ber, Gulmohar, Peacock flower, Aam. Shrubs and herbs include Lantana, *Ipomea cornea*, Ghentu, *Cassia tora*, Malabar nut, Tulsi, *Cannabis sativus,* Dumur, *Parthenium grass* (exotic species), *Argemon maxicana* and few other grasses species. Mango and Litchi plantation are also found in the study area.

Land use of the study area is mainly agriculture and no significant wildlife is observed in the area. Mammals observed during study area include squirrel, rat & mongoose. Other domesticated species like cow, goats and buffaloes were also observed during the visit in study area. Mamals found in study area includes rat, hare, langur, squirrel, field mouse, bat, fox, Mongoose, Jungle cat, Indian Porcupine etc. Reptiles found in study area includes snakes like Cobra, Common Krait & Rat Snakes, Chameleon, Garden Lizard and Russel viper. Amphibians found in the study area are toads & frogs. Farakka is an important bird area. Migratory birds visit this area during Winter season. The common avifauna of the study area include jungle crow, house crow, common babbler, red-vented babul, robin, black drongo, weaver bird, common mayna, pied mayna, house sparrow, India cuckoo, koel, parakeet, bee-eater, kingfisher, hornbill, hoopoe, owl, pariah kite, pigeon and dove duck, lapwing, along with several varieties of egret and heron. Migratory bird species visiting Farakka Lock Site includes Y*thya baeri* (Baer's Pochard), *Aythya fuligula* (Tufted Duck), *Dendrocygna bicolor* (Fulvous Whistling-Duck), *Gyps bengalensis* (White-rumped Vulture), *Gyps indicus* (Indian Vulture), *Leptoptilos javanicus* (Lesser Adjutant) and *Rynchops albicollis* (Indian Skimmer). *(EIA Report of lock at Farakka, 2015)*

The existing lock is parallel to the new lock. Aquatic ecology of Study area (River Ganga & Canal) near lock site includes variety of planktons, fishes & benthos. Environmental condition determines the aquatic life in concern zone.

Phytoplankton found near Farakka Lock during study are Achnathes*, Bacillaria, Caratoneis, fragillaria, Navicula, Frustulia, diatoma, diatomella, cymbella, Actinastrum, Chlamydomonas, Chlorella, Closterium, Tetracylus, Anabaeana, Ocillatoria, Microcystis* etc.

The most common Zooplankton of Ganga River canal at Farakka Lock were *Arcella,* Difflugia*, Noctiluca, Paramecium, Vorticella, Brachionus, Filinia, Keratella, Lecane, Nothlca, Rotaria, Cyclops, Bosmia, Chydorus, Daphnia, Moina*.

The most common Benthos of Ganga River canal at Farakka Lock were *Gabbia sp. Bellamya sp. Lymnaeasp, Belostomaindica* and *Cybister confuses.* Gangetic Dolphins are not present in the River stretch where Farakka Lock is being constructed. No other RET species are found to be present in the study area.

The most important commercial fishes of Ganga at Farakka are *Labeo* sp., *Catla catla*, *Notopterus* sp., *Hilsa* sp., *Rita rita*, *Clarias* sp., *Mystu*s sp., *Osteobram*a sp., *Chandanama*, *Puntius* sp., *Heteropneustes fossilis*, *Cyprinus carpio*, *Cyrhinus mrigala*, *Wallago attu*, etc. *(EIA Report of lock at Farakka, 2015)*

Landuse: As per the land use analysis within the 10 km radius zone about 53.55% of the land is under cultivation, about 17.61% of the land is under water bodies, about 8.8% land is under vegetation, 16.86 % land is under settlement and rest of the land falls under other uses

Sensitive Ecosystem: No sensitive eco-system including national parks, wildlife sanctuaries, migratory routes of wildlife, Biosphere reserve, tiger reserve, elephant reserve, wetlands under Ramsar convention are present within 10 km distance of the project site.

1.9 Environmental Impacts and Mitigation Measures

Key environmental issues associated with the project are identified during the renovation and modernization phase of the project. Probable impacts anticipated are increased siltation of river, river bank erosion, effect on aquatic life, alteration of drainage pattern, change in land use, disturbance to air quality and increase in noise levels of the area, water pollution and increase in traffic. However no eco-sensitive zone and RET species are found to be occur in study area. However, Farakka is important bird area and various migratory birds visit Farakka during Winters. Keeping the identified impacts in consideration, mitigation measures are designed and proposed for the project. Mitigation Measures proposed focus on prevention and minimization of the environmental pollution and enhancement of the project benefits and are listed in detail in Chapter 5.

1.10 Environment Management & Monitoring Plan

The Environmental Management Plan (EMP) is the synthesis of all proposed mitigation and monitoring actions, set to a time frame with specific responsibility assigned and follow-up actions defined. EMP is a plan of actions for avoidance, mitigation and management of the negative impacts of the project. Environmental enhancement is also an important component of EMP. A detailed set of mitigation measures have been compiled in view of the above identified impacts associated with the proposed new Farakka lock. The summary of EMP is given in Table 6.1 of Chapter 6 of EIA. It is proposed to establish environment management cell which will work to ensure the effective implementation of the proposed mitigation measures. Environment Management Plan consist of following

- Negative Impacts Mitigation Measures
- Pollution Prevention Plans

- Environmental Management Plans
- Environmental Monitoring Plan
- Environmental Management Budget
- Reporting System
- Grievance Redressal System

1.11 Environment Health and Safety Cell

It is essential to establish environment health and safety cell for the project by contractor to ensure the health & safety of workers and environmental management of study area through effective implementation of EMP. Highly qualified and experienced persons in the field of Environmental Management of Similar projects shall be considered for the positions of General Manager (GM) and managers who will ensure the effective implementation of the environment management plan.

1.12 Reporting Requirements

It is required that contractor will submit quarterly compliance report to Project Management Consultants (PMC) as well as to SEMU (social and environmental Management Unit) of IWAI. PMC will analyse the report and notify the corrective action if any required to contractor under intimation to IWAI.

1.13 Grievance Redress Mechanism

The concern/grievances from local/affected people may come up related to inappropriate implementation of various components of EMP. These issues can be easily addressed through acknowledgement, evaluation and corrective action and response approach. To resolve grievance from public or stakeholders concerning the project will be directed to the PMU/Director concerned. Firstly, it will be assessed if the grievances are genuine or suggestion is acceptable. Accordingly, response will be given within 15-30 days by the PMU in consultation with PMC and Director concerned. In case the PMU is unable to resolve the issue, the matter will be forwarded to Project Director at Head Quarter. The corrective action will be started as per the response or action plan indicated to the stakeholder. The outcome shall also form part of quarterly report to World Bank.

1.14 Environmental Monitoring Plan

A monitoring schedule has been sketched based on the environmental components that may be affected during the renovation and modernization phase of the project and is given in Table 4.

1.15 Environmental Management Budget

Environment budget has been prepared for renovation and modernization phase of the project. Environmental budget will highlight the amount which is dedicated for environmental management, which is given in Table 5. This can become part of BOQ if contractor so as he can incorporate all the proposed mitigation measures while preparing his proposal and can implement these without any problems.

Table 4: Environment Monitoring Plan

S. No.	Aspect	Parameters to be monitored	No of sampling locations & frequency	Standard methodsfor sampling and analysis	Role & Responsibility	
					Implementation	Supervision
Renovation Period						
1.	Air Quality (Ambient & Stack)	PM10, PM2.5, SO2, NO2, HC and CO	Three Locations including project site, labour camp and nearest habitation-once in two months	• Fine Particulate Samplers for PM2.5 • Respirable Dust Sampler fitted PM10 • Respirable Dust Sampler fitted with Gaseous sampling arrangements for SO2 and NO2, CO analyzer /portable CO meter for CO portable HC meter or tubes for HC; TO-14A, TO- 15, USEPA Method for sampling and analysis of VOCs in ambient air	Contractor	IWAI & PMC
2.	Surface Water Quality	Physical, chemical and biological	River Ganga- upstream & downstream- Once a month	Grab sampling and analysis by using standard methods	Contractor	IWAI & PMC
3.	Drinking water Quality	Physical, chemical and biological	Drinking water for labour camps Once a month	Grab sampling and analysis by using standard methods	Contractor	IWAI & PMC
4.	Noise Level	Day time and night time noise level (max, min & Leq levels)	Construction labour camp, construction site and nearest village Once a month	Noise meter	Contractor	IWAI& PMC
5.	Soil Quality, Erosion & Siltation	Soil texture, type, Electrical conductivity, pH, infiltration, porosity, etc.,	Construction site, labour camps and debris disposal site Once in 6 months	Collection and analysis of samples as per IS 2720	Contractor	IWAI & PMC
6.	Greenbelt development	Plantation survival rate	Lock gate premises	Survey, counting, recording & reporting	Contractor	IWAI & PMC
7.	Soil Erosion	---	Upstream & downstream of project site near river bank-- Once a month	Survey & observation; Extent and degree of erosion; Structures for controlling soil erosion	Contractor	IWAI & PMC
8.	Aquatic ecology	Phytoplankton, Zooplankton	River Ganga Six monthly	Species diversity index.	Contractor	IWAI & PMC
9.	Integrity of embankment	---	Upstream & downstream of lock gate site-Once a month	Survey & observation; Extent and degree of erosion; Structures for controlling soil erosion	Contractor	IWAI & PMC

Table 4: Environment Management Budget

Component	Item	Unit	Quantity	Rate	Amount
RENOVATION STAGE					
Technical Support	• Environmental Impact Assessment Study, Bio- diversity Conservation Plan, Preparation of EMP	Lump sum	-	-	15,00,000
Greenbelt development	• Tree, shrub and herb plantation	No. of	100 trees	500 Rs/tree	50,000
Flora	• Aftercare and monitoring of plantation	Lump sum	50 trees	@100 Rs/Tree	5000
Drainage Congestion and disposal of accumulated water	• Provision of adequate surveillance	Covered in project design and engineering cost			--
Erosion & Sedimentation	• Embankment, and River Bank Protection Measures	Covered in project design and engineering cost			--
Land	• Compensation against land acquisition	Covered in R&R Budget			--
Soil	• Soil contamination protection (Septic tanks, grease taps etc) and rehabilitation of borrow areas/debris disposal site/plant site & labour camps	Covered in project design and engineering cost			--
Noise	• Canopy for DG sets • PPEs like ear plug • Timely maintenance of the machinery, equipment and vehicles • Barricading the site	Covered in project design and engineering cost			--
Water	• Provision of storm water and wastewater management system	Estimated @ RS 5,00,000 for construction site & 5,00,000 for labour camps (1 camp sites)			10,00,000
	Construction of soak pits at construction sites & labour camps	Estimated @ RS 3,00,000 per site estimated (construction & camp site)			6,00,000
	Provision of clean drinking & domestic water facility at labour camps and construction site	25,000 Per month for 20 months			5,00,000
Dust Management during construction	• Water Sprayer / Watering for Dust suppression	Covered in project design and engineering cost			
Safety	• Appointment of Safety Officers	Covered in project design and engineering cost			
	Safety signages, speed breakers, fire-fighting measures etc.	Covered in project design and engineering and cost			

Component	Item	Unit	Quantity	Rate	Amount
	Provision of trainings and PPE to workers	To be included in construction cost			To be part of contractor's costs
Health	Health checkup camps for construction workers	Camps	2 camp/year	2 lakhs/camp	4,00,000
Environmental Monitoring in the construction phase	Terrestrial and Aquatic Fauna	3,00,000 per season (Once in six month)			6,00,000
	Ambient Air Quality	1,00,000 per monitoring for 20 months (Once in two month)			10,00,000
	Surface Water Quality	30,000 for upstream & downstream (Once in month)			2,70,000
	Drinking Water Quality	15,000 (Once in month)			1,35,000
	Noise & Vibration	12,000 per monitoring for 20 months (Once in month)			2,40,000
	Soil Quality, Erosion & Siltation	1,00,000 per Six months			2,00,000
		SUB TOTAL (RENOVATION STAGE)			**65,00,000**
TRAINING AND AWARENESS					
Training	• Environmental training & awareness	-	-	Lump sum	2,00,000
ESTABLISHMENT AND SYSTEMS					
Establishment	• Supervision Consultant (Environment and Social)	-	-	Included in overall NW-1 Project Budget	-
	• Renovation Stage (Site Environmental officer)	-	-	Included in overall NW-1 Project Budget	-
	• Operation Stage	-	-	Included in overall NW-1 Project Budget	-
Management Systems	• Adoption of EHS management systems	1	1	Lump sum	4,00,000
	• Management Information and tracking system	1	1	Lump sum	4,00,000
SUBTOTAL (ESTABLISHMENT & TRAINING and MANAGEMENT SYSTEM)					**1000000**
SUB TOTAL (Renovation and mobilization)					**750000**
CONTINGENCIES @ 5 % on total Environmental Costs					**4,12,500**
Grand Total (in Rs.)					**86,62,500 (0.87 Cr)**

Chapter 1

1 INTRODUCTION

1.1 Project Background

Waterways are considered as one of the cheapest modes of cargo movement internationally. However, in India transportation of cargo through waterways is very low compared to the international status. Govt. of India has constituted Inland Waterways Authority of India (IWAI) through IWAI Act in 1985 to enhance this sector. Since then, IWAI, with the empowerment under above Act, is maintaining identified waterways and also undertaking the task to develop and regulate the waterways for navigation. IWAI has also declared various waterways as national waterways.

Amongst the waterways, the national waterway on Ganga (NW-1 between Haldia to Allahabad) is the longest waterway (1620 km) and is of prime importance considering its strategic location. IWAI has been maintaining the least available depth (LAD) of 3 m between Haldia and Farakka (560 km), 2.5 m in Farakka — Barh (400 km), 2 m between Barh — Ghazipur (290 km) and 1.2 to 1.5 m in Ghazipur — Allahabad (370 km) since along. Nowadays this waterway is being used by various cargo, tourist and IWAI vessels. Already good amount of cargo movement is taking place between Haldia and Farakka (3 million metric tons 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 utility, IWAI has initiated the project of “Capacity Augmentation of National Waterway-1” between Haldia and Allahabad named as “Jal Marg Vikas Project”.

The existing navigation lock at Farakka is one of the means of improving navigation in NW-1. Existing lock of Farakka is located on Feeder canal 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. Hence renovation of existing lock is proposed by the IWAI for the optimal utilisation.

This report is focusing on environmental impact of Existing Lock at Farakka during renovation and modernization phase of the project. The environmental management plan (EMP) of this lock will ultimately form part of the overall project. The overview of NW-1 and Farakka Lock is given in subsequent sections. Index map of Farakka navigational lock is shown at Figure 1.1.

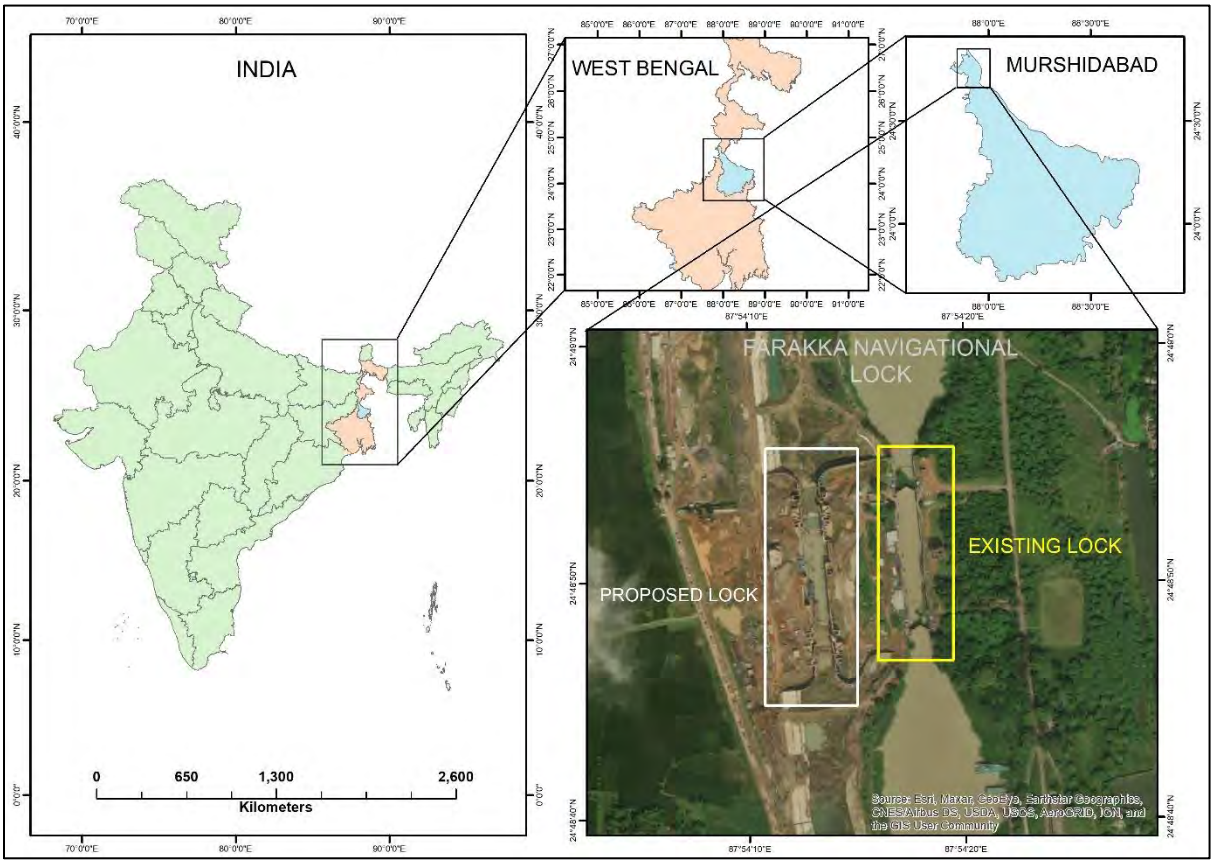


Figure 1.1 Index map of Navigational Lock

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 to be made in port/lock facilities, connecting road/rail infrastructure, navigation aid and dredging facilities. While other modes of transport are often confronted with congestion and capacity problems, IWT offers congestion free reliable mode of transport with availability of large untapped capacity for expansion.

Till middle of 20th century, IWT had been 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 due to shift in transportation focus to rail and road modes. However, IWT use has started showing increasing trend since 2003-2004 and touched 70 million tons level in 2011-2012 compared to 32.48 million tons in 2003- 2004 which is just 0.34% of total inland cargo of about 1000 btkm. IWAI has set a target of increasing IWT share to 2% of total inland cargo by 2025. The main commodities carried by IWT (comparable with NW-1) include building materials (34%), metals\ores (19%) and coal\coke (17%). On demand side in NW-1 (Allahabad — Haldia) 10 thermal power plants are located along this 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 can generate an estimated 7.65 lakh ton of cargo requirement per year. Further, there are prospect of movement of container also. It is therefore obvious that IWT and NW-1 in particular can play a very important role when high quality ports/locks and waterway connections are available in combination with high transport demand, industrial activities, connecting rail and road transport networks. The need of IWT can further be emphasized with associated economic and environmental benefits.

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 role that this mode could perform to take care of other objectives like providing access 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.

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 is estimated as 1.06 Rs/ tkm compared to 1.41 Rs / tkm by railways and Rs 2.58 Rs/ tkm by highways**.**

Environmental Need: Potential for Fuel Efficiency and GHG Emission: It is considered as the useful method from the point of view of energy saving. 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 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 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.

IWT on NW-1 has the potential to provide a cost efficient, economic, reliable, safe and environment friendly mode of transport. When developed for use by modern inland vessels operating on dependable fairway, it can reduce congestion and investment needs in rail & road infrastructure, promote greater complementarities in the riparian states, enhance intra-regional trade and through increased economies of scale, significantly reduce overall logistics costs for the benefit of the entire economy and India's global trade competitiveness.

Considering the strong potential for transportation of multiple cargoes such as coal, fly ash, cement and clinker, stone chips, edible oils, petroleum products, foods grains and over dimensional cargo, the Client is implementing "Jal Marg Vikas Project (JMVP)" for capacity augmentation of NW-1 with the technical and financial assistance of the "World Bank" to improve the navigability of NW-1 through: (i) fairway development by providing an assured depth of 2.2m to 3.0m throughout the corridor for atleast three hundred thirty (330) days in a year to make it navigable for comparatively larger vessels of 1,500-2,000 DWT; and (ii) civil structures, logistics and communications interventions required that includes multimodal terminals, jetties, navigational locks, barrages, channel marking systems etc. With regard to the terminals, the Client has developed floating terminals at twenty (20) locations and four (4) Reinforced Cement Concrete (R.C.C) jetties / permanent terminals at GR Jetty-2 (Kolkata), Gaighat (Patna), Multi-modal terminals (MMTs) at Varanasi (Uttar Pradesh) and Sahibganj (Jharkhand) for handling / berthing of cargo vessels, cruise vessels and others inland vessels. Also, one (1) MMT at Haldia, one (1) Inter-modal terminal (IMT) at Kalughat (Bihar) and a new navigational lock at Farakka (West Bengal) have also been taken up under JMVP.

1.3 Need of Renovation of Existing Lock

Farakka barrage has been constructed at River Ganga to divert water from River Ganga to River Bhagirathi through feeder canal. There is significant difference in water level of up- stream pond of the Barrage and feeder canal which varies according to the flow in river Ganga & the feeder canal.

Navigation lock is required for navigation from main River Ganga upstream to River Bhagirathi-Hooghly downstream through feeder canal due to prescience of significant water level difference in River Ganga and feeder canal. A Navigation lock is a structure used for negotiating the stretch of a waterway with significant difference in water level. It is used for raising and lowering boats, ships and other watercraft between such stretches.

However, the 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 is needed to ensure the smooth operation of the lock.

1.4 Objective of EIA Study

The renovation and modernization of the existing navigation lock at Farakka will have its associated environmental impacts. The objective of this study primarily focuses on defining environmental impacts associated with the lock project (offshore and onshore facilities both) during design, and renovation stages of development. The impacts are identified for all project activities on physical and ecological environment. The report also defines the mitigation measures, environmental management and monitoring programme which are required to minimise these impacts and sustain the benefits. Institutional mechanism is also developed for effective implementation of EMP.

Since the project is being developed with funding from the World Bank, the EIA study has been carried out in accordance with the operational policies of World Bank, Environment Impact Assessment Guidance Manual on Ports and Harbours and Guidelines of MoEF&CC for carrying out EIA studies from time to time.

1.5 Extent and Limitation of EIA Study

The Environmental Assessment was done in tandem with the preparation of DPR report. The EIA is based on up-to-date project details, primary field investigations / assessment, secondary data collected from 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, Forest Department, published journals\books and site observations and EIA for proposed navigation Lock at Farakka in NW-1. The EIA study covered all activities proposed for the renovation and modernization of the existing lock. Professional judgement and subjective interpretation of facts and observations has been applied for the preparation of the EIA Report.

1.6 EIA Contents

The EIA report is presented in 7 chapters following this introduction chapter.

Chapter 1: Introduction

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

Chapter 3: Description of Project: This chapter provide in detail the various components of the project. This chapter also provides details of alternatives considered and selection of most appropriate and least impact alternatives.

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: - Identification of impacts on environment due to renovation of existing navigational lock and its mitigation measures has been discussed in this chapter.

Chapter 6: Environmental Management Plan and Monitoring Indicators: - Various environmental management plans and different monitoring indicators with respect to the impacts that can occur due to design and renovation of existing navigational lock are discussed here.

Chapter 7: Conclusions and Recommendations: This chapter provide the summary of findings and concluding remarks.

1.7 Methodology

The EIA study was carried out using reconnaissance survey, review of previous studies, field visits, 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. Toposheets as available and Google maps were used for the above. Since it is renovation and modernization project, larger emphasis was given for primary data collection with regard to air, water, noise and soil. Sampling and field data collection techniques were applied for this assessment.

The scope of the EIA extends well beyond the vicinity of the existing lock area. 10 kilometres radius around the lock site is considered as the general impact zone. The immediate 2 km area around the project site was considered as the primary impact zone where most of the possible impacts are likely to occur. The decision to expand the environmental assessment impact zone to 10-kilometre radius is based on the following considerations:

- To provide a comprehensive environmental baseline information and to ensure that environmental impacts associated with the project are extensively identified and assessed,
- To provide base information for identification of appropriate locations for construction camps, other temporary activities and borrow area.

The established practices (like trend analysis, expert assessment, stakeholders' perception and concerns, resource availability) were followed to identify potential impact associated with the renovation 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 and biological (terrestrial and aquatic) 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 noise, air quality, water quality (ground and surface water both) and soil. 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 project site. Similarly, ambient noise level was monitored for day and night in project area. The water quality of surface and ground were monitored at different locations in the study area to get representative water quality information. River bed samples were also tested to assess the contamination level of river bed material.

Form the metrological data it be observed that the rainy season or most of the rainy days occurs in the month of June to sept. Since the best suitable time during the project was September 2022 therefore, the primary data was collected in September 2022. However, it was ensured that no rainfall occurs in last 10 days in the project area and corresponding monitoring locations. The observed data of September 2022 has been compared (Table1.1) with the environmental data of new navigation lock collected by EPC contractor during September, October and November 2022. From the Table 1.1 it can be inferred that collected primary data are within the permissible limits.

Table 1.1 Comparison of primary data collection

Drinking water							
Characteristics	Sep By EPC Contractor	Oct By EPC Contractor	Nov EPC Contractor	Sep by PKS-Floodkon	Requirement (Acceptable Limit)	Permissible Limit	Remark
pH	7	6.83	6.56	7.86	6.5-8.5	No Relaxation	Within limit
Turbidity	0	0	BDL (DL: 1.0)	0.3	1	5	Within limit
TDS	274	44	36	123	500	2000	Within limit
Anionic Detergents	0	0	BDL (DL: 0.05)	0	0.2	1	Within limit
Calcium	48	4	3.96	70.8	75	200	Within limit
Chloride	49.98	100	4.9	23.9	250	1000	Within limit
Fluoride	0	0	BDL (DL: 0.2)	1.05	1	1.5	Within limit but more than acceptable limit
Free residual Chlorine	0	0	BDL (DL: 0.1)	0	0.2	1	Within limit
Iron	0	0	BDL (DL: 0.05)	0.01	1	No Relaxation	Within limit
Magnesium	24	0	2.38	14.32	30	100	Within limit

Drinking water							
Characteristics	Sep By EPC Contractor	Oct By EPC Contractor	Nov EPC Contractor	Sep by PKS-Floodkon	Requirement (Acceptable Limit)	Permissible Limit	Remark
Nitrate	0.98	0	BDL (DL: 0.4)	0.21	45	No Relaxation	Within limit
Sulphate	2.1	0	BDL (DL: 1.0)	0	200	400	Within limit
Total alkalinity	178.2	19.8	20.4	156	200	600	Within limit
Total hardness	220	10	19.8	129.5	200	600	Within limit
Aluminum	0	0	BDL (DL: 0.01)	0.01	0.03	0.2	Within limit
Manganese	0	0	BDL (DL: 0.02)	0	0.1	0.3	Within limit
Total arsenic	0	0	BDL (DL: 0.005)	0.002	0.01	No Relaxation	Within limit
E. coli	Not Detected	Not Detected	Not Detected	Not Detected		Not Detectable	
Total coliform Bacteria	Not Detected	Not Detected	Not Detected	Not Detected		Not Detectable	

Surface Water				
Characteristics	Sep By EPC Contractor	Oct By EPC Contractor	Nov EPC Contractor	Sep by PKS-Floodkon
Turbidity	0	1.6	1.8	3
TSS	0	3.1	3.2	165
TDS	106	130	150	309
pH	7.09	7.24	7.67	7.44
Temperature	25	25	25	29.3
O and G	0	0	BDL (DL: 1.4)	0.001
BOD	0	0	BDL (DL: 2.0)	3.4
COD	0	11.52	8	40
Dissolved Phosphate	0	0	0.08	2.53
Fe	0	0.08	BDL (DL: 0.05)	0.02
Nitrate	0	1.23	0.98	1.02
Cr+6	0	0	BDL (DL: 0.01)	0.004
DO	0	4.4	6.8	4.6
As	4.4	0	BDL (DL: 0.005)	0.002
Pb	0	0	BDL (DL: 0.005)	0.004
Cd	0	0	BDL (DL: 0.001)	0.0001

Surface Water				
Characteristics	Sep By EPC Contractor	Oct By EPC Contractor	Nov EPC Contractor	Sep by PKS-Floodkon
Cu	0	0	BDL (DL: 0.02)	0.004
Zn	0	0	BDL (DL: 0.02)	0.003
Ni	0	0	BDL (DL: 0.01)	0.001
Hg	0	0	BDL (DL: 0.0002)	0.001
TOTAL COLIFORM MPN	24	11	<1.8	2300
FACCAL COLIFORM MPN	4	1.8	<1.8	1700

Noise									
Location	Parameters	unit	Sep By EPC Contractor	Oct By EPC Contractor	Nov EPC Contractor	Sep by PKS-Floodkon	Day Time (Limit as per CPCB)	Night Time (Limit as per CPCB)	Remark
Crane No-CS-100-04(West side)	Average	dB	59.1	66.7	65	54.2 and 40.7 for Day time and night time	75	70	Below the Limit
CS-100-03	Average	dB	69.5	67.7	63.9				
CS-50-20(east side)	Average	dB	69.8	66.7	63.2				
DG NO-40KVA/02 WEST SIDE	Average	dB	66.2	67.2	61.2				
DG NO-125KVA/03 WEST SIDE	Average	dB	69.7	66.6	65.5				
DG NO-180KVA/03 WEST SIDE	Average	dB	70.8	67.3	63.6				
DG NO-82.5KVA/02 WEST SIDE	Average	dB	71	61.4	61.9				
DG NO-40KVA/03 WEST SIDE	Average	dB	71.1	64.8					
DG NO-40KVA/01 WEST SIDE	Average	dB	71.4	59.8	60.9				
		Avg	68.7	65.4		47.9			

1.9 References

Large secondary data was collected for preparation of this EIA report. 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 organization	Report/source Name	Type of data
CPCB & MOEF	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 Ganga2013	Water Quality of NW-1stretch
MOEF & CC	Endangered Species Brochure, 2009	Endangered Species
Indian Meteorological department	Climatologically Normal 1969-1960	Met Data
	First order seismic micro zonation IMD	Seismicity and seismic map and Cyclone Hazard Prone Map
MOEF & CC	Information of Wetlands	Wetland information
Central Ground Water Board	Ground Water Boucher of Farakka District	Geology, Ground Water related information
NGBRA	River Ganga at a Glance: Identification ofIssues and Priority Actions for Restoration	Waterways quality
NGBRA (IIT Consortium)	Main Plan Document by Consortium of 7Indian Institute of Technology's (IITs)	Ganga basin
Botanical Survey of India	Red Data Book of Indian Plants	RET species
Zoological Survey of India	Red data book on Indian Animal	RET species
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
NGBRA	Status of higher aquatic Vertebrates in Ganga River By Consortium of India's IIT Institutes	Schedule-I species Dolphin, Aquatic Fauna
Hua, Y., Zhao, Q., & Zhang G. 1989.The habitat and behavior of Lipotesvexillifer. In W. F. Perrin, R. L. Jr. Brownell, K. Zhou & J.	Biology and conservation of the river dolphins Occasional Paper of the IUCN Species Survival Commission (No.3., pp. 92-98).	Conservation Dolphin

Liu (Eds.)		
IUCN (International Union for Conservation of Nature) 1980	Gland, Switzerland: International Union for Conservation of Nature. IUCN (International Union for Conservation of Nature) 1980.World Conservation Strategy: Regional strategies for international river basins and seas.	RET species
IWC (International Whaling Commission) 2000	Report of the standing sub-committee on small cetaceans. Journal of Cetacean Research and Management 1 (Supplement),	Cetacean fauna
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 Clupisomagaruain the River Gangetic, India.Journal of the Bombay Natural History Society 93, 86-88.	Oil impact on Aquatic fauna
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
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.	
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

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
KK Vass, S K Mandal, S Samanta, V R Suresh and P K Katiha, (CIFRI)	The Environment and Fishery status of River Ganges	Fish
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
Farakka Forest Division	Forest Working Plan of Farakka Forest Division	Flora and Fauna
NGBRA (Indian Institutes of Technology)	GRB EMP: Ganga River Basin Environment Management Plan	Flora& Fauna
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
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
Agriculture Department Farakka	Agriculture plan of Farakka district	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 Farakka district	Basic Amenities
Guideline, Standard and recommendations as published by Environmental Committee of PIANC	• Initial Assessment of Environmental Effect of Navigationand Infrastructure Project (WG 143-2014) • Sustainable waterway within the context of Navigation andFlood Management (WG 107-2009) • Climate Change and Navigation (TG3-2008) • Dredging Management Practices for the Environment (WG100-2009) • Dredging Material as a Resources (WG 104-2009) • Environmental Impact Assessments of Dredging	

	andDisposal Operation (WG 10-2006) • Biological Assessment Guidance for Dredged Material (WG8-2006) • Ecological and Engineering Guidelines for Wetland Restoration in relation to the Development, Operation andMaintenance of Navigational Infrastructure (WG 7-2003) • Management of Aquatic Disposal of dredged material (WG1-1998) • Dredged Material Management Guide 1997. • Guidelines for sustainable Inland Waterways andNavigation WG 6-2003 • Environmental guidelines for aquatic, nearshore andupland confined disposal facilities for contaminated dredged material WG 5-2002 • Dredging the environmental facts-where to find what youneed to know? PIANC-IADC-WODA brochure-2001 • Environmental management framework for ports andrelated industries WG 4-1999 • Dredging: the fact WODA brochure-PIANC-IADC-CEDA-IAPH1999

Chapter 2

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 wildlife 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 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 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 2.1.

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 (However EIA Notification 2006 does not classify locks on river or dredging in the river as a project requiring environmental clearance. The applicability of this legislation shall be re-confirmed from the concerned authority). Borrowing of earth (if any) for road realignment and construction shall fall under mining category and would require prior environmental clearance.	Environment Clearance Operation stage for EC for borrowing earth	MoEF& CC & SEIAA/SEAC	EPC Contractor for obtaining environmental clearances as applicable. EPC contractor shall also be responsible for EMP implementation and compliance to environmental clearance conditions. Borrowing may not be required due to availability of surplus earth
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 during renovation phase.	Consent to Establish (CTE) & Consent to Operate (CTO)	SPCB	EPC contractor shall obtain CTE, for setting up lock, 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

Name	Key Requirement	Applicability	Type of permit and stage of applicability	Administrative Authority and indicative time frame for grant of permission	Responsibility
					CTO for lock site before its handover to IWAI.
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 renovation 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 lock site shall also be obtained by EPC contractor along with CTE / CTO under Water 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 renovation stage.	No permits issued under this act	SPCB & CPCB	EPC contractor and IWAI to ensure compliance to Ambient Noise Level Standards as per the rules.
Hazardous Wastes (Management Handling and Trans-boundary) Rules, 2008.	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 renovation 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	No specific permit is required,	Chief Controller of Explosives,	EPC contractor and IWAI

Name	Key Requirement	Applicability	Type of permit and stage of applicability	Administrative Authority and indicative time frame for grant of permission	Responsibility
		HSD/LPG	however precautions defined under the material safety datasheets shall be followed. Safety audit and other requirements shall have to be complied if storage quantity exceeds the threshold limit	MoEFCC & DC	
The Bio Medical Waste (Management and Handling rules) 1998	To control store, transport and disposal of Bio Medical Waste.	Not applicable	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
The Batteries (Management and Handling) Rules 2001	To regulate the disposal and recycling of lead acid batteries	Applicable for disposal of used lead acid battery if likely to be used in any equipment during renovation stage.	No specific registration required. Compulsion to buy and sale through registered vendor only.	MoEF&CC	EPC contractor and IWAI

Name	Key Requirement	Applicability	Type of permit and stage of applicability	Administrative Authority and indicative time frame for grant of permission	Responsibility
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.	Not applicable as the project does not fall in coastal area	CRZ Clearance	State Coastal Zone Management Authority and MoEF&CC	Not Applicable
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 offorested areas into non- forested areas and deforestation	Not Applicable.No forest land is being diverted.However few no. of tree cutting may be undertaken but prior permission from forest department to be taken before any tree cutting	Forest Clearance / Permission for tree cutting.	Forest Department, MoEFCC	NOC shall be obtained from forest department prior tree cutting (if any). Compensatory plantation shall be carried out in ratio of 1:7. NOC for tree cutting shall be obtained by IWAI through 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	NA

Name	Key Requirement	Applicability	Type of permit and stage of applicability	Administrative Authority and indicative time frame for grant of permission	Responsibility
Wild Life Protection Act, 1972& Wildlife Protection Rules, 1995	To protect wildlife through notifying National Parks and Sanctuaries and buffer areas around these zones	Not Applicable as no eco-sensitive zone notified under this act is lying within 10 kms area of the project site	Wild life clearance	Chief Wildlife Warden, of the State, State Govt. &, MoEFCC	Not applicable
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 renovation 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 fromliability arising dueto accidents fromhandling of hazardous chemicals.	Not Applicable.The project does not involvestorage of anychemicals (HSD)beyond the threshold limit during construction	No permits issued underthis act. Owner of project shalltake out insurancepolicies providing for contracts of insurance so as he is insured against liability to give relief, before handling any such hazardous material	Collector ofthe Area	Not applicable

Name	Key Requirement	Applicability	Type of permit and stage of applicability	Administrative Authority and indicative time frame for grant of permission	Responsibility
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 renovation 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	Not Applicable as no storage of HSD/LPG or any other petroleum product may be required for the project purpose more than the threshold limit	License to store petroleum beyond prescribed quantity.	Chief Controller of Explosives/D C	EPC Contractor / IWAI
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 renovation 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

Name	Key Requirement	Applicability	Type of permit and stage of applicability	Administrative Authority and indicative time frame for grant of permission	Responsibility
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 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).	Not Applicable as no notified ancient monument is located within 300 m of the project site.	No objection certificate	Archaeological Dept. GoI, Indian Heritage Society and Indian National Trust for Art and Culture Heritage (INTACH).	Not applicable

Name	Key Requirement	Applicability	Type of permit and stage of applicability	Administrative Authority and indicative time frame for grant of permission	Responsibility
Merchant Shipping Act, 1958	To prevent marine pollution from ships beyond 5 km of the coastline and to make the transportation safe.	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 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/Infra structure project proposals in non-notified areas, 2012	To regulate extraction of ground water for drinking and domestic purpose	Applicable if bore well is done for extracting water for meeting drinking/domestic water needs of lock & vessels	No objection certificate	Central ground Water Authority/Board & MoEFCC	Contractor/IWAI shall obtain NOC from CGWA/CGWB prior digging any bore well during renovation phase

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 development of the lock 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 nationalwaterways	Applicable for development of the lock for all the vessel plying in National Waterway	IWAI
The NationalWaterway-1 Act, 1982	Provision for regulation and development of that river for purpose of shipping and navigation on the NW-1 and for the matters connected therewith or incidental thereto	Applicable for development of the lock for all the vessel plying in National Waterway	IWAI
New Inland Vessel Act,2015 & Rules Under IV Act	Economical and safetransportation through inland waters	Applicable for development ofthe lock for all the vessel plying in National Waterway	IWAI

2.2 International Best Practices and Guidelines

2.2.1 Operational Polices 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 B considering nature of activities and impacts
OP 4.04 Natural habitats	Ensures conservation of natural habitats and discourages disturbance of any natural habitat due to project development by recommending adoption of alternative method/route/approach or adopting management measures	Not Triggered	Applicable for projects lying in close vicinity to notified eco-sensitive zones like wildlife sanctuary, wetlands under Ramsar convention, national parks bird sanctuary, turtle breeding grounds etc. However, Farakka is important bird area thus mitigation and management plan address the protection and conservation of the avifauna of the area including migratory bird species
OP 4.36 Forests	Ensures that project activities do not 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.	Not Triggers	No diversion of forest land is involved. No tree cutting is envisaged at this stage. However, if any tree cutting will be required, prior permission from forest department will be obtained and the mandates of the operation policy shall be followed.
OP 4.12 Involuntary Resettlement	Ensures minimal involuntary resettlement by considering feasible alternatives project	Not Triggers	Entire land belongs to IWAI.

Name	Key Requirement	Applicability	Remarks
	design, assisting displaced people to improve their former 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	Not Triggers	No indigenous group of people are present in the study area.
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	Not Triggers	No community resource or property requires shifting (Refer SIA Report)

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 renovation and modernization of navigational lock at Farakka. The renovation and modernization project development will have moderate impact on both the environment and social component. Components to be impacted due to renovation and modernization are quality of life, livelihood, terrestrial and aquatic ecology, air quality, water quality, economy of the country, noise levels etc. Also, it is anticipated that associated project impacts are both positive & negative, long term & short term, temporary & permanent, significant & insignificant and irreversible & reversible depending on the activity and stage of the project. Also, it is anticipated some of the environmental components like aquatic ecology, land use, drainage, air quality and economy will be moderately impacted due to project development and requires proper management and pollution prevention and mitigation plans to minimize the negative impact, Thus the project is classified as Category B and a rapid environment assessment study has been undertaken for the project.

2.2.2 Relevant International Environmental Convention

2.2.2.1 International Maritime Organisation 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 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 Safetyof 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 FormAnnex 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 and 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/locks, thus standards issued by other renowned bodies are referred. Suggested list of standards are listed below and given in detail at **Annexure 3**.

1. 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)
2. Classification of Surface water Bodies on basis of Quality (Source: Guidelines for Water Quality Management-CPCB, 2008)
3. Water Quality Standards for Coastal Waters, SW-IV & V-Harbor and Navigation & controlled waste disposal (EIA Guidance Manual for Ports & Harbours, MoEF, GoI)
4. Standards for permissible level of water quality indicators (Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992)
5. Permissible limit for off-shore dumping of dredged material (Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992)

6. Criteria for harmful bottom sediments (Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992)
7. Approximate Quantity of Suspended Sediments Generated by Dredging or Dumping Operations (Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992).

2.3.1 Guideline Standards 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 environmentally 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

Chapter 3

3 PROJECT DISCRIPTION

3.1 Introduction

Farakka Barrage Project (FBP) was commissioned in the year 1975 with the primary objective of improving the navigation facilities of river Hooghly and maintaining Kolkata Port. As part of FBP, a navigation lock was constructed and commissioned in the year 1987 at Farakka (in Murshidabad district of West Bengal) to facilitate movement of inland vessels on National Waterway-1 (NW-1) through Feeder Canal. The navigation lock along with all ancillary assets was taken over by the Inland Waterways Authority of India from FBP Authority in April 2018.

The navigation lock has: (a) an internal length of 179.8m and a width of 25.148m and consists of two (2) sets of mitre gates on upstream (u/s) and downstream (d/s) side (two (2) leaves per set, each hinged about a vertical axis); (b) two (2) floating caisson type stop log gates; (c) four (4) numbers of radial valve gates with maintenance bulkheads; (d) eight (8) sets of mooring bits; and (e) a control tower for remote control operation.

Since the commissioning of navigation lock in the year 1987, no major repairs of hydraulic and electro-mechanical components have been carried out. As a result, mitre gates, radial valve gates, bulkheads, floating caissons and other mechanical components including electro-mechanical operating system are in dilapidated condition. Hence, it is required to renovate/modernize the existing navigation lock at Farakka.

Since it is an important part of NW-1 and renovation of the navigation lock will helps to achieve overall goals of JMVP and improve the navigability of NW-1 through: (i) fairway development by providing an assured depth of 2.2m to 3.0m throughout the corridor for at least three hundred thirty (330) days in a year to make it navigable for comparatively larger vessels of 1,500-2,000 DWT and (ii) civil structures, logistics and communications interventions required that includes multimodal terminals, jetties, navigational locks, barrages, channel marking systems etc.

3.2 Connectivity of the Lock Site

Highway and Railway: - The lock gate site is well connected with road & rail. The road passes through the site and connects the NH-80 which is located about 1.6 km West of the existing Lock gate site. The site is also well connected with rail network. Nearest railway station is Farakka Railway Station located about 2.6 km South of the site. Champagram railway station is located about 6 km East of the site.

Waterways: - River Ganges is navigable in this stretch and is being used to transport material from Haldia port to Farakka. At present NTPC Farakka is transporting imported coal from Haldia to plant site at Farakka by NW-1 and NTPC had a 7-year contract with Jindal ITF for coal transportation.

3.3 Existing Lock

Existing lock gate site is located at Farakka in Murshidabad District of West Bengal, on the Feeder Canal of Farakka Barrage. The Ganga River is flowing about 1.2 km East of the existing lock gate site. There are no environmentally sensitive components such as National Park, Wildlife Sanctuary, Elephant / Tiger Reserve and Wetland notified under Ramsar Convention, present within 10 Km radius of Lock gate site. The salient features of the existing lock site are given in Table 3.1 (Source Howe India).

Table 3.1 Salient Features of Existing Lock

S. No.	Parameter	Details
1	Number of Locks	One (1)
2	Length of lock	179.8m (b/w Mitre Gates) 250m (b/w Caisson Gates)
3	Width of lock	25.148m
4	Average depth of lock	12.89m at u/s to 10.89m at d/s
5	Major Structural Components	· Base Slab, Retaining Walls & Guide Walls · Filling / emptying Culverts including gate chambers · Bollards – eight (8) numbers floating type (four (4) on each bank) and fourteen (14) numbers fixed type (seven (7) on each bank) · 1 Central Control Room and 2 local control room
6	Major Hydromechanical Components	· Mitre Gates – two (2) sets 1 on U/S and 1 on D/S end, having two (2) leaves per set, · Caisson Gates/Stoplogs - 2 numbers (one (1) for u/s & one (1) for d/s) · Radial Gates – four (4) numbers (two (2) for u/s & two (2) for d/s) · Bulkhead Gates – eight (8) numbers (four (4) numbers for u/s and d/s each)

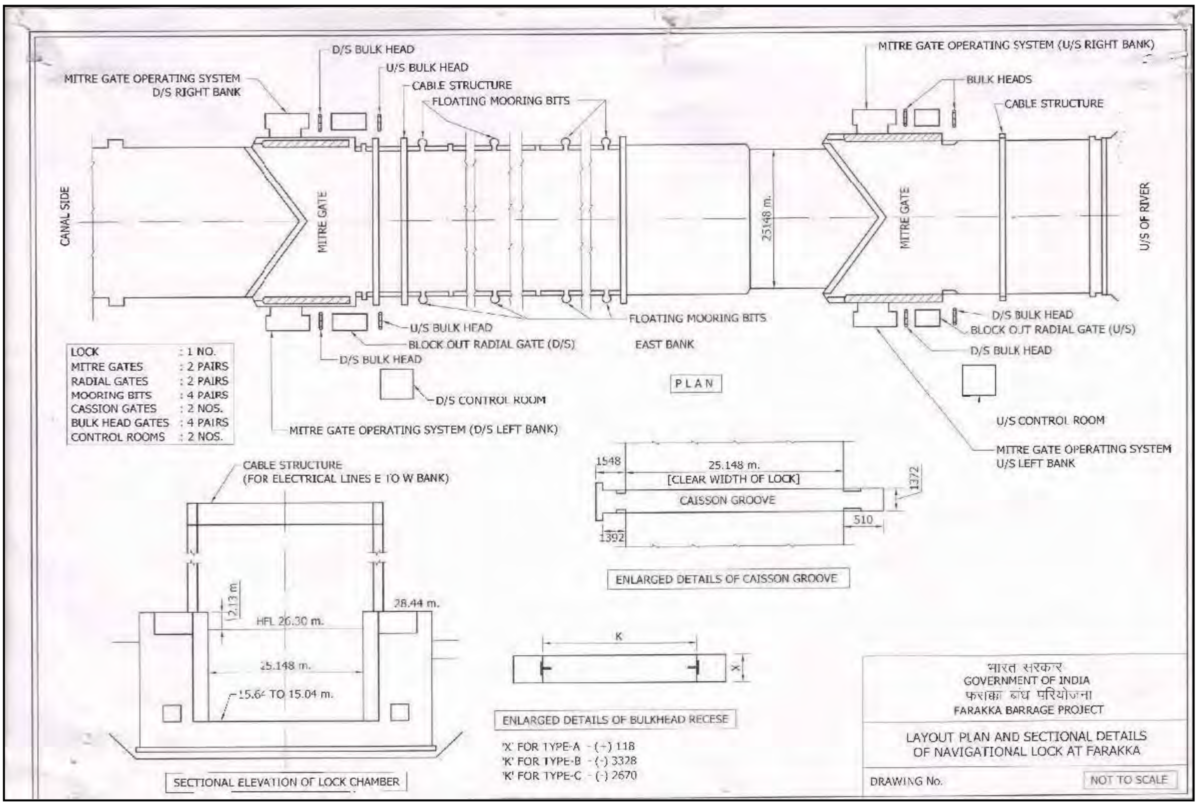


Figure 3.1 Layout of Existing Farakka Lock

Figure 3.2 Photographs of Existing Lock

3.4 Project Components

3.4.1 Topographic Information

Topographic survey has been conducted for the site. The ground levels at the site, broadly, vary from RL +13.00 to RL +29.00 m. The survey plan along with contours is shown in the Figure 2.7. The topographic survey is presented in the Drawing No. FL-1001.

3.4.2 Hydraulic Design of Existing Lock

The water levels U/S and D/S with reference to Operation/ maintenance Manual for existing Lock are as given below in Table 3.2. New lock will be designed for the same water levels.

Table 3.2 Water Level in U/s and D/s of Existing Lock

High Water Level	U/S RL +26.30 m
Low Water Level	U/S RL +18.288 m
High Water Level	D/S RL +24.38 m
Low Water Level	D/S RL +18.288

3.4.3 Project Components

All the construction work for the renovation and modernisation of existing navigational lock will be completed on shore which includes the activities like excavation, concreting etc. Contractor is required to make suitable arrangements to keep it free of water during construction.

Components of the existing navigational lock are given below.

1. Counter fort Retaining Wall
2. Inlet /outlet structure
3. Base Slab
4. Scour Protection and Shore Protection
5. Internal Roads & buildings

3.4.3.1 Counter fort Retaining wall

A reinforced concrete counterfort retaining wall is available at the sides of the Navigation lock. The retaining wall is dimensioned as counterfort retaining wall to take the earth pressure and earthquake forces etc. The top of wall is kept at El.

28.438m in the U/S and 26.056 in D/S The bottom elevation of wall varies from El. 15.545m to El. 15.240m. Non-destructive testing of concrete both for above water and under water portion has been carried out to assess the homogeneity and characteristics of concrete. Repair of concrete shall be carried out as and where required.

For caisson parking bay construction of retaining wall is proposed in the upstream and downstream of the existing navigational lock on the left bank. (RL)

3.4.3.2 Inlet/Outlet Structure

The project consists of four feeder culverts, two at U/S and two at D/S (one on each side). The water is carried through culvert system on both sides of the Lock for filling/emptying of the Lock. The Inlet /Outlet system comprises of inlet structures at one end and outlet structures at another end. The inlet is provided with multiple opening for efficient flow. The invert level of the inlet at culvert inlet is kept at EL. 15.545 m at U/S and D/S. The invert level at the entrance of the inlet is suitable to ensure sufficient depth of water above the inlet level of the tunnel for proper flow conditions. The top level of inlet is kept at EL. 17.755 m. The inlet is provided with a radial gate as main operating gate which is required to be opened / closed for Lock operations. On the upstream of the radial gate, an emergency gate is provided for inspection and maintenance of Radial gate and embedded parts.

Outlet is provided with only vertical gate which can be operated for the maintenance of Radial gate at Inlet. The whole filling/emptying system can be isolated by operating the gates at inlet and outlet.

Repair of concrete shall be carried out as and where required.

3.4.3.3 Base Slab

The sub-surface flow of water plays an important role for the stability of structure. The base slab gets destabilized due to uplift pressure and provision of sufficient floor thickness prevents this kind of failure. The base slab is 2.44 m thickness. The structural strengthening/retrofitting work shall be carried out.

3.4.3.4 Scour Protection and Shore Protection work

The river bank slope of U/S and D/S approach channel have been provided with two layers of back pitching with PCC blocks of size of 1 m x 1m x 0.6 m. 6 m wide launching apron has been provided at bottom of the slope comprising of two layers of concrete blocks of size 1.5 m x 1.5 m x 0.9 m. Shore protection is depicted in **Figure 3.7.**

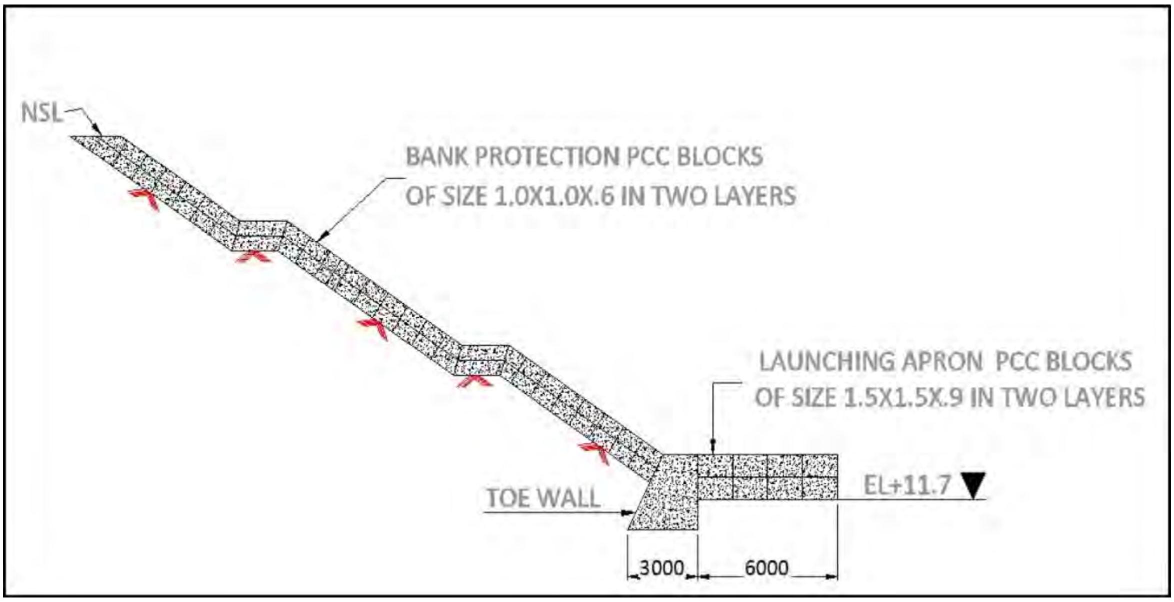


Figure 3.3 Typical Cross-section of Bank Protection

3.4.3.5 Internal roads and Buildings

Internal roads will be developed within the lock gate for facilitating movement of vehicles. Width of the internal roads is 7 m. It is proposed to provide green belt all along the length of the roads.

Control room building comprising of store/diesel generator room and rest room for the workers is available beside local control room for gate operation.

3.4.3.6 Other Facilities

Other proposed/existing onshore facilities include storm water drainage system with dump pond for collection of run off for its reuse, sewerage system with soak pit and septic tank, water supply with water storage (only potable water), power supply system, Lighting System, communication system, general fire-fighting system, power supply and back-up system.

3.5 Renovation Phase Activities

3.5.1 Onshore Activities

3.5.1.1 Preparation of Site

Site is slightly undulating with level variation of RL + 13 to RL + 29 m. Also due to the construction of dedicated parking bay for caisson gates, minor cut & fill will be required at the site. The estimated cutting of earth is 10000 m^3 and filling of earth is 30000 m^3. Filling will be done to achieve the finished level of 28.438 m amsl level which is above highest water level of the existing lock, i.e., RL+26.30 m.

The proposed renovation and modernization of the existing lock shall not require additional land and even the new parking bays at upstream and downstream of the lock has been proposed within the existing boundary of the lock area and the ownership of the land vests with the IWAI Few trees and shrubs are present at the site. Shrubs will be cleared for preparation of site. Trees will be retained to the extent possible as part of green belt. Tree cutting, if required will be undertaken after obtaining permission from forest department.

3.5.1.2 Excavation and Maintaining stability of cut slope

For renovation and modernisation of existing lock, it is proposed to carry out open excavation. Silty sand and silty clay are encountered along the bank of the river. The slopes of the excavation considered in the analysis are 1.5H: 1 V. 2 m wide berm has been provided at every 5 m height.

3.5.1.3 Construction of the facility

Proposed onshore structures shall be constructed through contractor. Temporary facilities tobe developed during renovation phase are:

- Establishment of Construction labour camp
- Establishment of Plant site (batching plants/Hot Mix Plant/Construction machinery & equipment)
- Storage sheds/rooms for raw material & debris
- Sanitation facilities (toilets, septic tanks/soak pits and bathing & washing area)
- Waste collection area (dustbins & main collection point)
- Temporary storm water drainage system
- Green belt
- Temporary power supply system

3.6 Construction Material Sourcing

Construction material required such as bricks, cement, reinforcement, timber will be sourced from Sahibganj and nearby areas, which is app. 100 kms from site in NW direction.

Stone and aggregates will be sourced from the quarries located in Rajmahal hills of Sahibganj District. Site is slightly undulating and will require cutting and filling. Surplus earth from the site will be used for filling the slopes and embankments proposed to be provided.

3.7 Utilities Requirement and Managements

Water Requirement

16.5 KLD water will be required for construction period. Out of the total requirement about 6.5 KLD will be required for domestic purpose which will be sourced from Farakka Barrage supply. About 10 KLD water will be required for construction purpose which will be sourced from River. Permission shall be taken from irrigation department prior to withdrawal of water. Water require for operation phase will be 0.65 KLD (650 litres/day) which will be sourced from Farakka Barrage supply. Water requirement during different phase for project is given in Table 3.3.

Table 3.3 Water Requirement

S. No.	Use	Total Water Requirement Renovation Phase (In KLD)	Total Water Requirement Operation Phase (In KLD)
1	Raw Water for dust suppression and other construction activity	7.3	-
2	Raw Water for Horticulture	2.7	-
3	Potable Water Requirement forPersonnel at lock site	6.5	0.65
6	**Total Water Requirement**	**16.5 KLD (16500 lit/day)**	**0.65 KLD (650 lit/day)**

3.8 Environmental Provision

Renovation and modernisation of existing lock has associated environmental impacts and requires integration of environmental protection measures in project design. EIA team has coordinated and given various design inputs for mitigation of likely environmental impacts at the site. The input considered by design team for Lock design are summarized below:

3.8.1 Green Belt Development

Green belt will be developed all along the boundary within the site. This will help in improving the aesthetic value of the area and to prevent spread of dust beyond lock boundary. About 100 trees along with herbs and shrubs will be planted in the green belt area.

3.8.2 Flood Protection Measures

Achieved finished level of site will be 28.44 m + RL which is above the high-water level of the existing lock. Strengthening of existing levees and banks to prevent the erosion and flooding. Scour protection & bank protection measures to prevent bank erosion and scouring of banks is discussed in section 3.4.3.4 above.

3.8.3 Seismic Protection

The Lock lies in **Seismic Zone III**. Seismic forces are calculated in accordance with the IS 1893: 2002. Project is designed considering the guidelines specified for buildings falling in seismic zone IV, i.e., for handling risks for earthquakes of higher intensity.

3.8.4 Fire Protection and Emergency Measures

Fire-fighting system will be developed as per TAC Guidelines. Potable fire extinguishers will be provided in all the required areas. Fire alarm system will be provided at the site.

3.8.5 Energy Saving Measures

Energy saving measures including installation of roof top solar panel on office building/control room can be considered. Solar street lights should be provided for lighting in common areas and access road. Awareness regarding energy saving should be spread at site by displaying signage for energy saving.

3.9 Implementation Schedule of the Project

The time of renovation of the lock is estimated to be 20 months.

3.10 Before and After Renovation of Project

Physical Environment: In the "After Project" scenario, the air quality and noise levels are likely to be impacted during renovation phase only but construction activities are temporary in nature and will be confined to renovation stage and to the construction area majorly. These emissions can be minimized by taking the environment management measures to large extent.

The construction materials to be used are stone aggregates, cement, stones, sand, sub- grade and steel majorly. The usage of this material will lead to permanent impact at quarry sites of sand and stone. The steel and cement usage will also have indirect impact on natural resources. During operation phase there will be no requirement of these materials. Construction material will be obtained from the licensed vendors only.

Majorly waste generated from the site will be municipal in nature and will comprise of food waste and food packaging waste. This waste should be disposed off on regular basis to prevent piling of waste and creation of unhygienic conditions at site. Small quantity of hazardous waste like used/waste oil will be generated from the site which will be disposed through authorized vendors.

Biological Environment: Vegetation present at the proposed land is commonly found shrubs and herbs. Further Green belt will be provided along the lock gate premises to enhance the biological environment.

Before Project renovation options

Physical Environment: In the “Before project‟ Scenario, the capacity of timely movement of goods will remain constrained. This will persist the pressure on already stressed roads & railways. The traffic jams on highways and railways crossing will continue to deteriorate the air quality and Noise levels due to idling of vehicles. Also, the fuel consumption for road transportation is much more than required in IWT mode. Thus, the emissions will continue to be generated due to transportation of goods by road.

Biological Environment: Biological conditions 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.

Chapter 4

4 DESCRIPTION OF THE ENVIRONMENT

4.1 Background and Salient Environmental Features of the Study Area

Generation of environmental baseline status of the project impact area is an important phase of any Environmental Impact Assessment process. Baseline data provide vital information on the existing environmental quality in which a development is planned. It is also useful for delineating environmental sensitivities of the areas for preparing an Environmental Sensitivity Map for any contingency planning. In this study, the environmental characteristics of the project area were established through extensive literature search, field sampling/measurements, laboratory analysis, stakeholder consultation and data interpretation.

Secondary data based on literature search were also incorporated for establishing baseline. The secondary data was obtained from various Govt. sources i.e., Meteorological Department, CPCB publications, NMGC, IIT consortium reports and others as listed under chapter 1. The primary baseline environmental data generation has been done through in situ field studies conducted during September 2022. The study area within a 10 km radius around the proposed lock gate site has been considered as general impact zone and 2 Km radius as specific impact zone (which more critical for such projects) for EIA study. Primary and secondary data has been collected for both the zones however; focus of primary data generation has been more for 2 km radius.

4.1.1 Environmental Setting and Salient Environmental Features of the Project Area

Environmental setting of the 10 Km radius zone around the existing Farakka Lock gate is presented at Figure 4.1 There are no environmentally sensitive components such as National Park, Wildlife Sanctuary, Elephant / Tiger Reserve and notified wetlands under Ramsar Convention, present within 10 Km radius of Lock gate site. The Salient Environmental Features of Farakka Lock gate site within 500m, 2 Km and 10 Km radius is summarized at Table 4.1.

Table 4.1 Salient Environmental Features of Farakka Lock gate Site

S. No.	Environmental Features	Within 500 m areaaround existingLock gate site	Within 2 km area around existing Lock gate site	Within 10 km area around existing Lock gate site
1	**Ecological Environment**			
A	Presence of Wildlife Sanctuary/ National Park/Biosphere Reserves	None	None	None
B	Reserved /Protected Forests Wetland of state and/or of national/international importance	None	None	None
C	Migratory route for wild animals	None	None	None
D	Presence of Schedule-I Terrestrial Fauna	None	None	None
E	Presence of Schedule-I Aquatic Fauna	None	None	None
F	Tree cover	Few trees in the site. Mainly herbsand shrubs are present	Yes Typical road side plantation	Yes Typical sparse vegetation road sideplantation.
G	Major Industries	None	None	NTPC thermal Power -3.6 km SSW and Ambuja Cement Ltd.- 4.2 km SW

2.	**Physical Environment**			
H	Critically Polluted Area	None	None	None
I	Rail connectivity	None	None	Farraka railway Station -2.6 km towards South and Champagram Railway station-6 km towards East
J	Defense Installation	None	None	None
K	Densely Populated Area	None	Farakka town	Many depicted in 10km radius map
L	Topography	Almost flat with elevation rangingbetween 25-31 m amsl as per GIS mapping	Mainly flat with elevation ranges between 19-45 meters amsl as per GIS mapping	Mainly flat with elevation ranges between 17-56 meters amsl as perGIS mapping
M	Seismicity	Falls in Zone-III moderate risk zone	Falls in Zone-III moderate risk zone	Falls in Zone-III moderate risk zone
N	Surface Water Resources (Rivers)	Existing Lock	Ganga River - 1.2 km East of the Lock gate	Feeder Canal -2.3 km Farakka Barrage-2.4 km towards Southeast
O	Groundwater Zone	Safe	Safe	Safe
P	Soil and Land-use	Clay loam Land use in 500m of site is under existing lock and agriculture. Land for the existing lock belongs to FBP.	Clay loam Land use in 2 km area of site is under road, existing lock, agriculture and village settlements.	Clay loam As per the land use analysis about 57.5% of the land is under agriculture, about 11.02% of the land is under water bodies, about 9.13% land is under vegetation, 8.30% land is under settlement and rest of the land is under other uses
3	**Social Environment**			
Q	Physical Setting None None	rural	rural	Urban & Rural
R	Physical Sensitive Receptors	None	Yes (Temples,	Yes (Temples, Schools,

			School)	College, Hospital)
S	Archaeological Monuments	None	None	None

Figure 4.1 Environment setting of 10 km radius around Farakka Lock gate Site

4.1.2 Site Connectivity

Highway and Railway: 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 existing lock gate site. This road connects the NH-80 is located about 1.6 km West of the existing Lock gate site and is connected. The site is also well connected with rail network. Nearest railway station is Farakka Railway Station located about 2.6 km South of the site. Champagram railway station is located about 6 km East of the site.

Waterways: - River Ganges is navigable in this stretch and is being used to transport material from Haldia port to Farakka. At present NTPC Farakka is transporting imported coal from Haldia to plant site at Farakka by NW-1 and NTPC had a 7-year contract with Jindal ITF for coal transportation.

4.1.3 Existing source of Pollution

There are only two major industries currently operating in the study area. One is Farakka Super Thermal Power Plant (2100 MW) of NTPC located at about 3.6 km SSW of the purposed lock. The second is Ambuja Cements Ltd (Unit: Farakka) located at about 4.2 km SW of the existing navigational lock. No other major source of pollution exists within the designated impact zone. There is an existing Farakka barrage on Ganga River and details are given below:

Farakka Barrage:

The Farakka Barrage Project with headquarters at Farakka in West Bengal is designed to serve the need of preservation and maintenance of Calcutta Port by improving the regime and navigability of the Bhagirath-Hoogly river system. The Bhagirathi, the Feeder Canal and the Navigation Lock at Farakka form part of the Haldia-Allahabad Inland Waterway (National Waterway No.1). The construction of Farakka barrage across the river Ganges started in 1961 and completed in 1975. Its operations started on April 21, 1975. The barrage is about 2,240-metres (7,350 ft) long. The length of feeder canal from the barrage connecting the Bhagirathi-Hooghly River is about 25-miles (~40-km) long.

The barrage has 112 gates and 11 numbers of head regulator gates, whereas feeder canal is of 38.38 kms length and it emanates from the right bank of Ganga River and is meant to carry water from Ganga to Hooghly. The feeder canal is designed to divert 40,000-cusecs water continuously from Ganga into Bhagirathi / Hooghly. Photograph of Farakka Barrage is given in Figure 4.2. Satellite imagery showing Ganga — Hooghly River system, Feeder canal and Navigation channel connecting Ganga River to Feeder canal is shown in Figure 4.3

Figure 4.2 Photographs of Farakka Barrage

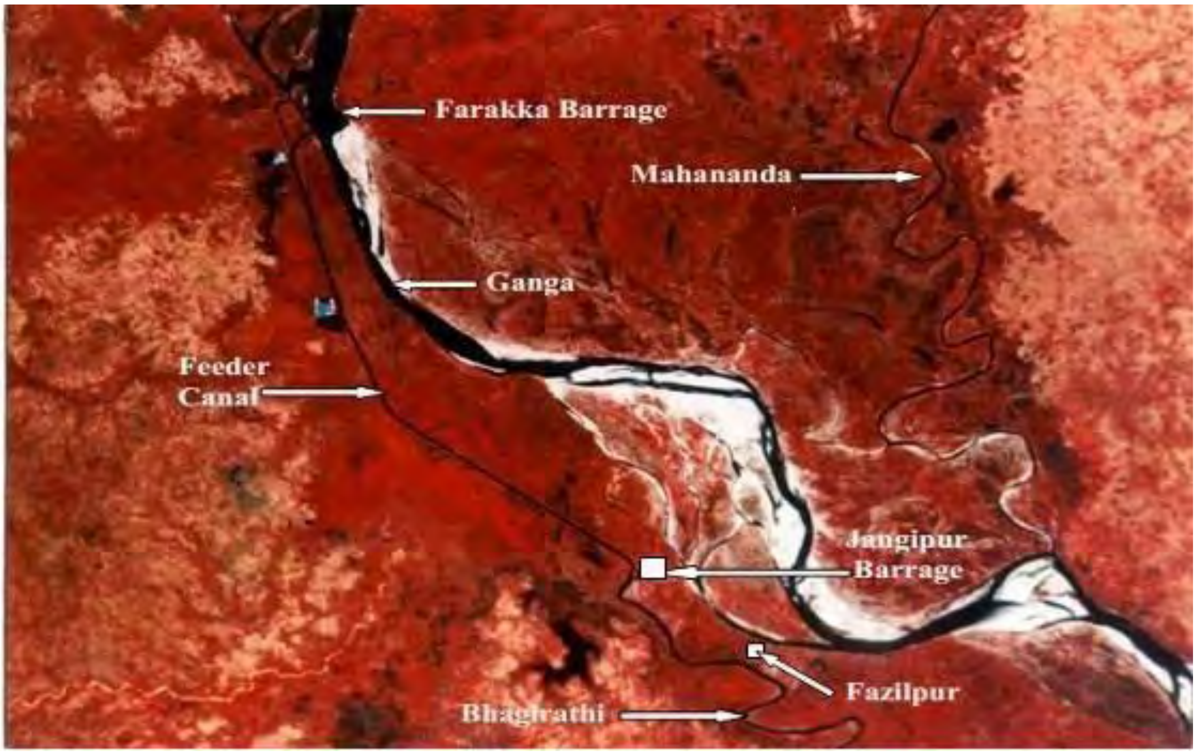


Figure 4.3 Satellite Image showing Navigation channel, Feeder canal and Ganga-Hooghlysystem

4.1.4 Primary Data Collection: Monitoring Plan and Quality Assurance Procedures

The study period and methodology for primary data collection is followed as per the monitoring plan approved by IWAI and World Bank in line with prescribed TOR by IWAI Summary of monitoring plan with sampling testing methodology followed is summarised in Table 4.2.

Table 4.2 Summary of Methodology for Primary/Secondary Baseline Data Collection

Parameters	No. of sampling stations (location of sampling stations)	Frequency	Remark
Ambient Air Quality			
PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO	One location (Refer Table No.4.21)	Once	AAQ monitoring was carried out at one location (representing upwind,downwind directions of the site). 24 hours sampling was carried out as per CPCB guide lines (CPCB Gazette notification dated 18.11.2009 on AAQ).
Meteorology			
Temperature, Humidity, Windspeed, Direction, storm, barometric pressure, Strom, Rainfall etc.			Meteorological status of the impact zone is analyzing based on secondarydata collected from nearby IMD station located at Malda for past 30 years.
Ground Water Quality			
Turbidity, pH, Temperature, TDS, Electrical Conductivity, Total Hardness, Iron, Chlorides, Fluoride, Calcium, Magnesium, Copper, Manganese, Sulphate, Nitrate, Phenolic compounds, Mercury, Cadmium, Arsenic, Cyanide, Lead, Zinc, Chromium, Nickel, Total Alkalinity, Aluminum **Biological Parameter:** Total coliform per 100 ml) E. Coli per 100 ml	One Location (Refer Fig. No.4.17)	Once	Ground water sampling was conducted at one location. Monitoring iscarried out at one location within 1 km radius area of project as they will be impacted most if any pollution occurs due to renovation and modernization of existing lock. Samples were preserved, transported and analyzed for different parameters based on APHA methods. Temp, conductivity and pH were measured at site itself.
Surface Water Quality			
Turbidity, pH, Temperature, TDS, Electrical Conductivity, Do, BOD, COD, TSS, Iron, Chlorides, Potassium, Sodium, Magnesium, Oil & Grease, Phosphate, Copper, Sulphate, Nitrate, Mercury, Cadmium, Arsenic, Silica, Lead, Zinc, Chromium, Nickel **Biological Parameter:** Total coliform per 100 ml) Fecal Coliform per 100 ml	One location (Refer Fig. No.4.17)	Once	To know the base line quality of the river water sampling was conducted at one location of the site. Samples were preserved and transported for analysis for different parameters based on APHA methods. Temp, conductivity, DO and pH weremeasured at site itself.
Soil			

Texture, bulk density, pH, conductivity, cation exchange capacity, organic matter, TotalN, P, K, and Heavy metals	2	Once	Soil samples were collected at one location from the site to know the impact of the project and analyzed as per IARI method
River bed Sample			
Texture, bulk density, pH, electrical conductivity, cation exchange capacity, available Potassium, Phosphorous, Organic matter, Total kjeldahl Nitrogen, Zinc, Copper, Iron, Sodium available	One	Once	Sedimentation sampling was collectedfrom the river bed near site to assess the base line quality and analyzed as per Soil Manual Govt. of India and IS 2720.
Noise			
Noise profiling for 24 hrs	One (Refer Fig. No.4.17)	Once	Noise monitoring was conducted within the 2 km area considering themaximum impacted areas due to theproject. Monitoring was done for 24 hrs using integrated sound level meter, as per CPCB guidelines.

Standard methods and procedures have been strictly adhered to within the course of this study. QA/QC procedures were strictly followed which covers all aspects of the study including sample collection, sample handling (chain of custody), laboratory analyses, data coding, statistical analyses, presentation and communication of results. All analysis was carried out with the support of NABL/MoEF accredited/recognized laboratory.

4.2 Physical Environment

4.2.1 Topography

Topography of Lock site and surrounding 2 Km area: Topography within 2 km zone of the existing Lock site is almost flat with gentle slope. The average elevation of the Lock site is ranges between 25-31 meters amsl as per GIS mapping. Average slope in one km zone ranges between 0-5.75 degrees. Contour Map of the 2 km area around Lock site is shown in Figure 4.4 (Source EIA Report, 2015). The range of elevation of 2 km area varies from 19 — 43 m.

Topography within 5 Km Area: Topography around 5 km zone of the existing lock gate site is also generally flat with gentle slope. The average elevation[3] of the zone varies between 17-56 metres above mean sea level. Contour Map of the 5 km area around Lock site is shown in Figure 4.5 (Source EIA Report, 2015).

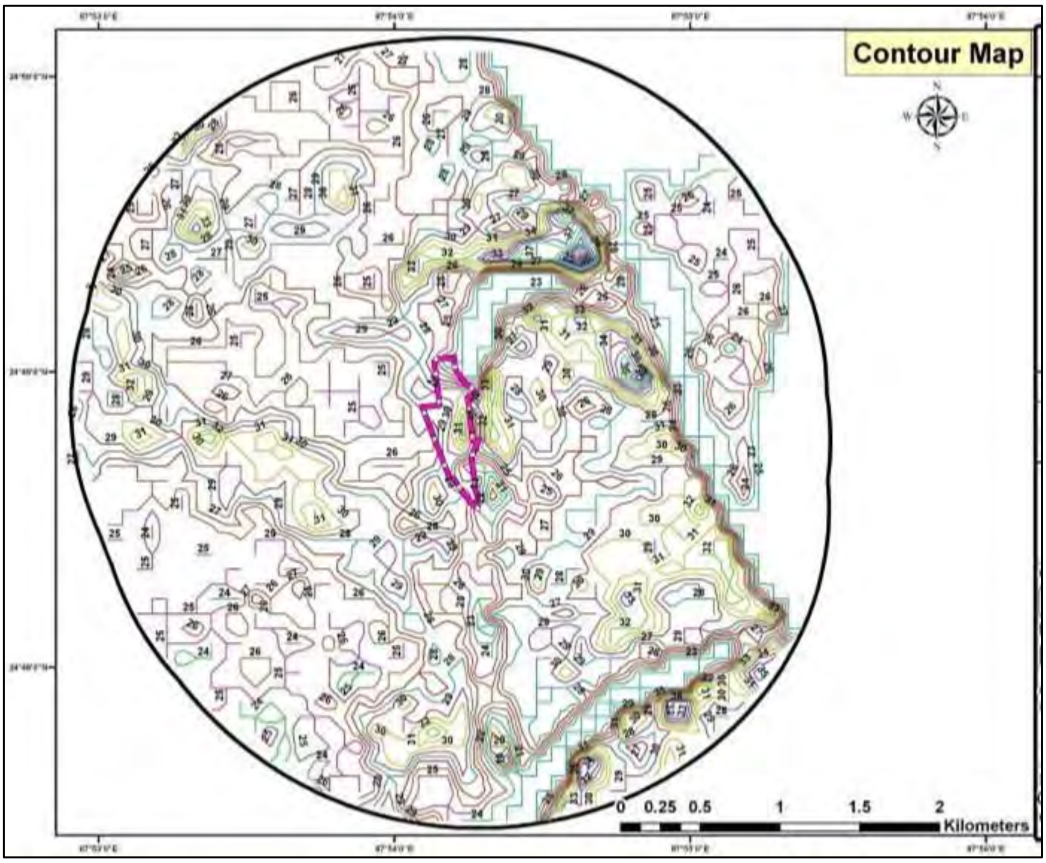


Figure 4.4 Contour Map in 2 km area around Lock Gate Site

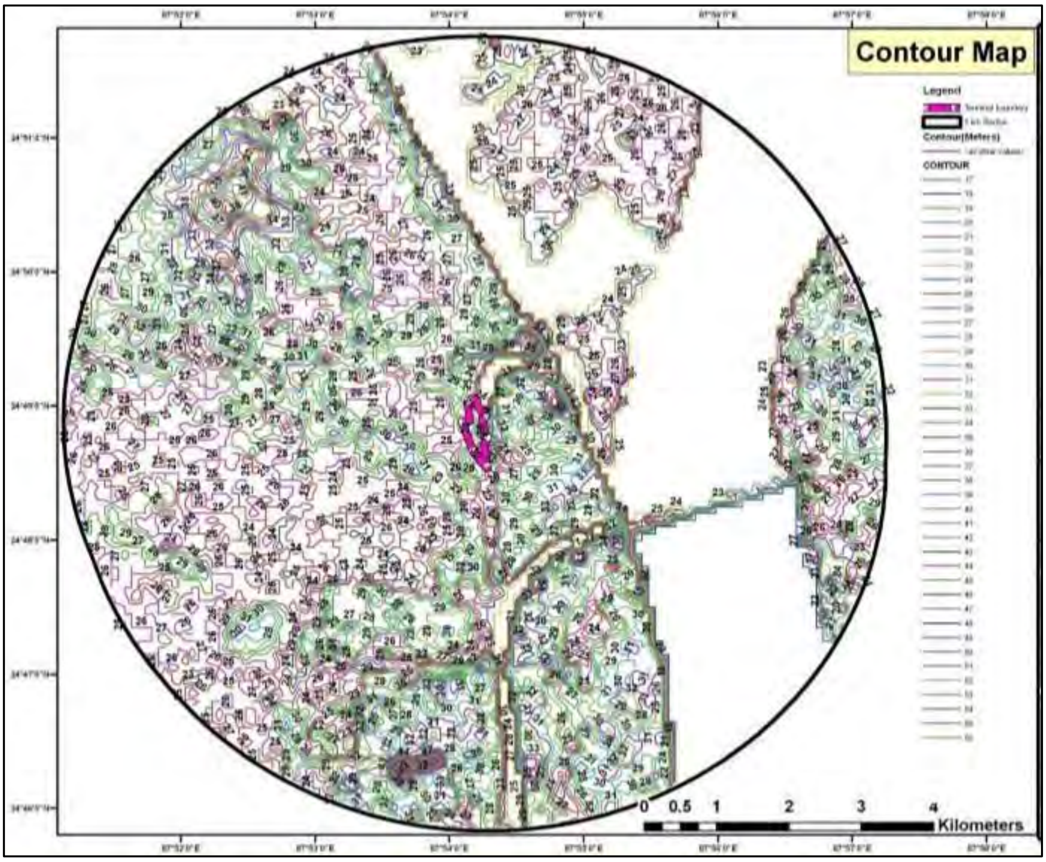


Figure 4.5 Contour Map of 5 Km area around Lock Gate Site

4.2.1.1 Drainage Pattern

The study area of 10 km radius forms a part of Ganga River basin. The area is well-drained by Ganga Rivers. Geologically the area has thicker alluvium sediment. The river system composed of the Ganges and its distributaries, of which the most important are Ganga-Bhagirathi River system, Gumani and feeder canal which originates from Farakka barrage. Bhagirathi is a branch of the Ganges, and flows southwards from Farakka barrage where it originates from the Ganges. It flows southwards through the district and divides it into approximately two equal halves. In1974 introduction of feeder canal from Farakka barrage to connect to River Bhagirathi has made the river navigable (Murshidabad Zilla Gazetteer, 2003).

Ganga River, Gumani River and feeder canal are the water bodies that command the drainage of the 2 km area. A small natural drain is also located within the 2 km area of the Lock gate site.

The drainage map of 2 km and 5 km study area is given in Figure 4.6 and Figure 4.7 respectively (Source EIA Report, 2015).

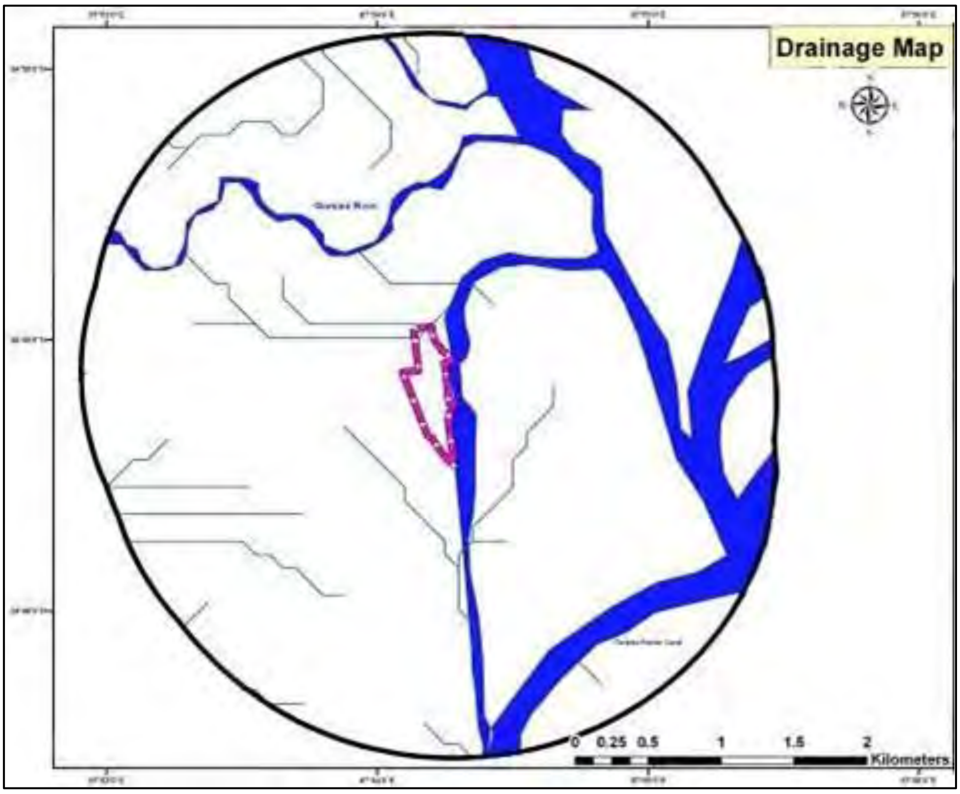


Figure 4.6 Drainage Map of 2 Km area around Lock gate site

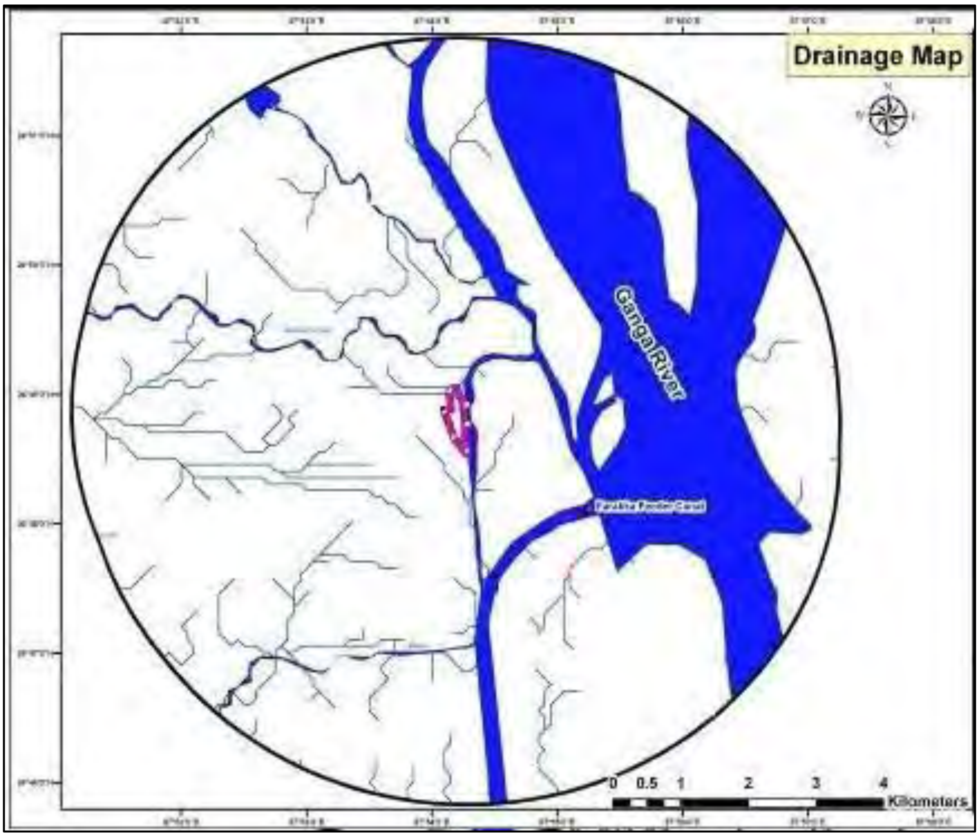


Figure 4.7 Drainage Map of 5 Km area around Lock gate site

4.2.1.2 Land Use Pattern

The land use analysis was carried out using remote sensing data. Systematic interpretation was carried out using a set of digitised images with color coding for delineating the land use classes. By integrating the areas demarcated under different land use/land cover as different colours are assigned to different land use/land cover types of satellite imagery.

Lock gate site belongs to IWAI. As per the land use analysis (2015) within the 10 km radius zone about 57.51% of the land is under cultivation, about 11.02% of the land is under water bodies, about 9.13% land is under vegetation, 8.30% land is under settlement and rest of the land falls under other uses (refer Figure 4.8 and Table 4.3).

As per land use analysis (2022) 53.55% area falls under agriculture land, about 17.61% area is waterbody, about 16.86% area is under built up area and rest of the bifurcation has been given in

Table 4.4 and shown in Figure 4.9.

Table 4.3 Land use of the Study Area (2015)

Sl. No.	Class	Area (Sq. km)	Percentage
1	Agricultural land	193.30	57.51
2	Open shrub land	25.79	7.67
3	Dry river bed	15.22	4.53
4	Settlement	27.88	8.30
5	Waterbody	37.03	11.02
6	Plantation	6.2	1.84
7	Vegetation	30.69	9.13
Total		**336.1**	100.00

Table 4.4 Land use of the Study Area (2022)

S.N.	Category	Area (Sq km)	Percentage
1	Water	57.89	17.61
2	Forest	12.98	3.95
3	Flooded Vegetation	0.71	0.22
4	Crops	176.08	53.55
5	Built Area	55.45	16.86
6	Dry River Bed	9.76	2.97
7	Scrub/Shrub	15.93	4.85
	Total	**328.81**	**100**

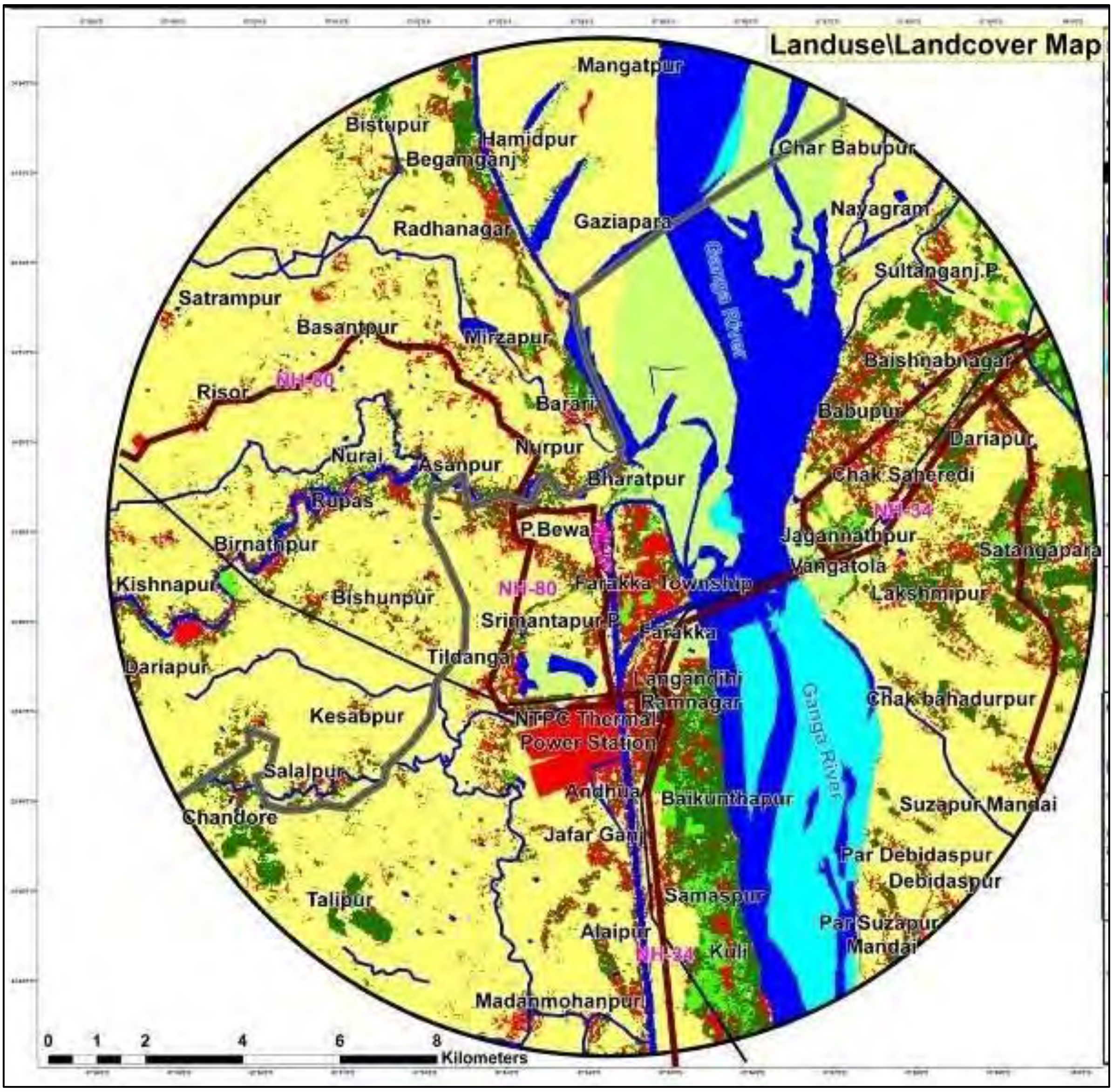


Figure 4.8 Land use Map of 10 Km Area around Lock gate site

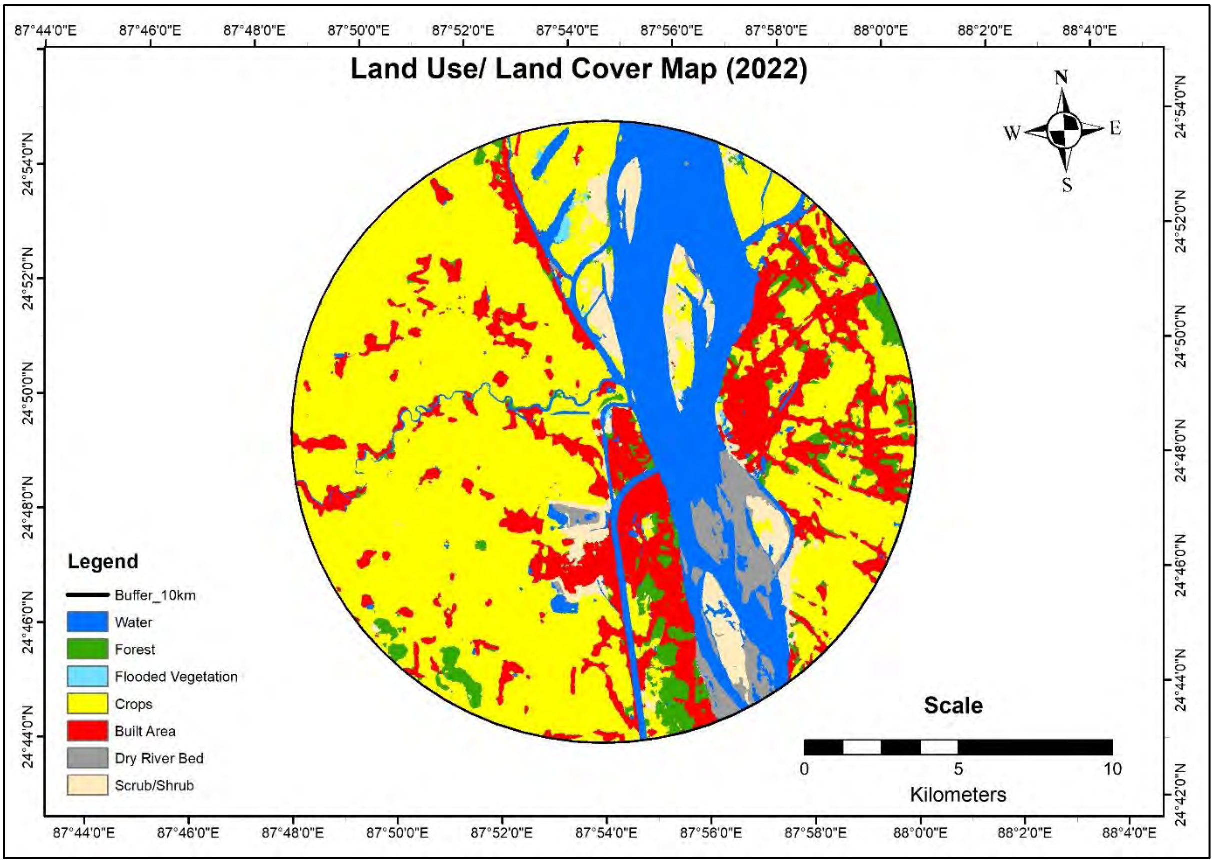


Figure 4.9 Land Use Land Cover map (2022)

4.2.1.3 Habitation along the river near Lock gate site

Ghoraipara village is the nearest village to the existing lock gate site. The other habitation around the lock gate site is Tildanga village about 3.3 km southwest, Farakka barrage colony is located about 1.28 km south east. Farakka town which is a densely populated town is located about 3.4km south of the lock gate site.

4.2.1.4 Archaeological Protected areas

No protected archaeological site is present within 300 m of the site or even upto 10 km radius of the project site.

4.2.2 Geology

The topography of Murshidabad district is almost flat. The area lies within the Ganga Bhagirathi basin and have a general height 45 to 75 m above MSL. The general slope of the land as mentioned earlier is towards south. The Farakka area is characterized by the quaternary alluvial deposits. This deposit has been classified into four informal stratigraphic units. Each formation has two facies- a piedmont plain facies and flood-plain facies. The former is characterized by dominance of gravel and the latter by sand-silt-clay. The main rock type in the area is basalt. Detail is given below in Table 4.5

Table 4.5 Geology in the study area

Subdivision/ Blocks	Soil Characteristics According to origin	Type	Texture
Jangipur (Sagardighi)	Very deep, poorly drained, fine soils occurring on very gentle sloping low lying alluvial plain with clayey surface associated with very deep, moderately well drained, fine loamy soils	Fine Acric Hapleauepts	Loamy soils
Jangipur (Farakka, Raghunathganj)	Very deep, poorly drained, fine soils occurring on level to nearly level low lying alluvial plain with clayey surface and severe flooding associated with very deep moderately well drained fine loamy soils	Very fine Acric Hapleauepts	Loamy soils

Geomorphologically the area forms a part of late quaternary alluvium plain which also have defined. The geological formation of the area is broadly classified into three parts viz. a) recent alluvium, b) Pleistocene- recent older alluvium and lateritic clay and c) Jurassic Rajmahal Trap.

a) **Recent alluvium:** The “bagri” region of the district is occupied by recent alluvium. The soil is mainly composed of sands and clays brought by the rivers. All types of soils that prevail are fertile and produce all kinds of crops.

b) **Pleistocene-** recent older alluvium and lateritic clay: A major part of the "rarh" region that is the western part of the river Bhagirathi is occupied by older alluvium and lateritic clay. It may be the continuation of the sub-Vindhyan region of lateritic clay and nodular limestone. The "kankar" (the beds of limestone) are scattered at places in this western part.

c) **Jurassic Rajmahal Trap:** The northern part of the district consists of basaltic lava which flowed with intercalated, carbonaceous shale and clays. The basalt is a black-coloured, fine- grained amygdaloidal rock. The amygdales are filled with chalcedony, calcite, zeolite and other secondary minerals. The Quaternary sediments have been classified in Table 4.6 below

Table 4.6 Geomorphic Sub-division and its Characteristics

Geological Time Scale	Geomorphic Sub-Division	Morphological Characteristics
Recent Pleistocene	Younger Deltaic Plain formation (YDP)	River terrace sediments • Alluvial sediments with soil containing soft ferruginous nodules
	Older Deltaic Plain Formation (ODP)	Alluvial sediments with soil containing calcareous nodules
	Lateritic Formation	Hard lateritic and mottled clay with underlying alluvial sediments

Source-http://shodhganga.inflibnet.ac.in/bitstream/10603/28039/8/08_chapter-3.pdf

4.2.2.1 Rock Types

Rajmahal Trap is the major rock type in the district. The other geological formations of the district are alluvium and Laterite. The alluvium occurs in the northern and eastern boundary of the district, which is composed mainly of sand and sub ordinate clay. Laterites are mainly of in-situ origin and have been formed by sub-aerial erosion of underlying basalts under favourable climatic conditions. The rock type in study area is alluvium which is mainly composed of sand and clay.

4.2.2.2 Regional tectonic settings (reported fractures/faulting, folding, warping)

The Lower Ganga plains are quite distinctive in terms of its geological setting. After draining through a wide alluvial plain in Bihar plains, the Ganga River suddenly become as confined on both banks; the right bank is bordered by the outliers of the Rajmahal hills and the left bank is bound by the old alluvium of the Barind Tract. Several tectonic elements have been mapped in this region based on the seismic and gravity surveys carried out by Geological Survey of India. Two major faults run nearly parallel to the Ganga River namely the

Rajmahal Fault along the right bank and Malda–Kishanganj Fault along the left bank; these two faults have forced the river to flow in a relatively narrow valley for approx 80-km long stretch. East of Malda–Kishanganj Fault, positive gravity anomalies and very shallow basement mark the Malda–Rangapur Ridge. A number of smaller faults are also mapped cutting across the Malda–Kishanganj Fault to the east of the Ganga River. It is clear that a major part of the course of the Ganga River in the study area is geologically- controlled. Between 1594 and 1975, seven earthquakes of moderate size have occurred around Farakka and adjoining regions (Singh and Singh 1989) which suggests that the area is geotectonically active. Map showing the tectonic settings of the area is given below in Figure 4.10**.**

4.2.2.3 History of any volcanic activity

Volcanic activity occurs at two types of plate boundaries: mid-ocean ridges and seduction zones. There were no records of volcanic eruption in Farakka or even in surrounding areas

4.2.2.4 Seismicity and Associated Hazards all along the waterway

BIS has divided India into different seismic zone and Murshidabad district falls under Zone III, although few areas of West Bengal falls under Zone IV and V. Malda is the most earthquake-prone district and the Lower Ganga Fault line just touched the northern portion of this district. The seismic zoning map of India shows four distinct seismic zones and is attached as Figure 4.10.

- Zone - II: This is said to be the least active seismic zone.
- Zone - III: It is included in the moderate seismic zone.
- Zone - IV: This is considered to be the high seismic zone.
- Zone - V: It is the highest seismic zone.

- **Figure 4.10 Seismic zone of India**

According to BIS micro zonation map of the India the Farakka lock gate area falls under Zone-III. It means that the area is covered under “Moderate Seismicity-hazard zone.

4.2.2.5 Information on quarries along the waterway

There are no stone/sand quarries located along the Hooghly River within the study area.

4.2.3 Soil

Soils may be defined as a thin layer of earth's crust that serves as a natural medium for the growth of plants. It is the unconsolidated mineral matter that has been subjected to and influenced by genetic and environmental factors. Soils serve as a reservoir of nutrients for plants and crops and also provide mechanical anchorage and favourable tilts. Soil is our most important natural resource (a natural resource is anything that comes from the earth and is used by mankind. We depend on the soil for food, clothing, shelter, minerals, clay & water. Soil is the seat of many macro and micro flora like algae, fungi, earthworms, bacteria etc. These are very beneficial in promoting soil reactions and decomposing the organic matter by which essential nutrients for plants are liberated.

4.2.3.1 Regional soil type

Geomorphologically the Farakka region falls in Tal region of the District Murshidabad. The Soils of Tal region are clay loam to sandy loam in texture. These soils are light loam called “Do-ash”. It is a later alluvial formation and consists of an admixture of clay and sand. Soil investigation study has been carried out at site to understand the soil profile of the area.

4.2.3.2 Soil Classification

Murshidabad district is divided in the two regions i.e., Rath region and Bagri region. The “rath” region is substantially a continuation of the sub- Vindhyan region of lateritic clay and nodular ghuting. The soil is grayish or reddish mixed with lime and iron oxide and scattered nodular lime glutting (kankar). The “bagri” region lying in the Bhagirathi recent surface has little soil development. The surface composed of loose and completely unconsolidated sediments exhibiting a variety of sedimentary structures. About 1-2 meters of thick brown mottled soil with soft and incipient ferruginous concretion develop on Younger Deltaic Plain.

4.2.3.3 Study sampling and analysis

One soil sample was collected from open land near Farakka Barrage Ring Road and analysed for physico-chemical characteristics. The soil sample wes collected from three different depths; 1-5 cm, 10-20 cm and 40-50 cm below the surface. The samples were homogenized and the quantity was reduced using the coning and quartering method. Locations of different environmental parameters are shown in Figure 4.11.The soil sampling location and analysis results of soil samples are presented in Table 4.7 and Table 4.8.

Table 4.7 Soil sampling location

Sr. No.	Location Code	Location	Source	Coordinates
1	S-1	Farakka Barrage Ring Road	Open field near site	24°48'51.9192"N 87°54'7.596" E

Figure 4.11 Sampling locations of different environmental parameters

Table 4.8 Physiochemical Characteristics of Soil

S.No	Name of Test	Unit	Test Method	Observed Value
1	Texture	-	Soil Manual Govt. Of India; 2011	Sandy Silty Clay
2	pH	-	IS 2720 (P-26);1987	8.21
3	Electrical conductivity	µs/cm	Soil Manual Govt. Of India; 2011	484.6
4	Cation exchange capacity	meq/100g	IS 2720 (P-24); 1976 R.A 2020	8.2
5	Available Potassium (as K)	mg/kg	Soil Manual Govt. Of India; 2011	234.1
6	Bulk Density (Core Cutter Method)	gm/cc	IS 2720 (P:29)	1.42
7	Phosphorous (as P)	mg/kg	Soil Manual Govt. Of India; 2011	75.3

8	Organic Matter	% by mass	IS 2720 (P-22); 1972 R.A 2010	0.78
9	Total kjeldahl Nitrogen	mg/kg	Soil Manual Govt. Of India; 2011	1320.1
10	Zinc	mg/kg	Soil Manual Govt. Of India; 2011	28.4
11	Copper	mg/kg	Soil Manual Govt. Of India; 2011	<1.0
12	Iron (as Fe)	% by mass	Soil Manual Govt. Of India; 2011	0.062
13	Sodium Available (as Na)	mg/kg	Soil Manual Govt. Of India; 2011	164.8

4.2.3.4 Soil Characteristics

Physical Characteristics

The physical characteristics examined include texture, and bulk density. Texture and bulk density of soils in the study area is sandy silty clay and 1.42 gm/cm^3, respectively.

Chemical Characteristics

The soil is slightly basic with pH of 8.21. Electrical conductivity (EC) was found 484.6 μs/cm. Available potassium content in this soils' is 234.1 mg/kg thereby is indicating that the soils are with medium levels of available potassium content. Nitrogen is an integral component of many compounds including chlorophyll and enzyme essential for plant growth. Available nitrogen content in the surface soils is 1320.1 mg/kg thereby indicates that soils are high in available nitrogen content. Available phosphorus content is 75.3 mg/kg thereby indicating that soils are medium in available phosphorus. Cation exchange capacity (CEC) is 8.2 meq/100g. Other micronutrients are also observed in medium range. The overall fertility status of the soils within the study area is reasonably good and is not expected to be detrimental to the growth of agricultural and forest crops.

4.2.4 Meteorological data

4.2.4.1 Rainfall

Gridded rainfall data has been collected from India Meteorological Department (IMD) for the project location between latitude and longitude of 24.75° N, 88° E and 24.75° N, 87.75° E. The data has been collected for a duration of 41 years from year 1980-2021. Average annual rainfall is around 1470 mm and the maximum rainfall occurs in the month of July which is of the order of 350 mm. The average monthly rainfall data from 1980-2021 is presented in Table 4.9 and plotted in Figure 4.12.

Table 4.9 Rainfall (mm) Data for the Project Site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	6.9	2.8	11.6	8.3	185.6	299.3	506.4	703.8	346.0	90.7	0.0	0.0	2161.2
1981	33.4	11.4	6.1	130.4	193.5	123.1	488.5	262.3	286.3	0.0	2.8	35.2	1572.7
1982	1.0	4.7	40.1	11.9	52.9	216.7	200.5	316.0	117.3	55.4	37.9	0.5	1054.7
1983	11.9	0.9	23.9	33.1	88.5	134.4	331.8	180.3	367.2	126.3	0.0	29.0	1326.9
1984	45.9	25.4	4.3	8.1	128.2	375.0	388.5	234.6	227.0	114.7	0.0	1.4	1552.8
1985	4.2	1.9	3.4	11.9	174.3	170.2	406.7	209.5	281.7	162.1	0.0	3.7	1429.4
1986	0.6	7.8	0.1	58.2	90.8	152.9	284.8	109.2	261.8	227.4	3.3	6.2	1202.9
1987	0.2	3.8	25.7	61.3	94.1	174.4	581.0	751.3	357.4	50.3	6.4	3.9	2109.4
1988	0.3	15.2	29.1	29.1	99.6	260.8	287.7	399.9	171.6	69.6	33.0	2.7	1398.3
1989	0.7	16.0	0.4	0.0	189.4	155.4	341.2	193.3	433.6	60.9	0.0	12.1	1402.8
1990	0.0	28.4	20.2	20.0	196.1	162.1	514.9	251.6	257.3	145.0	0.9	0.0	1596.2
1991	6.2	5.7	9.1	13.1	116.2	327.4	391.8	204.6	472.4	60.7	0.0	68.6	1675.6
1992	0.0	14.3	1.5	4.7	84.1	161.9	458.5	237.2	200.2	75.1	9.0	0.6	1246.6
1993	21.0	1.8	21.7	67.7	71.1	340.6	236.2	385.2	396.9	67.0	37.4	0.0	1646.3
1994	21.9	20.6	0.0	13.2	27.4	240.6	171.9	200.3	150.3	131.9	0.0	0.0	977.9
1995	3.1	7.9	0.5	1.9	48.2	186.4	278.8	322.9	1020.3	9.1	58.8	8.1	1945.7
1996	10.3	10.4	0.4	15.1	29.6	248.0	303.0	513.7	277.9	70.0	0.0	0.0	1478.1
1997	23.3	9.4	8.3	77.9	109.5	242.3	387.5	510.3	270.1	29.8	14.2	32.8	1715.2
1998	7.6	11.1	61.9	45.7	141.5	143.7	568.1	359.1	324.4	226.2	20.5	0.0	1909.7
1999	0.0	0.0	0.4	5.7	108.3	308.1	489.5	566.6	541.6	172.9	0.6	0.0	2193.3
2000	4.1	36.2	26.6	111.4	181.5	327.5	264.9	176.1	635.2	25.9	0.0	0.0	1789.2
2001	0.3	0.0	1.5	16.9	185.7	272.8	221.8	230.6	259.7	209.9	0.0	0.0	1399.0
2002	10.9	0.6	2.9	88.1	104.1	195.5	259.3	358.2	329.9	54.8	9.3	0.0	1413.3
2003	1.0	52.7	30.8	14.5	136.8	309.7	194.3	176.1	210.7	258.5	0.0	2.0	1386.8
2004	19.0	0.0	2.0	44.7	62.7	346.7	332.7	215.2	130.7	485.9	0.0	0.0	1639.4
2005	15.6	3.8	52.1	17.2	96.6	87.1	571.4	329.9	163.3	154.8	0.0	0.0	1491.7

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2006	0.0	0.0	4.3	67.6	99.1	204.3	239.8	247.3	488.2	67.8	11.3	0.5	1429.9
2007	0.0	42.7	44.2	0.4	85.8	275.2	549.3	235.7	272.2	51.5	0.9	0.0	1557.6
2008	43.3	1.9	5.0	21.0	40.1	392.8	416.3	292.5	216.9	34.6	0.0	0.0	1464.1
2009	0.8	5.3	0.9	0.2	227.4	73.4	298.9	463.4	157.5	276.7	2.4	0.0	1506.8
2010	0.0	1.8	0.1	30.9	168.8	187.4	151.1	113.8	239.4	106.3	9.6	9.5	1018.5
2011	0.0	0.5	0.1	9.0	43.0	79.0	473.0	308.2	323.8	18.6	0.3	0.0	1255.2
2012	6.6	0.1	1.4	70.1	26.6	128.1	299.3	160.7	164.3	88.4	39.2	0.0	984.6
2013	0.1	14.3	1.0	32.6	134.2	320.9	118.1	381.8	169.3	309.5	2.9	0.0	1484.5
2014	0.3	55.0	1.4	11.5	168.3	236.5	382.0	251.2	217.0	29.6	0.0	0.0	1352.6
2015	18.9	2.9	35.7	97.5	137.2	269.9	452.5	322.6	221.6	32.0	3.0	0.0	1593.5
2016	14.9	0.0	4.0	16.6	78.2	130.8	358.4	163.9	338.9	46.7	0.0	0.0	1152.2
2017	2.1	0.0	7.6	69.5	101.2	87.9	311.4	413.4	165.6	111.8	0.2	8.9	1279.4
2018	0.0	13.2	24.6	143.2	142.5	91.3	199.6	157.4	115.3	69.0	0.0	13.5	969.4
2019	0.0	33.0	2.1	65.4	113.1	65.9	333.7	148.5	269.4	174.4	0.0	1.3	1206.6
2020	9.2	13.2	55.7	74.3	170.9	329.4	263.0	197.1	272.7	89.2	0.1	0.0	1474.5
2021	0.0	0.0	1.9	6.9	356.1	252.0	233.3	272.9	112.5	83.6	0.0	6.3	1325.2
Average	**8.2**	**11.3**	**13.7**	**38.7**	**121.1**	**216.3**	**346.2**	**298.3**	**291.3**	**112.5**	**7.2**	**5.9**	**1470.7**

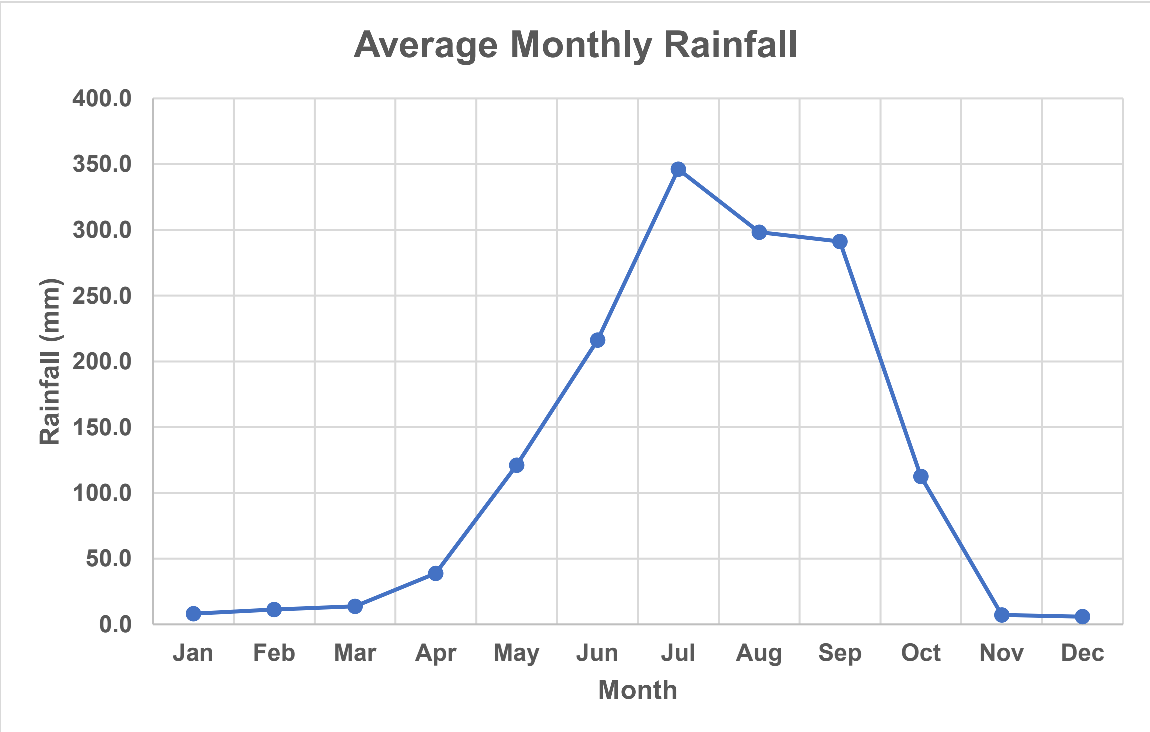


Figure 4.12 Average monthly rainfall distribution

4.2.4.2 Wind Speed

Wind speed data at 2m above ground has been collected from NASA POWER LARC for the project location. The data has been collected for a duration of 40 years from year 1981-2021. Average annual wind speed at the project location is around 2m/s. The maximum wind speed occurs in the month of June i.e., 2.60 m/s. The average wind speed varies from 1.38 m/s to 2.60 m/s throughout the year. The average monthly wind speed from 1981-2021 is presented in Table 4.10 and plotted in Figure 4.13.

Table 4.10 Average Monthly Wind Speed

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	1.57	1.85	1.91	2.25	2.41	2.91	2.76	2.24	1.65	1.27	1.54	1.59	2.00
1982	1.60	1.95	1.90	2.03	1.98	2.66	2.51	2.92	1.95	1.30	1.42	1.61	1.98
1983	1.59	2.02	2.47	2.66	2.27	3.27	2.90	3.00	2.41	1.76	1.45	1.59	2.28
1984	1.77	2.18	2.11	2.05	2.55	3.11	2.52	2.56	1.77	1.48	1.52	1.52	2.09
1985	1.73	1.74	2.24	2.47	2.50	2.66	2.69	2.53	1.87	1.68	1.65	1.66	2.12
1986	1.92	2.25	2.28	2.14	1.91	3.27	2.74	2.25	2.28	1.28	1.08	1.36	2.06
1987	1.54	1.55	1.62	2.27	1.91	2.69	2.45	2.17	1.93	1.38	1.70	1.66	1.91
1988	1.80	1.71	2.10	1.93	2.58	3.30	2.49	2.53	1.84	1.84	1.85	1.64	2.14
1989	1.87	2.62	2.38	2.43	2.95	3.23	2.24	2.63	2.32	1.45	1.45	1.57	2.26
1990	1.64	1.70	1.64	2.10	2.57	3.47	2.34	2.18	2.17	1.95	1.58	1.43	2.06
1991	1.62	2.00	1.84	2.00	2.47	2.70	2.94	2.70	1.88	1.44	1.32	1.51	2.04
1992	1.29	1.73	3.20	2.50	2.12	2.52	2.71	2.75	2.35	1.50	1.55	1.36	2.13
1993	1.81	1.54	2.52	2.23	2.57	3.55	3.33	2.71	2.38	1.20	1.42	1.57	2.24
1994	1.77	1.92	2.16	2.09	2.41	3.48	3.20	2.92	2.44	1.66	1.50	1.62	2.27
1995	2.05	2.00	2.75	2.07	2.53	3.40	2.77	2.56	2.61	1.32	1.71	1.62	2.28
1996	1.95	1.99	2.50	2.01	2.38	3.02	2.64	2.30	1.62	1.73	1.63	1.66	2.12
1997	1.79	2.00	2.20	1.90	2.09	3.17	2.49	2.40	1.79	1.16	1.40	1.65	2.00
1998	1.65	2.01	2.39	1.97	2.41	2.84	2.55	1.89	1.76	1.35	1.45	1.38	1.97
1999	1.55	1.87	2.25	1.83	2.16	2.50	2.30	2.41	2.25	1.56	0.98	1.19	1.91
2000	1.47	1.80	1.67	2.18	2.42	2.52	2.70	2.16	2.09	1.18	1.12	1.21	1.88
2001	1.54	1.39	1.90	1.90	2.59	3.06	2.98	2.06	1.51	1.30	1.10	1.17	1.88
2002	1.43	1.80	1.52	2.11	2.50	2.45	2.26	2.56	1.91	1.19	1.26	1.06	1.84
2003	1.48	1.62	1.76	1.95	2.05	3.00	2.56	2.43	2.01	1.49	1.12	1.42	1.91
2004	1.46	1.52	1.73	2.05	2.27	2.53	2.62	2.55	2.34	1.52	1.00	1.15	1.90
2005	1.36	2.12	1.89	1.56	2.15	2.82	2.56	2.02	1.58	1.70	1.02	1.29	1.84
2006	1.27	1.23	1.77	1.68	2.30	2.12	2.60	2.41	2.21	1.03	1.29	1.34	1.77
2007	1.44	1.68	1.77	2.05	1.88	2.70	2.91	1.91	2.08	1.25	1.56	1.35	1.88
2008	1.55	1.38	1.51	1.69	1.81	2.90	2.20	2.17	1.63	1.30	1.20	1.12	1.70
2009	1.29	1.89	1.62	1.81	2.34	2.31	2.60	2.07	1.87	1.53	1.32	1.15	1.81
2010	1.63	1.70	2.03	2.01	2.39	2.43	2.65	2.05	1.71	1.59	1.30	1.41	1.91
2011	1.58	1.77	2.06	1.66	2.04	2.99	2.36	2.37	2.45	1.06	1.11	1.25	1.89
2012	1.64	2.08	1.92	2.19	2.12	2.69	2.27	1.62	1.94	2.05	2.18	2.29	2.08
2013	2.69	3.18	2.45	2.19	2.17	1.88	2.39	1.92	1.62	1.61	1.48	1.34	2.07

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2014	1.94	2.22	2.16	1.88	2.44	1.95	2.49	2.22	1.69	1.14	1.30	1.72	1.93
2015	2.03	1.65	2.66	2.02	2.51	3.16	2.38	2.11	1.52	1.08	0.95	1.22	1.95
2016	1.45	1.70	2.26	2.56	2.24	2.53	2.75	2.48	1.52	1.18	1.28	1.63	1.97
2017	1.75	1.73	1.89	2.27	2.30	2.77	2.66	2.02	1.66	1.62	1.31	1.40	1.95
2018	1.60	1.54	1.70	2.02	2.39	2.23	2.72	1.91	1.82	1.22	1.21	1.57	1.83
2019	1.65	1.88	2.10	1.85	2.50	2.73	2.78	2.28	1.92	1.35	1.48	1.71	2.02
2020	1.61	1.56	1.86	1.93	2.31	2.45	2.30	2.27	1.62	1.05	1.43	1.17	1.80
2021	1.27	1.35	1.88	1.73	2.23	2.59	2.41	1.99	1.82	1.61	1.23	1.39	1.80
Average	**1.65**	**1.84**	**2.06**	**2.05**	**2.31**	**2.79**	**2.60**	**2.32**	**1.95**	**1.42**	**1.38**	**1.45**	**1.99**

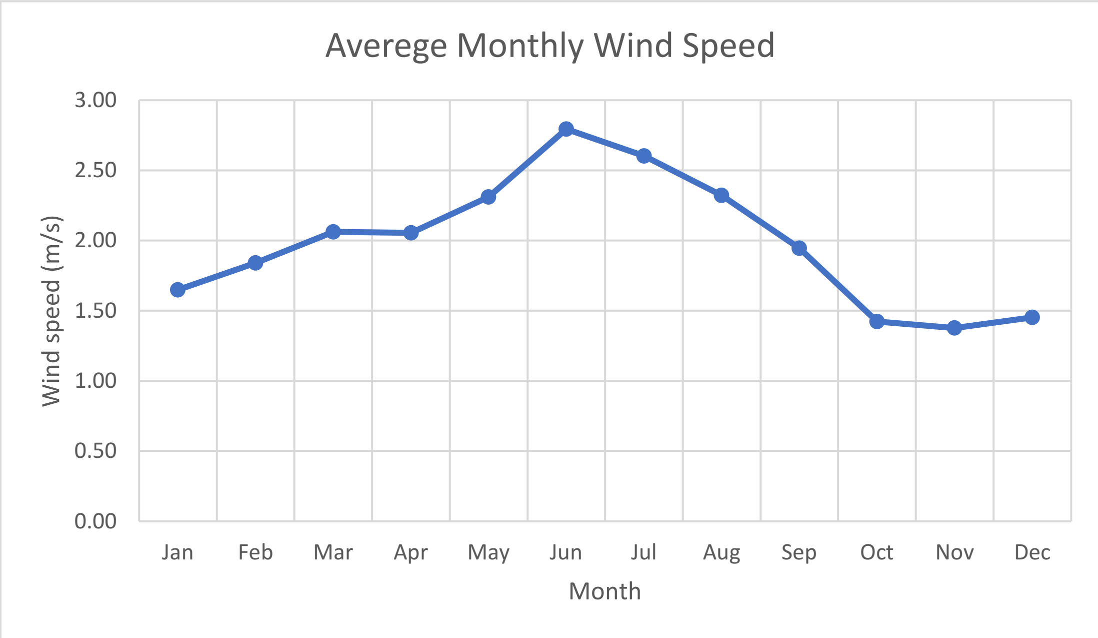


Figure 4.13 Average Monthly wind speed plot

4.2.4.3 Temperature

Temperature data has been collected from NASA POWER LARC for the project location. The data has been collected for a duration of 40 years from year 1981-2021. Average annual maximum and minimum temperature at the project location is around 44° C and 6° C respectively. The average maximum and minimum temperature varies from 27.8° C to 43.1° C and 6.6° C to 25.9° C respectively. The maximum and minimum average monthly temperature from 1981-2021 is presented in Table 4.11 and Table 4.12 respectively and plotted in Figure 4.14

Table 4.11 Maximum Temperature (° C) at the project site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	28.8	35.9	37.1	39.7	41.2	41.6	34.8	33.6	33.8	31.6	30.7	29.1	41.6
1982	30.4	31.7	37.3	40.2	43.0	40.6	40.6	34.6	35.1	36.1	33.1	29.0	43.0
1983	31.0	34.2	40.2	42.9	43.9	46.8	41.7	38.0	36.0	36.0	32.6	29.4	46.8
1984	28.2	32.4	41.5	44.5	43.8	42.1	35.3	35.6	32.4	33.4	31.8	30.3	44.5
1985	31.0	33.7	41.2	44.9	44.0	43.1	37.9	37.6	37.0	36.1	32.2	28.9	44.9
1986	30.5	34.3	43.7	43.7	41.1	43.6	37.8	36.8	36.4	30.8	29.3	27.9	43.7
1987	29.0	35.3	39.9	42.2	43.0	43.1	38.1	34.6	33.7	35.0	34.4	30.1	43.1
1988	29.8	34.7	40.0	43.9	46.3	42.3	37.9	37.6	37.8	37.0	34.5	31.0	46.3
1989	29.0	35.7	40.1	44.2	45.6	41.6	39.1	38.9	39.2	36.4	33.8	31.0	45.6
1990	34.2	32.8	39.5	44.0	42.3	41.9	36.0	36.7	37.3	32.8	35.2	30.1	44.0
1991	31.1	36.9	40.1	43.0	45.8	41.7	39.1	38.7	35.8	32.9	32.5	29.1	45.8
1992	31.1	32.5	42.0	44.9	44.4	42.8	42.7	40.4	39.8	37.2	36.0	29.3	44.9
1993	29.8	36.3	38.5	42.0	44.2	41.6	38.7	37.5	37.8	36.7	33.3	30.8	44.2
1994	31.2	34.4	41.2	42.9	45.4	43.8	38.0	38.9	37.6	37.3	34.5	30.3	45.4
1995	29.1	35.0	41.6	44.8	45.6	43.4	36.7	36.8	36.7	36.0	34.6	28.8	45.6
1996	28.5	34.3	41.5	44.2	45.8	43.3	38.5	36.0	37.6	36.7	35.8	30.3	45.8
1997	28.7	33.6	38.4	40.2	44.2	43.7	34.6	34.6	33.0	31.3	31.1	28.6	44.2
1998	28.0	32.7	36.5	41.2	43.6	45.6	34.6	32.6	33.4	32.8	29.0	25.0	45.6
1999	27.0	34.4	39.7	46.1	43.9	40.9	33.8	32.9	31.9	30.9	30.2	25.4	46.1
2000	28.3	30.1	37.7	43.1	40.1	36.2	35.3	33.2	32.8	32.3	30.1	26.8	43.1
2001	28.6	34.2	39.2	45.0	40.3	37.2	34.5	33.9	32.7	31.7	30.0	24.9	45.0
2002	28.1	33.4	38.4	40.5	44.1	38.4	35.8	33.8	32.8	32.3	28.5	26.3	44.1
2003	27.5	31.6	36.7	41.7	42.5	41.4	35.2	34.4	33.3	31.2	29.2	26.6	42.5
2004	27.3	34.7	41.2	43.8	43.7	38.7	33.2	32.7	32.4	30.8	27.5	25.2	43.8
2005	25.2	34.4	39.2	41.2	43.2	44.7	36.9	34.2	33.5	31.1	27.3	24.4	44.7
2006	25.3	36.5	39.7	42.4	41.1	38.5	34.0	34.2	33.7	32.9	29.5	27.8	42.4
2007	28.8	31.5	39.8	42.0	42.9	42.8	34.6	34.8	32.8	32.6	28.6	24.8	42.9
2008	27.0	30.2	39.3	42.4	41.7	37.4	33.8	35.0	33.2	32.3	29.7	27.7	42.4
2009	29.3	34.7	37.9	42.3	42.6	42.5	36.8	34.4	33.0	32.4	29.3	25.5	42.6
2010	25.7	31.9	41.9	44.3	43.5	41.4	34.7	35.2	33.2	32.3	31.0	27.7	44.3
2011	27.6	33.4	40.3	39.6	39.3	39.7	34.3	34.7	32.7	31.7	27.8	27.0	40.3
2012	26.2	34.6	39.7	42.2	44.9	44.7	36.6	33.8	33.7	32.0	28.8	26.6	44.9
2013	28.2	34.4	39.5	43.4	43.7	36.6	34.1	33.8	33.3	31.2	28.6	25.7	43.7
2014	27.0	30.6	41.2	43.7	45.1	40.9	35.1	33.7	34.2	32.6	30.4	28.0	45.1
2015	29.0	34.7	39.0	39.4	43.4	43.4	35.4	33.8	33.9	33.4	30.6	30.5	43.4
2016	28.7	36.4	39.7	45.0	43.3	42.6	36.1	34.6	32.4	32.8	30.1	27.5	45.0
2017	30.6	35.3	40.5	41.4	39.9	41.3	33.7	33.3	33.7	32.6	29.3	26.6	41.4
2018	24.6	32.7	37.7	39.8	39.1	39.6	34.7	34.2	33.0	33.2	32.8	28.2	39.8
2019	28.6	34.0	39.7	43.2	43.5	40.8	35.8	35.1	33.1	31.2	28.7	25.3	43.5
2020	25.2	29.6	37.0	39.3	40.8	36.1	33.5	34.8	33.3	32.7	29.8	25.6	40.8
2021	26.7	34.9	40.1	42.5	40.2	36.8	34.1	34.2	33.1	32.4	27.2	26.5	42.5
Average	**28.5**	**33.8**	**39.6**	**42.6**	**43.1**	**41.3**	**36.2**	**35.2**	**34.4**	**33.3**	**30.9**	**27.8**	**43.9**

Table 4.12 Minimum Temperature (° C) at the project site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	8.3	9.5	13.9	16.6	23.7	24.8	25.1	25.4	23.5	16.2	11.5	7.7	7.7
1982	7.4	8.9	11.9	19.1	21.9	25.8	25.6	25.2	20.9	19.0	9.8	8.9	7.4
1983	7.3	6.5	14.1	19.4	24.4	27.7	26.3	25.5	24.6	15.8	13.7	7.0	6.5
1984	7.3	7.9	12.1	20.4	22.3	25.6	24.9	25.3	20.1	16.8	11.5	6.5	6.5
1985	8.9	9.3	14.9	20.9	25.0	27.6	25.0	25.3	24.0	17.2	10.5	8.4	8.4
1986	7.0	10.4	14.9	20.6	19.4	25.1	24.4	24.7	22.8	15.7	12.4	7.0	7.0
1987	6.0	11.7	14.9	20.7	21.3	26.1	25.7	24.8	23.2	16.6	9.8	9.1	6.0
1988	7.7	9.5	14.2	17.9	25.0	24.7	26.2	25.2	23.6	19.8	13.5	10.1	7.7
1989	5.4	9.9	11.8	16.3	22.4	26.0	23.5	24.7	24.5	17.1	13.5	7.6	5.4
1990	7.3	10.0	13.0	16.2	25.1	26.1	25.4	25.0	24.3	15.5	11.4	8.6	7.3
1991	7.3	11.5	15.4	19.8	26.2	24.1	26.5	25.9	22.9	17.0	11.1	7.0	7.0
1992	5.9	9.4	13.0	19.8	22.5	25.5	26.0	25.1	22.3	16.5	13.2	9.8	5.9
1993	5.9	9.5	14.3	18.4	25.4	26.2	26.0	24.9	24.5	16.7	11.8	9.5	5.9
1994	7.7	10.8	13.3	21.3	24.0	26.4	26.1	25.9	20.4	17.7	13.7	7.1	7.1
1995	6.6	9.9	13.7	18.7	25.7	26.4	25.8	25.3	23.9	16.9	10.0	8.7	6.6
1996	7.2	7.7	15.6	16.4	22.7	26.6	25.4	24.7	24.3	17.8	10.9	8.2	7.2
1997	7.4	8.0	14.3	18.5	20.6	25.5	25.2	25.1	20.7	16.6	14.6	7.4	7.4
1998	6.0	8.9	11.8	19.0	24.3	27.1	25.8	25.5	23.8	15.7	11.1	7.3	6.0
1999	6.4	8.2	12.8	18.9	24.8	26.0	25.5	23.9	23.6	18.7	10.1	8.4	6.4
2000	5.1	8.1	11.6	18.1	23.7	25.3	25.2	24.8	21.9	15.8	13.3	8.9	5.1
2001	5.6	8.6	14.3	19.6	24.3	25.3	25.7	25.3	23.9	19.0	11.3	7.6	5.6
2002	6.9	7.2	14.1	18.3	23.2	25.7	25.6	24.8	23.0	15.3	13.3	9.0	6.9
2003	4.9	11.1	10.6	19.3	22.0	26.3	25.1	25.8	24.2	18.5	10.9	8.0	4.9
2004	6.7	8.0	12.3	21.5	21.3	26.2	25.1	25.5	22.8	16.2	13.7	5.9	5.9
2005	7.7	7.9	16.3	17.9	23.2	26.6	25.0	25.2	24.0	18.9	12.9	7.1	7.1
2006	6.3	11.6	15.0	19.9	24.1	25.5	25.2	24.6	23.7	17.1	10.3	8.5	6.3
2007	6.8	11.2	12.9	20.8	24.1	26.2	24.5	24.7	23.6	17.3	12.9	6.6	6.6
2008	7.3	6.3	14.8	19.0	25.3	24.7	25.5	25.0	23.4	16.6	11.4	10.4	6.3
2009	8.1	10.2	13.2	19.9	23.8	26.2	26.1	25.0	23.5	15.7	10.0	6.7	6.7
2010	6.4	7.9	15.2	21.3	24.7	26.0	25.1	25.0	21.9	17.1	13.1	6.9	6.4
2011	6.0	10.7	11.5	18.8	22.8	26.2	25.0	24.6	23.2	15.7	12.8	7.0	6.0
2012	6.2	7.2	13.7	21.6	24.5	27.0	25.9	25.4	21.9	14.0	9.1	4.7	4.7
2013	2.5	9.1	13.7	19.6	23.9	25.7	26.1	25.1	23.9	17.2	11.8	7.6	2.5
2014	6.1	8.8	14.1	19.8	24.7	26.2	25.8	25.4	23.3	17.1	11.3	6.6	6.1
2015	6.8	8.0	13.6	20.4	24.5	25.1	25.1	24.9	22.7	18.7	16.7	8.0	6.8
2016	6.7	10.1	18.5	21.0	25.1	26.4	24.8	24.6	24.7	19.1	11.7	8.8	6.7
2017	5.0	11.0	13.1	19.0	23.3	26.5	25.4	24.9	25.1	18.2	10.2	8.3	5.0
2018	5.2	11.2	15.0	21.1	22.6	25.6	26.2	25.2	22.2	17.7	13.9	6.7	5.2
2019	7.4	9.0	11.2	20.3	22.6	26.4	25.5	25.5	23.1	17.9	14.0	4.5	4.5
2020	6.1	7.2	14.3	18.7	22.4	25.6	25.6	25.4	24.5	18.3	10.8	6.2	6.1
2021	6.3	6.9	15.7	19.0	23.4	25.0	25.1	24.9	24.2	16.0	11.9	5.3	5.3
Average	**6.6**	**9.1**	**13.8**	**19.3**	**23.6**	**25.9**	**25.4**	**25.1**	**23.2**	**17.1**	**12.0**	**7.6**	**6.2**

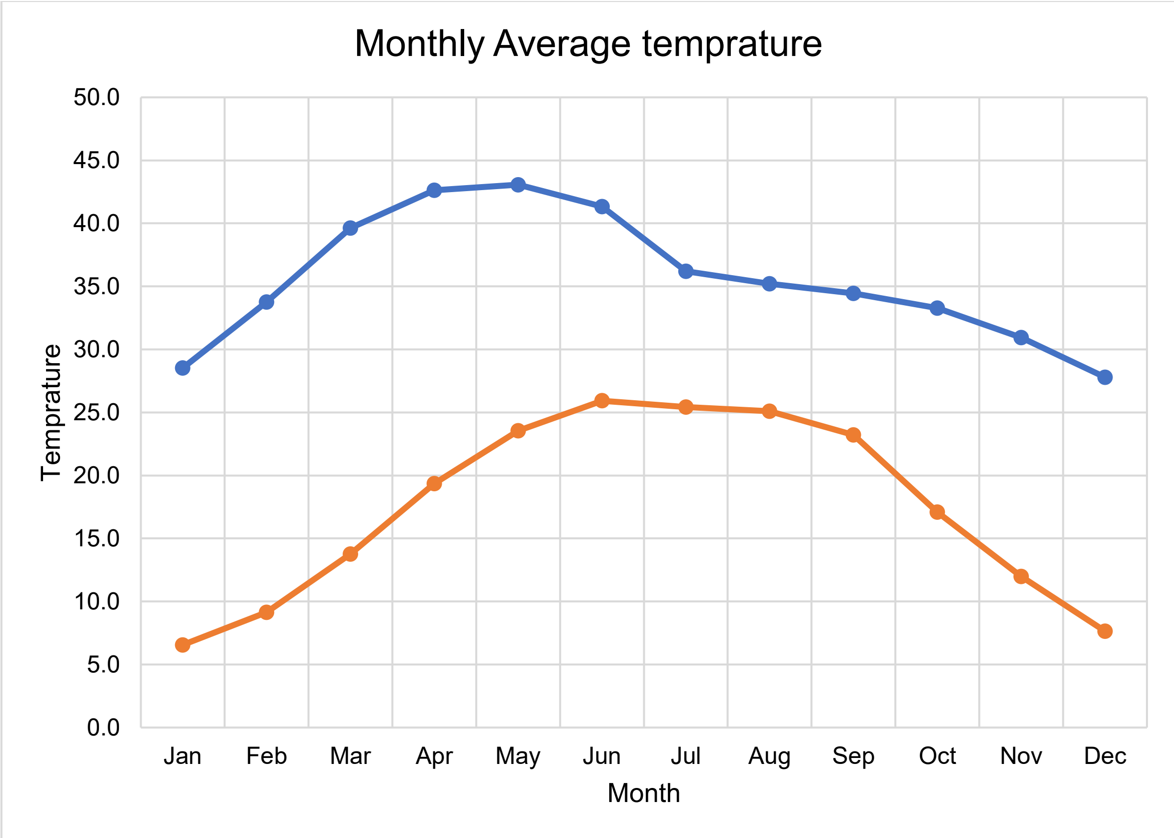


Figure 4.14 Monthly Average Temperature Variation at Project Site

4.2.4.4 Relative Humidity

February and March are driest with relative humidity between 61-40%. The maximum humidity during rainy season is 77% and minimum was 73%. High humidity is found during daytime and low humidity values during night time in all the months Figure 4.15.

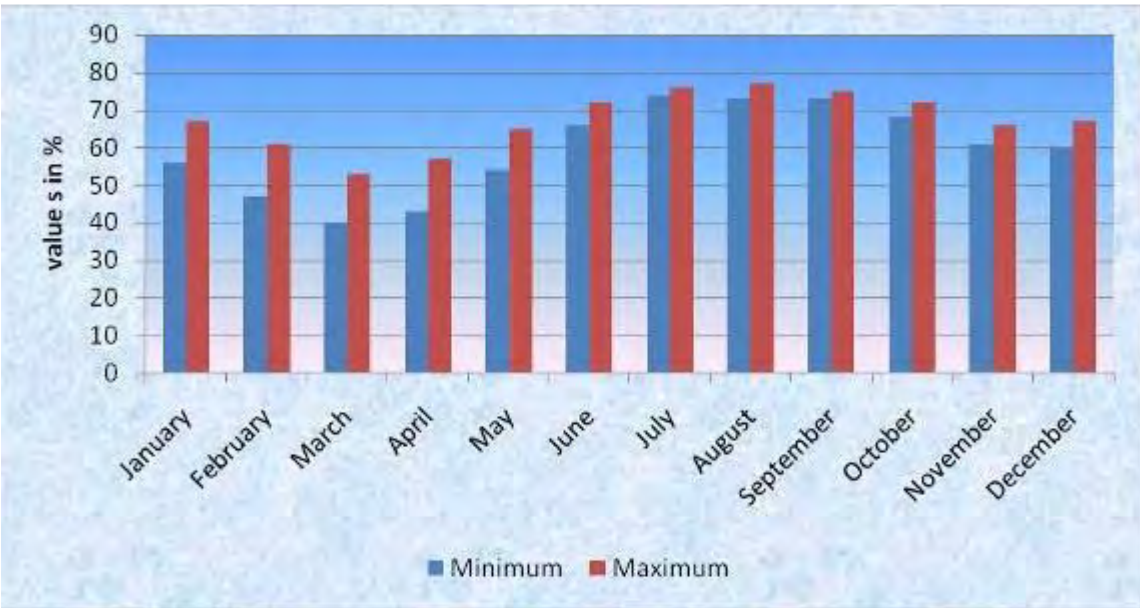


Figure 4.15 Monthly Relative Humidity

4.2.4.5 Calm Periods

The calm period constitutes an important factor in the dispersion of air pollution. The calm period is more during night-time compared to daytime. The maximum calm period occurs during September to February. Monthly calm percentage is shown in Table 4.13.

Table 4.13 Monthly Percentages of Calm Periods

Calm	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Day	33	37	36	19	16	15	23	18	28	41	35	27
Night	42	38	30	25	20	20	32	31	43	63	62	53

(Source-EIA report based on IMD Malda)

4.2.4.6 Cloud Cover

Cloud cover is an important meteorological parameter because it indicates the prevalence of atmospheric stability class. In the study area, clear weather prevails in most of the time during post monsoon, winter and summer seasons. Only during monsoon months of July, August and September, moderate to heavy clouds are observed. Relevant details about the number of days with zero oktas of cloud cover (all clouds) for all months are shown in Table 4.14.

Table 4.14 No. of Days with Zero Oktas of Cloud Cover

Calm	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Day	33	37	36	19	16	15	23	18	28	41	35	27
Night	42	38	30	25	20	20	32	31	43	63	62	53

(Source-EIA report based on IMD Malda)

4.2.4.7 Barometric Pressure

The atmospheric pressure at IMD site Malda (located at about 110 km from project site) ranges between 997.1 to 1013.7 h Pa. The pressure is high in winter months and low in monsoon season.

4.2.4.8 Cyclones

The project site is located in Farakka, West Bengal. As per Cyclone Hazard Prone Map of India (IMD of India) the study area does not fall in Cyclone prone area. Cyclone hazard prone districts map of India based on frequency of total cyclones, total severe cyclones, actual/estimated maximum wind and PMSS associated with the cyclones showing existing Lock gate site is shown in Figure 4.16 Cyclone hazard prone area map showing is shown in Figure 4.17.

Figure 4.16 Cyclone Prone area Map of India (Map of India)

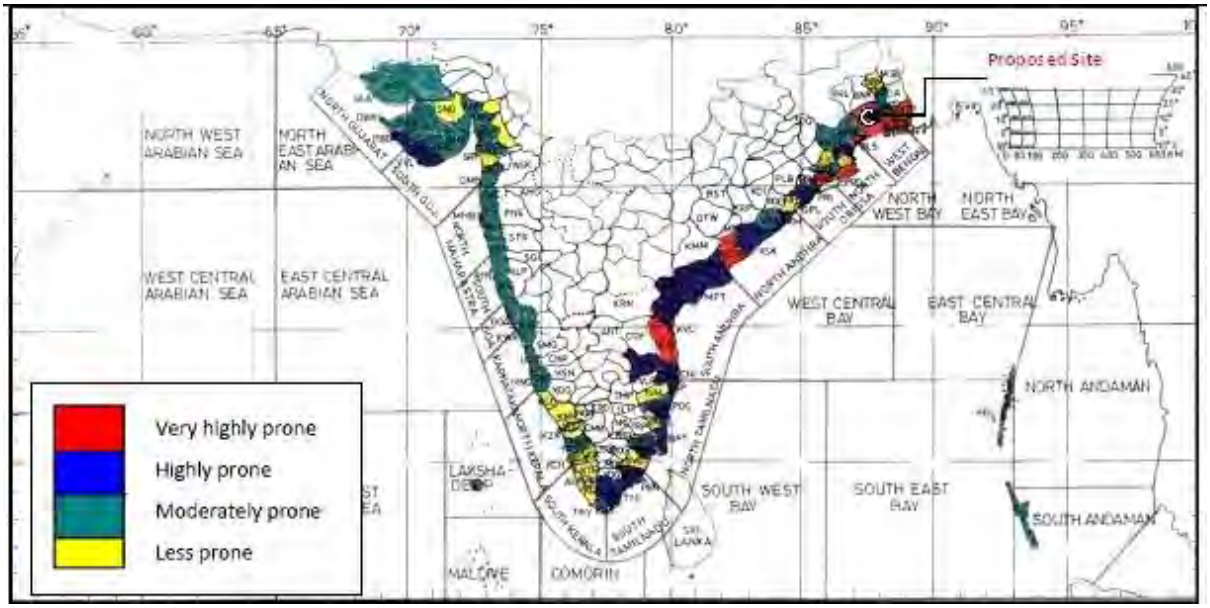


Figure 4.17 Cyclone hazard prone districts of India based on frequency of total cyclones, total severe cyclones, actual/estimated maximum wind and PMSS associated with the Cyclones (*Source: National Disaster Management Authority of India)*

4.2.4.9 Tidal Surges

Tidal surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tides. The lock gate site is located far away from the sea coast; no records of tidal surge are reported in this area.

4.3 Water Environment

4.3.1 Groundwater Quality

Groundwater is the water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations. Groundwater is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formationsof soil, sand and rocks called aquifers.

Ground water samples were collected from one location within 2 km area of the existing lock gate site and were analysed as per protocols given earlier. The water samples were examined for physico-chemical parameters as well as for bacteriological parameters. Samples for chemical analysis were collected in polyethylene carboys. Samples for bacteriological analysis were collected in sterilized bottles. The names of sampling location with coordinates is presented in Table 4.15. Map showing location of the location of surface, and groundwater sampling is given in Figure 4.11. Analysis results of groundwater are presented in Table 4.16.

Table 4.15 Ground water sampling location

Sl. No.	Ground Water Sampling Locations			
	Code	Location	Source	Co-ordinates
1	GW-1	Near Farakka lock site	Borewell	24^0 48‟ 51.1632”N 87^0 54‟ 18.5328”E

Table 4.16 Ground Water Quality at sampling locations

S.No	Name of Test	Test Method	Observed Value	Acceptable Limit (ref: IS 10500:2012)	Permissible Limit (ref: IS 10500:2012)
1	Turbidity, NTU	IS 3025 (P-10); 1984 R.A 2002	0.3	1	5
2	pH	IS 3025 (P-11); 1983 R.A 2002	7.86	6.5-8.5	No relaxation
3	Temperature. °C	IS 3025 (P-9); 1984 R.A 2002	29.4	-	-
4	TDS, mg/L	IS 3025 (P-16); 1984 R.A 2002	123	500	2000
5	Electrical Conductivity, µS/cm	IS 3025 (P-14); 1984 R.A 2002	256	-	-
6	Total Hardness (as CaCO3), mg/L	IS 3025 (P-21); 1984 2009	129.5	200	600
7	Iron, mg/L	IS 3025 (P-53); 2003 R.A 2009	0.01	0.3	No relaxation
8	Chlorides, mg/L	IS 3025 (P-32); 1988 R.A 2007	23.9	250	1000
9	Fluoride, mg/L	IS 3025 (P-60); 2008	1.05	1	1.5
10	Calcium, mg/L	IS 3025 (P-40); 1991 R.A 2003	70.8	75	200
11	Magnesium, mg/L	IS 3025 (P-46); 1994 R.A 2003	14.32	30	100
12	Copper, mg/L	IS 3025 (P-42); 1992 R.A 2003	0.03	0.05	1.5
13	Manganese, mg/L	IS 3025 (P-59); 2006	0.01	0.1	0.3
14	Sulphate, mg/L	IS 3025 (P-24); 1986 R.A 2003	8.2	200	400
15	Nitrate, mg/L	IS 3025 (P-34); 1988 R.A 2003	0.21	45	No relaxation
16	Phenolic Compound (as C6H5OH), mg/L	IS 3025 (P-43); 1992 R.A 2003	<0.001	0.001	0.002
17	Mercury, mg/L	IS 3025 (P-48); 1994 R.A 2003	<0.001	0.001	No relaxation
18	Cadmium, mg/L	IS 3025 (P-41); 1992 R.A 2003	0.002	0.003	No relaxation
19	Arsenic, mg/L	IS 3025 (P-37); 1988 R.A 2003	0.002	0.01	0.05
20	Cyanide, mg/L	IS 3025 (P-27); 1986 R.A 2009	<0.01	0.05	No relaxation
21	Lead, mg/L	IS 3025 (P-47); 1994 R.A 2009	0.004	0.05	No relaxation
22	Zinc, mg/L	IS 3025 (P-49); 1994 R.A 2003	0.12	5	15
23	Chromium (as Cr6+), mg/L	IS 3025 (P-52); 1994 R.A 2003	0.003	0.05	-
24	Nickel, mg/L	IS 3025 (P-54); 2003	0.001	0.02	No relaxation
25	Total Alkalinity (as CaCO3), mg/L	IS 3025 (P-23); 1986 R.A 2003	156	200	600
26	Aluminium, mg/L	IS 3025 (P-55); 2003	0.01	0.03	0.2
27	Total Coliform, Per 100 ml	IS 1622; 1981 R.A 1996	Absent	-	-
28	E.Coli, Per 100 ml	IS 1622; 1981 R.A 1996	Absent	-	-

4.3.1.1 Observation on Ground Water Quality

The Physico-chemical characteristics of the ground water samples were in good agreement with IS: 10500.TDS, all the parameters in all sample of ground water are well within the desirable limits. As regards heavy metals, only Fe and Zn were present but quite lower in concentration whereas the other heavy metals were in traces. Hence, the GW within the impact zone is neither contaminated nor high in any metallic contamination from any natural sources. The ground water can be safely used for drinking purposes after proper filtration.

4.3.2 Surface Water Quality

One sample was collected from surface water bodies present in the study area as per the standard protocol mentioned earlier viz. samples for bacteriological analyses were collected in sterilized bottles. Details of sampling locations are presented in Table 4.17. The water samples were examined for physico-chemical parameters and bacteriological parameters. Samples were analysed for various parameters using the IS 3025 and IS 1622 Criteria. The analysis results of surface water are presented in Table 4.18.

Table 4.17 Surface Water Sampling Locations

S.No.	Code	Location	Source	GPS Coordinates
1	SW-1	Ganga River Upstream of existinglock site	Stream	24^0 48'43.8552"N 87^0 54' 15.3072"E

Table 4.18 Surface Water Quality at sampling location

S.No	Name of Test	Test Method	Observed Value	Limit (ref: IS 2296 Grade D)	Limit (ref:IS 2296 Grade E)
1	Turbidity, NTU	IS 3025 (P-10); 1984 R.A 2002	3		
2	pH	IS 3025 (P-11); 1983 R.A 2002	7.44	8.5	8.5
3	Temperature, °C	IS 3025 (P-9); 1984 R.A 2002	29.3		
4	TDS, mg/L	IS 3025 (P-16); 1984 R.A 2006	309	-	2100
5	Electrical Conductivity, µs/cm	IS 3025 (P-14); 1984 R.A 2002	619	-	-
6	DO, mg/L	IS 3025 (P-38); 1989 R.A 2019	4.6	4	-
7	BOD (3 days), mg/L	IS 3025 (P-44); 1993 R.A 2019	3.4	-	-
8	COD, mg/L	IS 3025 (P-58):2017	40		
9	TSS, mg/L	IS 3025 (P-17):2021	165		

10	Iron, mg/L	IS 3025 (P-53); 2003 R.A 2009	0.02	-	-
11	Chlorides, mg/L	IS 3025 (P-32); 1988 R.A 2007	19.99	-	600
12	Potassium, mg/L	IS 3025 (P-45); 2019	7.5	-	-
13	Sodium, mg/L	IS 3025 (P-45); 2019	32.25	-	-
14	Magnesium, mg/L	IS 3025 (P-46); 1994 R.A 2003	26.5	-	-
15	Oil & Grease	IS 3025 (P-39); 2021	0.001	0.1	-
16	Phosphate	IS 3025 (P-31); 2012	2.53		
17	Copper, mg/L	IS 3025 (P-42); 1992 R.A 2003	0.004	-	-
18	Sulphate, mg/L	IS 3025 (P-24); 1986 R.A 2003	16.78	-	1000
19	Nitrate, mg/L	IS 3025 (P-34); 1988 R.A 2003	1.02	-	-
20	Mercuty, mg/L	IS 3025 (P-48); 1994 R.A 2003	<0.001	-	-
21	Cadmium, mg/L	IS 3025 (P-41); 1992 R.A 2003	0.001	-	-
22	Total Arsenic, mg/L	IS 3025 (P-37); 1988 R.A 2003	0.002	-	-
23	Silica, mg/L	IS 3025 (P-35); 1986 R.A 2009	0.02	-	-
24	Lead, mg/L	IS 3025 (P-47); 1994 R.A 2009	0.004	-	-
25	Zinc, mg/L	IS 3025 (P-49); 1994 R.A 2003	0.003	-	-
26	Chromium (as Cr^{6+}), mg/L	IS 3025 (P-52); 2003	0.004	-	-
27	Nickel, mg/L	IS 3025 (P-54); 2003	0.001	-	-
28	Total Coliform, Per 100 ml	IS 1622; 1981 R.A 1996	2300	-	-
29	Fecal Coliform, Per 100 ml	IS 1622; 1981 R.A 1996	1700	-	-

4.3.2.1 Observation on Surface Water Quality

The river water quality parameters are compared with BDU Criteria of CPCB (**Annexure 3**). The river water quality with respect to pH and DO in Ganga River at the sampling location comply with the Class C of BDU Criteria of CPCB. BOD and COD does not comply with the standards. Fecal Coliform and total Coliform are observed higher than the criteria at both the locations. Heavy metals, only Fe and Zn have been recorded with lower concentration & rest of the heavy metals were in traces. No metal contamination has been found in Ganga water at this location. Pesticides are also found negligible.

Overall, the Ganga water quality near Lock gate site is meeting the Class C of BDU Criteria of CPCB for its suitability for drinking water source after conventional treatment and disinfection.

4.3.3 River Sediment Characteristics

Sediment serves as a habitat for benthic biota (such as insects and clams, which are important in the river water food chain as these are consumed by fish), as both acts as a source as well as a removal mechanism for various contaminants deposited on the sediments. And act as a vehicle for contaminant getting transported downstream. Aquatic biota also is important in the food web of terrestrial organisms, such as fish & other,because these also consumed by people outside and wildlife.

For Analysing the river bed sediment, one sample of river bed sediment sample at random in the adjoining river stretch was collected and analysed as per standard method. The analysis results of riverbed sample are provided in Table 4.19.

Table 4.19 River sediment characteristics at sample location

S.No	Name of Test	Unit	Test Method	Observed Value
1	Texture	-	Soil Manual Govt. Of India; 2011	Silty-Sand
2	pH	-	IS 2720 (P-26);1987	8.51
3	Electrical conductivity	µs/cm	Soil Manual Govt. Of India; 2011	368
4	Cation exchange capacity	meq/100g	IS 2720 (P-24); 1976 R.A 2020	2.12
5	Available Potassium (as K)	mg/kg	Soil Manual Govt. Of India; 2011	91.3
6	Bulk Density (Core Cutter Method)	gm/cc	IS 2720 (P:29)	1.28
7	Available Phosphorous (as P)	mg/kg	Soil Manual Govt. Of India; 2011	39.2
8	Organic Matter	% by mass	IS 2720 (P-22); 1972 R.A 2010	0.49
9	Chromium (as Cr)	mg/kg	Soil Manual Govt. Of India; 2011	<0.01
10	Mercury	µg/kg	Soil Manual Govt. Of India; 2011	<0.01
11	Zink (as Zn)	mg/kg	Soil Manual Govt. Of India; 2011	11.3
12	Copper (as Cu)	mg/kg	Soil Manual Govt. Of India; 2011	<1.0
13	Iron (as Fe)	% by mass	Soil Manual Govt. Of India; 2011	0.046
14	Arsenic (as As)	µg/kg	Soil Manual Govt. Of India; 2011	<0.01

4.3.3.1 Observations on river sediment quality

Physical Characteristics

The physical characteristics examined include texture, and bulk density. Texture and bulk density of soils in the study area is silty sand and 1.28 gm/cm^3, respectively.

Chemical Characteristics

The soil is slightly basic with pH of 8.51. Electrical conductivity (EC) was found 368 µs/cm. Available potassium content in this soils' is 91. mg/kg thereby is indicating that the soils are with medium levels of available potassium content. Available phosphorus content is 32.9 mg/kg thereby indicating that soils are medium in available phosphorus. Cation exchange capacity (CEC) is 2.12 meq/100g. Other micronutrients are also observed in medium range. The overall quality of river sediments within the study area is reasonably good and is not expected to be detrimental to the growth of river ecosystem.

4.4 Air Environment

Air environment is an important component of ESIA report. In this project although there are no air pollution sources during operational phase but during renovation and modernization phase the activities like DG sets, fugitive emissions from various material handing activities may affect not only the ambient air quality but also the river water quality and ecological component due to dust getting settled on the river surface and surface of flora. The base line data collected during field studies is summarized as under.

4.4.1 Selection of Monitoring Stations

One monitoring station was set up to assess the prevailing ambient air quality within the study area. The CPCB guide lines were followed for selection of monitoring station and carrying out the monitoring. However, certain adjustments were incorporated because of local availability of infrastructure/logistics. Typical logistic considerations are ready accessibility to the monitoring site, security, availability of reliable power supply etc. These were examined while finalizing the monitoring location. The monitoring station was located at existing lock gate site. The location of the monitoring stations was based on the dominant wind directions during the monitoring period and the location of sensitive receptor like human habitation.

Ambient air quality monitoring at upwind and downwind locations within the study area was carried out in September 2022. All the ambient air analysis with respect to each parameter were analysed as per IS 5182 guidelines. The AAQ monitoring location is provided in Table 4.20. Ambient Air Quality test results are presented in Table 4.21.

Table 4.20 Ambient Air Quality at Monitoring Locations

Location Code	Name of Location	Distance & Direction from site	Characteristics/Terrain Features	Coordinates
AAQ-1	Lock gate Site	Site	flat terrain, close to the existing lockgate site	24°48’51.8148”N 87°54“18.45”E

Table 4.21 Ambient air quality at monitoring stations

S.No	Name of Test	Unit	Test Method	AAQ-1 Upwind	AAQ-1 Downwind	Limits as per CPCB Notification, 18th Nov, 2009
1	PM_{10}	$\mu g/m^3$	IS 5182 (P-23); 2006	64	67	100
2	$PM_{2.5}$	$\mu g/m^3$	IS 5182 (P-24); 2019	34	35.4	60
3	CO	mg/m^3	IS 5182 (P-10); 1999 R.A 2019	2.13	2.24	4
4	SO_2	$\mu g/m^3$	IS 5182 (P-2);2001	11.2	16.7	80
5	NO_2	$\mu g/m^3$	IS 5182 (P-6);2006	31.8	41.3	80

4.4.2 Observation on Ambient Air Quality

Particulate Matter (PM_{10}): Particulate Matter PM_{10} within study area varies from 64 to 67 µg/m^3. Value of PM_{10} in all locations is within the specified limit of 100 µg/m^3 as per CPCB. The highest level of PM_{10} (67 µg/m^3) is observed. The higher dust levels are because of vehicular pollution and fossil fuel burning in the study area.

Particulate Matter ($PM_{2.5}$): $PM_{2.5}$ levels vary from 34 to 35.4 µg/m^3. All value of $PM_{2.5}$ are within the specified limits (60 µg/m^3) as per CPCB. High values with respect to $PM_{2.5}$ were recorded. The higher dust levels are because of power plant operating in the area and domestic (coal and biomass burning) and vehicle movement.

Sulphur Dioxide (SO_2): SO_2 level is found comparatively low with respect to other pollutants. Background level of SO_2 ranges from 11.2 to 16.7 µg/m^3. The highest levels of SO_2 are found which may be due to vehicular movement.

Oxides of Nitrogen (NO_2): The NO_2 level is found ranging from 31.8 to 41.3 µg/m^3. NO_2 is within the permissible limits of CPCB. The highest levels of NO_2 were found.

Carbon Mono-oxides (CO): CO level is found ranging from 2.13 to 2.24 µg/m^3. Overall, the ambient air quality of the all the two monitoring locations of the study area is meeting the prescribed limits of CPCB.

4.5 Ambient Noise Quality

The noise level was measured at one location. As mentioned earlier in network design table a sound level meter has been used to measure noise levels which give an instant noise reading which are integrated over a given period to give Leq values as A weighted averages. At sampling location, readings were taken at uniform interval of. 5 seconds over a period of 10 minutes per hour for 24 hours period, with further divisions of day and night noise as per CPCB guidelines (between 6.00 A.M to 10.00 P.M and between 10.01 P.M to 5.59 A.M representing day and night period noise levels).

4.5.1 Noise Levels in the Study Area

Ambient noise monitoring was carried out at one location in the study area of the Lock gate site. Noise monitoring locations and results recorded for day time and night time is presented in Table 4.22.

Table 4.22 Ambient Noise Quality in Study Area

S.No	Parameter	Test Method	Observed Value (dB)	Observed Value (dB)	Permissible Sound Level (dB)	Permissible Sound Level (dB)
			Day Time	Night Time	Day Time	Night Time
1	L10	IS 9876; 1981 R.A 2001	57	42	-	-
2	L50	IS 9876; 1981 R.A 2001	51	38	-	-
3	L90	IS 9876; 1981 R.A 2001	39	31	-	-
4	Leq.	IS 9876; 1981 R.A 2001	54.2	40.7	65	55
5	Lmax	IS 9876; 1981 R.A 2001	62	45	-	-
6	Lmin	IS 9876; 1981 R.A 2001	34.5	29	-	-

4.5.2 Observation of Ambient Noise Quality

The ambient noise quality of the study area is within the prescribed National Ambient Noise Quality Standard for respective residential and commercial category at all the monitored locations.

4.6 Biological Environment (Project Site and Zone of 10 km radius)

Ecological studies are one of the important aspects of Environmental Impact Assessment with a view to conserve environmental quality and biodiversity. Ecological systems show complex inter-relationships between biotic and abiotic components including inter dependence, competition and mutualism. Biotic components comprise of both plant and animal communities, which interact not only within and between themselves but also with the abiotic components viz. physical and chemical components of the environment.

Generally, biological communities are good indicators of climatic and edaphic factors. Studies on biological aspects of ecosystems are also important in Environmental Impact Assessment for projecting the health of natural flora and fauna of the region. The biological environment includes terrestrial and aquatic ecosystems. The animal and plant communities co-exist in an eco-balancing manner. Their natural settings can get disturbed by any significant induced anthropological activities or by naturally occurring calamities or disaster. So, once this setting is disturbed, it sometimes is either practically impossible or take a very long time to come back to its original state. Hence changes in the status of flora and fauna are very sensitive components of Environmental Impact Assessment studies. Information on flora and fauna was collected within the study area from Draft EIA report of new navigation lock at Farakka.

4.6.1 Ecological Profile within Impact Zone

The ecology of 10 km zone around the project site focused on the nature of protected forest ecosystem, agrarian ecosystem as well as of aquatic ecosystem of

Ganga River. The status of ecological health of the impact zone is discussed under the following heads:

- Terrestrial Ecology (Flora & Fauna)
- Aquatic Ecology (Flora & Fauna)

4.6.2 Terrestrial Ecology

The terrestrial ecology within the entire impact zone of 10 km radius is discussed as under:

4.6.2.1 Flora of Core Zone

The 2 km area around the Lock gate site represents the core zone. The vegetation within the 2 km radius area of the Lock gate is primarily of agriculture type. No forest is present within 2 kms area. The prevailing vegetation found in the study area represents the commonly found trees and river riparian vegetation with dominance of agricultural fields. Major tree species in core zone comprises of *Azadirachta indica, Delbergia sisoo, Albizia lebback,* Tal (*Borassus flabellifer L*), Krishnachuda (*Caesalpinia Pulcherrima*), Aam (*Mangifera indica L*), *Ficus religiosa*, *Ficus bengalensis etc.* Herb & shrubs species in the study area includes riparian vegetation such as *Xanthium strumarium, Narium indicum, Calotropis procera, Lantana camara, Casia tora, Vitex negundo, Zizyphus mauritiana,* Tulsi (Ocimum sanctum*), Canabis sativa, Parthenium grass* (exotic species), *Argemon maxicana* and few other grasses species.

4.6.2.2 Flora of Buffer zone of 10 km

The terrestrial flora of the buffer zone includes agrarian ecosystem. Agro ecosystem is defined as a spatially and functionally coherent unit of agricultural activity with its living and non-living components along with their interactions. Taad and Khjur trees predominantly spreads all over the impact zone. The flora of this zone is characterized by the arborescent species such as Simul (*Salmali amalabarica*), Neem (*Azadirachta indica*), Amlaki (*Phyllanthus emblica*), Khejur (*Phoenix dactylifera L.*),Tal (*Borassus flabellifer L.*), Bat (*Ficus bengalensis L.*), Asvattha (*Ficus religiosa L.*), *Delbergia sisoo*, Shireesha (*Albizzia lebbek*), Bans (*Bambusa arundinacea*), Arjun (*Terminalia arjuna*), Ber (*Syzygium cumini*) Krishnachura/Gulmohar (*Delonix regia)*, Peacock flower (*Caesalpinia pulcherrim*a), Aam (*Mangifera indica L.*) along with shrubby species such as *Lantana camara*, *Ipomea cornea*, Ghentu or Bhat (Clerodendron infortunatum Gaertn.), *Cassia tora*, *Malabar nut (Adhatoda vasica)*, Tulsi (*Ocimum sanctum*), *Cannabis sativa*, and Dumur (*Ficus hispida L.*) (EIA Report of lock at Farakka, 2015)

Mango and Litchi plantation: In the buffer zone of the study area cultivation of huge Mango and Litchi orchard are found. Photographs showing vegetation of study area is given in Figure 4.18. List of the floral species present in the study area is given in Table 4.23.

Figure 4.18 Type of vegetation in the study area

Table 4.23 List of flora in the study area (Source: EIA Report of lock at Farakka, 2015)

S. No.	Local / Hindi Name	*Botanical name*	Family	Core Zone	Buffer zone
Trees					
1	Acacia/ Sunajhari	*Acacia auriculiformis*	Mimosaceae	+	+
2	Akasmali / Akas nim	*Mellingtonia hortensis*	Bignoniaceae	-	+
3	Arjun	Lockia arjuna	Combretaceae	+	+

4	Amba/Am	*Mangifera indica*	Anacardiaceae	+	+
5	Ambta	*Bauhinia recemosa*	Fabaceae	+	+
6	Amla/ Aunla	*Emblica officinalis*	Euphorbiaceae	-	+
7	Aswatha/Peepal/Osta	*Ficus religiosa*	Moraceae	+	+
8	Babul	*Acacia nilotica*	Mimosaceae	+	+
9	Bara	*Ficus bengalensis*	Moraceae	-	+
10	Bilayati babul	*Prosopis juliflora*	Mimosaceae	+	+
11	Baikan	*Melia azadiratch*	Meliaceae	-	+
12	Barabakulia/Dhoben	*Dalbergia paniculata*	Fabaceae	+	+
13	Barkoli	*Ziziphus mauritiana*	Rhamnaceae	+	+
14	Bel	*Aegle marmelos*	Rutaceae	-	+
14	Chakunda	*Cassia siamea*	Ceasalpinaceae	-	+
15	Debadaru	*Polyalthia longifolia*	Annonaceae	-	+
16	Dhalasiris	*Albizia procera*	Mimosaceae	+	+
17	Eucalyptus/ Nilagiri	*Eucalyptus sp.*	Myrtaceae	+	+
18	Gohira	*Acacia leucophloea*	Mimosaceae	-	+
19	Gulmohar	*Denonix regia*	Fabaceae	+	+
20	Imli	*Tamarandus indica*	Fabaceae	+	+
21	Jamun	*Syzygium cumini*	Myrtaceae	+	+
22	Jungle jalebi	*Pithocelobium dulce*	Fabaceae	+	+
23	Kachnar	*Bauhinia variegata*	Fabaceae	+	+
24	Kadamb	*Mitragyna parvifolia*	Rubiacaea	+	+
25	Kalasiris	*Albizia lebbeck*	Mimosaceae	+	+
26	Karanja/kanji	*Pongamia pinnata*	Fabaceae	+	+
27	Kathabadam	*Lockia catappa*	Combretaceae	-	+
28	Litchi	*Lichi chinensis*	Sapindaceae	-	+
29	Mahanimba	*Ailanthus excelsa*	Simarubaceae	-	+
30	Neem/Limbo	*Azadirachta indica*	Meliaceae	+	+
31	Nimbu	*Citrus aurantifolia*	Citraceae	-	+
32	Oau	*Dillenia indica*	Dilleniaceae	-	+
33	Panas	*Artocarpus integrifolia*	Moraceae	-	+
34	Palas	Butea monosperma	Fabaceae	-	+
35	Radhachuda	*Peltophorum ferrutgineum*	Caesalpiniaceae	+	+
36	Saguan	*Tectona grandis*	Verbenaceae	+	+
37	Sajana	*Moringa oleifera*	Moringaceae	-	+
38	Sahtut	*Morus alba*	Moraceae	-	+
39	Simal/Simili	*Bombax ceiba*	Bombacaceae	+	+
40	Sissoo	*Dalbergia sissoo*	Fabaceae	+	+
41	Shishum	*Dalbergia latifolia*	Fabaceae	+	+
42	Amaltas	*Cassia fistula*	Caesalpinaceae	-	+
43	Tala/Tad	*Borassus flabelliformis*	Palmae/Arecaceae	+	+
45	Nariyal	*Cocus nucifera*	Palmae/Arecaceae	-	+

Bamboo					
46	Dababans/kantabans	*Bambusa arundinacea*	Poaceae	+	+
47	Salia/Hill bamboo	*Dendrocalamus strictus*	Poaceae	-	+
Shrubs / Herbs					
48	Amiri/ Raipani	*Ipomea fistula*	Acanthaceae	-	+
49	Ankarati	*Solanum xanthocarpum*	Solanaceae	+	+
50	Arakha	*Calotropis gigantean*	Asclepiaceae	+	+
51	Aragha	*Adhathoda vasica*	Convolvulaceae	-	+
52	Ratanjot	*Jatropha gossypifolia*	Euphorbiaceae	-	+
53	Bankadaii	*Musa sapientum*	Musaceae	-	+
54	Bankhajuri/Pinokhajuri	*Phoenix sylvestris*	Palmaceae	+	+
55	Begunia	*Vitex negundo*	Verbenaceae	+	+
56	Bisalyakarani	*Tridax procumbens*	Asteraceae	-	+
57	Dumar	*Ficus hispida*	Moraceae	+	+
58	Kaner	*Narium indicum*	Apocynaceae	+	+
59	Iswarjata	*Celosia cristata*	Amaranthaceae	-	+
60	Lantana/Bholupadi	*Lantana camara*	Verbenaceae	+	+
61	Mayurachulia	*Celosia argenta*	Amaranthaceae	-	+
62	Tulsi	*Ocimum sanctum*	Lamiaceae	+	+
63	Ak /madar	*Calatropis prosara*	Asclepiadaceae	+	+
64	Kantaber	*Zizyphus numilaria*	Rhamnaceae	+	+
65	Kathaneem /gandhela	*Murraya koenigii*	Rutaceae	-	+
66	Jharberi	*Zizuphus marutiana*	Rhamnaceae	+	+
67	Neel /basanta	*Indigofera hirsuta*	Fabaceae	-	+
68	Pavar /pakavad	*Cassia tora*	Fabaceae	+	+
69	Bhang	*Cannabis sativa*	Cannabaceae	+	+
70	Bhant	*Clerodendron viscosum*	Verbenaceae	+	+
Grasses					
72	Dhanidhana	*Nyctynthes arbortristris*	Harsingar /siharu	+	+
73	Dhanwantary/Khara	*Cymbopogon martini*	Poaceae	+	+
74	Duba	*Cynodon dactylon*	Poaceae	+	+
75	Keuti	*Cyperus corymbosis*	Cyperaceae	+	+
76	Panighasa	*Eragrostis japonica*	Poaceae	+	+
77	Sinkhola	*Heteropogon contortus*	Poaceae	_	+

Note: + denotes present and – denotes absent

4.6.2.3 Protected Areas

There is no National Park, Wild life sanctuary, Biosphere reserve, Wetland under Ramsar Convention and Wild life reserve area present within 10-km radius zone. No reserved or protected forest area exists within the core zone.

4.6.2.4 Rare/Endangered/Threatened (RET) Plant Species

The secondary information as well as observations on the floral species present has been cross-checked with the typology given in Red Data book published by Botanical Survey of India. No extinct, endangered, vulnerable, rare and/or critical floral species has been found within the entire impact zone including buffer zone.

4.6.3 Status of Fauna:

The existing Lock gate site is located at Goraipada village of Farakka. There are no national park(s), Wildlife sanctuary, Elephant/Tiger/Wildlife Reserve or Wildlife corridor present within 10 km radius study area. No significant wildlife has been observed in the study area. The other observations on faunal species within the designated impact zone are given in following sections.

4.6.3.1 Fauna in Core Zone (2km Zone)

No Reserved/Protected or any other forest land are present within 2 km area from the lock gate site. The land use of 2 km area is primarily for agriculture, settlement and/or for roads. Due to absence of any forest or wildlife habitat in this zone, the fauna diversity is confined to common mammal, amphibian and reptile species. Few birds were spotted during the visit in this zone. Details of the faunal species as observed are given at Table 4.24 and Table 4.25.

Table 4.24 Mammals Observed within the Core Zone (Source: EIA Report of lock at Farakka, 2015)

S.No.	Local Name	Common Name	Scientific Name	Feeding Status	Schedule
1.	Gilahri	Striped s squirrel	*Funambulus pennant*	H	IV
2.	Chuha	Field rat	*Bandicota bangalonsis*	H	V
3.	Nevala	Mongoose	*Herpestes edwardsi*	C	IV

H – Herbivorous, C – Carnivorous, O – Omnivorous

Table 4.25 Amphibians and Reptiles Observed within Core Zone (Source: EIA Report of lock at Farakka, 2015)

S.No.	Common Name	Scientific Name	Vernacular Name	Family	Feeding Status	Schedule
Amphibians						
1	Frog	*Rana tigrina*	-	-	C	IV
Reptiles						
1	Binocellate Cobra	*Naja naja*	Nag	Elapidae	C	II
2	Common Krait	*Bungarus coeruleus*	-	Elapidae	C	IV
3	Rat snake	*Ptyas mucosus*	Dhaman	Colubridae	C	II

C – Carnivorous

Avifauna: The common avifauna found within 2 km area is jungle crow, house crow, commonbabbler, red-vented babul, robin, black drongo, common mayna, pied myna, house sparrow, India cuckoo, koel, parakeet, bee-eater, kingfisher, hornbill, hoopoe, owl, and dove duck, lapwing, and several varieties of egret and heron. (EIA Report of lock at Farakka, 2015)

4.6.3.2 Fauna in Buffer Zone (10 Kms Zone)

As mentioned, there is no forest present in the buffer zone also. Wildlife of this zone is confined to commonly found mammals comprising of Langur, Nevla, Porcupine etc. Poisonous snakes are found very common which include various kinds of cobra, krait and the deadly Russell's vipers. The faunal species observed in the study area are listed in Table 4.26.

Table 4.26 List of the Mammals observed in Buffer Zone (Source: EIA Report of lock at Farakka, 2015)

S. No	Scientific Name	Common Name	Schedule as per WPA (1972)
Amphibians			
1	*Rana tigriana*	Common frog	Sch-IV
2	*Bufo melanosticus*	Toad	Sch-IV
Reptiles			
3	*Calotes versicolor*	Common garden Lizard	Sch-IV
4	*Chamaleon zeylanicus*	Indian Chameleon	Part-II of Sch-II
5	*Bangarus sp.*	Krait	Sch-II
6	*Najanaja*	Indian Cobra	Sch-IV
7	*Vipera sp.*	Russels viper	Part-II of Sch-II
Mammals			
8	*Rattus ratus*	Rat	Sch-V
9	*Lepus nigricollis*	Hare	Sch-IV
10	*Presbytis entellus*	Langur	Part-I of Sch-II
11	*Funambulus palmarum*	Squirrel	Sch-V
12	*Rattus norvegicus*	Field mouse	Sch-V
13	*Rhinolopus sp.*	Bat	Sch-V
14	*Vulpus bengalensis*	Fox	Part-II of Sch-II
15	*Herpestes edwardsi*	Mangoose	Sch –IV
16	*Felis chaus*	JungliBilli	Sch-II
17	*Hystrix indica*	Indian Porcupine	Sch-IV
18	*Funambulus pennant*	Squirrel	Sch-IV

4.6.3.3 Avifauna Within Buffer Area (10 kms Zone)

Avifauna is an important part of the ecosystem playing various roles as scavengers, pollinators, predators of insect, pest, etc. They are also one of the bio- indicators of prevailing eco-balance in the zone which is affected by urbanization, industrialization process due to human interference. They can also be used as sensitive indicators of pollution and imbalance caused to the ecosystem. The common avifauna of the study area include jungle crow, house crow, common babbler, red-vented babul, robin, black drongo, weaver bird, common mayna, pied mayna, house sparrow, India cuckoo, koel, parakeet, bee-eater, kingfisher, hornbill, hoopoe, owl, pariah kite, pigeon and dove duck, lapwing, along with several varieties of egret and heron.

Farakka is a very important bird area and various migratory birds visit this area during Winters.

Important Bird Area: The Farakka Barrage and adjoining area on Ganges River is a majorwintering site for many of migratory water birds and has been designated as an Important Bird Area (IBA) by Bird Life International (Islam & Rahmani 2004). Some of the rarer visitors to Farakka Barrage are Y*thya baeri* (Baer's Pochard), *Aythya fuligula* (Tufted Duck), Dendrocygna bicolor (Fulvous Whistling-Duck), Gyps bengalensis (White-rumped Vulture), Gyps indicus (Indian Vulture), Leptoptilos javanicus (Lesser Adjutant) and Rynchops albicollis (Indian Skimmer). Complete list of birds visiting the Farakka barrage and surroundings with their conservation status is highlighted in Table 4.27. (EIA Report of lock at Farakka, 2015)

Table 4.27 List of the Birds Visiting Farakka Barrage and Surrounding Areas (Source: EIA Report of lock at Farakka, 2015)

S. No.	Common name and Scientific name		Status	IUCN status
1.	Great Cormorant	*Phalacrocorax carbo*	RM	LC
2.	Little Cormorant	*Phalacrocorax niger*	RM	LC
3.	Indian Shag	*Phalacrocorax fuscicollis*	RM	LC
4.	Darter or Snake Bird	*Anhinga melanogaster*	RM	NT
5.	White-bellied Heron	*Ardea insignis*	R	CR
6.	Goliath Heron	*Ardea goliath*	R	LC
7.	Purple Heron	*Ardea purpurea*	R	LC
8.	Black-crowned Night-Heron	*Nycticorax nycticorax*	R	LC
9.	Indian Pond Heron	*Ardeola grayii*	RM	LC
10.	Cattle Erget	*Bubulcus ibis*	RM	LC
11.	Little Erget	*Egretta garzetta*	RM	LC
12.	Large Erget	*Casmerodius albus*	RM	LC
13.	Median Erget	*Mesophoyx intermedia*	RM	LC
14.	Lesser Adjutant -Stork	*Leptoptilos javanicus*	RM	VU
15.	Asian Openbill-Stork	*Anastomus oscitans*	RM	LC
16.	Black-necked Stork	*Ephippiorhynchus asiaticus*	R	NT
17.	Glossy Ibis	*Plegadis falcinellus*	R	LC
18.	Oriental White Ibis	*Threskiornis melanocephalus*	R	NT
19.	Lesser Whistling- Duck	*Dendrocygna javanica*	R	LC

20.	Large Whistling- Duck	*Dendrocygna bicolor*	R	LC
21.	Greylag Goose	*Anser anser*	M	LC
22.	Gadwall	*Anas strepera*	M	LC
23.	Garganey	*Anas querquedula*	M	LC
24.	Eurasian Wigeon	*Anas penelope*	M	LC
25.	Spot-billed Duck	*Anas poecilorhyncha*	RM	LC
26.	Ferruginous Pochard	*Aythya nyroca*	R	NT
27.	Red-crested Pochard	*Netta rufina*	M	LC
28.	Common Pochard	*Aythya ferina*	R	LC
29.	Tufted Pochard	*Athyra fuligula*	M	LC
30.	Baer‟s Pochard	*Aythya baeri*	M	CR
31.	Mallard	*Anas platyrhynchos*	M	LC
32.	Greater Spotted Eagle	*Aquila clanga*	R	VU
33.	White-breasted Waterhen	*Amaurornis phoenicurus*	R	LC
34.	Purple Swamphen	*Porphyrio porphyrio*	R	LC
35.	Eurasian Coot	*Fulica atra*	M	LC
36.	Common Kingfisher	*Alcedo atthis*	RM	LC
37.	White-breasted Kingfisher	*Halcyon smyrnensis*	R	LC
38.	Lesser Pied Kingfisher	*Ceryle rudius*	R	LC
39.	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	M	LC
40.	Bronze-winged Jacana	*Metopidius indicus*	M	LC
41.	Greater Painted-Snipe	*Rostratula benghalensis*	RM	LC
42.	Marsh Sandpiper	*Tringa stagnatilis*	M	LC
43.	Gery-headed Lapwing	*Vanellus cinereus*	M	LC
44.	Black-winged Stilt	*Himantopus himantopus*	R	LC
45.	Black-bellied Tern	*Sterna acuticauda*	R	EN
46.	Gull-billed Tern	*Gelochelidon nilotica*	RM	LC
47.	Common Myna	*Acridotheres tristis*	R	LC
48.	Bank Myna	*Acridotheres ginginianus*	R	LC
49.	Jungle Myna	*Acridotheres fuscus*	R	LC
50.	Asian Pied Starling	*Sturnus contra*	R	LC
51.	Red-vented Bulbul	*Pycnonotus cafer*	R	LC
52.	Black Drongo	*Dicrurus macrocercus*	R	LC
53.	Brown Shrike	*Lanius cristatus*	M	LC
54.	Great-Grey Shrike	*Lanius excubitor*	RM	LC
55.	Paddyfield Pipit	*Anthus rufulus*	R	LC
56.	White Wagtail	*Motacilla alba*	RM	LC

Status: R - Resident; RM - Resident migratory; M - Migratory. IUCN status: LC- Least Critical, CR - Critically Endangered; EN - Endangered; VU - Vulnerable; NT - Near Threatened.

4.6.3.4 Rare/Endangered/Threatened (RET) Fauna

As per secondary data available and observed faunal species, no extinct, endangered, vulnerable, rare and/or critical mammal, reptile, amphibian etc. species is found in the core zone or even in buffer impact zone. However, being an important bird area, some migratory birds classified under endangered, vulnerable and critically endangered criteria has been recorded for Farakka barrage and its surroundings.

4.6.4 Aquatic Ecology

At the existing lock, Ganga water transparency recorded was 32cm, temperature recoded was 28.2^{0}C, depth recorded was about 4 m wand velocity recorded was 0.50 m/s near the lock site. Aquatic ecology of the canal is described below.

4.6.4.1 Aquatic Flora

Water quality parameters such as temperature, pH, turbidity, transparency etc influence the aquatic ecosystem. There are several aquatic floral species in the riparian zone and in aquatic habitat near the channel. Phytoplankton are the dominant diversity represents the aquatic planktons in the10 radius of Farakka Lock. Phytoplankton identified under the microscope with the reference of standard book of Edmondson. Bacillariophyceae (diatoms) dominated having maximum abundance as compared to Chlorophyceae and process of photosynthesis in aquatic ecosystem and act as primary producers. The list of phytoplankton observed within 500-meter radius of Farakka lock is given in Table 4.28.

The main species of Phytoplankton found at Farakka Lock were *Achnathes, Bacillaria, Caratoneis, fragillaria, Navicula, Frustulia, diatoma, diatomella, cymbella, Actinastrum, Chlamydomonas, Chlorella, Closterium, Tetracylus, Anabaeana, Ocillatoria, Microcystis* etc. (EIA Report of lock at Farakka, 2015)

Table 4.28 Phytoplankton of Ganga River at 10km stretch of Farakka, West Bengal (Source: EIA Report of lock at Farakka, 2015)

S.N.	***Taxa***	**Ganga River canal upstream of Lock Site**	**Ganga River canal downstream of Lock Site**
Bacillariophyceae			
1.	*Amphora sp.*	+	-
2.	*Amphipleura*	+	+
3.	*Achnanthes sp.*	+	+
4.	*Asterionella sp.*	+	-
5.	*Bacillaria sp.*	+	+
6.	*Biddulphia sp.*	+	+
7.	*Brebissonia sp.*	+	+
8.	*Ceratoneis sp.*	-	+
9.	*Coconeis sp.*	+	+
10.	*Cymatopleura sp.*	+	+
11.	*Cymbella sp.*	+	+
12.	*Denticula sp.*	+	+
13.	*Diatoma sp.*	+	+
14.	*Diatomella sp.*	+	+
15.	*Epithelmia sp.*	+	-
16.	*Fragilaria sp.*	+	+
17.	*Frustulia sp.*	+	+
18.	*Gomphoneis sp.*	-	+
19.	*Gomphonema sp.*	+	+
20.	*Gyrosigma sp.*	+	+
21.	*Hantzchia sp.*	+	+
22.	*Melosira sp.*	+	+
23.	*Meridian sp.*	+	+
24.	*Navicula sp.*	-	+
25.	*Nedium sp.*	+	+
26.	*Nitzschia sp.*	+	+
27.	*Tetracylus sp.*	+	-
Chlorophyceae			
28.	*Actinastrum sp.*	+	+
29.	*Chlamydomonas sp.*	-	+
30.	*Chlorella* sp	+	+
31.	*Chlorococium sp.*	+	+
32.	*Cladophora sp.*	+	-
33.	*Closterium sp.*	+	+
34.	*Coelastrum sp.*	+	+
35.	*Oedogonium sp.*	+	+
36.	*Pandorina sp.*	+	+
37.	*Mesotaenium*sp	-	+
38.	*Stigeclonium*sp	+	-
39.	*Tetradesmus*sp	+	+
40.	*Rhizoclonium*sp	+	+

Cyanophyceae			
41.	*Spirulina sp*	-	+
42.	*Rivularia sp.*	+	+
43.	*Schizothrix sp.*	-	+
44.	*Oscillatoria sp.*	+	+
45.	*Anabaena sp .*	+	+
46.	*Microcystis sp.*	+	+

4.6.4.2 Aquatic Fauna

Aquatic fauna can be categorized as asprotozoa, cladocera, annelids, Mollusca, larvae of insects, copepods, rotifers, fishes and mammals. Protozoans and rotifer dominated over other groups of zooplankton. Every species has its own importance in aquatic ecosystem. Some organisms act as primary consumer and transfer the energy from one trophic level to apex level and others act as scavenger and/or as carnivores consuming the produced material. Importance fish species of Ganga River adjoining Farakka are rita, catla, mystus, masta cembelus, labeo. These species are having the commercial importance within the Farakka region.

4.6.4.3 Zooplankton

Zooplankton are heterotrophic and this word is derived from the Greek Word Zoon meaning "animal", these are usually these are microscopic and motile organism usually present on the surface of water and are considered as primary consumer in aquatic ecosystem and feeds on phytoplankton. The zooplankton diversity of upwards and downwards existing Farakka Lock is given below in Table 4.29.

The most common Zooplankton of Ganga River canal at Farakka Lock were *Arcella, Difflugia, Noctiluca, Paramecium, Vorticella, Brachionus, Filinia, Keratella, Lecane, Nothlca, Rotaria, Cyclops, Bosmia, Chydorus, Daphnia, Moina. (*EIA Report of lock at Farakka, 2015)

Table 4.29 Zooplankton of Ganga River canal at Farakka Lock, West Bengal (Source: EIA Report of lock at Farakka, 2015)

Zooplanktons		Ganga River canal upstream of Lock Site	Ganga River canal downstream of Lock Site
Protozoa			
1.	*Arcella*sp .	+	+
2.	*Chilodonella*sp .	+	+
3.	*Difflugii*asp.	+	+
4.	*Globigerina* sp.	+	+
5.	*Noctiluca*sp .	+	+
6.	*Paramecium* sp .	+	+
7.	*Sphenoderia*sp	+	+
8.	*Vorticella* sp		
Rotifera			
9.	*Brachionus*sp.	+	+
10.	*Filinia*sp.	+	+
11.	*Horaella*sp.	+	+
12.	*Keratella*sp .	+	+
13.	*Lecane*sp.	+	+
14.	*Notholca*sp.	+	+
15.	*Rotaria*sp.	+	+
16.	*Testudinellasp*	+	+
Copepoda			
17.	*Cyclops sp.*	+	+
18.	*Nauplii*	+	+
Cladocera			
19.	*Bosmina*sp	+	+
20.	*Ceriodaphnia*sp.	+	+
21.	*Cydorus*sp.	+	-
22.	*Daphnia* sp.	+	+
23.	*Diphanosoma*sp.	+	+
24.	*Moina*sp	-	+
25.	*Simocephalus*sp	+	+

4.6.4.4 Benthos:

Habitat of Benthos in the river is aphotic zone or benthic zone. Aphotic zone of the aquatic ecosystem is zone where sunlight is completely absent. These are depending on sediments and they take the nutrients for their survival from sediments. Benthos found within 10 Km stretch (upwards and downwards) of River from Farakka Lock site is given below in Table 4.30.

The most common Benthos of Ganga River canal at Farakka Lock were *Gabbia sp. Bellamya sp. Lymnaeasp, Belostomaindica* and *Cybister confuses.* (EIA Report of lock at Farakka, 2015)

Table 4.30 Benthos of Ganga River canal at Farakka Lock, West Bengal (Source: EIA Report of lock at Farakka, 2015)

S. No.	Benthos	Ganga River canal upstream of Lock Site	Ganga River canal downstream of Lock Site
1.	*Limnodrilus hoffmeisteri* [oligochaeta]	+	+
2.	Nephtys sp.	+	+
3.	May fly nymphs [insectaEphemeroptera]	+	-
4.	Odonate nymphs [odonata]	+	+
5.	Corixidae [Hemiptera]	+	-
6.	*Anisopssardea* [Hemiptera; Notonecitidae]	+	+
7.	*Ranatrafiliformis* [Hemiptera; nepidae]	+	+
8.	*Diplonychus annulatum*	+	+
9.	*Belostoma indica* [Hemiptera; Belostomatidae]	+	+
10.	*Cybister confuses* Predaceous diving beetle [Coleoptera; Dytiscidae]	-	+
11.	*Orectocheilusgangeticus* [Coleoptera;Gyrinidae]	+	+
12.	*Hydrophilusolivaceous* [Coleoptera; Hydrophilidae]	+	+
13.	Chironomidae [Diptera; Chironomidae]	+	+
14.	*Nepa sp.*	-	-
15.	*Novaculinagangetica* [Pelecypoda; Lamellibranchiata]	+	+
16.	*Parreysiafavidens* [Pelecypoda; Lamellibranchiata]	+	+
17.	*Lamellidensmarginalis* [Pelecypoda; Lamellibranchiata]	+	+
18.	*Bellamyasp .*	+	+
19.	*Gabbiasp .*	+	+
20.	*Lymnaeasp .*	-	+
21.	*Thiaria sp.*	+	-

4.6.4.5 Mangroves:

Mangrove is type of forest which is the home of small and large height of various types of shrubs /trees. In India presently five mangroves namely Sundarban, Bhitarkanika in Odisha, Godavari Krishna in Andhra Pradesh, Pichavaram near Chidamvaram in Tamil Nadu and Bharatang island at located at Great Andaman and Nicobar Island mangroves are present. No mangrove found in the riparian area of Farakka Lock at 500-meter radius.

4.6.4.6 Marshes:

A marsh is a wetland that is dominated by herbaceous rather than woody plant species. Marshes can often be found at the edges of lakes and streams, where they form a transition between the aquatic and terrestrial ecosystems. No marshes are found in the riparian area of Farakka Lock at 500-meter radius.

4.6.4.7 Endangered Species:

Endangered species is a species which has been categorized by the International Union for Conservation of Nature (IUCN). Some authors and local people of the area reported that *Platanista gangetica* (Gangetic Dolphins) are found in this region before Farakka Barrage construction. However Gangetic Dolphins are not present in the river stretch where Farakka Lock is located. Therefore, there is no endangered species found in the activity area.

4.6.4.8 Details of fisheries and Zooplankton and Phytoplankton

Fishes are important resource for humans worldwide, especially as food. Fish have role in culture through the ages, serving as, religious symbols etc. Fish interrelate with their environment in complex habits. To avoid direct competition for food and space in rivers, species have become specialized during millions of years of evolution. Fishes feed on a variety of food items, depending on where they live, their behaviour, and the size and shape of the mouth. These adaptations enable some fishes to feed on small, microscopic organisms, and others to eat large prey. Types of feeding behaviour can be described by three general terms. An omnivore eats any available food item, including insects, other fish, plants, seeds and algae. A piscivore is adapted to eat mostly other fish. Planktivores feed on small microscopic food organisms floating in the water. Bottom feeders are effective vacuum cleaners that take their food from bottom sediment, rocks, plants, logs, and water. They locate their food by touch, taste, and sight. Some of the items eaten are aquatic insects, small snails, clams, algae, and microscopic animals. Surface feeders commonly eat flying insects at the water's surface. These insects include immature aquatic stages that are changing to the flying adult stage, as well as land insects that fall into the water. Filter feeders sieve small microscopic animals (zooplankton) or small microscopic plants (phytoplankton) living in the water. These small organisms are common in the river and provide an easy food source for fishes equipped to collect them. Small prey opportunistic feeders frequently eat any small animals that are easily captured; these commonly include immature stages of aquatic insects, such as stoneflies, mayflies, dragonflies, damselflies, and flies. Other organisms in the diet include scuds, crayfish, water fleas, and small fish. Large prey opportunistic feeders eat a variety of crayfish, mature and immature aquatic insects, fish, and microscopic animals. The eggs and young (larvae) of fish are adapted to survive in certain regions. Fish spawn in areas with certain features that help to meet the needs of their eggs and larvae. One important factor for survival is oxygen. Adult fish absorb oxygen from water through their gills but fish eggs and young are sensitive to low oxygen in the surrounding water. Some species are adapted to living in low concentrations of oxygen and their young can live in protected backwater areas with muddy or silty bottoms and little current. On the basis of our observation fishes lays their eggs in Open water, Sand, roots over sand, Rocks, gravel, mussel beds and flowing waters, Rocks, gravel, and limited flow Submerged aquatic plants, Shrubs and logs. The fishes are important for the socio-economic growth of the society in concern area. The various types of fishes have been use commercially.

The most important commercial fishes of Ganga at Farakka are *Labeo* sp., *Catla catla*, *Notopterus* sp., *Hilsa* sp., *Rita rita*, *Clarias* sp., *Mystu*s sp., *Osteobram*a sp., *Chandanama*, *Puntius* sp., *Heteropneustes fossilis*, *Cyprinus carpio*, *Cyrhinus mrigala*, *Wallago attu*, etc. (EIA Report of lock at Farakka, 2015)

Plankton is the name given to any organism in the ocean that is unable to swim against a current. The name phytoplankton is given to plankton which is capable of harvesting the sun energy in a process called photosynthesis. Plankton is a word derived from Greek for “drifters”. It refers to all the plants and animals that drift with the water currents as inhabitants of the open waters. Only physical objects that can remain near the surface without floating are living organisms. For living plants and animals, there are only a few ways to remain near the surface in safety. This is because in open water there is no cover, no trees or rocks behind which they can hide. The planktons are heterogenous assemblage of minute organisms which occur in the natural water and float about by the wave action and movements of water.

The aquatic ecosystem covers a vast area and the organisms occurring in this area are under the influence of its environmental conditions. Diversity of zooplankton depends on its productivity, which in turn is influenced by abiotic factors and the level of nutrients in the water. In a fresh water system, the phytoplankton forms an important group, as most of them are primary producers and makes themselves available to be eaten by higher organisms in food chains including fish and contribute significantly to the biological productivity of this ecosystem. The abundance of phytoplankton is most pronounced in the slower moving portions of a river system where deeper water tend to reduce velocity of current and silt deposition which make them indistinguishable from typical lentic and lotic habitats. Freshwater streams and lakes are habitats for complex ecosystems, of which plankton is an important component in which phytoplankton are primary producers of ecosystem and provides energy to the trophic levels, on the other hand zooplankton are primary consumers and act as bio-indicator of aquatic health and fish production is mainly depends on zooplankton.

4.6.4.9 Fishes of River Ganga at Farakka

The fish population of Ganga is largely dependent on phytoplankton, zooplankton, periphyton and zoo benthos which establish itself in the form of food chain. Fishermen of the Farakka believe that fish production is declining in Ganga River. However, due to unique characteristics of Ganga water at Farakka there are varieties of fishes. Some researchers reported that Farakka Barrage has stopped migration of economically important species like the Hilsa (*Tenualosa ilsha*) and *Macrobrachium prawns*. Both Ilish (*Hilsa*) and Chingri (*Macrobrachium*) hold a special significance to people in West Bengal and Bangladesh (EIA Report of lock at Farakka, 2015). About

2 lakh fisher folks in Malda district are dependent on riverine fisheries for their livelihood and Hilsa was the backbone of the fishing economy. The fishing boats used by the fisherman are mostly indigenous. The list of fish found in Ganga River at Farakka area is given in Table 4.31.

Table 4.31 Fishes of Ganga River at Farakka Area (Source: EIA Report of lock at Farakka, 2015)

S. No.	Fishes	Ganga River canal upstream of Lock Site	Ganga River canal down stream of Lock Site
1.	*Channagachua* (Hamilton)	+	+
2.	*Channamarulius*(Hamilton)	-	+
3.	*Channaorientalis*(Hamilton)	+	+
4.	*Channapunctatus*(Bloch)	+	+
5.	*Chela labuca* (Hamilton)	+	+
6.	*Cirrhinusmrigala*(Hamilton)	-	+
7.	*Cyprinuscarpio*(Linnaeus)	+	+
8.	*Labeobata*(Hamilton)	+	+
9.	*Labeoboga*(Hamilton)	+	+
10.	*Labeocalbasu*(Hamilton)	+	+
11.	*Labeogonius*(Hamilton)	+	-
12.	*Labeopangusia*(Hamilton)	+	+
13.	*Labeorohita*(Hamilton)	+	+
14.	*Mastacembelusarmatus*(Lacepede)	+	+
15.	*Mastacembelus puncalus* (Lacepede)	+	+
16.	*Monopterus albus* (Zuiew)	+	+
17.	*Monopterus cuchia*(Hamilton)	-	+
18.	*Mystusaor*(Hamilton)	+	+
19.	*Mystusbleekery*(Day)	+	+
20.	*Mystuscarcio*(Bloch)	+	+
21.	*Mystuscavasius* (Hamilton)	+	+
22.	*Mystustengara*(Hamilton)	+	+
23.	*Mystusvittatus*(Bloch)	+	+
24.	*Osteobramacotio*(Hamilton)	+	+
25.	*Puntiuschola*(Hamilton)	+	+
26.	*Puntiusconchonius*(Hamilton-Buchanan)	+	-
27.	*Puntiussarana*(Hamilton)	+	+
28.	*Puntiussophore*(Hamilton-Buchanan)	+	+
29.	*Puntiusticto*(Hamilton-Buchanan)	+	+
30.	*Rhinomugilcorsula* (Hamilton)	+	+
31.	*Rita rita*(Hamilton)	+	+
32.	*Tenualosa ilsha*	_	+

33.	*Wallagoattu*(Schneider)	+	+
34.	*Xenentodoncancila*(Hamilton)	+	+

4.7 Archaeological / Religious / Historical Monuments

No archaeological monument of national importance either lies in the project area or in its submergence area. There is also no structure of national heritage within 300 m of the project site.

4.8 Social Economic and Occupational Health Environments

The development projects are invariably planned based on the availability of exploitable natural resources. These projects attract flow of finances, investments, jobs and other livelihood opportunities, which brings in people from different cultural and social background. Such planned activities not only provide impetus to the local economy but also bring about a multi-dimensional economic, social and cultural change. Most often it has been observed that such development projects are commissioned in economically and socially backward areas, which are inhabited by some of the indigenous populations.

Impact on the socio-economic environment in the vicinity of any project area revolves around the modes of change that are likely to occur due to beneficial and adverse effects arising out of proposed developmental activity. Secondary data is collected for 10 km radius from the project site. The following sections highlight the overall socio-economic status of the study area, i.e., the 10 km area around the lock gate site which falls in Murshidabad district of West Bengal and Sahibganj district of Jharkhand state. The statistics given in the chapter are extracted from Primary Census Abstract 2011 and Village profile of Sahibganj and Murshidabad District.

4.8.1 Demography

Murshidabad district has 6% of the area and comprises 7.78% of the total population of West Bengal. As per Census 2011, the total population of the district is 71.02 lakh. Literacy rate is 63.88%. Murshidabad has a large concentration of minority population may be more than 66% of the total population. The proposed project site is located at Farakka Barrage area.

4.8.2 Demography within 2 km Study Area

The 2 km area of the project site has been considered as core zone and secondary data has been collected for the area. Administratively, the villages and settlement within 2 km area falls in Paharpurrural Village of Sahibganj District in Jharkhand State and Bewa Panchayat & Farraka Barrage Township (CT) in Murshidabad District in West Bengal. According to 2011 census the total population of the 2 km study area is 35908 comprising 18474 males and 17434 females. Male female ratio of the study area is 944 female / 1000 male. Total no. of households is 8104.

4.8.3 Demography within 10 Km Area:

Administratively the villages and settlements with in 10 km area around the proposed site falls in Sahibganj district of Jharkhand and Murshidabad District of West Bengal. One Municipality/town and 56 villages in District Sahibganj, Jharkhand and 47 villages in District Murshidabad falls within 10 km Area of the site. According to 2011 census the total population of the 10 km study area including Sahibganj and Murshidabad district is 238470 comprising 121523 males and 116947 females. Sex ratio of 10 kms study area is 962.The total population of villages falls under Sahibganj district study area is 67766 comprising 34424 males and 33342 females.

Sex ratio in the Sahibganj Part of the Study area is 969 female / 1000 male. Total no. of households in this area is 13523. Total population of villages falls under Murshidabad district study area is 170704 comprising 87099 males and 83605 females. Sex ratio of this area is 960. Total no. of households is 34992.

4.8.4 Scheduled Caste and Schedule Tribe Population in Study Area

The schedule Caste (SC) and Schedule Tribe (ST) community are considered as socially weak; hence the state and central governments have several welfare schemes for their economic and social development. The SC and ST population of the study are is described in following section.

4.8.4.1 SC and ST Population in the Study area falling under District Sahibganj

There are 56 villages falls under Sahibganj District. Total SC population in Sahibganj part of study area is 5411 comprising of 2809 males and 2602 females. Total ST Population in study area of the site is 6084 comprising of 3058 males and 3026 females. Out of the total population the SC and ST population is 40.01% and 44.99% respectively.

4.8.4.2 SC and ST Population in the Study area fall under District Murshidabad:

There are 47 villages which falls under Murshidabad District. Total SC population in study area is 26998 comprising of 14044 males and 12954 females. Total ST Population in study area of the site is 4115 comprising of 2086 males and 2029 females. Out of the total population the SC and ST population is 15.82% and 2.41% respectively.

4.8.5 Occupation/ Livelihood Pattern of the community

According to the Census definition "work" may be defined as participation, mental or physical, in any economically productive activity. People engaged in such an activity constitute the workforce. Workforce can be classified as main or marginal". A person who has worked for more than 183 days in a year is called the main worker. Marginal workers are those who have worked any time in the year preceding the census but have not worked for major part, which is not more than 183 days, of the year. Occupational pattern of the concerned study is recorded to assess skills of people. Occupational pattern also helps in identifying dominating economic activity in the area. The proposed construction and operation of site involves engaging skilled, semiskilled and unskilled work force. It is generally felt that engaging the locals in the various activities of the proposed project during the construction phase and also during the operational phase wherever possible will increase the work participation rate of the people in the impact area. This is one of the direct benefits accruing to the local people due to the proposed project.

Occupation Pattern in Sahibganj Part of Study Area

About 23% are main workers, 22% are marginal worker and 55% are non-workers

Occupation Pattern in Murshidabad Part of Study Area

About 31% are main workers, 12% are marginal worker and 57% are non-workers. As per socio-economic profile, it is found that semi-skilled and unskilled workers are available in plenty in the study area.

4.8.5.1 Distribution of Main Worker

The agricultural related activities, fishing daily workers in stone quarries are the main occupation of the study area. Farming and agricultural activities generates the maximum employment in the study area. Male and female equally counts its growth. Agricultural related activities are generally seasonal. Therefore, these agricultural workers may not be employed during all seasons. The services of agricultural labourers can be potentially utilized for the construction phase of the project. The classification of the main worker of the study area is given in Table 4.39.

4.8.6 Economic Livelihood Pattern of the community Depending on the river

Fisherman community of the Farakka region is dependent on Ganga River for fish catch. Most importance fish species of Ganga River adjoining Farakka are Rita, Catla, Mystus, Mastacembelus, Labeo species etc and all are having the commercial importance within the Farakka region.

4.8.7 Medical Infrastructure Facilities

In Farakka Barrage township, a Central Govt. Hospital under Ministry of Health & Family Welfare and a state-owned primary health centre exits. The public health facility in the villages of the study area is very limited. In most of the village people have to go to town to avail of any medical facility.

4.8.8 Infrastructure Facilities (within 10km radius of project site)

There is no settlement with in 500 m of the lock gate site. The Basic infrastructure available within 500 m of the proposed lock site is the road connecting to Farakka and NH-80. The basic infrastructure facilities available in the study are (10 km area) is discussed in following sections.

4.8.8.1 Transport Network (Road/Rail/Water and Airways)

Highway and Railway: The lockage site is well connected with road as well as with rail route. The Farakka-Rajmahal highway (NH-80) is located at about 1.6 km West of the Western boundary of the proposed lock gate. As far as rail connectivity is concerned the nearest railway station Farakka is located about 2.6 km south of the site. Champagram railway station is located at about 6 km east of the site. **Waterways:** - River Ganges is navigable in this stretch and is being used to transport material from Haldia port to Farakka. At present NTPC Farakka is transporting imported coal from Haldia to plant site at Farakka by NW-1 and NTPC had a 7-year contract with Jindal ITF for coal transportation.

Air Ways: No airport facility is available within the study area the nearest airport is Kolkata located about 250 km away from the Farakka. There are only two major industries currently operating in the study area. One is Farakka Super Thermal Power Plant (2100 MW) of NTPC located at about 3.6 km SSW of the purposed lock. The second is Ambuja Cements Ltd (Unit: Farakka) located at about 4.2 km SW of the proposed navigational lock. Murshidabad district is also famous for brass and bell metal ware.

4.8.8.2 Education Facilities

It is well known that education is a necessity for the all-round human development. Schools in the town include Farakka Barrage Project Higher Secondary School (Estd. 1965), a fully Central Govt School up to Class 12 and a Primary School (Bengali Medium) & a Middle High School (Hindi Medium) both under West Bengal State Govt. is also here. All the village of the study area have the primary school. There are 2 Polytechnic in the village of study area.

Chapter 5

5 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

5.1 Introduction

Environment Impact Assessment is the most important activity of any EIA study. It helps in identifying the likely change in environment quality of surrounding area post implementation of a project. Impact analysis is carried out for all stages of project viz, design, renovation, and operation stage. Impact analysis is carried out for all three broad aspects of environment namely physical, biological and socio-economic aspects. Many scientific techniques and methodologies are available to predict qualitative and quantitative environmental impacts due to the project. Key issues identified requiring greater attention are related to effect on aquatic biodiversity due to lock renovation and vessel movement, water quality, land use change, air pollution and noise pollution from lock renovation and operation.

5.2 Impact Identification

Project development activities will interface with various environmental and social components including air, surface water, ground water, aquatic ecology, terrestrial ecology, soil, hydrology, and river morphology. Environmental impacts have been assessed considering present environmental setting of the project area, nature, and extent of the proposed activities. Suitable qualitative and quantitative (modelling) impact assessment approach was followed to ascertain likely impacts of the lock during renovation stages. Valued Environmental Components were identified during initial site visit followed by its detailed investigation during later stage of the study Suitable mitigation measures are also proposed to eliminate or minimise the impacts. An EMP is also prepared to ensure effective implementation of identified mitigation measures (refer chapter 6). Identified impacts of the project activities on the environment and social components are given in Table 5.1 along with the activities associated.

Table 5.1 Impact Matrix for Proposed Project

No.	Project Activity	Anticipated Impacts	Positive Impact		Negative Impacts				Remarks
			Short Term Impacts	Long Term Impacts	Short Term Impacts	Long Term Impacts	Reversible Impacts	Irreversible Impacts	
Pre-Renovation and Phase									
A	**Resettlement & Rehabilitation**	No private land to be acquired andno R & R associated as no additional land is required.				√			No Compensation to be given
Renovation Phase									
B	**Renovation of Lock gate**	Loss of Top soil				√		√	The top soil should be preserved and used for landscaping purpose
		Soil contamination due to spillage of material			√		√		Cleanup operations should be taken up immediately after spillage
		Surface water contamination			√		√		Measures should be taken to prevent contamination of run- off and mixing of contaminated run-off with River.
		Air pollution			√		√		Measures to be taken to minimize pollutant generation
		Noise pollution			√		√		Measures to be taken to minimize noise

									generation
		Increase in traffic			√		√		To avoid traffic jams and accidents traffic management suggested
		Unpleasant view			√		√		Restoration and rehabilitation of worked areas
		Impact on Health & safety			√		√		Safe working and use of Personnel protecting equipment
		Aquatic Ecology			√		√		Measures should be taken to prevent contamination of run- off and mixing of contaminated run-off with River.
		Employment	√						Employment generation during renovation phase,

5.3 Impacts on Physical Environment

5.3.1 Impact on Climate

5.3.1.1 Impacts during Renovation Phase

The development of Lock and associated activity would require land clearing. No major vegetation is present at site. Shrubs and herbs species along with few trees are present that will be cleared. Hence no major impact on climate is associated

Mitigation Measures:

- There is major vegetation present on site. As far as possible trees present at site will be retained as greenbelt.
- Further under greenbelt development plan about 100 trees in along with small herbs and shrubs will be planted around the project premises which will enhance the scenic aesthetics of the area.
- Ensuring maximum survivability of trees planted under greenbelt development. and create additional GHG sink by planting additional trees.

5.3.1.2 Impacts during Operation Phase

This project is subproject under Capacity Augmentation of NW-1 project which will offer low costs option of bulk cargo movement. NW-1 will result in substantial shift of load from road to waterways. Since waterways are most fuel-efficient mode of transport, it results in almost 10 times lesser GHG emissions compared to road. This will shift some of the load from road and railway to the waterways. This mode of transportation will involve minimum emission generation if compared to road and railway. The new lock will also enhance the vessel movement of vessels/cargo across the lock due to efficient functioning of lock.

Mitigation Measures

- It is recommended to adopt all energy efficiency measures at the lock site.
- To maintain the green belt at the site

5.3.2 Impact Due to Natural & Operational Hazard

Natural hazard anticipated at the site are floods and earthquake. As per seismic zone map of India, site falls in the zone III which is categorised under medium seismic zone thereby meaning that the probability of higher intensity earthquake is low. Project design should consider seismic load for zone IV. Project site lies close to River Ganga and is thus prone to flooding.

In addition to natural hazard, operational hazard like accidents and grounding of cargo can happen at the site. Provision of adequate fire protection measures will be provided. Adequate safety provisions like caution sign boards, emergency hooters, designation of assembly points should be made. International environmental and occupational health and safety management systems as per ISO14001/OHSAS18001 should be adopted. Standard safety guidelines covering most probable accident scenarios should be developed and followed. Adequate provision should be made for first aid facilities at the lock gate and periodic health check-ups.

Mitigation Measures:

- Relevant IS code for structures should be adopted for designing the civil structuresto sustain the earthquake of intensity zone IV.

- All infrastructure/facilities should be developed above HFL. The navigational channel embankment should also be strengthened protection considering high flood levels to prevent soil erosion.
- Preparation of emergency preparedness and response plan for natural and man- made hazards like earthquake, floods, fires, shocks, explosion of hazardous materials etc.

5.3.3 Utilities & Infrastructure Shifting and Safety Planning

No utility shifting is involved for the project development.

Mitigation Measures:

- Alternate route should be provided for movement of vehicle prior diversion
- No route should be blocked for diversion of the road
- Pedestrian movement should not be hampered and if hampered, alternative route should be provided
- No open excavated pit should be left without refilling or closure should be carried out as soon as the work is carried out
- If any other utility is required to be shifted, then it should be relocated immediately after shifting

5.3.4 Impact on Land Environment

The site is slightly undulating with level variation of RL + 13 to RL + 29 m. Also due to the construction of dedicated parking bay for caisson gates, minor cut & fill will be required at the site. The estimated cutting of earth is 10000 m^3 and filling of earth is 30000 m^3. Filling will be done to achieve the finished level of 28.438 m amsl level which is above highest water level of the existing lock, i.e., RL+26.30 m.

Excavation of the soil & removal of shrubby vegetation will make it loose thereby making soil prone to erosion. Such a land use or topographical changes are temporary in nature but the resultant impacts will not be significant in comparison to economical gains of the region. To minimize the impact, productive top layer of soil should be stripped (15 cm) and should be used for landscaping purpose within the site to the extent possible.

In case fuel oil is stored at site then occurrence of accidental fuel spillage or leakage cannot be ruled out which in the process may contaminate the soil. Such soil contamination can be severe in case of voluminous leakage.

Movement of construction vehicles and equipment may lead to soil compaction on haulage roads and nearby area. Soil may be contaminated due to inappropriate disposal of liquid waste, (lubricating oil and fuel spills, waste oil and lubricant and vehicle/equipment washing effluent) and solid waste (fuel filters, oily rags) likely to be generated from repair and maintenance of transport vehicles, construction equipment and machinery. But such a surface soil contamination will be short term and insignificant in nature.

Construction waste (debris, unused iron bars or damaged support structures, quarry dust) may affect the soil quality at the site if such wastes are stored on unpaved surfaces and disposed in an uncontrolled manner.

Mitigation Measures

- Excavation and filling operations should be carried out in parallel so as to minimize the soil erosion. Unusable debris material should be suitably disposed off at pre designated safe disposal sites, but with prior approval of the concerned authority.

- Soil compaction at the site should be undertaken by regulated water sprinkling to minimize any surface runoff or soil erosion.
- About 15 cm of top soil layer should be stripped prior to excavation and stored separately in covered condition and should be used for landscaping of the lock gate site.
- The remaining excavated soil should be used for filling of site and road realignment. Excess earth, if any shall be disposed off at the locations designated by the authorities or to the debris disposal site identified for the project within 5 kms of the project site.
- Contractor should submit a plan prior excavation to the IWAI for management and disposal of the surplus earth.
- Fuel & lubricants should be stored in HDPE containers on paved surfaces with provision of catchment pit to prevent soil contamination from oil spillages.
- Sanitary latrines and soak pits should be provided at construction site and camp site for disposal of sewage.
- Efforts should be made to improve the Aesthetic of the area. No construction wasteor other wastes should be dumped at unidentified areas.
- Hazardous waste like used oil generated from DG sets should be stored safely in HDPE containers located on paved surfaces in isolated location to prevent any spillage (during storage) and soil contamination. Used oil should be disposed off through authorized vendors only.
- Storage area should be paved with gentle slope to a corner and connected with a chamber to collect any spills of the oils.
- Provision of “oil interceptors” at wash-down and re-fuelling areas.

- Oil and grease spill and oil-soaked materials are to be collected and stored in labelled containers (Labelled: WASTE OIL; and hazardous sign be displayed) and sold off to SPCB/ MoEF authorized vendors.
- Caution board in local language should be placed at different locations to prevent dumping of Municipal solid waste and other waste all around the project site areas which is happening substantially at present.
- Provision of cross drainage structure should be made in the access road if required to maintain the natural drainage pattern and prevent soil erosion.
- Provision of side drain should be made in realigned road if required to prevent soil erosion.
- Provision of geo-textiles matting, stone pitching, retaining wall, apron etc should be made to prevent the erosion of bank and scouring of bed during renovation phase Movement of construction vehicles should be restricted to the designated haulage roads only.
- The earth stockpiles to be provided with gentle slopes to prevent any soil erosion.
- Shore protection through stone pitching and scouring of banks all along the channel in u/s and d/s of lock should be armoured by providing apron.
- Bio-turfing of embankments should be made to enhance the slop stabilization
- The waste water generated from concrete mixing tanks washing or floor washing should not be allowed to percolate. Such waste water should be collected and should drain into settling tanks and sediments shell be dried and recycled as construction material.

- Land earmarked for dumping of construction waste, setting up of construction camps, plant sites etc should be free from any social and R&R issue and away from settlements

5.3.5 Impact on Air Environment

5.3.5.1 Impacts during Design, renovation and modernization Phase

Site preparation, vegetation removal and construction material sourcing are the key air pollution causing activities prior renovation. Preparation of site involves cut and fill activity to achieve finished level of 28.44 m amsl. Excavation/filling activities and piled up excavated soil will generate fugitive dust emissions. Renovation activities include construction of counter fort retaining wall, Inlet /outlet structure, Base slab, control room buildings, culverts, control room for lock gate operation etc. All these activities will lead to generation of dust.

Emissions will also be generated from operation of excavators & levellers. Operation of construction machinery & equipment and DG sets (assuming 1000 KVA) will generate the emissions. These emissions may increase the concentration of PM (particulate matters) SO_2, NO_x, & CO in the project area. After removal of shrubs and herbs from the land, loose soil will be exposed to wind and will add on to the dust.

Apart from this construction material (22000 m^3 cement, 22000 m^3 sand, 44000 m^3 aggregates etc.) will be transported to the site by road majorly from Sahibaganj, Rajmahal and nearby area (located at about 50 -100 km from site). Transportation of raw materials will generate dust and emissions from the transportation vehicles. These emissions will be restricted to renovation period only, which is 20 months. No habitation is present within 500 m of the site, thus the impact due to increased air pollutant concentration will be insignificant on health of the villagers due to polluted air quality. The impacts anticipated are short term and moderately significant. As per baseline study, concentration of air pollutants SO_2, NO_x, PM_{10} & $PM_{2.5}$ in the study area is within the prescribed limits as per NAAQS, 2009 and it is expected that the pollutant concentration will not rise beyond the prescribed standards, if the proposed mitigation measures are implemented.

Mitigation Measures

- Barricading the site to prevent dust dispersion to nearby areas
- Excavation and filling to be carried out parallelly.
- Excavated soil should be stored under covered conditions
- Transport of loose and fine materials through covered vehicles.
- Controlled flow of the sprinklers to avoid ponding of water.
- Top soil stripping before excavating the soil and storage under covered conditions for usage in landscaping at later stages
- Green belt development around the project premises
- Vehicles delivering loose and fine materials like sand and aggregates should be covered. Other material should also be carried in covered vehicles
- Regular water sprinkling on haul roads and other dust generating areas.
- Masks and PPE should be provided to people working in high dust prone areas.
- Loading and unloading of construction materials should be made at designated locations in project area with provisions of water fogging around these locations

- Construction vehicle, machinery & equipment should be regularly serviced and maintained and should comply with emission standards as per CPCB norms. Vehicles entering the construction site should carry valid PUC certificate
- Low sulphur diesel should be used for operating DG sets and construction equipment.
- Diesel Generating (DG) sets should be fitted with stack of adequate height as per regulations (Height of stack = height of the building + 0.2 √ KVA.)
- Wheel wash facility should be provided at exit points of the site.
- Mixing Plant, crushers and batching plant should be located on downwind direction of the site fitted with adequate stack height to ensure enough dispersion of exit gases. with appropriate pollution control measures
- Monitoring of air quality should be carried out on monthly basis to check the level of pollutants and effectiveness of proposed EMP
- Green belt development around the project premises.

5.3.6 Impact on Noise Environment

5.3.6.1 Impacts during Renovation Phase

The major Impact on noise level of the proposed project, during the renovation phase, is envisaged due to the noise generation by the operation of the machineries, equipments and construction activities. There are many equipments and machineries likely to be used during the renovation. These are mainly recognized to be Dozers, Cranes, Excavators, Trailers, Generators, and Concrete Conveyor etc. It is envisaged that noise level due to this equipments will be 70 to 85 dB(A) at receptor point at associated work/construction area. The impacts due to noise of these equipments will be local and temporary as well as negligible due to the efficient implementation of proper mitigation measures like provision of Ear Protective Safety Equipment (ear plug & ear muff) for the personnel likely to be exposed to high noise level. The noise level of these machineries / equipments should be minimized by proper lubrication, modernization, maintenance, muffling and provision of silencers wherever possible. Typical noise generation from these equipments as per CPCB are given in Table 5.2.

Table 5.2 Typical Noise Levels of Excavating and Levelling Equipment

Equipment	Noise Level in dB(A) at 50 feet
Bulldozer	80
Front end loader	72-84
Dump Truck	83-94
Jack Hammer	81-98
Crane with ball	75-87
Scraper	80-93
Grader	80-93
Roller	73-75
Welding generator	71-82
Concrete mixer	74-88
Concrete pump	81-84
Concrete vibrator	76
Air compressor	74-87
Pneumatic rods	81-98
Cement and dump truck	83-94
Front end loader	72-84
Paver	86-88
Truck	83-94
Backhoe	72-93

Source: CPCB

It is evident from the above table that operation of these equipments will generate high noise and will lead to increase in ambient noise level at the site and nearby areas. These equipments will not be operated throughout the day thus noise generation from these equipment is considered to be of intermittent type. As per occupation standards, workers exposure to 90 dB(A) noise level should not be more than 8 hours.

As per baseline monitoring, ambient noise levels at the site are within the permissible limits as prescribed by CPCB for residential areas. Thus, the resultant noise level (ambient noise level +increase noise levels due to operation of equipment) should be higher. However, noise level attenuates with increase in distance from its source and follows the below given equation.

$$L2 = (L1 - 20 \log D2/D1 - Ae - An)$$

where, L1 and L2 are the noise levels at a distance of D1 and D2 from the noise source; Ae and An are attenuation coefficient due to environment correction and background, respectively.

The affected area will be the project site under construction activities for development of the proposed project and immediate area of the lock site. Since the nearest habitation is located more than 500 m from the site thus no major impacts are anticipated in the habitation area due to the project development and construction activities. Further, construction activity would be carried out at daytime to prevent increase in noise level during night time.

There is no considerable habitat of fauna in vicinity of the project site. The major effects of the noise due to the predicted sources will be limited to the workers exposed to the high noise area. Thus, there would not be any considerable impacts on ecological factors as well as social layout.

Mitigation Measures

Provision should be made for:

- Provision of PPEs (ear protective safety equipments) as well as planning of workhours & shift of workers as per Factory Act or NIOSH / OSHA.
- Restriction on Honking at the project site.
- Use of low noise generating equipments.

- Restriction of high noise generating activity between 6:00 AM to 10:00 PM.
- and effectiveness of proposed EMP
- Construction equipment and machinery should be fitted with silencers and maintained properly.
- Barricading (Temporary noise barrier) the construction site to minimize the noise level outside the site boundary
- Hearing test for the workers prior to deployment at site and high noise areas followed by periodic testing every six months.
- All equipment shall be fitted with silencers and will be properly maintained to minimize its operational noise. Noise level will be one of the considerations in equipment selection, which will favour lower sound power levels
- Periodic monitoring (monthly level) of noise levels to check the level of pollutants and effectiveness of proposed EMP

5.3.7 Impact on Water (Surface and Ground) Environment

5.3.7.1 Impact during Renovation Phase

Activities involved during pre-renovation phase are excavation and vegetation (mainly shrubs and herbs) removal from the site. 16.5 KLD water will be required for renovation period. Out of the total requirement about 6.5 KLD will be required for domestic purpose which will be sourced from municipal supply Farakka. About 10 KLD water will be required for renovation purpose which will be sourced from River for which permission will be obtained from the concerned authority. Labour colony will be established away from the river channel and will be provided with proper sanitation including mobile toilets and bathrooms. The labour force employed during this phase will be provided potable water to avoid any waterborne diseases. The domestic wastewater / sewage generated from the labour colony will be disposed in septic tanks and soak pits and it will be used for developing green plantation, which will be an eco-friendly solution.

Run-off from site will increase due to removal of vegetation from site and quality of run-off will degrade due to contamination of run-off with loose soil, raw material & debris at site etc. Contaminated run-off may pollute the quality of surface water body in which it will be drained. Contaminated run-off may increase turbidity & sediments in water. Increased sediments and turbidity are harmful for the aquatic flora & fauna.

Wastewater will be generated from construction site from cleaning & washing area, curing sites and toilets, bathing & kitchen area at labour camps and site. This wastewater if not managed can pollute the surface and ground water significantly. Mitigation measures are required to be taken during renovation phase to minimize the anticipated impacts and are given below.

Mitigation Measures

- Water required for renovation should be sourced from rivers with due permissionfrom authorities.
- Water required for domestic uses should be sourced from supply water.
- Efforts to restrict water intensive activities during summer period (April, May, June)
- Excavation activity should not be carried out during monsoon season
- Restoration of changes in the stream, if any, made during renovation to its original level.

- Mobile toilets with anaerobic digestion facility should be fixed at construction site. No domestic waste should be discharged to river.
- Excavated areas should be covered to the extent possible to prevent entry of rainfall run-off in case of rains
- Garland drains with jute filters to arrest siltation should be provided around excavated area to channelize the run from upper catchment area to river and prevent flooding of construction area.
- The storm water drain should be connected to a collection cum sedimentation pond to collect the surface run of the construction area. The collected rain water should be used for dust suppression purposes at construction material handling area.
- Storm water drains should be provided for the parking areas also and these drains should be provided with oil & grease trap
- No waste should be disposed off in river and ground while filling and excavating. 100 m distance has been kept between the existing and proposed lock to prevent the direct runoff to the water channel.
- Washing of vehicle and equipment should not be carried out at river or any water body. Washing area should be provided with the storm water drains fitted with oil & grease trap.
- Storage of debris and raw material should be carried out in paved and covered areas. This will minimize interface of run-off with raw material and debris.
- Septic tank/soak pit should be provided at site for disposal of sewage from the toilets at site and from the labour camps. Adequate toilets & bathrooms should be provided to prevent open defecation.

- Water use should be minimized by using RMC, practicing curing by water sprinkling, maintaining flow of sprinklers, covering the water storage tanks to minimize water evaporation, creating awareness for water conservation and regular inspections at site to monitor the leakages in water storage area
- In case RMC is not used then concrete transit mixer should be washed and cleaned daily. Wash from these mixers should be collected in block work tanks which will allow settling of concrete, removal of aggregates and allowing the waste to wastewater drain. This collected waste concrete can be dried and used for various purpose at site like construction of temporary roads at site.
- Fuel should be stored in leak proof containers and containers should be placed on paved surfaces.
- Permission should be obtained from irrigation department in case river water is used. Ground water shall source from supply water.
- Provision should be made for geo Synthetic Screen for arresting silt flowing down stream.
- Turbidity traps/curtains should be providing or Geo-Textile synthetic sheet curtain should be placed around pilling and construction area to prevent movement ofsediments and construction waste
- Natural Drainage pattern of area around should be maintained.
- Proper collection, management and disposal of construction and municipal waste from site should be made to prevent mixing of the waste in run-off and entering the water bodies
- Monitoring of surface water quality should be carried out on monthly basis to check the level of pollutants and effectiveness of proposed EMP

5.3.8 Impact on Biological Environment

5.3.8.1 Impacts during Renovation Phase

Impact on Terrestrial flora and Fauna: The major infrastructure of existing lock gate facility is to be setup in riverfront area. The site does not support significant vegetation. Hence there will not be any significant impact on terrestrial ecology due to development works for proposed project within site. Some of the trees present at the site will be retained as green belt.

No wildlife habitat is present at site and nearby area thus no wildlife was observed during the visit. No RET species is present in the site. Due to site levelling and vegetation removal, there will be loss of existing biodiversity of riparian soil strata and sub-soil micro to macro- limnetic flora and fauna.

During the renovation of project, the transportation of heavy vehicle carrying the construction material will move in the project area. It will generate dust and noise during movement. The dust will be settled on the surface of the leaves which could reduce the photosynthesis activity thereby impacting the productivity. However, the rains would wipe out all the dust rendering the leaves free from dust.

High noise level may also impact the fauna residing in nearby areas. However, no significant faunal species were observed in nearby areas. Nocturnal animals and birds may get disturbed but the noisy construction activities will be restricted to day time only. Thus, impact on faunal species is insignificant.

Impact on Avifauna (Important bird area of Farakka barrage and its surroundings): The Farakka Barrage and adjoining area on Ganges River is a major wintering site for many of migratory water birds and has been designated as an

Important Bird Area (IBA) by Bird Life International (Islam & Rahmani 2004). Some of the rarer visitors to Farakka Barrage are *Ythya baeri* (Baer's Pochard), *Aythya fuligula* (Tufted Duck), *Dendrocygna bicolor* (Fulvous Whistling-Duck), *Gyps bengalensis* (White-rumped Vulture), *Gyps indicus* (Indian Vulture), *Leptoptilos javanicus* (Lesser Adjutant) and *Rynchops albicollis* (Indian Skimmer). The increased noise level during renovation phase would temporarily disturb the avifauna (Important bird area of Farakka barrage). The project will generate noise during construction which may affect the migratory bird movement the in the area. However, the designated imported bird area is located more than 4 km from the construction site. Thus, impact on avifauna during renovation phase will be insignificant.

Mitigation Measures

- There are very few trees and some agricultural land scattered around the location, besides the green meadows around. Development of a green belt has been proposed all along the lock gate boundary. This would help in settlement of dust and keep atmospheric humidity under check.
- As far as possible the existing trees present at site shall be retained under greenbelt.
- Permission should be obtained from forest department prior tree cutting if any.
- Thick green belt should be developed around the periphery of the lock site. App. 100 trees will be planted at the site. Green belt should include native tree species like Pepal, Bargad, Arjun, Sheesham, Kaner, Neem etc. Green belt should be developed as per the CPCB guidelines proposed above climate section.

- Maximum survival rate for plantation shall be ensured hunting, poaching and harming any animal (specially avi -fauna) by any worker or project related person shall be strictly prohibited and monitored.
- The designated imported bird area is located more than 4 km from the however it is recommended that, to conserve the local biodiversity (migratory birds of Farakka bararege area) the construction activities may stop for migratory periods of the birds if required.
- Construction activities should be restricted to 6:00 Am-10:00 Pm especially noise generating activities
- Illumination at the site shall be reduced during the night time (if no activity is going on) as it may disturb the nocturnal animals.
- Noise generating activity shall not be undertaken during night time to minimize disturbance to animals.
- Noise generation activities shall also be restricted during migratory period of the birds, i.e., Winter season as it may impact their activities
- Noise levels shall be maintained within the prescribed CPCBs limits to the extent possible during the day time.
- No hazardous material or waste should be disposed off in the other land or nearby area as it may harm the animals, if consumed accidently
- Regular water sprinkling shall be done in dust prone areas and haul roads.
- Construction site shall be barricaded to reduce the dust and noise generation.
- Speed limit will be for construction vehicle shall regulate to control noise and dust emission.
- Regular maintenance of the dumper and construction machineries shall be done

- No timber usage should be allowed for cooking or any other purpose at site during design, renovation phase of the project. Clean fuel like LPG should be used

Impact on Aquatic flora and Fauna: The major infrastructure of existing lock gate facility is to be setup in riverfront area that is close to the existing navigational channel. However, 100 m distance has been kept between existing lock (navigational channel) and existing lock gate. Maximum of the construction facilities will be finished in land. Only culvert construction work will be done close to the existing channel. Thus, no major impact due to lock construction is anticipated on aquatic fauna. However, entry of contaminated run-off from site may have impact on water quality and thus aquatic fauna. Waste & wastewater dumping in the river will also deteriorate the water quality which will again impact the aquatic life in that stretch

Increased sedimentation due to construction activities: The maximum construction activities will be restricted to the land area. During renovation period the soil of the riparian area will become loose. But again, this is a temporary phase. It will be only during monsoon days that it will lead to enhance turbidity in river, which is not uncommon for aquatic flora and fauna and is soon mitigated through natural processes. The muddiness of river stream may impact the aquatic life by reducing the visibility, chocking the gills etc. Higher turbidity for a short while helps fishes to get rid of many parasites over the skin. Mitigation measures proposed to minimize impact on aquatic ecology are listed below.

Mitigation Measures

- No breeding ground is noticed around the project site. However, construction activity should be restricted during spawning & breeding period of fishes, i.e., June to August
- To avoid the siltation in water 100m distance has been kept between existing and existing lock gate.
- To avoid the construction debris, wash or blown into the water the construction area shall be surrounded by silt screens.
- The screens should also be placed around storage areas, to prevent waste from blowing away and to prevent sediment run-off into the river.
- All the material and debris shall be stored at least 20 meters away from the high-water mark and construction equipment must not be cleaned or washed within 50 meters of the high-water mark.
- Run-off from site should pass through oil/grease traps and sedimentation tank before its reuse. All efforts shall be made for its reuse to avoid its discharge to river.
- Construction activities shall be carried out rapidly. Culvert construction should not be carried out during breeding and spawning season means during rainy season.
- Maintaining equipment in good condition to prevent leaks or spills of potentially hazardous materials like hydraulic fluid, diesel, gasoline and other petroleum products
- Positioning water borne equipment in a manner that will minimize damage to fish habitat.

- Turbidity traps/curtains should be provided or Geo-Textile synthetic sheet curtain shall be placed around the construction area to prevent movement of sediments and construction waste.
- Excavation activities onshore shall not be undertaken during monsoon season so as to minimize sediment load of run-off.
- All workers should be made aware of not throwing any waste in the river or any drain
- No construction debris/ already accumulated solid waste at site or waste generated from labour camp should be thrown in river or any drain
- Sewage generated from labour camp should not be directed into river but should be disposed off through septic tank/soak pit.
- Engineering controls modify the equipment or the work area to make it quieter. Examples of engineering controls are: use of quieter equipment; retro-fitting equipment with damping materials, mufflers, or enclosures; erecting barriers; and maintenance.
- Aquatic ecology monitoring shall be carried out prior start of renovation and after completion of renovation so as to assess the impact of renovation activities on aquatic life.
- Soil stabilization works in the bank must consider implications on changes in hydrological flow, current and behaviour of the river. Such changes may create new problems such as change of river course, erosion of river embankment, change in erosion and inundation pattern of the bank etc. which will in turn impact the habitat ofaquatic life

- Sedimentation and siltation should be prevented to maintain productivity of aquatic ecosystem and availability of food such as aquatic fauna, vegetation to the avian fauna.

5.4 Impact on Socio-Economic Environment

5.4.1 Impact during Renovation Phase

During Renovation Phase no land acquisition is involved in the project. No settlement is present on the identified land thus no displacement and rehabilitation are involved with the project.

Excavation and filling activities involve risks for accidents to the workers involved. Dust generation during these activities may have impact on health of workers and nearby residing population. No additional land is not required temporarily for setting up labour camps, debris disposal site etc. Following additional measures are proposed which can minimize the impact of project on the socio-economic environment.

Mitigation Measures

- Large no. of workers (semiskilled and skilled) will be required during renovation period; preference in construction job should be given to affected people.
- Labour camp and rest area with all sanitation facility including drinking water should be provided at site in which workers can rest after the lunch hours
- Site should be barricaded with sign boards and should have entry guarded by security guard. Register should be maintained for entry of outsiders.

- Workers should wear the personal protective equipment like helmet, gum boots, safety shoes, safety jackets, ear plugs, gloves etc while working
- Noise level in the work zone should be maintained and followed as per OSHAS norms.
- Non-productive lands, barren lands, raised lands; wastelands should be used for setting up labour camps, plant sites and debris disposal site. The above sites should be located more than 1000 m away from the settlement and other sensitive location.
- Fishermen should be consulted prior restricting fishing activity in the activity area
- Necessary permits should be obtained from concerned authorities in case any quarry site, batching plant, hot mix plant, WMM plant etc. is set up.
- Contractors should adopt and maintain safe working practices. SOPs should be prepared for each and every activity and all activities should be undertaken as per SOPs under supervision of site engineer
- Training should be given to workers to handle emergency and heavy equipment to prevent accidents
- Complete medical check-up and first aid facilities should be provided at the site.
- Rest area should be provided at the site where labour can rest after lunch andshould not lie on site anywhere. Working hours of labour should not exceed than standard norms as per state factory law
- Construction labour camps and site should be properly cleaned and hygiene should be maintained

- Proper sanitation facility like toilet and bathing facility should be provided at site and labour camps. Wastewater generated from these facilities should be disposed off through septic tanks and soak pit
- LPG should be provided as fuel for cooking to workers and open burning of fuel should not be allowed
- Wastewater from construction site should not be allowed to accumulate at site as standing water may lead to breeding of mosquitoes. Septic tanks/soak pits should beprovided for its disposal
- Temporary storm water drainage system should also be provided at camp site and construction site so as to drain the storm water and prevent accumulation of storm water at site and thus breeding of mosquitoes/flies
- Safety officers should be appointed at site so as to ensure all safety measures are taken at the site
- All construction workers should be provided with personal protective equipments like helmet, gloves, gumboots, safety jackets etc and fines should be imposed if foundnot wearing
- Awareness on AIDS should be spread among the workers
- Traffic manager should be present at the site all the time to manage incoming andoutgoing traffic to prevent accidents
- Crèche facility should be provided for kids if female workers are employed
- Regular inspection for hygiene and safety in labour camps should be done
- Speed limit of vehicles should be restricted at site to prevent any accidents and dust.
- Noise level in the work zone should be maintained and followed as per OSHA norm

- Dustbins should be provided at labour camps for collection of waste and waste should be regularly disposed off through the concerned agency
- Arrangement of fire-fighting should be made at site and workers should be trained to use the system in case of fire
- All proposed environmental pollution measures should be taken during renovation phase of lock gate to minimize the harm to existing environmental quality of the area, which is being enjoyed by the residents of that area
- Sprinkling of water should be carried out in roads and other dust prone area in construction site.

5.5 Analysis of alternatives

As the proposed project involves renovation and modernization of an existing structure (existing navigation lock) the analysis of alternatives has not been carried out.

Chapter 6

6 ENVIRONMENTAL MANAGEMENT PLAN AND MONITORING INDICATORS

6.1 Introduction

The Environmental Management Plan (EMP) is the synthesis of all proposed mitigation and monitoring actions, set to a time frame with specific responsibility assigned and follow-up actions defined. EMP is a plan of actions for avoidance, mitigation and management of the negative impacts of the project. Environmental enhancement is also an important component of EMP. A detailed set of mitigation measures have been compiled in view of the likely impacts associated with the existing new lock gate at Farakka.

6.2 The Environmental Management Plan with Budget

The EMP consists of a set of mitigation, monitoring and institutional measures to be taken during the renovation stage of the project. The EMP has been designed keeping in view the regulatory and other requirements to ensure the following:

- Minimum disturbance to the environment and social components
- Compliance with the environmental acts, rules and guidelines of GoI & maintaining the quality of air, water, soil and noise as per the prescribed norms by regulatory bodies.
- Conservation of natural resources to the extent possible
- Enhancement of Project benefits for Society & Environment
- Sustainable development and operation of project

Considering all the identified impacts associated with the renovation stage of the project identified during the EIA study, mitigation measures and management plans are proposed. Detailed EMP for the project is tabulated in Table 6.1.

Table 6.1 Environment Management Plan for Existing Lock gate at Farakka

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
RENOVATION PHASE							
1. Climate							
❖ Project is unlikely to cause negative effect on climate. However, project can contribute positively for climate	• No tree cutting shall be carried out without obtaining permission from Forest department • Trees at the site shall be retained as green belt. Additionally, 100 trees should be planted within the project site. • Provision of alternative energy options like solar energy • Adoption of best practices to cut down resources and energy requirement	Kyoto Protocol, National WaterPolicy, 2012 & National ForestPolicy	Construction site	During Renovation stage	Green belt Plantation (@ Rs 500 per tree for 100 trees)- 50,000	Contractor,	IWAI/PMU/PMC
2. Natural & Man-made Hazard							
❖ Earthquake- Seismic Zone –III damage risk zone ❖ Risk of flood	• Adoption of Relevant IS codes while designing the civil onshore & off-Shore structures to sustain the earthquake of moderate to high magnitude. • Designing of structures above theHFL • Preparation of emergency preparedness and response plan for natural and man-made hazards like earthquake, floods, fires, shocks, explosion of hazardous materials etc.	NBC, 2005, local building bye laws, statefactory rules, Petroleum Rules and MSIHC Rules, 1989	Construction site & Navigation Channel	During Renovation stage.	Part ofProject Costs	Contractor	IWAI/PMU /PMC
3. Site Preparation: **Levelling Lock Gate Site, Construction Camp, Construction Works**							
❖ Leveling of lock gate site & Removal of vegetation	• Tree cutting is very less however tree cutting if any required should be carried out only after obtaining NOC from forest department.	Municipal SolidWastes (Management and Handling) Rules, 2015	Construction site	During Renovation Stage	Part ofProject Costs	Contractor.	IWAI/PMU/PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	• Excavation and filling operations should be carried out in parallel so as to minimize the soil erosion • Water sprinkling to be carried out for dust suppression • Top soil (15 cm) should be stripped and preserved under covered conditions for landscaping purpose in later stage. This should be stored in the form of the heap with the slide slopes covered with grass. Excavated soil should be used within the site for filling purpose and for realignment of the existing road. Any surplus soil should be disposed off to safe location/identified debris disposal site approved by IWAI within 5 kms of project site. • Contractor should submit a plan prior excavation to the IWAI for management and disposal of the surplus earth. • Green belt should be developed at the site and as per the Green Belt Management Plan (Annexure 3). • Survival rate of tree should be regularly monitored. • Work timings should be restricted from 6:00 AM to 10:00 PM. Adequate illumination should be provided at site during evening hours • Rest area should be provided for workers at site and sleeping/lying down at site should be strictly	Social Impact Assessment requirements					

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	prohibited • Safety guidelines as per operation, health & safety management plan **(Annexure 4)** should be followed **Municipal Solid Waste Management:** • Excavated soil should be stored in covered conditions only • Arrangement should be made for segregation of waste into recyclable and non-recyclable waste • Non-recyclable waste generated should be disposed regularly through authorized agency. Recyclable waste should be sold to authorized vendors. • Construction waste generated should be segregated at site into recyclable, reusable & rejected fraction. Recyclable should be sold to authorized vendor; reusable waste should be stored at site for usage and rejected fraction should be disposed at designated sites by the municipal authority • If no debris or waste disposal site exists in the area then a site should be identified for debris disposal, should be approved by IWAI and should be used & manage for the same as per the Debris Management Plan **(Annexure 5)**						
❖ Setting of Labor Camps: contamination of land and	**Location of Camp:** • Construction camp siting, establishment, location and management should be as per	The Building and Other Construction workers	Labour Camp Locations	During Renovation Stage	Approximate Rs 500,000/-per campfor sanitation and	Contractor.	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
water resources from municipal waste from Camps, worker"s health, Pressure on natural resources due to establishment of labour camps	proposed Construction & Labour Camp Management Plan **(Annexure 6)** • Labour camps should be located close to the construction sites to the extent possible **Sanitation and Worker's Health:** • Hygiene in the camps should be maintained by providing good sanitation and cleaning facilities. Soak Pits can be provided only if labour camp is located away from river. • Camp should be well ventilated. It should have adequate provision for illumination, kitchen and safe drinking water facility. Proper drainage to be maintained around the sites to avoid water logging leading to disease • Preventive medical care to be provided to workers • Segregated, collection and disposal of solid waste on regular basis at identified municipal solid waste disposal location. If municipal solid waste site not available than waste should be land fill following the regulations. • Provision should be made essential material supply like cooking fuel (gas) • Provision should be made for day crèche for children	(Regulation of Employment and Conditionsof Service) Act 1996 and CessAct of 1996 andThe Water (Prevention & Control of Pollution) Act, 1974 and amendments thereof. Municipal Solid Wastes (Management and Handling) Rules, 2000			healthfacilities.		
❖ Setting up construction Camp:	• All these facilities should be installed at existing lock gate site itself. In case	Air (Prevention and Control	Site construction Camp	During Renovation Stage	approximate Rs 500,000/- per campfor	Contractor.	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
Concert Mix Plant, Hot Mix Plant, Mechanical Workshop, Fuel storages, Lubricant storages	these are to be set up away from site than these should be located at minimum distance of 500 m from habitation, water bodies. • All maintenance facilities, hot mix plant and concrete mixing plant should be established with prior consent to establish to be obtained from SPCB. • All such equipment/plant should be fitted with air pollution control system and should comply with condition of consent to establish. • Periodic monitoring should be carried as per consent conditions.	ofWater Pollution)Act, 1981 and Water (Prevention andControl of Water Pollution)Act, 1974			sanitation and healthfacilities.		
4. Site Preparation: Power supply, Water Supply, and Drainage, disposal of muck and debris							
❖ Power supply and Energy Conservation: Air Pollution, energy loss	• Power should be sourced from State electricity board in the area during construction stage as well operation phase. • DG sets should be used only in case of power failure • Back-up power should be set up with all provisions of containment for fuel leakages, air pollution control (stack height as per regulation) and with acoustic enclosure. • Solar energy should be used in the project. • Energy Conservation Building Code should be used as applicable to various office and other structures.	Air (Prevention and Control of Water Pollution) Act, 1981 & ECBC Norms,2007	Construction Sites and Labour Camp Locations	During Renovation stage	Part ofProject Costs	Contractor.	IWAI/PMU /PMC
❖ Water Supply, Drainage and	• Supply water shall be used fordrinking water.	Central GroundWater	Construction Sites and	During Renovation	Approx.Rs 300,000 for	Contractor.	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
effluent discharge	• Water required for construction should be sourced from river for which necessary permission should be obtained. • Caution sign should be placed at site for optimal use of water • Garland storm water temporary drains should be developed around the site to prevent any direct • discharge of contaminated or soiled water to river. It should be passes through de-siltation chamber and water collection pit. Collected water should be used for construction purposes. • All washing and maintenance effluent from the workshop area of vehicle maintenance area should Darin to separate collection areasfitted with oil and grease trap and de- siltation chamber. The treated water should be used for dust separation and green belt development. This water should not be discharged to river at all.	Board,Water (Prevention andControl of Water Pollution)Act, 1974	Labour Camp Locations	stage	constructionof grease traps andde-siltation chambers		
❖ Disposal of excavated earth, muck and debris: uncontrolled disposal may leads to increased sedimentation of the river.	• Provision should be made for collection and draining of water from the excavated earth. It should be used for embankment protection or road construction depending on its suitability. • Provision should be made for geo Synthetic Screen for arresting silt flowing down stream.	Solid Waste (Management &Handling) Rules, 2015	River Bank along the lock gate site	Pre-Renovation and Renovation Stage	Part ofProject Costs	Contractor.	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
5. Embankment Design and Construction, Drainage Pattern							
❖ Navigational channel Bank Erosion ❖ Protection: Construction of Embankment and construction of inlet and out let structure: may lead to accumulation of sediments on the updrift side and erosion of the downdriftside Contamination of river water quality and land may happen due to river bed material	• Stone pitching should be provided on left bank of the river for protection • The river bank slope of U/S and D/S approach channel should be provided with two layers of pitching with PCC blocks of size of 1 m x 1m x 0.6 m. 6 m wide. • Guide walls on U/S and D/S of the lock are tied to those of existing lock and cut offs to a depth of 5 m have been provided for protection against scour • During block pitching, the block should be placed at suitable distance and should not by dropping from height. Block should be placed by making grid in pitching area. • Erosion monitoring should be carried out periodically downstream as well. • River Bed material/dredged soil if any should be tested for contaminants before its use or disposal for land fill site. If any level of heavy metal contamination is found than it should be disposed off in a secure manner to TSDF.	Water (Prevention andControl of Water Pollution) Act, 1974	1500-meter stone pitching River Bank along the lock gate site & 40 m apron inside the river	During design, Pre-Renovation and Renovation Stage	Part ofProject Costs	Contractor.	IWAI/PMU /PMC
❖ Drainage Pattern	• Natural Drainage pattern of area around should be maintained. • Storm water management drains should be provided at site for management of storm water management		Construction Sites, Access Road, and Labour Camp Locations	During Renovation stage	Part ofProject Costs	Contractor.	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
6. Construction Material Sourcing							
❖ Borrow areas for sourcing earth for filling as required (erosion, loss of productive land, land degradation, air pollution)	• As surplus soil is available from excavation of the site, no borrow area may be required.	IRC Guidelines on borrowareas EIA Notification 2006(under Environmental Protection Act and Rules, 1986;)	-	During Renovation stage	Part ofProject Costs	Contractor	IWAI/PMU /PMC
❖ Quarries for sourcing stone and aggregates (loss of productive land, land degradation, air pollution. Any illegal quarrying may lead to land use change, unstable rock formation)	• Aggregates required for embankment stone pitching and roads should be procured from licensed quarries. • It should be ensuring that selected quarries are having requisite environment clearance, and comply with Air Pollution Control and Noise level requirements as per the law. • Copy of Environmental Clearance letter and Consent to operate and should be obtained from the quarry owner and submitted to IWAI. • Material should be transported under covered trucks only. • No new quarry should be opened without due permissions. If new quarry is opened then it is require to obtain environment clearance from MoEFCC/SEIAA • Each Quarry should be visited prior to its selection to ensure its compliance with lease conditions, EC and consent conditions.	EIA Notification 2006(under Environmental Protection Act and Rules, 1986)	Quarry Site	During Renovation stage	Part ofProject Costs	Contractor	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
7. Protection of Flora and Fauna							
❖ Protection of impact on aquatic Fauna & Flora due to Increased sedimentation downstreamof construction site	• To avoid the siltation in water 100m distance has been kept between existing lock gate. • No breeding ground is noticed around the project site. However, construction activity should be restricted during spawning & breeding period of fishes, i.e. June to August • To avoid the construction debris, wash or blown into the water the construction area shall be surrounded by silt screens. • The screens should also be placed around storage areas, to prevent waste from blowing away and to • prevent sediment run-off into the river. • All the material and debris shall be stored at least 20 meters away from the high water mark and construction equipment must not be cleaned or washed within 50 meters of the high water mark. • Run-off from site should pass through oil/grease traps and sedimentation tank before its reuse. All efforts shall be made for its reuse to avoid its discharge to river. • Construction activities shall be carried out rapidly. Culvert construction should not be carried out during breeding and spawning season means during rainy season.	• Wild Life (Protection) Act,1972	Around Pilling Area	During Renovation stage	Part ofproject costs	PMU through DFO	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	• Maintaining equipment in good condition to prevent leaks or spills of potentially hazardous materials like hydraulic fluid, diesel, gasoline and other petroleum products • Positioning water borne equipment in a manner that will minimize damage to fish habitat. • Turbidity traps/curtains should be provided or Geo-Textile synthetic sheet curtain shall be placed around the construction area to prevent movement of sediments and construction waste. • Excavation activities onshore shall not be undertaken during monsoon season so as to minimize sediment load of run-off. • All workers should be made aware of not throwing any waste in the river or any drain • No construction debris/ already accumulated solid waste at site or waste generated from labour camp should be thrown in river or any drain • Sewage generated from labour camp should not be directed into river but should be disposed off through septic tank/soak pit. • Engineering controls modify the equipment or the work area to make it quieter. Examples of engineering controls are: use of quieter equipment;						

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	retro-fitting equipment with damping materials, mufflers, or enclosures; erecting barriers; and maintenance. • Aquatic ecology monitoring shall be carried out prior start of construction and after completion of construction so as to assess the impact of construction activities on aquatic life. • Soil stabilization works in the bank must consider implications on changes in hydrological flow, current and behavior of the river. Such changes may create new problems such as change of river course, erosion of river embankment, change in erosion and inundation pattern of the bank etc. which will inturn impact the habitat of aquatic life • Sedimentation and siltation should be prevented to maintain productivity of aquatic ecosystem and availability of food such as aquatic fauna, vegetation to the avian fauna. • Green belt should be developed all around the project periphery. 1 ha of area is reserved as green area. App. 100 trees should be planted within the 1 ha of area to be provided at the site.						
❖ Impact on avifauna including Migratory birds	• Hunting, poaching and harming any animal (especially avi -fauna) by any worker or project related person shall be strictly prohibited and monitored. • The designated imported bird area is located more than 4 km from the	Wild Life (Protection) Act	Around Project Site	During Renovation stage	Part ofproject costs	PMU	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	however it is recommended that, to conserve the local biodiversity (migratory birds of Farakka barrage area) the construction activities may stop for migratory periods of the birds if required.						
❖ Impact on Terrestrial Flora & Fauna	• There are very few trees and some agricultural land scattered around the location, besides the green meadows around. Development of a green belt has been proposed all along the lock gate boundary. This would help in settlement of dust and keep atmospheric humidity under check. • As far as possible the existing trees present at site shall be retained under greenbelt • Permission should be obtained from forest department prior tree cutting if any. • Thick green belt should be developed around the periphery of the lock site. App. 100 trees will be planted at the site. Green belt should include native tree species like Pepal, Bargad, Arjun, Sheesham, Kaner, Neem etc. Green belt should be developed as per the CPCB guidelines proposed above climate section • Maximum survival rate for plantation shall be ensured. • Hunting, poaching and harming any animal (especially avi -fauna) by any worker or project related person shall	Wild Life Protection Act	In and Around Project Site	During Renovation stage	Part ofproject costs	Contractor	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	be strictly prohibited and monitored. • The designated imported bird area is located more than 4 km from the however it is recommended that, to conserve the local biodiversity (migratory birds of Farakka barrage area) the construction activities may stop for migratory periods of the birds if required. • Construction activities should be restricted to 6:00 Am-10:00 Pm especially noise generating activities • Illumination at the site shall be reduced during the night time (if no activity is going on) as it may disturb the nocturnal animals. • Noise generating activity shall not be undertaken during night time to minimize disturbance to animals. • Noise levels shall be maintained within the prescribed CPCBs limits to the extent possible during the day time. • No hazardous material or waste should be disposed off in the other land or nearby area as it may harm the animals, if consumed accidently • Regular water sprinkling shall be done in dust prone areas and haul roads. • Construction site shall be barricaded to reduce the dust and noise generation. • Speed limit will be for construction vehicle shall regulate to control noise						

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	and dust emission. • Regular maintenance of the dumper and construction machineries shall be done • No timber usage should be allowed for cooking or any other purpose at site during design, construction • phase of the project. Clean fuel like LPG should be used						
8. Air Quality							
❖ Fugitive Dust Generation due to construction activities	• Barricading the site to prevent dust dispersion to nearby areas • Excavation and filling should be carried out in parallel. Excavation and filling should be carried out in phases • Excavated soil should be stored under covered conditions • Transport of loose and fine materials through covered vehicles. • Loading and unloading of construction materials in covered area. • Approach roads should be paved and widened. • Water spraying on earthworks, unpaved haulage roads, other dust prone areas and construction yard. • Make Provision of PPEs like face masks to workers. • Raw materials like cement, sand and construction debris should be stored under covered conditions • Wheel wash facility should be provided at exit points of the site	Environmental Protection Act, 1986 and amendments thereof; The Air (Prevention andControl of Pollution) Act, 1981 and amendments thereof	Construction sites, Loading areas, storage areas,	During the Renovation phase	Part of project Costs	Contractor	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	• Monitoring of air quality should be carried out on monthly basis to check the level of pollutants and effectiveness of proposed EMP. • Development of green belt at the site efficient for arresting the particulate matter • Mixing Plant, crushers and batching plant should be located on downwind direction of the site fitted with adequate stack height to ensure enough dispersion of exit gases. with appropriate pollution control measures • Low sulphur diesel should be used for operating DG sets and construction equipment.						
❖ Exhaust gas emissions from machinery andvehicular traffic.	• Regular maintenance should be carried out of machinery and equipment. • Diesel Generating (DG) sets should be fitted with stack of adequate height as per regulations (Height of stack = height of the building + 0.2 √KVA.)	Environmental Protection Act, 1986 and amendments thereof; The Air (Prevention andControl of Pollution) Act, 1981 and amendments thereof	Construction camps and sites, batching plants, DG set's locations	During Renovation phase	Part of project Costs	Contractor	IWAI/PMU /PMC
❖ Emissions at access road: avoidance of traffic Jams	• Efforts should be made to move construction material early morning and late evening period. • Traffic regulators (Guard) should be posted in habitat area and at key junction areas to avoid congestion	Environmental Protection Act, 1986 and amendments thereof; The Air	Existing roads	During Renovation phase	Part of project Costs	Contractor	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	• No construction, material, equipment or vehicle should bestored or parked at any road or the non-project area • Transportation vehicle should strictly adhere to the designated routes and timings and should avoid the peak traffic hours	(Prevention andControl of Pollution) Act, 1981 and amendments thereof					
9. Noise and Vibration							
❖ Noise from construction vehicle, equipment and machinery.	• All equipment to be timely serviced and properly maintained to minimize its operational noise. • Construction equipment and machinery to be fitted with silencers and maintained properly. • Barricading the construction site to minimize the noise level outside the site boundary • Timely maintenance and servicing of construction equipment and vehicles to reduce the noise generation due to friction and abrasion • Protection devices (ear plugs or ear muffs) will be provided to the workers operating in the vicinity of high noise generating machines. • Honking should be prohibited at the project site • All safety measures and Job rotations should be practiced for workers, working in high noise level areas. • No noise generating activity should be carried out between 6:00 AM to 10:00 PM.	Noise Pollution (Regulation andControl) Rules,2000 and amendments thereof	Lock gate site and accesses road.	During renovation stage	Part ofproject Costs	Contractor	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	• Hearing test for the workers prior to deployment at site and high noise areas followed by periodic testing every six months. • Monitoring of Noise levels should be carried out on monthly basis to check the level of pollutants and effectiveness of proposed EMP.						
10. Land-use and Landscape							
❖ Land use Change and Loss of productive/top soil	• Efforts should be made to improve the Aesthetic of the area. No construction waste or other wastes should be dumped at unidentified areas. • Caution board in local language should be placed at different locations to prevent dumping of Municipal solid waste and other waste all around the project site areas which is happening substantially at present. • About 15 cm of top soil layer should be stripped prior to excavation and stored separately in covered condition and should be used for landscaping of the lock gate site. • The remaining excavated soil should be used for filling of site and road realignment. Excess earth, if any shall be disposed off at the locations designated by the authorities or to the debris disposal site identified for the project • Land earmarked for dumping of construction waste, setting up of	Design requirement	Around project site area and borrow area	During Renovation Stage	Approximately Rs25000 forfive caution boards @Rs 5000 per board	Contractor	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	construction camps, plant sites etc should be free from any social and R&R issue and away from settlements.						
❖ Soil erosion due to construction activities, earthwork	• Excavation and filling operations should be carried out in parallel so as to minimize the soil erosion. Unusable debris material should be suitably disposed off at pre designated safe disposal sites, but with prior approval of the concerned authority. • Provision of cross drainage structure should be made in the access road if required to maintain the natural drainage pattern and prevent soil erosion • Provision of side drain should be made in realigned road if required to prevent soil erosion • Provision of geo-textiles matting, stone pitching, retaining wall, apron etc should be made to prevent the erosion of bank and scouring of bed during renovation phase • Bio-turfing of embankments should be made enhance the slop stabilization.		Access road and river bank	During Renovation Stage	Part ofproject costs	Contractor	IWAI/PMU /PMC
❖ Soil erosion at earth stockpiles	• The earth stockpiles to be provided with gentle slopes to prevent soil erosion. • Provision of geo-textiles matting, stone pitching, retaining wall, apron etc should be made to prevent the erosion		At earth stockpiles	During Renovation Stage	Part ofproject costs	Contractor	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	of bank and scouring of bed during renovation phase • Soil compaction at the site should be undertaken by regulated water sprinkling to minimize any surface runoff or soil erosion						
❖ Compaction and contamination of soil due to movement of vehicles and equipment	• Fuel and lubricants to be stored at the predefined storage location. • Storage area should be paved with gentle slope to a corner and connected with a chamber to collect any spills of the oils. • Provision of "oil interceptors" at wash-down and re-fueling areas. • Oil and grease spill and oil-soaked materials are to be collected and stored in labelled containers • (Labelled: WASTE OIL; and hazardous sign be displayed) and sold off to SPCB/ MoEF authorized vendors. • Movement of construction vehicles, machinery and equipment should be restricted to the designated haulage route.		Lock gate site	During Renovation stage.	Part of project costs	Contractor	IWAI/PMU /PMC
11. Water Resources							
❖ Depletion of Groundwater resources due to unregulated abstraction for construction purpose	• Water required for construction should be sourced from rivers with due permission from authorities. • Water required for domestic uses should be sourced from supply water. • Efforts to restrict water intensive activities during summer period (April,			During Renovation stage	Part ofproject costs	Contractor,	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	May, June) • No dumping of waste/wastewater in the ground. waste or wastewater should not be stored in unlined ponds						
❖ Increase in water Siltation levels due to construction of lock due to disposal of domestic waste	• Restoration of changes in the stream, if any, made during construction to its original level. • Mobile toilets with anaerobic digestion facility should be fixed at construction site. No domestic waste should be discharged to river. • Excavation activity should not be carried out during monsoon season • Garland drains should be provided around excavated area so as to prevent entry of run-off to the excavated pits • Excavated areas should be covered to the extent possible to prevent entry of rainfall run-off in case of rains • The storm water drain should be connected to a collection cum sedimentation pond to collect the surface run of the construction area. The collected rain water should be used for dust suppression purposes at construction material handling area. Storm water drains should be provided for the parking areas also and these drains should be provided with oil & grease trap • No waste should be disposed off in river and ground while filling and		Lock gate site	During Renovation stage	Part ofproject costs	Contractor	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	excavating. • Washing of vehicle and equipment should not be carried out at river or any water body. Washing area should be provided with the storm water drains fitted with oil & grease trap. • Monitoring of surface water quality should be carried out on monthly basis to check the level of pollutants and effectiveness of proposed EMP • Storage of debris and raw material should be carried out in paved and covered areas. This will minimize interface of run-off with raw material and debris. • Water use should be minimized by using RMC, practicing curing by water sprinkling, maintaining flow of sprinklers, covering the water storage tanks to minimize water evaporation, creating awareness for water conservation and regular inspections at site to monitor the leakages in water storage area • In case RMC is not used then concrete transit mixer should be washed and cleaned daily. Wash from these mixers should be collected in block work tanks which will allow settling of concrete, removal of aggregates and allowing the waste to wastewater drain. This collected waste concrete can be dried and used for various purpose at site.						

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	• Wastewater generated from the washing/cleaning area after passing through oil & grease trap & curing area should be re-used for water sprinkling and wheel washing • Turbidity traps/curtains should be provide or Geo-Textile synthetic sheet curtain should be placed around pilling and construction area to prevent movement of sediments and construction waste. • Septic tank/soak pit should be provided at site for disposal of sewage from the toilets at site and from the labour camps. Adequate toilets & bathrooms should be provided to prevent open defecation. • Fuel should be stored in leak proof containers and containers should be placed on paved surfaces. • Proper collection, management and disposal of construction and municipal waste from site to prevent mixing of the waste in run-off and entering the water bodies • Natural Drainage pattern of area around should be maintained.						
12. Accident and Safety Risks							
❖ Accident risk from construction activities and health and safety of	• Contractors to adopt and maintain safe working practices. • Usage of fluorescent safety and cautionary signage, in local language at the construction sites	Central Motor and Vehicle Act 1988 EP Act 1986 Noise Rules 2002	Construction sites	Renovation period	Part ofproject costs	Contractor	IWAI/PMU /PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
workers	• Training should be provided to workers, especially machinery operators, on safety procedures and precautions. • The Contractors to appoint a safety officer mandatory. • At every work place, a readily available first aid unit including an adequate supply of dressing materials, a mode of transport (ambulance), nursing staff, and doctor to be provided. • Required PPE should be provided to workers. • Periodic medical checkup should be carried of the workers. • Training should be given to workers to handle the heavy equipment so as to prevent accidents • Training should be given to workers to handle emergency situation like fire, earth quake and flood • Rest area should be provided at the site where labour can rest after lunch and should not lie on site anywhere • Adequate illumination should be maintained in the working area, in labour camps and plant site. • Working hours of labour should not exceed than standard norms as per state factory law • Construction labour camps and site should be properly cleaned and						

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	hygiene should be maintained • Proper sanitation facility like toilet and bathing facility should be provided at labour camps. Wastewater generated from these facilities should be disposed off through septic tanks and soak pit • Safety officers should be appointed at site so as to ensure all safety measures are taken at the site • Activity like smoking and consuming liquor should be prohibited at the site • Awareness on AIDS should be spread among the workers • Regular inspection for hygiene and safety in labour camps should be done • Speed limit of vehicles should be restricted at site to prevent any accidents. • Noise level in the work zone should be maintained and followed as per OSHAS norm • Employment should be provided preferable to local & affected people • Dustbins should be provided at labour camps for collection of waste and waste should be regularly disposed off through the concerned agency • Arrangement of fire-fighting should be made at site and workers should be trained to use the system in case of fire						
13. Shifting of Common Property Resources and Pressure on Existing Resources in Study Area							

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
❖ Shifting of community properties and utilities	• Any CPR, if removed should be relocated at the earliest with consent of the villagers and the Gram Panchayat		ProjectArea	Pre-Construction	Part ofProject Costs	Contractor	IWAI/PMU /PMC
❖ Pressure on Existing resources	• Non-productive lands, barren lands, raised lands; wastelands should be used for setting up labour camps, plant sites and debris disposal site. The above sites will be located more than 500 m away from the settlement and other sensitive location. • Land should be used for establishment of construction camps, debris disposal site and plant site only after obtaining consent from land owner. • Necessary permits should be obtained from concerned authorities in case any quarry site, batching plant, hot mix plant, WMM plant etc. is set up. • Management, rehabilitation and closure of these sites should be as per the Management plans proposed for these sites. Records for starting, maintaining and closure should be maintained and should be approved by site engineers • Top soil should be stripped off from these sites prior to usage and should be sprayed back at the time closure. Top soil should be stored in covered condition • Entrance to any road/structure should not be blocked for renovation of lock gate.						

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Indicative/ MitigationCost	Institutional Responsibility	
						Implementation	Supervision
	• Site should be barricaded and should have entry guarded by security guard. Register should be maintained for entry of outsiders. No unauthorized person should be allowed to enter the site especially village children • A board should be displayed at entrance of site displaying name of project, area and hazards associated with the site on entrance and activities prohibited within and near site area in local language • All proposed environmental pollution measures should be taken during renovation phase of lock gate to minimize the harm to existing environmental quality of the area, which is being enjoyed by the residents of that area • Maintenance and repair of the road should be carried out both before and end of construction by contractor. • Sprinkling of water should be carried out in road also, so as to minimize • dust generation due to movement of construction vehicles						

6.3 Institutional Arrangement

IWAI will develop Environmental Management Framework with the help of World Bank. The institutional arrangement should align as per this framework. IWAI will have an Environmental and social cell which will coordinate with site engineers and PMC.

6.3.1 Environmental Management Cell

Apart from having an Environmental Management Plan, it is also necessary to have permanent organizational set up charged with the task of ensuring its effective implementation of mitigation measures and to conduct environmental monitoring.

Highly qualified and experienced persons in the field of Environmental Management of lock gate should be considered for the positions of General Manager (GM) and Managers for overall Environmental management for proposed project. The major duties and responsibilities of Environment Management Cell are:

- To implement the environmental management plan
- To assure regulatory compliance with all relevant rules and regulations
- To ensure regular operation and maintenance of pollution control devices
- To minimize environmental impacts of operations as by strict adherence to the EMP
- To initiate environmental monitoring as per approved schedule
- Review and interpretation of monitoring as per approved schedule
- Review and interpretation of monitoring results and corrective measures in casemonitored results are above the specified limit

- Maintain documentation of good environmental practices and applicable environmentallaws as ready reference
- Maintain environmental related records
- Coordination with regulatory agencies, external consultant, monitoring laboratories
- Maintain log of public complain and the action taken

The proposed environmental management cell should have all basic record keeping facilities such as hard ware/software facilities, adequate space, vehicle (transport) and basic furniture and all simple instruments such as GPS, Digital camera, Hand held noise metre etc. The cell should have all basic environmental management data of the project that includes but not limited to the following:

- Environmental Impact Assessment Report (both well preserved soft and hard copy)
- All valid and up to date environmental clearance and consent papers
- All latest Environmental legislations, policies, codes and manuals for ready references
- A list of consultants on environmental management need to be kept with yearly revision of the list. This will help to receive proper advice in case of an emergency or are requirement and also to implement day to day environmental management activities.

Over a period of time a system to understand and absorb the new revisions and changes in the environmental requirements and practices are to be established. This can only be achieved by regular training and genuine capacity building initiatives. Institutional framework for the project isgiven in Figure 6.1.

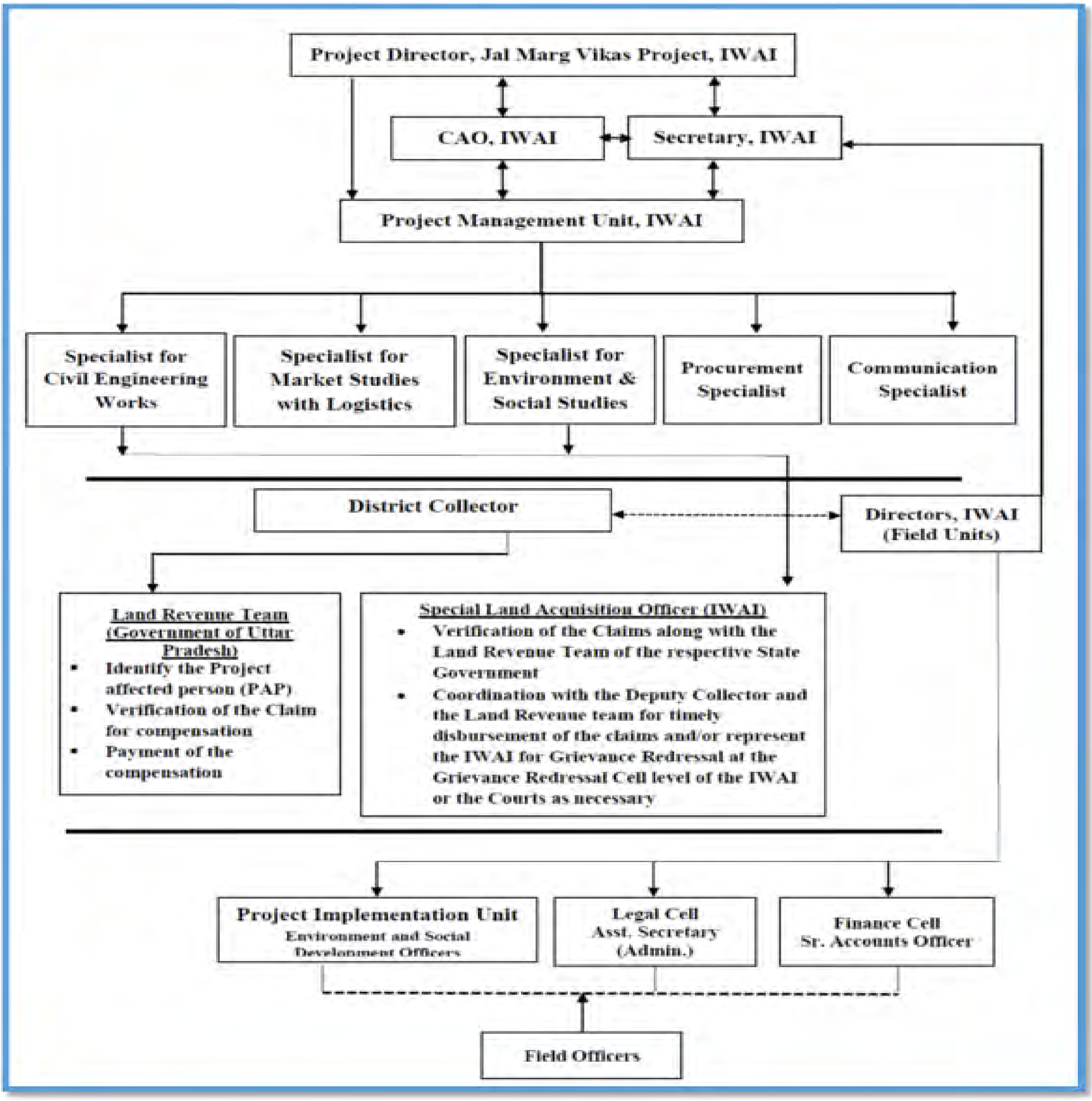


Figure 6.1 Institutional Framework

6.4 Environmental Standards for operation and maintenance of Lock

Project activities have potential to pose threat on the environmental quality. Regulatory Authorities of India and other countries have specified certain limits of pollutants which, if maintained, environmental pollution can be maintained. The Environmental standards applicable for the operation and maintenance stage of the project and that should be adhered to are listed below. Details of each of the standards is given in **Appendix 7.5** of this report

- Standards for discharged 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-Harbor and Navigation & controlled waste disposal (EIA Guidance Manual for Ports & Harbours, MoEF, GoI)
- Standards for permissible level of water quality indicators (Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992)
- Permissible limit for off-shore dumping of dredged material (Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992)
- Criteria for harmful bottom sediments (Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992)
- Approximate Quantity of Suspended Sediments Generated by Dredging or Dumping Operations (Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992)

6.5 Environment Monitoring Plan

The objective of environmental monitoring during the renovation phase is to compare the monitored data against the baseline condition collected during the study period to assess the effectiveness of the mitigation measures and the protection of the ambient environment based on national standards. The following are the main objectives of the environmental monitoring program:

- Provides information for documentation of monitoring of mitigation measures and impacts
- Tool for the statutory authority of unanticipated adverse impacts or sudden changes in the environmental condition due to the proposed project
- Provides information that could be used for evaluating the effectiveness of implemented mitigation measures
- Provides information that could be used to verify predicted impacts and thus validate impact prediction techniques
- The effectiveness of the mitigation measures being followed during renovation phase can be assessed and the measures can be revised, made more stringent and reinforced based on the monitoring results
- Environmental Monitoring can also serve a basic component of a periodic environmental regulatory auditing program for the proposed project

A monitoring schedule has been sketched based on the environmental components that may beaffected during the renovation phase of the project and is given in Table 1.2Table 6.2. Environment monitoring indicators identified are listed below

Monitoring Indicators

- Air quality- ambient air quality levels & stack emissions
- Surface Water quality
- Drinking water quality- for construction labours
- Noise levels- ambient noise level and work zone noise levels
- Soil quality- dredged sand quality and soil quality

- Solid & Hazardous Waste Management
- Wastewater disposal
- Re-plantation success / survival rate
- Soil Erosion
- Aquatic ecology– plankton and benthic communities
- Integrity of embankment

These indicators will be evaluated periodically based on the monitoring results, baseline conditions, predicted impacts and mitigation measures.

Table 6.2 Environment Monitoring Plan

S. No.	Aspect	Parameters to be monitored	No of sampling locations & frequency	Standard methodsfor sampling and analysis	Role & Responsibility	
					Implementation	Supervision
			Renovation Period			
1.	Air Quality (Ambient & Stack)	PM10, PM2.5, SO2, NO2, HC and CO	Three Locations including project site, labour camp and nearest habitation- once in two months	• Fine Particulate Samplers for PM2.5 • Respirable Dust Sampler fitted PM10 • Respirable Dust Sampler fitted with Gaseous sampling arrangements for SO2 and NO2, CO analyzer /portable CO meter for CO portable HC meter or tubes for HC; TO-14A, TO- 15, USEPA Method for sampling and analysis of VOCs in ambient air	Contractor	IWAI & PMC
2.	Surface Water Quality	Physical, chemical and biological	River Ganga- upstream & downstream- Once a month	Grab sampling and analysis by using standard methods	Contractor	IWAI & PMC
3.	Drinking water Quality	Physical, chemical and biological	Drinking water for labour camps Once a month	Grab sampling and analysis by using standard methods	Contractor	IWAI & PMC
4.	Noise Level	Day time and night time noise level (max, min & Leq levels)	Construction labour camp, construction site and nearest village Once a month	Noise meter	Contractor	IWAI& PMC
5.	Soil Quality, Erosion & Siltation	Soil texture, type, Electrical conductivity, pH, infiltration, porosity, etc.,	Construction site, labour camps and debris disposal site Once in 6 months	Collection and analysis of samples as per IS 2720	Contractor	IWAI & PMC
6.	Greenbelt development	Plantation survival rate	Lock gate premises	Survey, counting, recording & reporting	Contractor	IWAI & PMC
7.	Soil Erosion	---	Upstream & downstream of project site near river bank- -Once a month	Survey & observation; Extent and degree of erosion; Structures for controlling soil erosion	Contractor	IWAI & PMC
8.	Aquatic ecology	Phytoplankton, Zooplankton	River Ganga Six monthly	Species diversity index.	Contractor	IWAI & PMC
9.	Integrity of embankment	---	Upstream & downstream of lock gate site-Once a month	Survey & observation; Extent and degree of erosion; Structures for controlling soil erosion	Contractor	IWAI & PMC

6.6 Reporting Requirement

It is required that Contractor will submit quarterly compliance report to Project Management Consultants (PMC) of IWAI. PMC will analyse the report and notify the corrective action if any required to Contractor under intimation to IWAI. Also, compliance report should be prepared for the operation phase by IWAI for implementation of EMP.

6.7 Grievance Redress Mechanism

The concern/grievances from local/affected people may come up related to inappropriate implementation of various components of EMP. These issues can be easily addressed through acknowledgement, evaluation and corrective action and response approach. To resolve grievance from public or stakeholders concerning the project will be directed to the SPMU/Director concerned. Firstly, it will be assessed if the grievances are genuine or suggestion is acceptable. Accordingly, response will be given within 15-30 days by PMC and Director concerned. In case the PMC is unable to resolve the issue, the matter will be forwarded to Project Director at Head Quarter. The corrective action will be started as per the response or action plan indicated to the stakeholder. The outcome should also form part of quarterly report to World Bank (Figure 6.2).

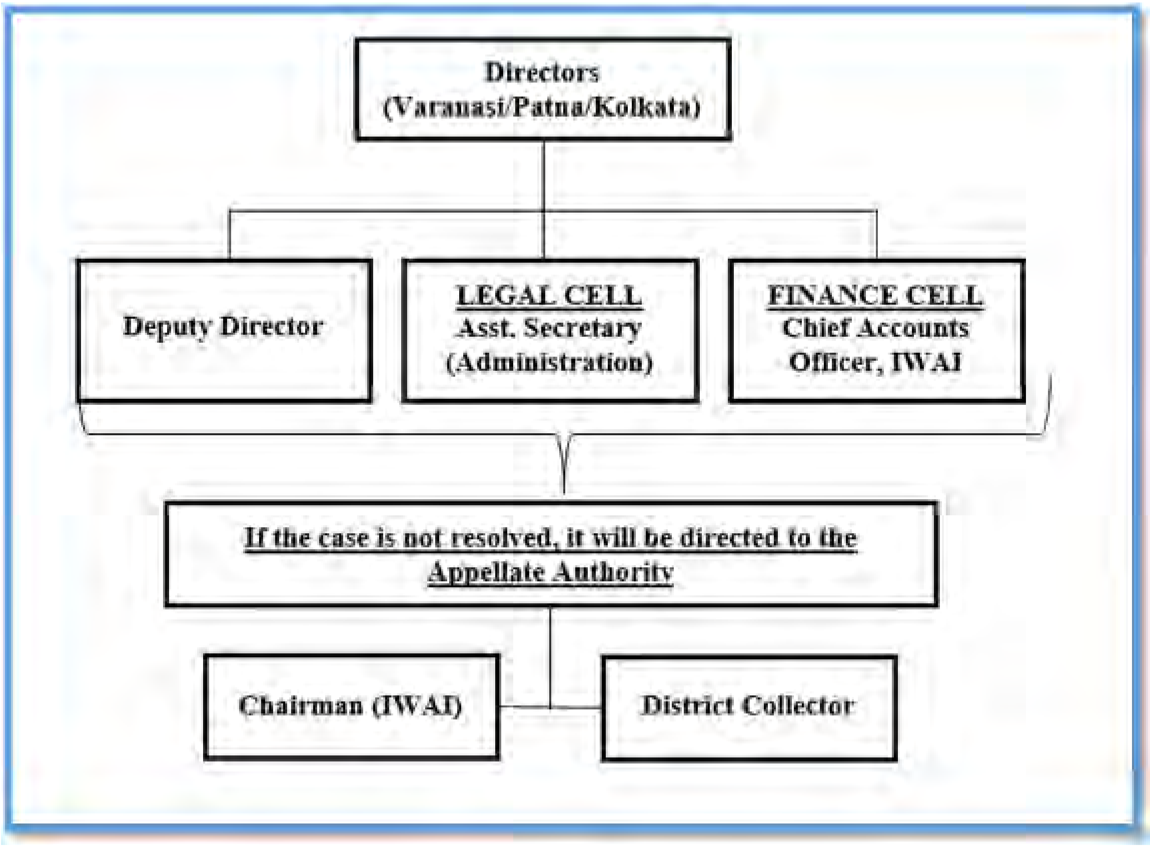


Figure 6.2 Grievance Redressal Cell

6.8 Environment Budget

Environment budget has been prepared for design, renovation phase of the project. Environmental budget will highlight the amount which is dedicated for environmental management. This can become part of BOQ if contractor so as he can incorporate all the proposed mitigation measures while preparing his proposal and can implement these without any problems, which is given in Table 6.3.

Table 6.3 Environment Management Budget

Component	Item	Unit	Quantity	Rate	Amount
RENOVATION STAGE					
Technical Support	• Environmental Impact Assessment Study, Bio- diversity Conservation Plan, Preparation of EMP	Lump sum	-	-	15,00,000
Greenbelt development	• Tree, shrub and herb plantation	No. of	100 trees	500 Rs/tree	50,000
Flora	• Aftercare and monitoring of plantation	Lump sum	50 trees	@100 Rs/Tree	5000
Drainage Congestion and disposal of accumulated water	• Provision of adequate surveillance	Covered in project design and engineering cost			--
Erosion & Sedimentation	• Embankment, and River Bank Protection Measures	Covered in project design and engineering cost			--
Land	• Compensation against land acquisition	Covered in R&R Budget			--
Soil	• Soil contamination protection (Septic tanks, grease taps etc) and rehabilitation of borrow areas/debris disposal site/plant site & labour camps	Covered in project design and engineering cost			--
Noise	• Canopy for DG sets • PPEs like ear plug • Timely maintenance of the machinery, equipment and vehicles • Barricading the site	Covered in project design and engineering cost			--
Water	• Provision of storm water and wastewater management system	Estimated @ RS 5,00,000 for construction site & 5,00,000 for labour camps (1 camp sites)			10,00,000
	Construction of soak pits at construction sites & labour camps	Estimated @ RS 3,00,000 per site estimated (construction & camp site)			6,00,000
	Provision of clean drinking & domestic water facility at labour camps and construction site	25,000 Per month for 20 months			5,00,000
Dust Management during construction	• Water Sprayer / Watering for Dust suppression	Covered in project design and engineering cost			
Safety	• Appointment of Safety Officers	Covered in project design and engineering cost			

Component	Item	Unit	Quantity	Rate	Amount
	Safety signages, speed breakers, fire-fighting measures etc.	Covered in project design and engineering and cost			
	Provision of trainings and PPE to workers	To be included in construction cost			To be part of contractor's costs
Health	Health checkup camps for construction workers	Camps	2 camp/year	2 lakhs/camp	4,00,000
Environmental Monitoring in the construction phase	Terrestrial and Aquatic Fauna	3,00,000 per season (Once in six month)			6,00,000
	Ambient Air Quality	1,00,000 per monitoring for 20 months (Once in two month)			10,00,000
	Surface Water Quality	30,000 for upstream & downstream (Once in month)			2,70,000
	Drinking Water Quality	15,000 (Once in month)			1,35,000
	Noise & Vibration	12,000 per monitoring for 20 months (Once in month)			2,40,000
	Soil Quality, Erosion & Siltation	1,00,000 per Six months			2,00,000
		SUB TOTAL (RENOVATION STAGE)			**65,00,000**
TRAINING AND AWARENESS					
Training	• Environmental training & awareness	-	-	Lump sum	2,00,000
ESTABLISHMENT AND SYSTEMS					
Establishment	• Supervision Consultant (Environment and Social)	-	-	Included in overall NW-1 Project Budget	-
	• Renovation Stage (Site Environmental officer)	-	-	Included in overall NW-1 Project Budget	-
	• Operation Stage	-	-	Included in overall NW-1 Project Budget	-
Management Systems	• Adoption of EHS management systems	1	1	Lump sum	4,00,000
	• Management Information and tracking system	1	1	Lump sum	4,00,000
SUBTOTAL (ESTABLISHMENT & TRAINING and MANAGEMENT SYSTEM)					**1000000**
SUB TOTAL (Renovation and mobilization)					**750000**
CONTINGENCIES @ 5 % on total Environmental Costs					**4,12,500**
Grand Total (in Rs.)					**86,62,500 (0.87 Cr)**

Chapter 7

7 SUMMARY AND CONCLUSIONS

Project involves renovation of the existing lock gate at Farakka, District Murshidabad, West Bengal. Land is slightly undulating with level variation of RL +13 to RL +29 m. Facilities proposed at the site includes control room building, control room for gate operation, counter fort retaining wall, inlet outlet structures, base slab, internal roads, waste management facility, storm water management system, fire-fighting facility and other allied facilities. Project site is well connected with Farakka-Rajmahal highway through a public road. Realignment of this road will be done along the western boundary of the existing lock gate site.

Baseline study has been carried out at the project site to study the existing condition of environmental and social parameters at site. On the basis of the baseline data and associated project activities, impacts of the project activities on social and environmental parameters were analysed. It is predicted that project will have impact (renovation phase) on air, water, noise, soil, drainage, hydrology, ecology and socio-economy of the area. However, mitigation measures and management plans are proposed for mitigating the anticipated negative impacts of the project.

Environment management plans are prepared to prevent/control/abatement of pollution resulting from project activities in different stages. Environment management plan defines the institutional framework responsible for implementation of EMP, environment monitoring plan andenvironment management budget.

As per the EIA study, it is concluded that the project “renovation of existing lock gate at Farakka” is very beneficial for the economic development of country as it will increase the efficiency of freight transportation through waterways and will be beneficial for environment by shifting freight load from road/railway to waterways and cutting down carbon emission. However, project development will have significant impacts on social and environmental parameters. Mitigation measures and management plans are prepared in line with impacts anticipated. If the proposed mitigation measures are taken and environment management plan is implemented, anticipated negative impacts of project can be reduced and benefits can be further enhanced. The project will overall bring development in the area.

Annexures

Annexure 1

International Maritime Conventions, Protocols and Agreements Relevant to the Project

S. No.	Issues	International Maritime Conventions, Protocols and Agreements	Remarks
1.	InternationalMaritime	IMO Convention, 1948	The Convention establishing the IMO was adopted in 1948 but the Organization started life as the Inter-Governmental Maritime Consultative Organization (IMCO) until it was changed to the IMO in 1982.The Aims of the IMO include a range of objectives: 1. To provide machinery for cooperation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade, and to encourage the general adoption of the highest practicable standards in matters concerning maritimesafety and efficiency of navigation; 2. To provide for the consideration by the Organization of any matters concerning shipping that may be referred to it by any organ or specialized agency of the United Nations; 3. To provide for the exchange of information among Governments on matters under consideration by the Organization. There have been a series of amendments to the Convention which are 1975 amendments, 1977 amendments, 1991 amendments.
2.	Maritime safety	SOLAS Convention, 1974	The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The 1974 version includes the tacit acceptance procedure - which provides that an amendment shall enter into force on a specified date unless, before that date, objections to the amendment are received from an agreed number of Parties. The Convention came into force on May 25, 1980
3.	Measurement of ships	Load Lines Convention,1966	It has long been recognized that limitations on the draught to which a ship may be loaded make a significant contribution to her safety. These limits are given in the form of freeboards, which constitute, besides external weather tight and watertight integrity, the main objective of theConvention.
4.	Preventing collisions at sea	Convention on International Regulations for Preventing Collisions atSea (COLREG), 1972	The 1972 Convention was designed to update and replace the Collision Regulations of 1960 which were adopted at the same time as the 1960 SOLAS Convention. One of the most important innovations in the 1972 COLREGs was the recognition given to traffic separation schemes - Rule 10 gives guidance in determining safe speed, the risk of collision and the conduct of vessels operating in or near traffic separation schemes.
5.	International	Convention on	IMO recognized the potential for satellite

	Maritime Satellite System	International Maritime Satellite Organization (INMARSAT), 1976	communications to assist in distress situations at sea soon after the launch of the world's first telecommunications satellite, Telstar, in 1962. In February 1966, IMO's Maritime Safety Committee (MSC) decided to study the operational requirements for a satellite communications system devoted to maritime purposes. In 1973, IMOdecided to convene a conference with the object of establishing a new maritime communications system based on satellite technology.
Anne	Prevention of Pollution fromShips	International Convention for the Prevention of Pollution from Ships (MARPOL), 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997(MARPOL)	The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and also includes the Protocol of 1997 (Annex VI). It has been updated by amendments through the years.
		Convention on Facilitation of International Maritime Traffic (FACILITATION), London, 1965	The Convention's main objectives are to prevent unnecessary delays in maritime traffic, to aid cooperation between Governments, and to secure the highest practicable degree of uniformity in formalities and other procedures. In particular, the Convention reduces the number of declarations which can be required by public authorities.
7.	Safety of maritime navigation	Convention for The Suppression of Unlawful Acts of Violence Against the Safety of Maritime Navigation (SUA convention), 1988	The main purpose of the convention is to ensure that appropriate action is taken against persons committing unlawful acts against ships. These include: • the seizure of ships by force; • acts of violence against persons on board ships;and • The placing of devices on board a ship which are likely to destroy or damage it. The convention obliges Contracting Governments either to extradite or prosecute alleged offenders.
8.	EnvironmentalSafety	Convention Relating to Intervention on the High Seas, 1969	Contracting States are empowered to act against ships of other countries which have been involved in an accident or have been damaged on the high seas if there is a grave risk of oil pollution occurring as a result.
9.	Standards of Training, Certification and Watch keeping for Seafarers	International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW) as amended, including the 1995 and 2010 Manila Amendments	The main purpose of the convention is to ensure the safety of seagoing personnel. Convention inexplained in two codes A & B. Code A is mandatorywhile Code B is recommendation. It intends to help parties implement the convention.
10.	Maritime Search and Rescue (SAR)	SAR Convention 79	Aimed at developing an international SAR plan, so that, no matter where an accident occurs, the rescue of persons in distress at sea will be coordinated by a SAR organization and, when necessary, by co-operation between neighboring SAR organizations.
11.	Safe containers	International Convention for Safe Containers(CSC) 72/77	The 1972 Convention for Safe Containers has two goals. • to maintain a high level of safety of human life in the transport and handling of containers by providing

			generally acceptable test procedures and related strength requirements • to facilitate the international transport of containers by providing uniform international safety regulations, equally applicable to all modes of surface transport to avoid proliferation of divergent national safety regulations The requirements of the Convention apply to the great majority of freight containers used internationally, except those designed especially for carriage by air. As it was not intended that all containers or reusable packing boxes should be affected, the scope of the Convention is limited to containers of a prescribed minimum size having corner fittings - devices which permit handling, securing or stacking.
12.	Safety of Fishing vessel	The Torremolinos International Convention for the Safety of Fishing Vessels (SFV),1977, superseded by the The 1993 Torremolinos Protocol; Cape Town Agreement of 2012 on the Implementation of the Provisions of the 1993 Protocol relating to the Torremolinos International Convention for the Safety of Fishing Vessels	The Protocol applies to fishing vessels of 24 metres in length and over including those vessels also processing their catch. The general trend in modern designed fishing vessels, if they are to be economically profitable, must include improvements in machinery and fishing gear, improvements in safety features as a whole and better working conditions for fishermen. The safety provisions include automatically controlled machinery spaces, improved life-saving appliances, immersion suits and thermal protective aids, satellite communication systems and other components of the global maritime distress and safety system.
13.	Standards of Training, Certification and Watch keeping for Fishing Vessel Personnel	International Convention on Standards of Training, Certification and Watch keeping for Fishing Vessel Personnel (STCW-F), 1995	General Provisions & certifications of Safety of Skippers, Officers, Engineer Officers and Radio Operators.
14.	Space Requirements for Special Trade Passenger Ships, 1973	Special Trade Passenger Ships Agreement (STP), 1971 and Protocol on Space Requirements for Special Trade Passenger Ships, 1973	Following the International Conference on Special Trade Passenger Ships, 1971, IMO, in cooperation with other Organizations, particularly the World Health Organization (WHO), developed technical rules covering the safety aspects of carrying passengers on board in special trade passenger ships (ships carrying large nos. of unberthed passengers such as in pilgrim area)
15.	Prevention of Marine Pollution by Dumping of Wastes and Other Matter	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LC), 1972 (and the 1996 London Protocol)	London Convention, one of the first international conventions for the protection of the marine environment from human activities, came into force on 30 August 1975. Since 1977, it has been administered by IMO. It contributes to the international control and prevention of marine pollution by prohibiting the dumping of certain hazardous materials. In addition, a special permit is required prior to dumping of a number of other identified materials and a general permit for other wastes or matter.
16.	Oil Pollution Preparedness,	International Convention on Oil	As per convention, Ships are required to carry a shipboard oil pollution emergency plan. Operators of

	Response andCo operation	PollutionPreparedness, Response and Cooperation (OPRC), 1990	offshore units under the jurisdiction of Parties are also required to have oil pollution emergency plans or similar arrangements which must be coordinated with national systems for responding promptly and effectively to oil pollution incidents. Ships are required to report incidents of pollution to coastal authorities and the convention details the actions that are then to be taken. The Convention calls for the establishment of stockpiles of oil spill combating equipment, the holding of oil spill combating exercises and the development of detailed plans for dealing with pollution incidents. Parties to the convention are required to provide assistance to others in the event of a pollution emergency and provision is made for the reimbursement of any assistance provided.
17.	Preparedness, Response andCo-operation topollution Incidents by Hazardous and Noxious Substances	Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol)	Convention aims to establish national systems for preparedness and response and to provide a global framework for international co-operation in combating major incidents or threats of marine pollution. Parties to the OPRC-HNS Protocol are required to establish measures for dealing with pollution incidents, either nationally or in co- operation with other countries. Ships are required to carry a shipboard pollution emergency plan to deal specifically with incidents involving hazardous and noxious substances. The OPRC-HNS Protocol ensures that ships carrying hazardous and noxious substances are covered by preparedness and response regimes similar to those already in existence for oil incidents.
18.	Control ofHarmful Anti- fouling Systems	International Conventionon the Control ofHarmful Anti-fouling Systems on Ships(AFS), 2001	Under the terms of the AFS Convention, Parties to the Convention are required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal of a Party. Anti-fouling paints are used to coat the bottoms of ships to prevent sealife such as algae and molluscs attaching themselves to the hull — thereby slowing down the ship and increasing fuel consumption. n the early days of sailing ships, lime and later arsenic were used to coat ships' hulls, until the modern chemicals industry developed effective anti-fouling paints using metallic compounds. These compounds slowly "leach" into the sea water, killing barnacles and other marine life that have attached to the ship. But studies have shown that these compounds persist in the water, killing sea-life, harming the environment and possibly entering the food chain. One of the most effective anti-fouling paints, developed in the 1960s, contains the organotin tributyltin (TBT), which has been proven to cause deformations in oysters and sex changes in whelks.
19.	Safe and Environmentally Sound Recyclingof Ships	The Hong Kong International Convention for the Safe and Environmentally	Convention aimed at ensuring that ships, whenbeing recycled after reaching the end of theiroperational lives, do not pose any unnecessary riskto human health and safety or to the environment. It intends to

		Sound Recycling of Ships, 2009	address all the issues around shiprecycling, including the fact that ships sold forscrapping may contain environmentally hazardoussubstances such as asbestos, heavy metals,hydrocarbons, ozone depleting substances andothers. It will address concerns about working andenvironmental conditions in many of the world'sship recycling facilities. Regulations in the new Convention cover: the design, construction, operation and preparation of ships so as to facilitate safe and environmentally sound recycling, without compromising the safety and operational efficiency of ships; the operation of ship recycling facilities in a safe and environmentally sound manner; and the establishment of an appropriate enforcement mechanism for ship recycling, incorporating certification and reporting requirements. Ships to be sent for recycling will be required to carry an inventory of hazardous materials, which will be specific to each ship.
20.	Control and Management of Ships' Ballast Water andSediments	International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004	Convention aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediment. Under the Convention, all ships in international traffic are required to manage their ballast water and sediments to a certain standard, according to a ship-specific ballast water management plan. All ships will also have to carry a ballast water record book and an international ballast water management certificate. The ballast water management standards will be phased in over a period of time. As an intermediate solution, ships should exchange ballast water mid-ocean. However, eventually most ships will need to install an on-board ballast water treatment system
21.	Tonnage convention	International Conventionon Tonnage Measurement of Ships 69/82	The Convention, adopted by IMO in 1969, was the first successful attempt to introduce a universal tonnage measurement system. The Convention provides for gross and net tonnages, both of which are calculated independently.
22.	Salvage Convention, 1989	International Convention on Salvage (SALVAGE),1989	As per convention, "special compensation" to be paid to salvors who have failed to earn a reward in the normal way (i.e. by salving the ship and cargo). The compensation consists of the salvor's expenses, plus up to 30% of these expenses if, thanks to the efforts of the salvor, environmental damage has been minimized or prevented. The salvor's expenses are defined as "out-of-pocket expenses reasonably incurred by the salvor in the salvage operation and a fair rate for equipment and personnel actually and reasonably used".

Annexure 2

Applicable Environmental Standards / Norms

1. **Ambient Air Quality Standards:** The MoEFCC has the overall responsibility to set policy and Standards for the protection of environment along with Central Pollution Control Board (CPCB). Ambient Air Quality Standard given below:

REVISED NATIONAL AMBIENT AIR QUALITY STANDARDS (16TH NOVEMBER 2009)

Pollutants	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural, otherareas	**Ecologically Sensitive Area (Notified by Central Government)**
Sulphur Dioxide (SO_2), µg/m^3	Annual * 24 Hours **	50 80	20 80
Nitrogen Dioxide (NO_2), µg/m^3	Annual * 24 Hours **	40 80	30 80
PM_{10}, µg/m^3	Annual * 24 Hours **	60 100	60 100
$PM_{2.5}$, µg/m^3	Annual * 24 Hours **	40 60	40 60
Ozone (O_3) µg/m^3	8 Hours * 1 Hour **	100 180	100 180
Lead (Pb) µg/m^3 in particulate matter	Annual * 24 Hours **	0.50 1.0	0.50 1.0
Carbon Monoxide (CO), mg/m^3	8 Hours ** 1 Hour **	02 04	02 04
Ammonia (NH_3), µg/m^3	Annual * 24 Hours **	100 400	100 400
Benzene (C_6H_6), µg/m^3	Annual *	05	05
Benzo(a)Pyrene (BaP) ng/m^{3}in particulate matter	Annual *	01	01
Arsenic (As), ng/m^3 in particulate matter	Annual *	06	06
Nickel (Ni), ng/m^3 in particulate matter	Annual *	20	20

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.
** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

2. **Ambient Noise Standards:** Ambient standard with respect to noise have been notified by the Ministry of Environment and forestvide gazette notification dated 26th December 1989 (amended in February 2000). It is based on „A" weighted equivalent noise level (Leq). The ambient noise standards are presented in table below:

AMBIENT NOISE QUALITY STANDARDS

Area code	Category of Area	Limits in dB(A) Leq	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Sensitive Area	50	40

Note: *Day time is from 6 am to 10 pm, Night time is 10 pm to 6.00 am; ** Silence zone is defined as area up to 100 meters around premises of hospitals, educational institutions and courts. Use of vehicle horns, loud speakers and bursting of crackers are banned in these zones.

3. Ground Water Quality Standards

BIS STANDARDS FOR DRINKING WATER (IS:10500)

S.No.	Parameters	Unit	Acceptable Limit IS:10500	Permissible Limit IS:10500
1	Colour	Hazen units	5	15
2	Odour	-	Agreeable	Agreeable
3	Taste	-	Agreeable	Agreeable
4	Turbidity	NTU	1	5
5	Total Dissolved Solids	mg/l	500	2000
6	pH	-	6.5 to 8.5	No Relaxation
7	Total Hardness as $CaCO_3$	mg/l	200	600
8	Iron as Fe	mg/l	0.3	No Relaxation
9	Aluminium	mg/l	0.03	0.2
10	Copper as Cu	mg/l	0.05	1.5
11	Manganese as Mn	mg/l	0.1	0.3
12	Zinc as Zn	mg/l	5	15
13	Magnesium as Mg	mg/l	30	No Relaxation
14	Barium	mg/l	0.7	No Relaxation
15	Calcium as Ca	mg/l	75	200
16	Silver	mg/l	0.1	No Relaxation
17	Selenium as Se	mg/l	0.01	No Relaxation
18	Molybdenum	mg/l	0.07	No Relaxation
19	Boron	mg/l	0.5	1.0
20	Nitrates as NO_3	mg/l	45	No Relaxation
21	Sulphate	mg/l	200	400
22	Sulphide		0.01	No Relaxation
23	Fluoride as F	mg/l	1.0	1.5
24	Chlorides as Cl	mg/l	250	1000
25	Ammonia	mg/l	0.5	No Relaxation
26	Chloramines	mg/l	0.2	No Relaxation
27	Residual, Free chlorine	mg/l	0.2	1.0
28	Total Alkalinity as calcium carbonate	mg/l	200	600
29	Phenolic compounds (as C_6H_5OH)	mg/l	0.001	0.002
30	Mineral Oil	mg/l	0.03	No Relaxation
31	Anionic detergents(as MBAS)	mg/l	0.2	1.0
32	Chromium	mg/l	0.05	No Relaxation
33	Arsenic as As	mg/l	0.01	0.05

S.No.	Parameters	Unit	Acceptable Limit IS:10500	Permissible Limit IS:10500
34	Mercury as Hg	mg/l	0.001	No Relaxation
35	Cadmium as Cd	mg/l	0.003	No Relaxation
36	Lead as Pb	mg/l	0.01	No Relaxation
37	Nickel as Ni	mg/l	0.02	No Relaxation
38	Cyanide as CN	mg/l	0.05	No Relaxation
39	Polynuclear Aromatic Hydrocarbons (as PAH)	mg/l	0.0001	No Relaxation
40	Polyclorinated biphenyls	mg/l	0.0005	No Relaxation
41	Total Coliform	MPN/100ml	Nil	No Relaxation

4. **Surface Water Quality**

BEST DESIGNATED USE CRITERIA FOR SURFACE WATERS STREAMS

Designated-Best-Use	Class	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	Total Coliforms Organism MPN/100ml <50pH between 6.5 - 8.5 Dissolved Oxygen > 6mg/l Biochemical Oxygen Demand < 2mg/l
Outdoor bathing (Organised)	B	Total Coliforms Organism MPN/100ml < 500pH between 6.5 - 8.5 Dissolved Oxygen > 5mg/l Biochemical Oxygen Demand < 3mg/l
Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism MPN/100ml < 5000pH between 6 - 9 Dissolved Oxygen > 4 mg/l Biochemical Oxygen Demand < 3mg/l
Propagation of Wild life and Fisheries	D	pH between 6.5 - 8.5 Dissolved Oxygen > 4mg/l Free Ammonia (as N) < 1.2 mg/l
Irrigation, Industrial Cooling, Controlled Waste disposal	E	pH between 6.0 - 8.5 Conductivity at 25°C:.< 2250 umhos/cmSodium Absorption Ratio < 26 Boron < 2mg/l

5. **Soil Quality**

STANDARD SOIL CLASSIFICATION

S. No.	Soil test	Classification
1.	Ph	5.51 - 6.0 Moderately acidic 6.01 - 6.50 Slightly acidic 6.51 - 7.30 Neutral 7.31 - 7.80 Slightly alkaline 7.81 - 8.50 Moderately alkaline
2.	Salinity as electrical conductivity(milli mhos/cm)	Upto 1.00 Average 1.01-2.00 Harmful to germination2.01-3.00 Harmful to crops
3.	Organic carbon (%)	0.21-0.4 Less 0.41-0.5 Medium 0.51-0.8 On an average sufficient0.81-1.00 sufficient
4.	Nitrogen (kg/ha)	51-100 Less 101-150 Good 151-300 Better >300 Sufficient

S. No.	Soil test	Classification
5.	Phosphorus (kg/ha)	16-30 Less 31-50 Medium 51-65 On an average sufficient
6.	Potassium (kg/ha)	120-180 Less 181-240 Medium 241-300 Average 301-360 Better

Annexure 3

Greenbelt Development Plan

1. Introduction

Green belt acts as bio filter for the air pollutants and play a major role in safeguarding the environment and controlling the increasing level of air and noise pollution. It can serve as buffer and shock absorber against transient and accidental release of pollutants from industrial activity.

The green belt has been recommended as one of the major components of the EMP which will further enhance the environmental quality by:

1. Mitigation of air pollution
2. Attenuation of noise level
3. Maintaining the bio diversity of the area and improve aesthetics.

1.1 Size of Green belt

Dense greenbelt is already present at the boundary of the existing lock gate premises. Additional 100 trees along with herbs and shrub will be planted. 3x3 m spacing will be kept between trees. A standard horticultural practice involving planting of saplings in pits of substantial dimensions i.e., 1m × 1m × 1m for big trees and along half of these dimensions for` smaller trees and shrubs. The pits are then filled with earth, sand, silt and manure in pre-determined proportions. Saplings planted in such pits are watered liberally during dry months.

1.2 Selection of Tree Species

The Project renovation involve movement of vehicle for transportation of material Thus emissions like particulate matter, SO2, NOx & CO shall be generated at site. Plants possess a large surface area and their leaves exhibit an efficient pollutant trapping mechanism. The effectiveness of plants to control pollution depends upon the physiological, morphological traits such as leaf epidermis, size, leaf orientation, internal enzyme system, etc. Systematic screening of plants for their ability to tolerate pollutant need be undertaken. For pollution abatement purposes tree species would be fast growing native species, wind firm, unpalatable to animals, hardy and dust and pollutants tolerant/resistant.

1.3 Time of Plantation

Plantation would be done two weeks after the rain starts. It is advised to avoid planting during the dry season, as this will require watering. It is advantageous to plant trees on cloudy days.

1.4 Recommended Plant species

Based on nature of pollutants following tree species are recommended to be planted

S. No.	Plant Species	Common Name	Habit
1.	Anthocephalus cadamba	Kadam	Tree
2.	Ficus bengalensis	Badh	Tree
3.	Magnifera indica	Aam	Tree
4.	Tectona grandis	Teak	Tree
5.	Ficus religiosa	Peepal	Tree
6.	Hibiscus rosa sinensi	Hibiscus	Shrub
7.	Litchi chenensis	Litchi	Tree
8.	Delbergia sisoo	shisham	Tree
9.	Bougainvillea glavra	Bougainvillea	Shrub
10.	Narium indicum	Kaner	Shrub
11.	Azidirachta india	Neem	Tree
12.	Delonix regia	Gulmohar	Tree
13.	Albizia lebbeck	Siris	Tree
14.	Cassia fistula	Golden shower	Tree
15.	Pongamia pinnata	Indian beech	Tree
16.	Grasses and hages	--	Herbs

1.5 Protection of Tree saplings

Circular tree guard should be placed after the plantation of the saplings for the protection of these young plants from the ravages of cattle, sheep and goat and other animals. If tree saplings died or damage occur after placing the circular tree guard, timely replacements of damaged plant and thereafter care is important.

1.6 After Care & Monitoring

The growing plants are cared at least for the first two years under favorable conditions of climate and irrigation. Nutrients in pits are supplemented and the juveniles provided protection.

Thinning shall start after the stand is 3-4 years old and repeated every 4 years until the stand is 15 years old. Between 15-25 years old, thinning should be conducted every 5 years and after 25 years old, thinning shall be done after every 10 years. When the canopy closes, at about 6 years, 30-40% of the stems shall be thinned to selectively remove suppressed, diseased and badly formed trees.

Periodic assessment shall be carried for survivability of the trees and maximum survival rate shall be achieved.

1.7 Records Keeping & Reporting

The following records shall be maintained:

- Record of Tree plantation
- Record of Survivability rate

Inspection shall be carried out at site to know the survival rate of the plantation. The tree plantation and survivability report shall be prepared every six monthly.

Annexure 4

Guidelines for On Site and Off-Site Emergency Management

1. INTRODUCTION

Many emergencies can occur on any construction site and need to be effectively handled. The environmental and occupational health and safety aspects and related emergency can include incidence such as Collapse / subsidence of soil / Fire / Explosion / Gas Leak, Collapse of Building / Equipment and other Occupational Accidents. On site and off site emergency management plan shall be developed to effectively handle them.

Thus every contractor shall have an approved on-site emergency plan. The contractor should submit a copy of this plan to PIU and Supervision consultant before the start of the work. Contractor shall develop the onsite emergency plan considering the potential environmental, occupational health and safety emergency situation at site and activities involved. This plan shall include a list of these potential emergency situations in the onsite emergency preparedness & response plan. Contractor shall get the plan approved from IWAI/PMC

1.1 ANTICIPATED EMERGENCIES AT CONSTRUCTION SITE

The potential emergency situations have been defined below for guidance purposes. The contractors can follow these for developing site-specific on-site emergency preparedness plan.

Emergency conditions / situations	Sources
Collapse / subsidence of soil	• Civil structures
Bulk spillage	• Hazardous substance / inflammable liquid storage • Vehicular movement on highway
Fire and explosion	• Inflammable Storage Areas • Gas Cylinder Storage Areas • Electrical Circuits • Isolated Gas Cylinders (LPG / DA) • Welding / Gas Cutting Activity
Electrical Shock	• HT line • LT distribution • Electrically Operated Machines / Equipment / Hand Tools / Electrical

	Cables
Gaseous Leakage	• Gas Cylinder Storage Areas • Gas Cylinder used in Gas Cutting / Welding Purposes
Accidents due toVehicles	• Heavy Earth Moving Machinery • Cranes • Fork Lifts • Trucks • Workman Transport Vehicles (cars / scooters / motor cycles / cycles) • Collapse, toppling or collision of transport equipment
Slips & Falls (Man & Material)	• Work at Height (Roof Work, Steel Erection, Scaffold, Repair & Maintenance, Erection of equipment, Excavation etc.) • Slips (Watery surfaces due to rain) • Lifting tools & Tackles (Electric Hoist & Forklifts)
Collision with stationary/ moving objects	• Vehicular movement
Other Hazards	• Cuts & Wounds • Confined Space (under & inside machinery etc.) • Hot Burns • Pressure Impacts (Plant contains several Pressure Vessels & pipefitting containing CO2, air, water, product & steam, which can cause accidents & injuries to person • around.)

1.2 DESIGN OF 'ON-SITE EMERGENCY PLAN'

The „On-site emergency plan" to be prepared by contractor and shall include minimum the following information:

- Name & Address of Contractor
- Updation sheet
- Project Location
- Name, Designation & Contact Numbers of the organization, nearby hospitals, fire agencies etc. and key personnel including their assigned responsibilities in case of an emergency.
- The roles and responsibilities of executing personnel
- Site Layout Diagram showing location of fire extinguishers, emergency collection area and fire alarm
- Identification of Potential Emergencies Situations/ preventive measures / control & response measures

- Location of Emergency Control Centre (or designated area for emergency control / coordination) with requisite facilities.
- Medical services / first aid
- List of emergency equipment including fire extinguishers, fire suits etc.

1.3 EMERGENCY CONTROL CENTRE

The emergency control centre shall be equipped with following facilities

- Copy of current on-site emergency plan
- Display of the name of site emergency controller
- Two numbers of artificial respiratory sets
- Two numbers of Stretchers
- Vehicle for 24 hours (for large construction sites)
- Inter personnel/section telephone (2 numbers)
- Site layout diagram with entry and exit routes / Assembly points
- Directory of internal / external emergency phone Numbers
- A set of fire extinguishers (DCP type / Foam Type / CO2)
- List of fire extinguishers installed in the construction site including maintenance record
- A set of personal protective equipment (PPE)
- Two numbers of first-aid boxes with prescribed first-aid medicines
- List of competent first-aiders
- of fire trained personnel
- Two numbers of blankets
- Drinking water
- Two numbers of rescue ropes
- Two numbers of high beam torches
- Two numbers of gas leak detectors
- Life boat & jackets (if working in or near water course)

1.4 RECORDS

The following records shall be maintained:

a. Record of emergency preparedness plan with emergency contact numbers
b. Mock drill/emergency preparedness exercise records
c. Corrective preventive action record after emergency is occurred

1.5 REPORTING

The accident and incident records and emergency preparedness drill reports shall form part of quarterly report to EA

1.6 RESPONSIBILITY

Contractor shall be responsible to handle emergency condition and shall be liable to compensate the damage against accident, if any occurs at site.

Annexure 5

Guidelines for Debris and Solid Waste Management

1. INTRODUCTION

Waste will be generated from the construction site and labour camps during the renovation phase. Type of the waste to be generated during renovation phase is given below.

Excavated Soil

Site is undulating and thus will require cut & fill for levelling. Finished level of the soil will be 37 m. Top excavated soil of 15 cm shall be stripped and shall be stored separately under covered sheds. This soil shall be used for green belt plantation.

Lower layers of excavated soil shall be re-used within the site for filling and levelling purpose, construction of approach & internal roads. If any extra soil is remained, then that should be disposed of to the approved debris disposal site.

Construction Waste

Construction waste will comprise of broken bricks, dry cement, discarded timber, metal piece, cement bag, dry asphalt/bitumen, glass, paint/varnishes box etc. These wastes should be segregated into recyclable and non-recyclable waste. Recyclable waste shall be stored in the covered area and shall be sold to authorized vendors regularly. Non-recyclable waste shall be disposed off at approved debris site in covered vehicles.

Municipal Waste

Municipal waste will be generated from labour camp. Dustbins for recyclable and non-recyclable waste shall be provided in labour camp area. Recyclable waste shall be sold to authorized vendors and non-recyclable shall be disposed off through authorized agency in area responsible for waste collection and management.

Waste generated requires proper management so as to minimize the negative impacts on environment. Concept of reduce, re-use and recycle shall be followed at site. The rejected waste should be disposed off in a secured manner. Thus a site should be identified for disposal of the rejected waste.

1.1 SELECTION OF DISPOSAL SITES:

The locations of Disposal sites have to be selected such that:

- Disposal sites are located at least 1000 m away from sensitive locations like settlements, water body, notified forest areas, wildlife/bird/dolphin sanctuaries or any other sensitive locations.
- Disposal sites shall not contaminate any water sources, rivers etc so the site should be located away from water body and disposal site should be lined properly to prevent infiltration of water.
- Public perception about the location of debris disposal site has to be obtained before finalizing the location.
- Permission from the village/local community is to be obtained for the Disposal site selected.
- Environment Engineer of PMC and Executive Engineer of Contract Management Unit must approve the Plan before commencement of work.

1.2 PRECAUTIONS TO BE ADOPTED DURING DISPOSAL OF DEBRIS / WASTE MATERIAL

The Contractor shall take the following precautions while disposing off the waste material.

- During the site clearance and disposal of debris, the Contractor will take full care to ensure that public or private properties are not affected, there is no dwellings around the dumpsite and that the traffic is not interrupted.
- The Contractor will dispose-off debris only to the identified places or at other places only with prior permission of Engineer-in-Charge of works.

- In the event of any spoil or debris from the sites being deposited on any adjacent land, the Contractor will immediately remove all such spoil debris and restore the affected area to its original state to the satisfaction of the Engineer-in-Charge of works.
- The Contractor will at all times ensure that the entire existing canal and drains within and adjacent to the site are kept safe and free from any debris.
- Contractor will utilize effective water sprays during the delivery and handling of materials when dust is likely to be created and to dampen stored materials during dry and windy weather.
- Materials having the potential to produce dust will not the loaded to a level higher than the side and tail boards and will be covered with a tarpaulin in good condition.
- Any diversion required for traffic during disposal of debris shall be provided with traffic control signals and barriers after the discussion with local people and with the permission of Engineer-in-Charge of works.
- During the debris disposal, Contractor will take care of surrounding features and avoid any damage to it. The debris should not be disposed along the bridges & culverts and near the water bodies.
- While disposing debris / waste material, the Contractor will take into account the wind direction and location of settlements to ensure against any dust problems.
- Contractor should display the board at disposal site stating the name of project, usage of the site and type of debris being disposed.
- A guard shall be kept at disposal site to prevent any unauthorized disposal of waste at the debris disposal site
- Material should be disposed off through covered vehicles only
- No contaminated/hazardous/e-waste shall be disposed off at the debris disposal site

1.3 RECORD KEEPING

Site approved by site engineer only can be used as disposal site. Record of all such site should be maintained along with the area of disposal site, type & quantity of material disposed off daily and capacity of disposal site.

1.4 GUIDELINES FOR REHABILITATION OF DISPOSAL SITES

The dumpsites filled only up to the ground level could be rehabilitated as per guidelines below and to be decided by the Engineer and the supervision consultant.

- The dumpsites have to be suitably rehabilitated by planting local species of shrubs and other plants. Local species of trees has also to be planted so that the landscape is coherent and is in harmony with its various components.
- In cases where a dumpsite is near to the local village community settlements, it could be converted into a play field by spreading the dump material evenly on the ground. Such playground could be made coherent with the landscape by planting trees all along the periphery of the playground.
- Closure of the disposal site should be upto the satisfactory level of site engineer

1.5 PENALTIES

Stringent action & penalties should be imposed off on contractor for dumping of materials in locations other than the pre-identified locations. Grievance Redressal mechanism should be in place for taking note and action on such complaints.

Annexure 6

Selection and Management of Construction/Labour Campsite

1. Selection and layout of construction camp

Labour camps, plant sites and debris disposal site shall not be located close to habitations, schools, hospitals, religious places and other community places. A minimum distance of 500 m shall be maintained for setting up such facilities.

2. Facilities at workers camps

During the renovation stage of the project, the contractor will construct and maintain necessary (temporary) living accommodation, rest area and ancillary facilities for labour. Facilities required are listed and elaborated below.

- Site barricading
- Clean Water Facility
- Clean kitchen area with provision of clean fuel like LPG
- Sanitation Facilities
- Waste Management Facilities
- Rest area for workers at construction site
- Adequate Illumination & ventilation
- Safe access road is required at camps
- Health Care Facilities
- Crèche Facility & Play School
- Fire-fighting Facility
- Emergency Response Area

2.1 Site Barricading

Site should be completely barricaded from all the sides to prevent entry of outsiders and animals into the site. Entry gate should be provided at the site and labour camp which should be guarded by security guard. All workers should be issued ID cards and entry of outsiders shall be maintained in the register at the gate. Board should be displayed at the site and the labour camp, the name of project, capacity of project, authority carrying our projects, restriction of entry without authorization, no smoking zone and associated risks. Plant operation shall be restricted to 6:00 Am to 10:00 PM

2.2 Clean Water Facility

Potable water shall be provided for construction labour for drinking & cooking purpose. Clean water shall be provided for bathing, cleaning and washing purpose. Water quality testing for water shall becarried out on monthly basis.

2.3 Clean Kitchen Area

Provision of clean kitchen area for cooking and storage of eatables shall be provided. Clean fuels like LPG shall be provided for cooking purpose. Burning of firewood, garbage, paper and any other material for cooking or any other purpose shall strictly be prohibited at the site.

2.4 Sanitation Facilities

Construction camps shall be provided with sanitary latrines and urinals. Toilets provided should have running water availability all the time. Bathing, washing & cleaning areas shall be provided at the site for construction labour. Washing and bathing places shall be kept in clean and drained

condition. Workers shall be hired especially for cleaning of the toilets and bathing area. Septic tanksand soak pits shall be provided at site for disposal of the sewage generated.

2.5 Waste Management Facilities

Waste generated should be segregated at the site by providing the different color bins for recyclable and non-recyclable waste. Recyclable waste shall be sold to authorized vendors and non-recyclable shall be handed over to authority responsible in area for waste management. Waste management for construction site shall be as per waste management plan proposed in EMP.

2.6 Rest Area for Workers at Site

A rest area/shelter shall be provided at the site for construction workers where they can rest after lunch time and shall not lay down at site anywhere. The height of shelter shall not less than 3m from floor level to lowest part of the roof. Sheds shall be kept clean and the space provided shall be on the basis of at least 1.0 Sq.m per head.

2.7 Adequate Illumination & Ventilation

Construction worker camps shall be electrified and adequately illuminated. Illumination level shall be maintained after 5.30 Pm at the site to minimum 200 lux. Labour camps shall be adequately ventilated. Fans shall be provided for ventilation purpose.

2.8 Safe Access Road for Labour Camps

Temporary paved surface shall be constructed to approach the labour camp from the site. Movement shall not be hampered during monsoon season due to water logging and muddiness.

2.9 Health care Facilities:

First aid box, first aid room and personnel trained in first aid shall be available at labour camp and site all the time (24X7). Equipment in first-aid box shall be maintained as pet State Factory‟s Law. Ambulance/ 4 wheeler motorized vehicle shall be available at the site for carrying injured to the nearby hospital. Tie-ups should be made with nearby hospital to handle emergency, if any. Nos. of ambulance, doctors and nearby hospital s hall be displayed in first-aid room, site office & labour camps. Workers shall be made aware about the causes, symptoms and prevention from HIV/AIDS through posters and awareness programs

2.10 Crèche Facility & Play School

Crèche facility and play school should be constructed at the site temporarily so as children of construction labour can be kept there. Care takers should be hired for taking care of children. Attendance records of children shall be maintained. Children should not be allowed to enter active work areas.

2.11 Fire-Fighting facilities

Fire-fighting facility such as sand filled buckets and potable fire-extinguishers shall be provided at labour camps and at site. Fire-extinguishers shall be provided as per NBC norms.

2.12 Emergency Collection Area

Area shall be demarcated as emergency collection area near the gate where all the workers shallbe guided to collect in case of any emergency like fire, flood and earthquake.

3. Activities prohibited at site

Activities which should be strictly prohibited at site shall include

- Open burning of wood, garbage and any other material at sit for cooking or any other purpose
- Disturbance to the local community.
- Operation of the plant and machinery between 10 pm to 6 am unless approved by team leader
- No animal (wild or domestic or bird) shall be harmed by any construction worker in any condition at site and nearby areas
- Cutting of tree without permission of team leader/authorized person
- No indigenous population shall be hurt or teased

4. Guidelines for night time working at the site.

No activity generating noise shall be carried out at the site after 10:00 PM. Night working protocol should be followed (if required) as per guidelines prepared by IWAI. Site should be well illuminated to maintain minimum illumination level of 200 lux. Personnel working shall obtain permit to work from the team leader prior carrying out any work in night time and the record of such working shall be maintained in register. Any accidents, if occurs at site during night time working shall be immediately reported and recorded. Penalty shall be imposed on the contractor for the accident. Analysis shall be carried out to find the reason for such accidents for future learning.

5. Record keeping & Maintenance

Record of entry/exit of the people in the construction site and labour camp area shall be maintained in register at gate. Record of material coming in and going out from site also shall be maintained.

6. Auditing & Inspection

Conditions of labour camp and site shall be inspected and audit report shall be submitted to IWAI on monthly basis.

7. Closure of the Construction Site and Construction labour Camps

Construction site and labour camps shall be restored back to the original site conditions. Following measures are required to be taken during closure

- Septic tanks/soak pits should be dismantled
- Any temporary/permanent structure constructed shall be dismantled
- Construction/demolition waste, hazardous waste and municipal waste at site and labour camp site shall be disposed off as per waste management plan in EMP
- The site shall be cleaned properly
- Tree plantation to be carried out, if any required for stabilizing the area
- Any pit excavated shall be filled back
- Closure of the site and labour camp shall be approved by authorized person.

Annexure 7

Environmental Standards Applicable to the Project

Standards for Discharge of Effluents: Under EPA Act, 1986, standards are prescribed for dischargeof effluents in inland water bodies and marine coastal area and are given in **Table 1**.

Table 1: Standards for Discharge of Effluents

S. No.	Parameters	Standards	
		Inland Surface Waters	Marine Coastal Areas
1	Color & odour	All efforts shall be madeto remove colour and unpleasant odour as far as practicable	All efforts shall be made to remove colour and unpleasant odour as far as practicable
2	Suspended solidsmg/l, Max	100	1. For process wastewater-100 2. For cooling water effluent 10% above total suspendedmatter of influent
3	Particle size of suspended solids	Shall pass 850 Micron IS sieve	1. Floatable solids max. 3 mm 2. Settleable solids max. 850microns
4	pH Value	5.5-9.0	5.5-9.0
5	Temperature	Shall not exceed 5^0 C above the receiving water temperature	Shall not exceed 5^0 C above thereceiving water temperature
6	Oil and grease mg/ l Max.	10	20
7	Total residual chlorine mg/l Max.	1.0	1.0
8	Ammonical Nitrogen(as N), mg/l Max.	50	50
9	Total Kjeldahl nitrogen (as NH3),mg/l Max.	100	100
10	Free ammonia (asNH_3) mg/l Max.	5.0	5.0
11	Bio-chemical oxygen demand (3 days at 270 C), mg/l max.	30	100
12	Chemical oxygen demand, mg/l max	250	250
13	Arsenic (as As), mg/l max.	0.2	0.2
14	Mercury (as Hg), mg/l max.	0.01	0.01
15	Lead (as Pb), mg/l max	0.1	2.0
16	Cadmium (as Cd), mg/l max.	2.0	2.0
17	Hexavalent chromium (as Cr +6), mg/l max	0.1	1.0
18	Total chromium (asCr) mg/l max	2.0	2.0
19	Copper (as Cu), mg/l max.	2.0	3.0
20	Zinc (as Zn), mg/lmax	5.0	15.0
21	Selenium (as Se),mg/l	0.05	0.05

S. No.	Parameters	Standards	
		Inland Surface Waters	Marine Coastal Areas
	max.		
22	Nickel (as Ni), mg/l max	3.0	5.0
23	Cyanide (as CN),mg/l max.	0.2	0.2
24	Fluoride (as F), mg/l max.	2.0	15
25	Dissolved phosphates (as P), mg/l max.	5.0	--
26	Sulphide (as S), mg/l max.	2.0	5.0
27	Phenolic compounds (as C6 H5OH), mg/l max.	1.0	5.0
28	Radioactivematerials: a. Alpha emittermicro curie/ml b. Beta emitter micro curie/ml	10^{-7} 10^{-6}	10^{-7} 10^{-6}
29	Bio-assay test	90% survival of fish after96 hours in	90% survival of fish after 96 hours in
30	Manganese (as Mn), mg/l	2	2
31	Iron (as Fe), mg/	3	3
32	Vanadium (as V),mg/l	0.2	0.2
33	Nitrate nitrogen (mg/l)	10	20

Standards Classification of Inland Surface Water Bodies: Surface water bodies are classified onthe basis of use by CPCB and the classification is given in **Table 2**.

Table 2: Surface Water Body Classification, CPCB

Designated – Best –Use	Class of Water	Criteria
Drinking Water Source withoutconventional treatment but after disinfection	A	1. Total Coliforms or Organism MPN / 100 ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20ºC2mg/l or less
Outdoor bathing (Organized)	B	1. Total Coliforms Organism MPN / 100 ml shall be 500 or les 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5 mg/l or more 4. Biochemical Oxygen Demand 5 days 20ºC 3 mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN / 100 mlshall be 5000 or less 2. pH between 6 to 9 3. Dissolved Oxygen 4 mg / l or more
Propagation of Wildlife and Fisheries	D	1. pH between 6.5 to 8.5 2. Dissolved Oxygen 4 mg / l or more 3. Free Ammonia (as N) 1.2 mg / l or less
Irrigation, Industrial Cooling, Controlled Waste Disposal	E	1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25ºC micro mhos /cm Max. 2250 3. Boron Max. 2 mg/l

Criteria for Classification of water bodies on basis of level of Eutrophication: Standard for accessing Eutrophication level in the water bodies is assessed on the basis of water quality, bottom sediments and aquatic biota quality and nos. in Environment Impact Assessment Study of Port Development, UN, New York, 1992. Same can be refereed here to assess the level on Eutrophicationin the river and tributaries.

Table 3: Criteria for Level of Eutrophication

Pollution level Environmental Indicator	Seprotrophic water (extremely polluted)	Pertrophic water(severely polluted)		Eutrophicwater (slightly polluted)	Ollgotrophic water (clean)
		Deep water area(more than several metres)	Shallow water area (lessthan several metres)		
Water Quality					
Transparency(m)	3	3		3 – 10	10
Discolouration	Blakish	Yellow, Olive, Brownish,etc		Temporal and local colouring	No colouring
COD (ppm)	10	3 – 10		1 – 3	1
BOD (ppm)	10	3 – 10		1 – 3	1
DO saturation(%)	(Anaerobic condition from surface layer to thesea bottom)	100—200% at surface layer (over saturated), 0—30% at the bottomlayer	100—200% atsurface layer (over saturated)	> 80% at surface andmiddle layer, 30—80% deeper layerthan several meters	In all layers (saturated)
Hydrogensulphide	Detected at most layers	Detectable at the bottom layer	Not detectable	Not detectable	Not detectable
Inorganic N compounding (µg at N/l)	100	10 – 100		2 – 10	2
Bottom Sediments					
Colour ofsediments	Black, Oxidation layer (brownish layer at the surface of the bottom) not found	Black, Oxidation layer notfound	Blackish Oxidation layer not found	Occasionally blackish Oxidation layer found	Natural Oxidation layer found
COD (mg/g)	-	> 30		5 – 30	5
Sulphide(mg/g)	10	0.3 – 3.0		0.03 – 0.3	0.03
Aquatic Biota					
Bacteria (cellno. / ml)	10^5	10^2 - 10^5		10^2 – 10^4	10^2
Phytoplankton(cell no. / ml)	10^5	10^2 - 10^5		10^1 – 10^3	10^1
Chlorophyll(mg/m^3)	>200	10 – 200		1 – 10	<1
Primary production (mgc/m^2/hr) (Gc/m^2/day)	>200 >10	10 – 200 1 – 10		1 – 10 0.3 – 1.0	< 1 < 0.3
Protozoa	Extremely	Abundant		Scarce	Scarce

Pollution level Environmental Indicator	Seprotrophic water (extremely polluted)	Pertrophic water(severely polluted)		Eutrophicwater (slightly polluted)	Ollgotrophic water (clean)
		Deep water area(more than several metres)	Shallow water area (lessthan several metres)		
	abundant				
Crustacean zooplankton	-	Scarce, little diversity		Abundant, great diversity	Scarce, great diversity
Benthic polychaetesworm	Scarce, little diversity	Scarce, little diversity	Abundant, great diversity	Abundant, great diversity	Scarce, great diversity
Crustacean	-	Scarce, little diversity		Abundant great diversity,	Scarce, great diversity
Typical waterarea	Enclosed bays or ports with abundant discharge of pollutants			Bays andcoastal zone	Offshore open water areas

Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992

Standards for permissible level of water quality indicator: The permissible level of indicators forassessing water quality, in port development in India is given below in **Table 4**.

Table 4 Standard for Permissible Level of Water Quality Indicator

Country	Purpose / Place	Indicator					
		Ph	DO (mg/l)	COD (mg/l)	BOD (mg/l)	Oil (mg/l)	Coliformbacteria (MPN / 100 ml)
India	Polluted area						
	• Recreation	6.5 – 9.5	3	-	5	0.1	1000
	• Harbour Non-pollutedarea	6.5 – 9.0	4	-	5	10 -	500
	• Bathing	-	5	-	3	-	500
	• Aquatic biota	-	4	-	6		500
Indonesia	Coastal Water						
	• Bathing	6.0 – 9.0	5	40	20	3	1000
	• Aquaculture	6.0 – 9.0	4	80	45	5	1000
	• MarinePark	6.0 – 9.0	4	80	45	5	1000
	• Industry	6.0 – 9.0	-	40	20	2	1000
Japan	Sea						
	• Bathing	7.8 – 8.3	7.5	2	-	0.5	1000
	• Industry (B)	7.8 – 8.3	5	3	-	0.5	-
	• Industry (B)	7.0 – 8.3		8	-	-	-
Malaysia	Sea						
	• Natural	6.5 – 8.5	7	10	1	ND	100
	• Aquatic biota	6.0 – 9.0	5 - 7	25	3	-	5000
	• Recreation	6.0 – 9.0	5 - 7	25	3	-	5000
	• Common	6.0 – 9.0	3 - 7	25	6	-	50,000
Philippines	Sea						
	• Recreation	6.5 – 8.5	5	-	-	2	1000
	• Aquatic biota	6.5 – 8.5	5	-	-	5	5000
	• Industry	6.5 – 8.5	3	-	-	5	
	• Navigation	6.0 – 9.0	2	-	-	10	

Thailand	Sea • Swimming • Conservation	 6.5 – 8.3 7.5 – 8.9	 4 5	 - -	 - -	 ND ND	 1000 -

Criteria for Disposal of Harmful Bottom Sediments: No specific standards are defined in India for disposal of dredged material. If dredged material is toxic / harmful then these sediments should either be disposed off in landfill or in Sea. Criteria followed in Japan are given in the **Table 5**.

Table 5: Criteria for Harmful Bottom Sediments, Japan (unit: mg/l)

Contaminated Material	Dumping in Landfills (mg/l)	Dumping at sea (mg/l)
Alkylmercuric compounds	Not detectable	Not detectable
Mercury and its compounds	0.005	0.005
Cadmium and its compounds	0.1	0.1
Lead and its compounds	1	1
Organophosphorus compounds	1	1
Chromium (VI) compounds	0.5	0.5
Arsenic and its compounds	0.5	0.5
Cyanogen compounds	1	1
PCB	0.003	0.003
Copper and its compounds	-	3
Zinc and its compounds	-	5
Fluoride	-	15

Note: Criteria are based on the examination of dissolution of contaminated materials
Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992

Criteria for Off-shore dumping of Dredged material: No criteria is defined for off-shore disposal of dredged material in India, thus reference to the UN standards can be made and is given in **Table 6**.

Table 6: Criteria for Off-Shore Dumping of Dredged Material (unit: ppm or ppb)

Substance	Canada	USA
PCB (ppb)	100	380
Hg (ppm)	0.5	0.15
Cd (ppm)	0.60	0.7
Zn (ppm)	169	105
Cu (ppm)	45	68
As (ppm)	(5 – 25)	12.5
Pb (ppm)	45	33
Organochlorine pesticide (ppb)	10 for any compound	5.0 Sum of DDT, DDE and DDD
Polyaromatic hydrocarbon (ppb)	(1,000) Sum of 16 compounds	680 Sum of six low mol. Wt.compounds 2,690 Sum of 10 high mol. Wt.compounds

Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992

Estimated Suspended Sediments Generation Standards from Dredging and Dumping operations: Estimations had been made in Assessment Manual for dredging and

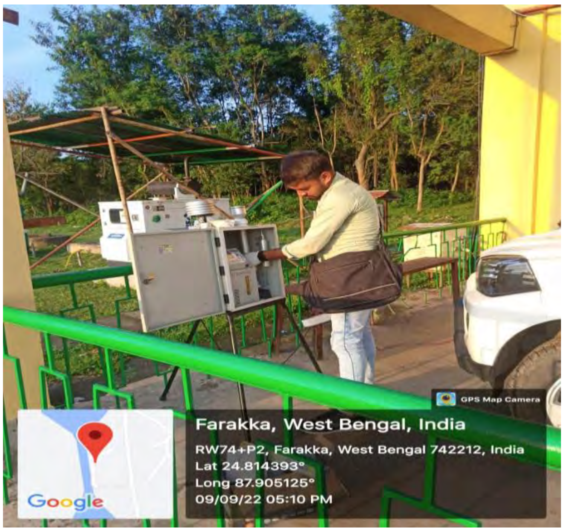
Reclamation, Ministry of Transport, Japan for suspended sediment generation from dredging and dumping operationsis given in **Table 7**. These can be used for estimating the suspended sediments to be generated from dredging for renovation of Lock

Table 7: Approximate Suspended Sediment Generation from Dredging Operation

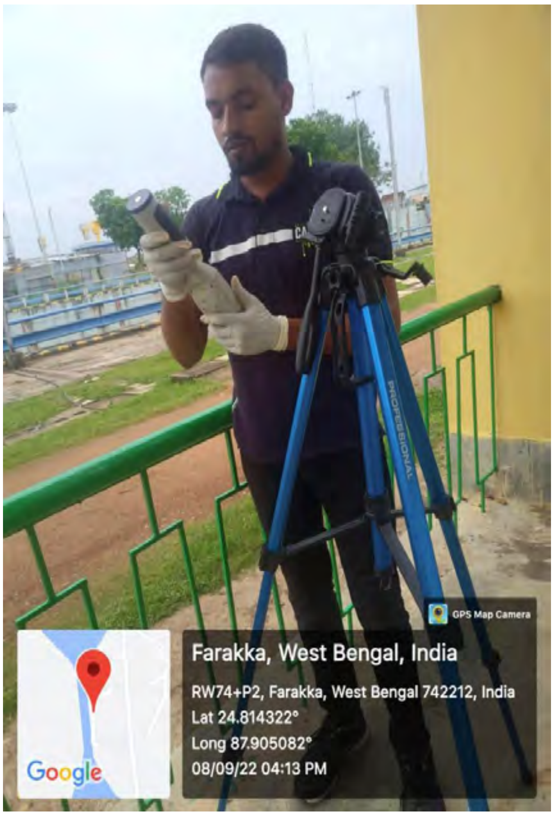
Activity / Type of the Bottom	**SS generated by dredging or dumping of one cubic metre ofsandy material**	**SS generated by dredging or dumping of one cubic meter ofsilt / clay**
Pump dredging	Kg/m^3	Kg/m^3
Ordianry 4,000 PS[1/]	(2) 2.2 – 4.5	(2) 1.2 – 1.4
Ordinary 2,000 PS	(3) 0.1 – 0.3	NA
Low – pollution type 1,600 PS	NA	(3) 1.2 – 1.6
Low – pollution type 800 PS	NA	(2) 1.5 – 3.5
Grab dredging		
Ordinary 8m^3 bucket	NA	(2) 10 – 89
Ordinary 3 m^3 bucket	(1) 8.4	(4) 12 – 84
Water – tight type 8 m^3 bucket	NA	(1) 3.5
Activity / Type of the Bottom	SS generated by dredging or dumping of one cubic metre of sandy material	SS generated by dredging or dumping of one cubic meter of silt / clay
Bucket dredger	(1) 17	(1) 56
Dumping		
By grab bucket	(11) 0.4 – 5.0	NA
From hopper barge	(2) 2.4 – 5.2	(5) 12 – 203

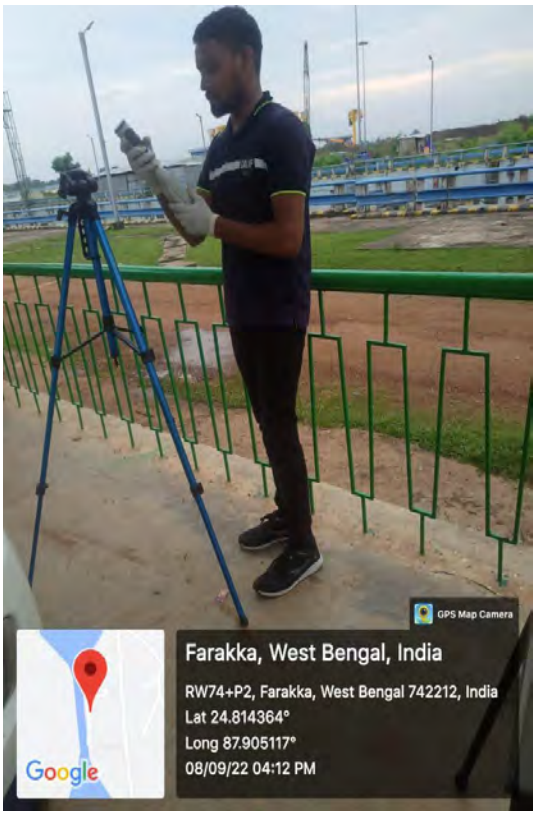
Note: Parentheses are the number of times of observations
NA: Not Available
[1/]: Capacity of pump in Horse Power
Source: Assessment of the Environment Impact of Port Development, United Nations, New York, 1992

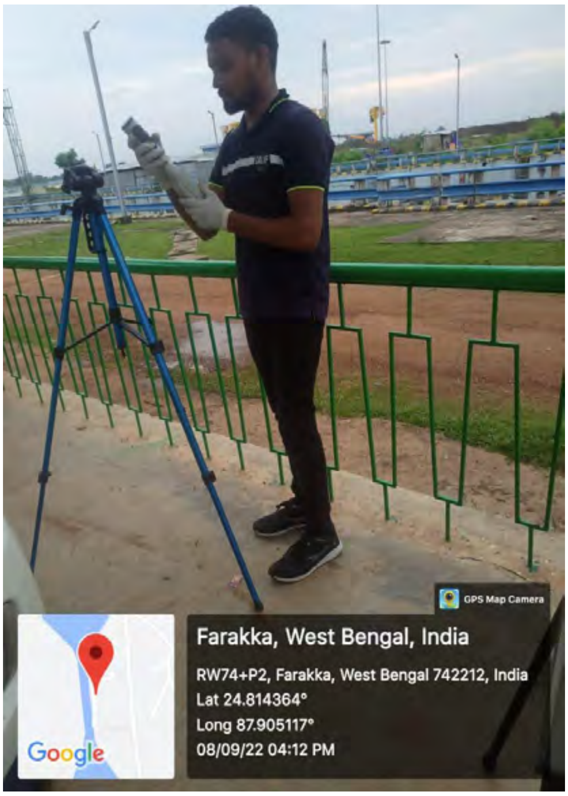
Air monitoring at Farakka Navigation Lock



Noise monitoring at Farakka Navigation Lock







Surface Water Sampling at Farakka Navigation Lock

Annexure 6

COMPLIANCE REPORT ON DRAFT DPR FOR THE RENOVATION/MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

DPR prepared by: PKS-Floodkon JV for the work awarded by Inland Waterways Authority of India, Government of India

Observation and comments by:

Dr. Dhrubajyoti Sen,

Professor, Department of Civil Engineering

IIT Kharagpur

April 2023

Abstract

The Detailed Project Report (DPR) for the work of renovating and modernizing the existing navigation lock at Farakka has been prepared by M/S PKS-Floodkon JV on a work awarded by the Inland Waterways Authority of India. M/S PKS-Floodkon JV, in turn, has approached IIT Kharagpur for vetting of the DPR, as per the contract of the work.

This report consists of the observations and suggestions on the contents of the DPR, based upon a detailed site inspection along with a team from M/S PKS-Floodkon JV on 25 March, 2023 and subsequent discussions with them. The newly constructed navigation lock was also jointly visited in order to understand the combined functioning of the two locks in future. On the whole, the DPR is found to be of acceptable standard and covers all the components of the renovation/modernization work of the existing navigation lock at Farakka. The observations and suggestions are provided chapter-wise, for ease of the users of the DPR.

Background of the DPR

The existing lock at Farakka forms a critical and vital link in the navigation route of National Waterway 1 between the main stem of river Ganga and the off-taking Bhagirathi-Hooghly River through the Feeder Canal. Since the volume of riverine traffic is expected to increase in future, the Inland Waterways Authority of India (IWAI) has envisaged to renovate the existing navigation lock at Farakka and construct another to run in tandem with that existing. It may be mentioned that the existing navigation lock has completed nearly 40 years of its service life and is showing signs of aging and deterioration. In this regard, a Detailed Project Report (DPR) has been prepared by M/S PKS-Floodkon JV through the work awarded to them vide work order IWAI/NW-1/WB/AG/Study-Exist.Nav.Lock/2020-21/321dated 08.12.2021.

Vetting of the DPR

As per the awarded contract for the preparation of the DPR, it has to be vetted by a government institution, preferably an IIT. Accordingly, the vetting task has been assigned to IIT Kharagpur, led by the team of Dr. Dhrubayoti Sen, Professor, Department of Civil Engineering. As a part of the vetting process, a site visit was undertaken by the IIT team along with the team from M/S PKS-Floodkon JV on 25 March, 2023. The following pages contain the observations on the DPR, arranged section-wise.

Chapter 1. Introduction

The chapter discusses the background of the project, that is, the navigation lock existing at Farakka, and the need for its renovation and modernization. It presents a description of the chapters.

Observation: The chapter appears to be complete in all respect.

Compliances: No changes have been made in this chapter

Chapter 2. Project Area

The chapter discusses the location of the site of the navigation lock vis-à-vis the link of the navigation route between river Ganga and the Feeder Canal. It also describes the major components of the navigation lock, which includes two pairs of Mitre gates, along with assisting gates like four Radial gates (for filling and emptying the lock chamber), two Caisson Gates (for use during repair and maintenance of the Mitre gates) and eight Bulkhead gates (for use during repair and maintenance of the Radial gates). The chapter also discusses prevailing atmospheric conditions at site, topographic information, hydrological information, and geotechnical information.

Observation: The chapter describes well the different characteristics of the site location and the hydro-mechanical components of the navigation lock. However, although the section on hydrological information provides the maximum and minimum upstream and downstream water levels, it may also mention the maximum velocity of flow or the discharge expected to occur in the approach and exiting channels, since the design of the bank protection is based upon this information.

A few editorial mistakes are pointed out as below:

1. In Table, the low water levels on the upstream and downstream of the navigation lock are mentioned as equal. Although it may be true, but still the same may be crosschecked.
2. Captions of Tables 2.7 and 2.8 are incorrect and may be revised.
3. Line number 9 from below on page 34 mistakenly mentions caisson-gate as casino-gate, which may be corrected.

Compliances: In the approach channel of the navigation lock only water level monitoring system are available. Also due to the navigation lock there is no direct or continuous flow of water in the approach channel. So, the velocities or the discharges in the approach channel are not measured. However, for the design of bank protection works, the design discharge of the feeder canal has been considered with an additional factor of safety. The design discharge of the feeder canal is 40000 cusecs. For bank protection works, the design discharge has been considered as 50000 cusecs (including FOS 1.25).

1. As suggested, we have cross checked the LWL from the operation manual and found that the LWL in upstream and downstream of the navigation lock is same as 18.288 m.
2. The caption of Table 2.7 and 2.8 has been corrected.
3. Spelling of the caisson gate has been corrected.

Chapter 3. Components of existing navigation lock

The chapter discusses the navigation lock chamber and approach structures, filling and emptying arrangement, the four types of gates, and mooring arrangement. It also includes the control room and wiring of the gate operating systems, and time of operation of the lock (which is compared with that of the new lock that is being installed parallel to the existing one).

Observation: The chapter appears to be complete in all respect. A comparison is made of the working time for the existing lock with that of new lock. It is shown that the international guideline (example is given of the Netherlands) requires the time of vessels to be within 40 minutes whereas the existing lock is seen to take more than an hour. The new lock, it is shown, satisfies the current requirement. The existing lock, therefore, after renovation and modernization, is thus expected to meet the international guidelines of the time of passage for vessels through the lock.

Compliances: No changes have been made in this chapter.

Chapter 4. Condition survey

The chapter discusses the technical inspection carried out by M/S PKS-Floodkon JV for the different components of the navigation lock, such as the civil structures and the hydro-mechanical equipment using different techniques. A performance indicator of the components, termed as the functional condition index (CI) is described. The actual values of this index are included in the subsequent chapters.

Observation: The chapter appears to be complete in all respect. The tests described for evaluating the functional health of the components of the navigation lock by visual inspection, non-destructive testing, and ultrasonic testing are considered sufficient for the purpose of the project.

Compliance: No changes have been made in this chapter.

Chapter 5. Renovation and modernization of civil components

The chapter presents a detailed discussion on the different civil components of the navigation lock from the perspective of the present condition of each component assessed from the results obtained from the condition survey described in the previous chapter (Chapter 4). The extent of renovation/rehabilitation/modernization measures required for each component is discussed.

Observation: The chapter is all right in every respect. However, some comments are as under:

1. Section 5.1.3.2, presently having a heading as “State of the Art Technology” may be renamed as “Renovation/Rehabilitating using State of the Art Technology”
2. Section 5.1.5 mentions about water level monitoring in the vicinity of the navigation lock, that is on the upstream, within and downstream of the lock chamber. Although there are many types of automatic water level sensors in use, it may be practical to use the ultrasonic type sensors, as these are non-invasive and easy to repair/replace in case of malfunctioning. The section also mentions about measuring water depth. It is not mentioned how this will be done and whether the measurement will be continuous (as proposed for the water level measurement).
3. Section 5.2.3, presently having a heading as “State of the Art Technology” may be renamed as “Rehabilitation measures for the Mooring Equipment”.
4. Section 5.3.3, presently having a heading as “State of the Art Technology” may be renamed as “Renovation and Restructuring of the Control Room Building”
5. Section 5.4.2, presently having a heading as “State of the Art Technology” may be renamed as “Repair and Rehabilitation of the Electrical Cable Bridge and Cable Network Trench”.

6. Section 5.5, titled “Bank Protection Work” mentions the detailed calculations for the pitching work is provided in Annexure 4. It is noted that in the annexure, the design calculation is based upon a discharge of 50,000 cusecs. However, it is not shown how this data is arrived at. And may thus be checked.

Compliances:

1. The heading of Section 5.1.3.2 has been renamed.
2. Section 5.1.5 has been updated with the details of water level and water depth measurement sensors. Ultrasonic type/ Down looking Doppler radar sensor has been proposed for the measurement of water level and depth which shall indicate any deposition of silt in the navigation lock. The Ultrasonic sensor for water level measurement shall be fixed above the HWL whereas the radar sensor shall be placed below the LWL. The integrated system of both sensors shall give the real time water level and water depth in the navigation lock.
3. The heading of Section 5.2.3 has been renamed.
4. The heading of Section 5.3.3 has been renamed.
5. The heading of Section 5.4.2 has been renamed.
6. In the approach channel of the navigation lock only water level monitoring system are available. Also due to the navigation lock there is no direct or continuous flow of water in the approach channel. So, the velocities or the discharges in the approach channel are not measured. However, for the design of bank protection works, the design discharge of the feeder canal has been considered with an additional factor of safety. The design discharge of the feeder canal is 40000 cusecs. For bank protection works, the design discharge has been considered as 50000 cusecs (including FOS 1.25).

Chapter 6. Safety aspects of existing lock

The chapter mentions the provision of three types of sensors (piezometers, settlement gauges, and inclinometers) within the navigation lock area for continuous monitoring of certain parameters. This aspect is new for the existing navigation lock and is found to be appropriate and worthwhile.

Observation: The contents of the chapter is all right. It may, however, be useful if the function of the piezometers is explained in brief – for example – to measure ground water table, and the purpose that these will serve.

Compliances: The purpose and the working of the all the safety monitoring instruments have been explained in detail.

Chapter 7. Renovation and Modernization of Hydromechanical Components

The chapter discusses the four different types of gates in use in the existing navigation lock, that is, mitre gate, radial gate, bulk-head gate, and caisson gate, and explains the replacement design in each case. It is noted that each of these gates have not only outlived their design periods (or nearing their design life) but also the present-day technologies for operating the major two gates, that is, the mitre and radial gates make use of hydraulic systems whereas the existing gates use the drum and cable arrangement for their opening and closing. The proposed design also envisages low operation times for these two gates.

Observation: The chapter is all right in every respect. No changes or modification to the content of the chapter is suggested.

Compliances: No changes have been made in this chapter.

Chapter 8. Electrical and Control System

The chapter discusses the electrical cabling (including power supply and distribution systems) and operation equipment for operating the different motors and machines of the existing navigation lock. Most of these are found to be in dilapidated condition and requires replacement with modern equivalents systems. It also proposes ventilation with air conditioning systems for the control cabins and instrumented and remotely operated control system for operation of the gates after modernization. Provision for communication and traffic signalling are enumerated. The latter items would be provided anew for the existing navigation lock.

Observation: The chapter is found to be in order. No changes or modification to the content of the chapter is suggested.

Compliances: No changes have been made in this chapter.

Chapter 9. Other Infrastructural Components

The chapter discusses the ancillary works in and around the navigation lock, such as residential quarters, boundary walls, internal roads, parking area, water supply provision, sewerage system, storm water drainage, firefighting facilities, rain-water harvesting system, etc.

Observation: The chapter is found to be in order, in general. However, it is suggested that in the working area of the navigation lock, it would be preferable if no residential quarters is permitted to be constructed. In this regard, it is recommended that the proposed residential accommodation for operating staff, if required, may be located outside the working area, probably close to the Farakka Barrage Project staff colony, or the National Thermal Power Project staff colony. Within the working area, only resting rooms for the lock operation staff may be constructed.

Compliance: The suggestion on residential quarters have been well taken and accordingly the residential quarters have been modified to retiring rooms similar to the ones which are available in Indian Railways. Two sets of retiring rooms have been proposed, one for Officer Section and other for the Staff Section.

Chapter 10. Model Studies

The chapter mentions the requirement for setting up of physical and mathematical models for the operation of the navigation lock, for understanding the different functional aspects of the structure, especially for its filling and emptying sequences.

Observation: The overall content of the chapter is found to be in order. However, a few changes are suggested, such as:

1. It may be clearly stated whether both mathematical and physical models are required to be made, or either of the two. About the physical model, a scale may be mentioned since certain physical features may not be apparent from a physical model if it is built too small. Also, larger scale models would be costlier.
2. The first sentence apparently is incomplete and may be rephrased by modifying the first part of the sentence as: "Mathematical/physical model studies are required to be carried out for the whole structure to assess the… ". Here, it may be cleared whether both or either one of the two is required to be carried out.
3. It may helpful if the entire lock system model is built to one scale (for checking the mitre gate opening and closing along with vessel movement simulations) and another detailed scale model be built for the radial gate operation (for checking the flow field, turbulence, cavitation, etc. within the filling and emptying conduits).

Compliances:

1. Mathematical Modelling has been proposed for the navigation lock systems and lock approaches at suitable scale (preferably between 1:1 to 1:10).

2. The sentence has been rephrased.
3. The mathematical modelling shall study the hydraulic parameters such as the filling/emptying time of the lock chamber, sedimentation in the hydraulic system, check for air entrapment in the hydraulic system, waves, currents and turbulence generation in the lock chamber as well as include the simulation of gate operation and vessel movement. The speed of the flow inside the culverts, head losses and cavitation, particularly in bends and inter-independent interaction of various elements such as, speed of the opening of the valves with the locking duration, mooring forces, will be made during detailed designs and modification to those, if required, will be made at that stage.

Chapter 11. Dewatering Arrangement

The chapter discusses the construction of coffer dams and dewatering arrangements that is to be made during the renovation work of the navigation lock.

Observation: The chapter is found to be in order. No changes or modification to the content of the chapter is suggested.

Compliances: No changes have been made in this chapter.

Chapter 12. Disposal of Construction Debris & Scrap of Hydromechanical and Electrical Components

The chapter discusses the wastes and scraps expected to be generated due to the renovation work of the navigation lock and the waste management plan.

Observation: The chapter is found to be in order. No changes or modification to the content of the chapter is suggested. However, a reference may be made to "Guidelines on Environmental Management of Construction & Demolition (C & D) Wastes" published by Central Pollution Control Board in this context.

Compliances: Proper waste management plan shall be adopted by the Contractor as per the Guidelines on Environmental Management of Construction & Demolition (C & D) Wastes by Central Pollution Control Board. This has been included in Section 12.1

Chapter 13. Land Details

The chapter mentions that there would be no requirement of additional land for carrying out the renovation, rehabilitation and modernization work, apart from the existing land designated for the navigation lock

Observation: The chapter is found to be in order. No changes or modification to the content of the chapter is suggested.

Compliances: No changes have been made in this chapter.

Chapter 14. Tender Documents

The chapter discusses the three volumes of tender documents, that is: (a) Bidding documents;

(b) Technical specifications and drawing; and (c) Bill of quantities.

Observation: The chapter is found to be in order. No changes or modification to the content of the chapter is suggested.

Compliances: No changes have been made in this chapter.

Chapter 15. Environmental Impact Assessment (EIA) and Environment Management and Monitoring (EMP)

The chapter discusses the Environmental Impact Assessment (EIA) and Environment Management and Monitoring Plan (EMP) for the renovation work of the navigation lock.

Observation: The chapter is found to be in order. No changes or modification to the content of the chapter is suggested, except that in the title, the word "Plan" may be inserted before "(EMP)".

Compliances: The title of the chapter has been modified and the word "plan" has been inserted in the title

Chapter 16. Lock Administration and Management

The chapter discusses the structure of the administrative and technical staff for operating the renovated navigation lock.

Observation: The chapter is found to be in order. No changes or modification to the content of the chapter is suggested.

Compliances: No changes have been made in this chapter.

Chapter 17. Maintenance Plan

The chapter discusses the maintenance tasks for running and operation of the renovated equipment of the navigation lock.

Observation: The chapter is found to be in order. No changes or modification to the content of the chapter is suggested.

Compliances: No changes have been made in this chapter.

Chapter 18. Implementation Schedule

The chapter discusses the scheduling of the different tasks envisaged to be involved in the renovation, rehabilitation and modernization work of the navigation lock.

Observation: The chapter is found to be in order. No changes or modification to the content of the chapter is suggested.

Compliances: No changes have been made in this chapter.

Chapter 19. Cost Estimates

The chapter discusses the cost summary and detailed cost estimates for carrying out the different tasks envisaged to be involved in the renovation, rehabilitation and modernization work of the navigation lock.

Observation: The chapter is found to be in order. In Table 19.2, under heading number 8 (Electrical Equipment's, Control Room Building and Fire Fighting System including mobilization and demobilization) item vii, 2 (two) number local control rooms have been mentioned. This may be changed to 4 (four), since there are 4 local control rooms in the original plan (existing on ground), and the same is required to be continued after modernization for the operation of the renovated and rehabilitated lock structure. Elsewhere in different places of the report, mention is made of 2 existing local control rooms (one each on the upstream and downstream), which may accordingly be corrected to 4 (two each on either bank of the lock passage with a pair each on the upstream and downstream).

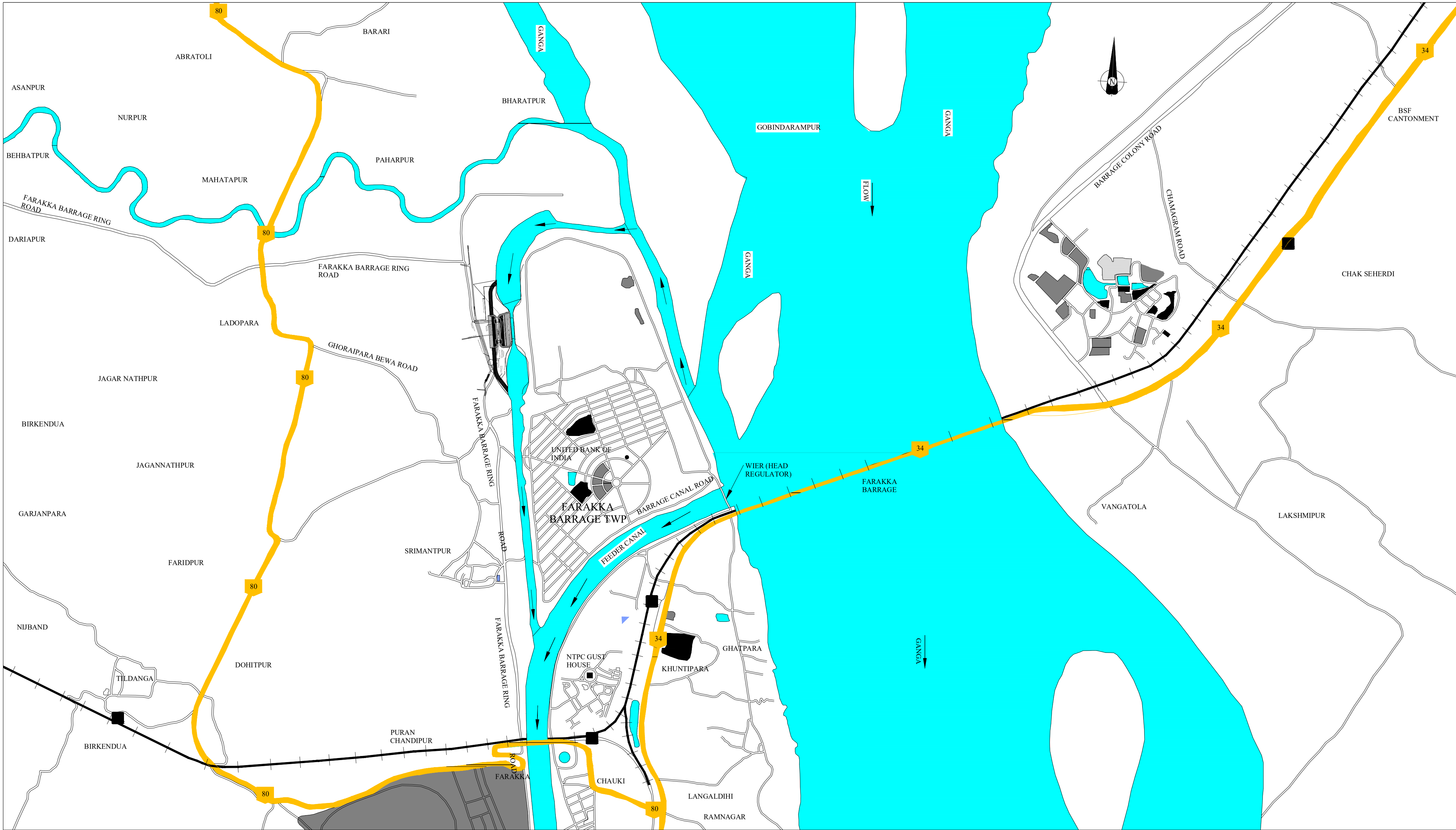
Compliances: There are 4 local control rooms, 2 each on the u/s and d/s of the navigation lock. Of the 2 local control rooms, there is 1 local control room on each side of the navigation lock to operate the respective radial gate and mitre gate leaf. The same has been corrected in Table 19.2 and also at all other sections in the reports where local control rooms have been mentioned.

General Comments on Drawings

Observation: All drawings should have a uniform formatting of text and dimensions. Also, the title block should be of uniform size in all sheets. Hatchings should be uniform and legends to hatchings mentioned clearly.

Compliances: The formatting of the text and dimensions in all the drawings have been corrected and made uniform. The title block has also been corrected and made uniform. The hatching and legends have been corrected.

Drawings



REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

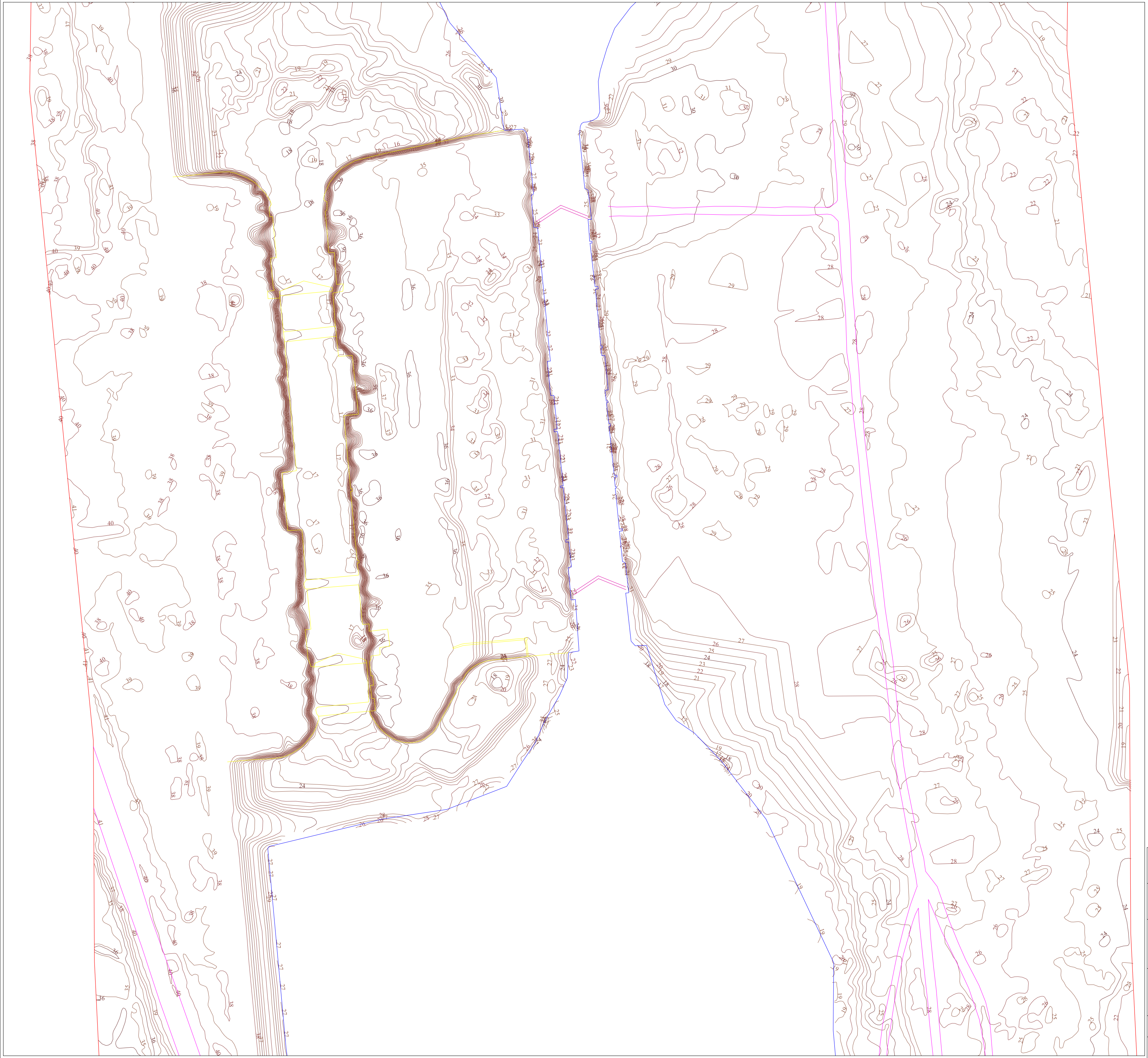
TITLE: INDEX PLAN OF THE EXISTING AND NEW NAVIGATION LOCK, FARAKKA

JOB. NO.

DRG. NO. ENL001

SIZE : A0

REV.



N

Legends

Contour Lines

Roads

Canal

New Navigation Lock

NOTE:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE SCALED OUT, ONLY WRITTEN DIMENSIONS ARE TO BE TAKEN AS CORRECT.

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

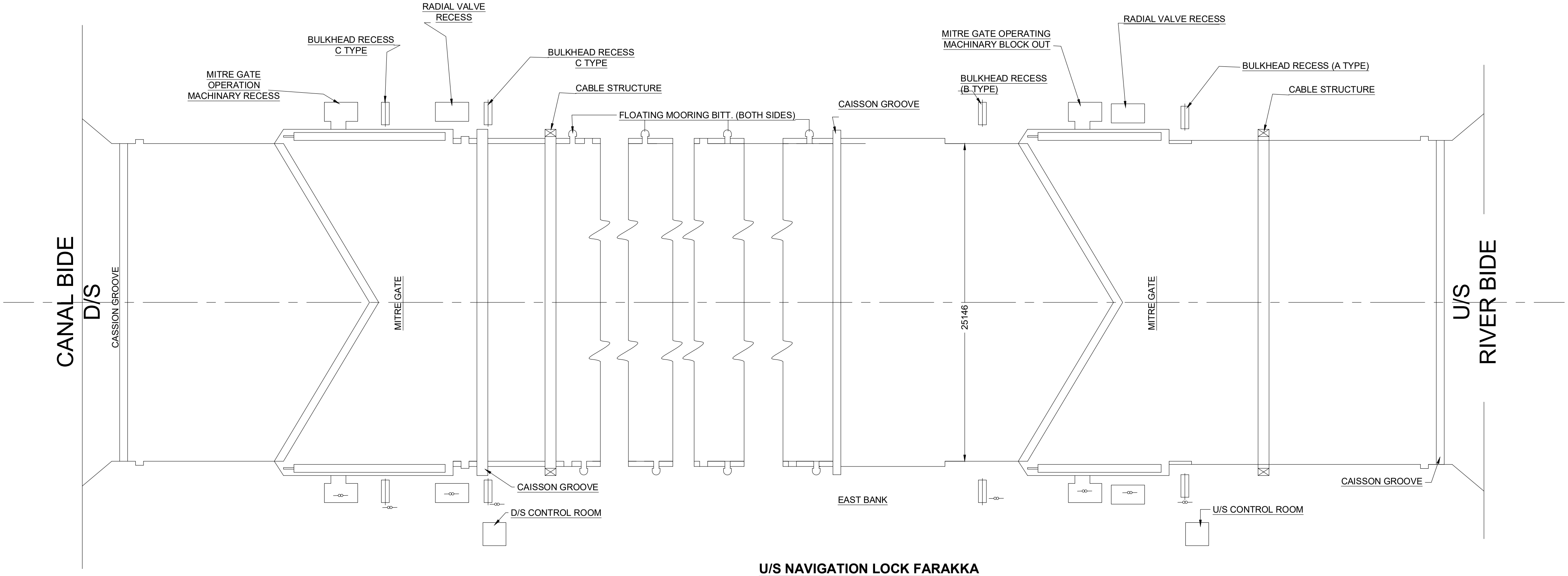
TITLE: TOPOGRAPHY SURVEY OF THE NAVIGATION LOCK, FARAKKA

JOB. NO.

DRG. NO. ENL002

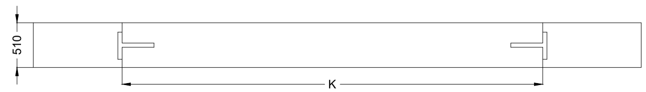
SIZE : A0

REV.



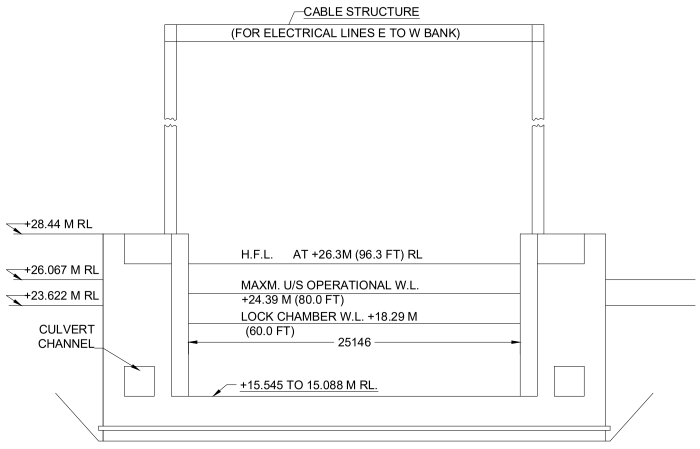
U/S NAVIGATION LOCK FARAKKA GENERAL LAYOUT

LOCK	: 1 NO.
MITRE GATES	: 2 PAIRS
RADIAL GATES	: 2 PAIRS
MOORING BITS	: 4PAIRS
CASSION GATES	: 2 NOS.
BULK HEAD GATES	: 4PAIRS
CONTROL ROOMS	:2 NOS.

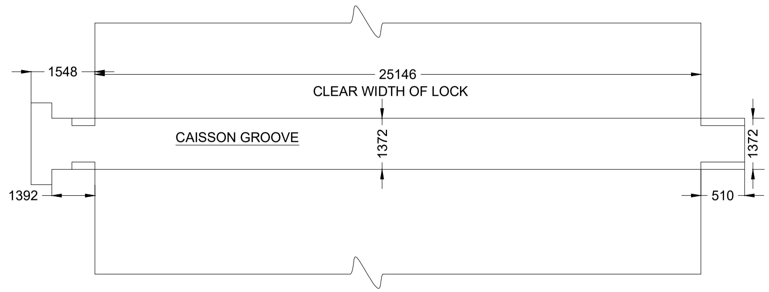


ENLARGED DETAIL OF BULKHEAD RECESS

"K" FOR TYPE - "A" = 4118
"K" FOR TYPE - "B" = 3328
"K" FOR TYPE - "C" = 2670



SECTIONAL ELEVATION OF LOCK CHAMBER



ENLARGED DETAIL OF CAISSON GROOVE

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

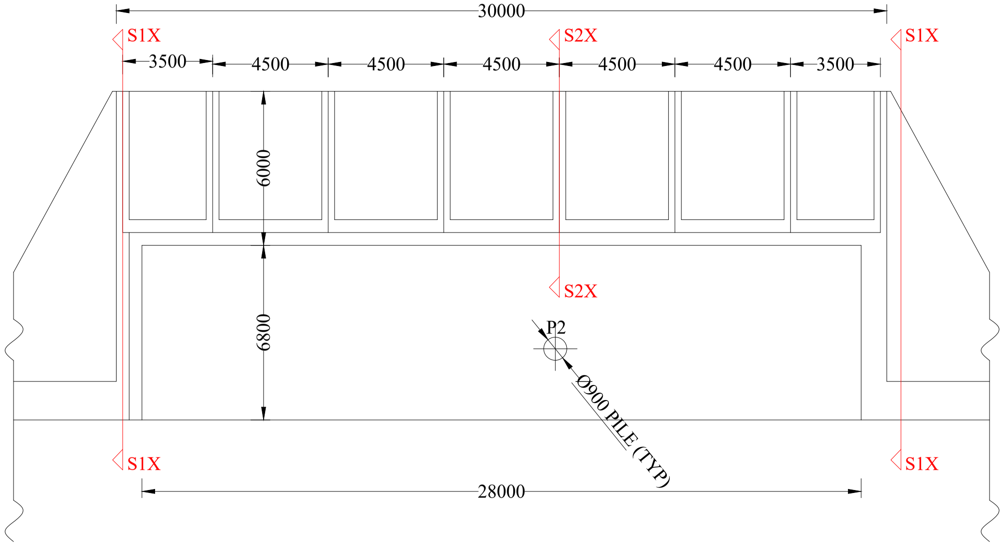
CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

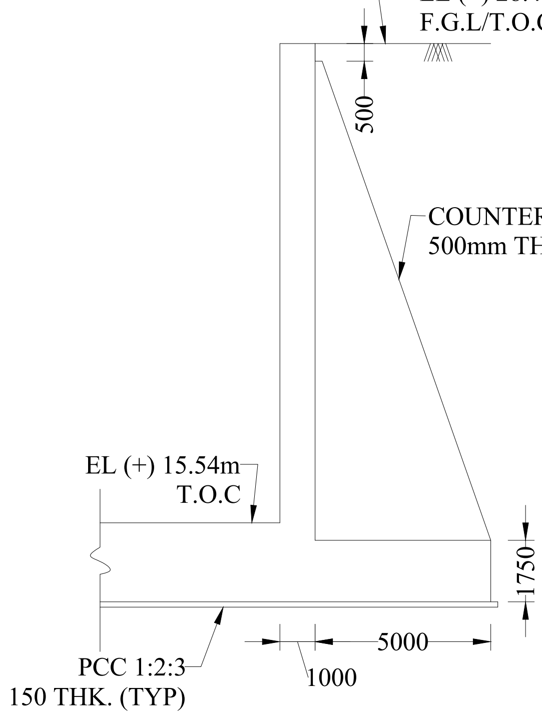
TITLE: GENERAL ARRANGEMENT DRAWING OF EXISTING NAVIGATION LOCK, FARAKKA

JOB. NO.
DRG. NO. ENL003

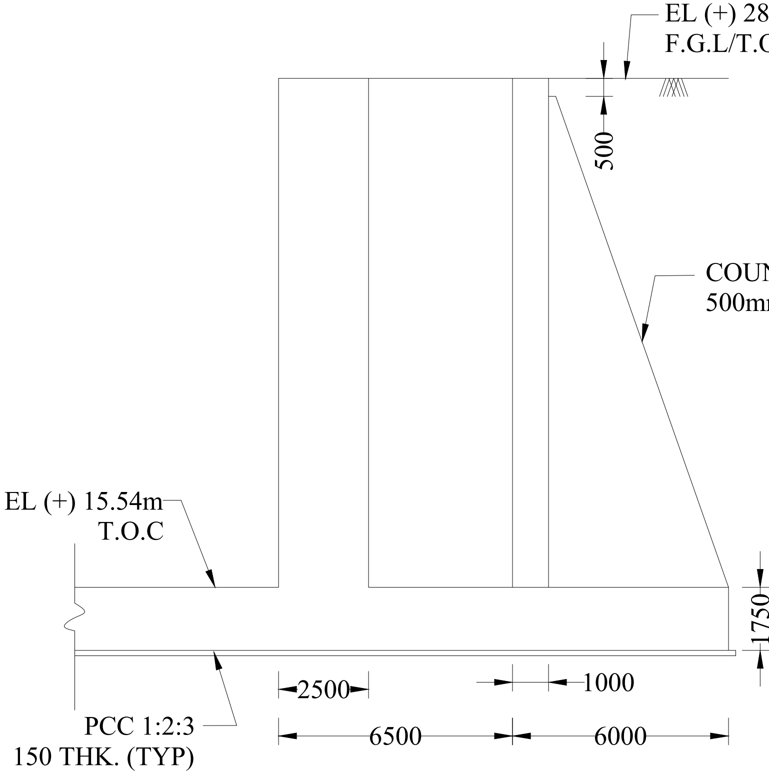
SIZE : A0 REV.



PLAN



SECTION S2X-S2X
NUM. DETAIL FOR LOCK PORTION



SECTION S1X-S1X
NUM. DETAIL FOR LOCK PORTION

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF PARKING BAY OF EXISTING NAVIGATION LOCK

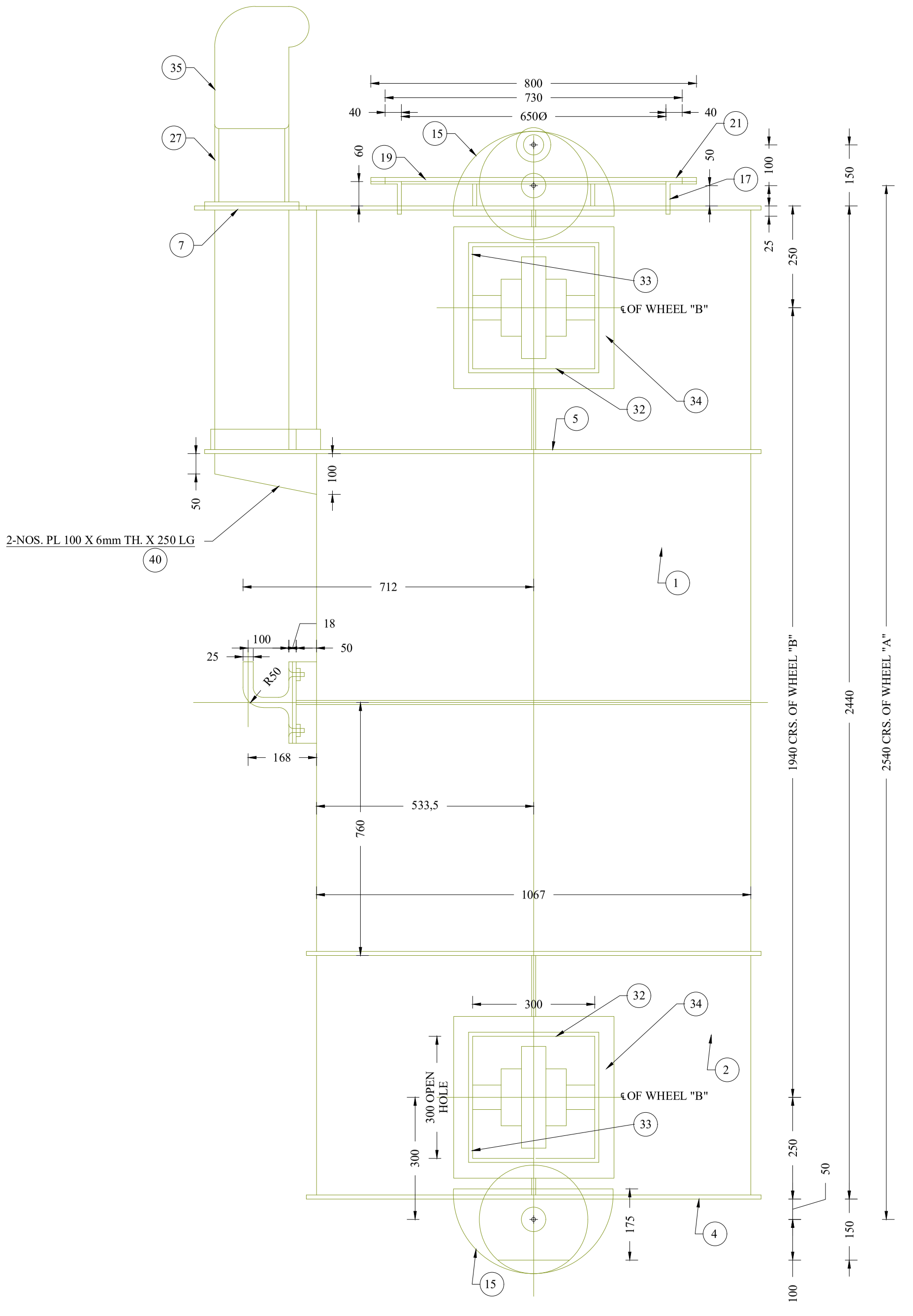
JOB. NO.

DRG. NO. ENL004

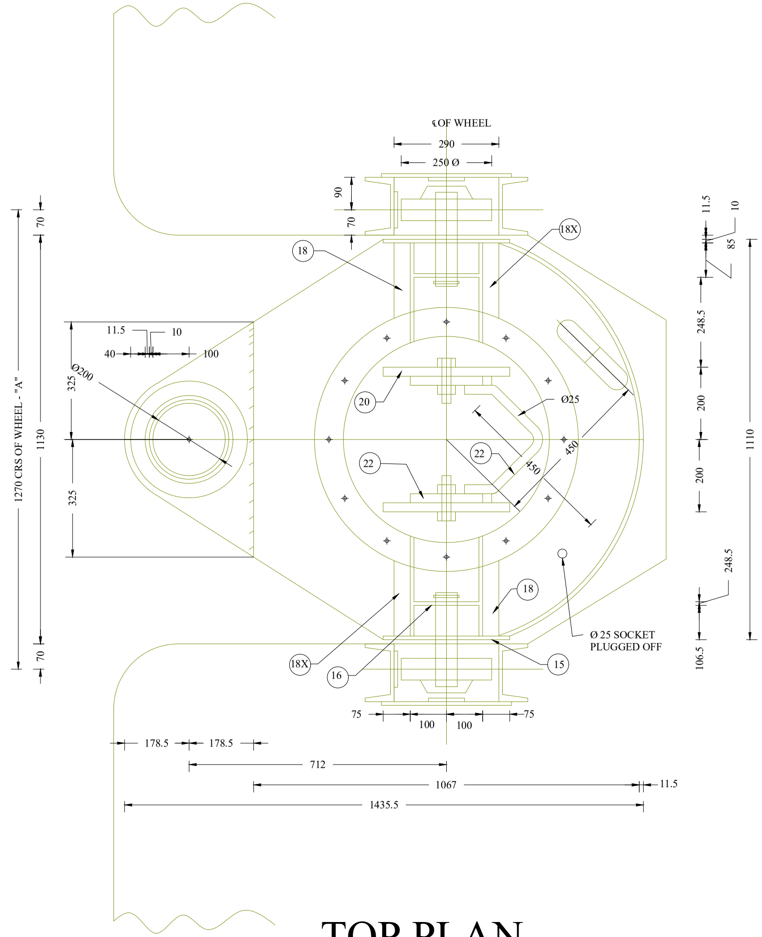
SIZE : A0

REV.

REV.	DATE	DESCRIPTION	DRN	CHD	APD



VIEW D-D



TOP PLAN

NOTE:
1.ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS, UNLESS OTHERWISE SPECIFIED.

2.NO DIMENSION SHALL BE SCALED OUT, ONLY WRITTEN DIMENSIONS ARE TO BE TAKEN AS CORRECT.

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

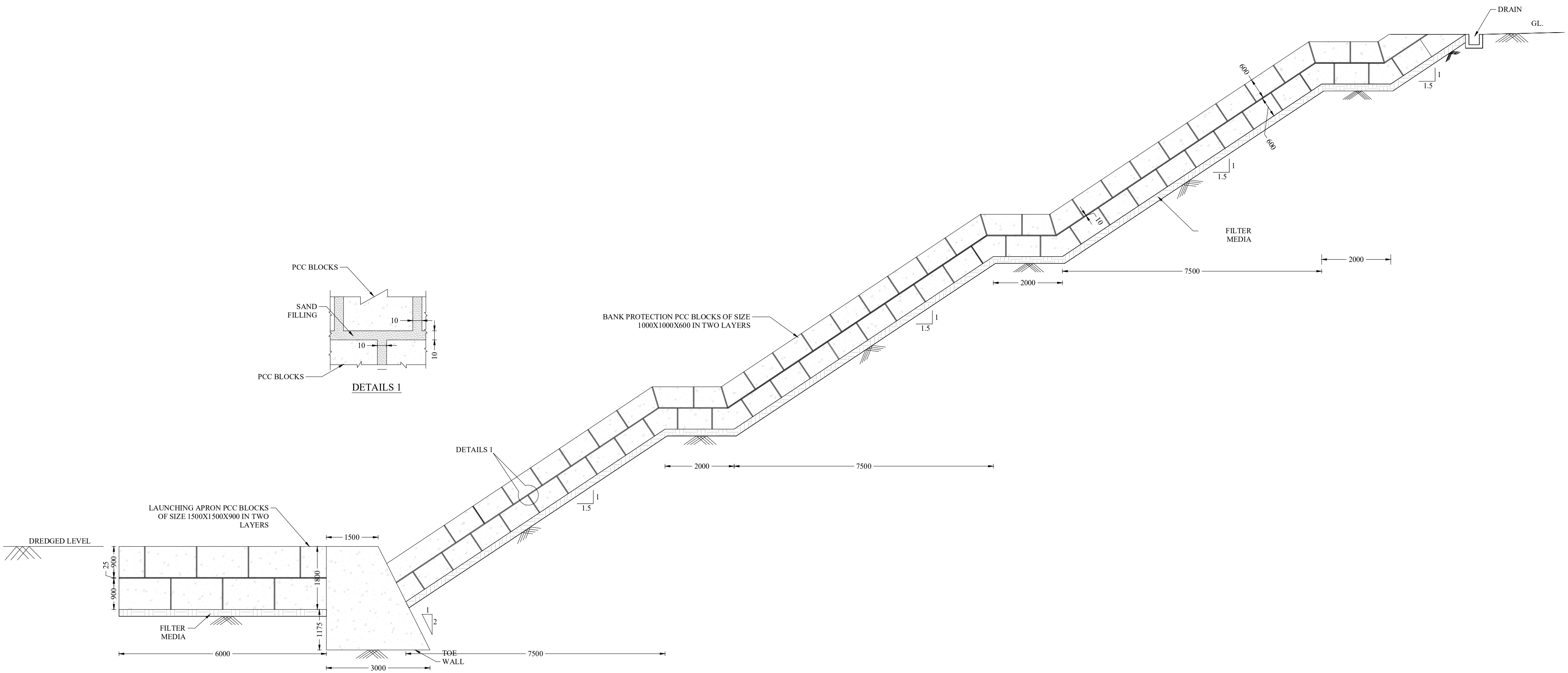
	NAME	SIGN	DATE
DRN			
CHD			
APD			

TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF MOORING EQUIPMENT OF EXISTING NAVIGATION LOCK

JOB. NO.

DRG. NO. ENL005

SIZE : A0 REV.



SECTION OF U/S BANK PROTECTION

LEGEND :-

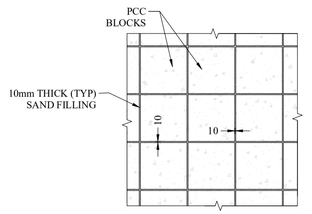
PCC

FILTER MEDIA

SAND

NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. PCC SHALL BE OF GRADE M15 AS PER IS 456:2000.



TYPICAL VIEW OF P.C.C BLOCKS

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers — PKS FLOODKON JV

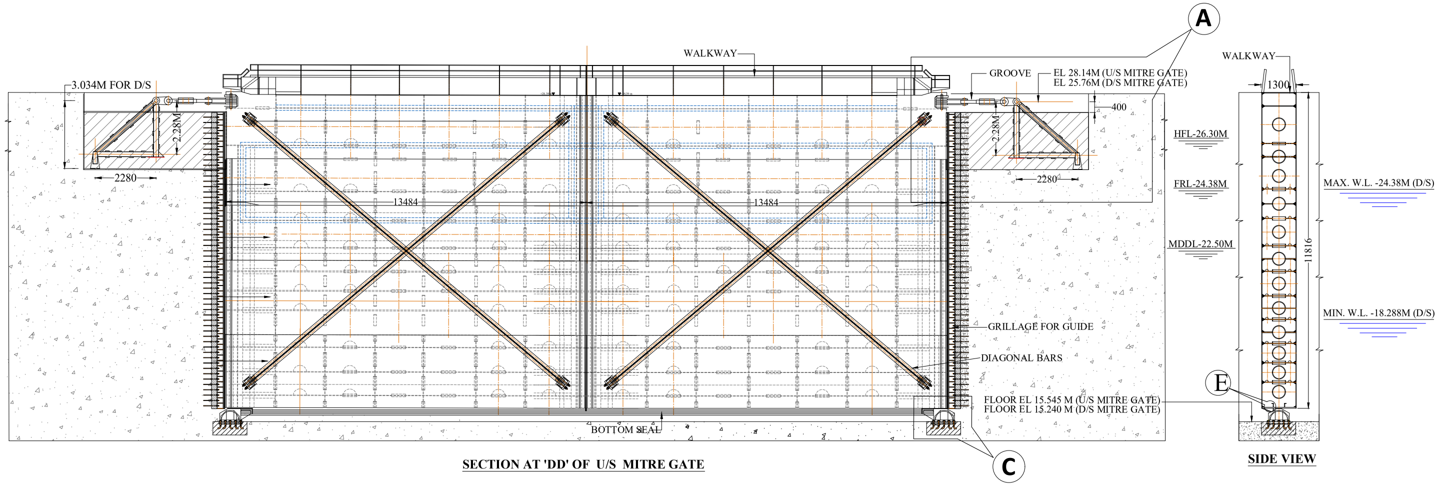
	NAME	SIGN	DATE
DRN			
CHD			
APD			

TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF BANK PROTECTION OF EXISTING NAVIGATION LOCK

JOB. NO.

DRG. NO. ENL006

SIZE : A0 REV.



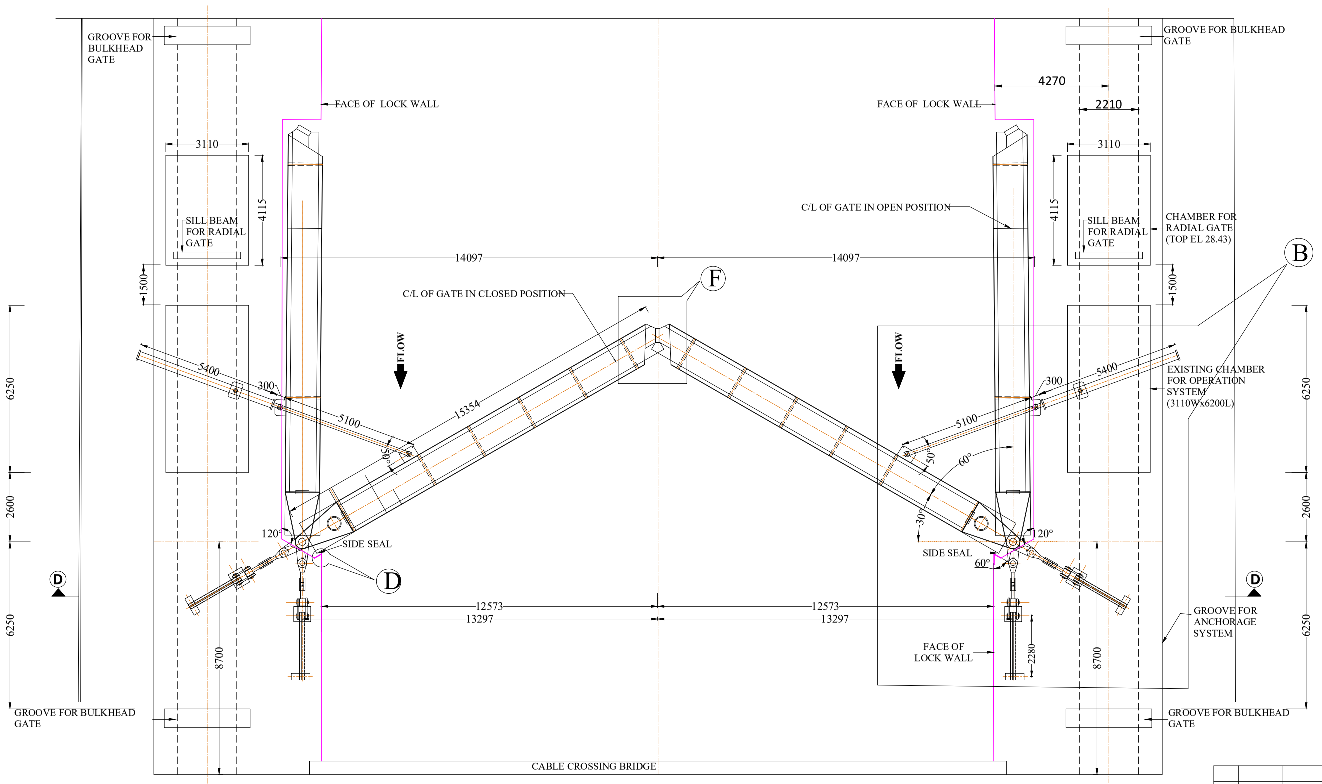
SECTION AT 'DD' OF U/S MITRE GATE

SIDE VIEW

	DETAILS OF HYDRAULIC HOIST
1	TYPE OF HOIST : DOUBLE ACTING
2	NO OF HOIST : 1+1=2 FOR EACH GATE
3	HOISTING CAPACITY : ADEQUATE FOR OPERATION OF GATE
4	WORKING / DESIGN PRESSURE : MAX.200KG/CM2
5	TEST PRESSURE : 1.5 TIMES OF THE DESING PRESSURE
6	STOKE : 5.4M
7	SPEED OF OPENING : 0.50M/MIN
8	HOIST : BOUGHT OUT ITEM
9	MAKE OF HYDRAULIC CYLINDER : MONTAN HYDRAULIK/BOSCH REXROTH/EATON
10	MAKE OF POWER PACK : MONTAN HYDRAULIK / BOSCH REXROTH /EATON

	TECHNICAL DETAILS
1	NO.OF GATES : 2NOS. (U/S & D/S)
2	VENT WIDTH : 25.146M
3	FLOOR LEVEL : 15.545M (U/S) AND 15.240M (D/S)
4	TOP OF WALL : 27.74M (U/S) AND 25.36M (D/S)
5	HEIGTH OF GATE LEAF : 27.74M (U/S) AND 25.36M (D/S)
6	OPERATION : HYDRAULIC HOIST
7	SKIN PLATE : RIVER SIDE OF GATE (U/S) AND LOCK SIDE OF GATE (D/S)

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. ALL STRUCTURAL STEEL CONFIRMING TO IS:2062 GRADE E-250B.



TOP PLAN OF U/S MITRE GATE

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

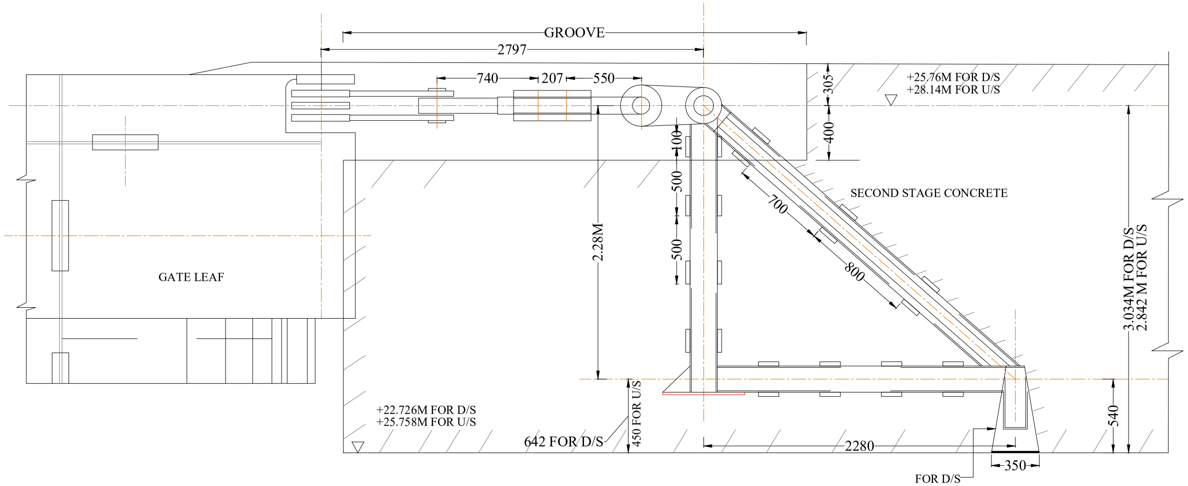
	NAME	SIGN	DATE
DRN			
CHD			
APD			

TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF MITRE GATE OF EXISTING NAVIGATION LOCK (SHEET NO. 01 OF 03)

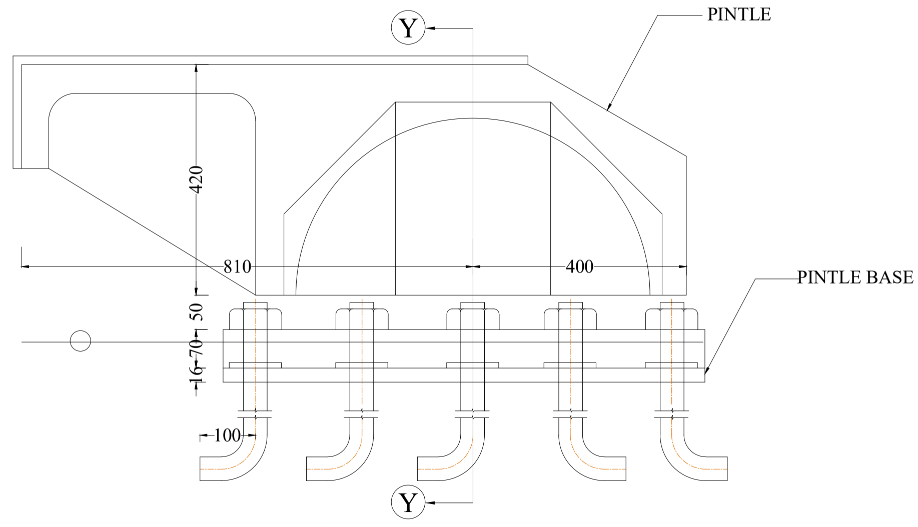
JOB. NO.

DRG. NO. ENL007-SH1

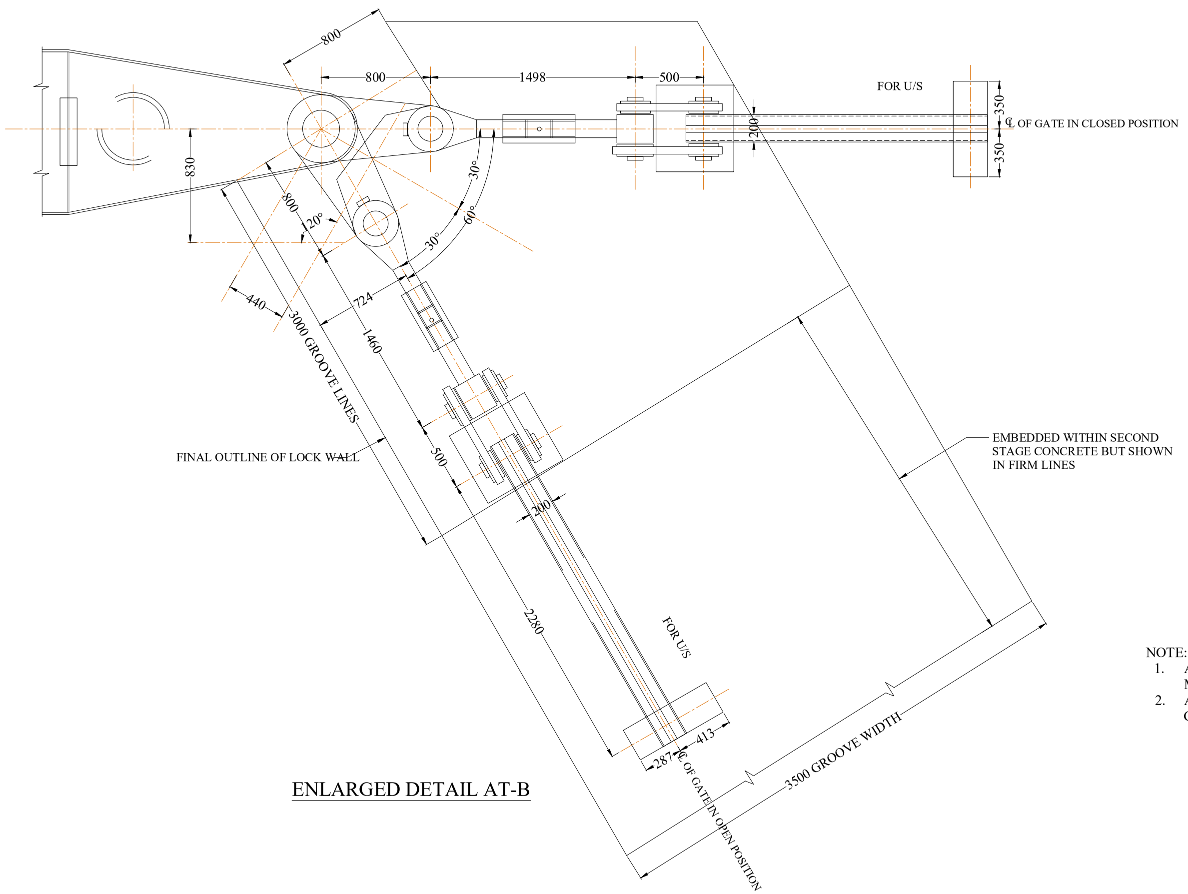
SIZE : A0 REV.



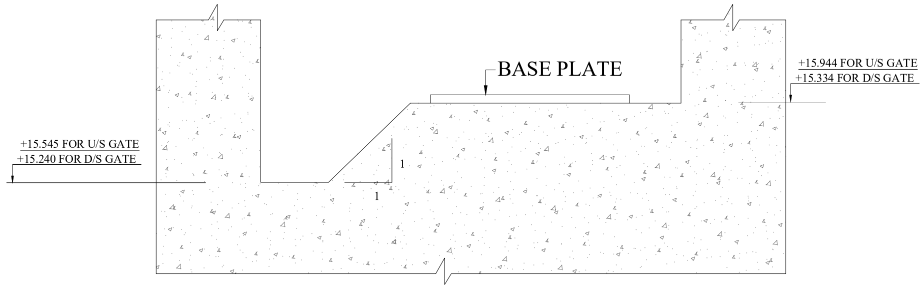
ENLARGED DETAIL AT -A



PINTLE & ITS BASE ARRANGEMENT
DETAIL AT - C



ENLARGED DETAIL AT-B



SECTION Y-Y

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. ALL STRUCTURAL STEEL CONFIRMING TO IS:2062 GRADE E-250B.

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

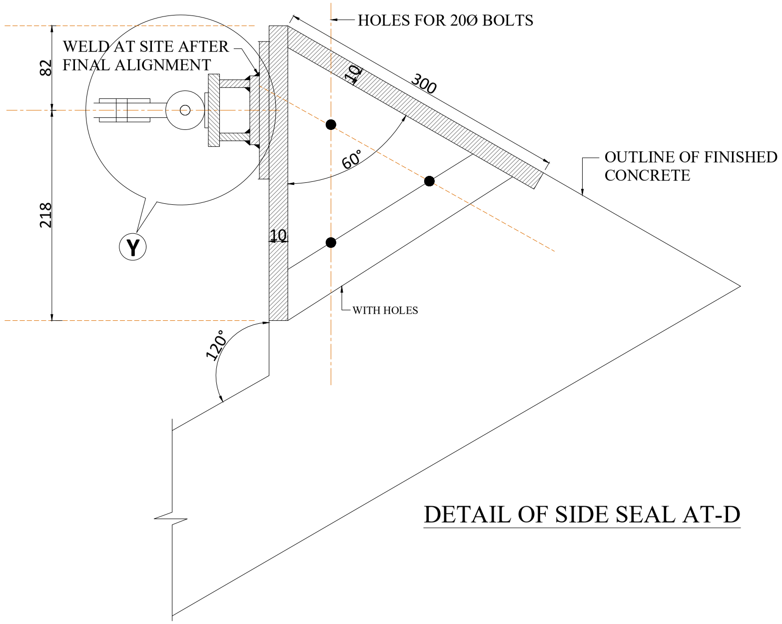
TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF MITRE GATE OF NAVIGATION LOCK (SHEET NO. 02 OF 03)

JOB. NO.

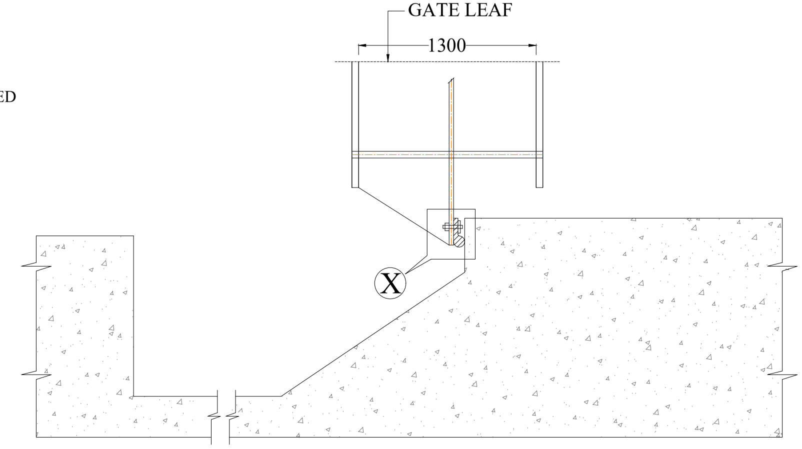
DRG. NO. ENL007-SH2

SIZE : A0

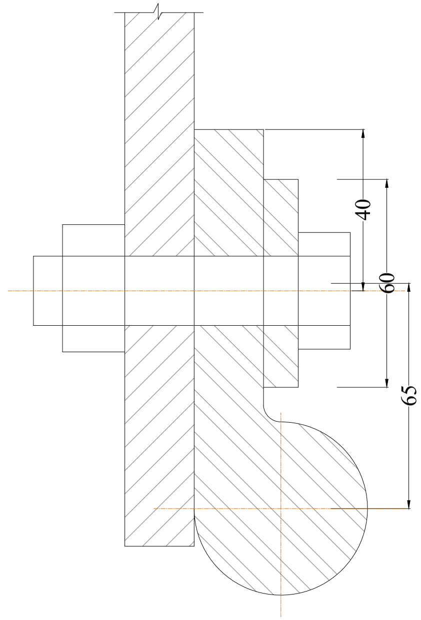
REV.



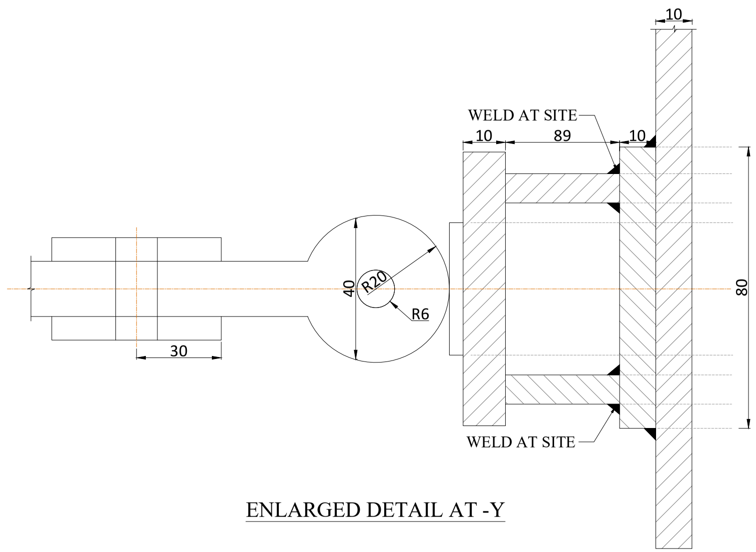
DETAIL OF SIDE SEAL AT-D



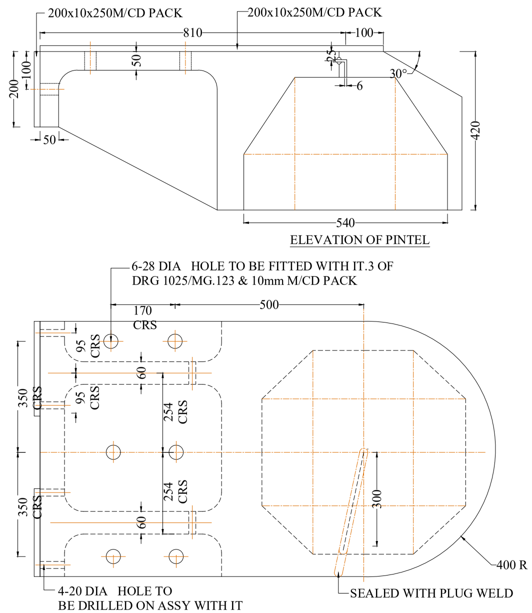
DETAIL OF BOTTOM SEAL AT-E



ENLARGED DETAIL AT -X

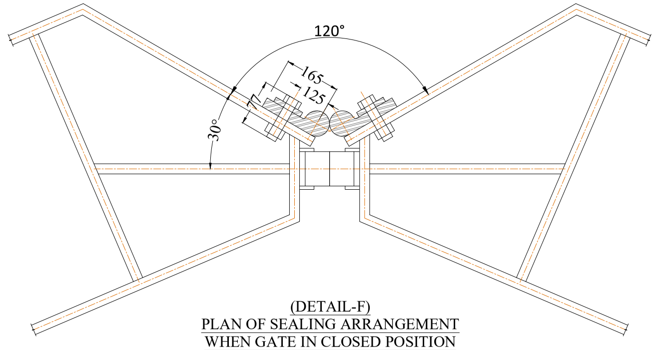


ENLARGED DETAIL AT -Y



ELEVATION OF PINTEL

PLAN OF PINTEL



(DETAIL-F)
PLAN OF SEALING ARRANGEMENT
WHEN GATE IN CLOSED POSITION

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS IN METERS UNLESS OTHERWISE SPECIFIED.
2. ALL STRUCTURAL STEEL CONFIRMING TO IS:2062 GRADE E-250B.

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

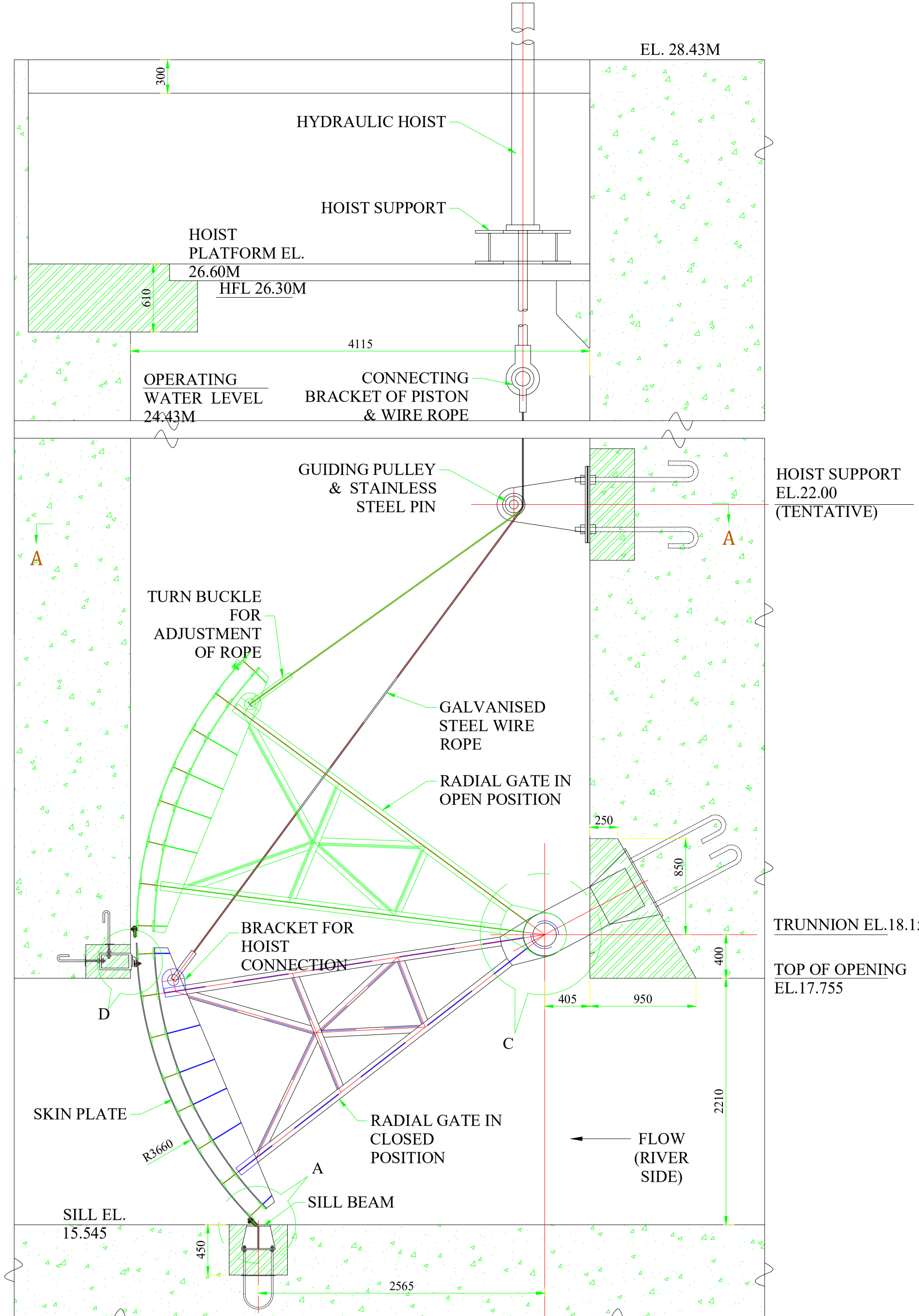
	NAME	SIGN	DATE
DRN			
CHD			
APD			

TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF MITRE GATE OF EXISTING NAVIGATION LOCK (SHEET NO. 03 OF 03)

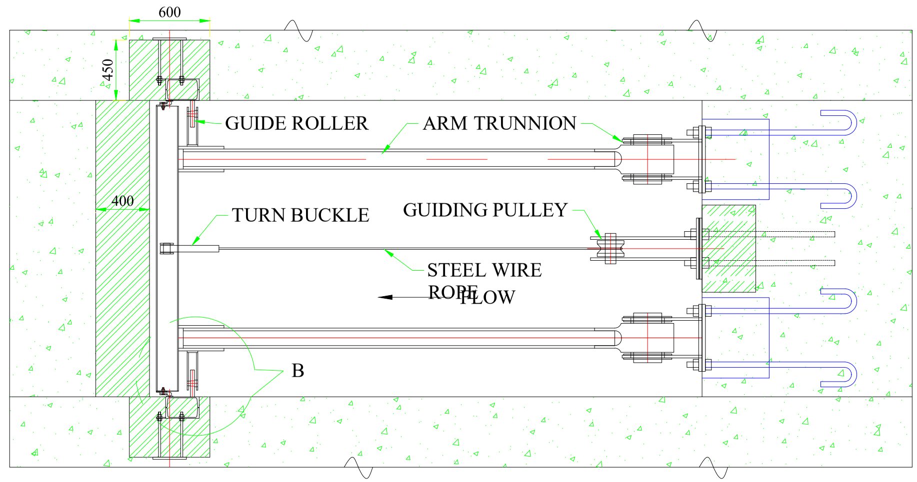
JOB. NO.

DRG. NO. ENL007-SH3

SIZE : A0 REV.



SECTIONAL ELEVATION AT C/L OF VENT



SECTION : A-A

TECHNICAL DETAILS OF RADIAL GATE :

- NO. OF FILLING CULVERTS : 2NOS. (1 IN EACH SIDE OF LOCK WALL)
- NO. OF EMPTYING CULVERTS: 2 NOS. (1 IN EACH SIDE OF LOCK WALL)
- TOTAL NO. OF OPENINGS : 4 Nos.
- NO. OF RADIAL GATES : 4 Nos.
- SIZE OF GATE OPENING : 2210MM X 2210MM
- SILL LEVEL : 15.545M
- TOP OF OPENING : 17.755 M
- TOP SEAL LEVEL : 17.855 M
- TRUNNION LEVEL : 18.155 M
- OPERATING BY : HYDRULIC HOIST
- HOIST STROKE : 2.275M (TENTATIVE)

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE SCALED OUT, ONLY WRITTEN DIMENSIONS ARE TO BE TAKEN AS CORRECT.
3. CONCRETE IN BLOCK OUTS SHALL BE TO ONE GRADE HIGHER THAN FIRST STAGE CONCRETE BUT NOT LESS THAN M-25 OF IS:456 (LATEST VERSION)
4. SURFACE OF CONCRETE BLOCK OUTS SHALL BE THOROUGHLY ROUGH FOR PROPER BONDAGE BETWEEN FIRST STAGE AND SECOND STAGE CONCRETE.
5. THE GATE SHALL BE OPERATED BY HYDRAULIC HOIST OF ADEQUATE CAPACITY, CONNECTED ON UPSTREAM (RIVER) SIDE.
6. EACH HOIST SHALL CONSIST OF A CYLINDER, INDEPENDENT POWER PACK, GATE POSITION INDICATOR ETC.
7. ALL FILLET WELDS SHALL BE CONTINUOUS AND MINIMUM OF 6MM LEG SIZE UNLESS STATED OTHERWISE. ALL BUTT WELDS SHALL BE FULL PENETRATION WELDS.
8. REFER SHEET 2 OF 2 FOR OTHER NOTES.

LEGENDS:

Ist STAGE CONCRETING (PRIMARY)

IInd STAGE CONCRETING (SECONDARY)

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

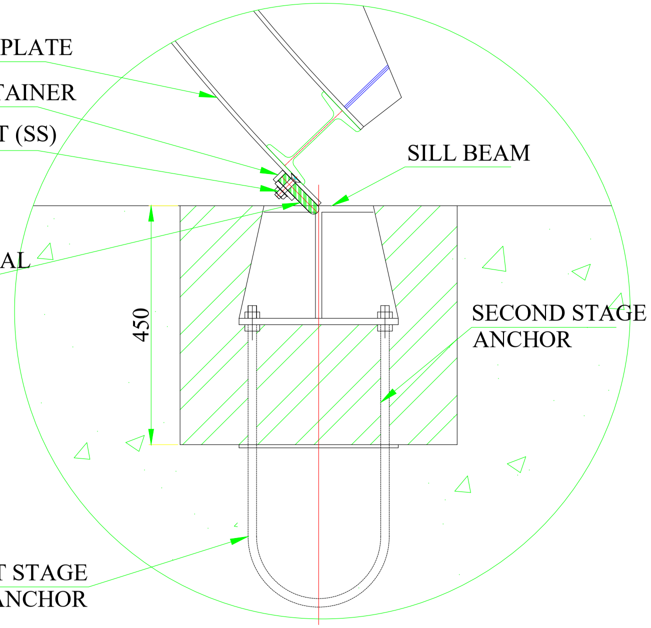
TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF RADIAL GATE OF EXISTING NAVIGATION LOCK (SHEET NO. 01 OF 2)

JOB. NO.

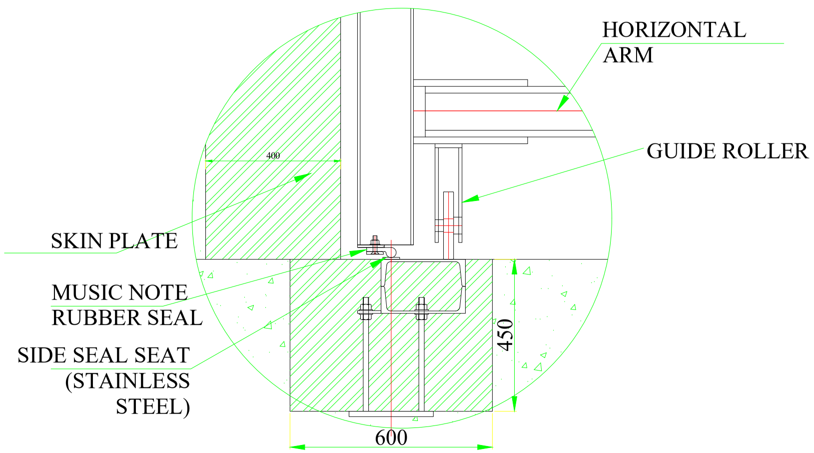
DRG. NO. ENL008-SH1

SIZE : A0

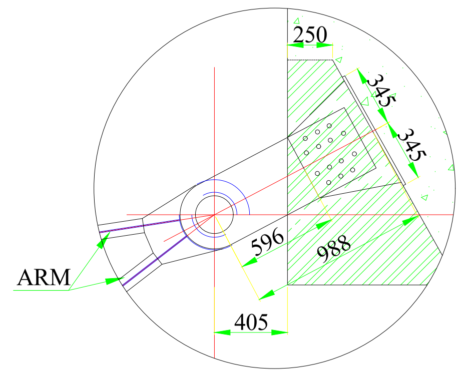
REV.



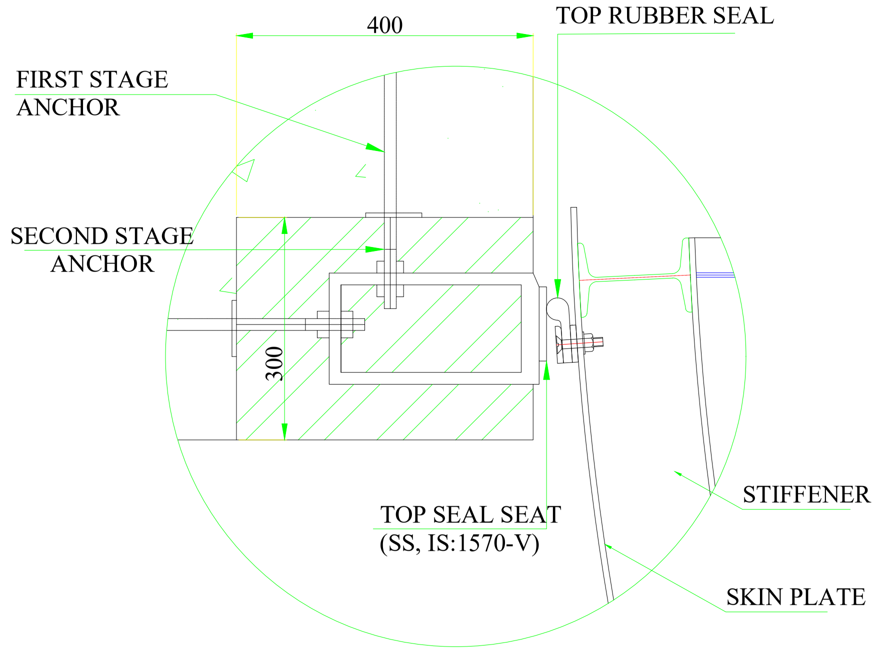
DETAIL - A
(REFER SHEET 1 OF 2)



DETAILS - B
(REFER SHEET 1 OF 2)



DETAILS - C
(REFER SHEET 1 OF 2)



DETAILS - D
(REFER SHEET 1 OF 2)

NOTE:

1. ALL THE SEALS SHALL BE CONTINUOUS AND WATER TIGHT.
2. ALL CORNERS AND EDGES IN CONTACT WITH RUBBER SEALS AND WELDING SHALL BE SMOOTH AND ROUNDED WITH MINIMUM ROUNDS OF 6MM.
3. THE GATE TRUNNIONS SHALL BE FITTED WITH EITHER SPHERICAL PLAIN BEARINGS OR SELF LUBRICATING TYPE BUSHINGS.
4. WELDING OF ALIGNMENT STUDS TO ANCHOR PLATES SHALL DEVELOP THE FULL STRENGTH OF THE STUD.
5. ARRANGEMENT SHOWN FOR BOTTOM SEAL IN THE DRAWING IS INDICATIVE TYPE ONLY. THE CONTRACTOR MAY PROPOSE AN ALTERNATIVE SUITABLE ARRANGEMENT FOR THE BOTTOM OF SEAL OF THE GATE KEEPING IN VIEW HEAVY SEDIMENT LOAD OF RIVER BUT IT SHALL BE ADOPTED, CONSIDERED APPROPRIATE BY THE EMPLOYER.
6. EXISTING SECOND STAGE EMBEDDED PARTS PROVIDED IN BLOCK OUTS SHALL BE MAINTAINED, HOWEVER IF THEY ARE FOUND INADEQUATE THE NEW EMBEDDED PARTS SHALL BE DESIGNED AND PROVIDED TO SUIT THE BLOCK OUTS PROVIDED AT SITE.
7. GATE SHALL BE DESIGNED IN ACCORDANCE WITH THE PROVISIONS OF IS 4623 TO SUIT THE SIZE OF OPENING AND CHAMBER WHICH SHALL BE VERIFIED BY ACTUAL MEASUREMENT AT SITE.
8. THE METHODOLOGY FOR REMOVAL OF EXISTING GATES SHALL BE FINALIZED CONSIDERING THE BOTTLENECKS AT SITE, TRANSPORTATION LIMITATIONS ETC. THE SITE SHALL BE CLEARED OF ALL THE REPLACED MATERIALS.
9. THE TOLERANCES FOR EMBEDDED PARTS & COMPONENTS OF GATE SHALL BE AS PER ANNEX.-E OF IS 4623.

MACHINING DETAILS :	
▽	FOR GUIDES & PIN
▽▽	FOR TRACKS
▽▽▽	FOR SEAL SEATS

LEGENDS:

- Ist STAGE CONCRETING (PRIMARY)
- IInd STAGE CONCRETING (SECONDARY)

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

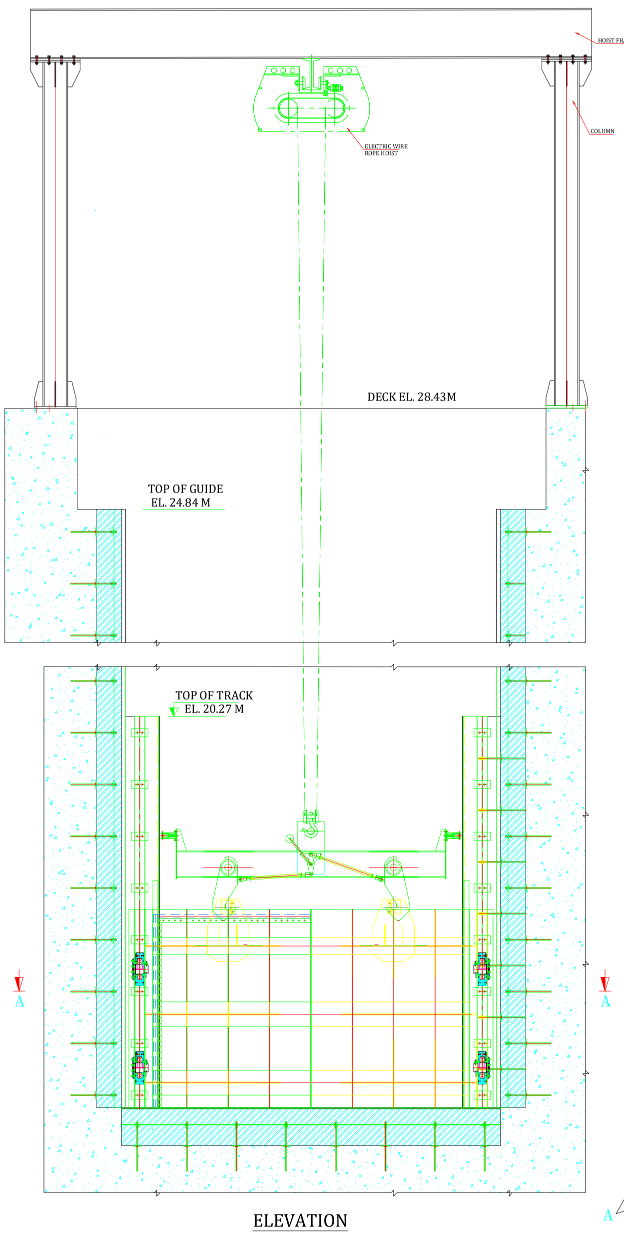
TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF RADIAL GATE OF EXISTING NAVIGATION LOCK (SHEET NO. 2 OF 2)

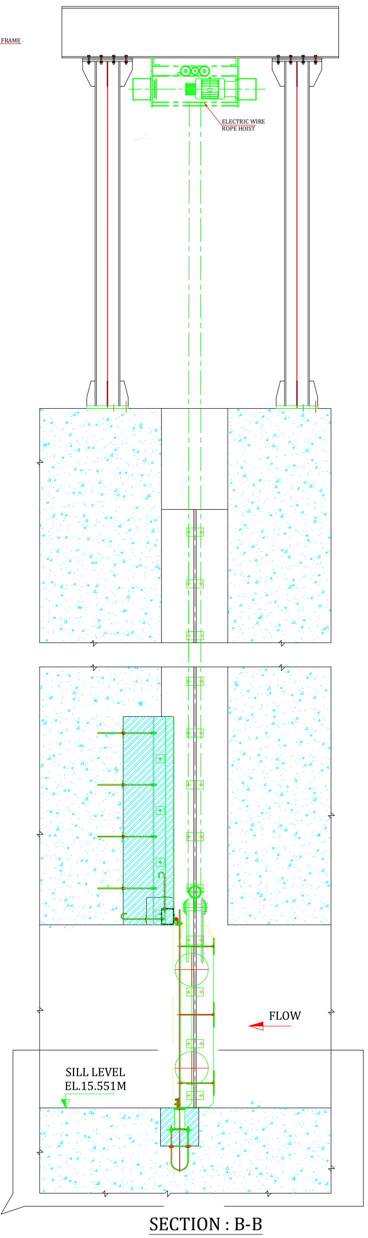
JOB. NO.

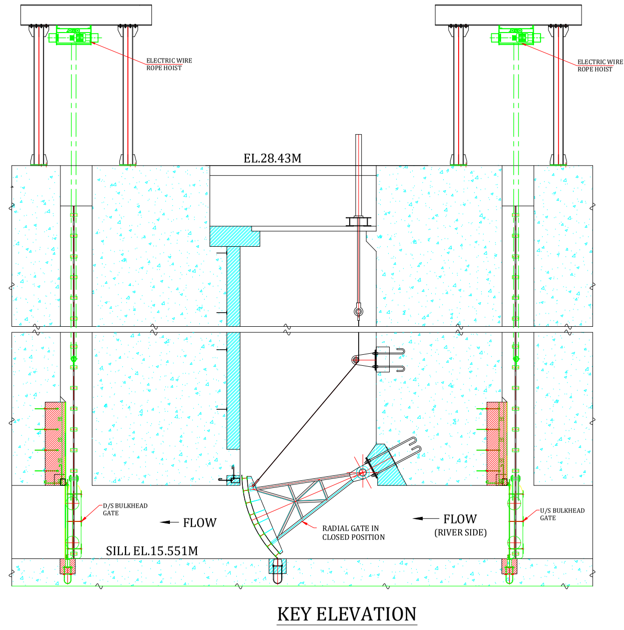
DRG. NO. ENL008-SH2

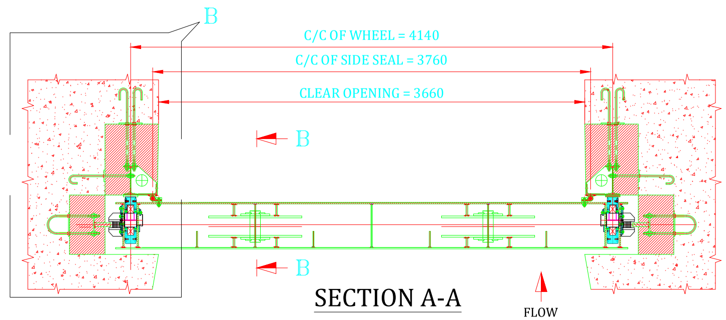
SIZE : A0

REV.









NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS & BLOCK OUT SIZES INDICATED IN THE DRAWING ARE AS PER EXISTING STRUCTURE & MAY VARY AT SITE.
3. ALL STRUCTURAL STEEL CONFIRMING TO IS-2062 GRADE E-250.
4. NO DIMENSIONS SHALL BE SCALED OUT ONLY WRITTEN DIMENSIONS ARE TO BE TAKEN AS CORRECT.
5. ALL SEALING ARRANGEMENT (BOTTOM, SIDE & TOP)SHALL BE WATER TIGHT.
6. ERECTION TOLERANCE FOR EMBEDDED PARTS & GATES TO BE AS PER IS : 4622.
7. DRY TESTING OF GATE SHALL BE CARRIED OUT BEFORE COMMISSIONING.
7. ALL FILLET WELDS SHALL BE CONTINUOUS AND MINIMUM OF 6MM LEG SIZE UNLESS STATED OTHERWISE. ALL BUTT WELDS SHALL BE FULL PENETRATION WELDS.
8. THE LEVELS AND DIMENSIONS SHALL BE VERIFIED AT SITE FOR ALL THE GATES.
9. REFER SHEET 2 OF 2 FOR OTHER NOTES.

Location of Gate	Filling culvert		Emptying culvert		No. of gates
	Width (m)	Height (m)	Height	Width	
Bulk Head Gate on U/S of upstream radial gates Type A	3.658 m	2.21	-	-	2
Bulk Head Gate on D/S of upstream radial gates Type B	3.268 m		-	-	2
Bulk Head Gate on upstream and downstream for D/S radial gates. Type C	-	-	2.210 m	2.205 m	(2+2)=4

TECHNICAL DATA

DESCRIPTION	GATE: TYPE-A	TYPE-B	TYPE-C
• TOTAL NO. OF OPENING	02	02	04
• TOTAL NO. OF GATES	02	02	04
• OPENING WIDTH	3.66M	3.27M	2.20M
• DESIGN WATER LEVEL	24.38M	24.38M	24.38M
• C/C OF ROLLER TRACKS	4.14M	3.75M	2.68M
• C/C OF SIDE SEAL	3.76M	3.37M	2.30M
• OPERATING BY	ELECTRIC WIRE ROPE HOIST		

LEGENDS:

Ist STAGE CONCRETING (PRIMARY)

IInd STAGE CONCRETING (SECONDARY)

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

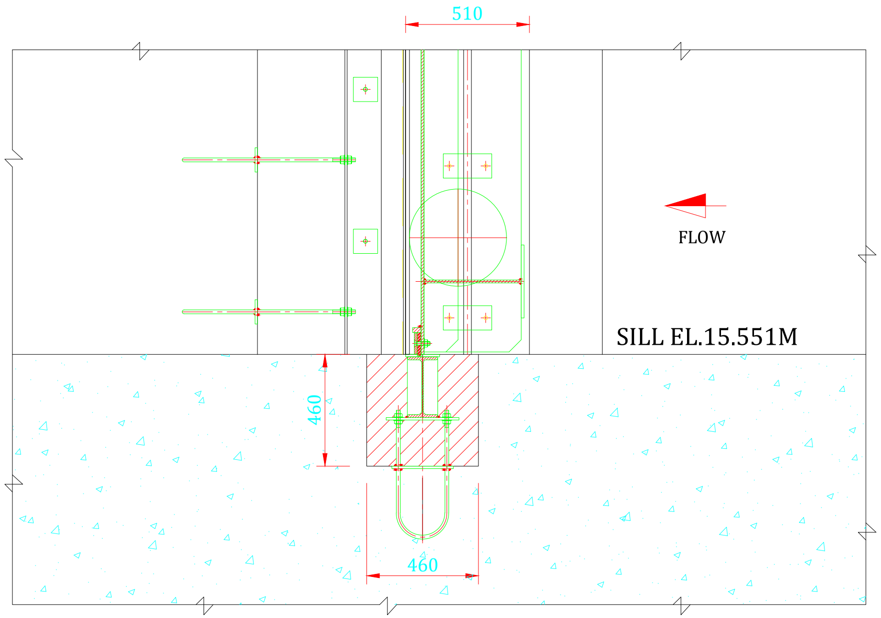
	NAME	SIGN	DATE
DRN			
CHD			
APD			

TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF BULKHEAD GATE OF EXISTING NAVIGATION LOCK (SHEET NO. 01 OF 02)

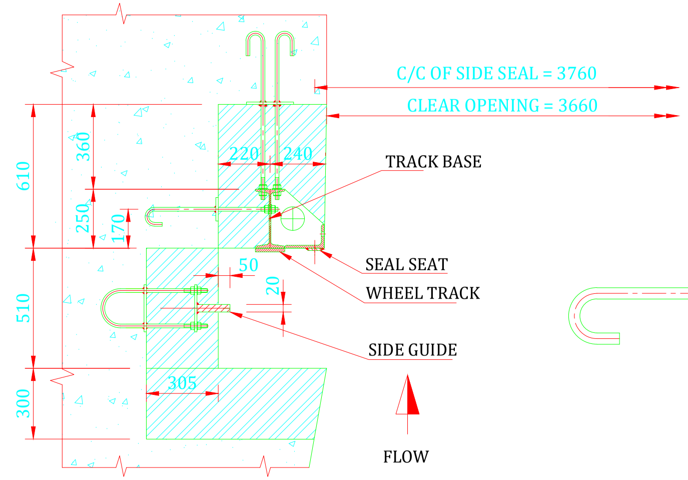
JOB. NO.

DRG. NO. ENL009-SH1

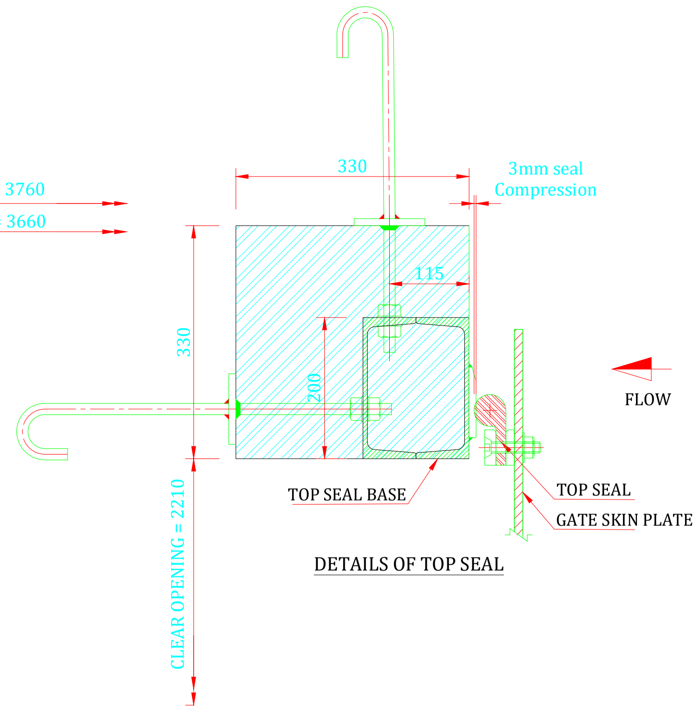
SIZE : A0 REV.



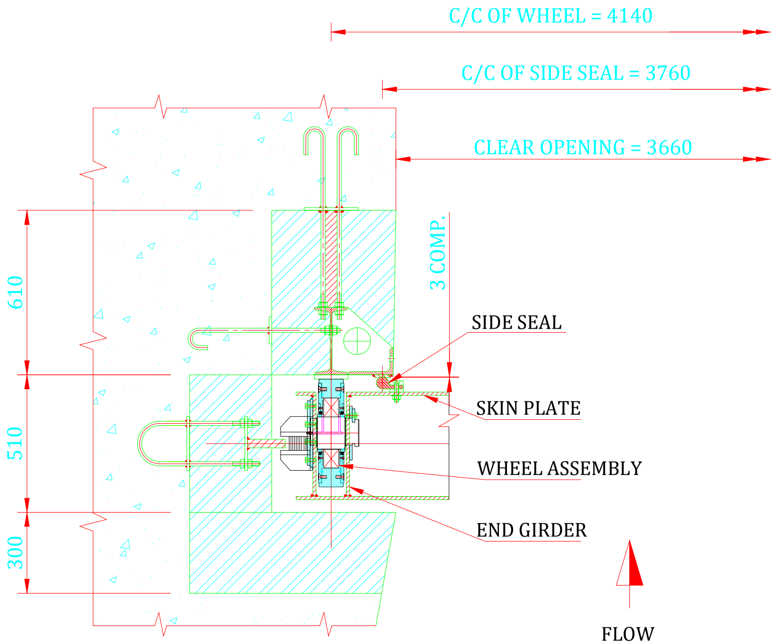
DETAIL : A
(REFER SHEET 1 OF 2)



GATE GROOVE DETAIL



DETAILS OF TOP SEAL



DETAIL : B
(REFER SHEET 1 OF 2)

NOTE:

1. ALL THE SEALS SHALL BE CONTINUOUS AND WATER TIGHT.
2. ALL CORNERS AND EDGES IN CONTACT WITH RUBBER SEALS AND WELDING SHALL BE SMOOTH AND ROUNDED WITH MINIMUM ROUNDS OF 6MM.
3. EXISTING SECOND STAGE EMBEDDED PARTS PROVIDED IN BLOCK OUTS SHALL BE MAINTAINED, HOWEVER IF THEY ARE FOUND INADEQUATE THE NEW EMBEDDED PARTS SHALL BE DESIGNED AND PROVIDED TO SUIT THE BLOCK OUTS PROVIDED AT SITE.
4. GATE SHALL BE DESIGNED IN ACCORDANCE WITH THE PROVISIONS OF IS 4622 TO SUIT THE SIZE OF OPENING AND CHAMBER WHICH SHALL BE VERIFIED BY ACTUAL MEASUREMENT AT SITE.
5. THE METHODOLOGY FOR REMOVAL OF EXISTING GATES SHALL BE FINALIZED CONSIDERING THE BOTTLENECKS AT SITE, TRANSPORTATION LIMITATIONS ETC. THE SITE SHALL BE CLEARED OF ALL THE REPLACED MATERIALS.
6. THE TOLERANCES FOR EMBEDDED PARTS & COMPONENTS OF GATE SHALL BE AS PER ANNEX.-E OF IS 4622.

MACHINING DETAILS :	
▽	FOR GUIDES & PIN
▽▽	FOR TRACKS
▽▽▽	FOR SEAL SEATS

LEGENDS :

- Ist STAGE CONCRETING (PRIMARY)
- IInd STAGE CONCRETING (SECONDARY)

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers — PKS FLOODKON JV

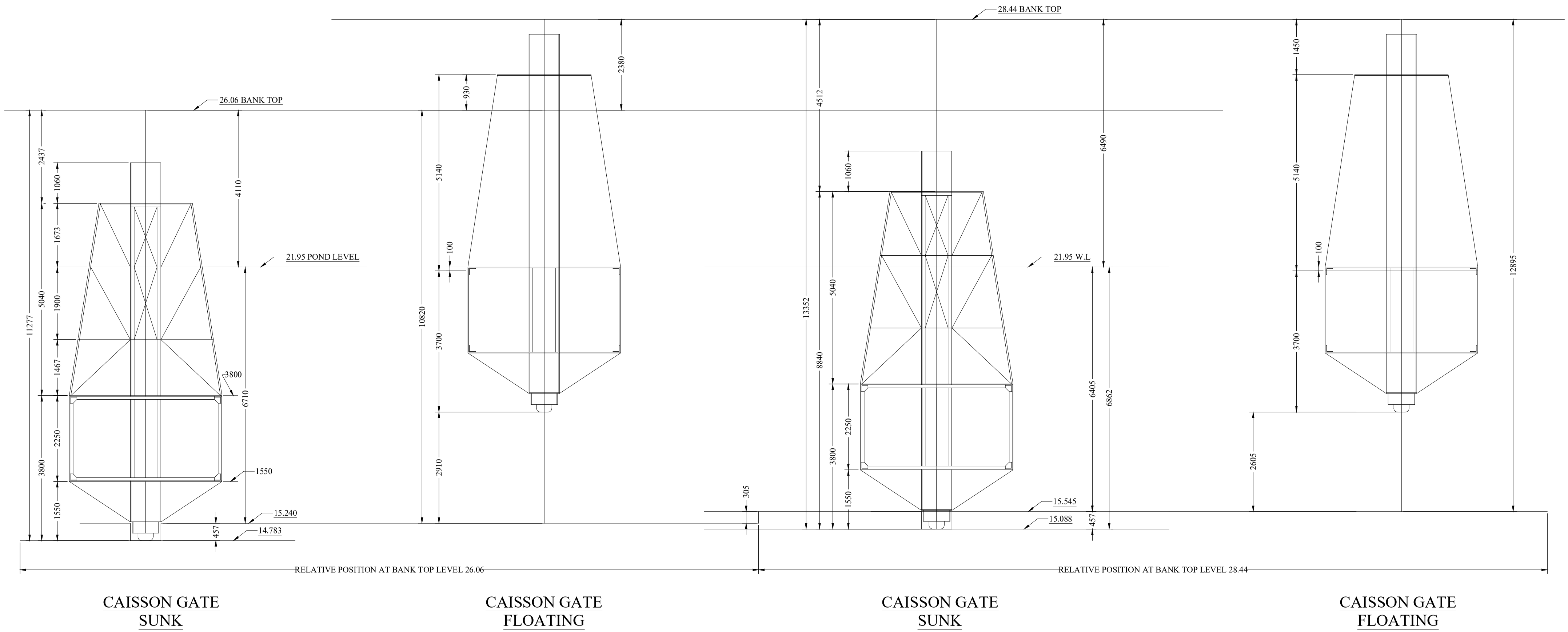
	NAME	SIGN	DATE
DRN			
CHD			
APD			

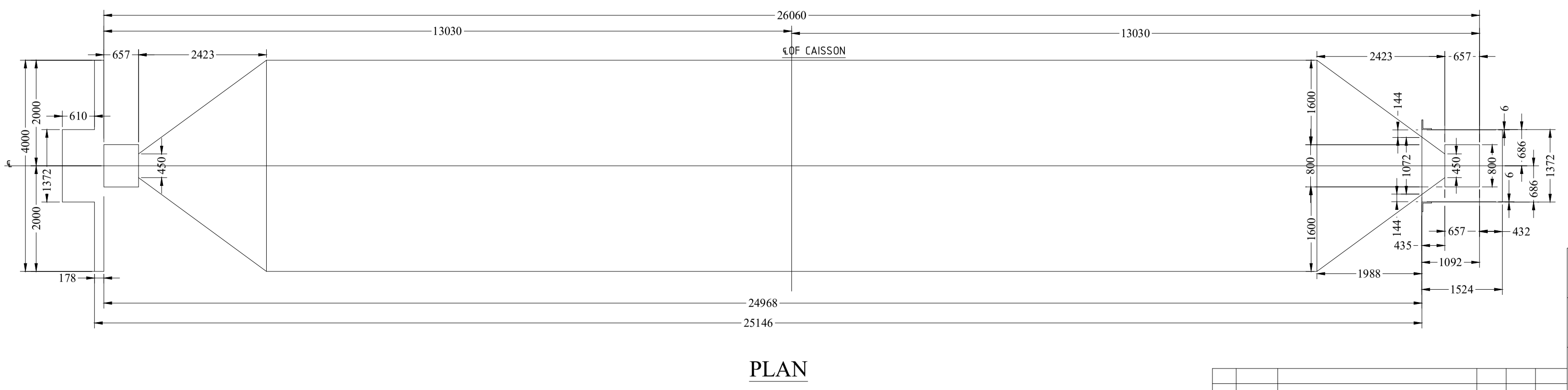
TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF BULKHEAD GATE OF EXISTING NAVIGATION LOCK (SHEET NO. 02 OF 02)

JOB. NO.

DRG. NO. ENL009-SH2

SIZE : A0 REV.





NOTE:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE SCALED OUT, ONLY WRITTEN DIMENSIONS ARE TO BE TAKEN AS CORRECT.

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

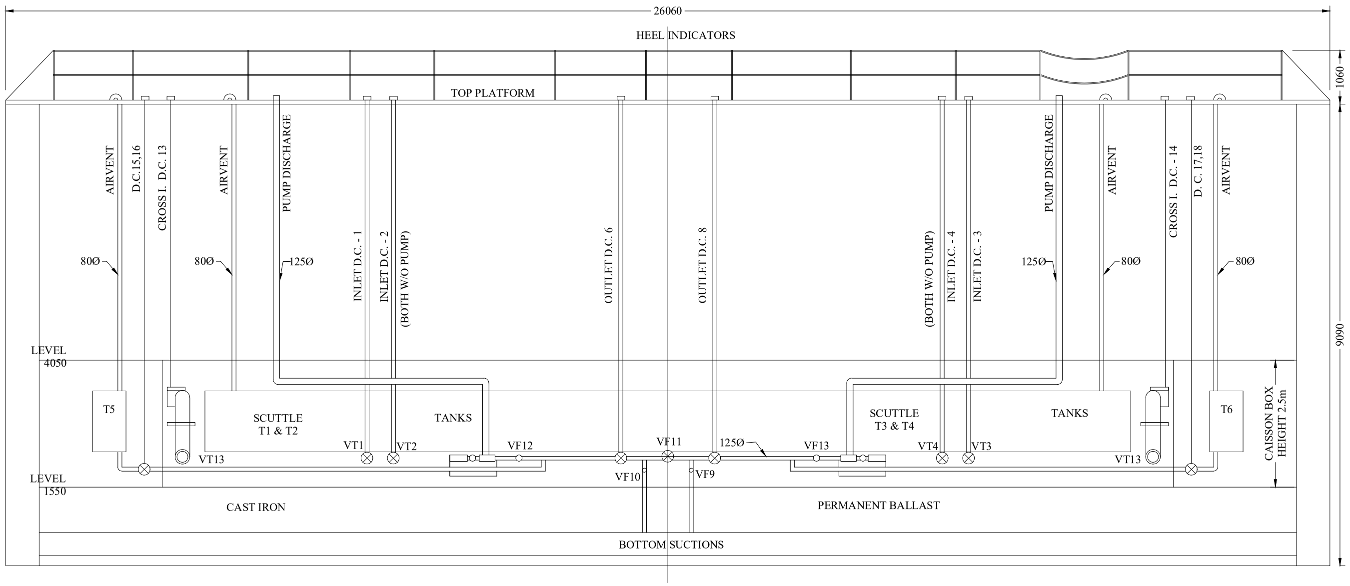
TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF CAISSON GATE OF EXISTING NAVIGATION LOCK (SHEET NO. 01 OF 04)

JOB. NO.

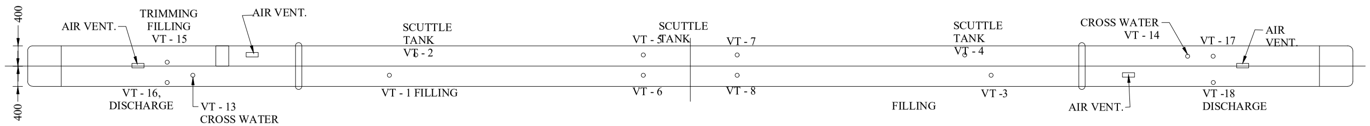
DRG. NO. ENL010-SH1

SIZE : A0

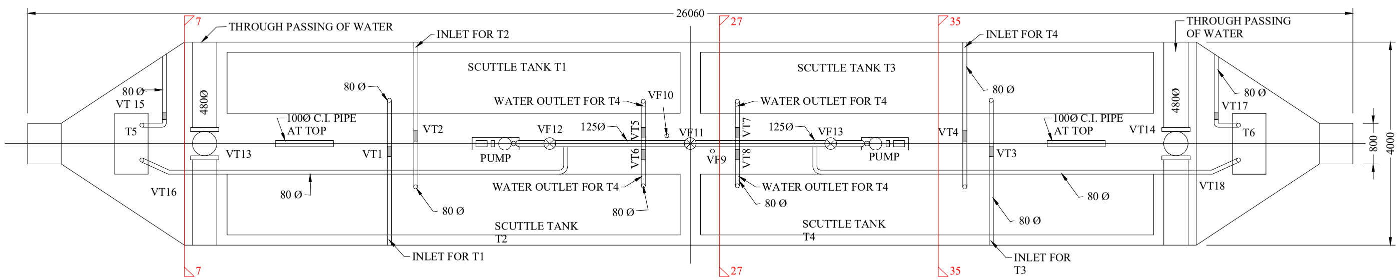
REV.



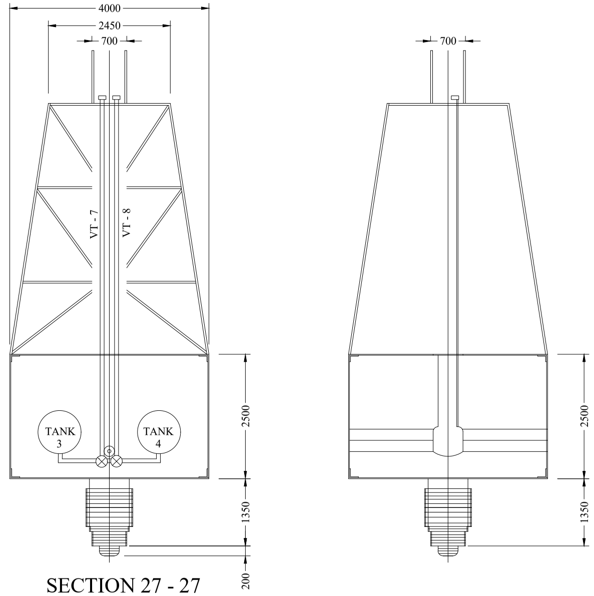
SECTIONAL ELEVATION



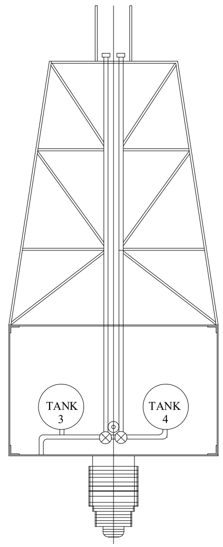
PLAN AT LEVEL 9090



PLAN AT LEVEL (1550-4050)



SECTION 27 - 27



SECTION 35 - 35

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REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

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CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

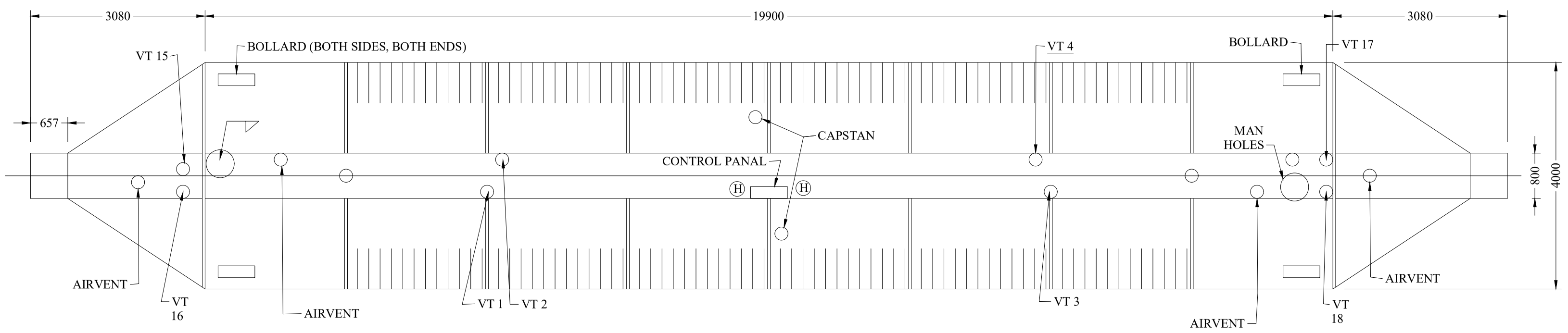
TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF CAISSON GATE OF EXISTING NAVIGATION LOCK (SHEET NO. 02 OF 04)

JOB. NO.

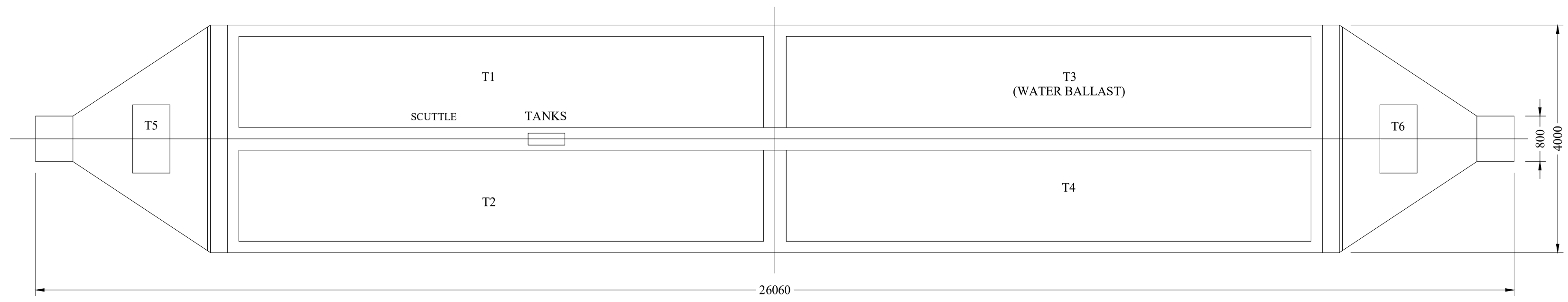
DRG. NO. ENL010-SH2

SIZE : A0

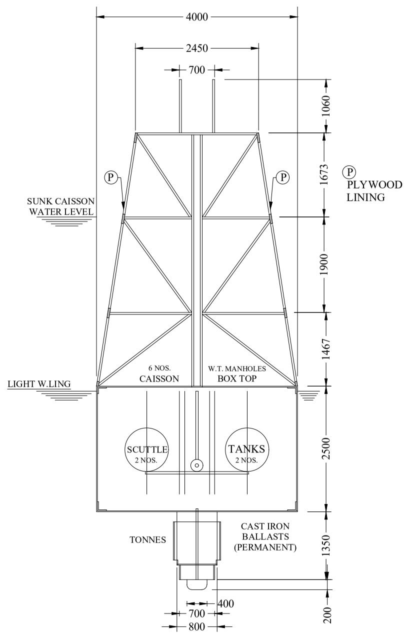
REV.



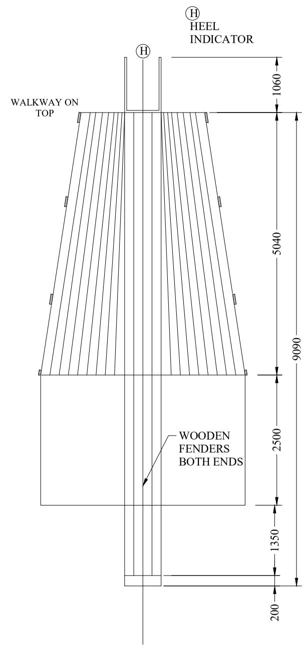
TOP PLAN



SECTIONAL PLAN SHOWING (T1 TO T4)
SCUTTLE & TRIMMING TANKS (T5,T6)



SECTIONAL VIEW



SIDE VIEW

NOTE:

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REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

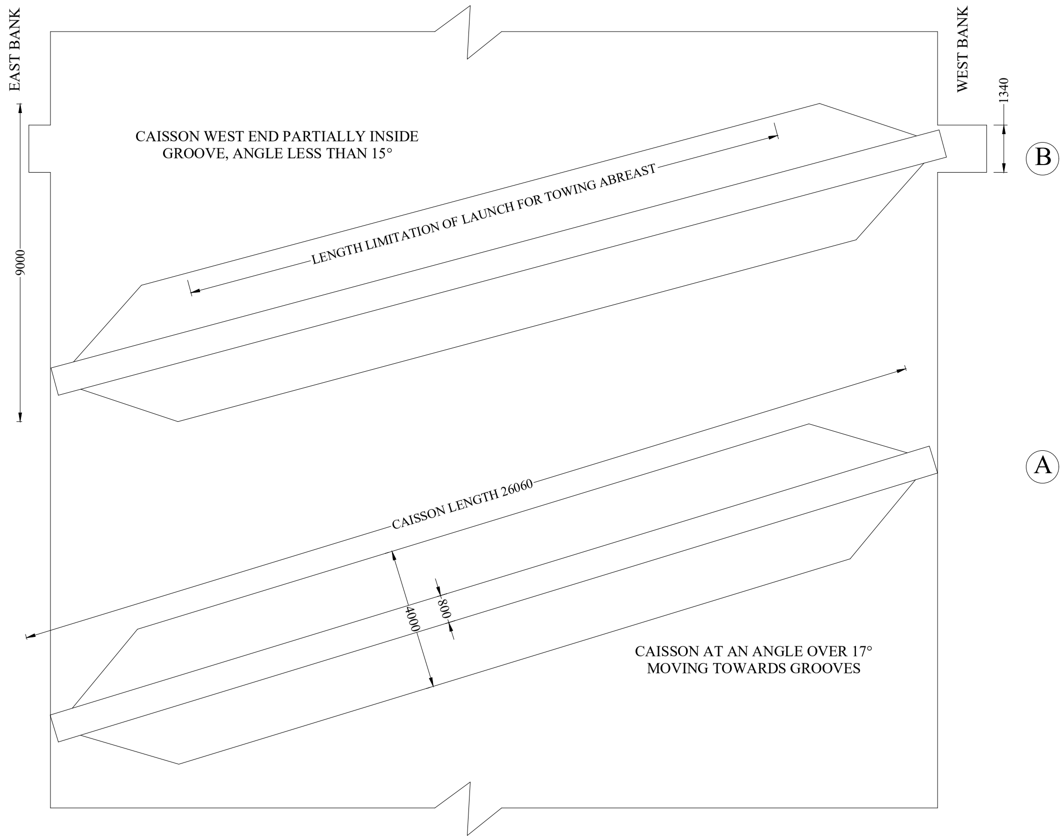
TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF CAISSON GATE OF EXISTING NAVIGATION LOCK (SHEET NO. 03 OF 04)

JOB. NO.

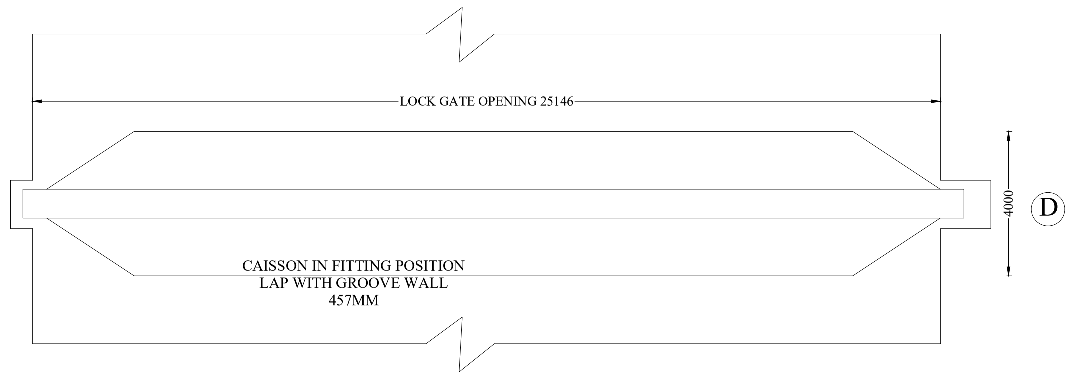
DRG. NO. ENL010-SH3

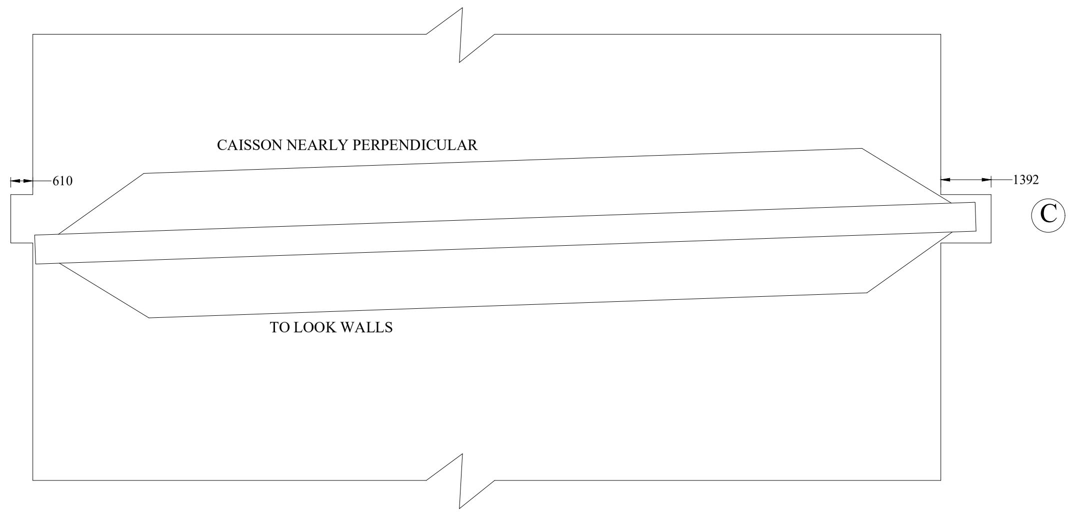
SIZE : A0

REV.



STAGES OF MOVEMENT





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REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

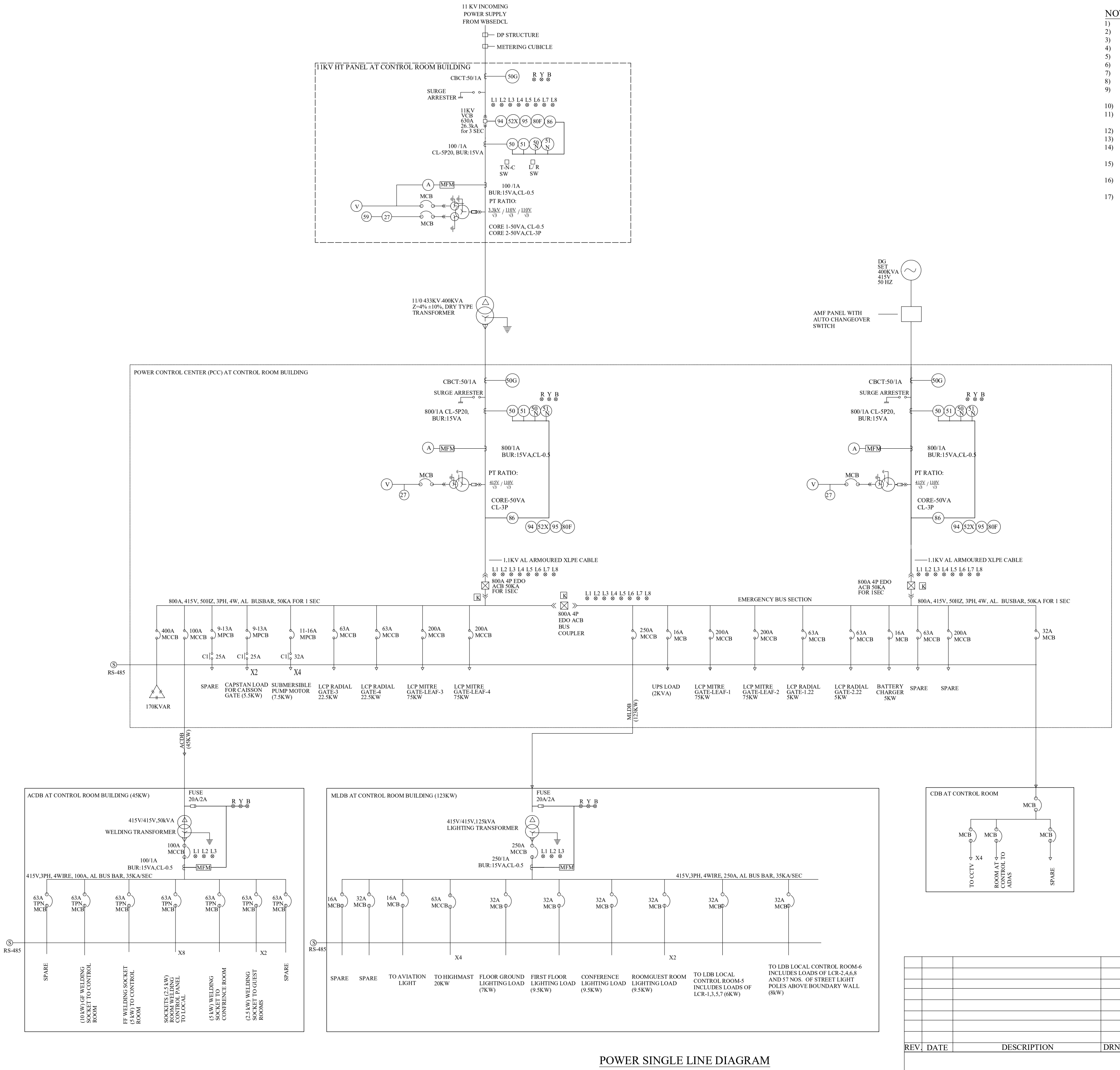
	NAME	SIGN	DATE
DRN			
CHD			
APD			

TITLE: GENERAL ARRANGEMENT DRAWING AND DETAIL OF CAISSON GATE MOVEMENT FOR OPERATION OF EXISTING NAVIGATION LOCK (SHEET NO. 04 OF 04)

JOB. NO.

DRG. NO. ENL010-SH4

SIZE : A0 REV.



POWER SINGLE LINE DIAGRAM

NOTES:-

1) HT & LT SWITCHGEAR PANEL SHALL BE SUITABLE FOR FUTURE EXPANSION ON BOTH SIDES.
2) AT LEAST 20% SPARE FEEDERS OF EACH TYPE AND RATING SHALL BE PROVIDED IN LT SWITCHBOARD.
3) DESIGN AMBIENT TEMPERATURE: 45°C.
4) CABLE SIZES & TRANSFORMER RATINGS SHALL BE AS PER APPROVED CALCULATIONS.
5) WELDING SOCKETS SHALL BE FED FROM 3PH, 4WIRE, AC DISTRIBUTION BOARD (ACDB) IN CONTROL ROOM.
6) POWER SOCKETS & LIGHTING LOAD SHALL BE FED FROM MAIN LIGHTING DISTRIBUTION BOARD(MLDB).
7) RATING OF COMPONENTS SHALL BE SELECTED AS PER TYPE-2 CO-ORDINATION OF IS 13947.
8) INDICATING LAMPS SHALL BE CLUSTER LED.
9) EACH PANEL OF HT & LT SWITCHGEAR SHALL BE PROVIDED WITH FLUORESCENT LIGHTING FIXTURE RATED FOR 240V,50 HZ SUPPLY FOR INTERNAL ILLUMINATION FITTING SHALL BE CONTROLLED BY THE RESPECTIVE PANEL DOOR SWITCH.
10) VA RATINGS OF CTs & PTs ARE INDICATIVE ONLY, VENDOR HAS TO CHECK THE SAME BASED ON LOAD.
11) ALL INCOMERS AND OUTGOINGS 125A AND ABOVE SHALL HAVE MICROPROCESSOR BASED O/L, S/C & E/F RELEASES AND BELOW 125A SHALL HAVE THERMAL MAGNETIC BASED O/L, S/C & THERMAL MAGNETIC BASED O/L, S/C & E/F RELEASES.
12) ALL RELAYS SHALL BE OF NUMERICAL TYPE.
13) DG SET RATING IS BASED ON EMERGENCY LOADS TO BE OPERATED IN CASE OF MAIN SUPPLY POWER FAILURE.
14) MLDB IN CONTROL ROOM SHALL FED POWER TO LIGHTING LOAD & POWER SOCKET LOAD OF CONTROL ROOM GROUND FLOOR, CONTROL ROOM FIRST FLOOR, CONFRENCE ROOM, GUEST ROOM-1&2 AND STAIRCASE LIGHTING.
15) LDB IN LOCAL CONTROL ROOM-5 SHALL FED POWER TO LIGHTING LOAD & POWER SOCKET LOAD OF LOCAL CONTROL ROOMS-1,3,5,7.
16) LDB IN LOCAL CONTROL ROOM-6 SHALL FED POWER TO LIGHTING LOAD & POWER SOCKET LOAD OF LOCAL CONTROL ROOMS-2,4,6,8 AND STREET LIGHTING POLES (57 NOS) ABOVE BOUNDARY WALL.
17) LOCATION OF LOCAL CONTROL ROOMS- 1,2,3,4,5,6,7,8 ARE SHOWN IN DRAWING NO FL-1025.

SYMBOL	DESCRIPTION
ACDB	AC DISTRIBUTION BOAD
CDB	CONTROL DISTRIBUTION ROAD
GF	GROUND FLOOR
FF	FIRSI FLOOR
ADAS	AUTOMATIC DATA ACQUISITION SYSTEM
LCR	LOCAL CONTROL ROOM

SYMBOL	DESCRIPTION
	TRANSFORMER
	DG SET
	MCCB/MPCB
	CONTACTOR
	ACB
	VCB
	INDICATION
27	UNDER VOLTAGE RELAY
50	INSTANTANEOUS OVER CURRENT RELAY
50N	INSTANTANEOUS EARTH FAULT RELAY
51	IDMT OVER CURRENT RELAY
51N	IDMT EARTH FAULT RELAY
86	LOCK OUT RELAY
94	ANTI PUMPING RELAY
50G	INSTANTANEOUS GROUND FAULT RELAY
80F	DC FAIL RELAY
52X	BREAKER CONTACT MULTIPLIER RELAY
95	TRIP CIRCUIT SUP, RELAY
59	OVER VOLTAGE RELAY
	SURGE ARRESTER
L1	BREAKER ON RED
L2	BREAKER OFF GREEN
L3	BREAKER TRIP AMBER
L4	SPRING CHARGED RED
L5	TRIP CIRCUIT HEALTHY
L6	BREAKER IN TEST POSITION
L7	BREAKER IN SERVICE POSITION
L8	DC FAIL
	POTENTIAL TRANSFORMER
K	ELECTRICAL & MECHANICAL INTERLOCK
LDB	LIGHTING DISTRIBUTION BOARD
MFM	MULTI FUNCTION METER
MLDB	MAIN LIGHTING DISTRIBUTION BOARD

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

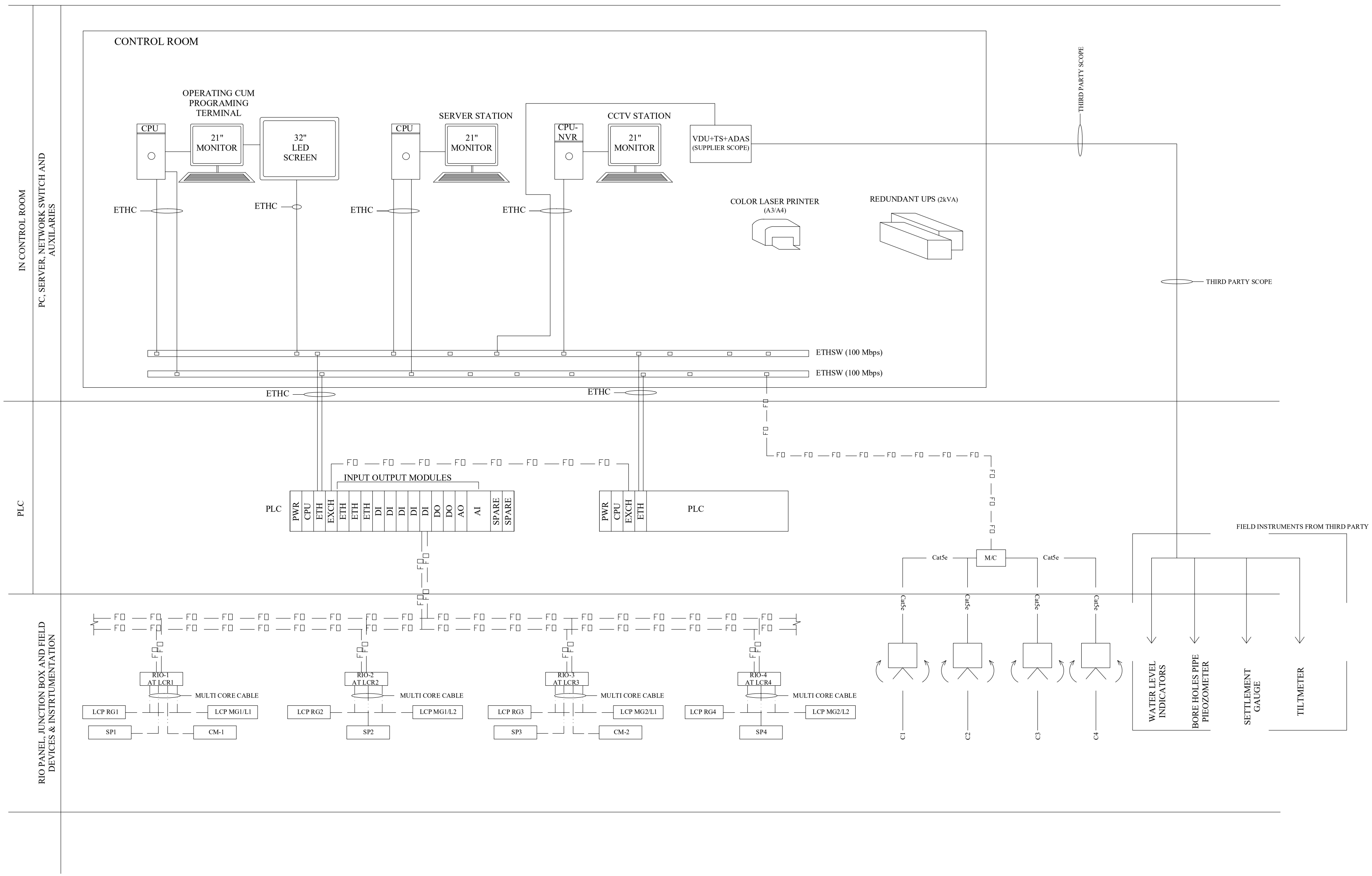
TITLE: POWER SINGLE LINE DIAGRAM OF EXISTING NAVIGATION LOCK, FARAKKA

JOB. NO.

DRG. NO. ENL011

SIZE : A0

REV.



LEGEND:-

UPS	UNINTERRUPTED POWER SUPPLY
ETHSW	ETHERNET SWITCH
PLC	PROGRAMMABLE LOGIC CONTROLLER
PWR	PLC POWER SUPPLY
CPU	PLC CENTRAL PROCESSING UNIT
EXCH	PLC MEMORY EXCHANGE WITH REDUNDANT PLC
ETH	PLC ETHERNET MODULE
DI	PLC DIGITAL INPUT MODULES
DO	PLC DIGITAL OUTPUT MODULES
SPARE	PLC SPARE I/O BASE
LCP	LOCAL CONTROL PANEL
CPU	CENTRAL PROCESSING UNIT
RG	RADIAL GATE
JB	JUNCTION BOX
MG/L	MITRE GATE/LEAF
CM	CAPSTAN MOTOR FOR CASSION GATE
SP	SUBMERSIBLE PUMP MOTOR
RIO	REMOTE INPUT OUTPUT
	CCTV CAMERA (Pan Till Zoom)
NVR	NETWORK VIDEO RECORDER
LCR	LOCAL CONTROL ROOM

CABLE LEGEND

FO	FIBRE OPTIC CABLE
	ETHERNET CABLE (ETHC)
	MULTICORE/ MULTIPAIR CABLES
Cat5e	Cat 5e ETHERNET CABLE

REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

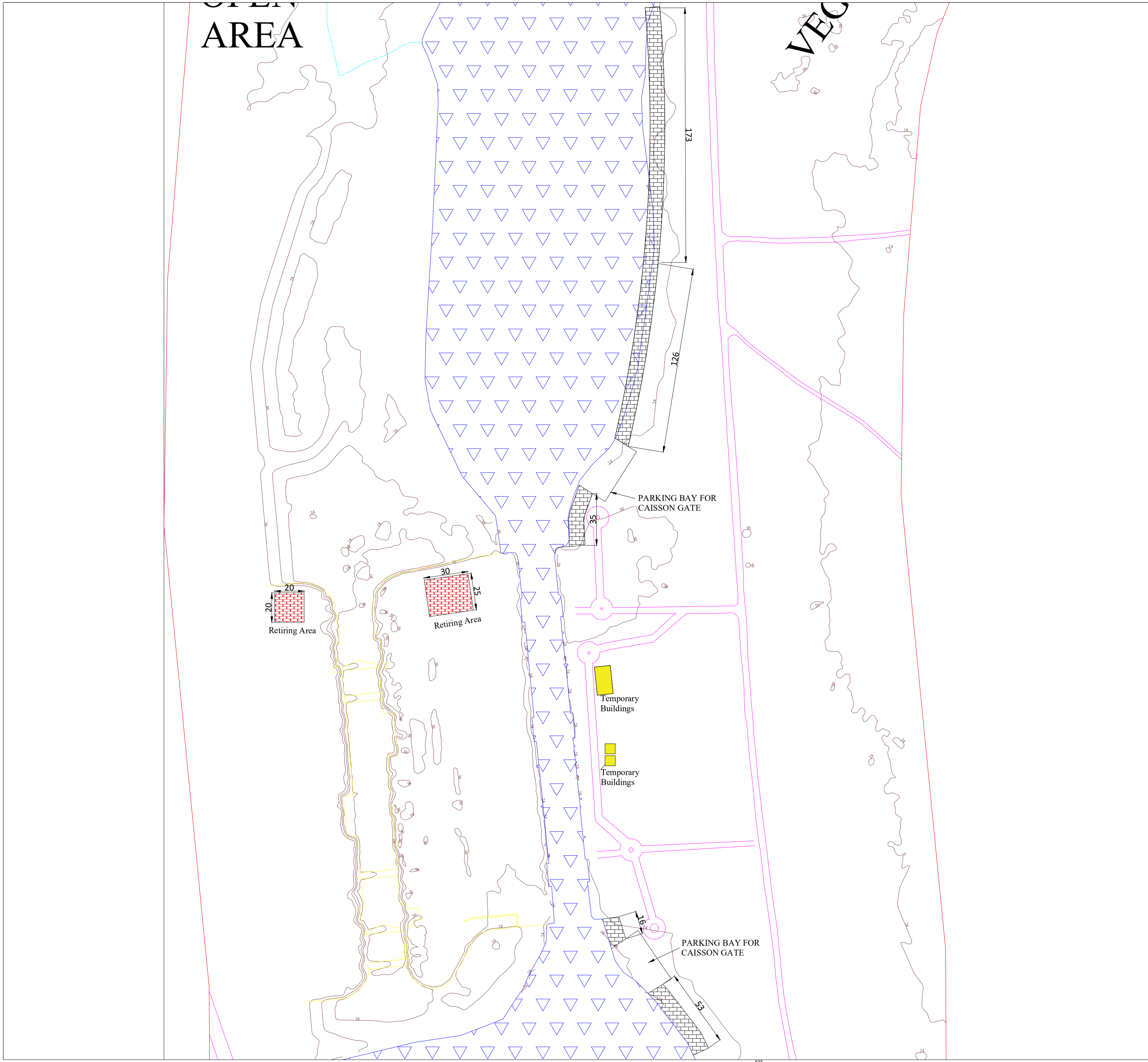
TITLE: BASIC CONTROL ARCHITECTURE OF EXISTING NAVIGATION LOCK, FARAKKA

JOB. NO.

DRG. NO. ENL012

SIZE : A0

REV.



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REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

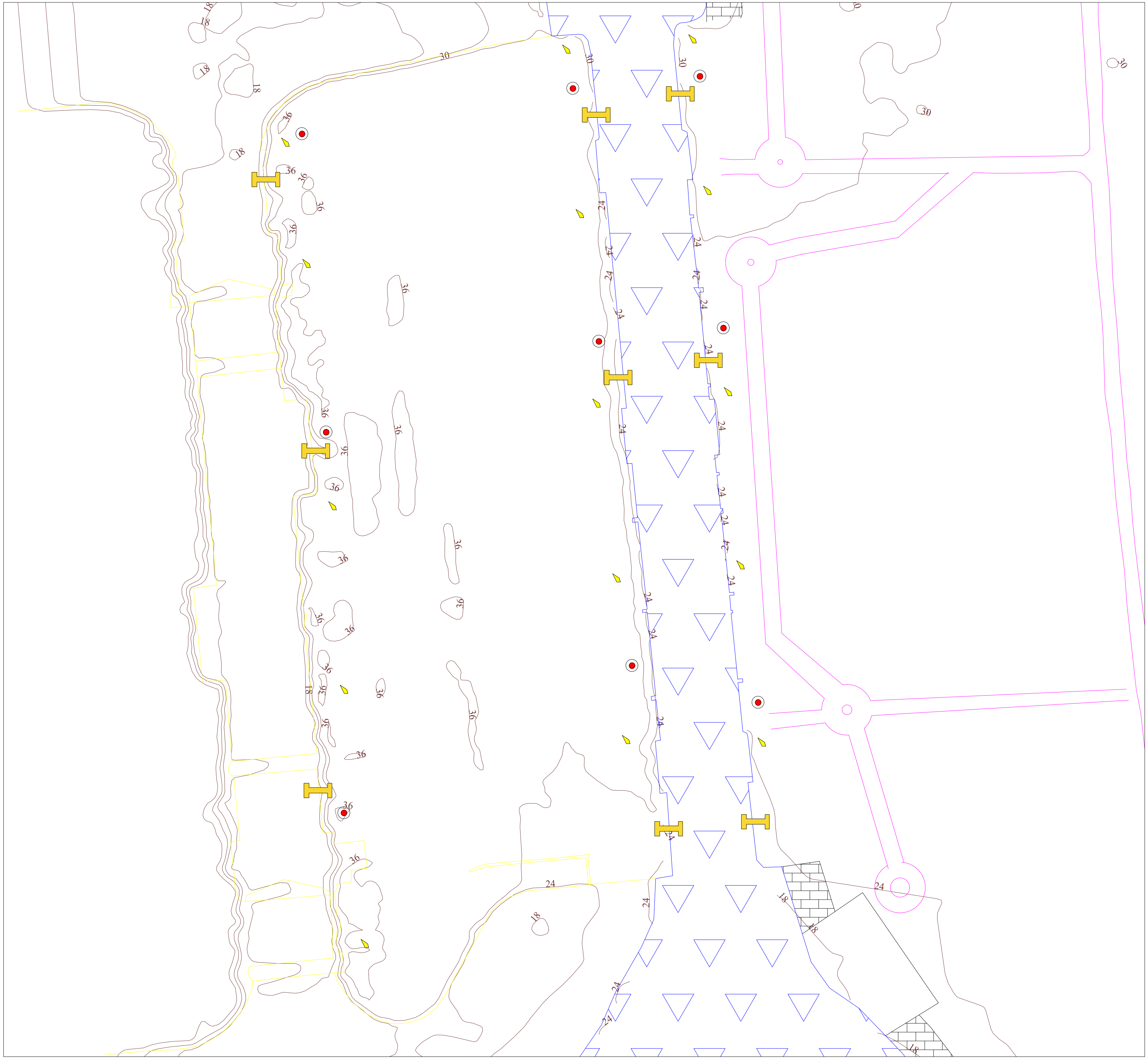
TITLE: GENERAL ARRANGEMENT DRAWING OF BANK PROTECTION, PARKING BAY, STORM WATER DRAINAGE AND ROAD, RETIRING AREA OF EXISTING NAVIGATION LOCK, FARAKKA

JOB. NO.

DRG. NO. ENL013

SIZE : A0

REV.



Legends

- Piezometer (15 N0.)
- Settlement Gauge (9 N0.)
- Inclinometer (9 No.)
- New Navigation Lock
- Contour Lines
- Roads

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REV.	DATE	DESCRIPTION	DRN	CHD	APD

INLAND WATERWAYS AUTHORITY OF INDIA

PROJECT: CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR THE WORK OF RENOVATION / MODERNIZATION OF EXISTING NAVIGATION LOCK AT FARAKKA

CONSULTANT: PKS Infra Engineers PKS FLOODKON JV

	NAME	SIGN	DATE
DRN			
CHD			
APD			

TITLE: GENERAL LOCATION PLAN FOR MONITORING INSTRUMENTATION OF EXISTING NAVIGATION LOCK, FARAKKA

JOB. NO.

DRG. NO. ENL014

SIZE : A0 REV.