REPORT

Final Detailed Project Report (DPR)

Center Cluster - Umananda

Client: Assam Inland Water Transport Development Society

Reference: DI1530-RHD-ZZ-UA-RP-Z-0010
Status: S4/P07
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Enhancing Society Together

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1 Introduction

1.1 Project Background

The Government of Assam with the assistance of funding from the International Bank for Reconstruction and Development (IBRD) is implementing the Assam Inland Water Transport Project (AIWTP). The funding pattern is such that 80% of the funding is being received from the World Bank and the remaining 20% from the Government of Assam. The main objectives of the AIWT Project are as follows.

1. Improve Passenger Ferry Infrastructure and Services in Assam.
2. Improve the Institutional Capacity and Framework for Inland Water Transport in Assam.

The key project components are as follows.

1. Institutional, regulatory and safety strengthening.
2. Ferry Infrastructure and Modernisation.
3. Improvement in terminal infrastructure.
4. Project Management Support.

Assam Inland Water Transport Development Society (AIWTDS) has been formed for management of overall infrastructural & institutional development of IWT within Assam.

Inland Waterways Authority of India (IWAI) maintains the navigational infrastructure and is currently aiming to maintain a navigable depth of 2.5m from Bangladesh Border to Neamati (629 Km), 2.0m from Neamati to Dibrugarh (139 Km) and 1.5m from Dibrugarh to Sadiya. The National Waterway-2 (NW-2) lies between Sadiya – Dhubri Stretch of Brahmaputra River (length 891 km) which was declared as NW-2 by Government of India (GoI) in 1988. The National Waterway-16(NW-16) lies between Lakhipur – Tuker Stretch of Barak River (length 152 km), which was declared as NW-16 by Government of India in 2016.

1.2 Assignment Outline

AIWTDS, as part of the AIWT Project and vide Contract no. IN-IWT-221779-CS-QCBS dated 03 November 2021 has appointed HaskoningDHV Consulting Private Limited (HDCPL) as Consultant for Preparation of Detailed Project Report (DPR) along with Engineering Design, Drawings, Tender Documents for Construction of Modular Terminal at Ferry Service of NW-2 and NW-16 in Assam (Assignment). This relates to planning and engineering for upgradation in terminal infrastructure component of the AIWT Project.

Under the AIWT Project, several IWT terminals are planned at various locations identified and shortlisted for priority development by AWITDS. These terminals are spread all along National Waterway 2 on River Brahmaputra.

The development comprises of 13 in no. terminals grouped in three main clusters as per their geographical location. Refer figure below for ferry terminal locations. The clusters and terminal locations within the clusters are listed below.

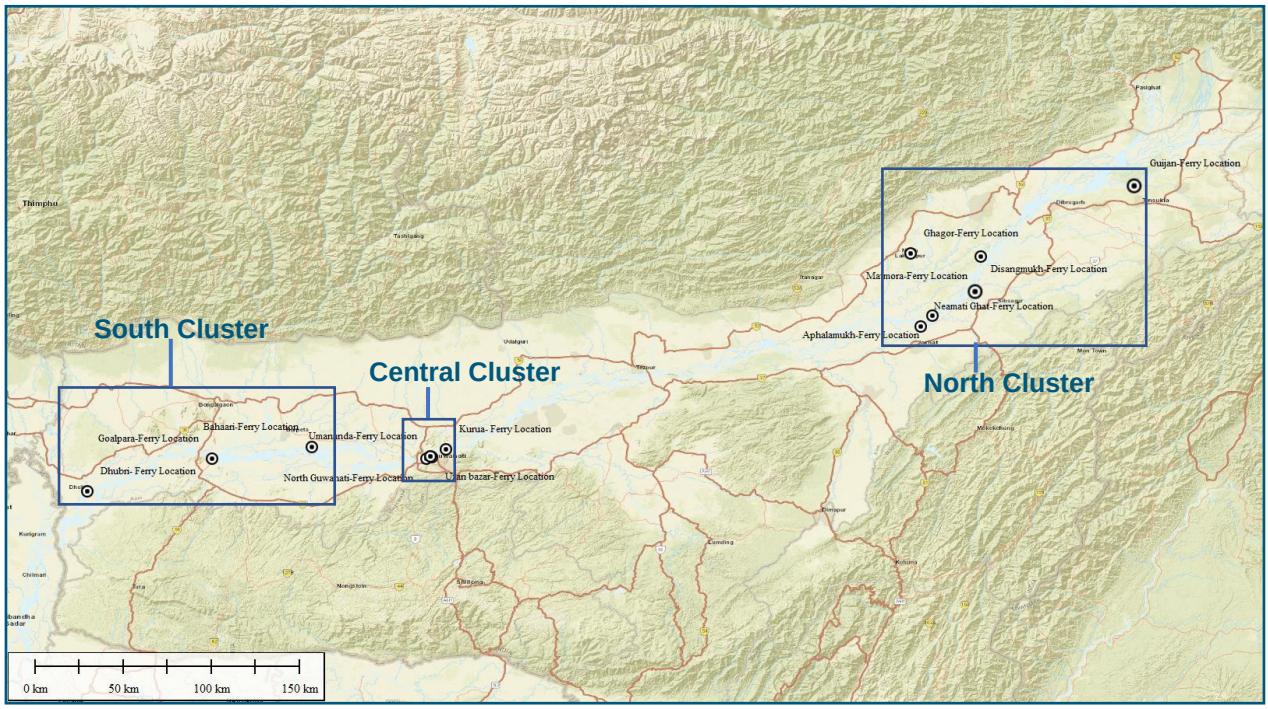


Figure 1-1: Ferry terminal locations

1. **South Cluster (3 in no. locations)**
a. Bahari
b. Dhubri
c. Goalpara

2. **Central Cluster (4 in no. locations)**
a. North Guwahati
b. Kurua
c. Umananda
d. Uzan Bazar

3. **North Cluster (6 in no. locations)**
a. Aphalamukh
b. Disangmukh
c. Matmora
d. Neamati
e. Ghagor
f. Guijan

These terminals shall be developed to cater to the transportation needs of a population cluster and shall to the extent feasible, have modular design based on local architecture style, indigenous construction practices and local construction material.

1.3 Broad Scope of the Assignment

The broad scope of this assignment shall be carried out under two tasks (Task 1 and Task 2).

Task 1 - Feasibility, Detailed Design, Engineering & Preparation of DPR

a. Data Collection.
b. Physical Surveys.
c. Model Studies.
d. Feasibility.
e. Design and Cost Estimation.
f. Implementation Schedule.
g. Financial and Economic Analysis.
h. Assessment of Environment and Social Aspects.
i. Detailed Project Report.

Task 2 - Preparation of Bid Document

This relates to preparation of tender documents, assistance during tendering, tender evaluation, and assistance during award of works contracts.

1.4 List of Deliverables

Deliverables that form part of the assignment are listed below.

1. Inception Report.
2. Physical Surveys.
3. Feasibility Report.
4. Draft Detailed Project Report.
5. Final Detailed Project Report.
6. Tender Documents.
7. Tender Evaluation Report.

1.5 Progress Made and Current Status

The Assignment is being progressed since the signing of contract, with the inception report submitted, completion of physical surveys, and feasibility report submitted.

Further, the detailed project report has been finalised and is being submitted as part of this report/submission. Also the tender documents have been finalised and submitted under separate cover.

1.6 Organization of Detailed Project Report

As per the Terms of Reference (ToR) for the above assignment, a detailed project report is to be submitted. This detailed project report is being submitted in accordance with the requirements of the ToR and is organised in the following sections.

Section 1 Introduction
Section 2 Data Collection
Section 3 Site Conditions
Section 4 Hydrology, Morphology and Mathematical Model Study

2 Data Collection

2.1 General

Data collection is required from various agencies and data sources for undertaking the assignment. Data is essential for assessment of site conditions, appreciation of existing terminal operations and forms the basis for undertaking physical surveys, model studies, planning and design of terminal infrastructure.

Data collection is aimed at receiving the following information.

1. Traffic volumes and growth rate for the proposed terminals.
2. Type, range, and size of vessels operating at the proposed terminals and plan for future.
3. Existing navigational route maps for the proposed terminals.
4. Details pertaining to existing terminal infrastructure for the proposed terminals.
5. Existing land use maps and future land use plans for the proposed terminals.
6. Earlier surveys, investigations, studies, and reports undertaken for the proposed terminals.
7. Hydrometeorological data such as water levels, discharge, velocity, sediment volume.
8. Information and details of the Thalweg Line at the proposed terminals.

Relevant correspondence for the data collected as part of the assignment is placed under **Appendix A** and can be referred for further details.

2.2 Hydrometeorological Data

Model studies have been undertaken considering a range of inputs, out of which river cross-section, discharge, water level, sediment, velocity, manning's n data from CWC HO sites/ stations in the basin is the prime input. The efficiency of these model studies largely depends upon the frequency and resolution of the input data. Key outcome from the model studies includes information on water levels, velocity, sedimentation, erosion, accretion or both specific to the proposed terminals.

The Chief Engineer, Brahmaputra and Barak Basin Organisation, Central Water Commission (CWC) at Guwahati has been requested for release of hydro-meteorological data of the Brahmaputra basin for model studies to be undertaken for examining the hydrodynamic, sediment transport, and morphological aspects of rivers in the Brahmaputra basin.

The data received has been analysed to supplement the approach agreed during meetings held with AIWTDS for progressing the assignment. The outcome of river modelling is outlined under section 4 of this report.

Relevant correspondence for the data collected is placed under **Appendix A** and can be referred for further details.

2.3 Information and Details of Thalweg Line

The information and details of Thalweg line at the proposed terminal is a regulatory requirement. The same is important to understand the extent of riverside infrastructure and effect on the riverbank due to proximity.

The Director, Inland Waterways Authority of India (IWAI) at Guwahati has been requested for release of information and details of the thalweg line at the proposed terminals. The information has been received in the form of paper copies and had to be analysed for incorporation in the base site plans. The quality of the

information received necessitated approximations to be made for digitising the information on the base site plans and subsequent use.

Relevant correspondence for the data collected is placed under **Appendix A** and can be referred for further details.

2.4 Traffic and Vessel Data

Data on traffic and vessel is required for estimating the facility requirements, planning the terminal infrastructure and to carry out the subsequent studies. The data received is summarised below.

1. Division wise traffic data for 2014-15. 2015-16, 2016-17, 2017-18
2. Data on vessels under Directorate of IWT, Assam as on 30 May 2017
3. Further data on traffic for 2018-19, 2019-20, 2020-21
4. Updated data on vessels

The review of data received is outlined under sections 5 and section 6 of this report. Relevant correspondence for the data collected is placed under **Appendix A** and can be referred for further details.

2.5 Earlier Studies and Reports

Earlier studies, reports and information made available by AIWTDS is listed below.

1. Detailed Project Report for various locations including Neamati dated February 2021 and prepared by M/s Tractabel for IWAI was collected as part of the site visits.
2. Detailed Project Report of North Guwahati dated September 2019 and prepared by M/s Tractabel for IWT, Assam.
3. Detailed Project Report of Aphalamukh dated February 2020 and prepared by M/s Tractabel for IWT, Assam.
4. Information on Thalweg line for locations under the Guwahati cluster except Kurua However, the information received was of poor quality and could not be relied upon.
5. Minimum water levels for the period 2000-2020 at Pandu and DC Court Guwahati.

Integrated Strategic Development Plan, Final Report Module 4, Feasibility Assessment for Pre-identified IWT Infrastructure dated August 2019 and prepared by M/s Inros Lackner and Development Design Consultants for IWT, Assam.

The earlier studies and DPR was reviewed to assess if the data available therein is adequate for design finalisation and subsequent work, such that DPR preparation under this assignment could be prioritised. However, the review concluded that the data available is useful to a limited extent only. The outcome of the review is documented in the Inception Report and can be referred for further details.

2.6 Land Records

Information on existing land use and ownership at the location of the proposed terminals was not available. A communication to AIWTDS for requesting the Office of Director of Land Records and Surveys, Guwahati for information and details regarding ownership of land at the location of the proposed terminals was sent and subsequently followed up through another communication. AIWTDS has since sent the request to the Office of Director of Land Records and Surveys, Subsequently, letters have also been issued to the District Administration and Circle Officers to provide the requisite data on land records. Relevant correspondence is placed under **Appendix A** and can be referred for further details.

A communication has now been received from the Circle Officer informing that there is no land record available in the Circle Office. The same is placed under **Appendix B** and can be referred for further details.

3 Site Conditions

3.1 Site Appreciation

Several visits have been taken place to the location of the proposed terminals. Some of the key observations made during these site visits are outlined below.

1. Type and size of vessels operating vary across locations. During the visits it was observed that small to medium size vessels are operating at most locations.
2. Ferry operations, frequency and routes are governed by the needs of the local public.
3. The main requirement of the local public is to cross the river from one bank to the other.
4. Absence of all-weather operations based on local knowledge.
5. Absence of integrated time schedule and ticketing between locations.
6. Traffic comprises of passengers, passengers, and 2-wheelers at most locations except some locations such as Nemati for example where the traffic comprises of 4-wheelers as well as cargo parcels in addition.
7. Water level variation between high and low flows is in the range of 8-10m.
8. Mix of gentle and steep slope across locations.
9. Significant variation in slope width across locations.
10. Local scour anticipated at most locations.
11. Bank protection measures will have to be implemented for locations prone to erosion.
12. Scale of facilities is basic at most locations and temporary in nature.
13. HFL and LFL is not demarcated at most locations. Local ferry operators make temporary arrangement like building an access road/ bridge using bamboos to the ferry during LFL.
14. Landside facilities and amenities not available at most locations.
15. The ownership of land varies across locations and reliable information on this will need to be gathered to assess land availability and acquisition.
16. Transport linkages and availability of public utilities (water and power supply) varies across locations.

The site appreciation of the subject terminal location is outlined in the table below.

Table 3-1 Terminal Site detailed information

SL. No.	Description	Umananda
1	Existing IWT Landing	Yes
2	Composition of Traffic	Passenger
3	Vessel	Catamaran
4	Origin and Destination	Uzan Bazar
5	Morphology of the Bank	Stable
6	Scale of Facilities	Basic and temporary in nature
7	Waiting Area and Ticket Counter	Catered on the Floating Pontoon
8	Nature of Adjoining Land	Island with Temple
9	Ownership of Adjoining Land	Government
10	Road Connectivity	-
11	Proximity to Transport Linkage	Island so not applicable

These observations shall be considered to assess the existing need, existing operations, site conditions and functional requirements of the subject terminal location

3.2 Site location

Umananda Island is the smallest inhabited river islet in the middle of river Brahmaputra, flowing through the city of Guwahati in Assam. The location is opposite the office of the Deputy Commissioner of Kamrup in Guwahati, Assam. The passenger vessels plying from the banks of the Brahmaputra to the island.

Figure 3-1: Proposed site location- Umananda island

3.3 Site Surveys

Physical surveys under the assignment comprises of hydrographic surveys, topographic surveys, and geotechnical investigations. On 26 November 2022, HDCPL appointed M/s Fargo Consultants Pvt Ltd (FCPL) as the specialist agency to carry out the physical surveys. FCPL is a local agency and has the experience of working on similar assignments in the Brahmaputra River.

These surveys commenced in early December 2021 and were undertaken at all thirteen (13) locations identified for the smaller terminals. The same were completed on March 2022.

The location for undertaking the physical surveys at each terminal was identified as an outcome of the joint site visit and the coordinates of the location for undertaking the surveys are tabulated below.

Table 3-2 Physical Survey Location and Coordinates

S. No.	Terminal Location	Latitude	Longitude
1	Umananda	26° 11' 46.12" N	91° 44' 42.73" E

Hydrographic and Topographic survey work consisted of recording spot levels at a spacing of 10m in orthogonal directions or at closer intervals where required for a length general covering approximately 2,000m along the bank. Major equipment used for undertaking the above surveys at site included DGPS, Electronic Total Stations, Multi Beam Echo Sounders, Auto Levels etc.

Selected images of physical surveys undertaken at various site locations are presented below.

Figure 3-2 Survey and site investigation

Following summarises the details of benchmark references made at site and observed high flood level at respective terminal locations.

Table 3-3 Summary of location wise reference benchmarks and high flood levels observed during physical surveys

Location	Cluster	Summary of Benchmark and High flood levels
Umananda	Central Cluster	Reference elevation (51.081m) is obtained from PB12CP point of PWD office. HFL is observed to be 48.380m

3.3.1 Scope of survey works

The following scope of survey was envisaged, including but not limited to the:

Table 3-4 Scope of survey works

Survey	Grid	Area	Equipment
Hydrography	10 x 10 m	-1 km upstream and downstream - River Bank Line* + 100 m (into the river	Multi beam echo sounder/ Single beam echo sounder
Topography	10 x 10 m	-1 km upstream and downstream - River bank Line*+ 300 m (into land)	Total Station survey

3.3.1.1 Scope to Execute Topography Survey

The scope of work comprised of conducting topographical survey using Total Station of two seconds accuracy and prepare Plans (Maps) on a suitable scale by taking all physical features like existing trees, railway line, buildings, boundary wall, temples, well, canal, pipeline, roads (pucca and kuccha) etc. The spacing between two spot levels was limited to 10.0 m over area. The Level Survey was used to generate the following:

a) Location, layout, and levels of all existing structures shall be presented
b) Spot levels at locations over area at an interval not exceeding 5 m.
c) Contour maps at site.

The grids for the survey work shall be established in N-S & EW direction (Corresponding to magnetic North) and the survey reference was spheroid WGS 84 (d) Carrying out the Benchmark (GTS/any other reference government Benchmark) to site/sites by double levelling, establishing, and marking benchmarks on existing structures in the field over the entire survey area.

3.3.1.2 Scope to Execute Bathymetry Survey

The scope of work at the proposed location comprised of Spot levels recorded for approximately 10 m interval in orthogonal directions. Spot levels shall be recorded for an area 1.0 km upstream and 1.0 km downstream of the selected location for a width of 100m. In locations where the depth of water is less than 1.50 m the bed levels will be recorded using a total station. Coordinates and depth measurements will be recorded using an echo sounder. The bathymetry survey also comprised of few points mentioned below.

a) Establishing at least reference points (permanent objects), to fix level and position in relation to standard references. The reference points were referenced to suitable permanent structures in the vicinity.
b) Survey to be carried out using necessary survey equipment properly connected to Differential Global Positioning equipment with a minimum of 12 channels.
c) Echo sounding (bathymetry) of the survey area to be carried out along the length of the river covering the cross-section of 100m or width of the river.

3.3.2 Topographic Survey

Adequate pair of control points were established using DGPS at suitable locations near the river edge parallel to the river embankment. Height control traverse will be run by connecting the local BM as provided by the department or available GTS Benchmark. A loop has been run over the control points and the circuit shall be closed to find out the closing error which shall be balanced, and the error distributed as per standard practice. On completion of the level traverse temporary Benchmarks will be kept for further detailing in height distribution and digital terrain modelling of the entire study area.

Detailed topographical survey of all the ground features man made features and natural features like houses, rivers/nallahs/drains, power lines, telephone lines, electric lines with posts were recorded.

Table 3-5 List of Instruments used in Topographic Survey

Equipment	Model	Accuracy
DGPS	Sokkia GRX1	Static: L1 + L2 band H: 3mm + 0.5ppm V: 5mm + 0.5ppm
Electronic Total Station	Sokkia 620	Distance measurement: (2+2ppmXD) mm Angle measurement: 6” Minimum display: 1”
Auto Level	Sokkia C330	Levelling Accuracy: 2.0mm for 1Km double run levelling

The survey covered the control points, and all topographical features as follows:

- Buildings, hutments, sheds, structures
- Boundary features (if existing)
- Roads, tracks, footpaths etc.
- Drains (Kaccha/pucca)
- Religious structures
- Trestles, pylons, poles of electric and telephone lines
- Optical fibre cable, water pipeline
- Individual solitary trees having girth 30cms and above.
- Cluster of trees, plantation area, forest area and their limits
- Agricultural land, barren land etc.
- Water bodies
- Rivers, streams, nallahs, reservoirs and their extent
- Bridges, culverts with their dimensions
- Limit of survey

Table 3-6 Benchmark Value and Description

Sl. No.	Proposed Site	Benchmark (BM) MSL Value (m)	Description	Approximate Coordinates (m)
1	Umananda	51.081	PWD Pillar (with PB12CP marking) near bridge construction at N. Guwahati	E:372830, N:2895450

Note: All locations are in Zone 46R except Dhubri which is Zone 45R

3.3.3 Hydrographic Survey

The bathymetry survey for proposed location is carried out to understand the riverbed profile and do the further planning accordingly.

Hydrographic survey has been comprised of the below mentioned points

a) Establishing at least reference points (permanent objects), to fix level and position in relation to standard references. The reference points were referenced to suitable permanent structures in the vicinity.
b) Survey was carried out using necessary survey equipment properly connected to Differential Global Positioning equipment with a minimum of 12 channels.
c) Echo sounding (bathymetry) of the survey area was carried out along the length of the river covering the cross-section of 100m or width of the river.

Table 3-7 List of Instruments used in Bathymetric Survey

Equipment	Model	Accuracy
DGPS	Sokkia GRX1	Static: L1 + L2 band H: 3mm + 0.5ppm V: 5mm + 0.5ppm
Electronic Total Station	Sokkia 620 Sokkia 520	Distance measurement: (2+2ppmXD) mm Angle measurement: 6”/5”/ Minimum display: 1”
Auto Level	Sokkia C330	Levelling Accuracy: 2.0mm for 1Km double run levelling
Echo Sounder	GPSMAP 585	Dual beam Vertical accuracy: 0.1m

Table 3-8 Reference Point Details

Sl. No.	Location	Field Marking	Easting (m)	Northing (m)	Elevation (m)
1	Umananda	C-2	374674.803	2898033.826	46.393
		C-3	374570.276	2897988.503	43.256
		C-4	374605.113	2898024.527	60.754

The HFL, LWL and average riverbed levels at the proposed site location are extracted from the survey. HFL level estimated as +48.38 m whereas LWL as + 41.55 m. Riverbed profile illustrates sudden steep or changes in contour significantly from +48 m to +41 m. On the landside part of the island, the maximum level recorded as +74 m. Presence of sandbar is recorded about 350 m away from the terminal close to Uzan Bazar Ferry Terminal.

Table 3-9 Summary of Topography & Bathymetry Survey

Location	LWL (m)	HFL (m)	River side Elevations (m)			Land Side Elevations (m)			Access Road Details
			Max	Min	Average	Max	Min	Average	
Umananda	41.55	48.38	42.554	22.050	34.061	74.843	41.440	59.583	0.7km to Uzan Bazar Ferry

The HFL data was established on ground after due deliberations with the representatives from the temple trust and locals staying along the banks of Brahmaputra River. *LWL is the observed water edge during survey. As no historical data is available for Umananda, the observed water edge will be considered as LWL.*

3.4 Geotechnical Investigation

As mentioned in Feasibility report, geotechnical investigation were conducted, one borehole for land and one borehole for river front was explored. Present document emphasises on the geotechnical investigation works conducted especially at Umananda terminal location only.

3.4.1 Ground Investigation Strategy

The main purpose behind conducting geotechnical investigations is to ascertain the subsoil conditions at the proposed site which is essential for the foundation and structural design purpose. Following are broad objectives of the soil investigations:

- To study geological parameters of soil/rock at the proposed borehole locations
- To assess the engineering parameters and to estimate bearing capacity of soil.
- Derive engineering parameters for design of piles for modular berthing structures.
- Assess soil strength parameters for slope assessment of proposed embankments.
- Design of foundation for supporting facilities such as terminal complex, food courts, ticketing counters etc.

3.4.2 Scope and Execution of the Investigation

The land boreholes are proposed to explore a maximum depth of 50m below existing ground level. Waterfront boreholes were explored to a maximum depth of 80m, as required based on our preliminary assessment of the site conditions.

The following works were carried out as part of the geotechnical investigation campaign:

Exploratory boreholes:

1 Nos. of land-based boreholes and 1 nos. of river-based boreholes were explored combined with SPT followed by rotary coring (triple tube core barrel), where the penetration refused. Exploration of all these boreholes were in the range of 15-21 m below ground / riverbed level.

In-situ Field Tests:

In-situ Standard Penetration Tests (SPT).

Geotechnical Laboratory tests:

Laboratory tests were conducted on soil and rock samples taken from the boreholes. The tests included the following:

Particle Size Distribution Tests.
Atterberg Limit Tests.
Specific gravity & Natural Moisture content test.
Uniaxial Compressive Strength and triaxial Test (UU & CU) on UDS samples.
Direct shear test & Consolidation test.
Point Load index & Uniaxial Compressive Strength test on rock samples.
Density, porosity, moisture content of rock samples.
Chemical Analysis of the soil and water samples.

The detailed geotechnical investigations were completed by M/s M/s Fargo Consultants Pvt Ltd in March 2022.

3.4.3 Ground Conditions

The following sequences of deposits/ solid geology were encountered during the ground investigation as shown on the borehole logs. Table 3-10 and Table 3-11 Summary of soil and rock layers observed for Umananda river borehole

Depth		Soil Description	Thickness (m)
From (m)	To (m)		
0.0	1.0	Silty fine sand	1.0
1.0	9.0	Completely weathered to highly weathered rock	8.0
9.0	21.00	Slightly weathered to fresh rock	12.0

indicates the presence of various types of soil layers encountered in both land and river boreholes respectively. Further, these layers are sub-categorised in different layers based on SPT-N values.

Table 3-10 Summary of soil and rock layers observed for Umananda land borehole

Depth		Soil Description	Thickness (m)
From (m)	To (m)		
0.0	1.5	Silty fine sand	1.5
1.5	4.5	Completely weathered to highly weathered rock	3.0
4.5	15.50	Moderately weathered to fresh rock	11

Table 3-11 Summary of soil and rock layers observed for Umananda river borehole

Depth		Soil Description	Thickness (m)
From (m)	To (m)		
0.0	1.0	Silty fine sand	1.0
1.0	9.0	Completely weathered to highly weathered rock	8.0
9.0	21.00	Slightly weathered to fresh rock	12.0

3.4.4 Evaluation of the Geotechnical Information

As reported in feasibility studies, considering the extent of project locations and geology of subsoil strata, terminal locations are subdivided into 3 clusters namely North Side Cluster on upstream side, then Central cluster followed by southern cluster on downstream side. Figure 3-3 shows the divided clusters of ferry terminal locations along the river flow direction. Umananda project site falls into central cluster as per geological location.

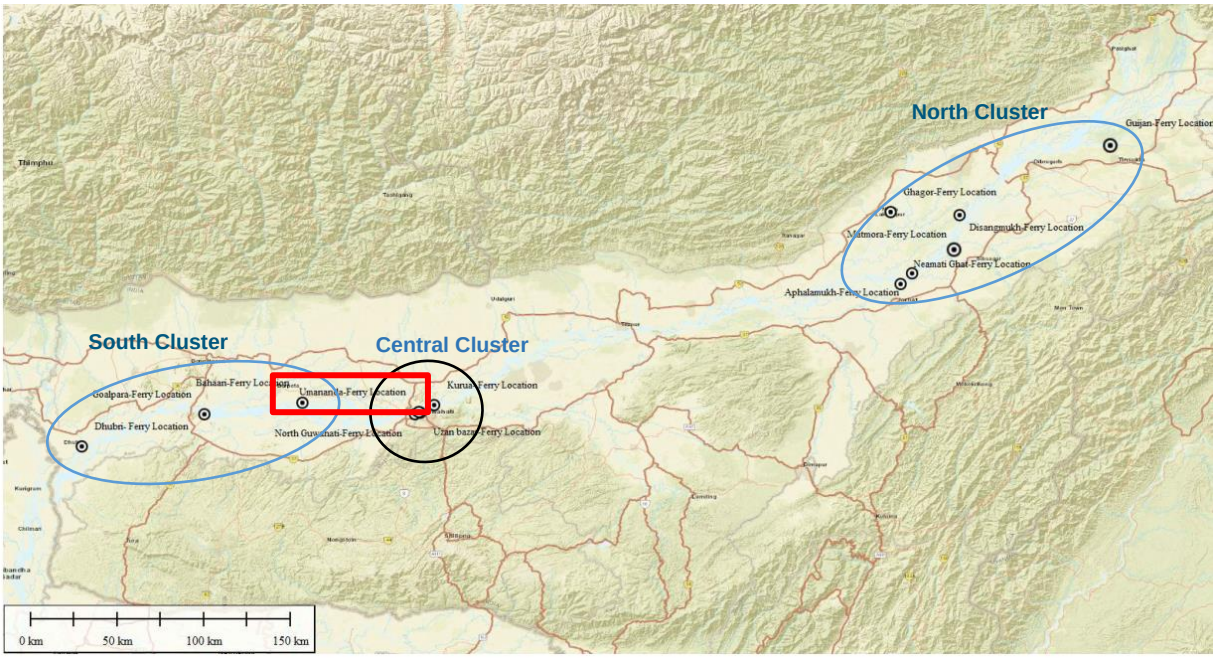


Figure 3-3: Umananda ferry terminal location with respective to cluster diversification

3.4.4.1 Landside Ground Conditions

Based on the topographic survey information, ground surface along the proposed jetty location is varying between +23m in the river to +74m at the landside. As seen in LBH-1 the ground level is +44.502m.

The following soil geology were encountered during the ground investigation as shown on the borehole logs. The soil/ rock deposits encountered have been grouped into different soil/ rock units.

Table 3-12 summary of soil layers w.r.t. LBH-1

Unit	Description	Depth below GL, m	Unit Weight (kN/m^3)	**Cohesion (kPa)	*Phi
Soil Unit 1	Not encountered	-	-	-	-
Soil Unit 2	Loose silty SAND	0 – 1.5	18.0	-	29
Rock Unit 1	Completely weathered Granite ROCK	1.5 to 15.5	20.0	200	38

**Friction angle is derived from IS 6403 based on SPT N values*
**Core material for slope stability assessment is considered with friction angle ~ 40 degrees, unit wt. ~21 kN/m^3.*
***Cohesion of Weathered granite rock is considered to be 200 kPa for conservative approach even though minimum UCS observed is ~ 13 MPa*

Variation of SPT N value, particle size distribution along the explored depth is presented in the following Figure 3-4.

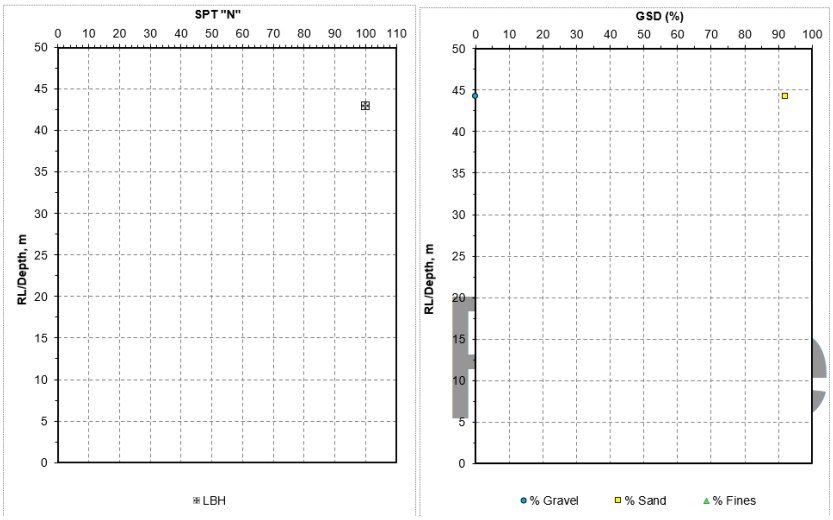


Figure 3-4: Plot showing variation of SPT N, particle size distribution along exploration depth of land borehole

3.4.4.2 Riverside Ground Conditions

Based on the topographic survey information, ground surface along the proposed jetty location is varying between +23m in the river to +74m at the landside. As seen in RBH-2 the ground level is +33.506m.

The following soil geology were encountered during the ground investigation as shown on the borehole logs. The soil/ rock deposits encountered have been grouped into different soil/ rock units.

Table 3-13: summary of soil layers w.r.t. RBH-2

Unit	Description	Depth below GL, m	Unit Weight (kN/m^3)	**Cohesion (kPa)	*Phi
Soil Unit 1	Not encountered	-	-	-	-
Soil Unit 2	Loose silty SAND	0 – 1	18.0	-	29
Rock Unit 1	Completely weathered Granite ROCK	1.5 to 21	20.0	200	38

**Friction angle is derived from IS 6403 based on SPT N values*
**Core material for slope stability assessment is considered with friction angle ~ 40 degrees, unit wt. ~21 kN/m^3.*
***Cohesion of Weathered granite rock is considered to be 200 kPa for conservative approach even though minimum UCS observed is ~ 13 MPa*

Variation of SPT N value, particle size distribution along the explored depth is presented in the following Figure 3-5.

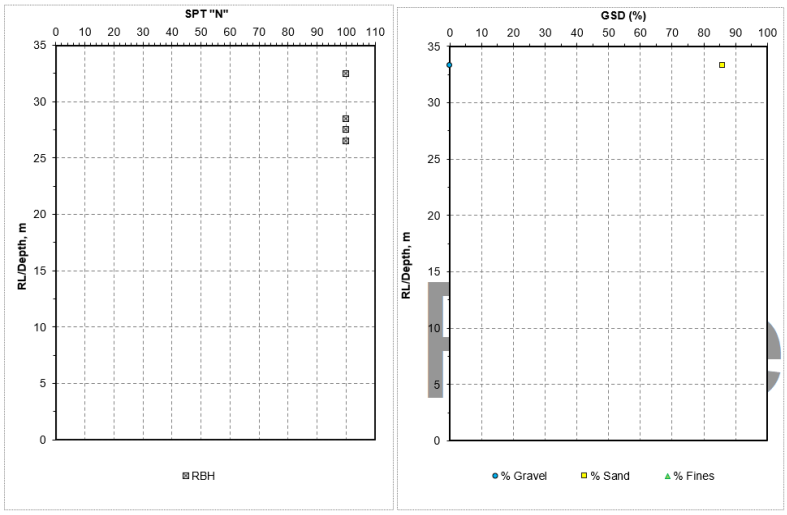


Figure 3-5: Plot showing variation of SPT N, particle size distribution along exploration depth of river borehole

3.4.4.3 Seismic Parameters

As per the IS 1893 (Part 1): 2016, the entire Indian region has been divided into four seismic zones namely zone II, zone III, zone IV and zone V. The intensities of zone II, III, IV and V are low, moderate, severe, and very severe respectively. These seismic zones are based on the frequencies of previous earthquakes in various parts of India. From the seismic map, it is observed that the Umananda area falls in the active seismic zone as per IS 1893 (Zone V).

In line with IS 1893:1984, horizontal seismic co-efficient is calculated as 0.12. The vertical seismic co-efficient is taken half of the horizontal seismic co-efficient. Therefore, the vertical seismic co-efficient is calculated as 0.06.

3.5 Existing Land Information

The existing land information based on site visits, physical surveys, and feedback from AIWTDS is presented in the table below.

Table 3-14 Existing Land Ownership

S. No.	Terminal Location	Ownership
1	Umananda	Government Land

It is essential to obtain reliable information and details regarding ownership of land at the location of the proposed terminals for confirming land availability and/ or land acquisition.

A communication has now been received from the Circle Officer informing that there is no land record available in the Circle Office. The same is placed under Appendix B and can be referred for further details

3.6 Existing Connectivity

Guwahati Ropeway is the longest river ropeway of India with a length of 1.82 kilometres. The tower T3 is provided on the island. However, there is no provision in ropeway for passengers to reach to the Umananda

island. Further, the Island can be only accessed from Guwahati and North Guwahati by ferries and steamers. At present, Inland Water Transport, which connects the island to Guwahati from Uzan Bazar Ferry Ghat

3.7 External Utilities

The terminal location does not have external or municipal utility connections for power supply, water supply and sewerage.

4 Hydrology, Morphology and Mathematical Model Study

4.1 Introduction

Modelling studies are conducted to understand the erosion and accretion pattern of the rivers for the purpose of designing the ferry terminals. shows the location of proposed ferry terminals on the Brahmaputra River and its tributary. Table 4-1 shows the distance between terminal sites

The approach adopted to conduct the modelling studies and the list of activities being carried out as part of modelling is as follows.

1. Desk study of the area.
2. List of data to be collected.
3. Data collection and processing.
4. Data analysis.
5. Develop modelling scenarios and carry out modelling.
6. Analysis of model results.
7. Preparation of report.

4.2 Objective of Modelling

The following are the objectives of modelling.

1. To carry out hydrological and morphological modelling by using all the data set collected to assess the potential effects with respect to erosion and accretion patterns.
2. The modelling to be carried out for various scenarios considering high and low flow rates.
3. The frequency and intensity of extreme events and their effects to be studied as part of modelling.
4. To carry out hydrological and morphological modelling.

Table 4-1: Distance between terminal sites

From	To	Approximate aerial distance (km)
Guijan	Matmora	94.00
Matmora	Disangmukh	9.75
Matmora	Ghagor	32.69
Disangmukh	Aphalamukh	27.60
Aphalamukh	Neamati	8.36
Neamati	Kurua	251.26
Kurua	Uzan Bazar	7.17
Uzan Bazar	Umananda	1.50
Umananda	North Guwahati	0.70
Bahari	Goalpara	50.00
Goalpara	Dhubri	66.53

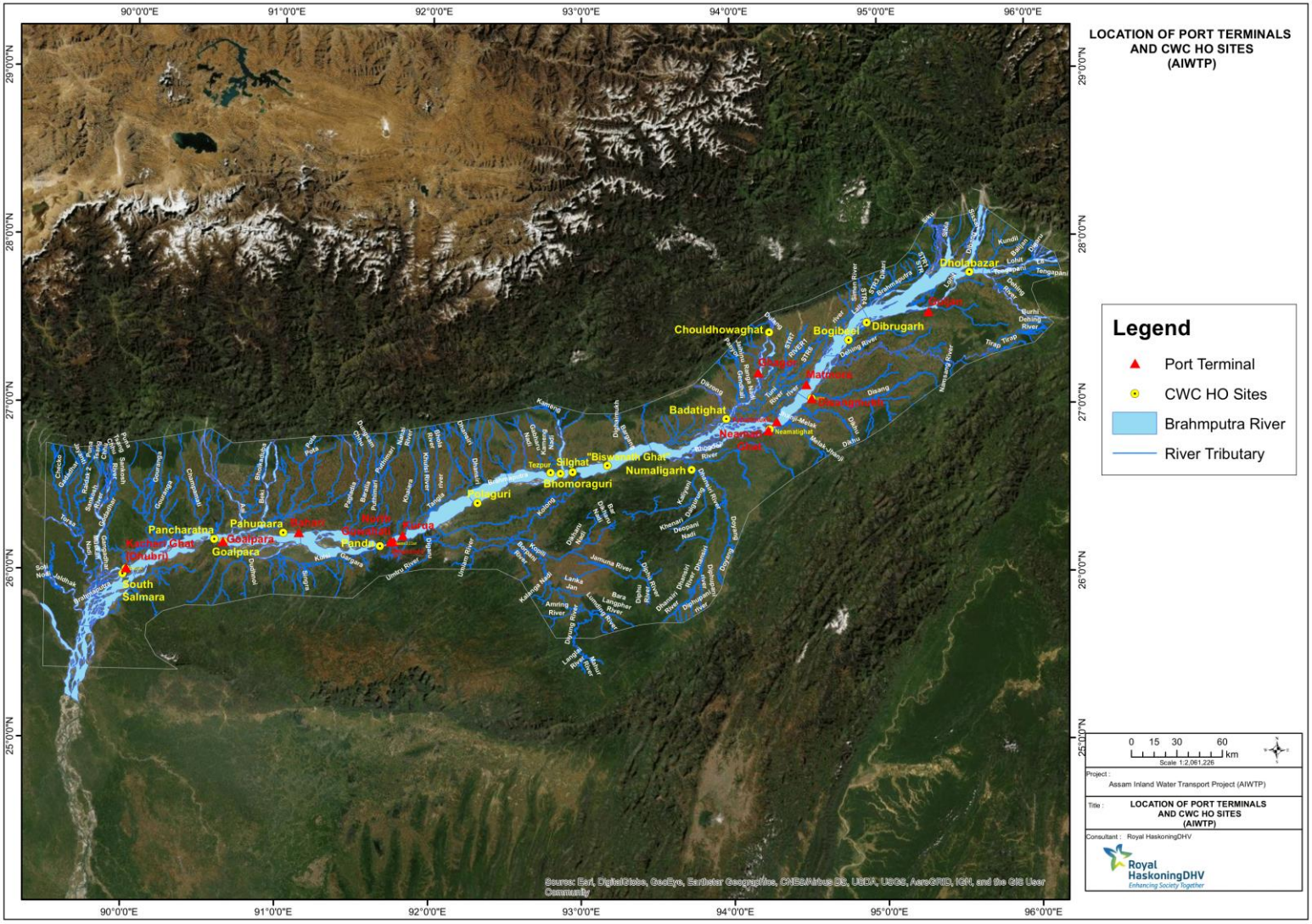


Figure 4-1 HO (CWC) Sites and Proposed Ferry Terminals

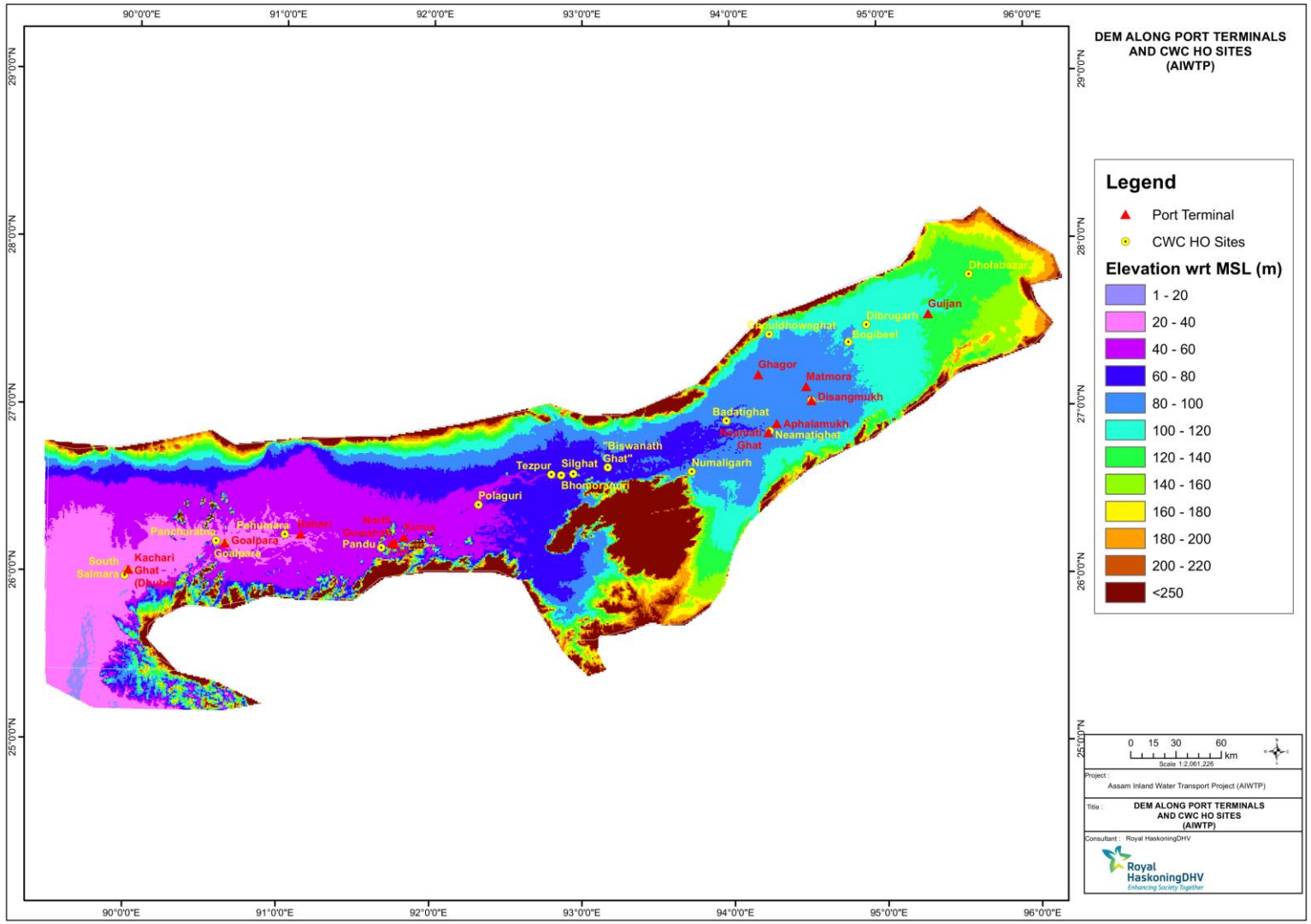


Figure 4-2 Digital Elevation Model (SRTM) showing elevation profile of river and superimposed HO sites (CWC) along with proposed ferry terminal locations

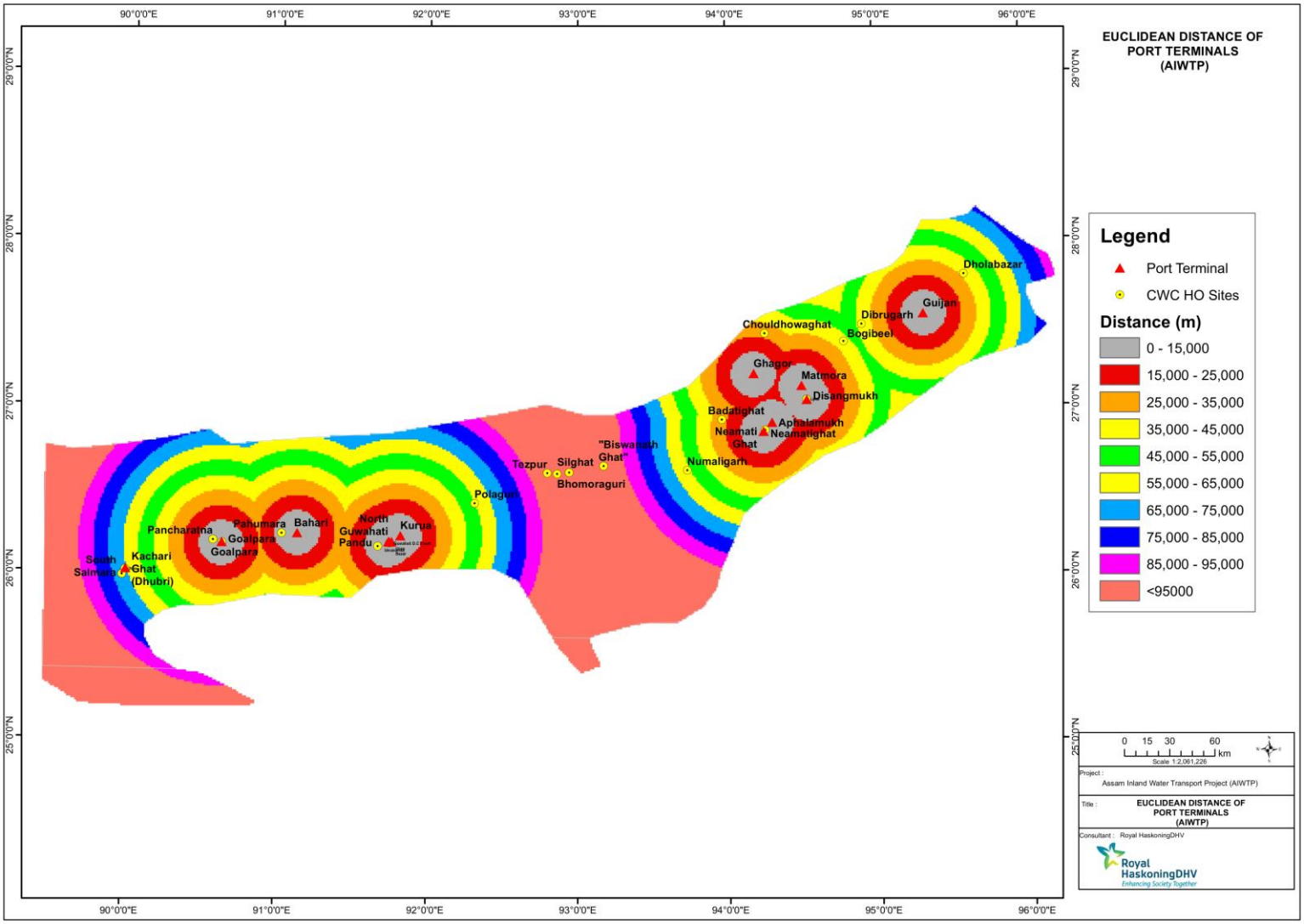


Figure 4-3 Euclidean distance of proposed ferry terminal location

4.3 Brief description of Brahmaputra

Brahmaputra basin forms a part of the major water division 'the rivers draining into Bay of Bengal'. Based upon the drainage outlet it is further included under the 'Brahmaputra drainage' water resources region.

The mighty Brahmaputra River originates in the great glacier mass north from Kailash ranges of Himalayas at an elevation of 5,150 m just south of the lake called 'Konggyu Tsho'. The Brahmaputra River traverses 2,900 km, through four countries, namely Tibet (China), Bhutan, India, and Bangladesh, before joining the Bay of Bengal. It has an average annual discharge of 19,820 cumecs, an average annual sediment load of 735 million metric tonnes, and a specific flood discharge of 0.149 cumecs/ sq.km.

Brahmaputra basin spreads over 580,000 sq.km which covers China (50.5%), India (33.6%), Bangladesh (8.1%) and Bhutan (7.8%). Although the main river does not flow through the Kingdom of Bhutan, 96% of Bhutan's area falls under this basin. The basin is of irregular shape; the maximum east-west length is 1,540 km and the maximum north-south width is 682 km.

There are 27-gauge sites, 5-gauge discharge sites, 40-gauge quality sites, 14-gauge discharge quality sites, 10-gauge discharge sediment sites, and 18-gauge discharge sediment quality sites in the basin which are maintained by Central Water Commission (CWC) for the study of hydro-meteorological observations (Source: INDIA WRIS).

In the Tractabel DPR Vol-I: Main Document "Consultancy services for preparation of DPR for development of Ro-Ro routes in NW-2 in Assam", 100-year return period flow of 63,000 cumecs is estimated at Pandu.

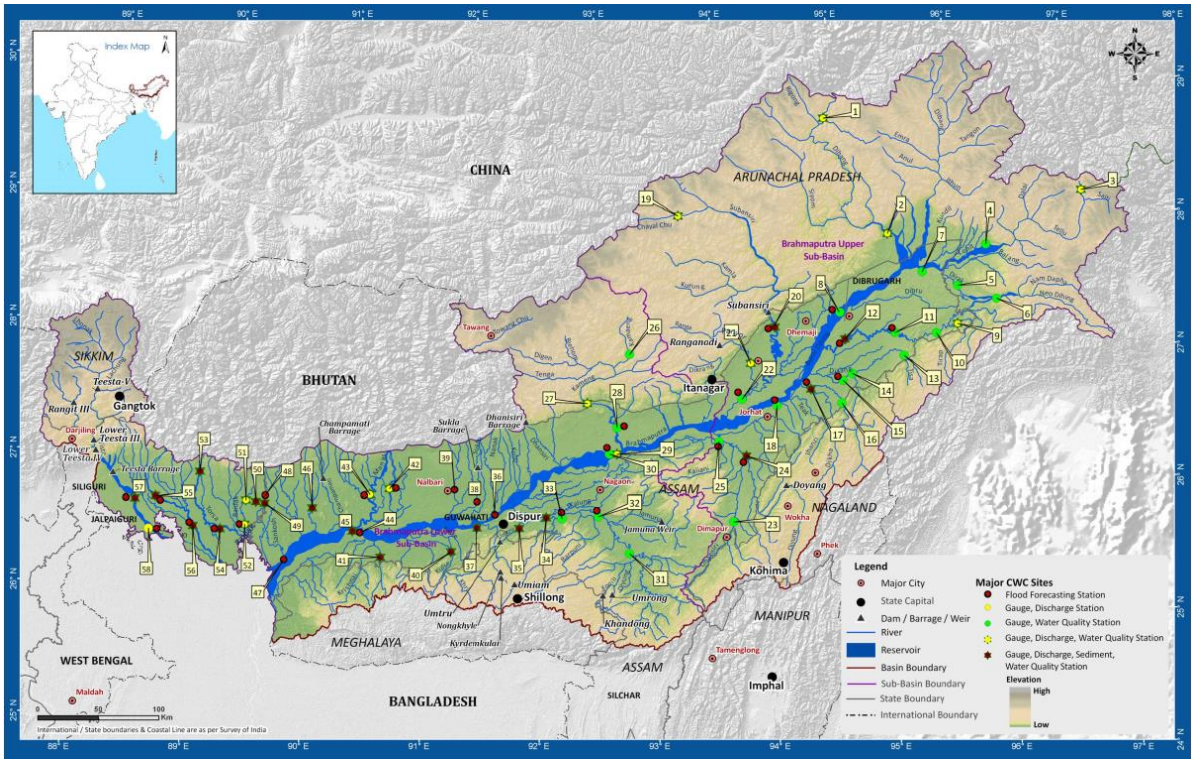


Figure 4-4: Brahmaputra basin (Source: INDIA WRIS)

4.3.1 Slope of River

The slope of the river is steep when it crosses the Himalayas as shown in the longitudinal profile of the river (Figure 4-5). The amount of slope of the river at different reaches are 1.63 m/ km in Tibet, 4.3 m/ km to 16.8 m/ km across the Himalayas, 0.62 m/ km in plains up to Kobo, 0.27 m/ km from Kobo to Dibrugarh, 0.17 m/ km from Dibrugarh to Neamatighat (near Bessamora), 0.15 m/ km from Neamatighat to Tezpur, 0.14 m/ km from Tezpur to Pandu (near Guwahati), 0.11 m/ km from Pandu to Jogighopa 0.094 m/ km from Jogighopa to Dhubri and 0.079 m/ km from Dhubri to the mouth. A sudden decrease in slope in front of the Himalayas near Pasighat results in a large amount of sediment deposition, which chokes up the channel and gives rise to development of prominent braiding pattern (Figure 4-6).

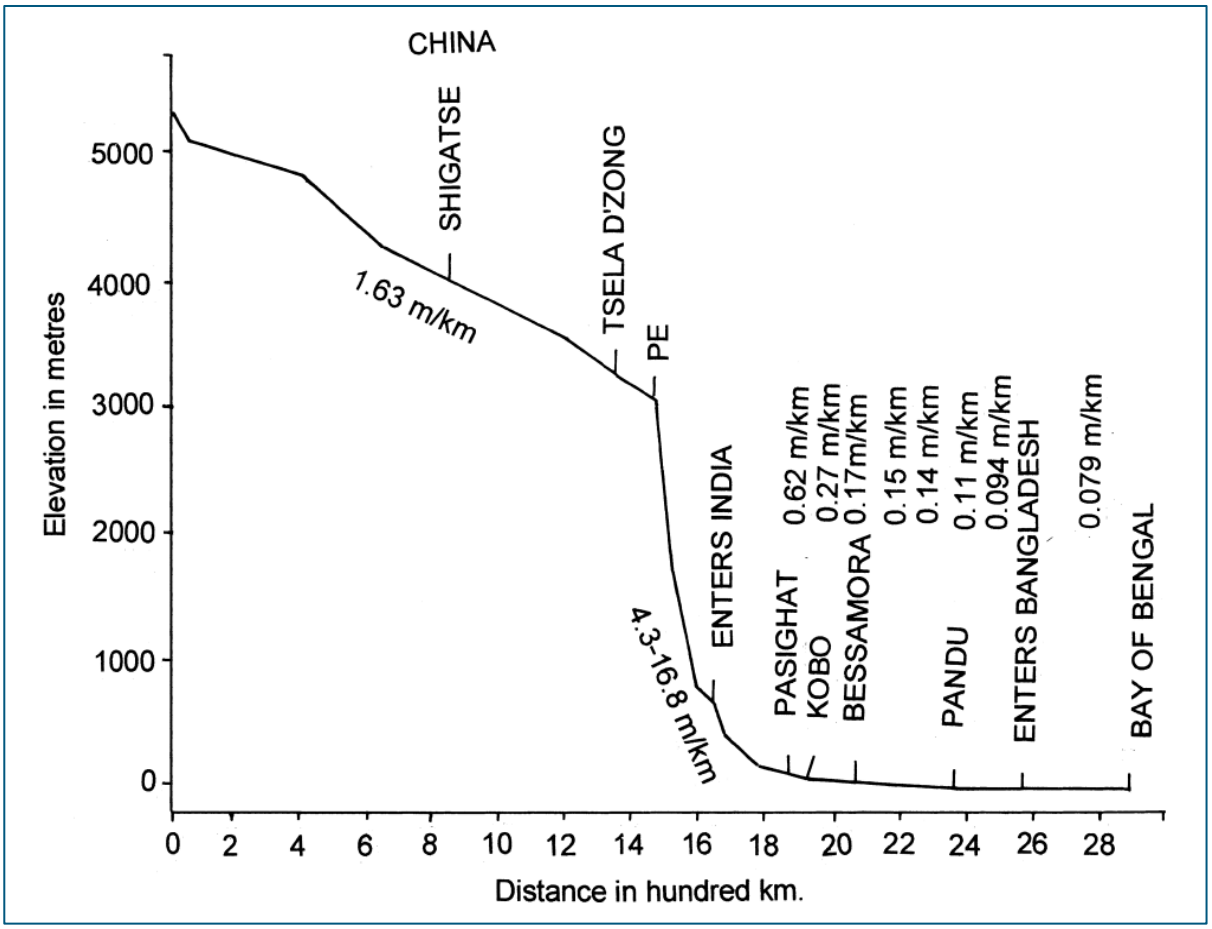


Figure 4-5: The longitudinal profile of the Brahmaputra River (Reference: Sarma, J. N. "Fluvial process and morphology of the Brahmaputra River in Assam, India." Geomorphology 70.3-4 (2005): 226-256)

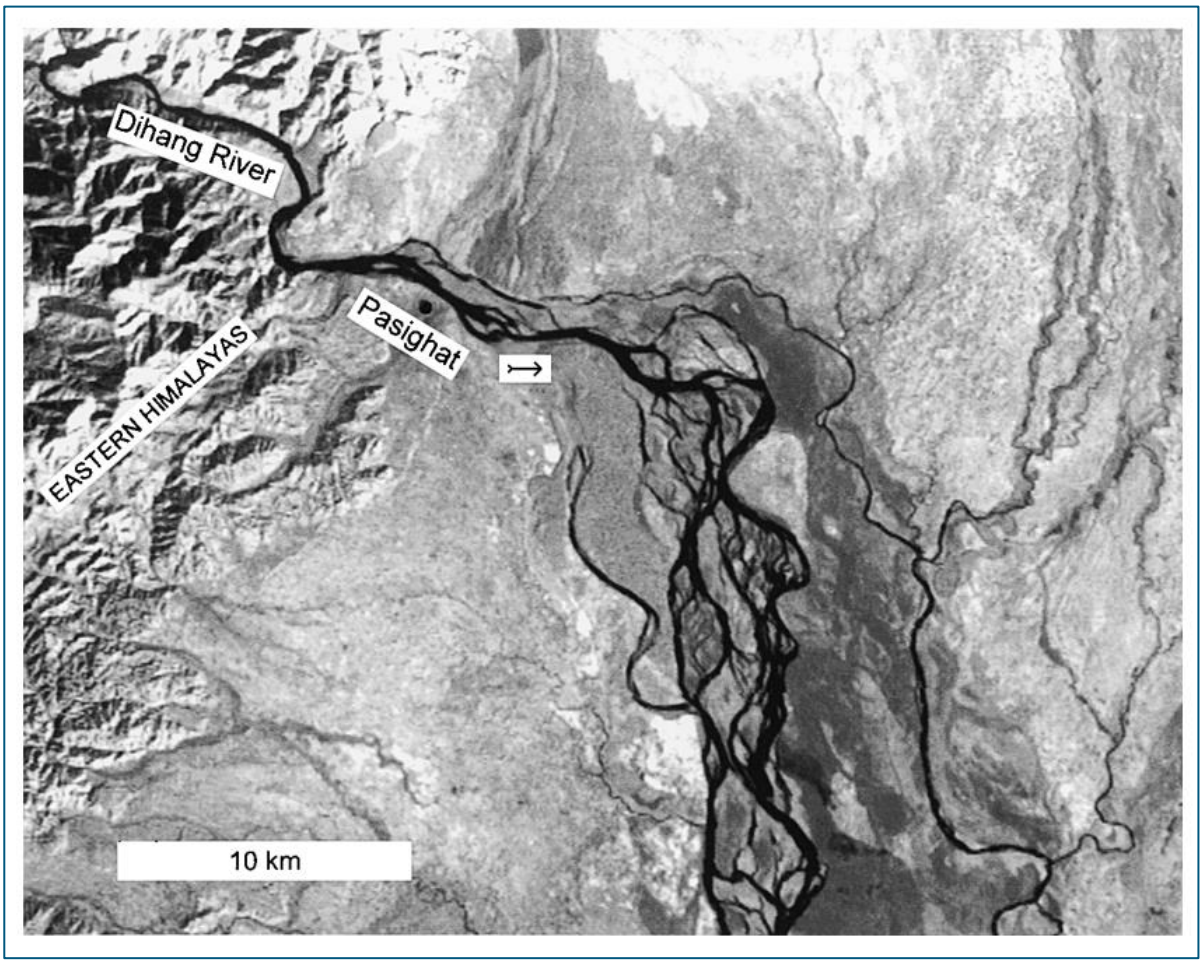


Figure 4-6: Landsat image (April 1988) around Pasighat showing development of braiding where the Dihang river enters the plain (Reference: Sarma, J. N. "Fluvial process and morphology of the Brahmaputra River in Assam, India." Geomorphology 70.3-4 (2005): 226-256.)

4.3.2 Morphodyamics

The configuration of the Brahmaputra channel experiences major changes in response to variations in the flow and sediment load. During November to March when the river discharge is low the channel is highly braided with several bars and islands. After April, May when discharge start increasing these islands and bars get submerged and river looks straight. During low water stage the main channel in a braided river, which carries portion of the discharge, is commonly situated nearby one of the riverbanks and is slightly curved moving from one bank to other. During rising stage when the flow increases rapidly, while the flow inclines to follow the deep channel, it is not able to develop rapidly to accommodate increasing flow and hence there is tendency for bank cutting and sloughing. This action helps migration of the thalweg in lateral direction.

Figure 4-7 shows the planform dynamics of the Brahmaputra River within the study area in 1928, 1976, 1987 and Figure 4-8 to Figure 4-17 shows the pattern of erosion and accretion between 2010 and 2020.

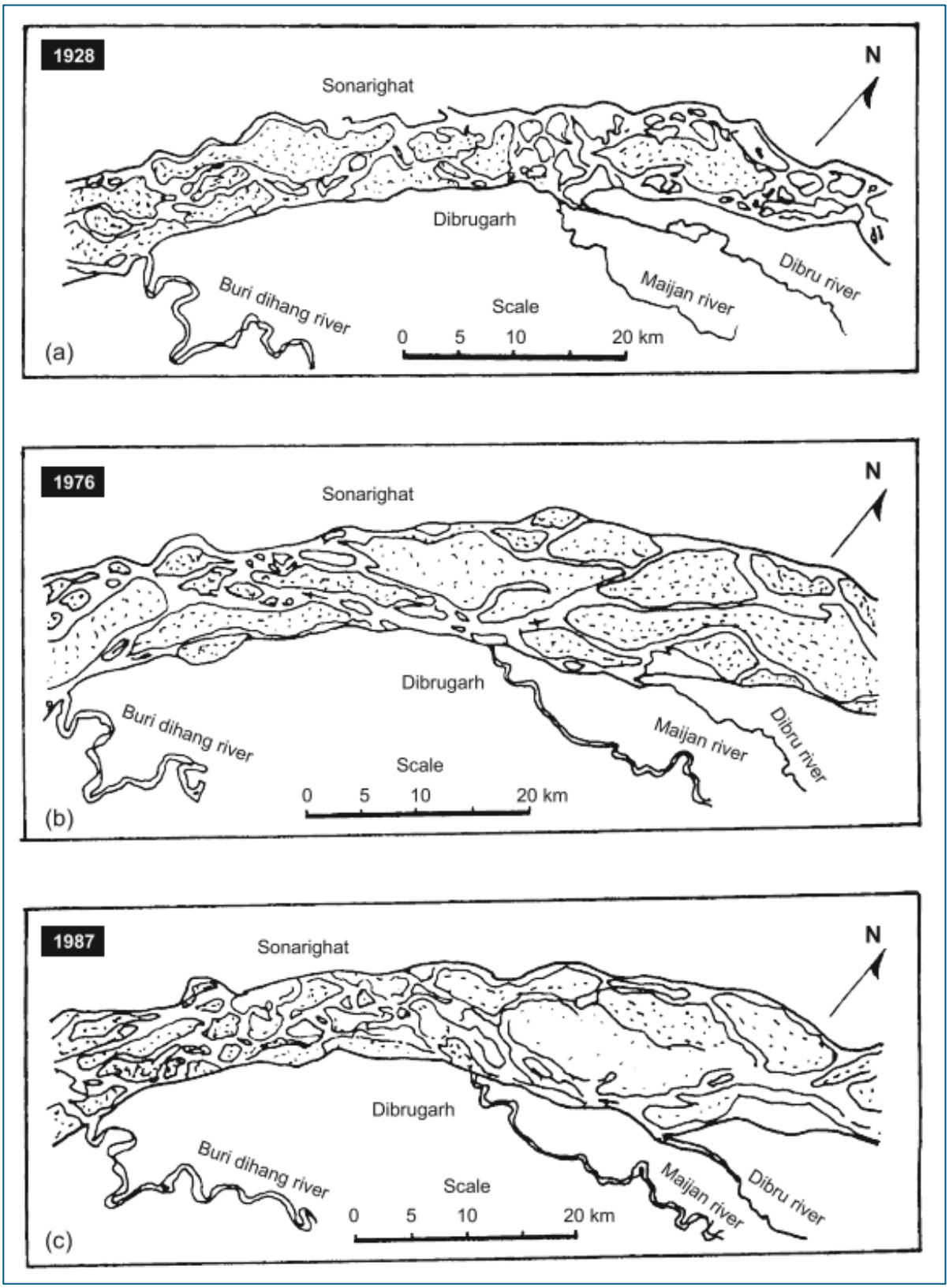


Figure 4-7 Plan form of the Brahmaputra River near Dibrugarh in year 1928, 1976 and 1927

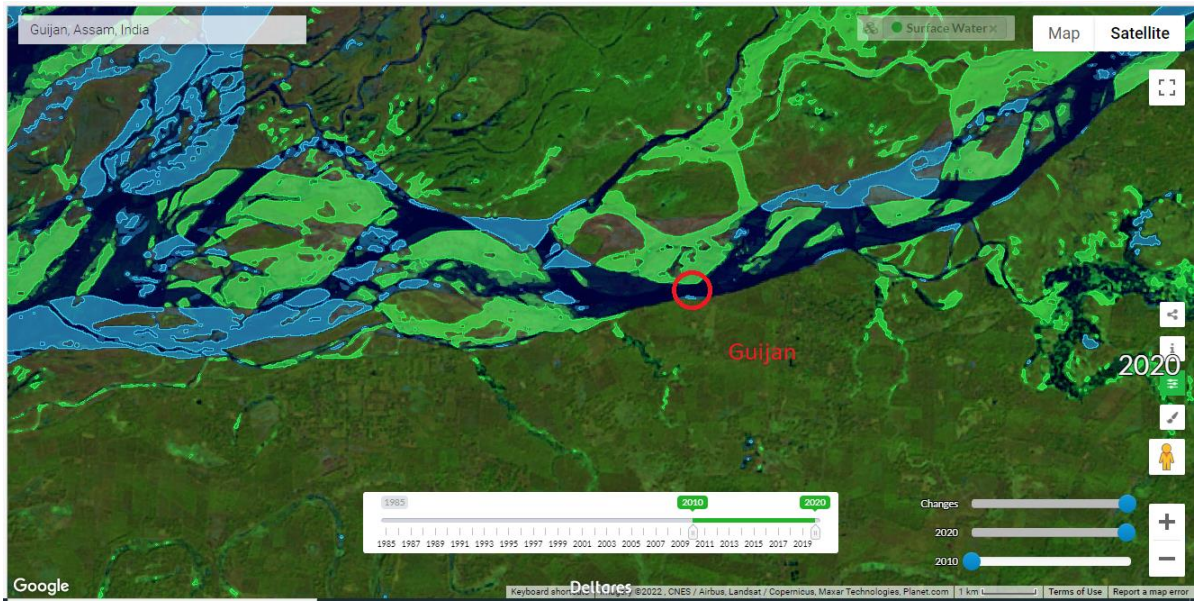


Figure 4-8 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at Guijan (Blue colour polygon indicates: land has become water and green colour polygon indicates water has become land)

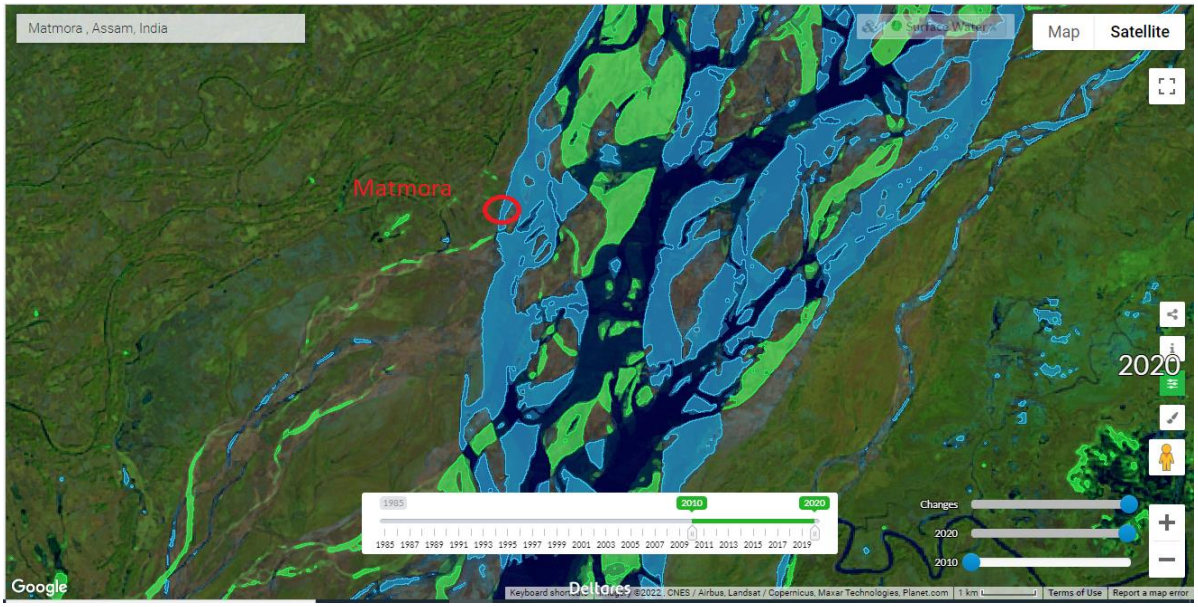


Figure 4-9 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at Matmora (Blue colour polygon indicates: land has become water and green colour polygon indicates water has become land)

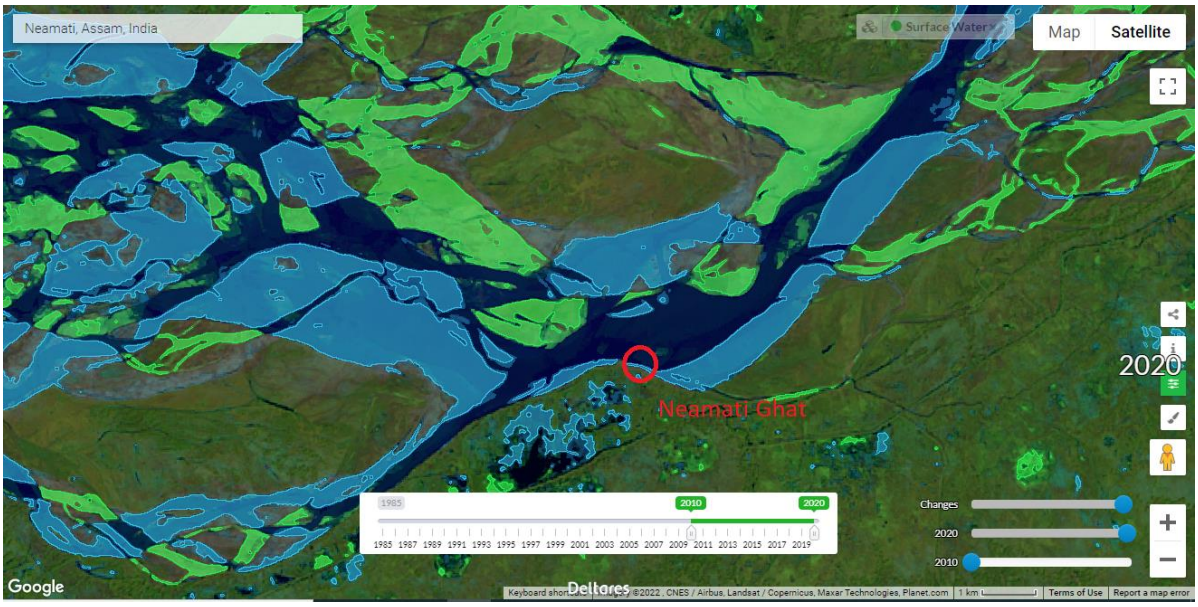


Figure 4-10 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at Neamati Ghat (Blue colour polygon indicates: land has become water and green colour polygon indicates water has become land)

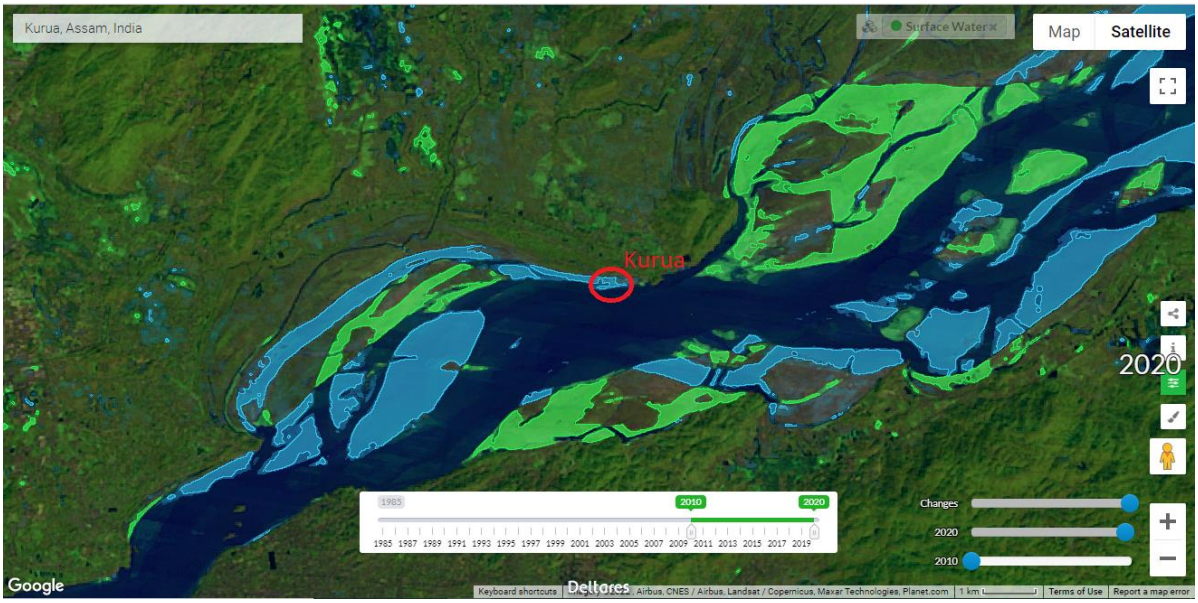


Figure 4-11 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at Kurua (Blue colour polygon indicates: land has become water and green colour polygon indicates water has become land)

Figure 4-12 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at Umananda (Blue colour polygon indicates: land has become water and green colour polygon indicates water has become land)

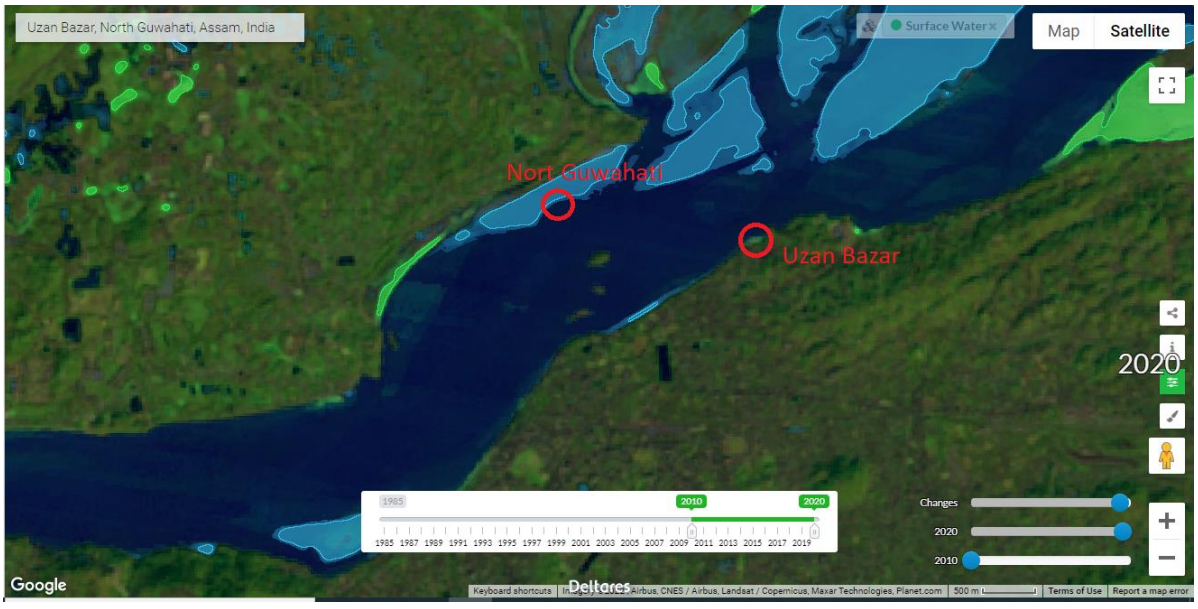


Figure 4-13 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at North Guwahati and Uzan Bazaar (Blue colour polygon indicates: land has become water and green colour polygon indicates water has become land)

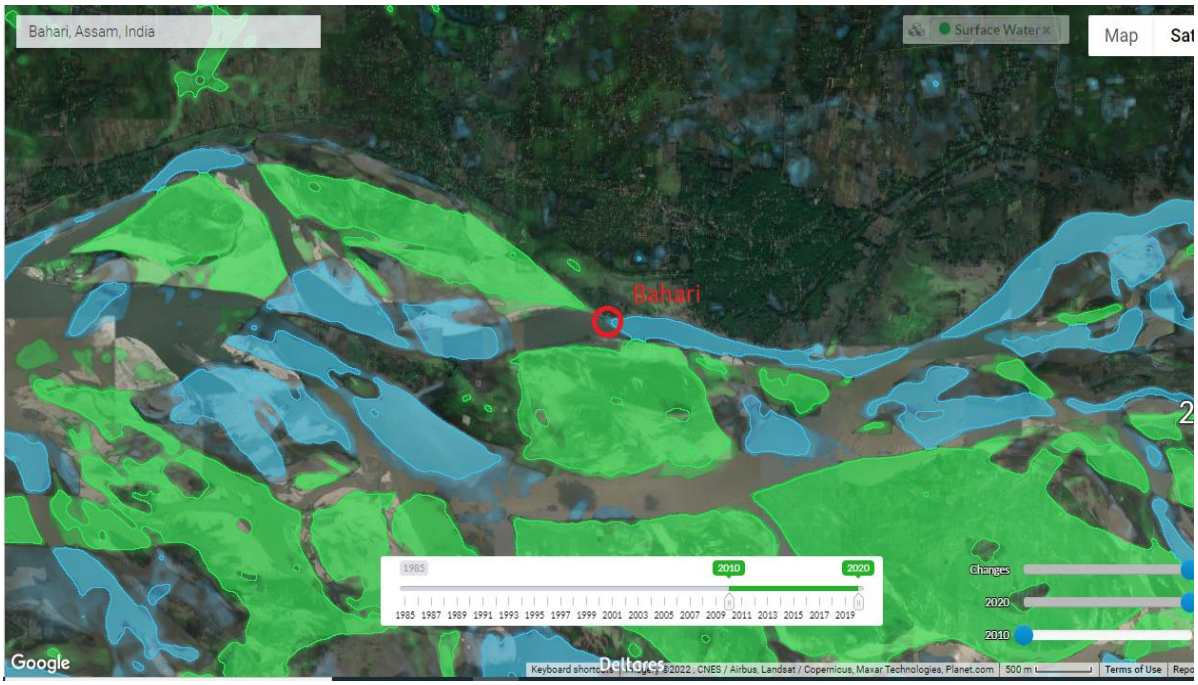


Figure 4-14 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at Bahari (Blue colour polygon indicates: land has become water and green colour polygon indicates water has become land)

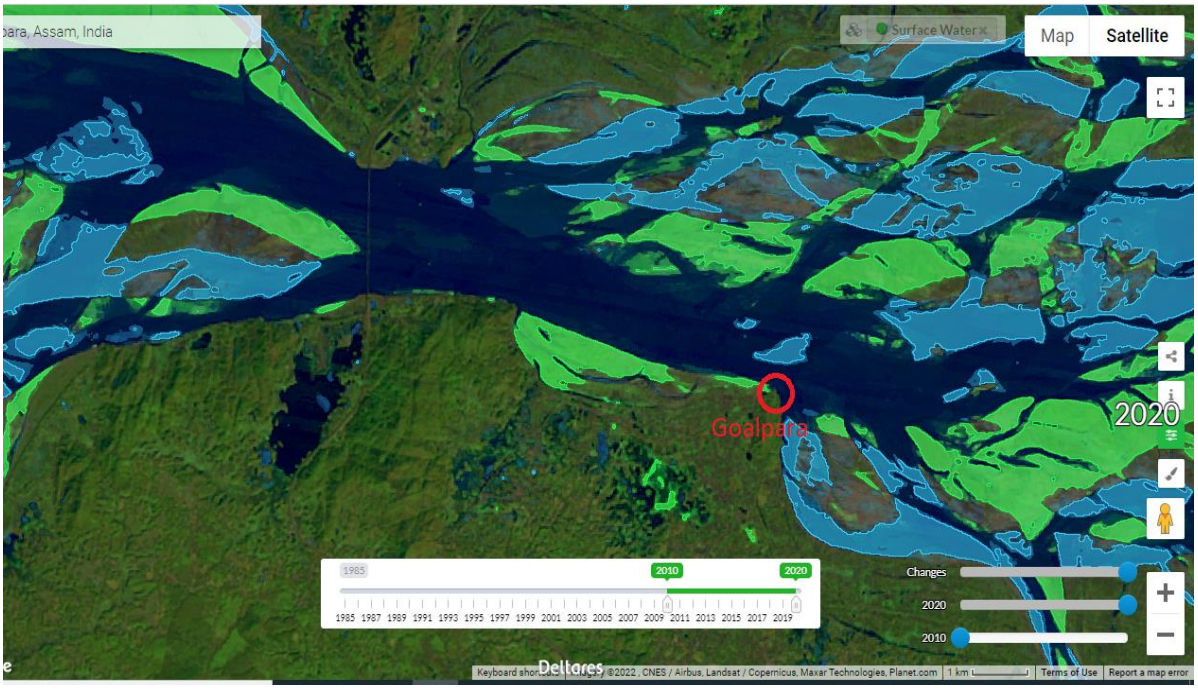


Figure 4-15 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at Goalpara (Blue colour polygon indicates: land has become water and green colour polygon indicates water has become land)

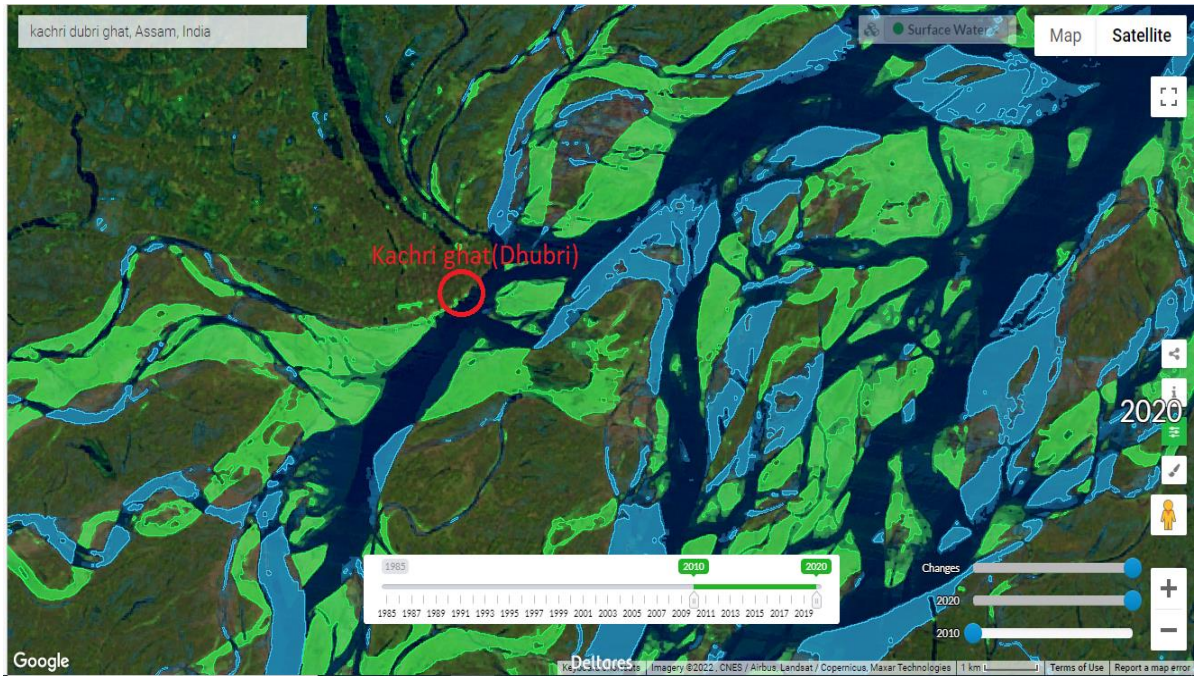


Figure 4-16 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at Kachri Ghat (Dhubri) (Blue colour polygon indicates: land has become water and green colour polygon indicates water has become land)

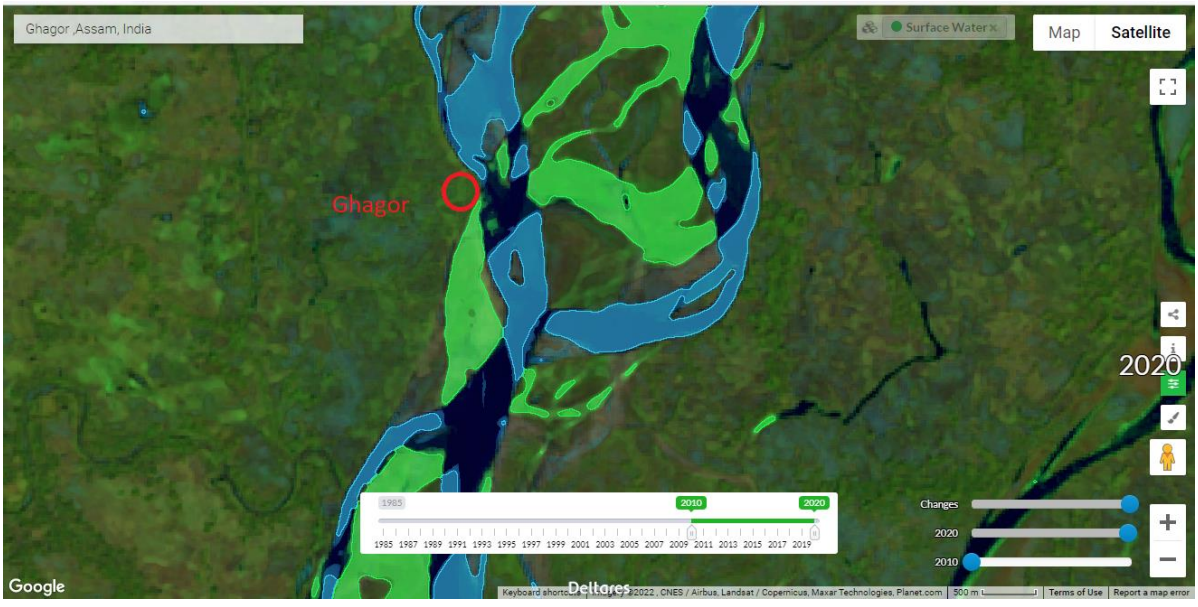


Figure 4-17 Aqua monitor images showing erosion and accretion changes from 2010 to 2020 (https://aqua-monitor.appspot.com/) at Ghagor in the tributary Subansiri, Brahmaputra, (Blue colour polygon indicates land has become water and green colour polygon indicates water has become land)

Table 4-2 Summary of morphological changes between 2010 and 2020 in the vicinity of the proposed ferry terminal sites

S. No.	Location name	Approximate bank erosion between 2010 and 2020 (m)	Approximate bank accretion between 2010 and 2020 (m)
1.	Dhubri	N/A	~100m
2.	Goalpara	N/A	~100m
3.	Bahari	~100 to 200m	~100 to 500m
4.	**Umananda**	**No change**	**No Change**
5.	Uzan Bazar	No change	No Change
6.	North Guwahati	~ 200m	N/A
7.	Kurua	~100 to 200m	
8.	Ghagor	~100 to 300m	~100 to 300m
9.	Neamati	~100 to 300m	
10.	Aphalamukh	~100 to 300m	
11.	Disangmukh	~100 to 200m	
12.	Matmora	~500m	
13.	Guijan	No change	No change

4.3.2.1 Topographic Levels

As shown from Figure 4-8 to Figure 4-17, the following four topographic levels can be recognized on the Brahmaputra riverbed:

Level 1: This level consists of active channels, abandoned channels and low bars which are submerged with a slight increase in water level.

Level 2: This level is about 0.50 m to 2 m higher than level 1 bar and water surfaces during the low flow period. It is either non-vegetated or has very scanty vegetation consisting of short grass and moss. Most parts of it are submerged with a slight increase in water level.

Level 3: This level is over 1 m higher than level 2 bar surface and is over 2.50 m higher than level 1 surface. It is submerged during the high flow period. It consists of tall grass and shrubs during the low flow period.

Level 4: This level is at least 0.50 m higher than level 3 bar surface and is up to 8 m higher than level 1 surface. It generally remains exposed during the high flow period but could be submerged in some areas during exceptionally high floods. It consists of high bars, islands and banks which consist of tall grass, shrubs, trees, and settlements.

4.3.2.2 Channel Bars

In the Brahmaputra riverbed there are many bar types can be observed, the principal ones being compound bars (mid-channel and side bars) and unit bars.

Mid-channel Bars: Mid-channel bars divide the primary and secondary channels into smaller channels. They are observed throughout the river reach within the study area. One type consists of bars which are elongated either parallel to the two banks of the main Brahmaputra channel or to the direction of upper regime flow. Another type consists of bars which are parallel to the lower flow regime channels. Furthermore,

some bars taper towards either downstream or upstream. However, all mid-channel bars have complex depositional histories. During the peak stage the river flows in mainly one direction. As the floods recede several secondary channels emerge. These channels flow in various directions. Thus, deposition of sediments takes place with flow in different directions along and across the channel. Episodes of deposition and erosion with passing time result in the formation of mid-channel bars. These bars generally consist of fine-textured sand and occasional layers of mud throughout the area.

Side Bars: Side bars are compound bars which develop in a similar way to mid-channel bars but occur along the riverbanks. They have no slip faces and descend gradually into the channel. Their upper surfaces consist of small unit bars, and mega and small-ripple marks, besides various bedforms. During the lower flow regime, the bar surfaces are dissected by chute and abandoned channels.

Unit Bars: Unit bars are present throughout the river reach. They emerge during the lower flow regime. They consist of either linguoid bars or small bars which are irregularly shaped. Linguoid bars are characteristic of low sinuousity streams. They may be rhombic or lobate with upper surfaces dipping gently upstream towards the preceding bar, and the downstream facing a sinuous avalanche slope termination. In the area of study two categories of unit bars are observed. In the first category unit bars occur within primary and secondary channels. These bars are subjected to constant erosion by flowing water during the lower flow regime and are liable to disappear within a short period of time. Unit bars of the second category are subjected to constant erosion by wind during the lower flow regime. They consist of structures such as ripple-drift cross-lamination, horizontal bedding, trough cross bedding, mud layers and planar (tabular) cross bedding.

4.3.2.3 River Width

The slope of the Himalayas was barren for several years after the earthquake, the loose debris and barren slopes together resulted in 45 billion m3 of sediment inputs into the river system in this rain-drenched region, which ultimately choked the bed of the Brahmaputra. The floodplain aggradation has not been able to keep up with channel aggradation, so channel capacity has declined. The bed of the Brahmaputra is raised by about 3 m in Dibrugarh, as revealed by a sharp rise in the low-water level of the Brahmaputra River at Dibrugarh because of deposition of the enormous amount of sediment on its bed following the 1950 great earthquake (Figure 4-18). The highest flood level (HFL) in Dibrugarh is 105.95 m and the danger level (DL) is 104.24 m. There is no record of the lowest water level. As the river became shallower, it became wider to accommodate its regular flow after 1950. Unfortunately, maps or images of the Brahmaputra immediately after 1950 are not available to confirm the widening of the channel. The larger number of segments (53 out of 64, or 82.8%) where there were increases in width in the period from (1912–1928) to (1963–1975) might be a consequence of the great Assam earthquake of 1950 that measured 8.5 on the Richter scale, whose epicentre was within the Brahmaputra basin (Figure 4-19).

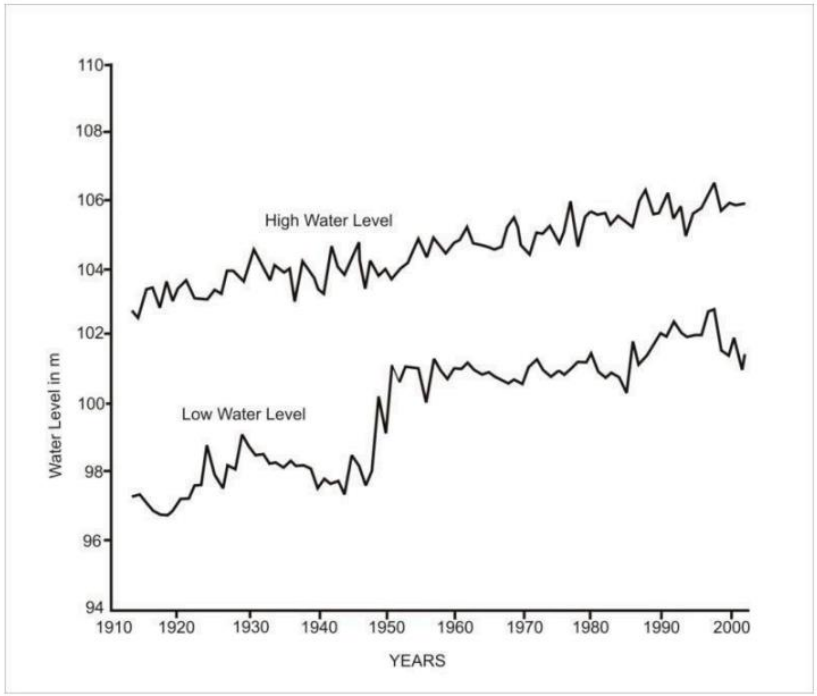


Figure 4-18 A sharp rise in the low water level of the Brahmaputra River at Dibrugarh gauging station because of deposition of an enormous amount of sediment on its bed following the 1950 great earthquake. (Source: Sarma, Jogendra Nath, and Shukla Acharjee. "A studon variation in channel width and braiding intensity of the Brahmaputra River in Assam, India." Geosciences 8.9 (2018): 343.)

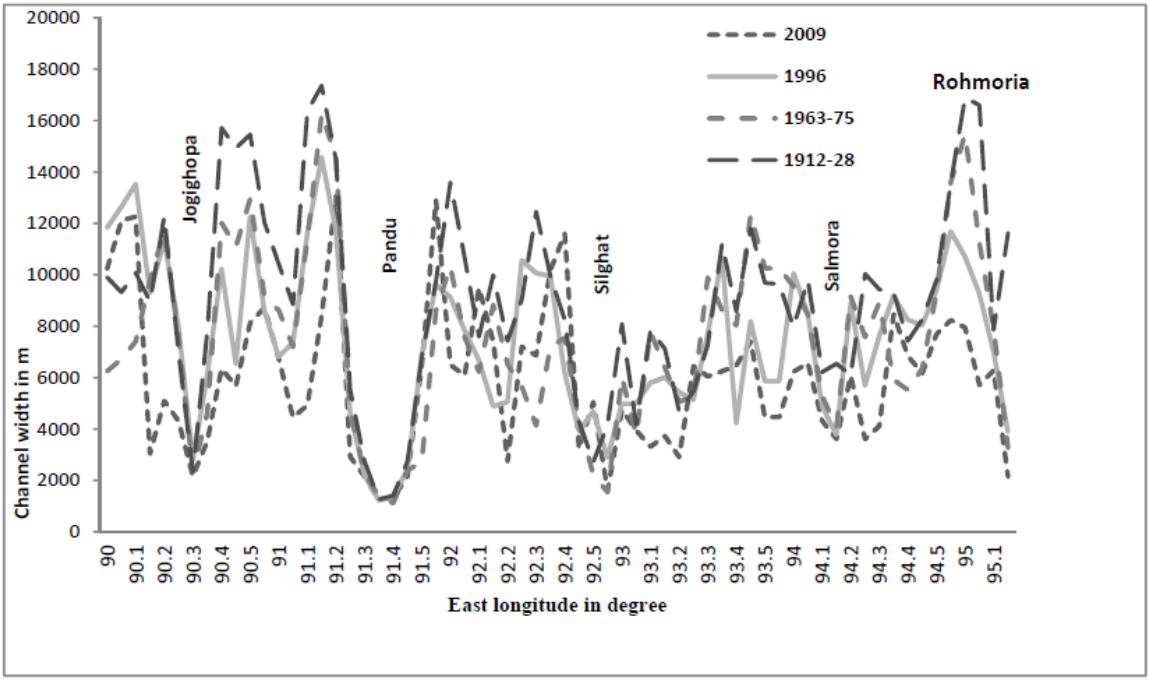


Figure 4-19 Superimposed channel width graphs along the course of the Brahmaputra River in four different time periods. (Source: Sarma, Jogendra Nath, and Shukla Acharjee. "A study on variation in channel width and braiding intensity of the Brahmaputra River in Assam, India." Geosciences 8.9 (2018): 343.)

4.3.2.4 Seismicity and Landslides

Brahmaputra basin is in a geodynamical unstable region characterized by active faults and continuing crustal movements. According to plate tectonics the Indian plate moving in the north-north-easterly direction is under thrusting the Eurasian plate and is causing deformation and instability in the Brahmaputra basin. It is believed that many E-W and transverse faults that dissect the Meghalaya Mikir blocks are active and are responsible for high seismicity. In the 60 years prior to 1980, over 450 small and large earthquakes have taken place in the area. There distribution is as follows.

Table 4-3 Earthquake intensity and number of incidents

Richter Magnitude	No. of earthquakes
8 or greater	3
7-8	15
6-7	167
5-6	270

Major earthquakes in this region appear to be separated by quiescent period of about 30 years. Among the earthquakes that have taken place in the region, the two most severe earthquakes were those of 1897 and 1950. The 1897 earthquake of Richter magnitude of 8.7 had its epicentre in Shillong plateau. It was felt over 450,000 square kilometres. The entire lower portion of the basin up to Goalpara district was affected.

4.3.2.5 Bank Instability

The bank line of the Brahmaputra is extremely unstable for most of its length. Bank failures are rampant and seem to be function of the hydraulic character of the flow and the engineering properties of the bank material. Several factors are responsible for short term changes in the bank line, these are.

1. Rate of rise and fall of water level.
2. Number and position of channels active during the flood stage.
3. Angle at which the thalweg approaches the bank line.
4. Amount of scour and deposition that occurs during flood.
5. Formation and movement of large bed forms.
6. Cohesion and variability in the composition of bed material.
7. Intensity of bank sloughing.
8. Relationship of abandoned river courses to present day channel.

4.3.2.6 Scour Depth

A local scour hole of 37.37m is estimated based on the riverbed contour data near Neamati site (see Figure 4-20).

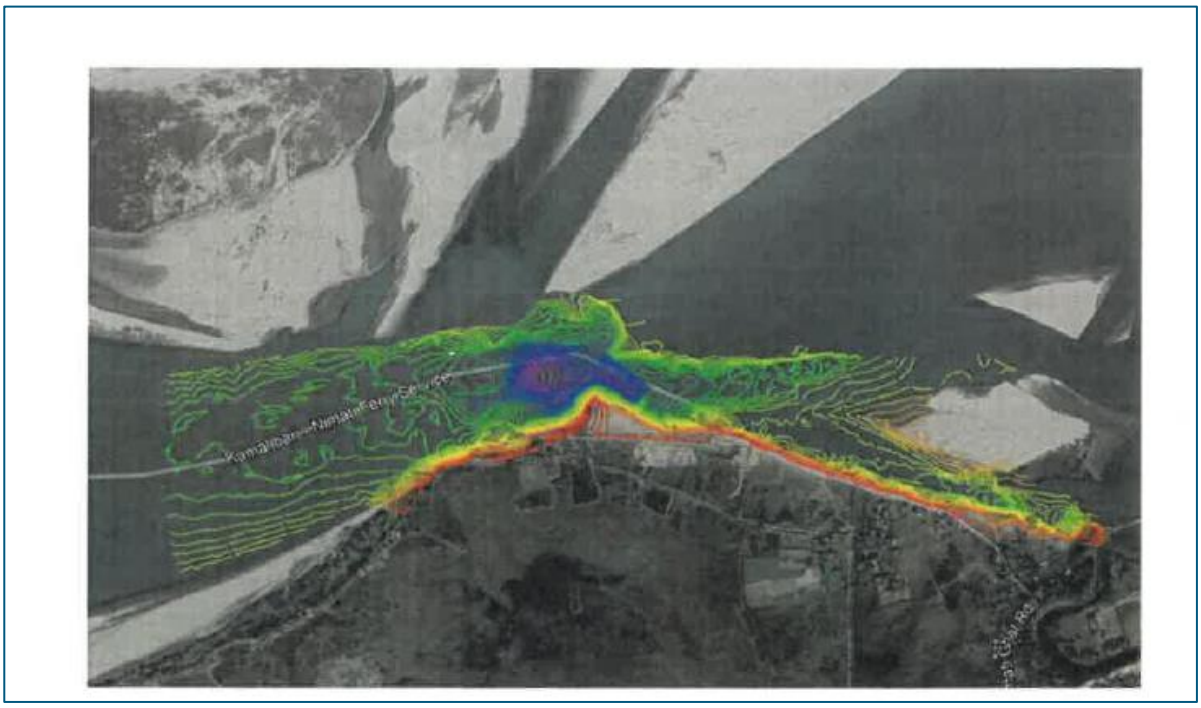


Figure 4-20 Riverbed contour near Neamati in Jan 2019 (Source: Source: Tractabel DPR Vol-I: Main Document "Consultancy services for preparation of DPR for development of Ro-Ro routes in NW-2 in Assam", original source: TEPL)

4.3.3 Sediment Load

4.3.3.1 Suspended and Bed Load

The Brahmaputra is one of the most sediment charged large rivers of the world. It is second only to the Yellow River in China in the amount of sediment transported per unit drainage area. During monsoon months, June through September, the daily rate of sediment discharge at Pandu averages 2.0 million metric tons, whereas average annual suspended load is 402 million tons. The transport of bed load in the Brahmaputra River is not measured at any station. Goswami (1989) has estimated the same at Pandu using sediment discharge formulas (Bagnlod, 1966; Einstein, 1942; Kalinske, 1947; Laursen, 1958; Yang, 1973). The formulas developed by Laursen (1958) are considered acceptable for the Brahmaputra. From the equation and assuming the possible error in suspended sediment measurement to be within 10%, the bed load at Pandu was found to be 5-15% of the total load of the river. Measured mean suspended sediment load at Pandu is 3520631 tons and the calculated total load is 4148323 tons. Hence, the bed load is 627692 tons, which is 15% of the total load. The depth wise strata of Brahmaputra River mentioned below in Table. Bed material of the river can be made of sand.

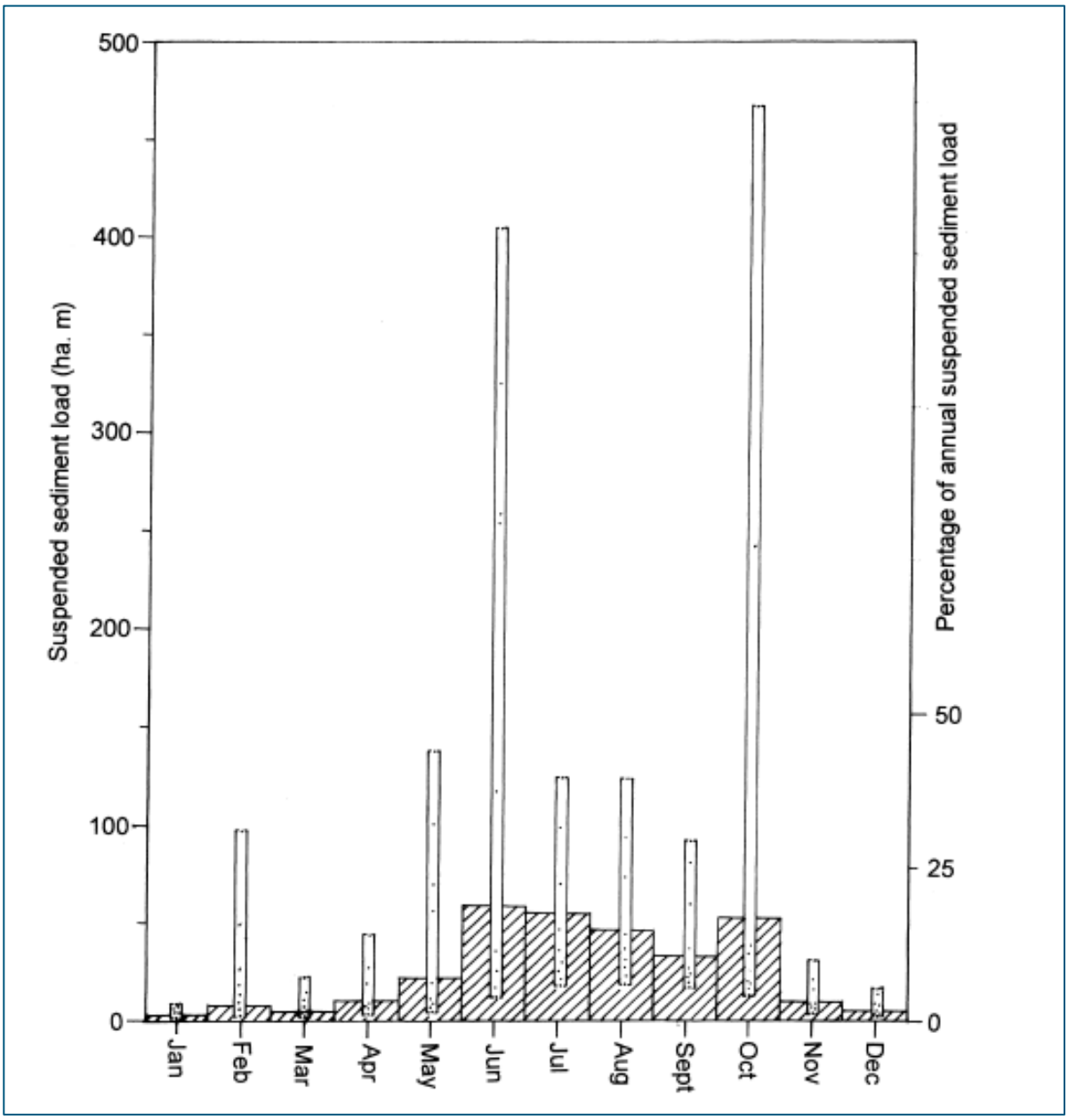


Figure 4-21 Dispersion graph of the monthly suspended sediment load of the Brahmaputra River at Bessamora. Mean monthly sediment is shaded percentage scale to the right. (Reference: Sarma, J. N. "Fluvial process and morphology of the Brahmaputra River in Assam, India." Geomorphology 70.3-4 (2005): 226-256

Table 4-4 Depth wise strata at Nemati Port area from RBH-4 (Source: Tractabel DPR Vol-I: Main Document "Consultancy services for preparation of DPR for development of Ro-Ro routes in NW-2 in Assam")

S. No.	Depth Zone (m)	Strata Type
1	0.00 – 3.50 m	Loose grey silty sand with very fine mica flakes
2	3.50 – 22.00 m	Medium dense grey silty sand with very fine mica flakes
3	22.00 – 23.50 m	Dense greyish brown to brownish grey silty sand
4	23.50 – 45.36 m	Very dense brownish grey to dark grey silty sand with very fine mica flakes

4.4 Data Collection

Hydrometeorological, topographic and sediment data was collected from the Central Water Commission (CWC). Table 4-5 shows the list of data requested and collected.

The hydrodynamic and morphological models of the river were developed based on the data collected under the Assignment. The efficiency of these models and analysis largely depends upon the quality of the data.

4.4.1 List of secondary data for modelling and analysis

1. River Gauge, discharge, and sediment for each Gauge (G), Gauge and Discharge (G&D), Gauge Discharge Sediment (GDS) and Gauge Discharge Sediment Quality (GDSQ) site.
    a. River gauges and discharges for the existing CWC sites.
    b. Observed sediment rate data (bed load, suspended load, sediment characteristics).
    c. River sediment size: bed material and suspended sediment: D16, D50, D84 including Particle size distribution (PSD) curve of the suspended sediment load and bed material.
    d. Vertical velocity distribution and vertical sediment distribution at significant river stages for each G&D site.
    e. Riverbank and bed material characteristics including PSD curves.

2. Cross sections of the river.
    a. Available bathymetry survey of rivers.
    b. River geometry and river cross section.
    c. Morphological cross-sections available with CWC.

3. Hydrographic survey of each study reaches for different river stages.
    a. ADCP survey of discharge, velocity profile and suspended sediment concentration if any.

Table 4-5 Data requested and received to date

S. No.	Site Type	River/ Tributary	Site	Minimum maximum data	Time series data and dura	Data received to date
1	GDSQ	Brahmaputra	Bhomoraguri	Minimum, maximum data of G, D, S, velocity for last 30 years Annual cross-section for last 30 years	Daily values of G, D, S, Velocity for last ten years Pre- and post-monsoon Cross-section for last 10 years	Bhomoraguri-HFL 1991 to 2021, Maximum discharge corresponding water level 1991 to 2021 Chouldhowaghat-HFL 1991 to 2 Maximum discharge corresponding water level 1991 to 2021 Pancharatna-maximum discharge and water level
2	GDSQ	Brahmaputra/ Subansiri	Chouldhowaghat			

S. No.	Site Type	River/ Tributary	Site	Minimum maximum data	Time series data and dura	Data received to date
3	GDSQ	Brahmaputra	Pancharatna			1991 to 2021
4	GDSQ	Brahmaputra	Pandu			Pandu- maximum discharge 1999 to 2021 and water level 1991 to 2021
5	GDQ	Brahmaputra	Pahumara	Minimum, maximum da G, D, Velocity last 30 years Annual cross-section for last 30 yea	Daily values of G, D, Velocity for last ten years Pre- and post-monsoon Cross-section for last 10 years	Pahumara– maximum discharge 2021 and water level 2021
6	GDQ	Brahmaputra	Polaguri			Polaguri- maximum discharge 2021 and water level 2021
7	G	Brahmaputra	Biswanath Ghat, Bogibeel, Dhubri, Dibrugarh, Goalpara, Guwahati D.C Cou Ligribari, Neamatig Silghat, South Saln Tezpur			Biswanath C maximum discharge 2021 and water level 2021
8	G	Brahmaputra/ Subansiri	Badatighat	Minimum, maximum data for last 30 years	Daily values of G for last ten years	Dhubri– maximum water level 2000 to 2021 Dibrugarh– HFL 1991 to 2021 Goalpara- maximum water level 1999 to 2021 Guwahati D.C Court- maximum water level 1991 to 2021 Neamati– HFL 1991 to 2021 Silghat- Maximum discharge 2021 and water level (2021

S. No.	Site Type	River/ Tributary	Site	Minimum maximum data	Time series data and dura	Data received to date
						South Salr maximum Discharge 2021 and water level 2021 Tezpur– HFL 1991 to 2021 Badatighat- HFL 1991 to 2021

Table 4-6 Summary of extreme values of discharge and water level data

S.N	Site	River	Details of Data		Date
1	Pandu	Brahmaputra	Maximum Discharge Observed	45952.647 cum	21-07-2011
			Minimum Discharge Observed	819.086 cum	06/03/2000
			Maximum Water Level	49.88 m	06/09/1998
			Minimum Water Level	40.19 m	21/02/2017
2	Pancharatna	Brahmaputra	Maximum Discharge Observed	80960 cum	30/08/1988
			Minimum Discharge Observed	1578.440 cum	31/01/1992
			Maximum Water Level	36.65 m	06/09/1998
			Minimum Water Level	27.28 m	02/03/1999
3	Guwahati (DC C	Brahmaputra	Maximum Water Level	51.46 m	21/07/2004
			Minimum Water Level	40.54 m	21/02/2017
4	Goalpara	Brahmaputra	Maximum Water Level	37.35 m	13/07/2004
			Minimum Water Level	28.29 m	31/01/2007
5	Dhubri	Brahmaputra	Maximum Water Level	30.37 m	17/07/2019
			Minimum Water Level	22.34 m	04/03/1999

Table 4-7 Summary of minimum values of discharge and water level data

HISTORICAL MINIMUM VALUES OF DISCHARGE AND GAUGE:

SITES	DISCHARGE			GAUGE(m)	
	Date	Discharge(Cumecs)	Corresponding Wl(m)	Minimum water level	date
1.Bhomoraguri	17/02/1997	1842.89	59.14	53.38	18/03/2020
2.Choulduwaghat	05/02/1995	332	96.34	90.03	10/02/2021

Table 4-8 List of data received and not received to date

S.No.	Station	Discharge data period	Frequency	WL data period	Frequency	x-section data period	Frequency	Sediment data period	Frequency	Velocity data period	Frequency
1	Pandu	2010-2021	Daily	2010-2021	Daily	1998-2020	Seasonal	2010-2021	Daily	None received	
2	Pancharatna	2010-2021	Daily	2010-2021	Daily	1991-2020	Seasonal	2010-2021	Daily	None received	
3	Guwahati			2010-2021	Hourly						
4	Dhubri			2011-2021	Hourly						
5	Pohumr			2020-2021	Daily						
6	Goalpara			2010-2021	Hourly						
7	B G Road			2019-2021	Hourly						
8	Polaguri			2019-2021	Hourly						
9	Silghat			2019-2021	Hourly						
10	Biswanath Ghat			2019-2021	Hourly						
11	South Salmara			2019-2021	Hourly						
12	Bhomoraguri	2010-2021	Daily	2016-2021 2010-2021	Hourly 3 times a day, daily	2010-2020	Seasonal	2013-2021	Daily	None received	
13	Chouldhowaghat	2010-2021	Daily	2014-2021 2010-2021	Hourly 3 times a day, daily	2010-2021	Seasonal	2010-2021	Daily	None received	
14	Bogibil			2019-2021	Hourly						
15	Dibrugarh			2010-2021	Hourly, 3 times a day						
16	Neamatighat			2010-2021	Hourly, 3 times a day						
17	Tezpur			2010-2021	Hourly, 3 times a day						
18	Badatighat			2010-2021	Hourly, 3 times a day						

4.4.2 Future scenario of climate change

A number of studies have been conducted on the effect of climate change on the Brahmaputra rivers. These were referred to understand and suitably consider the effect of climate change.

Table 4-9 Example list of relevant literature on climate change in Brahmaputra and Meghna river basins

S. No.	Journal paper title	Year of study	Source
1	A first look at the influence of anthropogenic climate change on the future delivery of fluvial sediment to the Ganges–Brahmaputra–Meghna delta	2015	https://pubs.rsc.org/en/content/articlehtml/2015/em/c5em00252d
2	Impacts of climate change and socio-economic scenarios on flow and water quality of the Ganges, Brahmaputra and Meghna (GBM) river systems: low flow and flood statistics	2015	https://pubs.rsc.org/en/content/articlelanding/2015/em/c4em00619d/unauth#!divAbstract
3	Model study of the impacts of future climate change on the hydrology of Ganges–Brahmaputra–Meghna basin	2015	https://hess.copernicus.org/articles/19/747/2015/
4	Impact of climate change on the hydrological regime of the Indus, Ganges and Brahmaputra river basins: a review of the literature	2015	https://iahr.tandfonline.com/doi/pdf/10.1080/07900627.2015.1030494?needAccess=true&

4.5 Data Analysis

Collected data have been processed and validated for data errors. Subsequently, error free discharge data are being used to conduct the flow frequency analysis to identify the extreme events. Flow duration curve of observed discharges and water levels are presented in this section to identify the high, medium, and low river conditions in the last decade. Also, plots showing the rate of rise and fall in water level is presented as these parameters are required for the design of any earth retaining structures. Comparison of cross-sections over time at CWC HO sites is presented in this section to understand the meso scale morpho dynamics of the river. Through these figures it can be observed that riverbed got 6 m eroded between 2015 and 2020 at Pandu CWC HO site whereas 10m over the same period at Bhomoraguri. 16m of riverbed eroded over 10years at Pancharatana CWC HO site.

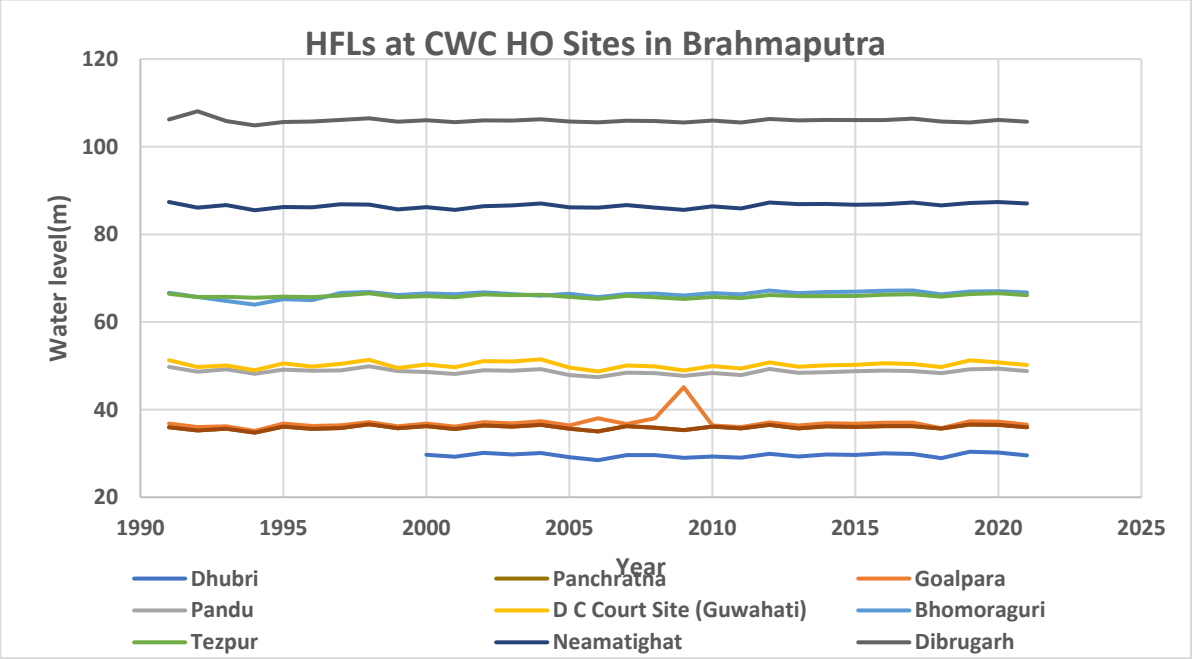


Figure 4-22:Time series plot of High Flood Levels (HFLs) at all CWC HO sites in Brahmaputra

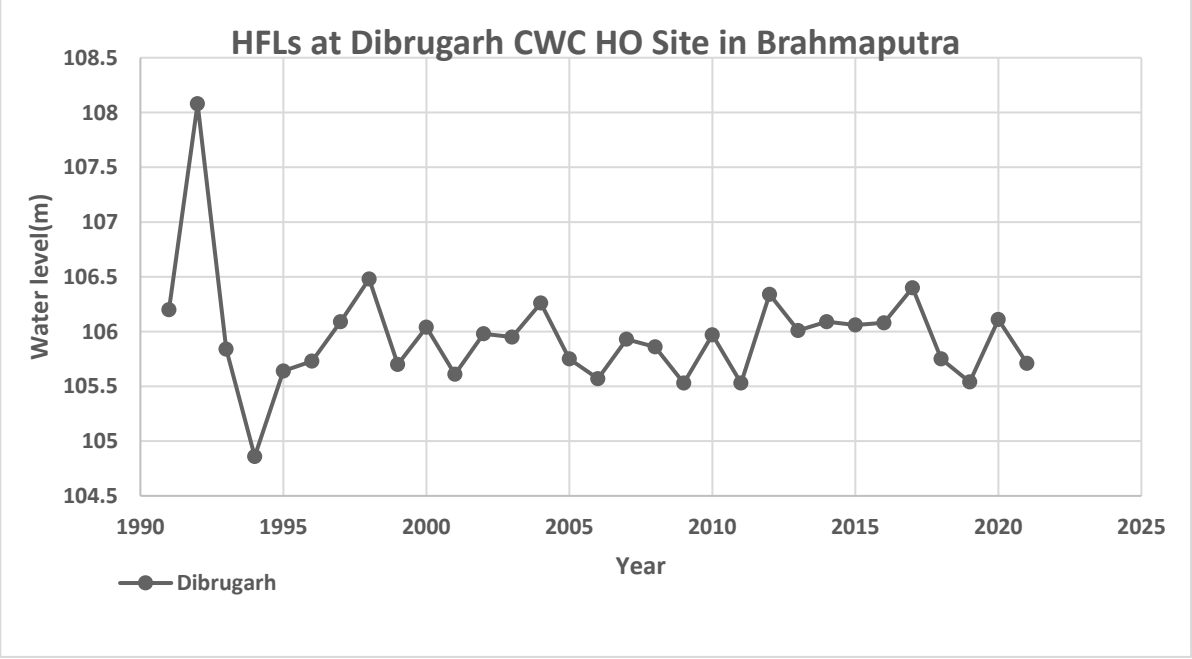


Figure 4-23: Time series plot of High Flood Levels (HFLs) at Dibrugarh CWC HO site in Brahmaputra

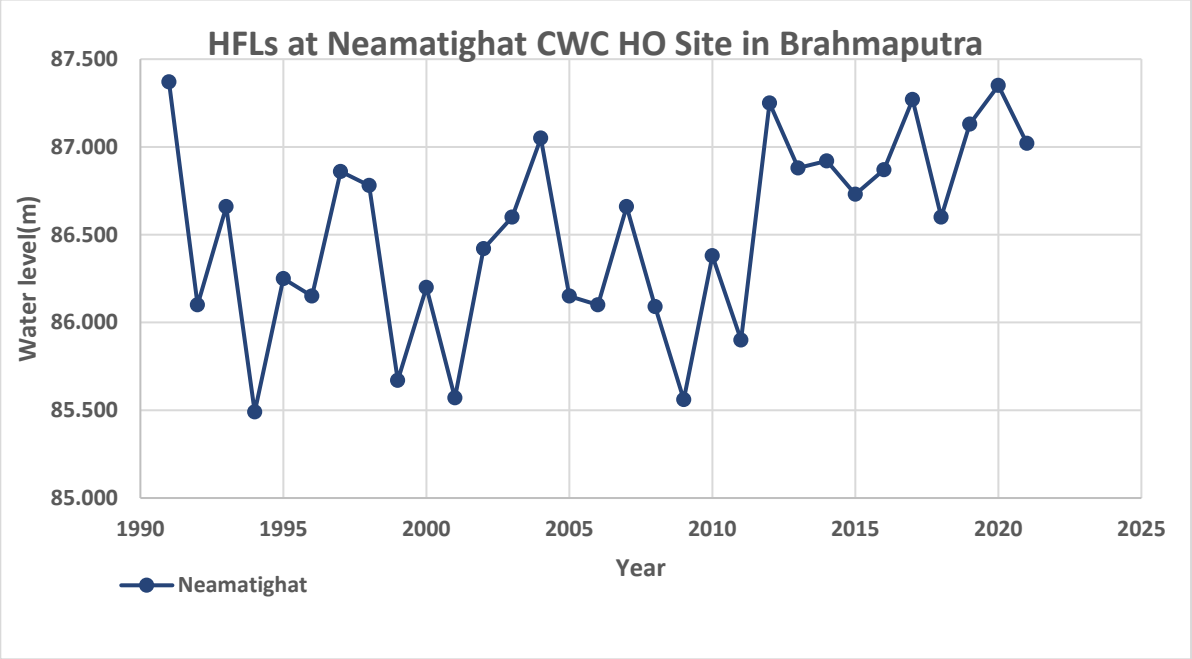


Figure 4-24: Time series plot of High Flood Levels (HFLs) at Neamati Ghat CWC HO site in Brahmaputra

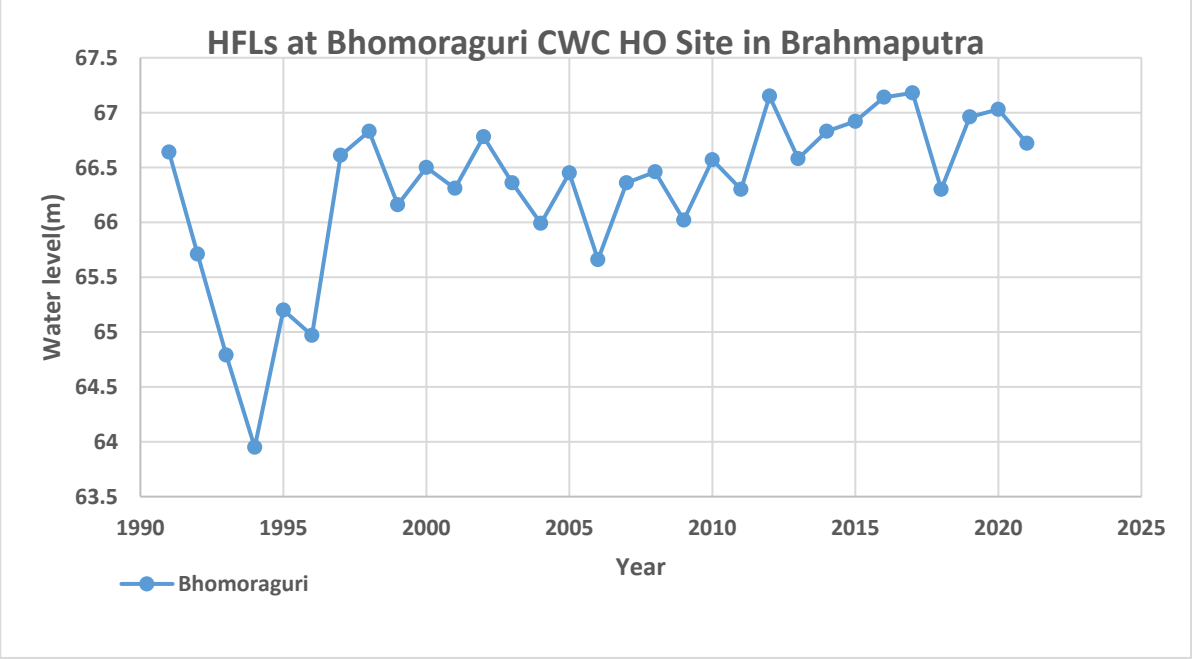


Figure 4-25: Time series plot of High Flood Levels (HFLs) at Bhomoraguri CWC HO site in Brahmaputra

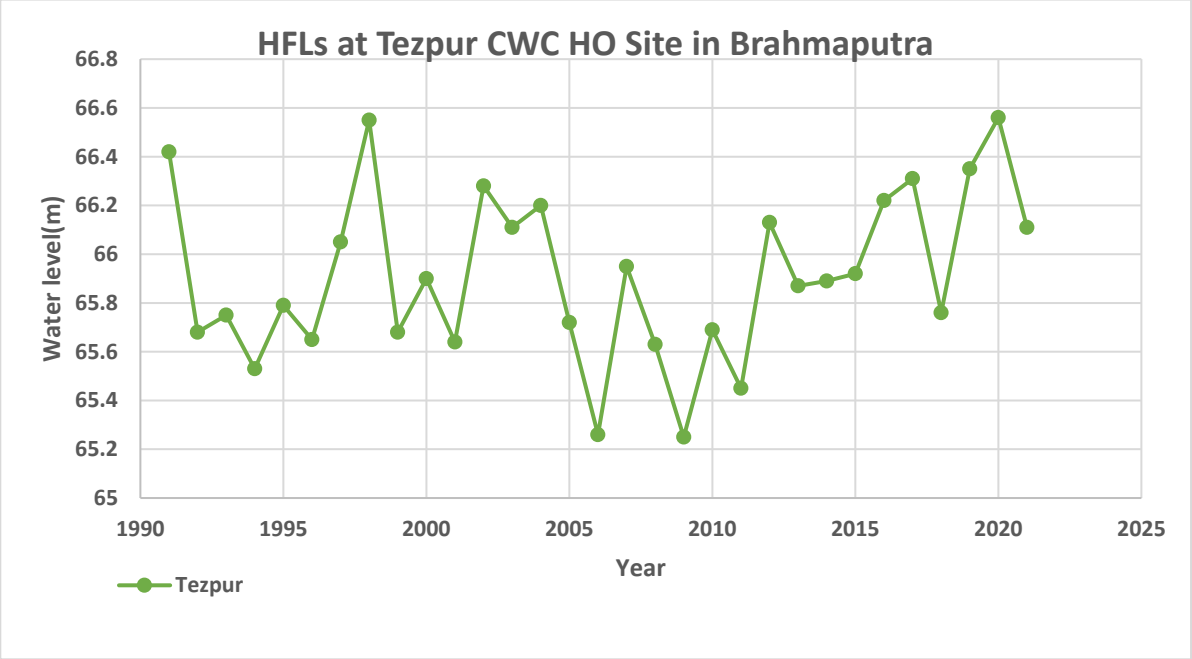


Figure 4-26: Time series plot of High Flood Levels (HFLs) at Tepur CWC HO site in Brahmaputra

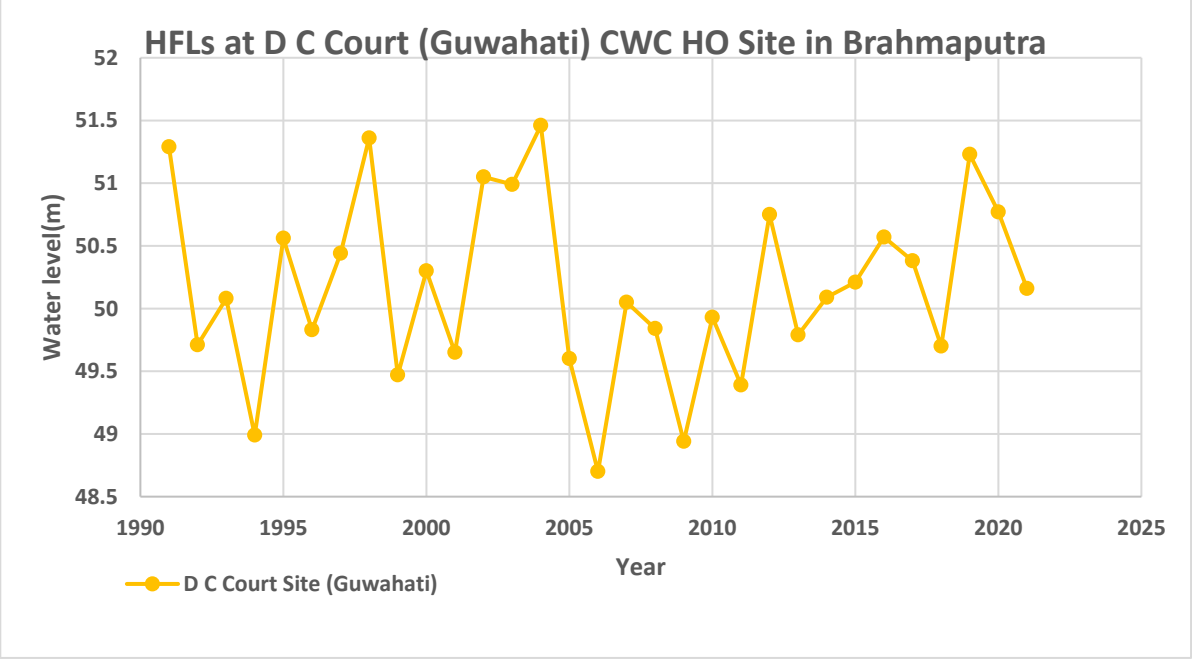


Figure 4-27: Time series plot of High Flood Levels (HFLs) at D C Court (Guwahati) CWC HO site in Brahmaputra

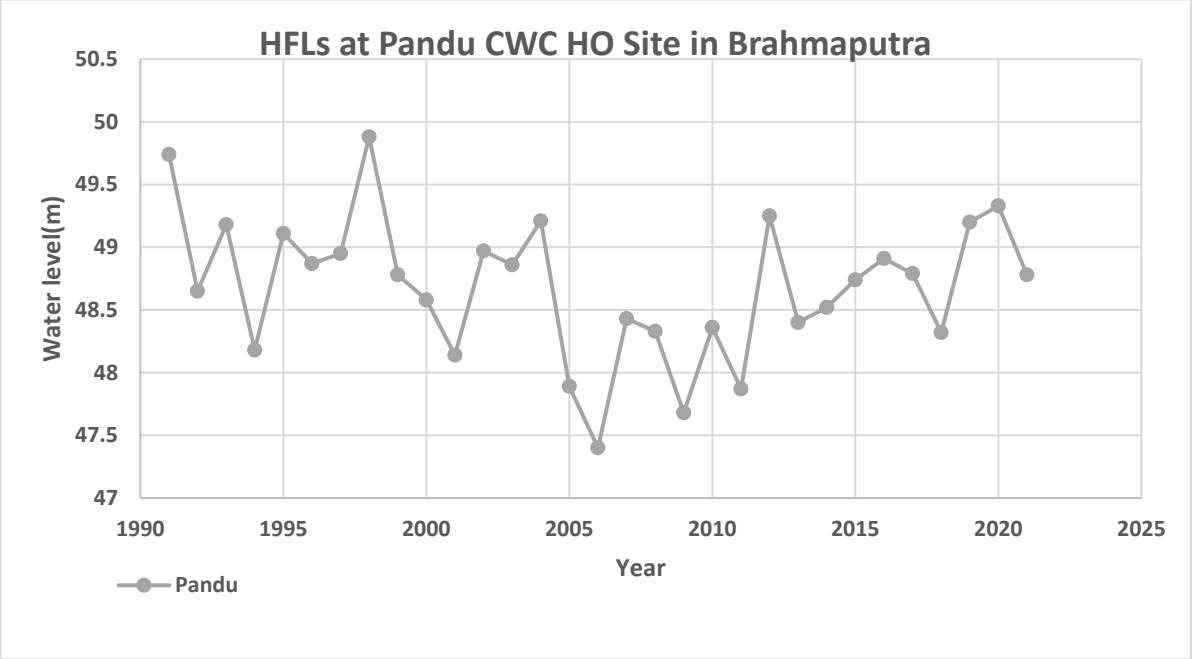


Figure 4-28: Time series plot of High Flood Levels (HFLs) at Pandu CWC HO site in Brahmaputra

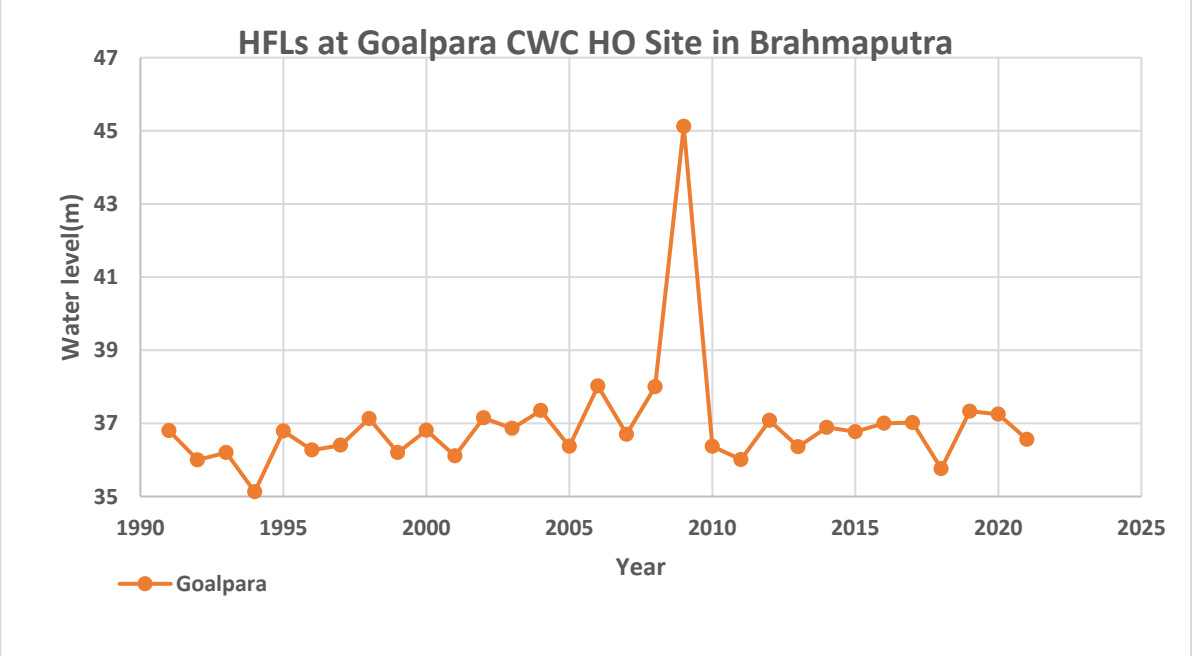


Figure 4-29: Time series plot of High Flood Levels (HFLs) at Goalpara CWC HO site in Brahmaputra

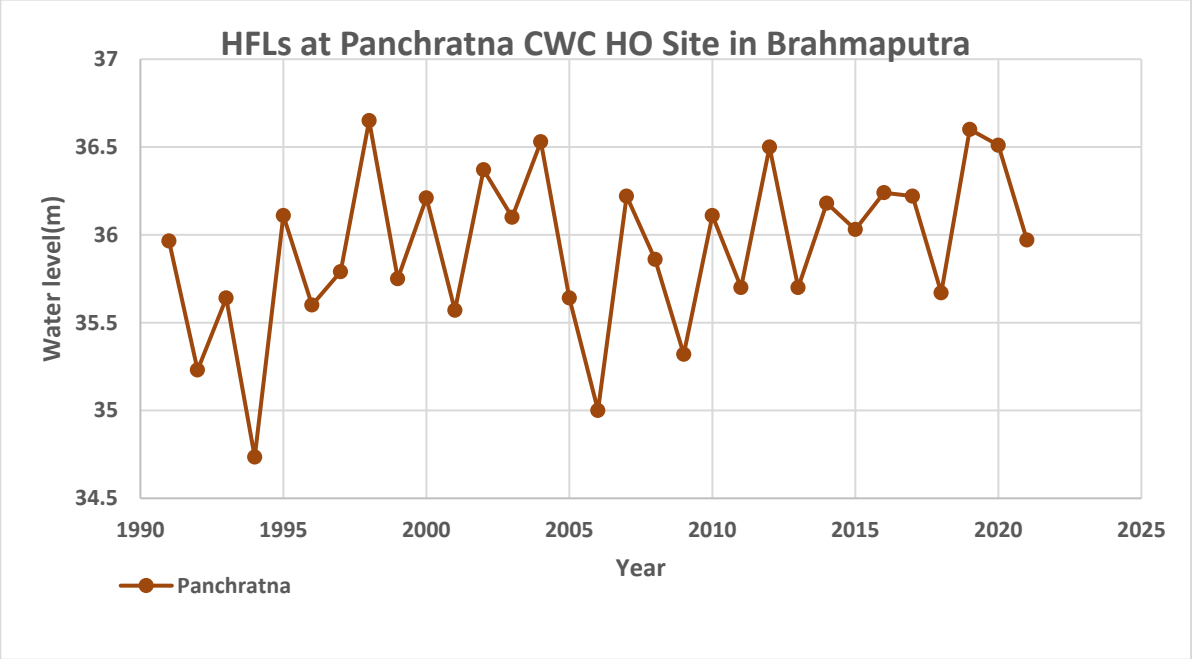


Figure 4-30: Time series plot of High Flood Levels (HFLs) at Panchratna CWC HO site in Brahmaputra

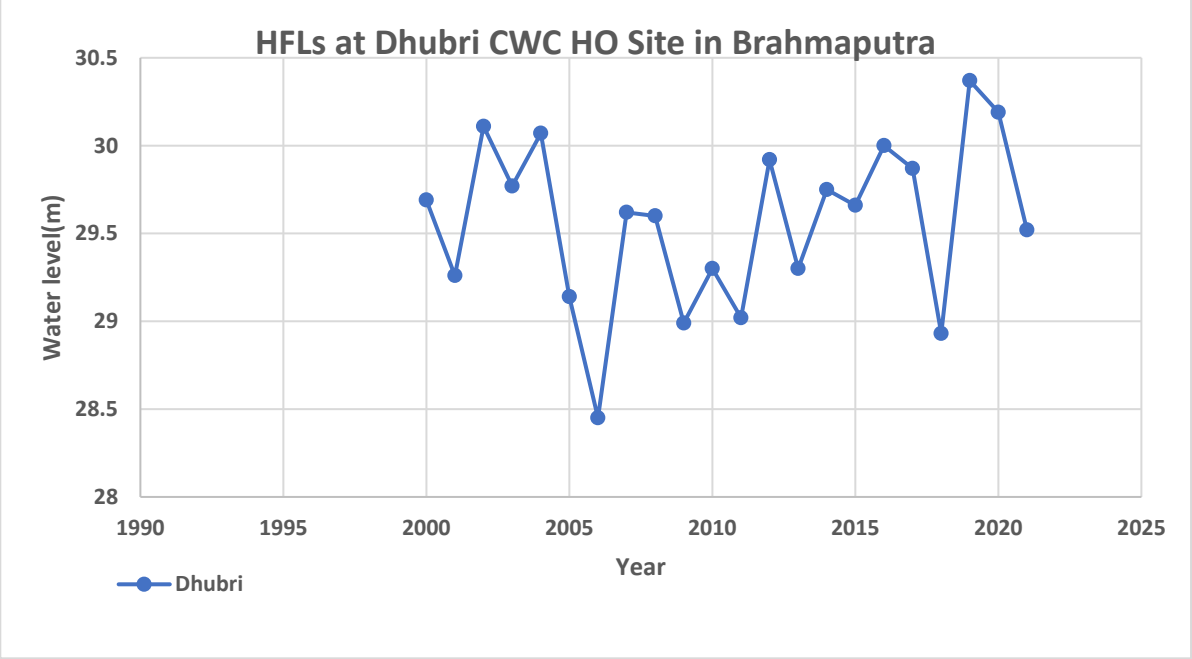


Figure 4-31: Time series plot of High Flood Levels (HFLs) at Dhubri CWC HO site in Brahmaputra

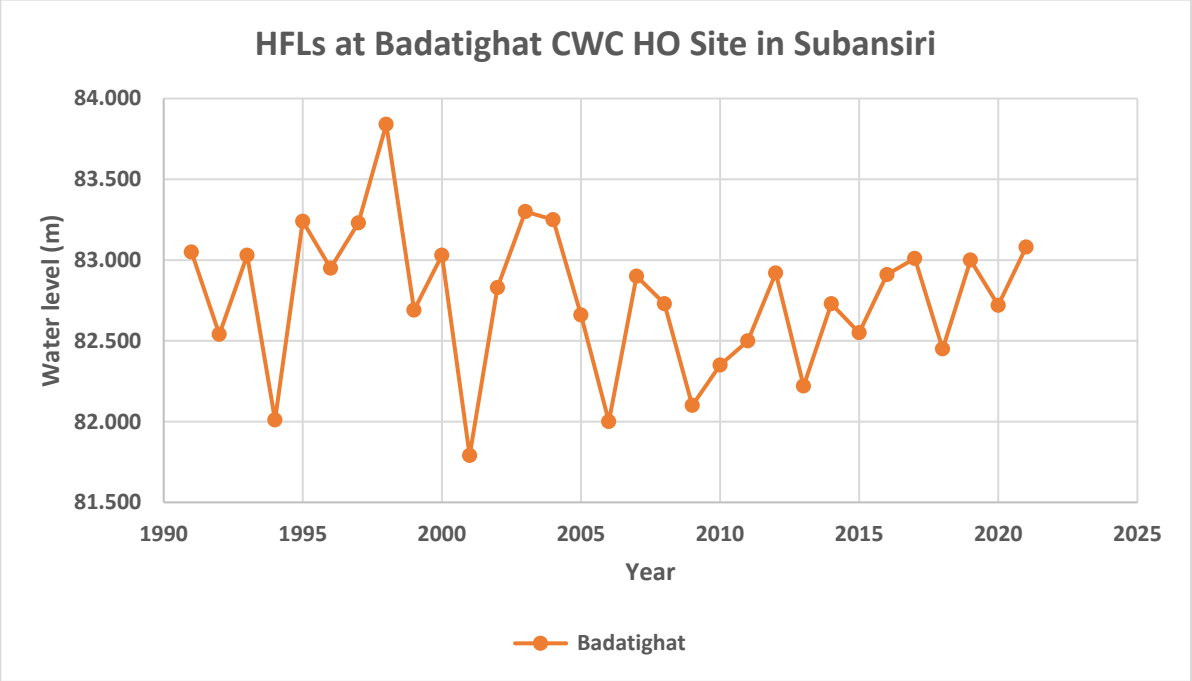


Figure 4-32: Time series plot of High Flood Levels (HFLs) at Badatighat CWC HO site in Subansiri, Brahmaputra

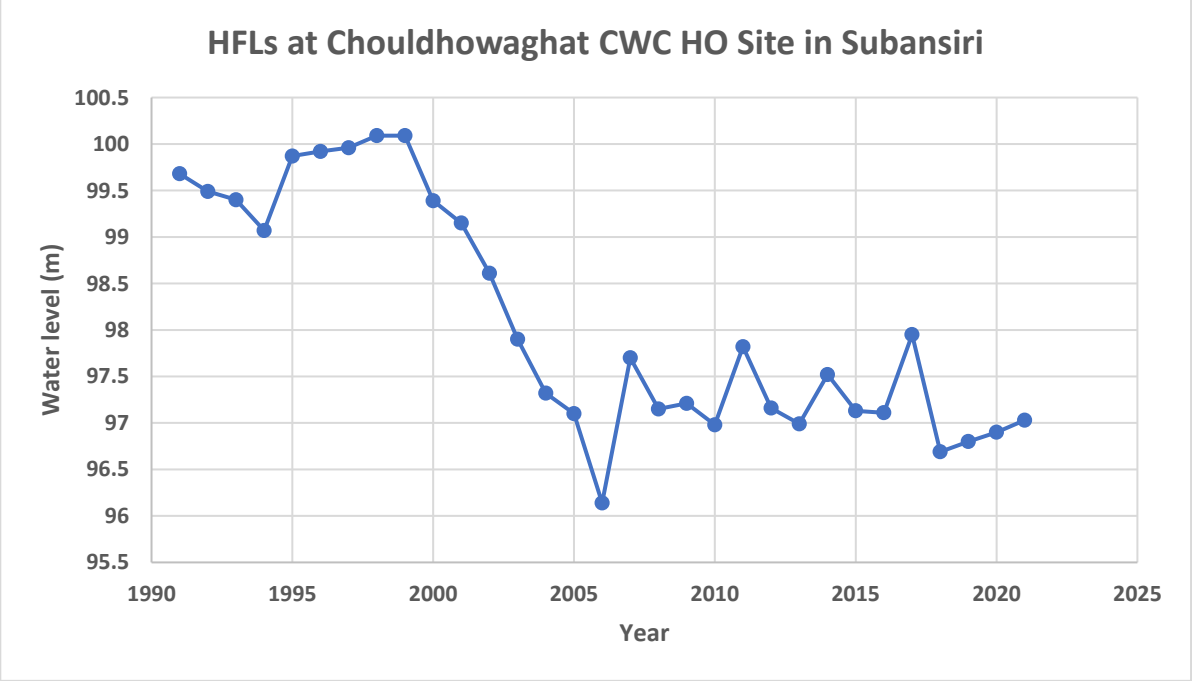


Figure 4-33: Time series plot of High Flood Levels (HFLs) at Chouldhowaghat CWC HO site in Subansiri, Brahmaputra

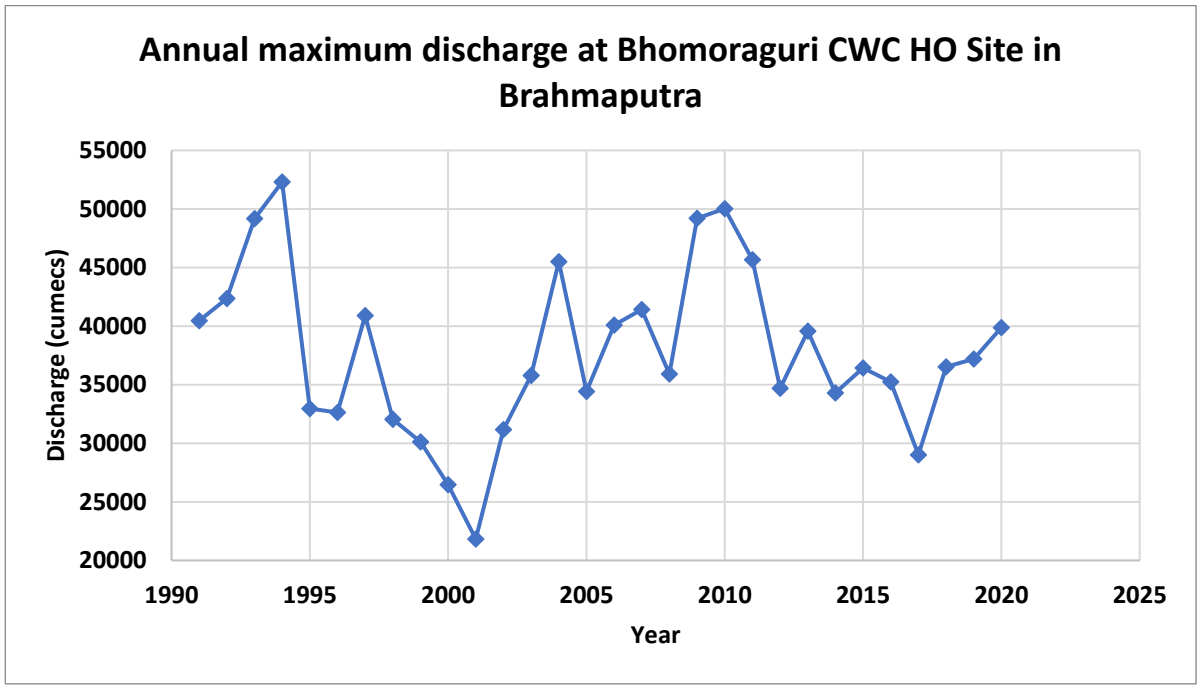


Figure 4-34: Time series plot of High Flood Levels (HFLs) at Chouldhowaghat CWC HO site in Subansiri, Brahmaputra

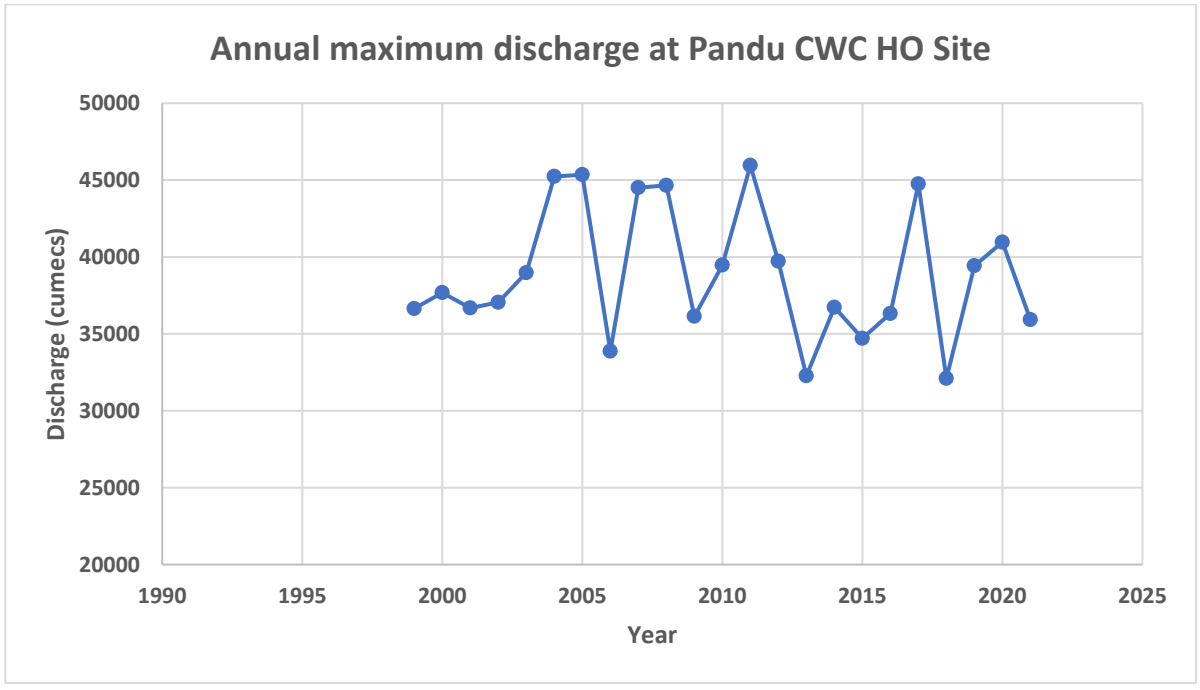


Figure 4-35: Time series plot of annual maximum discharge at Pandu CWC HO site in Brahmaputra (1999 to 2021 of CWC data)

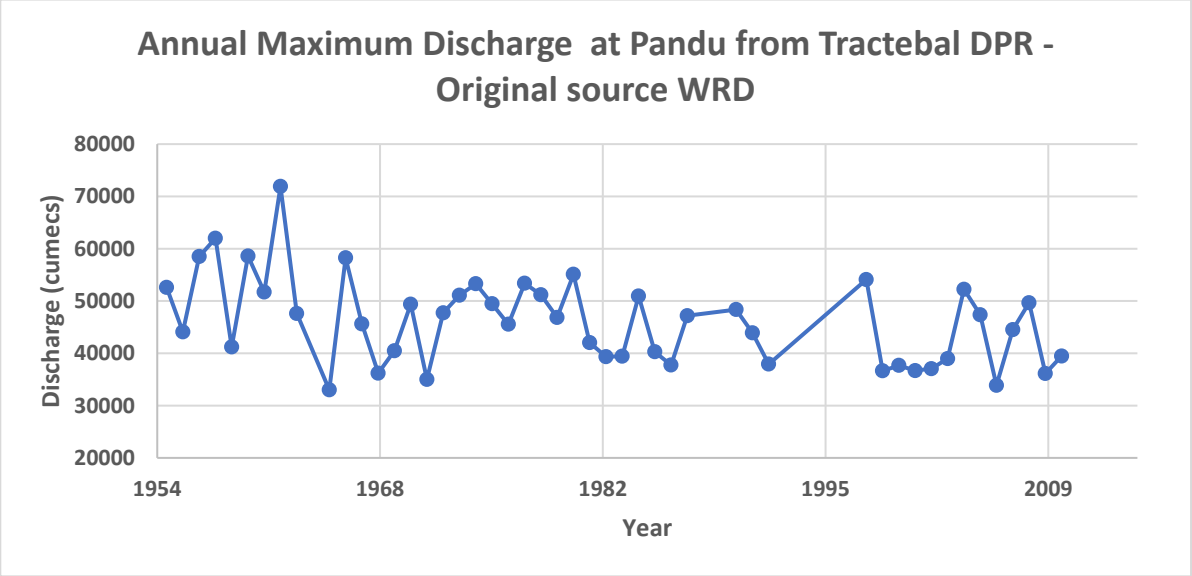


Figure 4-36: Time series plot of annual maximum discharge at Pandu CWC HO site in Brahmaputra (1955 to 2021 of combined CWC and WRD data)

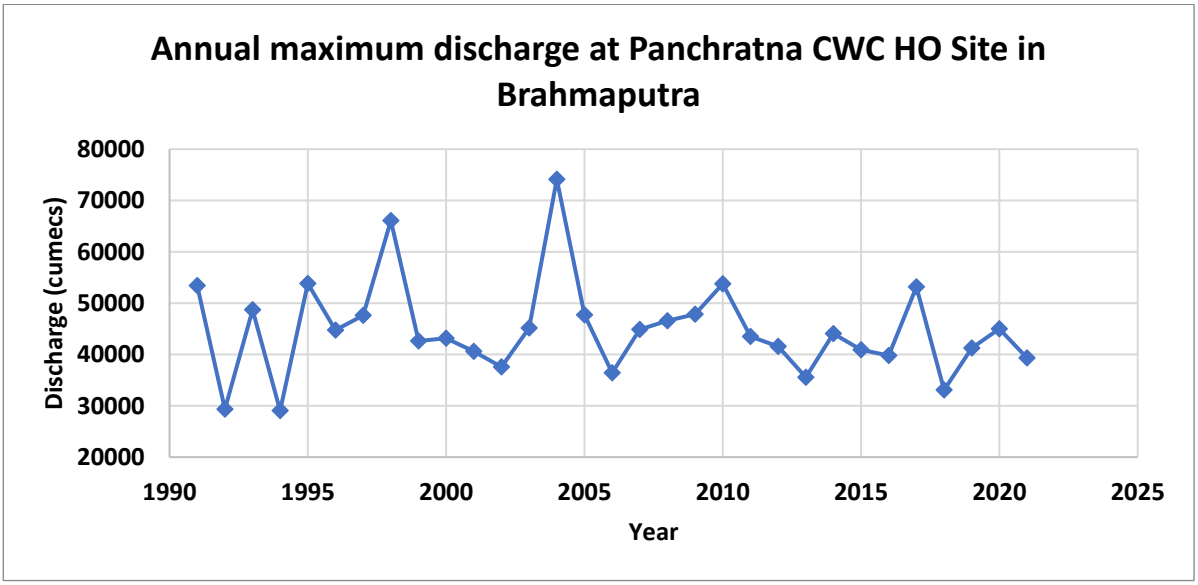


Figure 4-37: Time series plot of annual maximum discharge at Pancharatna CWC HO site in Brahmaputra

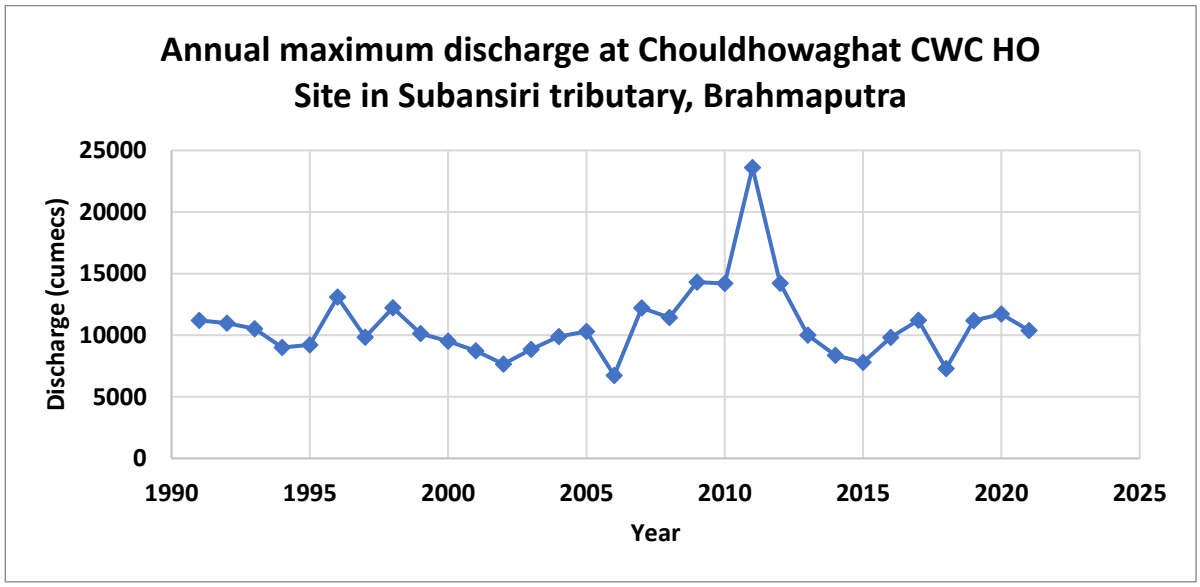


Figure 4-38: Time series plot of annual maximum discharge at Chouldhowaghat CWC HO site in Subansiri, Brahmaputra

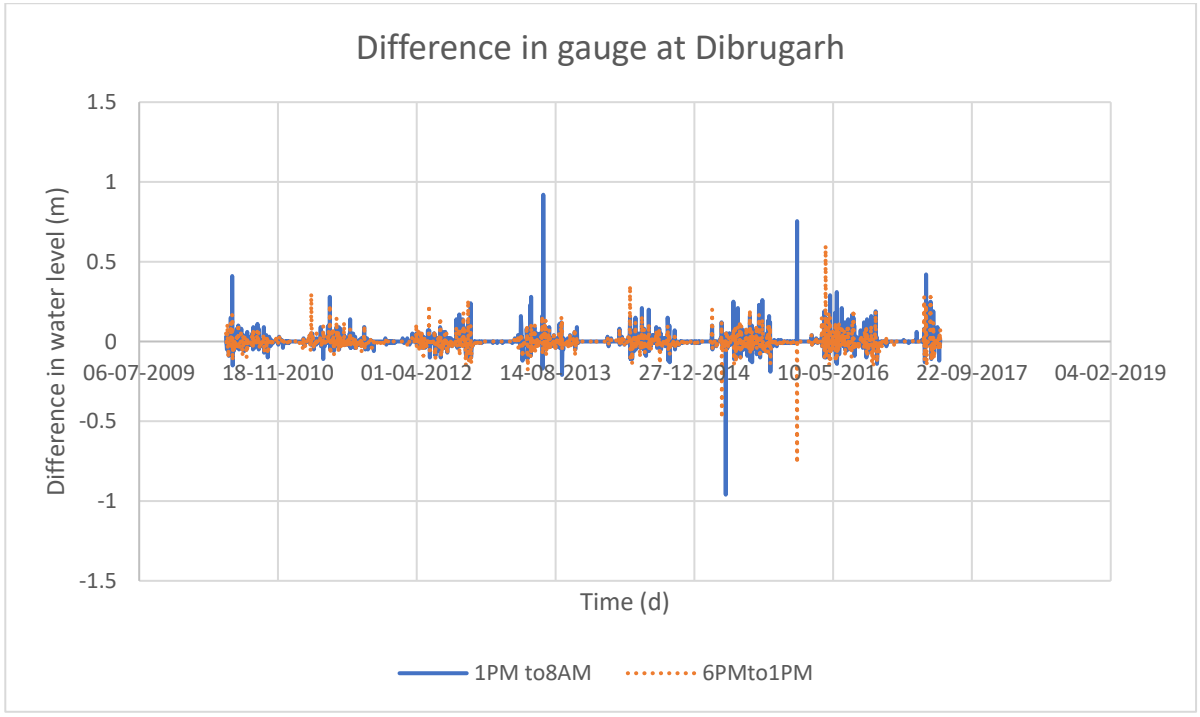


Figure 4-39 Calculated difference in water level between 1PM to 8AM, & 6PM to 1PM at Dibrugarh site (data source: CWC)

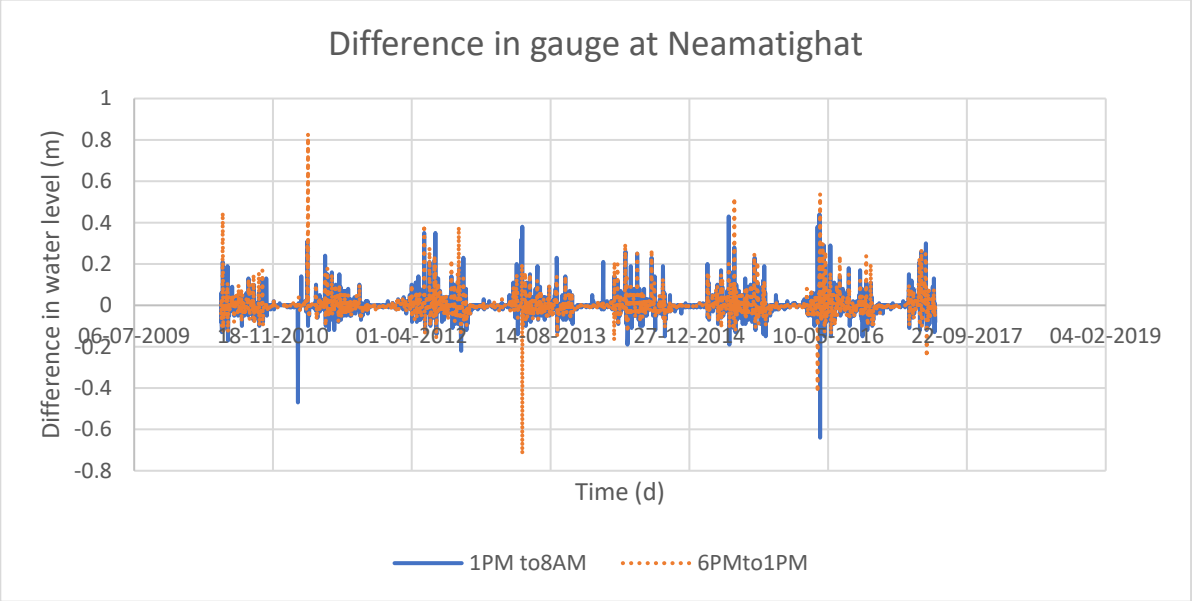


Figure 4-40: Calculated difference in water level between 1PM to 8AM, & 6PM to 1PM at Neamatighat site (data source: CWC)

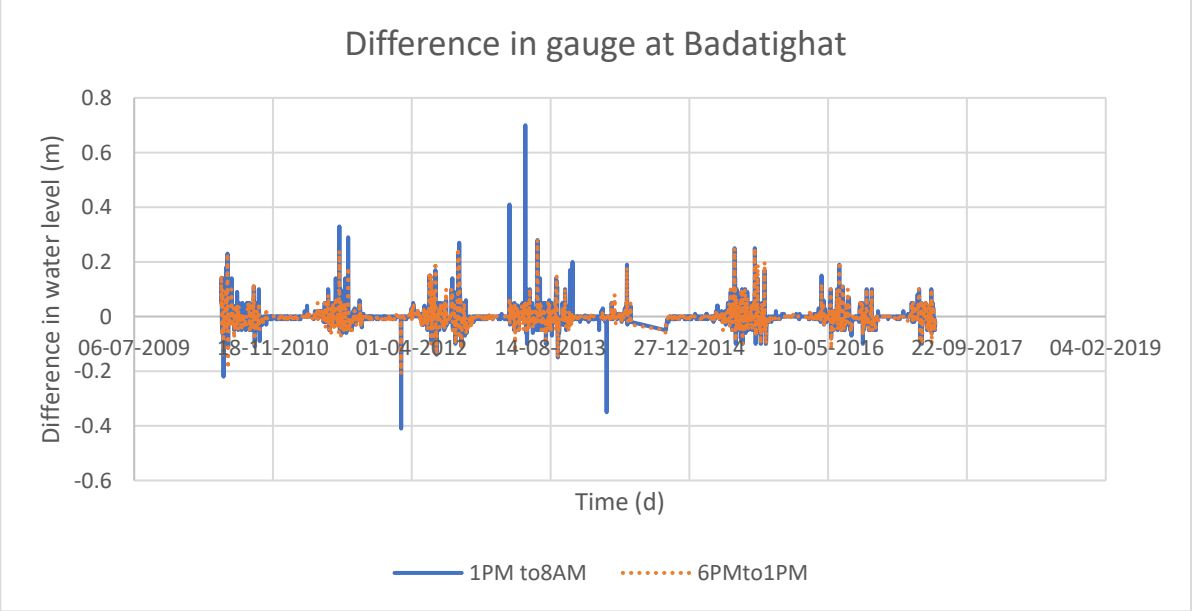


Figure 4-41 Calculated difference in water level between 1PM to 8AM, & 6PM to 1PM at Badatighat site (data source: CWC)

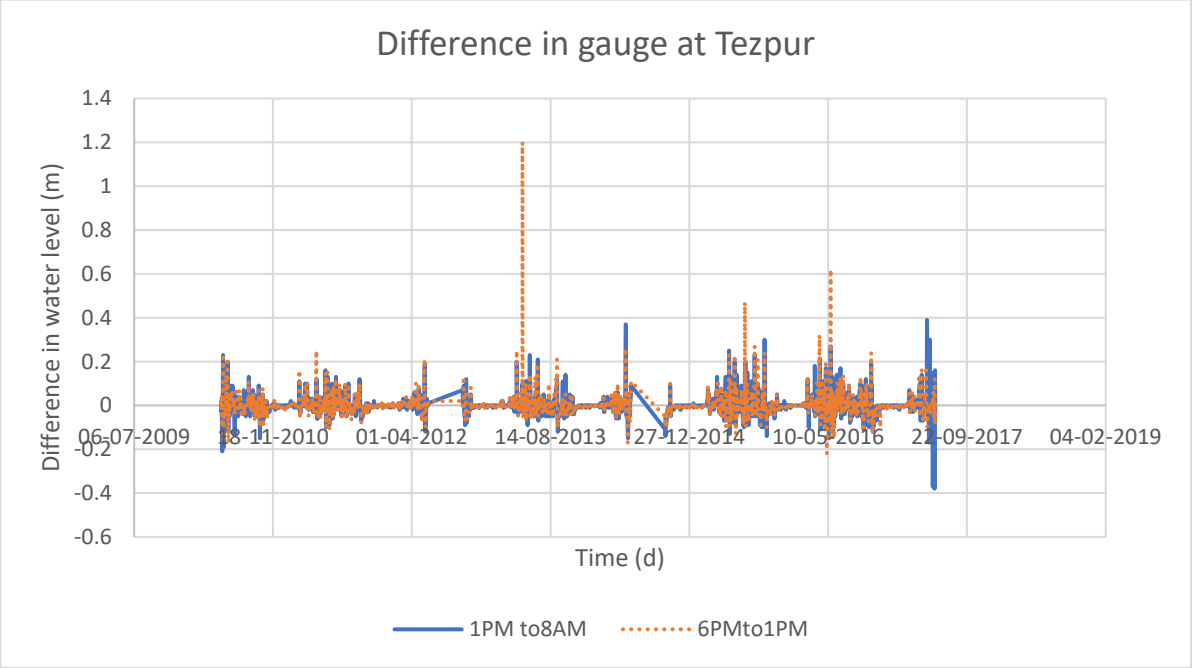


Figure 4-42 Calculated difference in water level between 1PM to 8AM, & 6PM to 1PM at Tezpur site (data source: CWC)

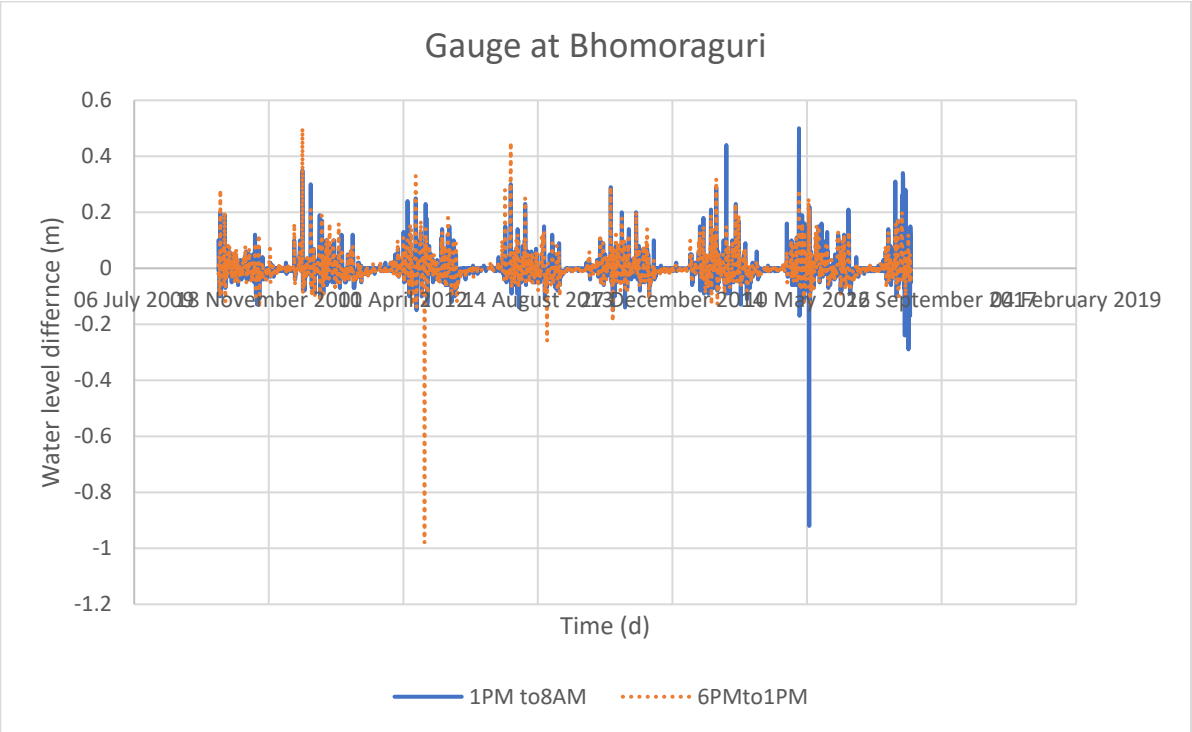


Figure 4-43 Calculated difference in water level between 1PM to 8AM, & 6PM to 1PM at Bhomoraguri site (data source: CWC)

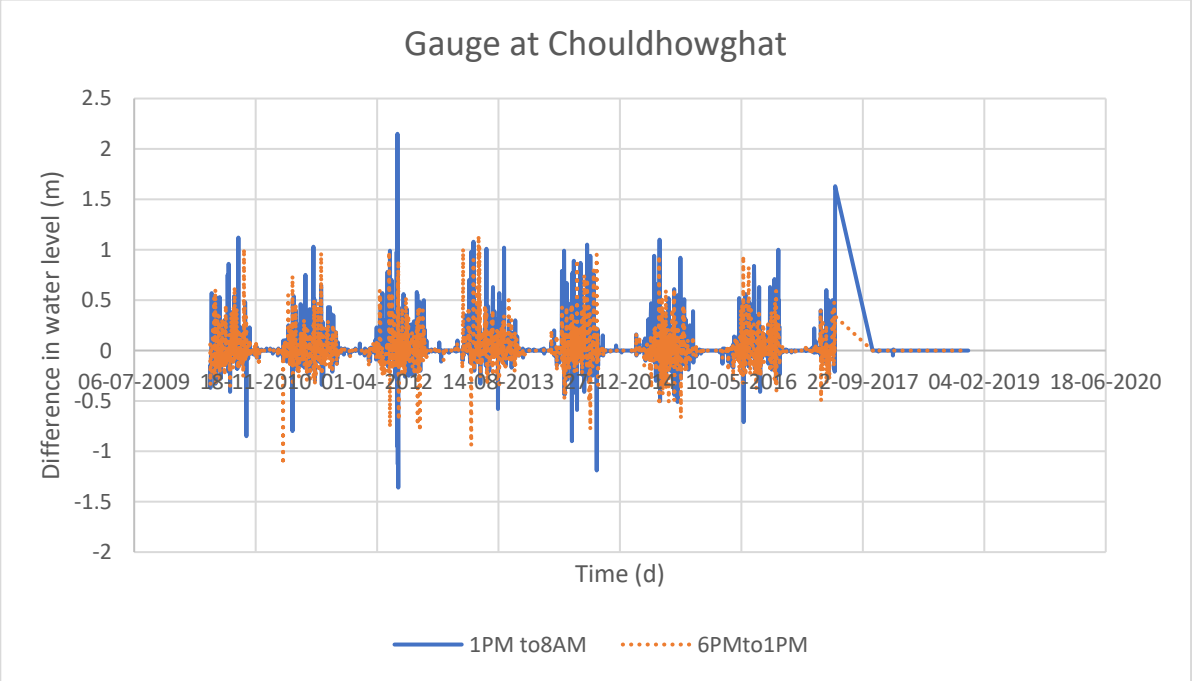


Figure 4-44: Calculated difference in water level between 1PM to 8AM, & 6PM to 1PM at Chouldhowaghat site (data source: CWC)

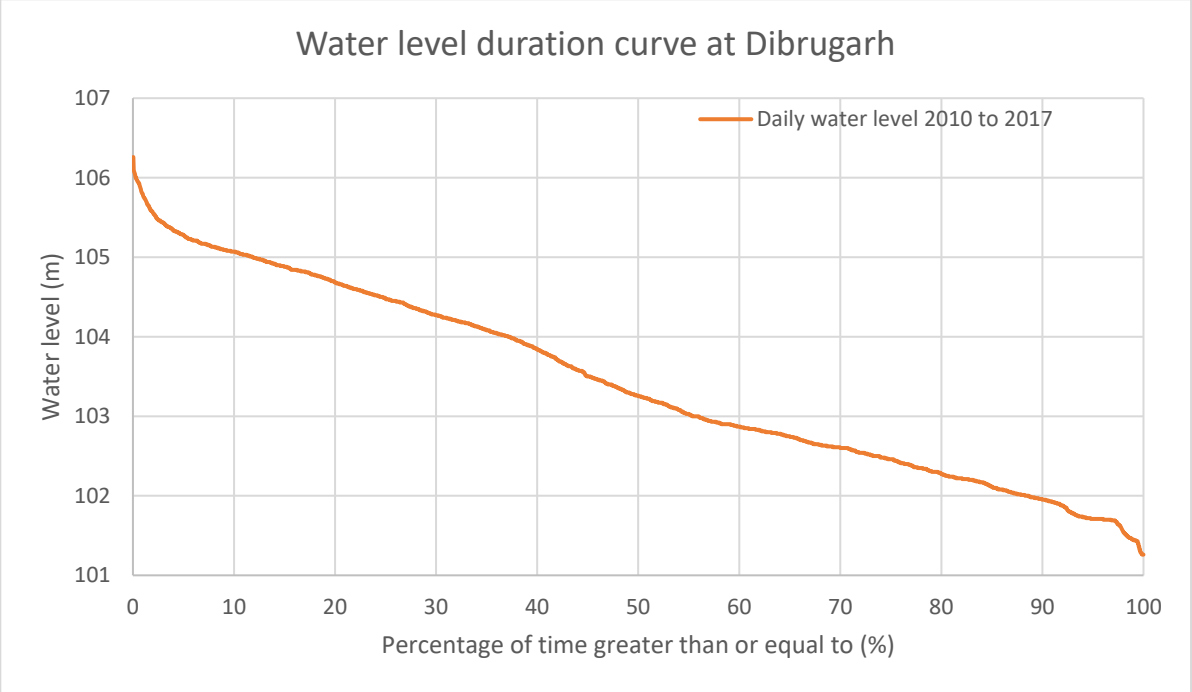


Figure 4-45: Water level duration curve at Dibrugarh between 2010 and 2017 (Data source: CWC)

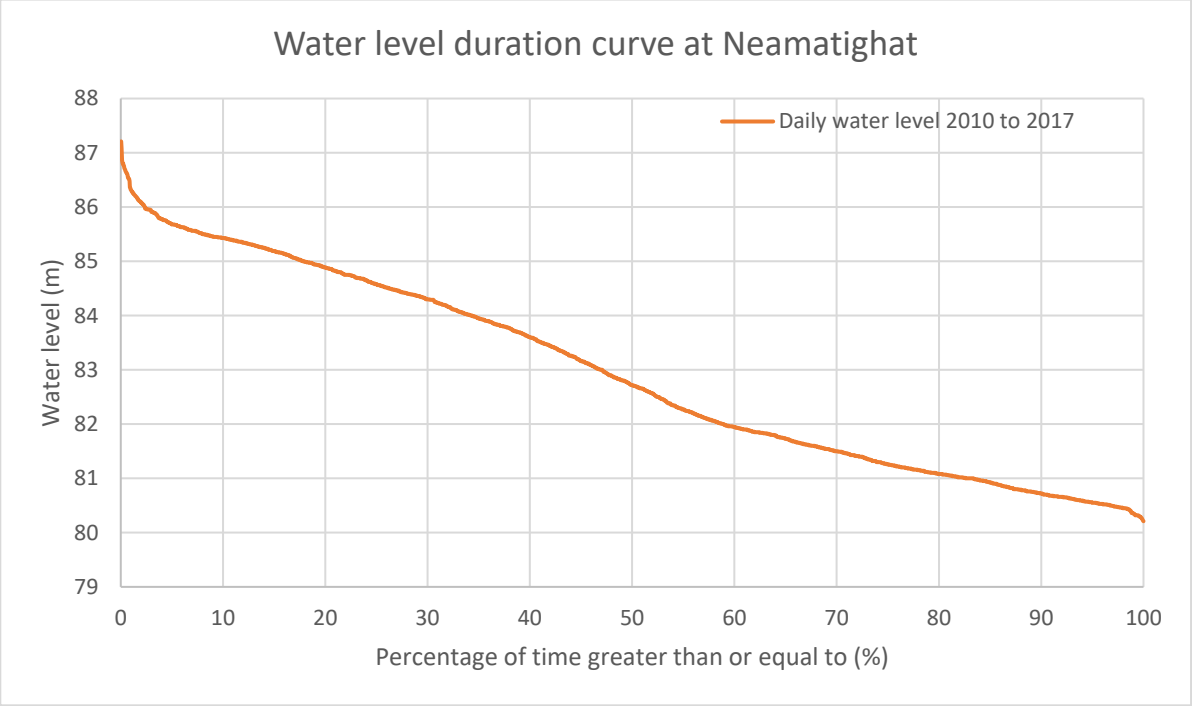


Figure 4-46 Water level duration curve at Neamatighat between 2010 and 2017 (Data source: CWC)

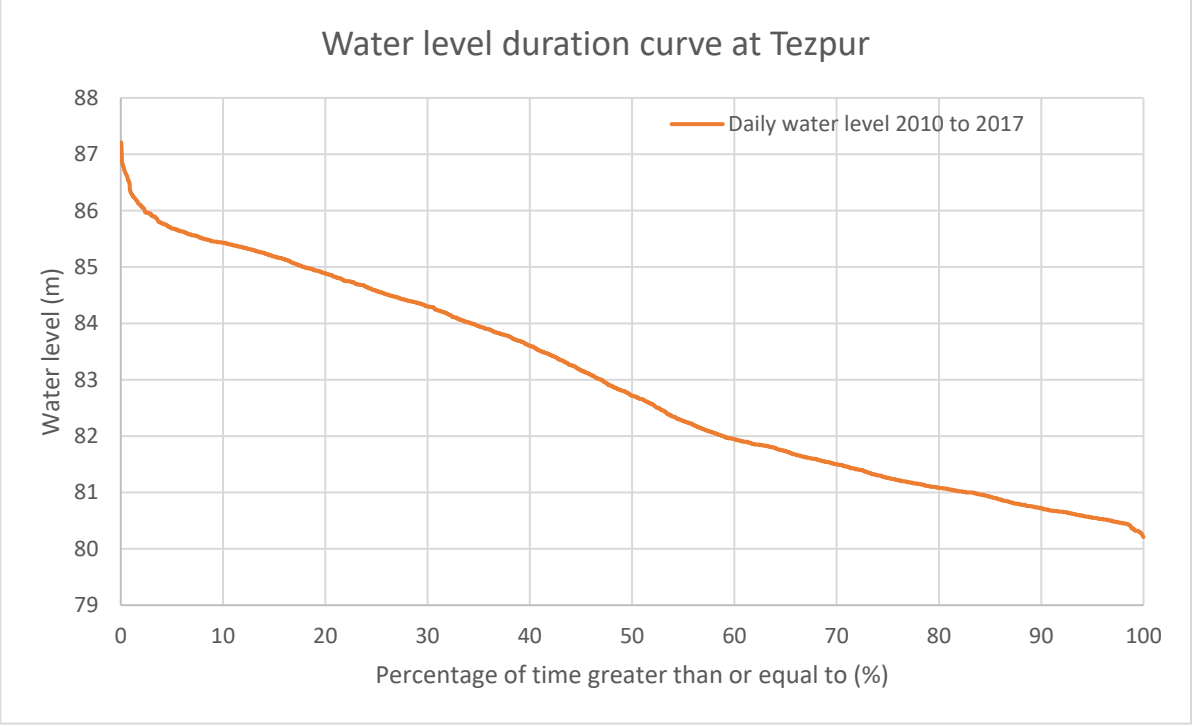


Figure 4-47: Water level duration curve at Tezpur between 2010 and 2017 (Data source: CWC)

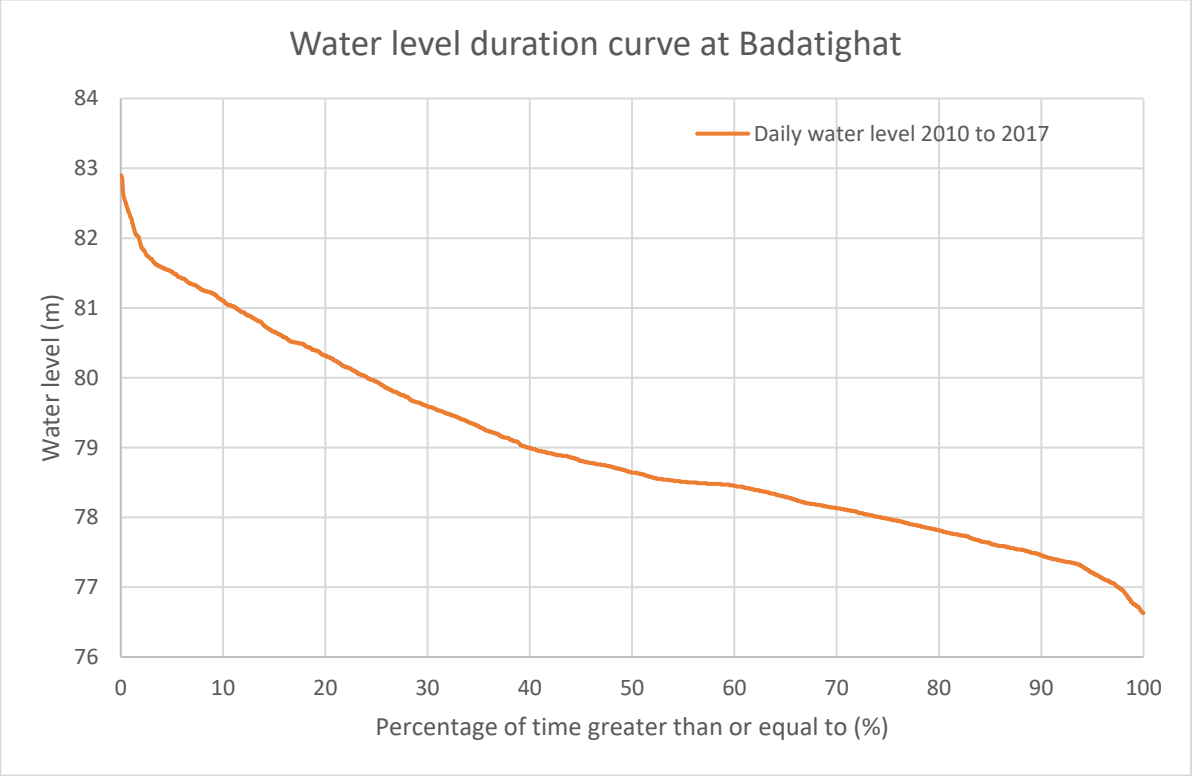


Figure 4-48Water level duration curve at Badaighat between 2010 and 2017 (Data source: CWC)

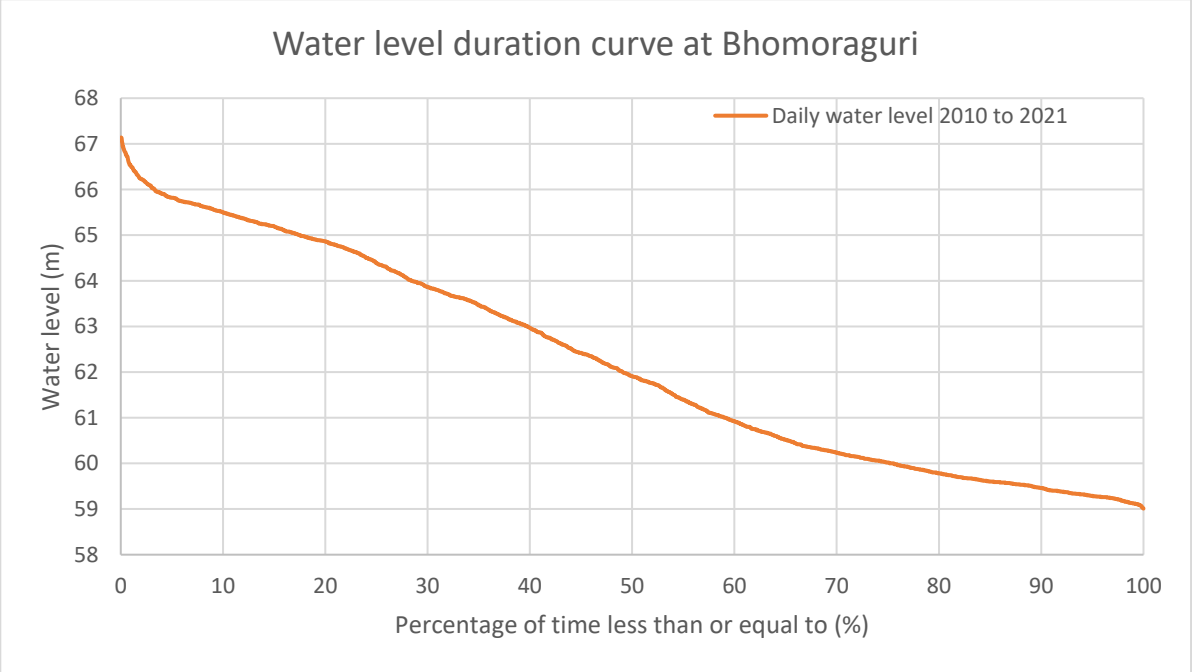


Figure 4-49: Water level duration curve at Bhomoraguri between 2010 and 2021 (Data source: CWC)

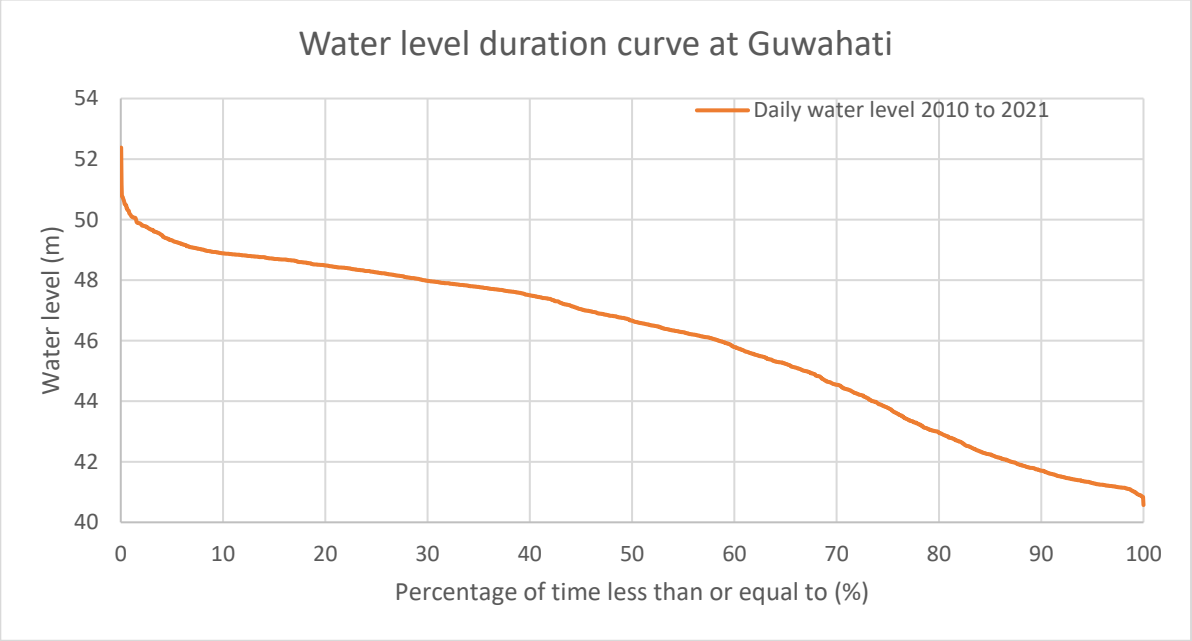


Figure 4-50: Water level duration curve at Guwahati between 2010 and 2021 (Data source: CWC)

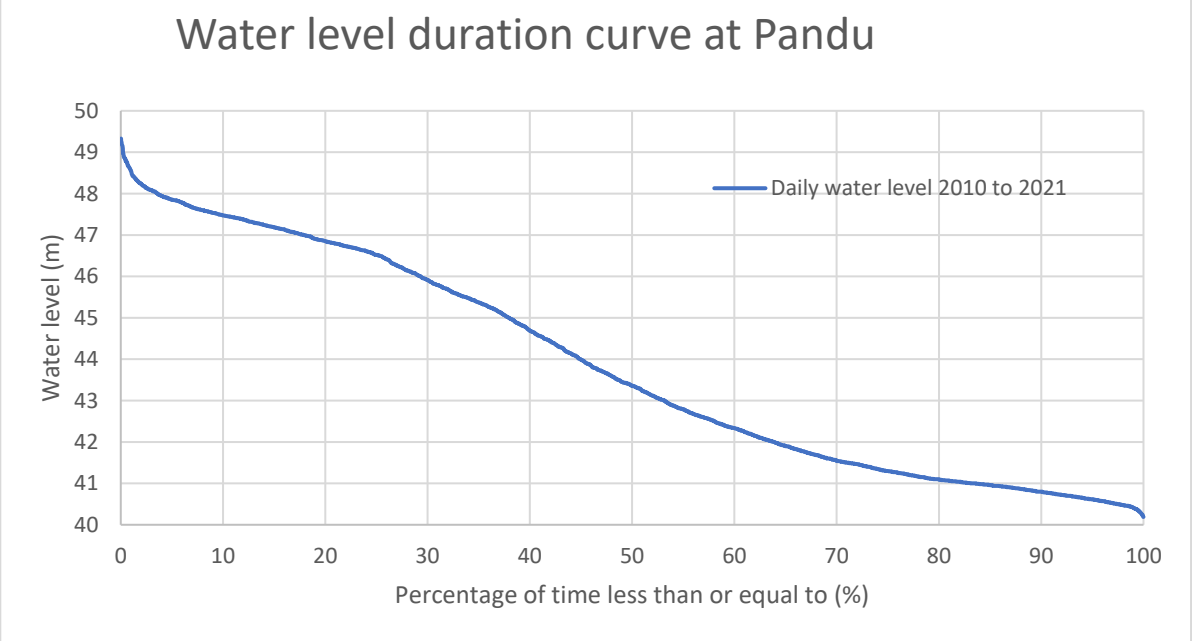


Figure 4-51Water level duration curve at Pandu between 2010 and 2021 (Data source: CWC)

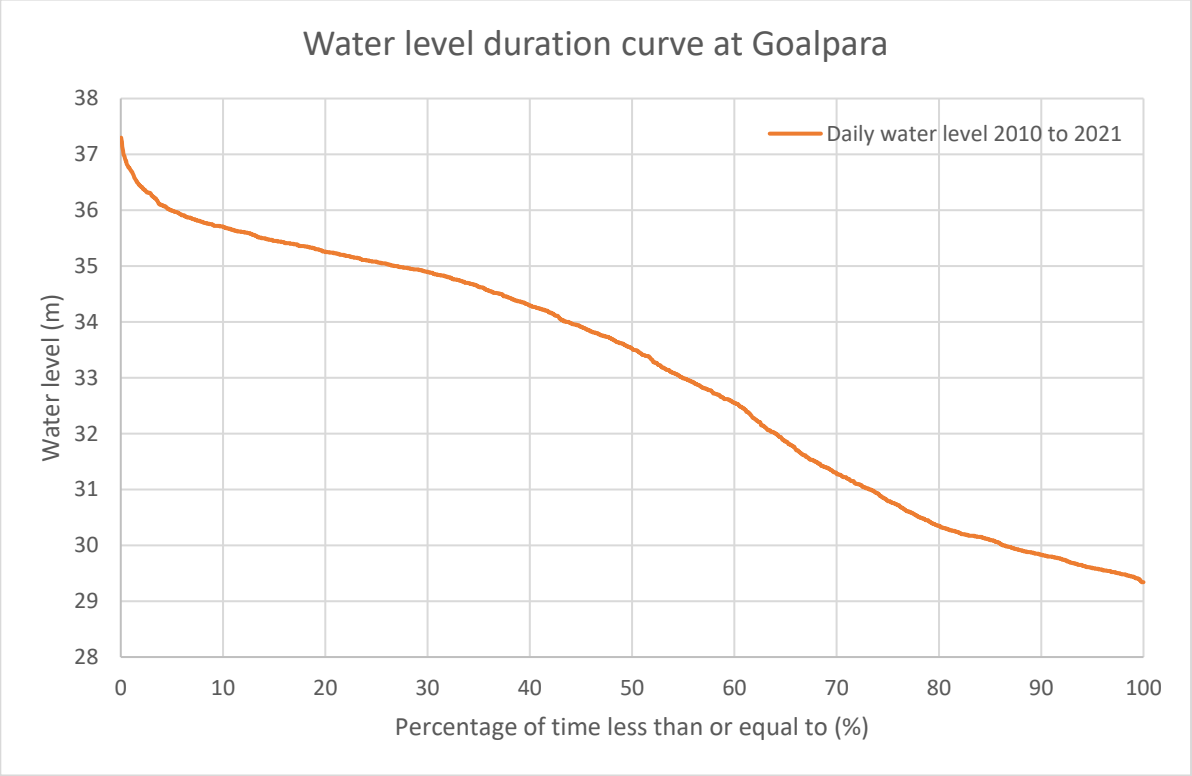


Figure 4-52: Water level duration curve at Goalpara between 2010 and 2021 (Data source: CWC)

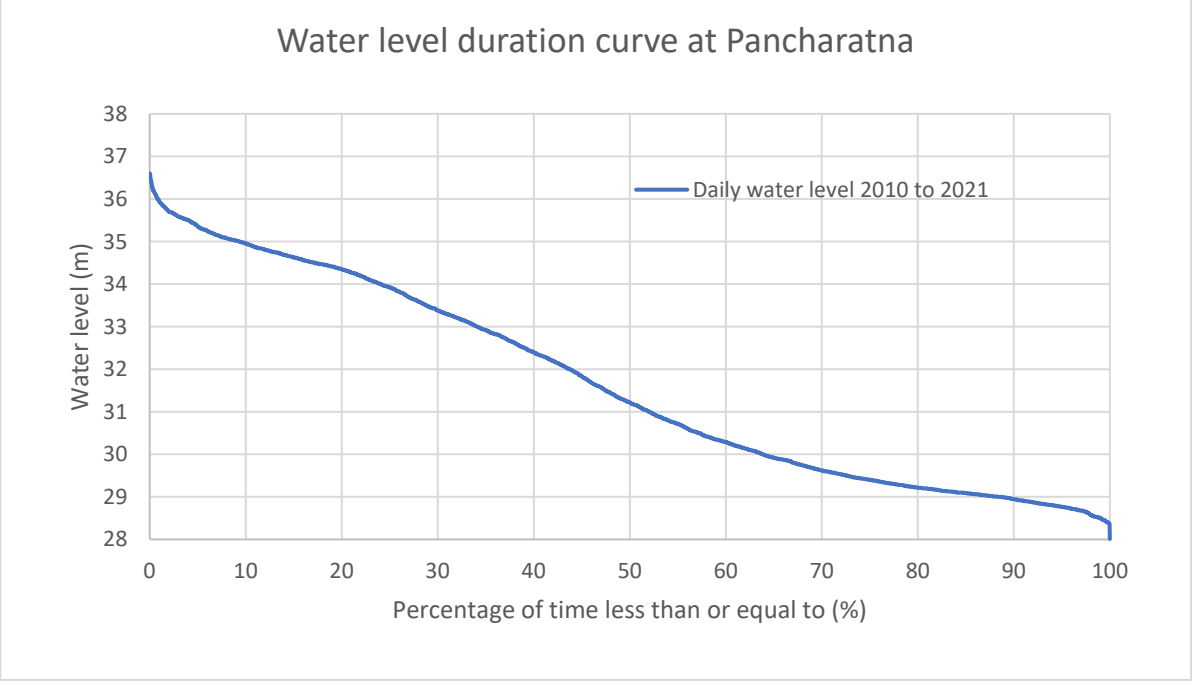


Figure 4-53: Water level duration curve at Pancharatna between 2010 and 2021 (Data source: CWC)

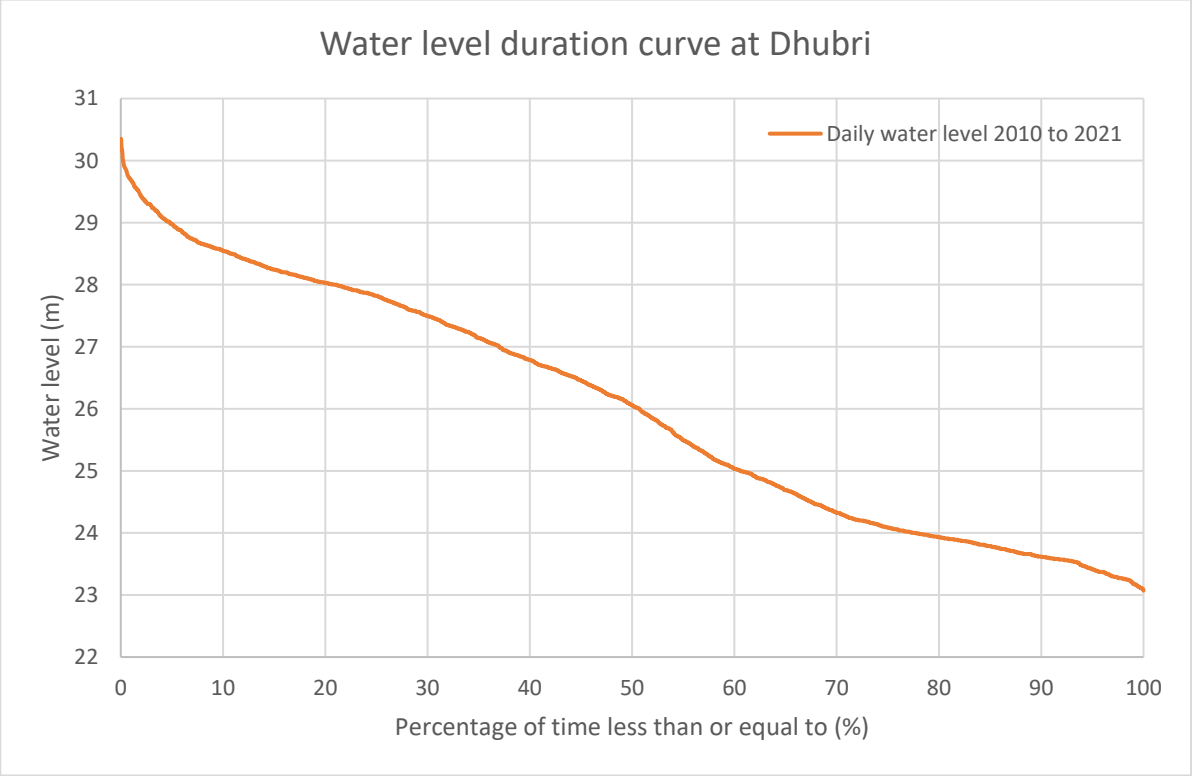


Figure 4-54: Water level duration curve at Dhubri between 2010 and 2021 (Data source: CWC)

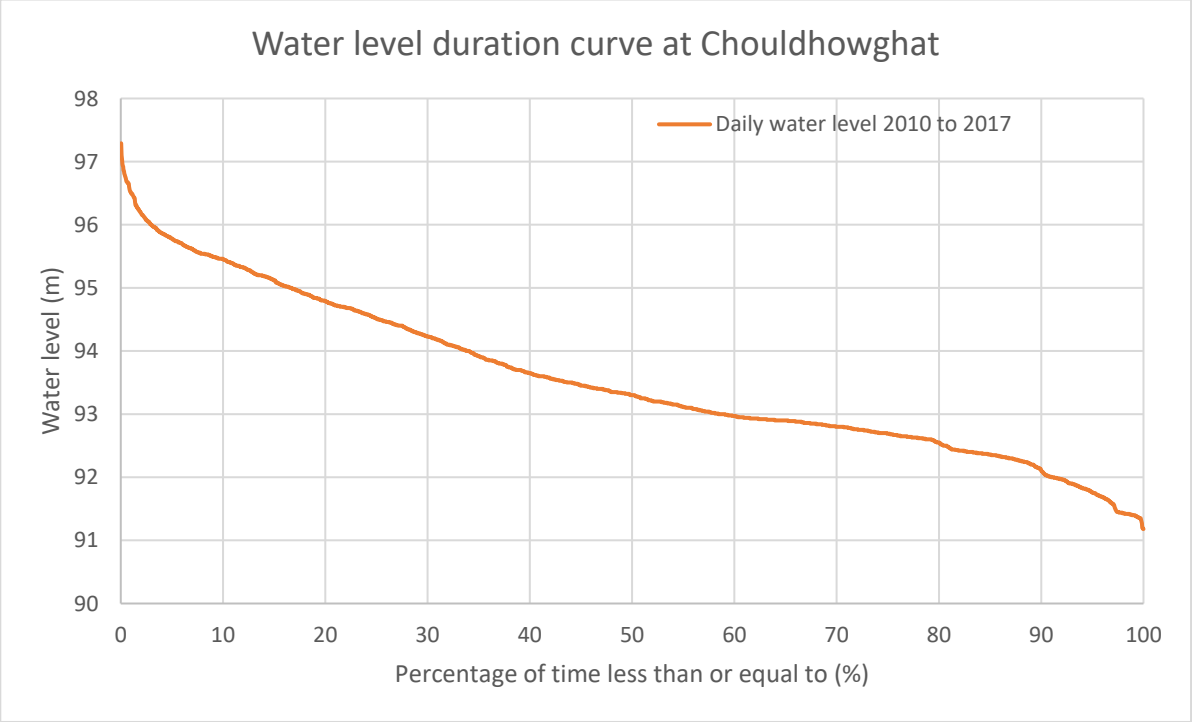


Figure 4-55: Water level duration curve at Chouldhowaghat between 2010 and 2017 (Data source: CWC)

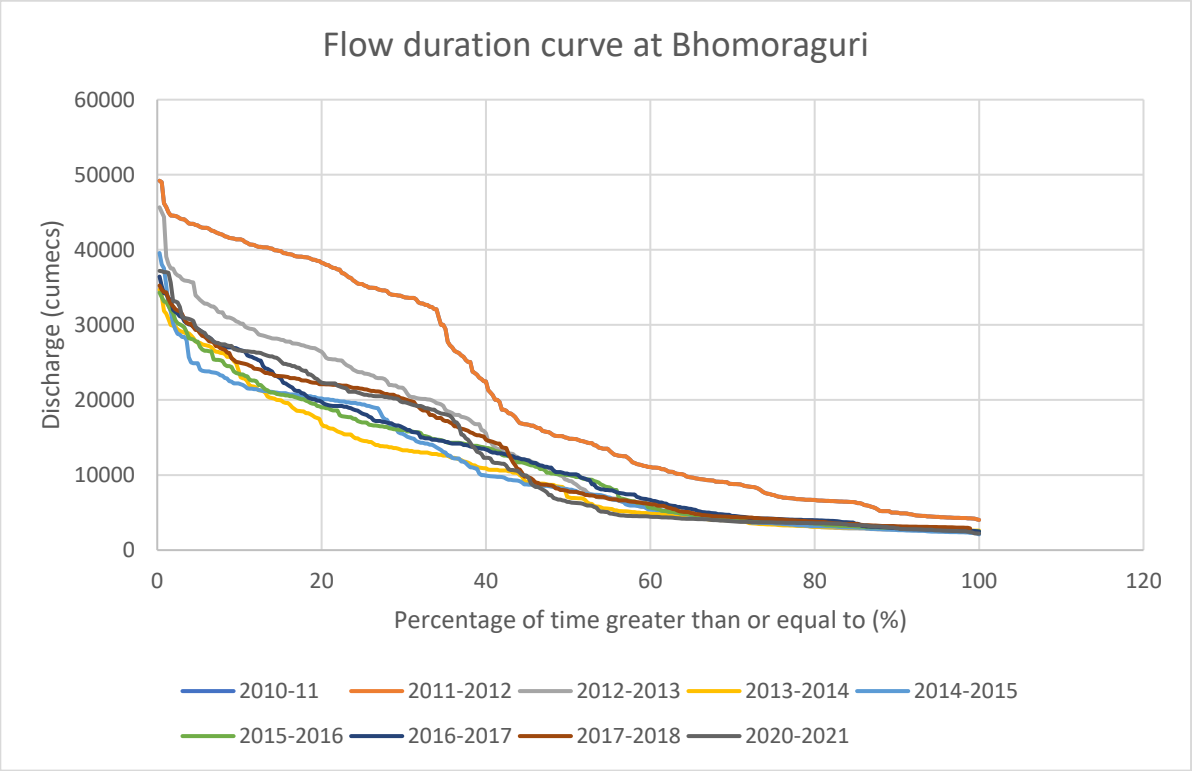


Figure 4-56: Flow duration curve at Bhomoraguri between 2010 and 2021 (Data source: CWC)

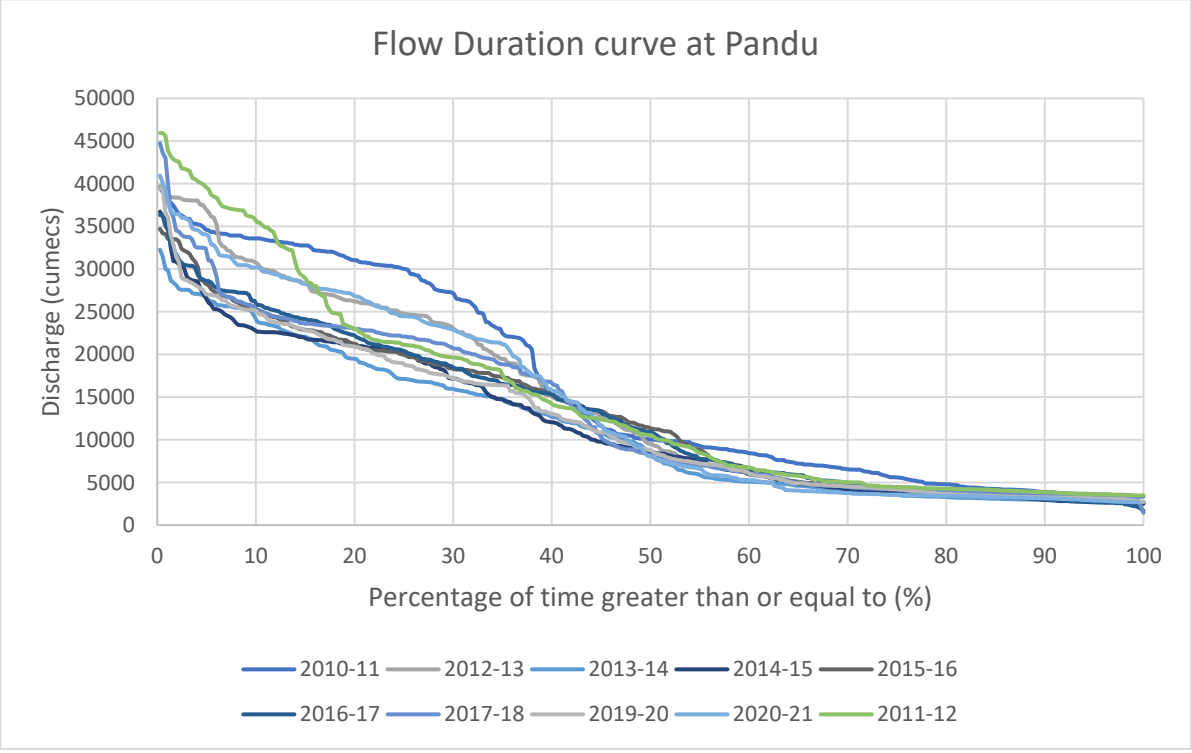


Figure 4-57: Flow duration curve at Pandu between 2010 and 2021 (Data source: CWC)

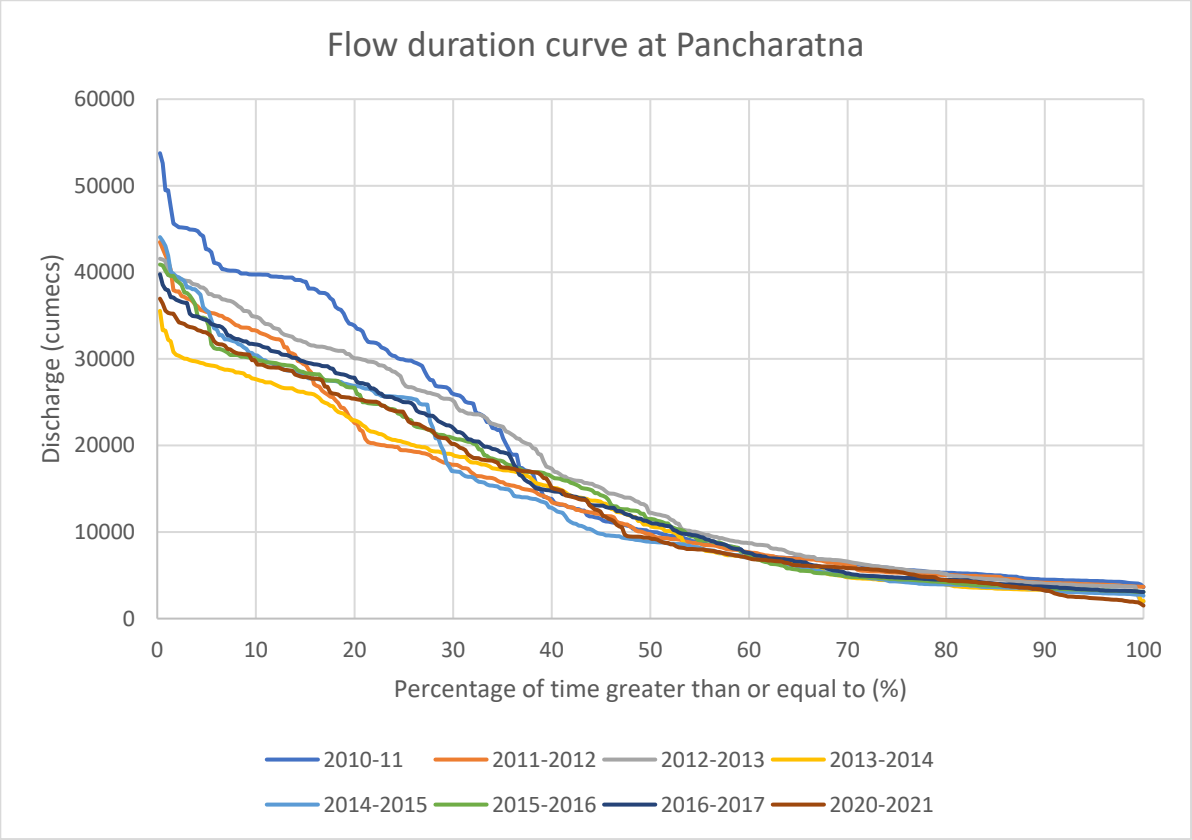


Figure 4-58: Flow duration curve at Pancharatna between 2010 and 2021 (Data source: CWC)

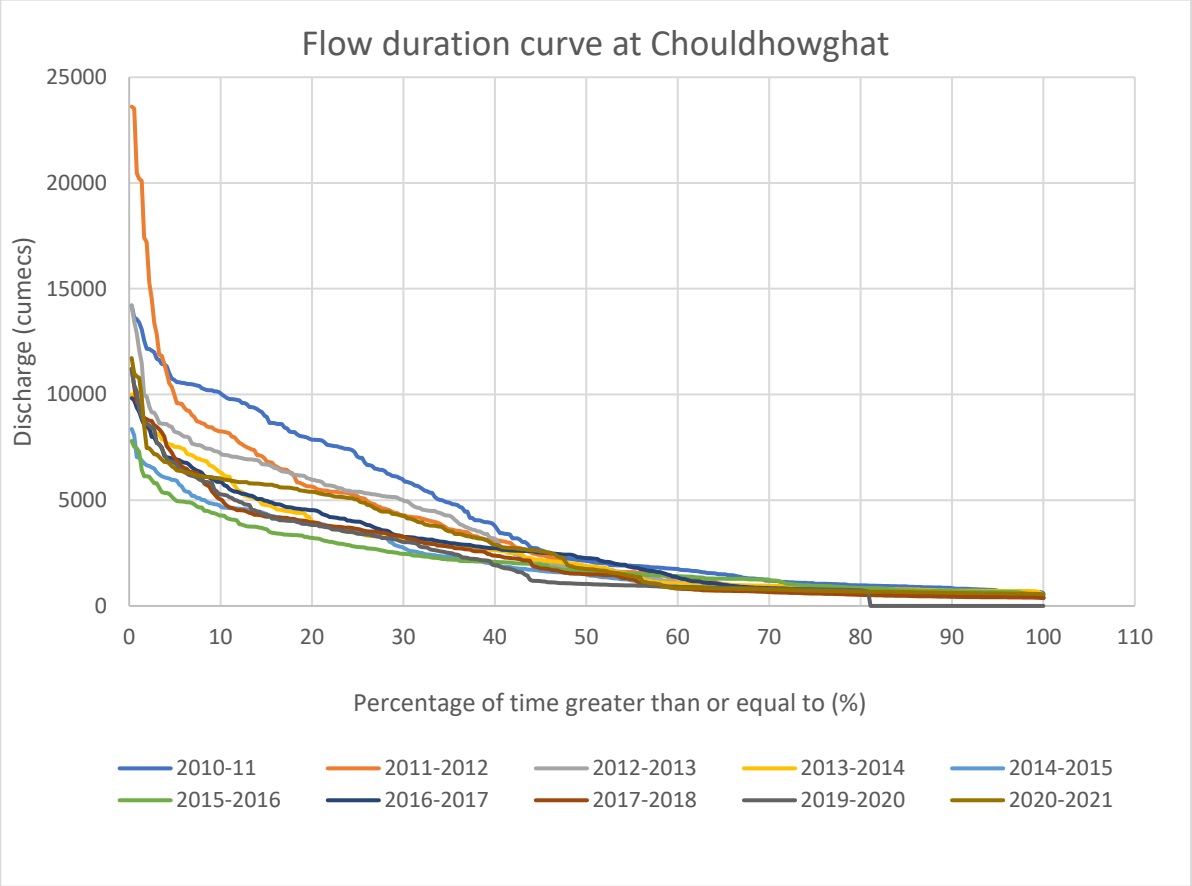


Figure 4-59 Flow duration curve at Chouldhowaghat between 2010 and 2021 (Data source: CWC)

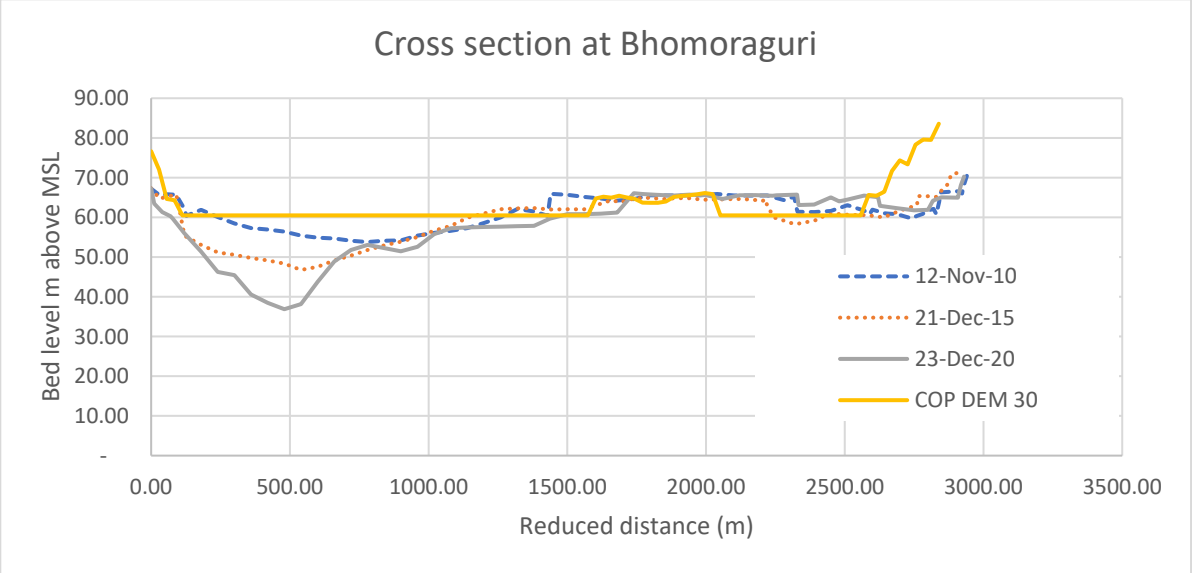


Figure 4-60Temporal variation of cross-section at CWC Ho Site Bhomoraguri and its comparison with Copernicu/Sentinnel DEM derived cross-section

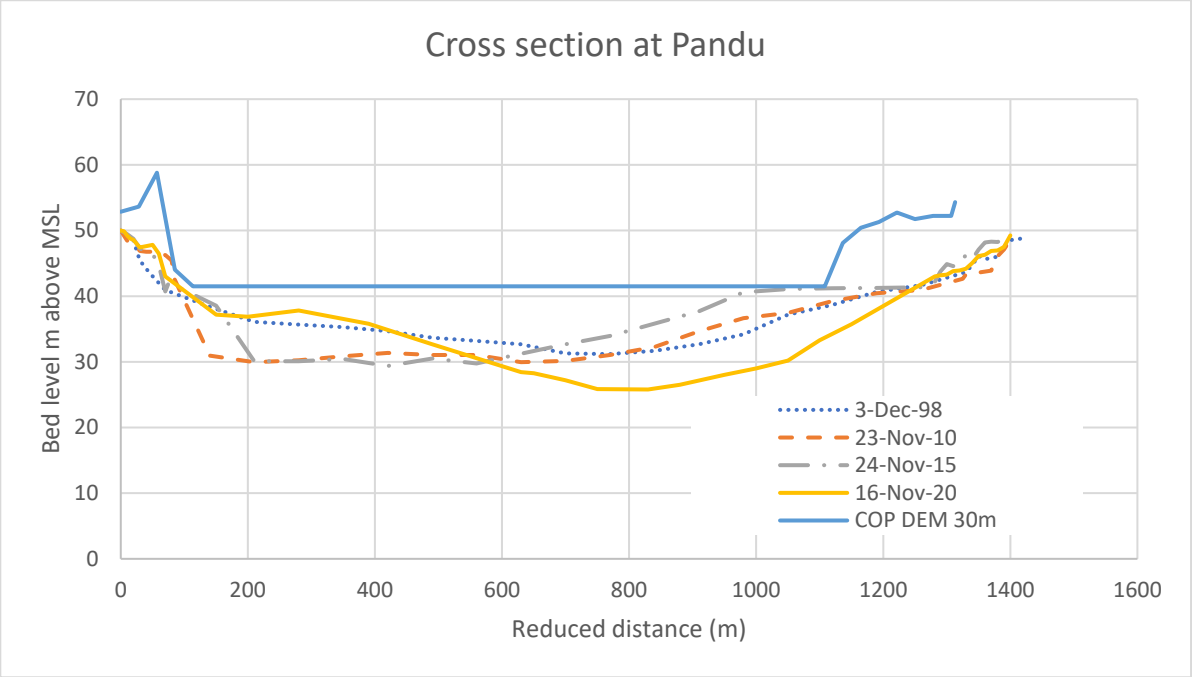


Figure 4-61: Temporal variation of cross-section at CWC Ho Site Pandu and its comparison with Copernicu/Sentinnel DEM derived cross-section

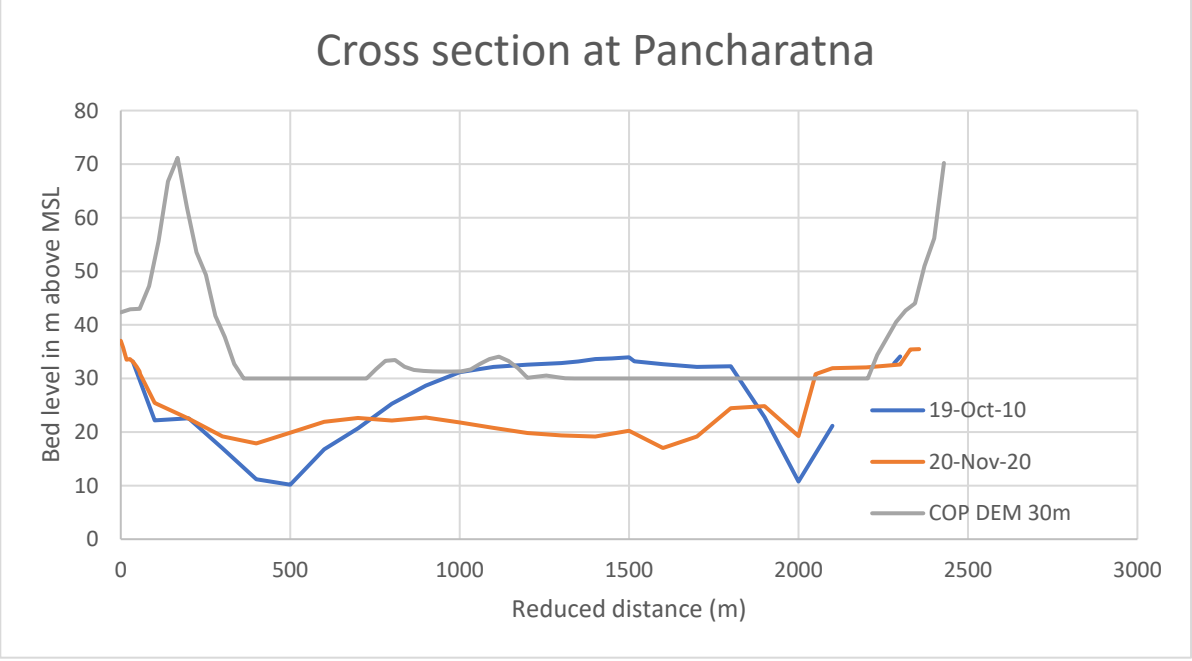


Figure 4-62 Temporal variation of cross-section at CWC Ho Site Pancharatna and its comparison with Copernicu/Sentinnel DEM derived cross-section

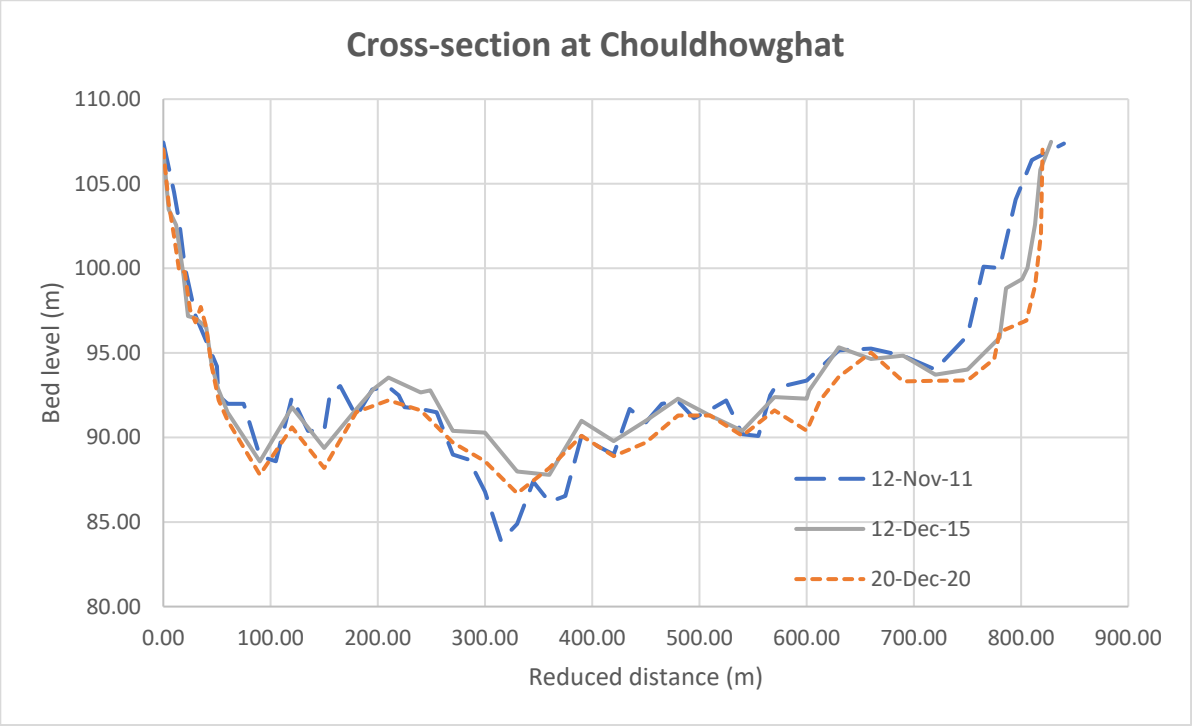


Figure 4-63 Temporal variation of cross-section at CWC Ho Site Chouldhowaghat and its comparison with Copernicu/Sentinnel DEM derived cross-section

Table 4-10 Flow frequency analysis and design discharge at Pandu based on combined WRD and CWC data from 1955 to 2021

S. No.	Probability	Return period	Flow at Pandu (cumecs)
1	0.667	1.5	39304
2	0.500	2	44699.2
3	0.200	5	52071.9
4	0.100	10	56953.3
5	0.040	25	61661
6	0.020	50	67696.4
7	0.010	100	72238.1

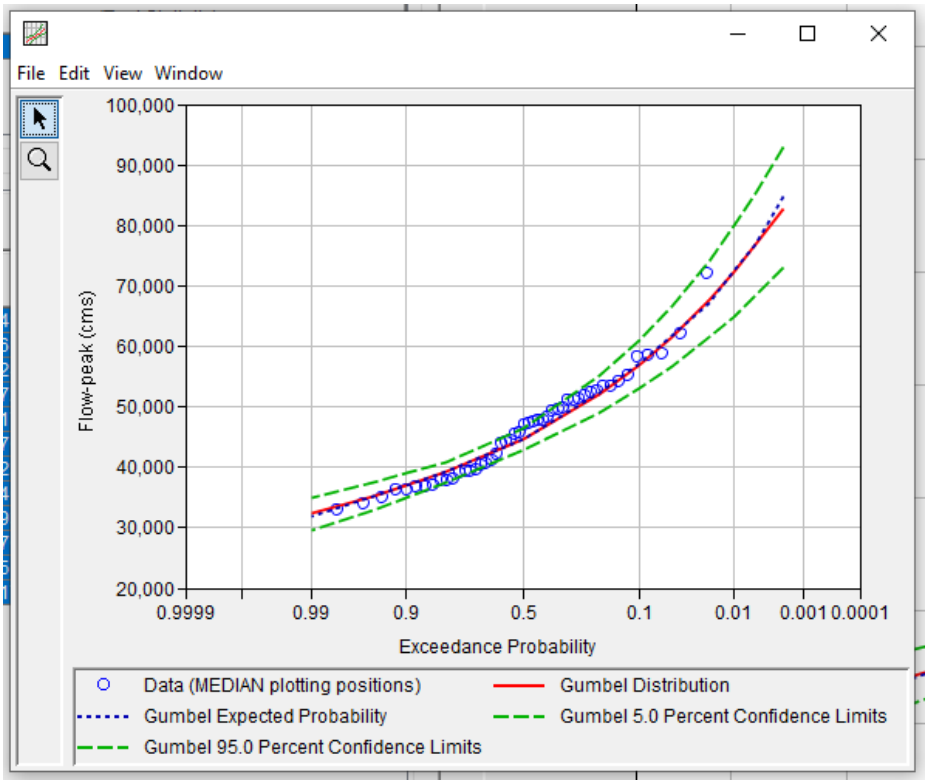


Figure 4-64: Flow frequency analysis and design discharge at Pandu

Table 4-11 Flow frequency analysis and design discharge at Pancharatna based on CWC data from 1991 to 2021

S. No.	Probability	Return period	Flow (cumecs)
1	0.667	1.5	36891
2	0.500	2	66040.5
3	0.200	5	61232.3
4	0.100	10	57156.2
5	0.040	25	61246
6	0.020	50	66040.5
7	0.010	100	69377.6

As Pandu site has more years of record than any other HO sites and have captured rare extreme events, the outcome of frequency analysis at Pandu is based combination of CWC and WRD data, 1955 to 2021. These results (Table 4-10 and Figure 4-64) are used with Dicken's formula to estimate design discharge at other sites (Table 4-11).

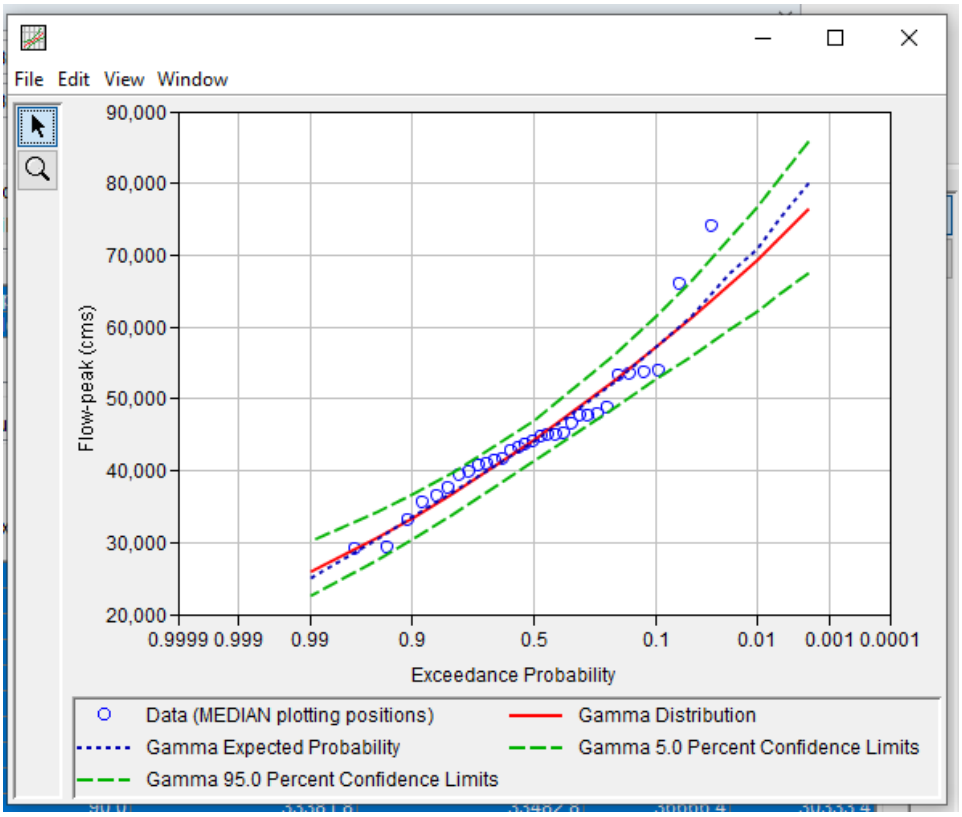


Figure 4-65: Flow frequency analysis and design discharge at Pancharatna

Table 4-12 Estimated design discharge at CWC HO Sites based on Dicken's formula

CWC HO Site	Catchment area (sq.km)	Q- 100yr return period (cumecs)	Adjacent ferry sites
Pandu	**417100**	**72238**	**North Guwahati, Umananda, Uzan Bazaar, Kurua**
Neamati	359500	64619	Neamati Ghat, Aphalamukh, Matmora, Disangmukh
Pancharatna	468790	78853	Bahari, Goalpara
Dhubri	476560	79831	Dhubri

Table 4-13 shows the estimated local scour depth following the IRC code and CWC handbook for design of flood protection, anti-erosion measures and river training works, Lacey's regime scour depth from High flood Level (HFL) has been estimated at each ferry sites. The estimated local scour depth was then compared against potential, which is derived here based on the SPT N value, from the ground investigation studies conducted as part of this project. As it can be seen, scour potential is very less, as small as 1 or 2m due to rocky bed, at many sites than the estimated scour depth. Here the scour potential is based on SPT N value > 70 (Source: Final Report Project Number 930-789 EVALUATION OF SCOUR POTENTIAL OF COHESIVE SOILS – PHASE 2 Highway Research Centre, Alabama Jan 2015). This factor must be taken in consideration during the design of structures. For more details on the bore hole investigation, refer the Geotechnical section of the report.

Table 4-13 Local scour depth based on Lacey's regime scour depth and scour potential based on the ground investigation at each proposed ferry terminal site

S. No.	Ferry sites	Discharge (cumecs)	Estimated local scour using Lacey's Regime Scour Depth from HFL (m) (silt factor=0.8)	Scour potential based on the depth of borehole (m) where SPT N value is equal to or greater than 70 (BH ref: LBH/RBH)
1	**North Guwahati, Umananda, Uzan Bazaar, Kurua**	**72238**	**21.22**	**13.05/2.03,1.50/1.03,45.43/37.73,1.55/20.50**
2	Neamati Ghat, Aphalamukh, Matmora, Disangmukh	64619	20.45	22.73/6.23,28.64/16.73,34.73/34.73, 31.73/24.23
3	Bahari, Goalpara	78853	21.85	36.23/37.73, 34.52/39.23
4	Dhubri	79831	21.94	1.03/12.11

The following figures present the sediment rating curve and particle size distribution of the suspended sediment based on the 2010 to 2021 data observed at CWC HO sites.

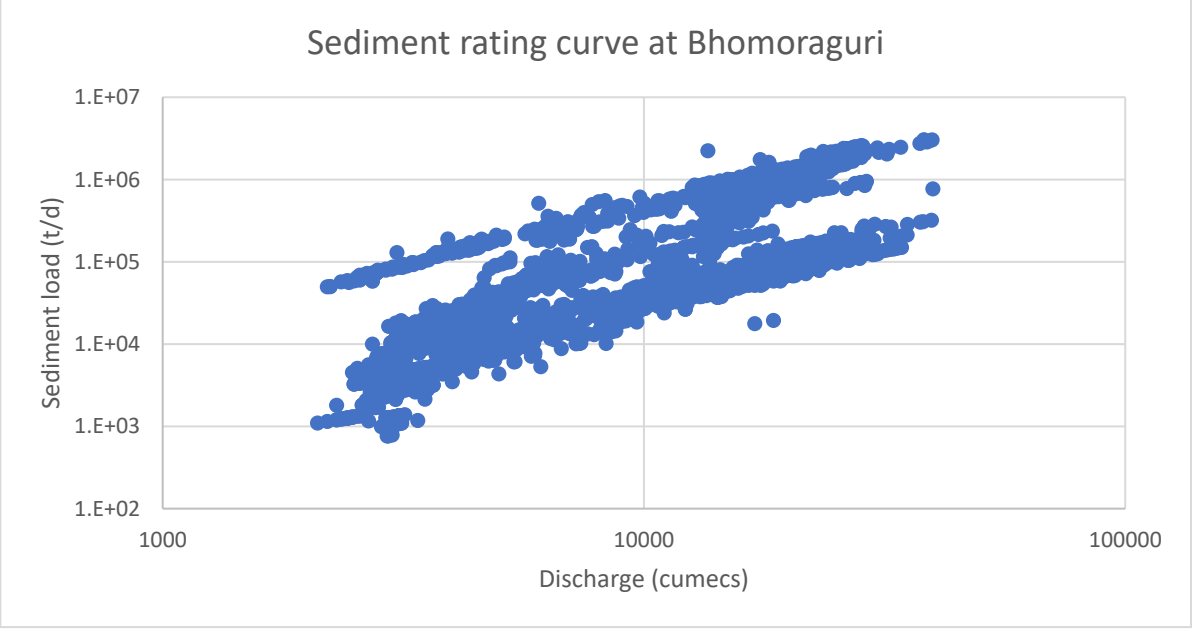


Figure 4-66::Sediment rating curve at Bhomoraguri based on the 2010 to 2021 data observed at CWC HO site

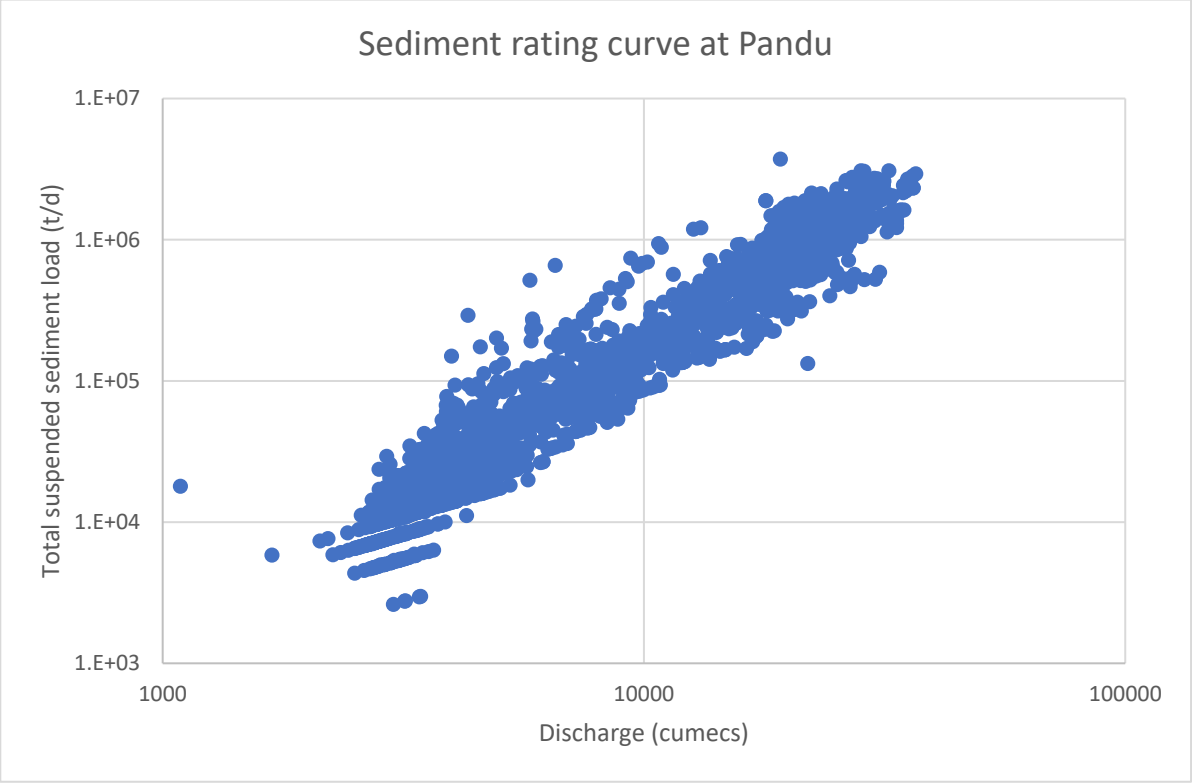


Figure 4-67: Sediment rating curve at Pandu based on the 2010 to 2021 data observed at CWC HO site

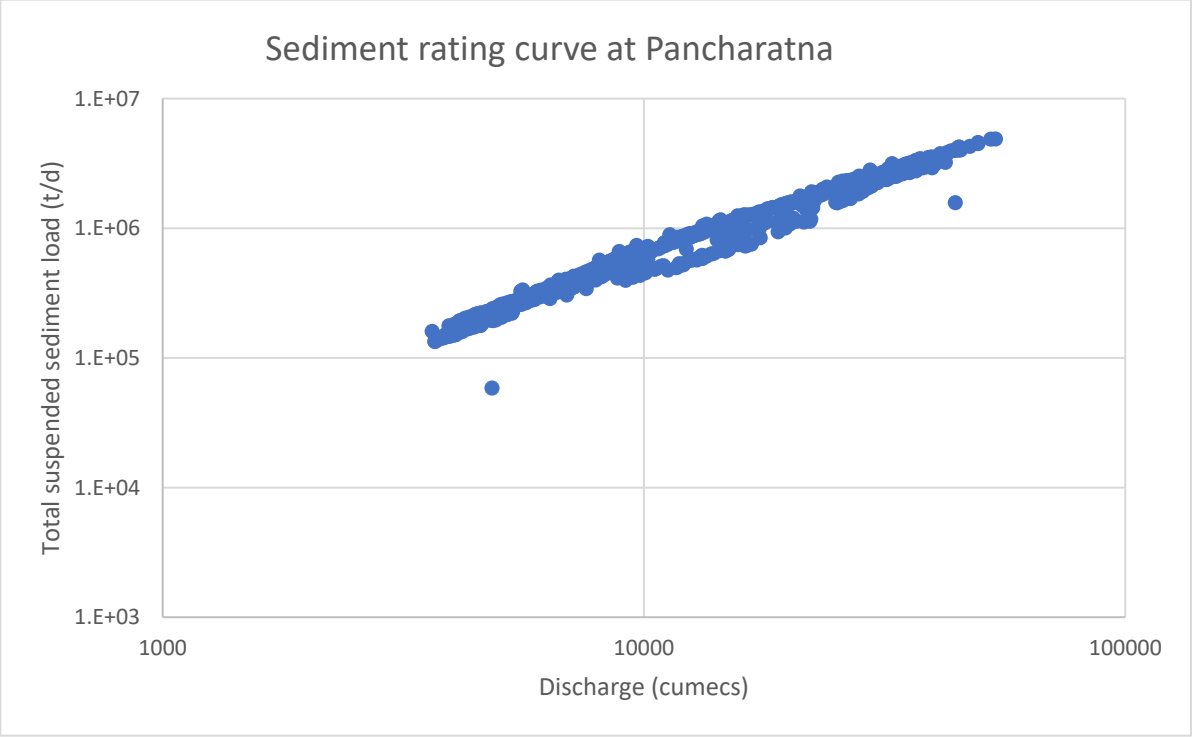


Figure 4-68:: Sediment rating curve at Pancharatna based on the 2010 to 2021 data observed at CWC HO site

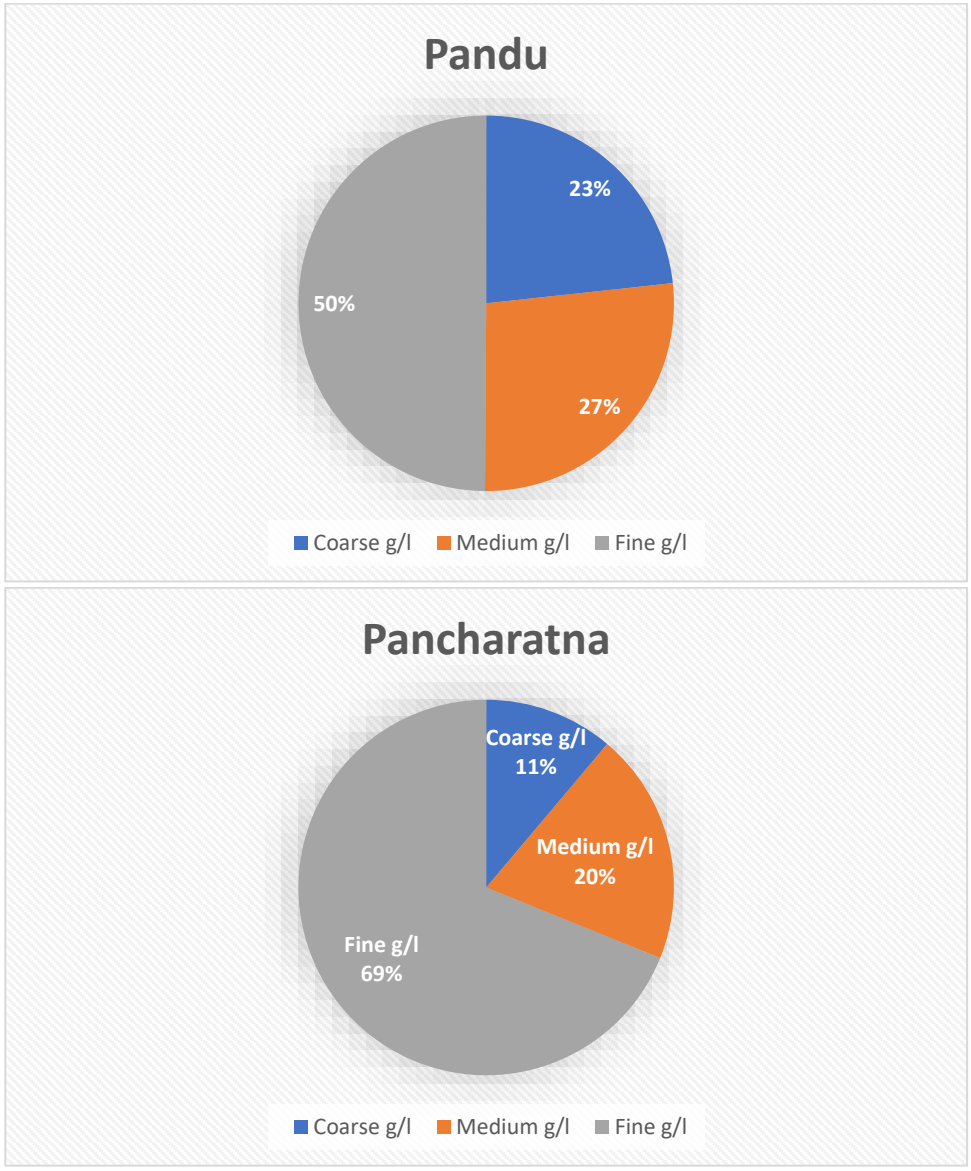


Figure 4-69:: Particle size distribution of suspended sediment at Pandu and Pancharatna based on the 2010 to 2021 data observed at CWC HO site

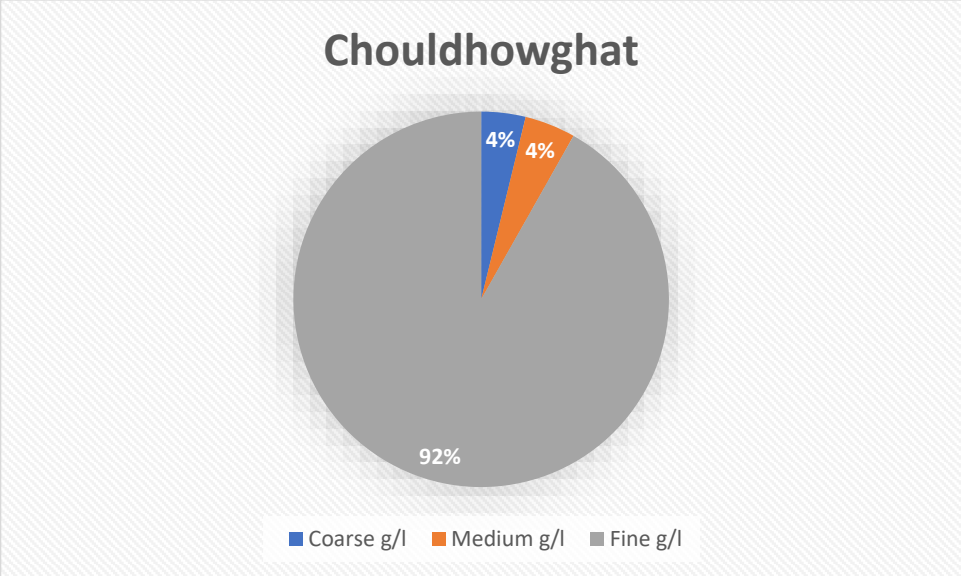


Figure 4-70:: Particle size distribution of suspended sediment at Chouldhowaghat based on the 2010 to 2021 data observed at CWC HO site

4.6 Modelling Scenarios

A number of aspects have been considered while undertaking the modelling and the same are outlined below.

4.6.1 Mathematical Models

4.6.1.1 Total Scour

In all mathematical models, total scour depth is found by adding up general scour, constriction/ contraction scour and local scour found separately as presented in the previous section.

4.6.1.2 General Scour

General scour is the scour which occurs irrespective of the presence of the bridges/structures due to the various morphological processes in a river, namely, aggradation and degradation of riverbed, meandering, braiding, cut-off formation, confluence of streams upstream of bridge sites, etc.

4.6.1.3 Constriction and contraction

Constriction or contraction scour occurs in a bridge where the road or railway approach embankment restricts the normal waterway. Lowering of the bed occurs locally within the contracted reach (i.e., under the bridge) due to flow acceleration and increased velocity of flow. Estimation of constriction scour should be done depending on whether the bed is stable (rigid) or live (mobile). The bed becomes mobile when the mean velocity of flow (V) in the channel exceeds the critical velocity (Vc) or the bed shear stress (τ_o) exceeds the critical shear stress (τ_c) at which the stream bed material just starts moving.

4.6.2 Morphological Modelling

A 2-dimensional model has been developed in HEC-RAS 2d based on the Copernicus/Sentinnel DEM 30m resolution. The reach of the river from Dhola Bazar to Dhubri is divided into two model domains (i) upper model domain from Dhola Bazaar to Bhomoraguri, and (ii) Lower model domain from Bhomoraguri to Dhubri. Table below shows the boundary conditions applied to the model. Flow parameters of 2010-2011 is considered as high flow year, and 2013-14 as low flow year as the outcome of flow duration curve analysis as presented above.

Table 4-14 2d model domains and boundary conditions

Model domain	Upstream boundary	Downstream boundary	Calibration point
Lower domain	Observed discharge at Bhomarguri	Observed Water level at Dhubri	Stage and flow hydrograph at Pandu and Pancharatna

Hydrodynamic model simulations were carried out for upper and lower domain with and without datum corrections as the DEM needed elevation correction and the outcome of results are presented below.

Table 4-15 2d model hydrodynamic model results

S.No.	Datum correction	Model domain	Model output analysis	Remarks
1	With no datum correction	Lower model domain	Average water level difference (simulated minus observed): 1.9m & 1.0m at Pandu (high and low flow years) Average water level difference (simulated minus observed): 1.29m & 0.8m at Pancharatna (high and low flow years)	Good match at higher water levels but overpredicted at lower water levels. Discharge is reasonably good at Pancharatna.
2	-10m based on cross-section: area-elevation curve	Lower model domain	Simulated water level is approximately 5.5m lower than the observed ones at	
3	-4.5m based on first model run output	Lower model domain	Average water level difference (simulated minus observed): -0.18m & -0.61m at Pandu (high and low flow years) Average water level difference (simulated minus observed): -1m & -1.25m at Pancharatna (high and low flow years)	Good match at lower water levels but not at higher water levels. Discharge is reasonably good at Pancharatna. Though water levels show reasonable match it doesn't mean that discharges and velocities are correct as the area and volume of conveyance may not be correct.
4	-2.5m based on second model output	Lower model domain	Average water level difference (simulated minus observed): 1.92m & -1m at Pandu (high and low flow years) Average water level difference (simulated minus observed): 1.29m & 0.8m at Pancharatna (high and low flow years)	

During 2010-11, high flow year, observed flow at Bhomoraguri, Pandu and Pancharatna showed the discharge is attenuating from upstream site to downstream site. But the model results showed either it attenuated more than observed or no attenuation at all.

Based on the cross-section comparison analysis, we find the following errors that can lead to the uncertainty in the model results:

1. Channel volume error

As the satellite derived DEM captures only ground level above water, volume below water level is unknown. Thus, exact volume of river channel is not used in model simulation.

2. Datum correction

Satellite derived DEM datum is different from the datum that is used in the study. Applying datum correction can remove this error partially but not completely. This can also lead to volume error as the simulated water can get attenuated more than actual or less than actual along the river.

The above two points can cause volume error in the flow simulation and thus affect the flow, velocity, and water level, and eventually morpho dynamics. Based on the maximum discharge and corresponding water level, cross-section averaged flow velocity has been studied at CWC HO sites, which is around 3.5m/s. However, further reference to secondary data, discussions with AIWTDS and specialist agencies with experience of working on recent projects along Brahmaputra revealed that local maximum velocity of 5.5m/s has earlier been observed during high flows. In view of the above a velocity of 6m/s which is considered to be on the conservative side shall be used for design.

Subsequently, however an attempt has been made by developing a detailed local, hydrodynamic model using HEC-RAS2D and survey data. The extent of the model is same as the extent of bathymetry survey carried out during this project. The extent of the model is shown in Figure 4-71.

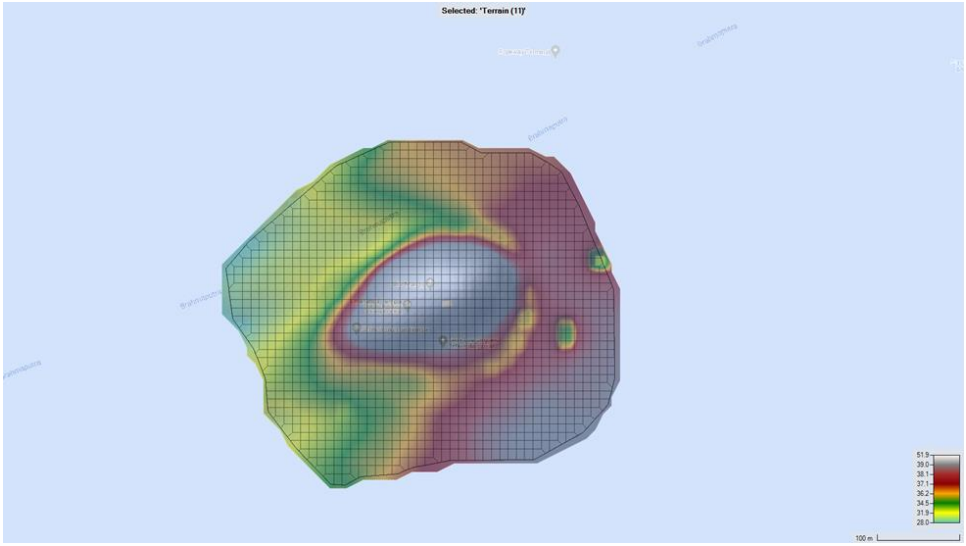


Figure 4-71: Terrain and model extent of model at Umananda based on Digital Elevation Model (DEM) generated from bathymetry survey

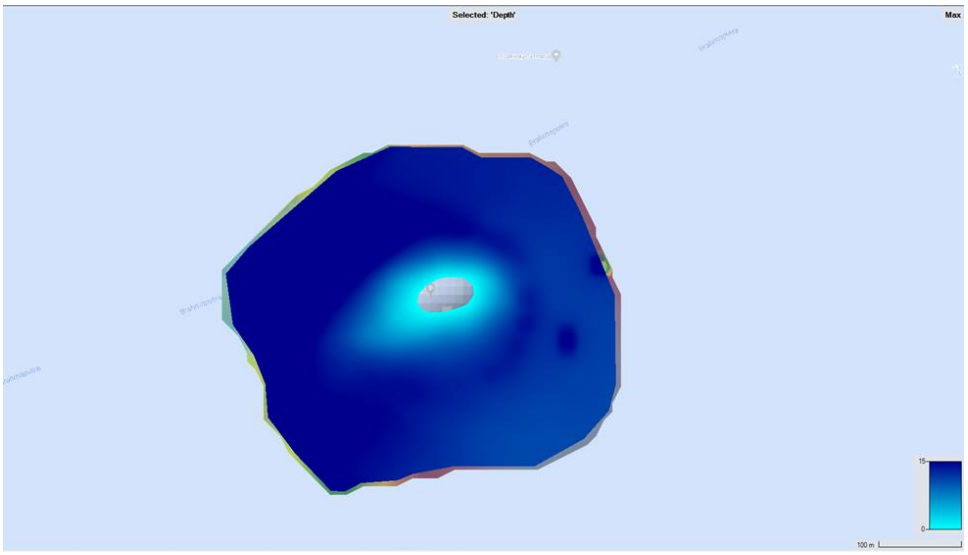


Figure 4-72: Simulated maximum depth (m) at Umananda

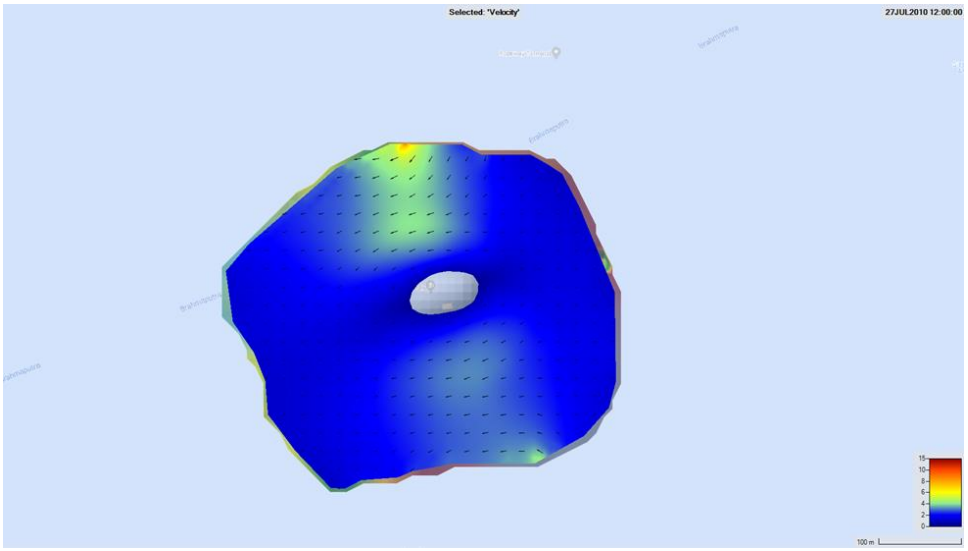


Figure 4-73: Simulated maximum velocity (m/s) at Umananda

The boundary conditions applied are observed water level of high flow year 2010-2011 at upstream and downstream of the model domain. Figure 4-72 and Figure 4-73 shows the simulated maximum water level and maximum velocity respectively. Limitations of the model include that the model domain is only a part of the big river Brahmaputra, which ranges from 2 to 8km whereas the currently model domain is only 0.5km wide. In this local model, the hydrodynamic process is not captured fully as it is very small. Notwithstanding and in order to close the gaos and the associated uncertainty, the specific parameters at terminal locations shall be based on the primary and secondary data collected as part of the assignment.

Notwithstanding, the hydrological and morphological modelling of the river has been carried out based on the data collected under the Assignment. A detailed analysis was also carried out to assess the morphological changes between 2010 and 2020 in the vicinity of the proposed terminal site and has been utilised to define the environmental categorisation.

Further, the outcome of modelling has been finalised considering data from physical surveys, data from earlier studies, literature survey, discussions with various stakeholders and specialist agencies with experience of working on recent projects along Brahmaputra. This forms the basis for establishing the key design parameters such as discharge, velocity and water levels. These parameters have been used to estimate the scour depth, apron length and design of bund/riverbank protection works to withstand the drag and lift caused by the river flow.

5 Traffic Analysis

5.1 General

Objective of this section is to analyse the passenger traffic data provided by AIWTDS, estimate the traffic volumes and number of terminals required at each location. Based on the information we have estimated the traffic volumes up to the year 2045 by assuming suitable growth rate in concurrence with AIWTDS.

5.2 Data Received

The data on yearly traffic for 2014-2015, 2015-2016, 2016-2017, and 2017-2018 was shared as the initial set of inputs for the study \along with vessel details plying in the Assam region by AIWTDS. The statistics included revenue, passenger, and cargo information for Assam Inland Water Transport vessels. Thereafter the annual traffic data for the years 2018-2019, 2019-2020, and 2020-2021 was provided. Later, the amended vessel details plying across Brahmaputra (Guwahati to Dibrugarh) region were provided as the information shared on vessel details was out of date.

Due to the occurrence of Covid Pandemic, the data available to us for the period of 2018 to 2021 shows a decline the traffic volumes. Hence, the data for this period has not been considered for our analysis. Also, most of the information in the yearly traffic data is Ferry service provider details rather than the origin and destination details of the service, making it difficult to conclude on the exact number of passengers as well as the type of vessels plying between the study regions. Hence, we have considered the data of the year 2018 given in the Contract as the base year for our analysis.

As the details of the traffic volumes for the Umananda location was not provided in the Contract, the traffic volumes were derived from the 4 months data of 2021 provided by AIWTDS. The average of the four-month data was used to estimate the 2021 annual passenger traffic volume, and the volume was brought back to the 2018 data using a 2% growth rate.

5.3 Summary of Data Review

We believe it is essential to examine the current operations at various terminals across the river for sizing the proposed terminals. Based on our interactions with AIWTDS and a site visit, it appears that only specific types and sizes of vessels are catered for at select terminals along the Brahmaputra River. Ro-Ro vessels operate between Neamati, Aphalamukh, and Kamalabari, for example, although all other places only have passenger boats of various sizes.

As a result, analysing the data below is necessary to arrive at the functional needs of terminal location.

1. Origin and destination details of passenger and all the vessels plying across the terminal location on monthly basis (seasonal variation). This helps in understanding the terminal sizes required to cater the necessities for both passengers as well as vessels and for the vessel it helps in determining the time consumed for the round trip.
2. Size & type of vessels which are plying between specific terminals. This data helps us to get the relation between transport volume and the Vessel Capacity which will be helpful in determining the Design Vessel for the development of Terminal infrastructure facilities.
3. Vessel schedule at ferry locations of various sizes. This data helps in getting the details on the waiting period in each terminal between the ferry services.

4. Navigational routes between the terminals. The navigational routes between terminals determine the time required for the vessel to cross between the banks in turn providing an idea of the number of trips possible between the terminals in a day.
5. Historical data of at least past 5 years along with the applicable growth rate of passengers and vehicles across ferryocations. This data helps in the rational assumption on the traffic growth for a particular terminal.

5.4 Approach to Progress

5.4.1 Assumptions

With the data summary review as mentioned above, to proceed with the study following assumptions have been made.

1. The volumes catered by the existing terminals have not been accounted to adjust the annual throughput volumes considered to estimate the terminal facility requirements.
2. The traffic volumes considered in our study is only the passenger volume as given in the Contract.
3. In our analysis, the traffic data from 2018 is used as the base year, as specified in the Contract and a yearly compounding traffic growth rate of 2.0 percent in discussions with AIWTDS is assumed up to the year 2045.
4. The traffic data provided in the Contract is taken as To and Fro data for a specific terminal, and the number of passengers at each terminal is divided in half for the total number of trips necessary.
5. Terminal operational period of 10 months (10 X 30 = 300 days) has been considered in this study.
6. The yearly traffic data is dispersed evenly across a 300-day operational period to provide a daily number, which is then multiplied by a peak factor of 1.3 to account for seasonal volatility.
7. The daily transportation capacity is determined based on each day's working hours, with traffic distributed equally throughout the day.
8. Number of berths needed at each of the terminal is determined by taking into account a vessel's average passenger carrying capacity.
9. Since exact trip time data of a vessel is unavailable, based on expected traffic flow data and site visit appreciation, the waiting period at each terminal is assumed.

5.4.2 Methodology

The methodology followed in the calculation are as follows.

1. From the yearly passenger data passenger number per day is obtained by following equation.
$$Passenger\ No./day = (yearly\ traffic\ data/Operational\ period) * Peak\ Feactor$$
2. Considering the waiting period between ferry services as 30- 45 min and operational hours for a day as 10-14 hrs maximum number of vessel movements in one direction that is from or to the terminal at each terminal is 20.
3. The Passenger no/day is assumed to be of To and Fro and half of that value is considered for calculation of ship trips required at each terminal.
$$= Passenger\ no/day/2$$
4. For the calculation of required berth at each location with the maximum passenger carrying capacity of vessel and trips possible at each location of 20.
$$Required\ Berth\ No. = \left(\frac{\frac{Passenger\ no/day}{2}}{passeneger\ capacity\ of\ vessel * 20} \right)$$

5.5 Traffic Forecast

The number of berths has been estimated based on the traffic volumes, vessel details and other information provided by AIWTDS. The traffic volumes and number of berths required at each location up to the year 2050 is obtained.

5.5.1 Berths Required

Table 5-1 Number of berths proposed at terminal locations

Terminal Location	Number of berths proposed
Umananda	**1**

Note: Number of Berths in Table 5-3 is requirement based on traffic numbers provided by the client. Whereas, Table 5-1 provide actual berth requirement proposed by the client/terminal operator.

Table 5-2 Passenger traffic volumes forecast at different locations

Terminals	FY18	FY18	FY20	FY25	FY30	FY35	FY40	FY45	FY50
	Passenger No/year	No/ day	No/ day	No/ day	No/ day	No/ day	No/ day	No/ day	No/ day
Umananda	1,40,561	609	634	700	772	853	942	1,040	1,148

Table 5-3 Number of Berths Required

Terminals	FY18 Ter no's	FY20 Ter no's	FY25 Ter no's	FY30 Ter no's	FY35 Ter no's	FY40 Ter no's	FY45 Ter no's	FY50 Ter no's
Umananda	1	1	1	1	1	1	1	1

Table 5-4 Number of berths proposed at terminal locations

Terminal Location	Number of berths proposed
Umananda	**1**

6 Vessel Size Analysis

6.1 General

The objective of this analysis is to examine the most suitable vessel type which can ply across the proposed 13 terminals on Brahmaputra River. It is understood from our site visits and interactions with AIWTDS personnel that the vessels plying across the proposed terminals have got a standard schedule depending on the traffic volumes and demand. It is also found that the vessels plying in the region operates with in few clusters such as Guwahati cluster, Dibrugarh cluster etc. Hence, it is evident that there is no standard vessel operating model connecting all the 13 terminals in the region which concludes that there is no requirement for the same considering time and cost dynamics.

6.2 Analysis of Vessel Data

The data received from AIWTDS consists of the following.

1. Name of the vessel
2. Category/ material of the vessel.
3. Specifications such as power, capacity in (tons) and type of vessel.
4. Details on its registration number and place of registration.
5. Construction year and principal dimensions.
6. Region at which the vessel is in operation.
7. Present status.

Of all the information available from the above details, capacity and dimensions of the vessels forms a key basis. However, as the capacity of the vessel has been given in terms of tons and not in bifurcation between no of passengers and vehicles allowed in the vessel, it is required to make certain assumptions (provided in the above chapter).

As per the AIWDS data, a total of approximately 270 vessels are available of which approx. 203 are in operation. The remaining vessels are not operational due to major repairs and submerged or abandoned. Of the 203 vessels, 171 vessels are in operation near to the proposed 13 terminals across Brahmaputra River. Since the analysis is being done for passenger traffic volume the type of vessel which is for Cargo transport has not been considered in the study. Length of the operational and relevant vessels in the region ranges from 12m to 32m, Width from 2.4m to 10m and Draft from 0.7m to 2.5m.

6.3 Summary of Data Review

After reviewing the data received from AIWTDS there were some areas where the information required was missing. The details are as given below.

1. The capacity in MT offered is the displacement tonnage or the dead weight tonnage based on the data provided.
2. The vessel information lists catamaran vessels but the information on dimensions and other details of these vessels is assumed appropriately
3. Outlook on vessel sizes over the development horizon because of fleet modernisation plans is not available.

6.4 Approach to Progress

With the data gaps mentioned above and to proceed with the study, following assumptions have been made.

1. The capacity in MT provided in the details is considered as the Dead Weight tonnage.
2. The vessel is classified by region, and the maximum dimensions of the vessel plying in that region shall be considered to arrive at the Design Vessel dimensions for terminal design purposes.
3. The vessel information only offers details about the region in which it operates, rather than the origin and destination terminals of the vessels, hence, several deliberations made with AIWT officials to rationalise the approach, and paved the way to determine the size of terminals
4. Modern vessels are expected to be sleek (similar length), have a reduced draught, and be confined to the Least Available Depth (LAD) for the stretch.

6.5 Vessel Size for Terminal

The table below lists the maximum vessel sizes for various locations according to the vessel data provided by AIWTDS. The berth is examined for a vessel with a 50-passenger carrying capacity, whose dimensions are 31.2m in length, 7m in breadth, and 0.6m in draught. New catamaran boats with dimensions 31.2m in length, width of 10.2m and draft of 0.75m are being added to the IWT fleet, and terminals will be designed to accommodate them.

Table 6-1 Vessel Size Analysis

Cluster or Location	Name of Vessel	Category	H.P.	Capacity (MT)	Type of Vessel	Registration details		Year of Construction	Principal Dimensions (m)	Present Condition	Classification Criteria
Guwahati	M.V. Kaziranga	Steel	165x2	120	M.V.	Assam	69	1976	L-32, B-10, D-1.80	Dry dock for retrofitting	Maximum length & width
	T.F. Bordoichila (Double decker)	Steel	no engine	490	TF	Assam	751	2007	L-28, B-7.0, D-2.50	Operational	Maximum draft and capacity

7 Interpretation of Guidelines for Ramp

7.1 General

Ramps allow persons in wheelchair or persons with disability or elderly to move from one level to another.

For the ramps (hard ramps) that are on the landside, reference is made to “Harmonised Guidelines and Space Standards for Barrier-Free Built Environment for persons with Disability and Elderly Persons (2016)” which is part of “Accessible India Campaign”, program.

For the ramps (articulated) specifically for floating platforms, for example linkspan, reference is made to “Guidelines for Floating Jetties/Platforms”, issued by Ministry of Ports, Shipping and Waterways (Sagaramala cell), Govt. Of India (2021).

7.2 Accessible Gradient

For the hard ramps, Table 7-1 of Accessible India campaign guidelines is followed for all the riverine terminals. Locations with bund as recommendation a minimum gradient of 1:12 with landings at every 5 meters of ramp run is considered. Locations where articulated linkspans are recommended a minimum gradient of 1:12 is considered. However, for Umananda considering hilly terrain, a milder gradient of 1:15 with landings at every 9 meters of ramp run is considered. The guidelines are reproduced below. The gradient and the landings adopted for the terminals are highlighted in the below table with red colour. In between the ramp provision of steps has been provided for normal pedestrians. The steps are having a tread of 1.80 m and riser of 0.15 m.

Table 7-1 Accessible Gradient

Table 7-1: Minimum specifications for Ramps

Level difference	Minimum gradient of Ramp	Ramp Width	Handrail on both sides	Comments
≥ 150 mm ≤ 300 mm	1:12	1200 mm	√	
≥ 300 mm ≤ 750 mm	1:12	1500 mm	√	Landings every 5 meters of ramp run.
≥ 750 mm ≤ 3000mm	1:15	1800 mm	√	Landings every 9 meters of ramp run.
≥ 3000 mm	1:20	1800 mm	√	Landings every 9 meters of ramp run.

For the articulated floating ramps (linkspan), section 3.6.2 of “guidelines for floating jetties/platforms” is referred, which states “where access for the disabled persons are required, the slope of the gangways and the tread plates should not exceed 1:8”. However, a gentle slope of 1:12 is provided which meets the minimum requirements of the ministry guidelines. It is anticipated that the disabled person shall always be assisted during their Journey along the ramps, including embarkment and disembarkment from the vessel until they reach the terminal premises.

8 Terminal Planning

8.1 Approach for Planning of River Side Infrastructure

The feasibility report has been prepared and submitted earlier. The riverine infrastructure is planned based on the data collection, site visits of all the thirteen (13) locations and several deliberations with client. The sites have been categorized considering the environmental conditions and functional requirement of terminals. The concept solutions have been proposed in view of all the above categorization in place. All the concept solutions have been discussed in detail in the subsequent sections.

Table 8-1 Details of categorization

Categorization	Type	Details
Environmental	Category 1	Severe Erosion
	Category 2	Moderate erosion
	Category 3	Stable
	Category 4	Moderate accretion
	Category 5	Severe accretion
Traffic composition	Category A	Ro-Pax vessels with Four and two wheelers and foot passengers
	Category B	Catamaran Vessels with two wheelers and foot passengers
	Category C	Catamaran Vessels with foot passengers
	Category D	Countryside Vessel with two wheelers and foot passenger

8.1.1 Terminal Site Categorization

8.1.1.1 Environmental Actions and Effects

The terminal site locations can be categorised according to past environmental actions and its effects on the riverbank condition. The time history bathymetry charts are the best representation to understand the morphological changes in the river. Those charts will help us understanding the stability of the riverbank over the years. In the absence of any such data time history satellite images are referred to understand the changes in riverbank. From the time history satellite images, it is observed that some of the existing terminal sites are exposed to moderate to severe riverbank erosion and other terminal sites are exposed to moderate to severe accretion. There are few terminal sites where riverbank is stable and past recorders are not showing any change in the riverbank profile. The terminal site categorisation is further elaborated below.

8.1.1.1.1 Category 1 - Severe Erosion

The riverbank at the terminal site locations experiencing severe erosion is grouped under this category. Terminal sites which fall under this category are listed in the Table 8-2. The time history satellite images show drastic shift of riverbank at terminal sites due to erosion. For these terminal sites, riverbank protection

is technically viable and uneconomical. Due to the instability in the riverbank, either a fixed or flexible terminal operation facility will be considered as a suitable solution.

8.1.1.1.2 Category 2 - Moderate Erosion

The riverbank at the terminal site locations experiencing moderate erosion is grouped under this category. Terminal sites which fall under this category are listed in the Table 8-2. The time history satellite images show moderate shift of riverbank at terminal sites due to bank erosion. For these terminal sites, riverbank protection is both technically and economically viable. Due to the moderated stability in the riverbank, either a flexible or fixed terminal operation facility will be considered as a suitable solution.

8.1.1.1.3 Category 3 - Stable Riverbank

The riverbank at the terminal site locations stable is grouped under this category. Terminal sites which fall under this category are listed in the Table 8-2. The time history satellite images show stable riverbank at the terminal sites. For these terminal sites, fixed terminal operation facility will be considered as a suitable solution.

8.1.1.1.4 Category 4 - Moderate Accretion

The riverbank at the terminal site locations experiencing moderate accretion is grouped under this category. Terminal sites which fall under this category are listed in the Table 8-2. The time history satellite images show moderate shift of riverbank at the terminal sites due to accretion. For these terminal sites, sand bar dredging is both technically and economically viable. Due to the moderated stability in the riverbank flexible or fixed terminal operation facility will be considered as a suitable solution.

8.1.1.1.5 Category 5 - Severe Accretion

The riverbank at the terminal site locations experiencing severe accretion is grouped under this category. Terminal sites which fall under this category are listed in the Table 8-2. time history satellite images show drastic shift of riverbank at terminal sites due to accretion. Sand bar dredging is technically viable or uneconomical. Due to the instability in the riverbank, flexible terminal operation facility will be considered as a suitable solution.

Table 8-2 Terminal Site categorization

SL. NO	Terminals	Cluster	Category	Erosion		Accretion		Stable
				Moderate	**Severe**	**Moderate**	**Severe**	
1	Umananda	Central	Category-3					✓

8.1.1.2 Traffic Categorization

The traffic composition and the vessel types are varying with the terminal project site locations. These factors have major influence on the terminal infrastructure planning. Based on the available data, terminal project site wise traffic composition and vessel types to be arrived at the berthing facility has been summarised in the Table 8-3. To bring more clarity on the individual terminal site requirements with regards to the type of traffic and vessels, a discussion is made in the subsequent sections on their categories.

8.1.1.2.1 Category A – Ro Pax vessels with Four and two wheelers and foot passengers

Under this category, the ferry terminals shall be planned with consideration of safe and efficient movement of the four and two-wheeler vehicles and foot passengers on the Ro -Pax vessels. The berthing facility will

have all the basic infrastructure that is needed for mooring the vessel and roll on and roll of vehicles. The access ramp shall be planned in straight line for the easy movement of the four wheelers. In such situation where there is a constraint for planning the straight access ramp, curved access shall be planned with safe turning radius provisions. Terminal sites which fall under this category are listed in the Table 8-3.

8.1.1.2.2 Category B – Catamaran Vessels with two wheelers and foot passengers

Under this category, the ferry terminals shall be planned with consideration of safe and efficient movement of the two-wheeler vehicles and foot passengers on the catamaran vessels. The berthing facility will have all the basic infrastructure that is needed for mooring the vessel and movement of vehicles and foot passengers. Terminal sites which fall under this category are listed in the Table 8-3.

8.1.1.2.3 Category C – Catamaran Vessels with foot passengers

Under this category, the ferry terminals shall be planned with consideration of safe and efficient movement of the foot passengers on the catamaran vessels. The berthing facility will have all the basic infrastructure for mooring the vessel and movement of foot passengers. Terminal sites which fall under this category are listed in the Table 8-3.

8.1.1.2.4 Category D – Countryside Vessel with two wheelers and foot passenger

Under this category, the ferry terminals shall be planned with consideration of safe and efficient movement of the two-wheeler vehicles and foot passengers for the countryside vessels. The berthing facility will have all the basic infrastructure for mooring the vessel and movement of vehicles and foot passengers. But Provision for country boats can be simpler than that for the catamaran vessels. The country boats are typically two deck vessels with 2-wheelers placed on the upper deck. Safe ramp provision to the upper deck shall be considered in the planning.

A summary of terminal sites which falls under each traffic category are listed in the Table 8-3.

Table 8-3 Vessel types and traffic composition for vessels

SL. NO	Terminals		Traffic Category	Vessel Type	Traffic Composition
1	Umananda	Central	Category C	Catamaran	Bike/Passengers

8.1.2 Types of Options/Concept Solutions Considered for Riverine Infrastructure

Based on the available data, it is noticed that the river morphological condition and the river velocities are dynamic in nature. The riverbank changes can be noticed from the satellite imageries over the years. With the above dynamics in consideration, the possibility of recommending a permanent, flexible, and mobile structural arrangement options were evaluated for planning the terminal infrastructure.

The permanent structures could be a fixed quay wall or piled jetty structure. The flexible option could be a floating pontoon with land side connectivity arrangement and a mobile option could be spud pontoon with suitable land connectivity arrangement.

A fixed quay wall or piled jetty structure is user friendly but will require significant structural work both in length and height which requires a lot of concrete and steel to accommodate large water level differences. Further, this option is not flexible and adaptable with the change in river behaviour and morphology. Therefore, it is not considered to be a pragmatic solution.

The flexible option will consist of minimal fixed infrastructure and the berthing activity for the vessels will carried out though floating pontoon. The main advantage of this option is that it is adaptable with the change in river behaviour and morphology.

The mobile option will be an ideal solution for terminal sites where riverbank erosion is severe. Due to riverbank erosion, the permanent riverine facilities will become redundant over the time that is clearly poor investment and lead to financial burden. Adversely, those poor planning directly affect in numerous ways including the daily lives and livelihood of the commuters since the berthing facility is no more operational. Under this option, the berthing facility can be relocated with the shift in the riverbank position which may happen over the years with minimum financial implications compared to other options. Mobile facility will keep the terminal operational most of the days in the year.

Since the river is more dynamic in nature with its behaviour and morphology changing continuously over the span of years, both flexible and mobile structural arrangement options shall be considered for the terminal planning.

Various solutions based on the traffic and environmental actions are listed below:

1. Concept solution 1- Linkspan perpendicular to sloping access bund
   - Concept solution 1a - Movable single floating pontoon with the movable linkspan
   - Concept solution 1b - Fixed multiple floating pontoons with the movable linkspan

2. Concept solution 2- Linkspan parallel to sloping bund
   - Concept solution 2 a - Movable floating pontoon and linkspan
   - Concept solution 2 b - Movable floating pontoon and linkspan with additional HDPE floating walkway

3. Concept solution 3- Fixed infrastructure
   - Fixed multiple floating pontoon with fixed linkspan from approach trestle

4. Concept solution 4- Dog-legged sloping bund
    - Movable floating pontoon, linkspan and stepped concrete ramp

5. Concept solution 5- Movable solution (Backup)
    - Movable floating pontoon, access ramp and staircase

8.1.3 Evaluation of Concept Solutions for Riverine Infrastructure

8.1.3.1 Concept Solution 1 – Linkspan Perpendicular to the sloping access bund

Under the concept solution 1, there are two sub-categories and they are solution 1a & solution 1b which are arrived on the basis of number of pontoons and its position, whether pontoon stationed permanent with respect to transverse movement or it is movable in transverse direction based on the seasonal water fluctuations. In both subcategories, the linkspan can be repositioned based on terminal needs.

8.1.3.1.1 Concept Solution 1a – Movable single floating pontoon with a movable linkspan

Concept solution 1a is combination of floating pontoon, linkspan and sloping access bund. The linkspan will act as a connecting bridge and it connects sloping access bund on the riverbank with floating pontoon. A schematic diagram representing Concept solution 1a is presented in Figure 8-1 and Figure 8-2.

The length of the sloping access bund is determined by the level difference between high and low water in the river. Also, the orientation of the sloping access bund mainly depends on the location of availability of the lowest water level in the river. The terminal site location where lowest low water available near the river bank the sloping access bund is proposed parallel to riverbank. The terminal site locations where the availability of the lowest water level is far away from the riverbank. The orientation of the sloping access bund proposed in an acute angle with respect to the riverbank. The main advantage of this type sloping bund arrangement is that the ferry terminal shall be under operation during intermediate to lowest low water level.

In a case where sloping access bund proposed is in an acute angle with respect to the riverbank it will be protruding into the river which has a probability to become a mode for sediment deposition on the upstream side of the sloping access bund. However, the possible effects due to this orientation will be arrived after completion of the hydraulic model studies. Based on the model study results, the orientation of the bund will be further modified and accordingly the final orientation of the bund shall be arrived.

The bottom edge of the sloping access bund which meet the riverbed shall be protected against the scour. The side slopes of the sloping access bund are arrived based on the stability Renomatress/gabion/ geobags.

The access bund slope to be maintained at 1:12 for the safe movement of the commuters and the vehicles. The surface of the sloping access bund will be paved with concrete for the smooth passage of the commuters and vehicles.

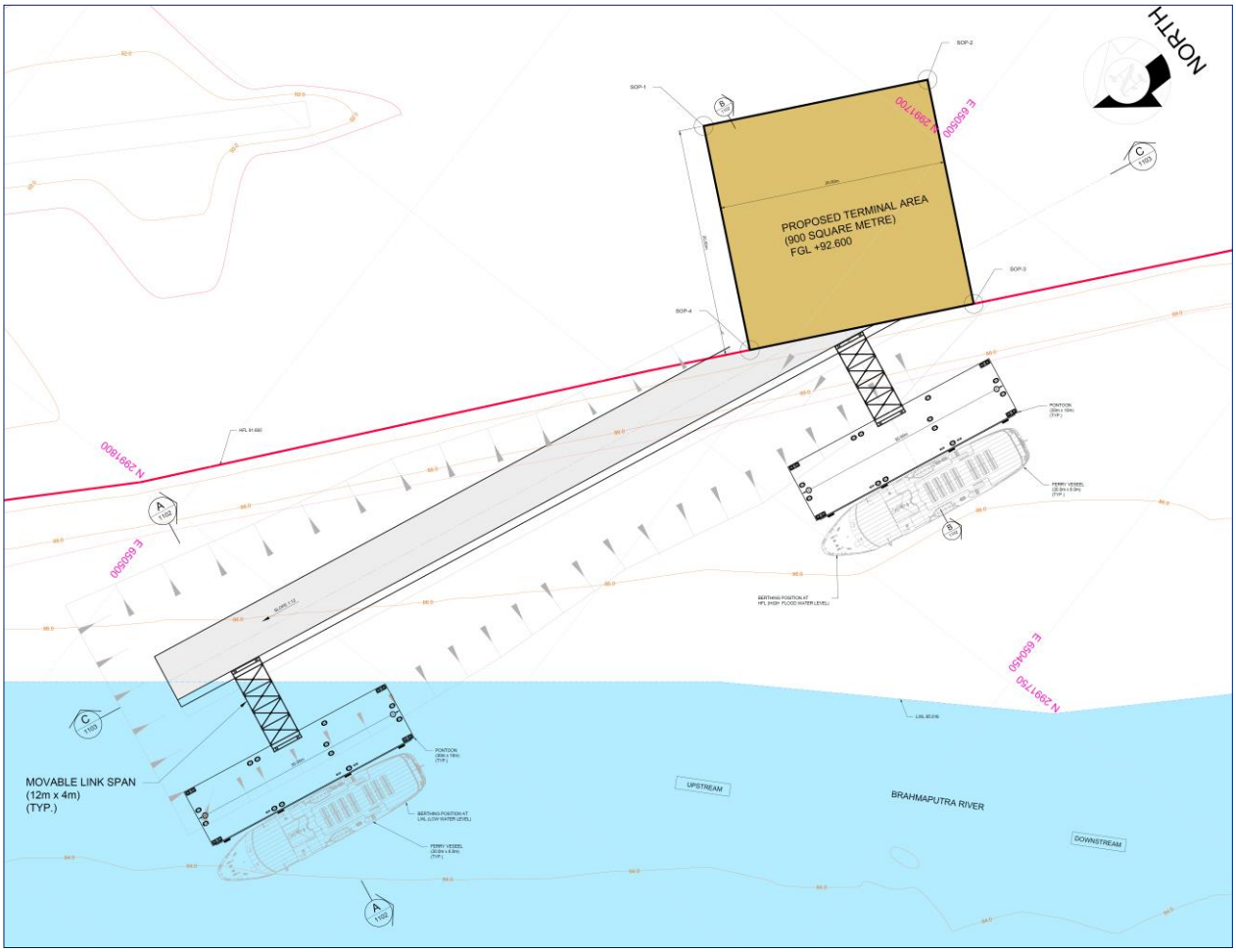


Figure 8-1 Concept solution 1a - Movable single floating pontoon with a movable linkspan

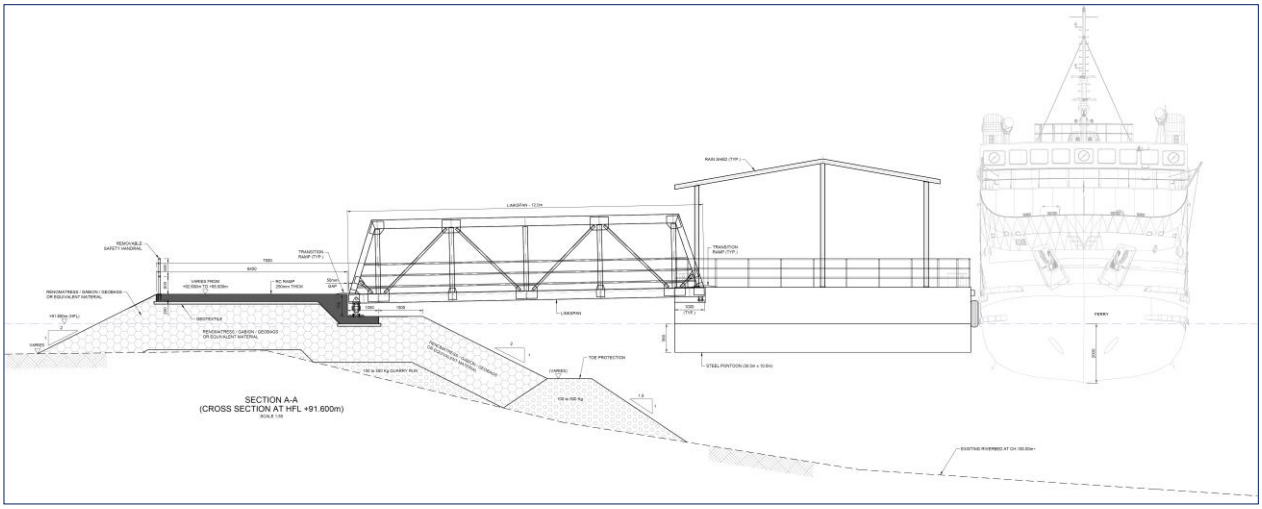


Figure 8-2 Concept solution 1a - Typical cross-sectional view

The position of the pontoon and the linkspan can be changed based on the seasonal water fluctuations in the river. One end of the linkspan, which is on the sloping bund can be slipped on the sloping access bund

over the guide rail with the help of a winch system at the same time the other end of the linkspan which is on the pontoon also has to be moved in the same direction.

The vessel berthing shall be carried out on the pontoon and the mooring lines of the vessel shall be tied on the bollards located on the pontoon. The size of the pontoon is governed by the vessel dimension and additional length of the pontoon for tying mooring line in an angle to the bollards. The width of the pontoon is governed by the passenger, vehicle and goods volume arrived per vessel based on the traffic study. The pontoon will be having covered roof for protecting the commuters form adverse weather effects. The pontoon and the linkspan shall be corrosion protective.

The passengers boarding and deboarding activity on the vessel shall be carried out through pontoon. For the boarding purpose, the passengers shall initially move through sloping access bund from the terminal area and thereafter through the linkspan and then to the pontoon and then to the vessel. This will be followed in the exactly reverse manner during the deboarding of the passenger, vehicle, and goods.

8.1.3.1.2 Concept Solution 1b – Fixed multiple floating pontoon with a the movable linkspan

Concept solution 1b is a combination of floating pontoon, guide piles, linkspan and sloping access bund. This concept solution is almost like that of concept solution 1a, but with an addition of guide piles to the pontoon. The pontoon shall be moored with guide piles and with suitable arrangements which will allow the pontoon to move in the vertical direction during the water level changes. A schematic diagram of concept solution 1b is presented Figure 8-3 and Figure 8-4.

Concept solution 1b is proposed for the terminal sites which are stable in terms of riverbank erosion and accretion and with a requirement of a greater number of berthing pontoons based on the traffic requirements. Further this option is ideal when sloping access bund length and the pontoon length match due to medium range water level variation between high flood level and lowest low water level.

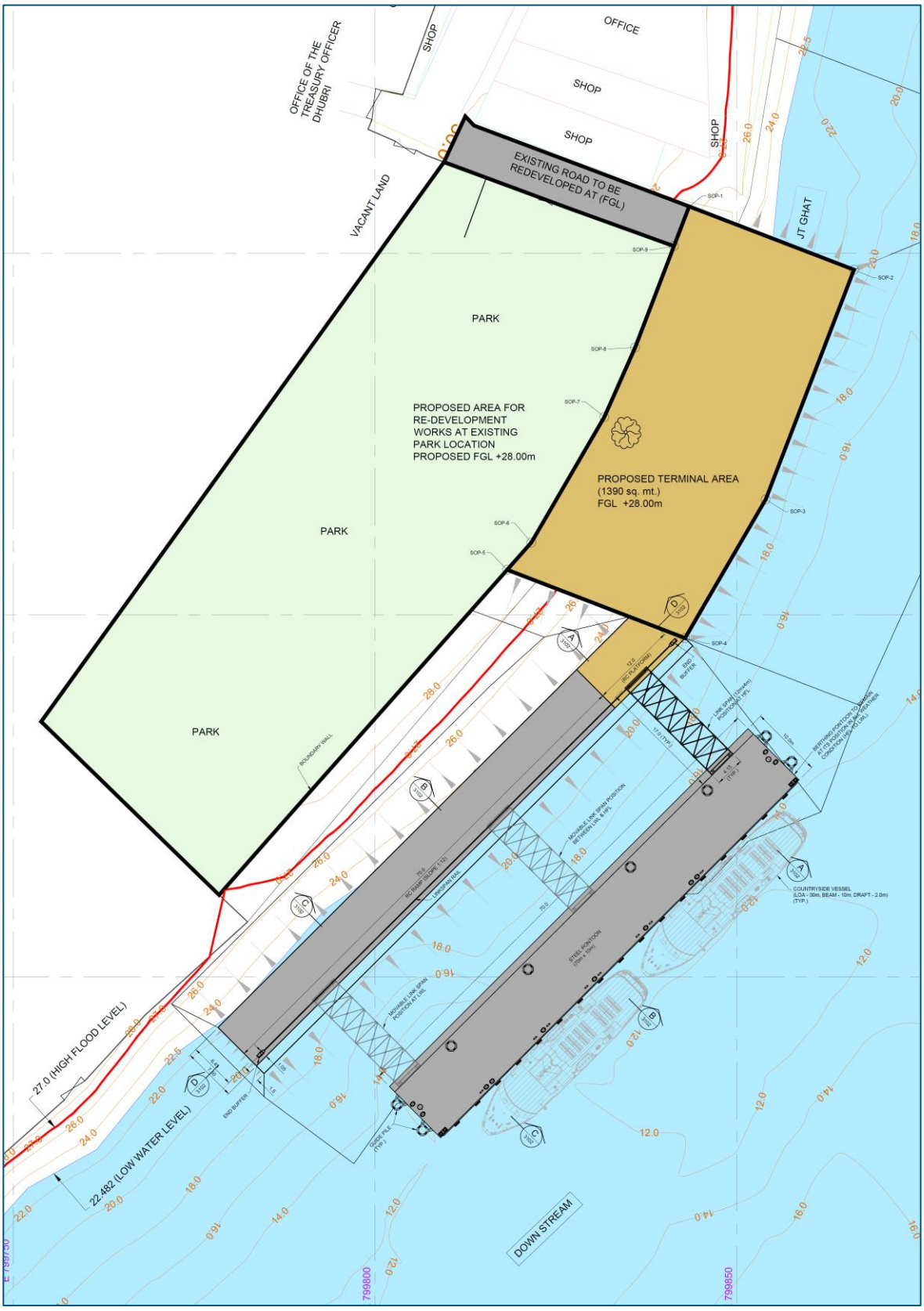


Figure 8-3 Concept solution 1b - Fixed multiple floating pontoons with the movable linkspan

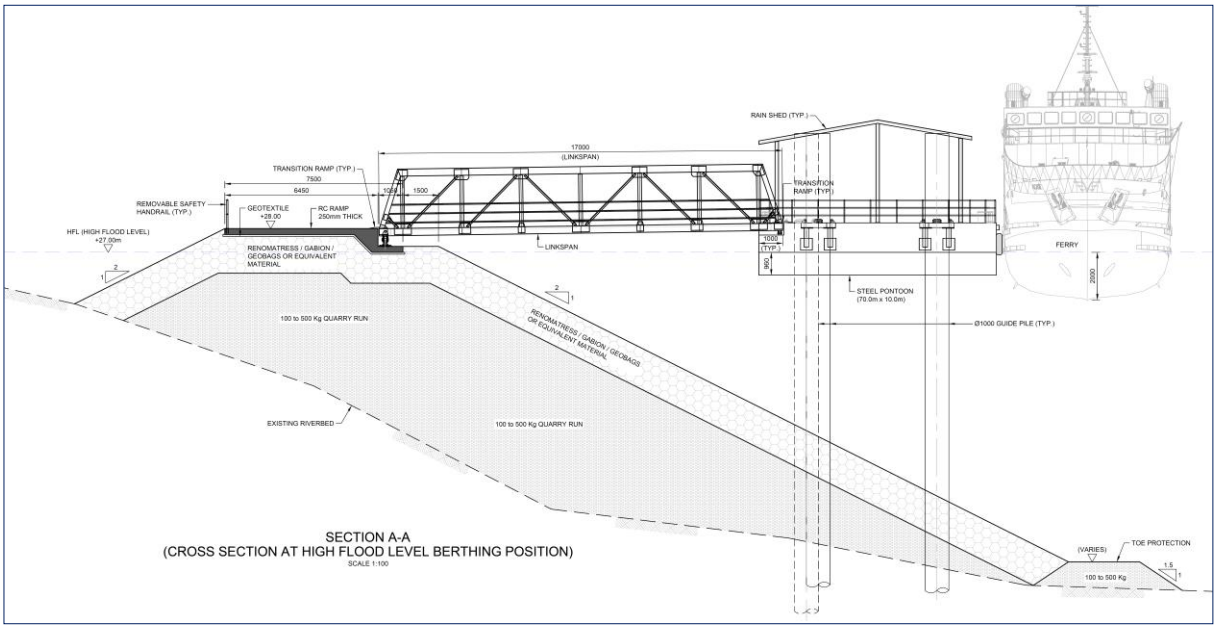


Figure 8-4 Concept solution 1b - Typical cross-sectional view

8.1.3.2 Concept Solution 2 – Linkspan parallel to the sloping access bund

8.1.3.2.1 Concept Solution 2a – Movable floating pontoon and linkspan

Concept solution 2a is a combination of floating pontoon, guide piles, linkspan and sloping access bund. This concept solution is almost like that of concept solution 1 a but differs based on the position of linkspan on the sloping access bund. The linkspan is planned to position parallel to the length of the sloping access bund. A schematic diagram representing concept solution 2a is presented in Figure 8-5 and Figure 8-6.

Concept solution 2a is applicable to terminal sites where the vehicle rolls off and roll-on activities must be carried out. Based on the position of the pontoon, the linkspan rear end which is placed on the bund shall be slipped on the sloping access bund with two number of guide rails and winch system to bring the linkspan to appropriate position to access.

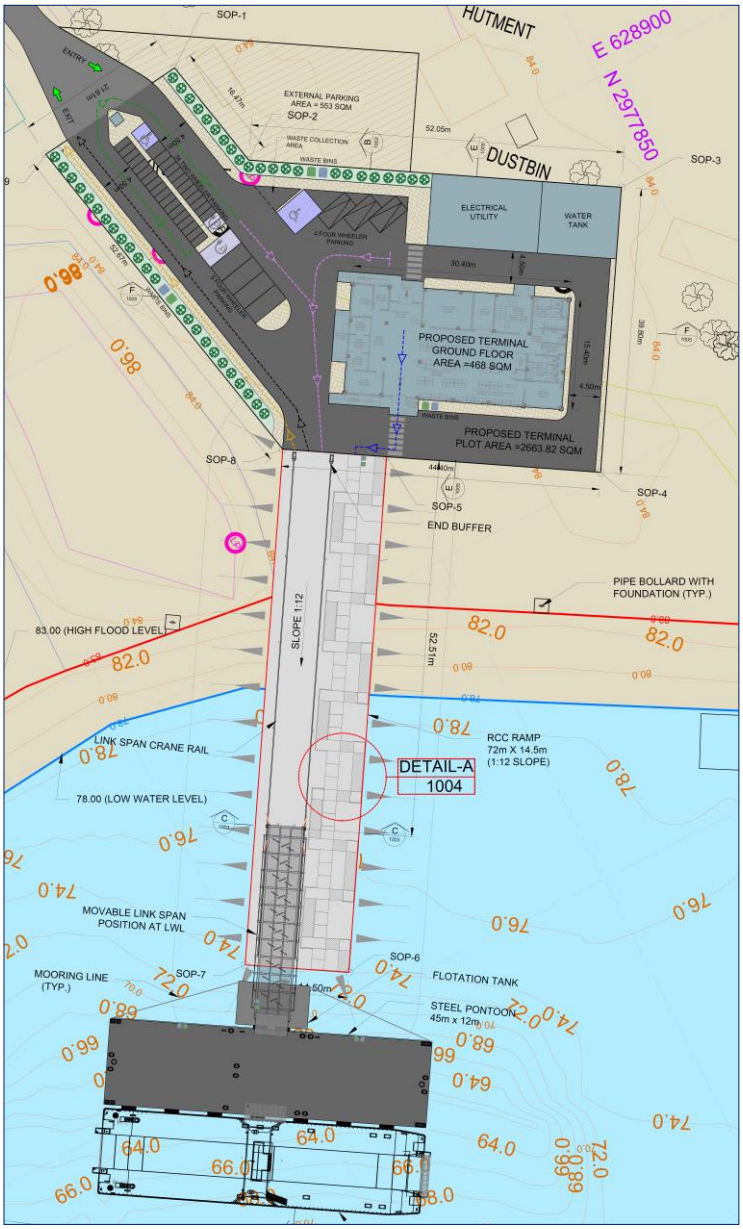


Figure 8-5 Concept solution 2a - Movable floating pontoon and linkspan

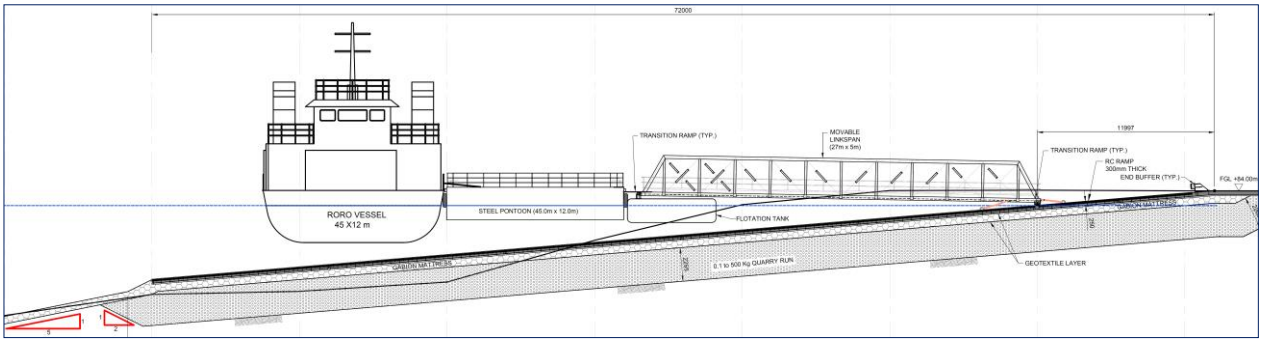


Figure 8-6 Concept solution 2a - Typical cross-sectional view

8.1.3.2.2 Concept Solution 2b – Movable floating Pontoon and link span with additional HDPE floating walkway

Concept solution 2b is essentially a floating pontoon and a HDPE floating access way connecting the sloping access bund with the riverbank. A schematic diagram of this concept solution is presented below.

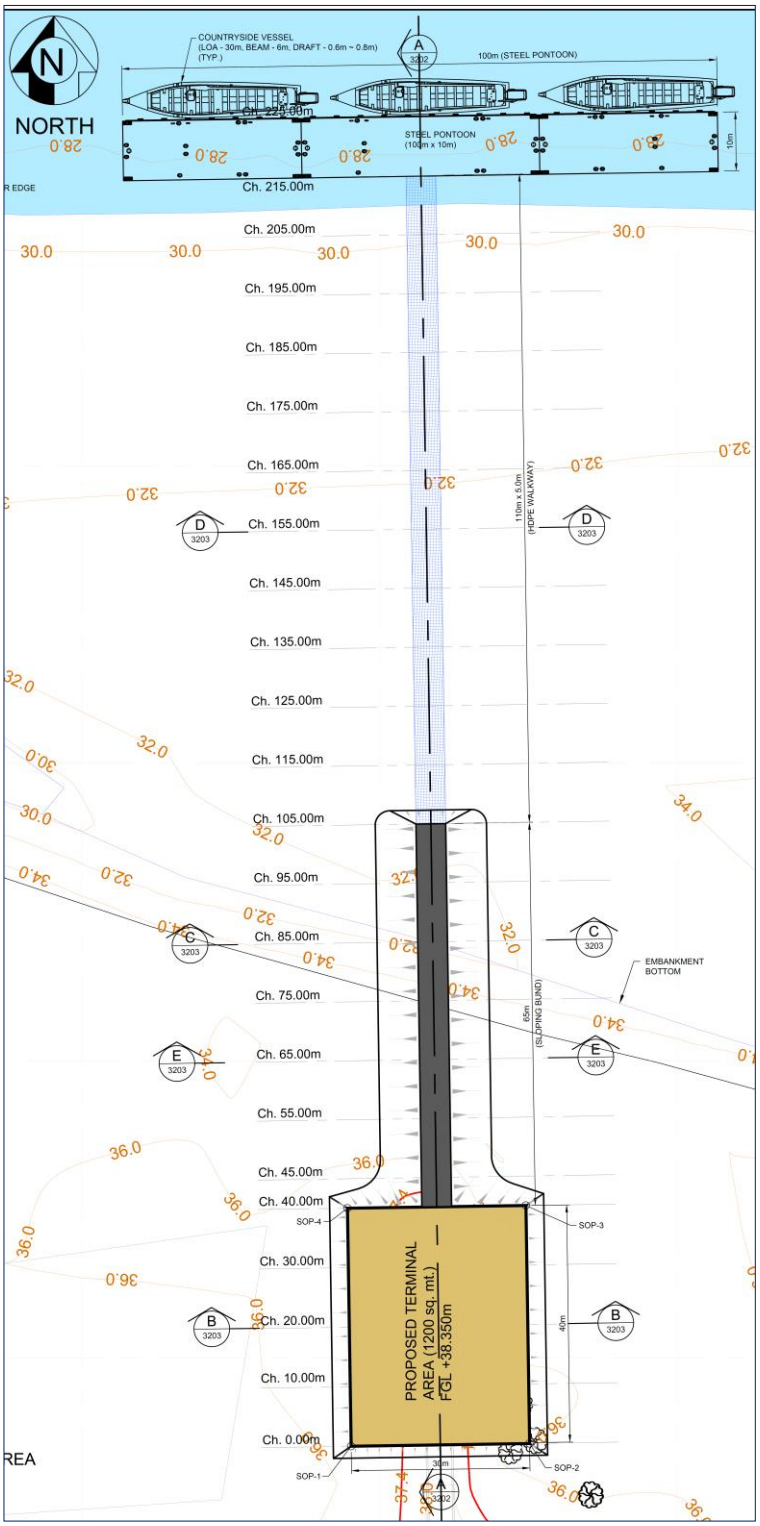


Figure 8-7 Concept Solution 2b -Pontoon and HDPE access blocks and Sloping Access Bund

The Concept solution 2b is like that of concept solution 2a but differs with an addition of floating HDPE solution connecting the pontoon and the access bund. This option is proposed for the terminal sites where the presence of the low water level location is very far away from the riverbank due to the presence of the sand bars in the river in between high and low water levels. The ideal option to create an access way to reach the low water level is having an installation of HDPE floating access way system.

The HDPE floating system will bridge the gap between the pontoon and the sloping access bund. The commuters can safely reach the berthing pontoon with this system.

The full length of the HDPE floating system will be in operational when the water level fluctuates between the low water level and the high-water level. During lean water season, these HDPE floating access system needs to be dismantled on the portion where it rests on the sand base and placed where localised streams present in the sand bars. During the high-water level, the access length to the boarding or deboarding of the vessel becomes shorter and thus the modular HDPE access blocks can be shortened to suit the requirement.

8.1.3.3 Concept Solution 3 – Fixed Infrastructure

8.1.3.3.1 Concept Solution 3a-Fixed Multiple floating pontoon with fixed linkspan from approach trestle

Concept solution 3a is a combination of floating pontoon, guide piles, linkspan and an approach trestle. This concept solution is proposed for the terminal site location where more than one number of vessel berthing is anticipated at the same time. For accommodating these vessels, the berthing facility shall be sufficiently larger in length in general. The concrete approach trestle shall be accommodating the linkspan rear end which will be in fixed position. The front end of the link span will be resting on the pontoon and will move in upward or downward direction along with the pontoon during the seasonal water level variation. The pontoon shall be moored with guide piles and thus restricting the movement of the pontoon in the horizontal direction.

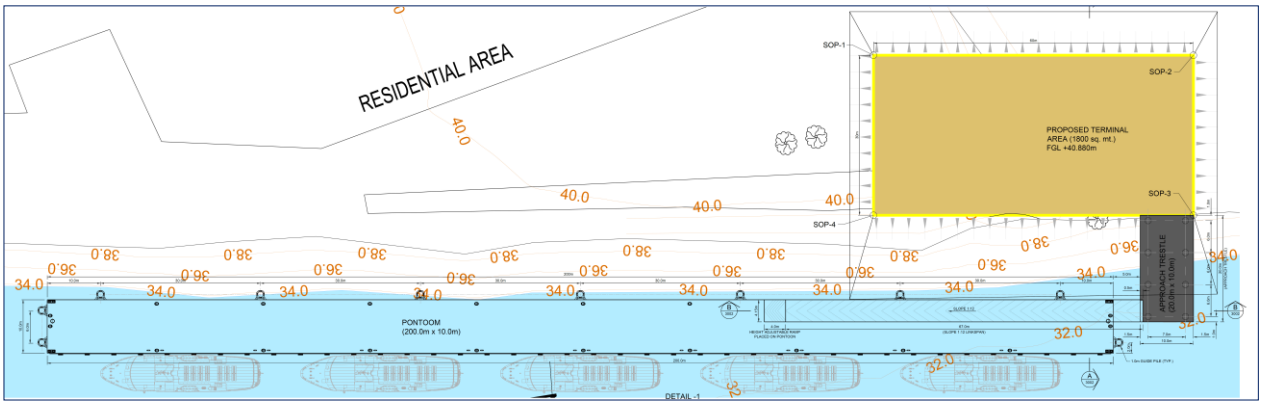


Figure 8-8 Concept Solution 3 - Fixed Pontoon and Fixed Linkspan and Approach Trestle

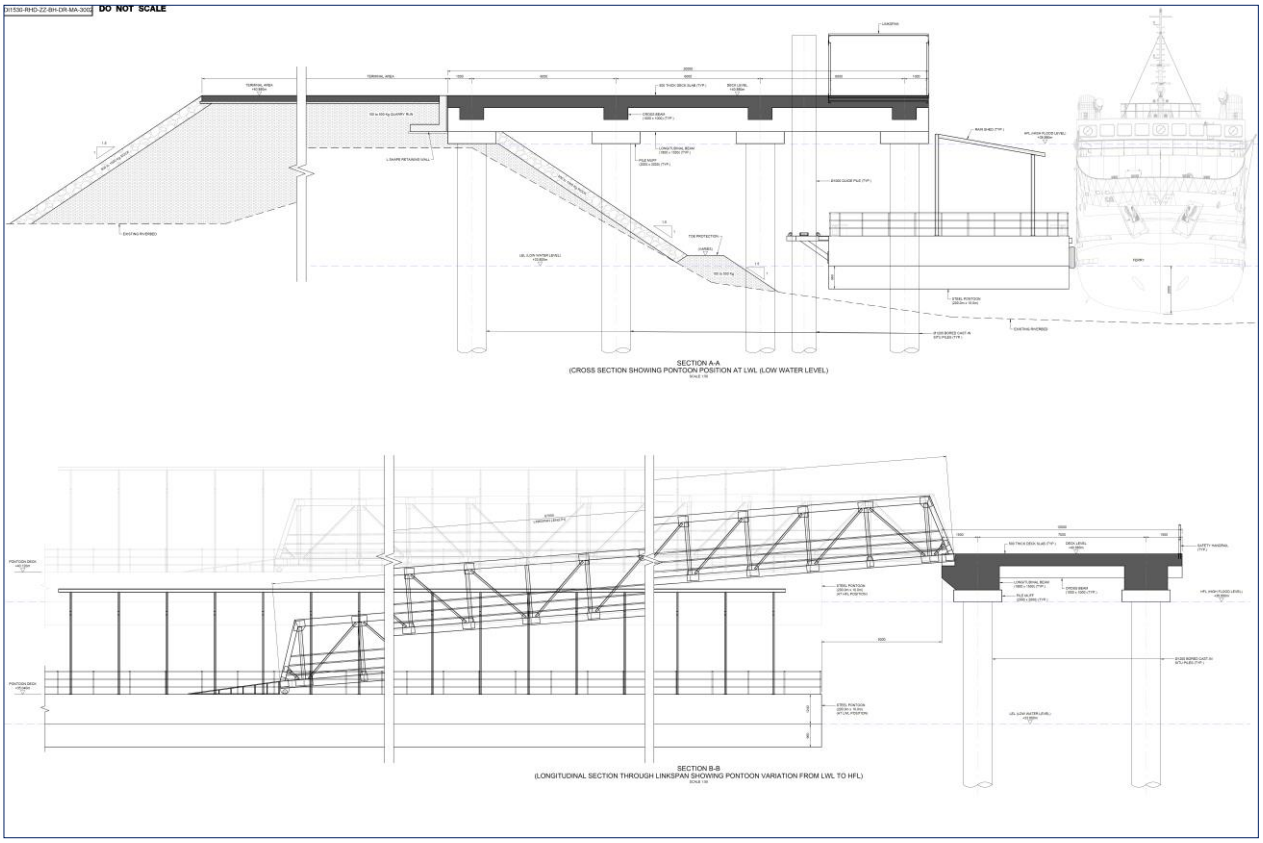


Figure 8-9 Concept Solution 3 - Typical cross-sectional view

Further, this option can be recommended for severe erosion terminal sites where appropriate bank protection measures are taken into consideration.

8.1.3.3.2 Concept Solution 3b-Fixed multiple floating pontoon with fixed linkspan on floating platform

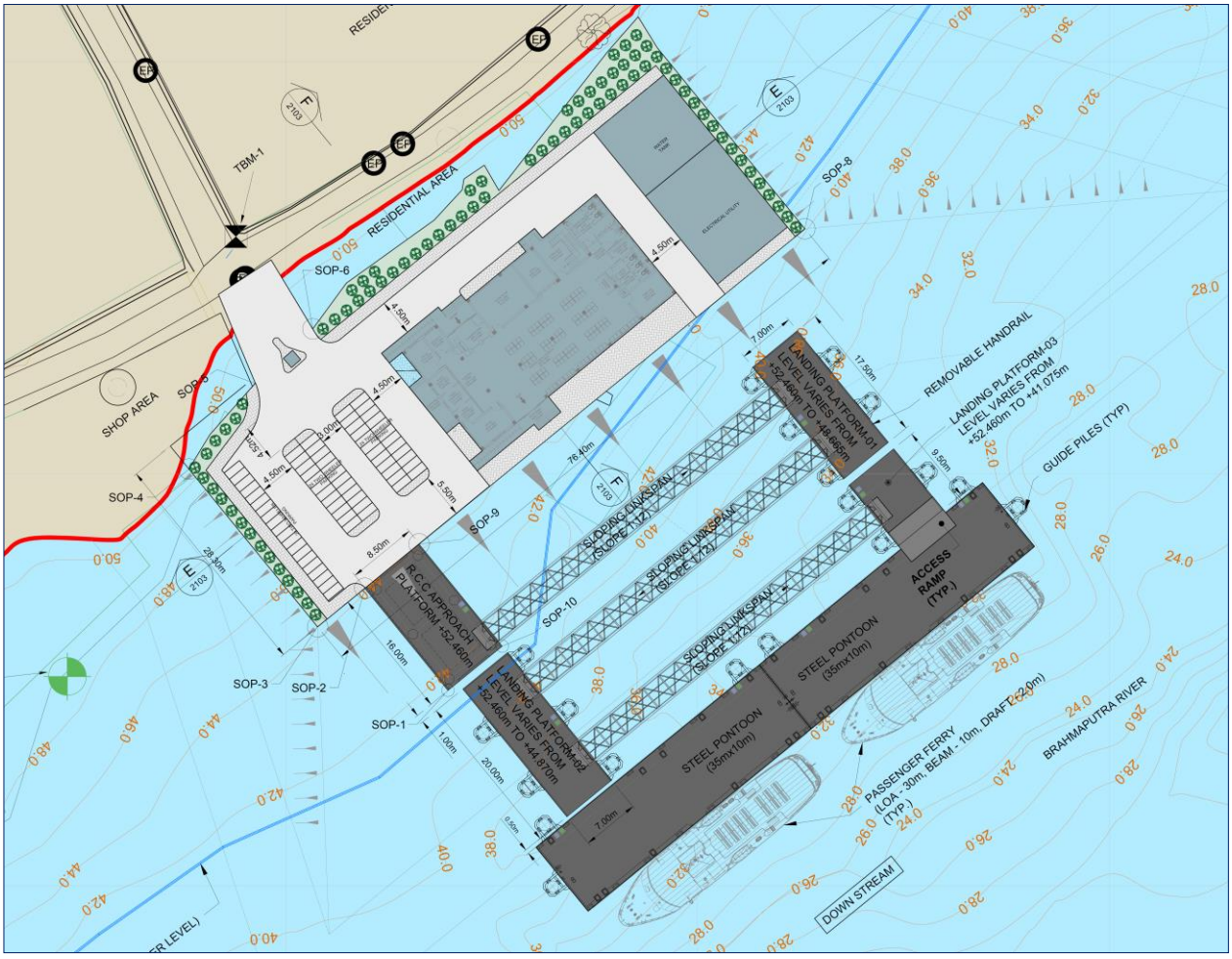


Figure 8-10 Concept solution 3b – Fixed multiple floating pontoons with fixed linkspan over floating platform

Concept solution 3b is a combination of floating pontoon, guide piles, linkspan, floating flatform and an approach trestle. This concept solution is proposed for the terminal site location where more than one number of vessel berthing is anticipated at the same time. The access structure proposed consisting of three equivalent spans of link spans which are resting concrete and floating platform at respective positions. The links span which is located near to the land side infrastructure shall be positioned on concrete flatform in the front end and floating flatform on the rear end. The remaining other two link spans shall always be positioned on the floating flatforms on both front and rear end. The floating flatforms which is located at the intermediate position of the access way will be in fixed position in terms horizontal movement and it will be freed to move to vertical direction with guided pile for certain fixed positions in relative to the water level variation of the river. The vessel berthing structure i.e. pontoon shall be moored with guide piles and thus restricting the movement of the pontoon in the horizontal direction.

8.1.3.4 Concept Solution 4 – Dog Legged Slopping Access

8.1.3.4.1 Movable floating pontoon and linkspan and stepped concrete Ramp

Concept solution 4 is essentially a floating pontoon and ramp connecting between sloping access on the riverbank and the pontoon. A schematic diagram of this concept solution is presented in Figure 8-11 and Figure 8-12.

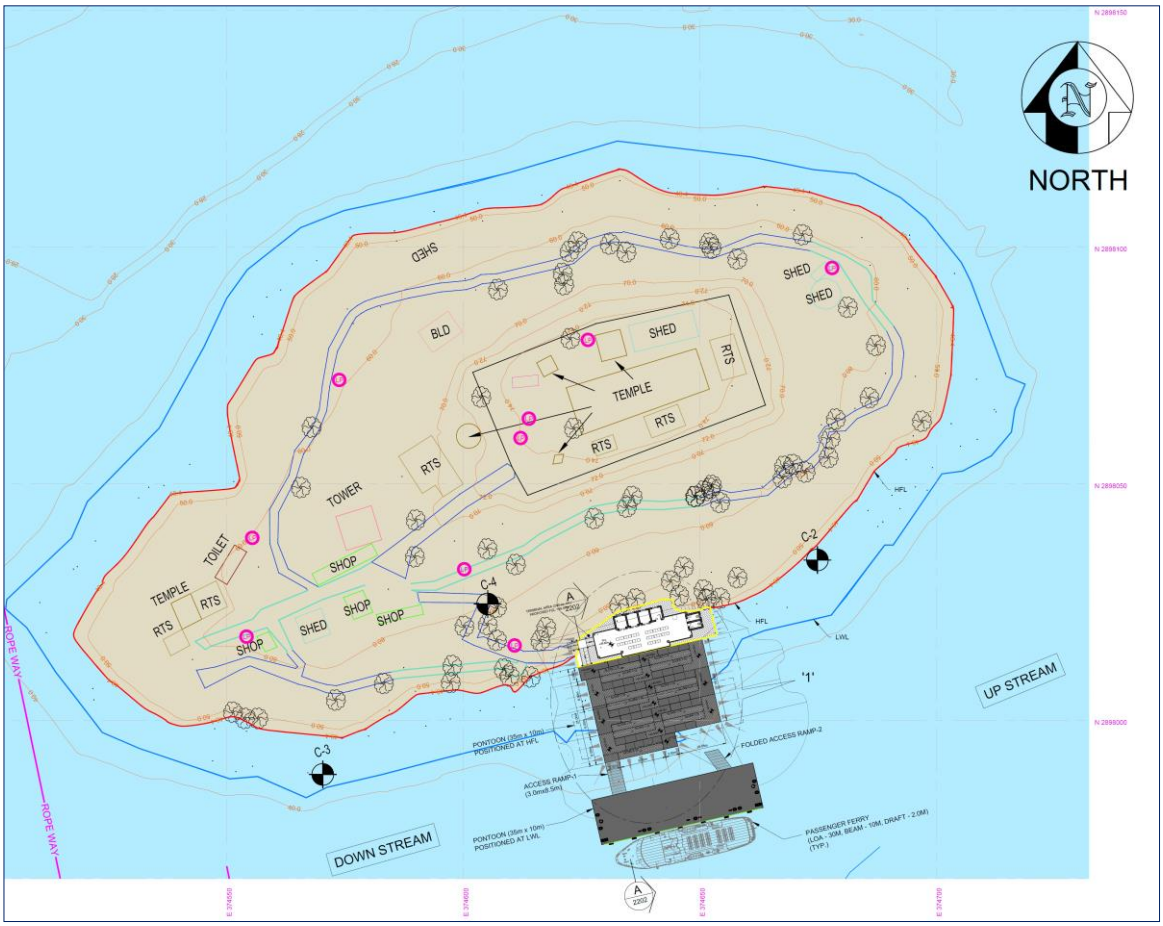


Figure 8-11 Concept solution 4 - Pontoon Linkspan and Sloping Access

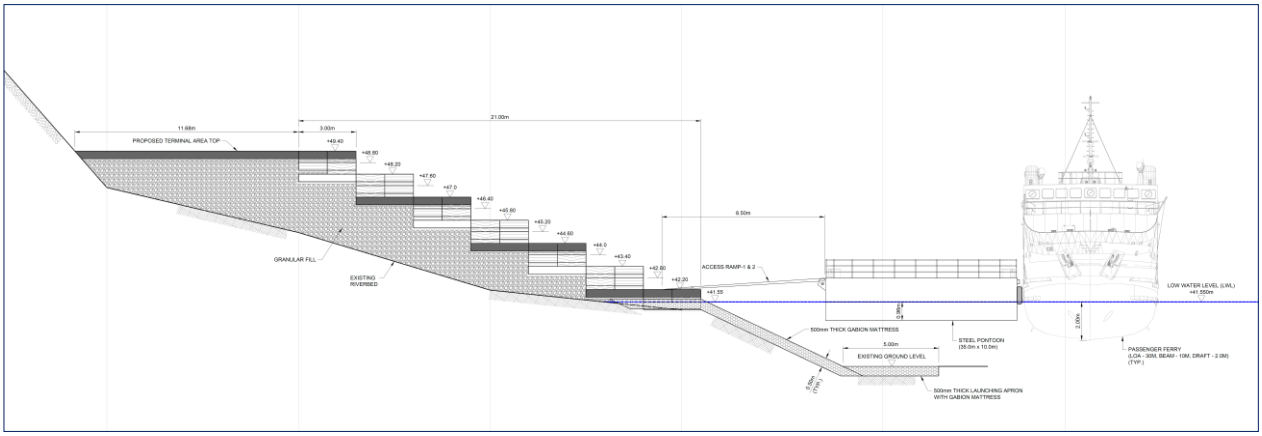


Figure 8-12 Concept Solution 4- Typical cross-sectional view

This concept solution is proposed to the terminal site where land mass is made up of rocky strata. The sloping access way shall be planned on the rock strata in a staggering manner. These staggered levels are proposed to connect the access way levels from low water level to high water. The slope of the access way shall be limited to 1:12. Each dead end of sloping access way will be having a landing point where the pontoon ramp will rest for the movement of the passenger. There will minimum two landing ramps on both ends of the pontoon and during the seasonal water variation in the river the respective ramp which is in the level of the access way landing point shall be placed on the landing point for the safe movement of the passengers. The material such as quarry run and gabions shall be proposed to create the access way.

8.1.3.5 Concept Solution 5 – Spud Pontoon and Land Connectivity

This concept solution is basically a spud pontoon with inbuilt access ramp resting on landside facility. The spud pontoon will act as a berthing facility and the inbuilt access ramp will provide safe passage for the movement of passengers and two wheelers. The vessels shall berth along the riverine face of the spud pontoon.

The flat deck of spud pontoon provides suitable platform for accommodating basic facilities of the berthing structure. The spud pontoon moored by inbuilt steel shafts which is by virtue of self-weight driven into the riverbed. The spud legs keep the platform securely in position without drifting away from river currents.

The main advantages of the spud pontoon are that its position can be shifted as per user requirements thus meeting the change in the riverbank position. While planning to relocate the spud pontoons, positions of each spud must be raised above the riverbed level and each spud must be pinned at raised position.

The size of the spud pontoon is governed by the vessel dimension. The width of the spud pontoon is governed by the passenger, vehicle and goods volume arrived per vessel which is based on the traffic study. The spud pontoon needs to be covered with a roof to protect the commuters form adverse weather effects.

Figure 8-13 Concept Solution 5 - Spud pontoon

The above solution is currently not proposed to any of the terminal site. Since rate of scouring is high in the river basin.

8.1.4 Preliminary Assessment of Concept Solutions

The choice of the solution may differ for each location of the terminal, based on available river frontage, water level variations in the river, location of lowest water level in river and composition of traffic. But the basic principles of the solution will remain common for all the terminals. Based on the evaluation for the

riverine infrastructure, Concept solution 1a & 1b, Concept solution 2a & 2b, Concept solution 3 and Concept solution 4 appear promising for locations under the South, Central and North Cluster.

Based on the evaluation of all the concept solutions, terminal site wise application of these concept solutions has been summarised in the following table

Table 8-4 Summary of terminal site wise applicability of concept solution

Concept solution	Solution Title	Relevant sites	Remarks
Concept Solution 1 - Linkspan Perpendicular to Sloping Bund			
Concept solution 1a	Movable single floating pontoon with movable linkspan		
Concept solution 1b	Fixed multiple floating pontoon with the movable linkspan		
Concept Solution 2 - Linkspan Parallel to Sloping Bund			
Concept solution 2 a	Movable floating pontoon and linkspan		
Concept solution 2 b	Movable floating pontoon and linkspan with additional HDPE floating walkway		HDPE solution shall be part of sloping bund
Concept Solution 3- Fixed Infrastructure			
Concept solution 3a	Fixed multiple floating pontoon with fixed linkspan from approach trestle		
Concept solution 3b	Fixed multiple floating pontoon with fixed linkspan on floating platform		
Concept Solution 4- Dog-legged Sloping Bund			
Concept solution 4	Stepped concrete ramp	**Umananda**	Island / only passengers / inadequate land area

8.2 Planning of Riverside Infrastructure - Umananda

The Umananda is an island in the Brahmaputra River and it is famous for the temple which is present on hills of the island. There is no residential areas and commercial spaces present in the island at this moment of time. Most of the commuters are devotees and tourists and there is very less chances of development of residential spaces. The people visit the temples by crossing the river through ferry service by parking the vehicle on the opposite bank of the river. Island is made up by rocks the rocky outcrops present across the hill.

8.2.1 Existing Facility

The existing ferry terminal consists of floating pontoon facility for berthing of vessels and boarding and deboarding of commuters. The ferry terminal users are having the wooden planks as access structure to

reach the pontoon. On the land side there are no terminal buildings, dedicated waiting areasetc. At this point of time the waiting area present in the pontoon or the vessel berth at the pontoon. The terminal site status is shown in the picture below

Figure 8-14 Existing ferry terminal

8.2.2 Proposed Facility

There is a need to develop a ferry terminal with all basic infrastructure and facilities. At the present stage except vessel berthing facility there is a lack of other infrastructures. From site visits and available data, noticed the vessel types are operating in this location are falls category-C. This ferry terminal shall be planned for the usage of foot passengers. The vehicular traffic is not anticipated at this moment since the devotees cross the river through ferry services and there is not any necessity to carry their bellowed vehicle till island.

From the desktop studies it is understood terminal site is stable over the years due to presence of the rocky strata in the island. This terminal site falls under category -3 that is stable riverbank. The entire terminal facilities development shall take place on the reclaimed land and slope protection shall be of Gabion matterssThe details of the landside facilities are provided in the subsequent sections. For better understanding of usable area after reclaiming, refer drawing number - DI1530-RHD-ZZ-UA-DR-C-2220

Consultant also evaluated the option of spud pontoon. Based on theGeotechnical investigations and bathymetry survey, it is noted that the weathered rock may get encountered at 1 m depth, moreover the riverbed profiles are steep in nature. The spud pontoon shall require appropriate ground condition to allow spuds to get embedded into the ground to attain maximum stability. Also spud pontoon require skilled operators and has high operation and maintenance cost. Therefore, recommendation of spud pontoon solution shall have high capital expenditure thus increasing the overall project cost hence the same is not considered for further assessment.

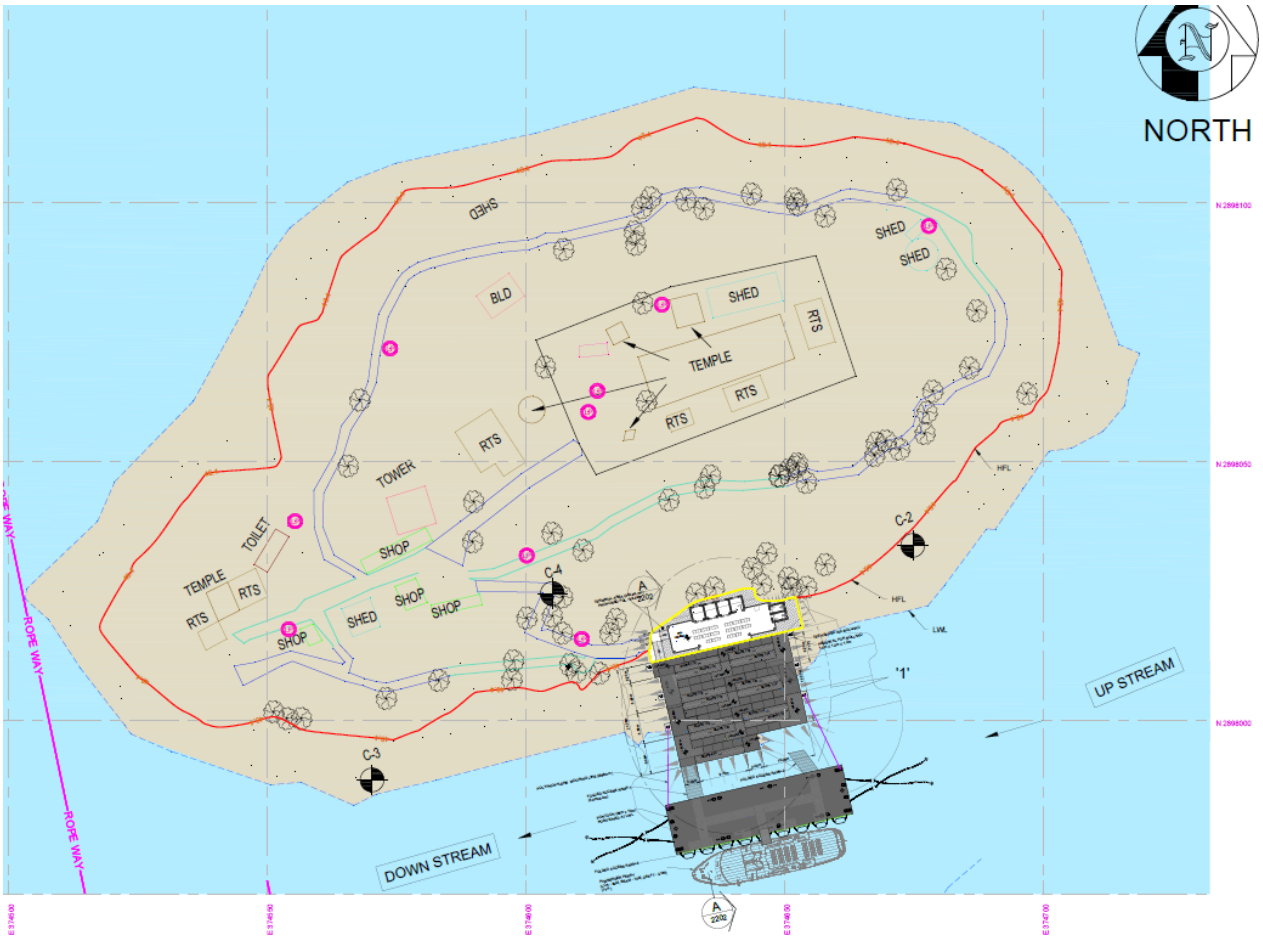


Figure 8-15 Proposed Solution – Umananda Location

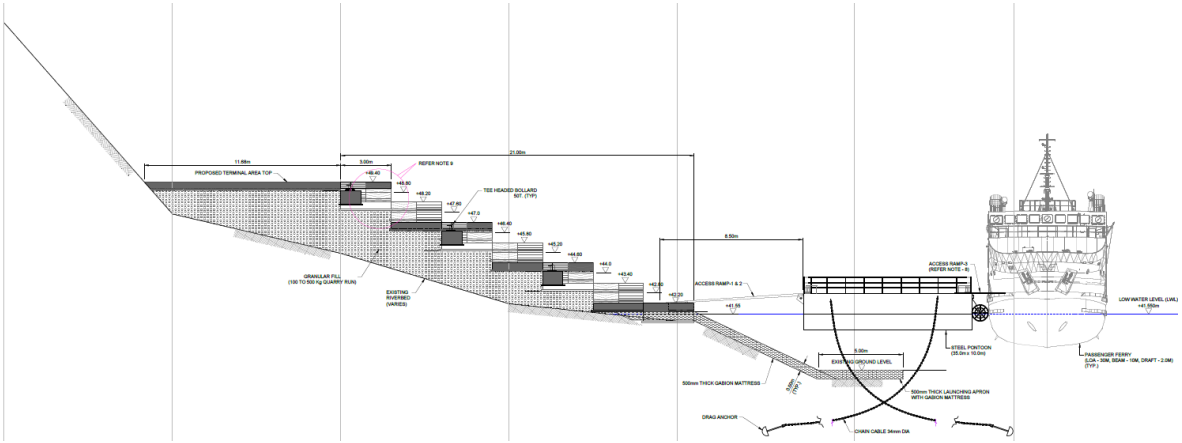


Figure 8-16 Proposed design- Typical cross-sectional view

The riverine infrastructure at the terminal is planned according to the Concept solution 4. It is essentially a floating pontoon and ramp connecting to sloping access on the riverbank and floating pontoon for the safe commute of the passengers. The details of the poonton and bund is presented in the sub section.

The overall layout, berthing arrangement at HFL, berthing arrangement at LWL and other details of the preliminary concept for the proposed ferry terminal can be referred from Drawing No. DI1530-RHD-ZZ-UA-DR-MA-2201 and 2202 placed under **Appendix D**. The site coordinates have been presented in the table below.

Table 8-5 Proposed Ferry Location Coordinates

Site Coordinates:	
Latitude	26°11'46.12"N
Longitude	91°44'42.73"E

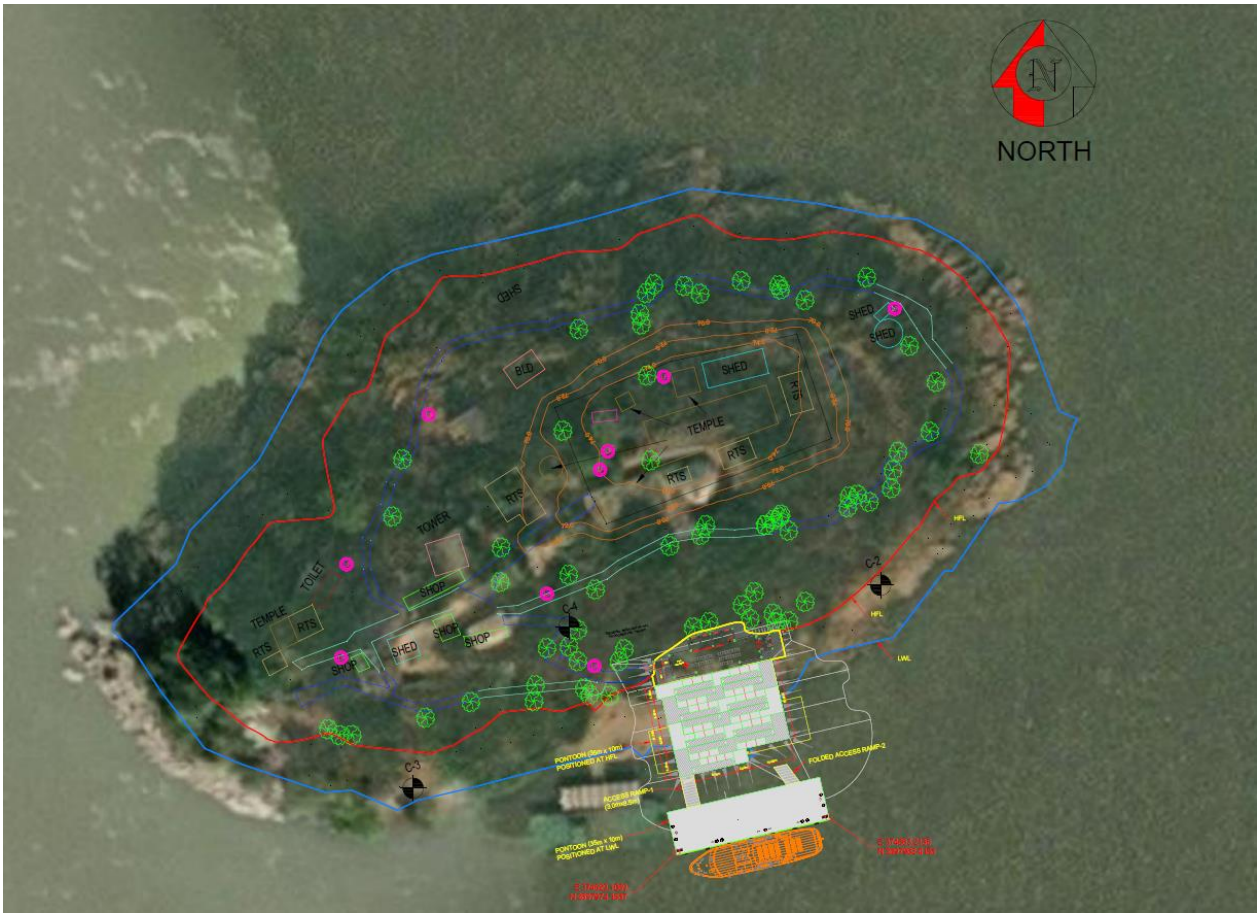


Figure 8-17 Satellite Imagery of Proposed Solution – Umananda Location

8.2.2.1 Floating Pontoon with Integrated Ramp

The floating pontoon shall be suitable for operations in inland waters to be stationed at the locations along the river and capable of being moved to various specified location for embarking/disembarking of passengers/vehicles from vessel to pontoon and vice versa.

Figure 8-18 Typical Pontoon Arrangement

In view of the proposed arrangement as per feasibility study, the pontoon is proposed to be moored at site either via catenary chains and suitable type of anchors or alternately electrically operated/diesel driven hoist able telescopic type spud poles could be considered. The number and type of structural or outfitting elements which are required for mooring the pontoon shall be finalized based on various static and dynamic loads, site conditions and statutory requirements. The construction of the steel pontoon will be based on normal shipbuilding practices and IRS/classification rules.

8.2.2.1.1 Estimated Principal Particulars.

The principal particulars provided below are for preliminary estimate purpose and the main particulars as well as scantlings are to be finalised in accordance with standard shipbuilding practice and classification rules.

- Type of pontoon: Box type steel all welded.
  A box type pontoon has been chosen as it has much better stability and provides adequate space for movement of passengers and cargo and thereby ease and safety of operations can be better ensured
- Dimensions of pontoon-
  - Length: 35.00 metres
  - Breadth: 10.0 meters
  - Moulded depth: 1.8 meters approx.
  - Draft: 0.5 meters approx.
- Number of pontoons -01 at designated locations
- Number of Integrated Ramps – 02 numbers, each of 8.0 m x 3.0 m
- The pontoon is expected to receive passenger's vessel with approx. 100 PAX capacity.
- The passage for movement of passenger to be of anti-skid type
- Reserve Buoyancy of the pontoon shall be in accordance with statutory rules and regulations.
- The bottom should be strengthened for loading and unloading aground.

8.2.2.1.2 General Arrangement and Facilities (Each Individual Pontoon):

The guideline general arrangement (GA) drawing is placed at **Appendix "D** ". Drawing number - DI1530-RHD-ZZ-UA-DR-C-2216. These facilities are to be suitably positioned on both the pontoons as per requirement. Following general facilities are proposed.

- One small cabin of at least 4 m x 4 m on deck for keeping stores, material etc suitably located.
- Railing of at least 1.25 m height (fabricated out of IS 4923 grade steel) at suitable interval for safety parameters & the railing shall have minimum two (2) rows of bars/chains running throughout the pontoon. The railing on the receiving side of the pontoon to be of collapsible type.
- Lifesaving appliances (at least 8 Nos. lifebuoys) to be provided.
- At least 04 number of portable dry powder fire extinguishers of 9 litre capacity for all classes of fire to be provided. In addition, 04 numbers Fire buckets (9 lit. Capacity) and 04 numbers Sand boxes (0.5 m x 0.5 m x 0.3 m to be provisioned. 02 numbers of Fire Hose with nozzle to be provisioned with fitting on Main Deck with provision to be connected from shore supply.
- Tactile tiles to be provided for visually impaired people
- Electrical fittings such as lights bulbs installed on poles etc. be fitted as per requirements at storage cabin and general-purpose lighting for operations during night etc
- Shore power line connection must be provided, with necessary cable and change over switches. The electric connections to be undertaken with duly approved P.V.C. insulated multi strand copper wire in flat casing capping conduit. The electric connections for deck fittings such as winches/davits to be provided as per requirement.
- One portable submersible pump of at least 10 tons/hr each along with discharge hose of adequate length to be provided for various pumping out purposes.
- Pontoon shall be facilitated by appropriate ballasting and de-ballasting arrangements.
- The passage on the deck to be of non-skid type. The paint scheme on the top deck should be anti-skid type
- Adequate number of double bollards of standard size or as suitable to be provided on the main deck distributed on the port and starboard side suitable spacing for effective mooring.
- Steel fenders are to be provided on either side for 95% of the length of pontoon. Tyre fenders of sufficient size are also to be provided on both sides of pontoon.
- Adequate number of fairleads as per number of bollards located on either side of bollards to be provided.

8.2.2.1.3 Navigation and General

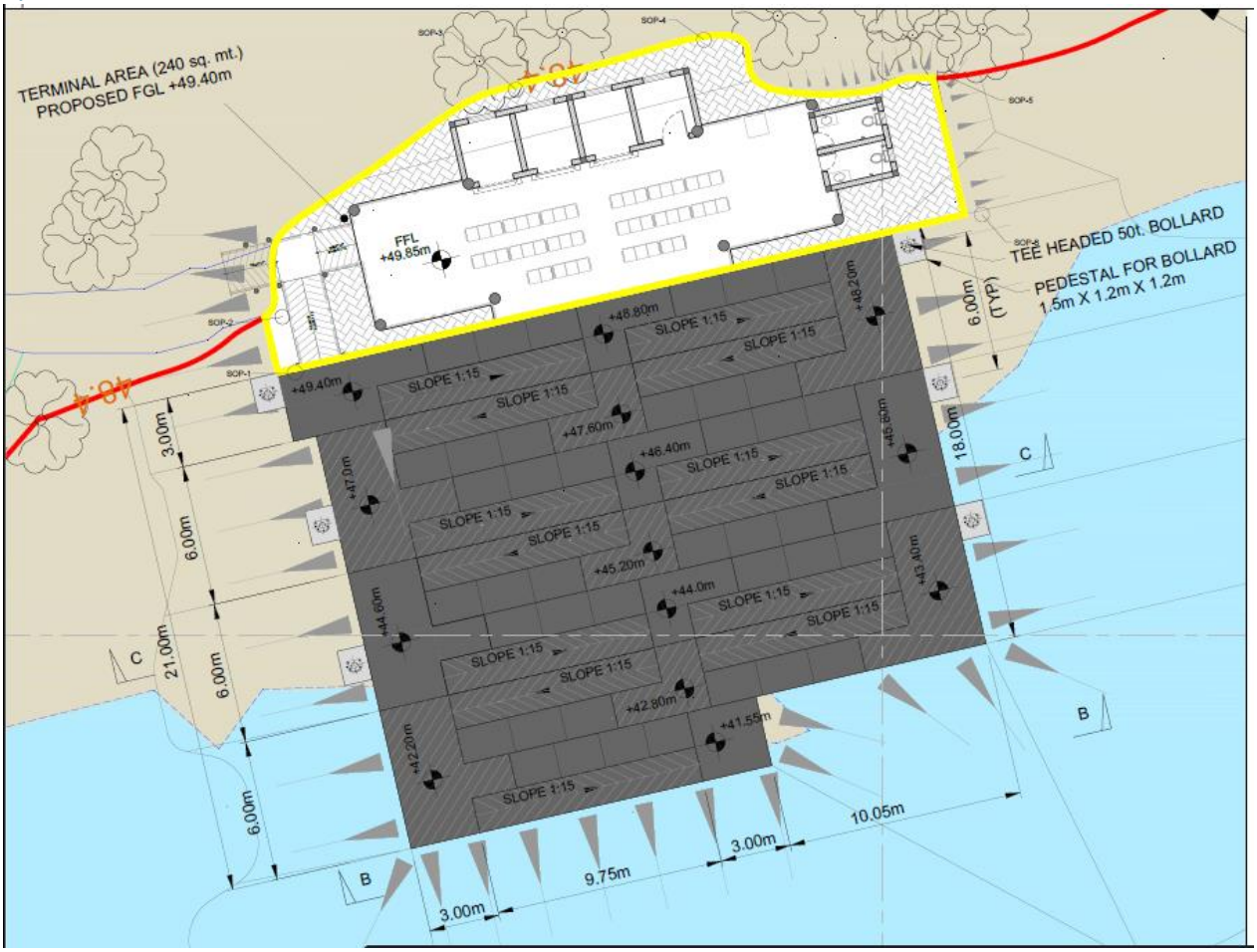
For general lighting/illumination purposes, 6 Nos. of masts with lights are envisaged to be provided onboard the pontoon. Navigational lights shall be as per the applicable Statutory/Regulatory requirements (COLREG regulations/Flag regulations) considering the towed regimes that this pontoon may undergo, portable navigational lights shall be planned as the usage pattern will be sparse considering its functional requirement.

8.2.2.2 Approach Bund

The approach bund is the contact point of pontoon ramp with landside infrastructure. The passengers disembarked from the pontoon shall move through ramp will reach the approach bund. The approach bund in the Umananda is planned in a staggered / doglegged manner due to the availability of less river frontage area. These staggered levels of the approach bund connect the access way from low water level to high water. Further this solution is proposed to the terminal site since land mass is made up of rocky strata. The slope of the access way shall be limited to 1:15 refer Table 7-1 for detailed information. Each dead end of

sloping access way will be having a landing point where the pontoon ramp will rest for the movement of the passenger. Approach Bund single flight/Ramp length is of about 9.50 m with (+/-) 0.60 m change in elevation. Further, the bollards are placed at specific locations at the edge of approach bund and shall be connected to RCC slab of approach bund, In the approach bund, the vertical cut/fill shall be stabilized by box gabions of suitable sizes to retain the granular fill.

Due to seasonal water level variation, accumulation of silt may occur over the sloping bund., . Therefore, as a part of annual maintenance if there is any silt accumulation it shall be removed for seamless ferry operations.



8.2.2.3 Riverbank protection

The six ferry terminal sites are prone in moderate erosion to severe erosion zones. Please refer Table 8-2 for erosion terminal site information. There is a need to protect the riverbank from the erosion and stabilise the riverbank to have the terminal operational. The proposed ferry terminal infrastructure will be under risk without proper bank protection measures. There are various methods available for the riverbank protection and the same can be achieved by having reno mattress or fabric form mattress.

- **Fabric form Mattress solution methodology**

Initially riverbank steep slopes trimmed to achieve ideal slope where the placing of the riverbank erosion protection component becomes easy, and which gets good stability. On the trimmed surface of riverbank non-woven Geotextile shall need to be placed. The geotextile shall be needle punched made of polyester

staple fibre. Finally, the fabric form mattress shall place over the geotextile surface. The fabric form mattress shall be filled with suitable filler material, in this case cement mortar considered as filler material shall be laid on geotextile base.

The minimum ultimate strength of the fabric form mattress filled with cement mortar should be 75 kN/m. The sketch of riverbank cross section with erosion protection component details are presented below

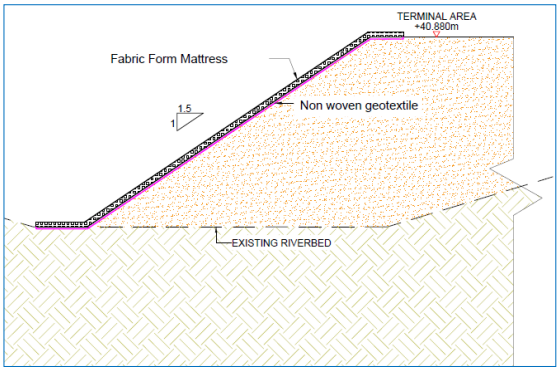


Figure 8-19 Riverbank protection for terminal site

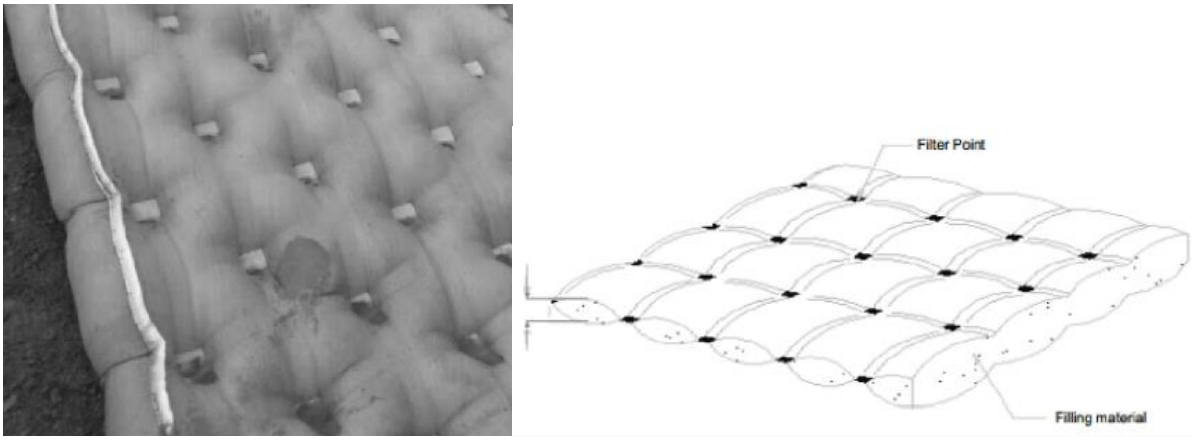


Figure 8-20 Fabric foam mattress

8.2.3 Operational Philosophy

- The 35 m x 10 m pontoon will have self-integrated two ramp arrangement. The ramp sizing shall be of 8 m x 3 m.
- The dog legged ramp arrangement is provided to cater to the seasonal water level variation. Sloping ramp with the landing at the either side of it, shall be used as landing platform from low water level, intermediate to high water level. At the Low Water Level condition i.e., 41.550 m the Access Ramp 1 (AR1) shall be resting on landing which is at 42.20 m at the same time the Access Ramp 2 (AR2) shall be in lifted position / unserviceable.
- Appropriate consideration of vessel draft, the pontoon shall be positioned using anchoring and mooring arrangement.
- Increase in the water level by 1.20 m, the tension in the mooring lines shall be relaxed to reposition the pontoon transversely towards the approach bund by maintaining a clear distance of 7 m between the Pontoon & the landing where the ramp shall rest.
- At this position, the Access Ramp 2 (AR2) will be in operation and Access Ramp 1(AR 1) will be unserviceable and pontoon shall be anchored and moored accordingly.

- The above stated procedure will be repeated until the water reaches the Design High Water Level at the top and vice versa while water retreats until it achieves the low water level. The facility shall not perform operations if the water exceeds the HFL or LWL.
-

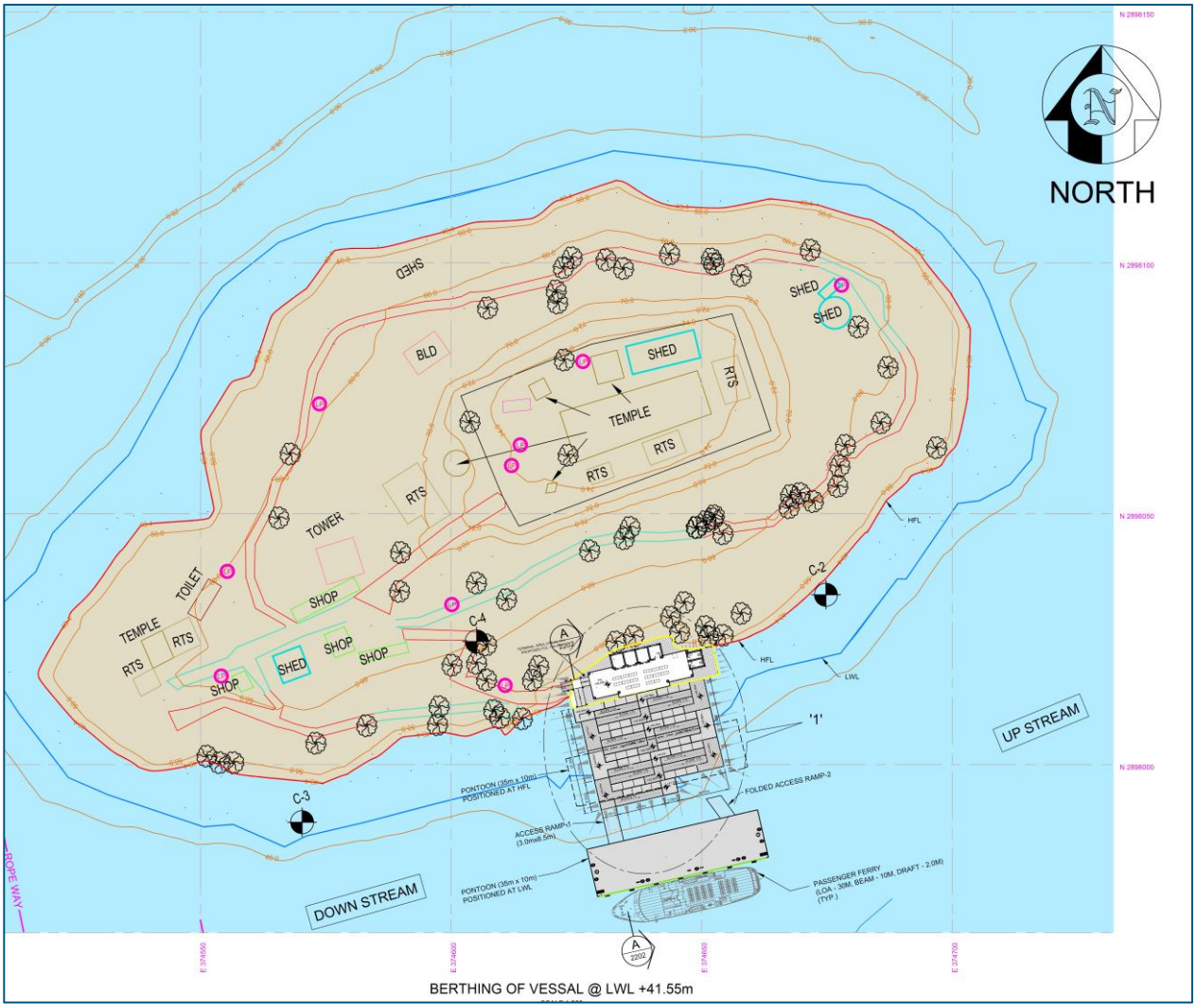


Figure 8-21 Typical Arrangement of Pontoon, Ramp and Approach Bund

8.3 Planning of Landside Terminal Infrastructure

The major requirement for the infrastructure designs is to cater to the functional needs with proper space utilisation by incorporating various sustainability & safety aspects.

The landside & riverine infrastructure proposed for the ferry terminal are robust structures and provide floating but permanent boarding/deboarding locations for passenger and vehicles. The design will also ensure a greater sense of safety among the passengers travelling through these vessels. The terminal utilities and services are provided for ease of operation and maintenance during any water levels.

Following component have been planned as part of Landside to fulfil operational needs to the proposed terminal.

- Land infrastructures
- Roads

- Landscaped areas
- Parking areas
- Terminal building
- Utilities for Electrical, water tanks, sewage treatment etc.

8.3.1 Design process adopted

The proposed terminal caters to the passengers traffic travelling to and from Umananda Ghat. The plans have been developed keeping below factors as prime objective

- Convenience
- Efficiency
- reliability
- Ease of logistics
- Safety & security,

providing easy and secured mode to access vessel from land.

The entire facility has been further divided to two subcategories

- Landside Facility
- Riverine Facility

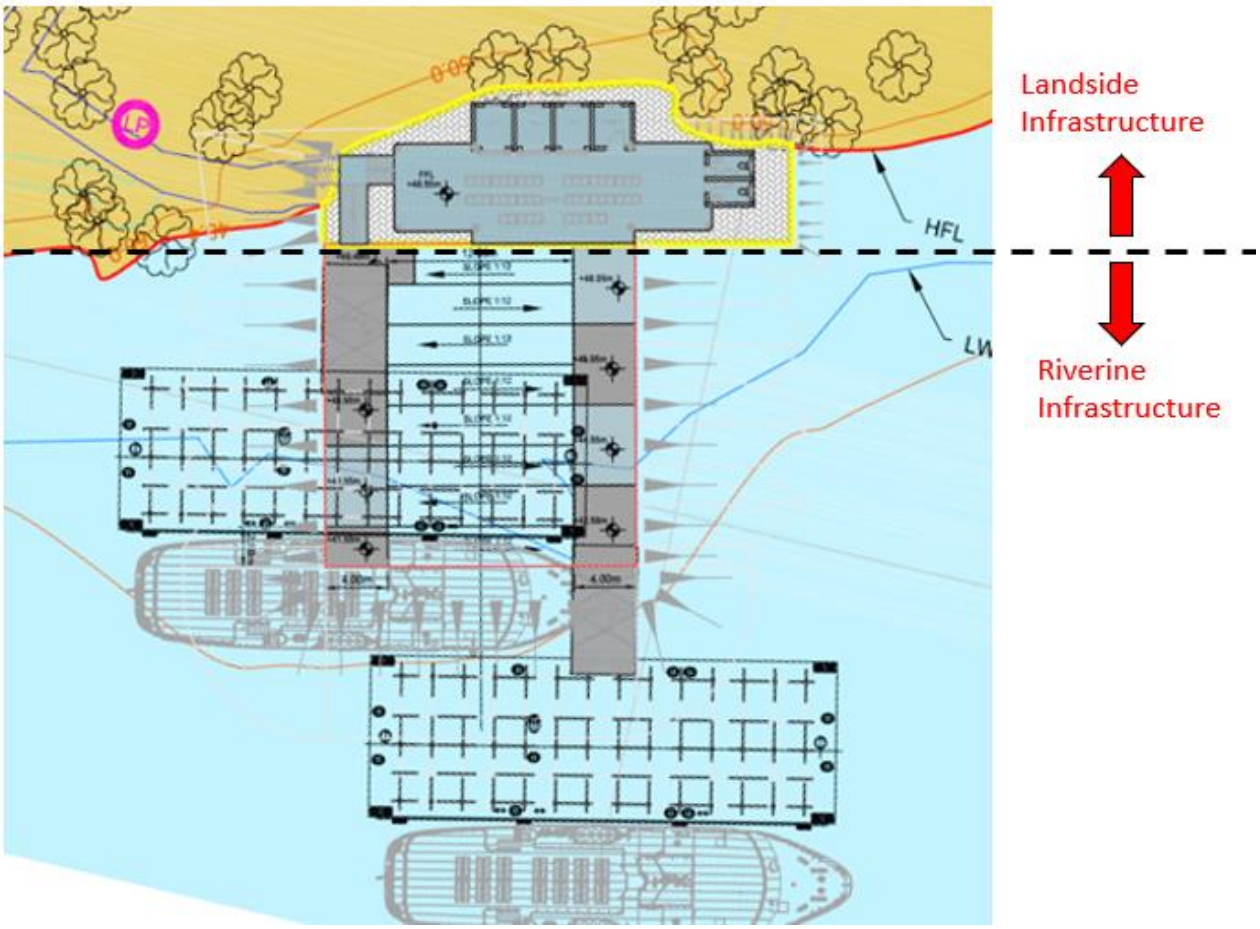


Figure 8-22: Terminal design plan

For Site Plan details refer drawing number DI1530-RHD-ZZ-UA-DR-A-2220

The riverine facilities will have,

- Approach ramps
- Sloping linkspans
- Pontoons

This section of documents covers complete design philosophy of developing entire terminal facility in detail.

The designs will be proposed with focus on the following aspects:

- Functionality
- Reliability
- Modularity
- Safety
- Sustainability
- Aesthetics
- Structural
- CAPEX and OPEX

8.3.2 Codes and Standards for terminal planning

Latest editions of the following codes and standards shall apply:

- National Building Code 2016
- CPWD Guidelines– Handbook on Barrier Free and Accessibility 2019
- Manual on Infrastructure 2015 CBEC
- Handbook on Planning of Office Building CPWD 2013
- Office Memorandum by Ministry of Urban Development
- IGBC New Building Guidelines
- Local Municipal Byelaws
- MORTH and IRC Specification and Regulation
- Bureau of Indian Standards
- Bureau of Energy Efficiency
- Indian Electricity Act

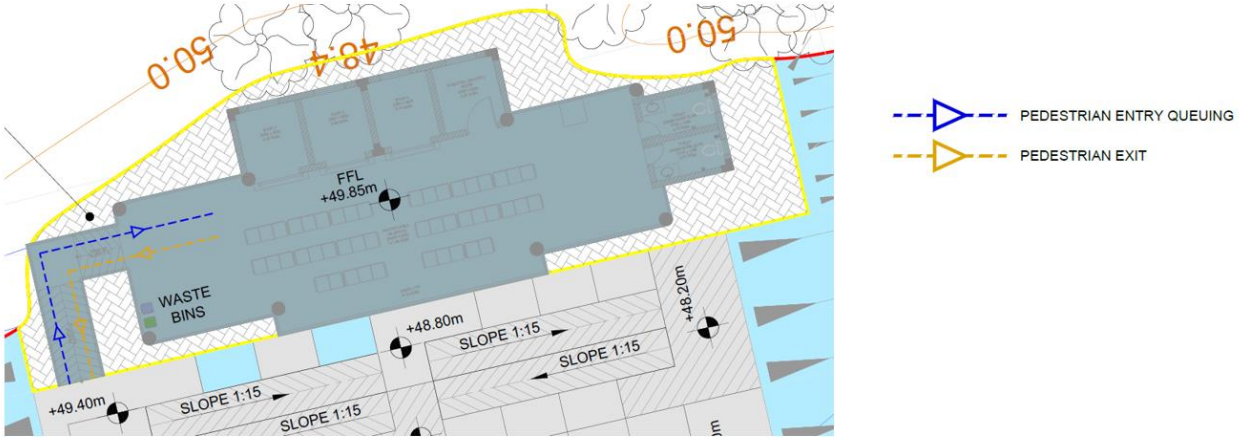
8.3.3 Operational philosophy

A typical sequence of events occurring during the dwell time can be summarized as follows, Dwell time can be described as the time during which the vessel is positioned at the ferry dock, the overall development of entire facility has been primarily designed considering below operational sequence,

- Vessels has been docked
- The vehicles are allowed to disembark from Vessels
- Passengers are directed to disembark to shore side passenger exit way
- Post offboarding vessel crew conducts security checks
- Vessel crew communicates to terminal staff to begin loading.
- Passengers are directed to embark onto the vessel via the separate lanes
- Vehicles are directed to board with separation.
- Vehicles are directed to board based on a first come first served basis with oversized

The overall site plan has been developed with clear segregation of vehicular and pedestrian traffic keeping above sequencing in mind. Traffic circulations has been developed for safety and secure access to all passengers,

Based on above sequencing, possible passengers and vehicles queuing arrangement can be seen in sketch below,



8.3.4 Concept Considered for Landside Infrastructure

The planning of terminal facilities is dependent upon many factors and varying degree of predictability. The operational efficiency is the prime concern in design of landside facility. Thus, ease of logistics has been given more importance while designing to reduce overall dwell time of vessels.

Ferry terminals are transport focused facilities. The main role of a terminal is the movement of people to and from ferries. Functionality means design should be responsive to –

- Easy and Convenient embarkment and disembarkment
- Positive customer response from entry to the building till the last mile connectivity
- Appropriate waiting areas and entrance lobbies
- Hassel free ticket purchase
- Segregation of departure and arrival points and split between pedestrian movement and vehicular movement
- Adequate parking
- Barrier free environment for differently abled
- Provision of first aid Services
- Emergency responsive building
- Public Address System
- Adequate space available for Infrastructure services

8.3.5 Land side zoning

Spatial arrangement of various zones revolves near the main building mass which comprises of the basic amenities for all the users & pedestrians. This arrangement provides conflict free circulation space for commuters.

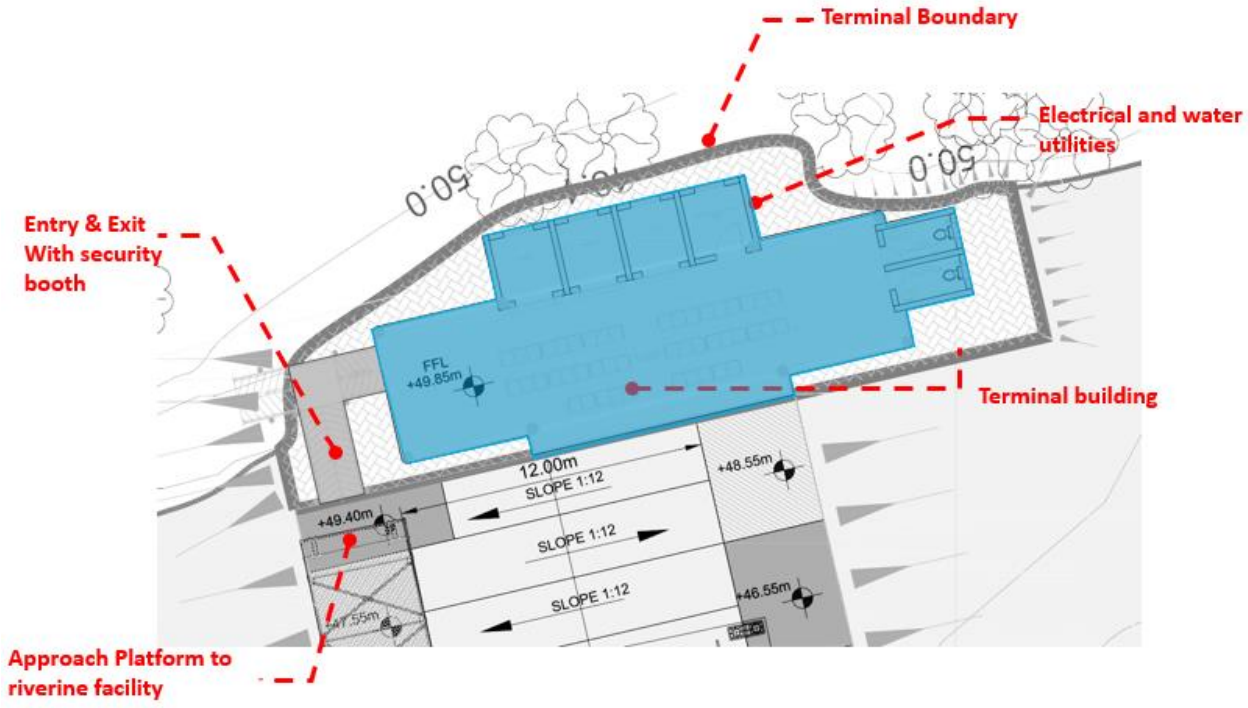


Figure 8-23: Landside facility zoning

8.3.6 Land side circulation

Terminal design aims at creating separate routes for the inbound and outbound movement to have least to no conflict in the two types of user movements. The movement pattern is shown below

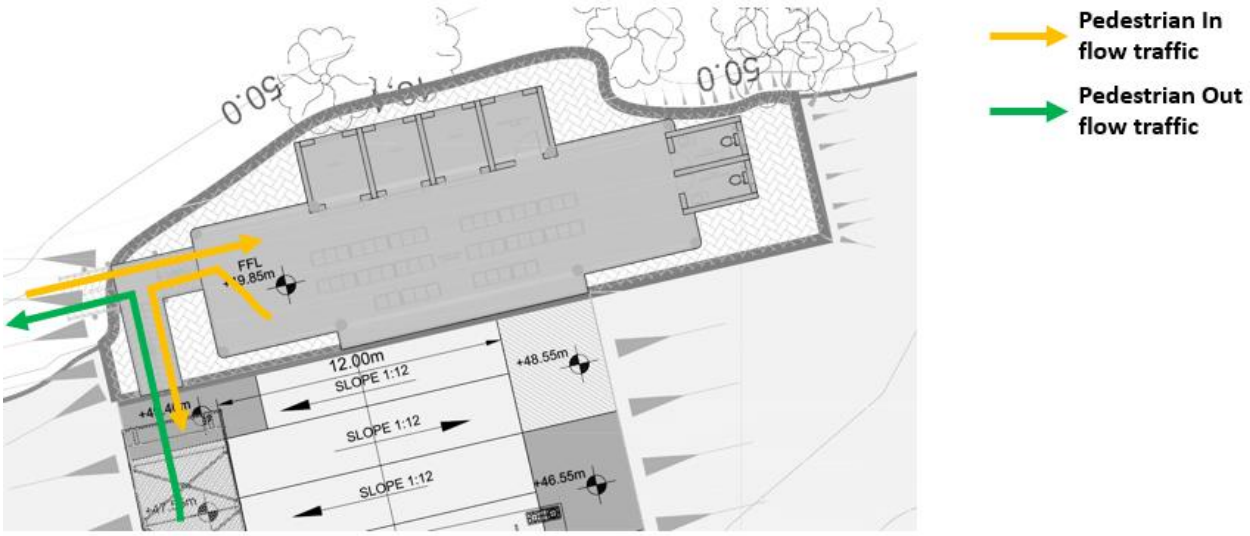


Figure 8-24: Landside facility traffic circulation plan

Circulation will mainly happen like

- Pilgrim's coming out from vessel will directly go out towards the temple
- Pilgrim's post visiting the Temple can enter facility for waiting and refreshments

- Exiting Commuters can take direct route outside facility without interfering with inbound traffic.
- Exiting Commuters who wish to use terminal building facilities can inter terminal facility.

All external areas will be equipped with accessories for ease and safe moment Street furniture like dustbins, signage, bollards, railings, etc. are knitted with the pedestrian circulation network for the ease of access & utilization.

8.3.7 Landside infra

8.3.8 Terminal buildings

8.3.8.1 Introduction

The major requirement for the architectural building designs is to cater to the functional needs with proper space utilisation. This is achieved by incorporating various sustainability & safety aspects.

8.3.8.2 Ambition

The ambition for the architectural design is to achieve the most efficient and sustainable designs. To start with, 4 important aspects has been considered as mentioned below.

- **Understanding user and terminal requirements as a functional approach** – By challenging the design/ requirements etc. and various exchanges
- Understanding **of the current operations with the existing facilities** – The facilities for current operations of user gives a neat look but it can be improved further to make the building functional, flexible and sustainable, with architecture representing the next generation.
- **The climate conditions** – Assam has a very beautiful river views, The built-up forms need to respond to it to make the users comfortable.
- Local representation/Architecture- keep local identity intact with modern approach.

8.3.8.3 General Approach

The project is designed with sustainable concepts at site level as well as building levels. To achieve the functionality and the optimal conditions within the building the following parameters have been considered:

Figure 8-25: Design Criteria for Terminal Building.

8.3.8.4 Sustainability Approach

The design will be implemented with sustainability factors to meet the guidelines provided in National Building code 2016 part 11.

Overall goal for sustainability to ensure.

- Use minimum energy in its functioning by its shape and form.
- Generate its own energy as much as possible.

The prime consideration will be to establish and achieve the fundamental and most important, passive concepts before applying higher technology.

The key objectives considered for aligning the project's infrastructure design with sustainability will include, but not be limited to, the following:

- Climate responsive design by incorporating passive design strategies
- Enhanced microclimate for better and healthy pedestrian comfort and reduced heat island effect
- Efficient storm water management
- Infrastructure to support energy efficiency and enhanced monitoring of energy consumption (SCADA)
- Transport and traffic management to ensure minimum pollution at site
- Renewable energy generation
- Efficient waste management

The design for site and building works will be considering below sustainability measure but not limited to,

- Site Planning
  - Grass pavers
  - Use of paver block/ grass gird in parking area cycle track, walkways where practical
  - Roadside Planters-tree pits
  - Install efficient water fixtures to reduce water demands
- Building Envelope
  - Insulation on external walls (if applicable)
  - Sustainable Glass facades
  - AAC Blocks/ Fly Ash bricks/ Siphorex
  - Insulation for Roof
  - Reflective tiles/ paints/ coatings on roof
  - Use of locally available materials
- Lighting
  - Highly efficient interior and exterior light fixtures (LEDs)
  - Occupancy sensors in non-regularly occupied spaces like staircases,
  - Corridors, common toilets, etc.
- Water Conservation
  - Efficient sanitary fixtures.
- HVAC
  - Efficient HVAC design for improved indoor climate
- Renewable Energy
  - Solar Photovoltaic Panels on Roof
  - Solar Exterior Lights
- Waste management infrastructure including:
  - Segregation facilities
  - Collection points

8.3.8.5 Building planning

As Umananda is pilgrimage site, people are only visiting temple located within island hence, the building design is kept minimalistic only to cater waiting area for people exiting island.

8.3.8.6 Approach

Typical elements/ Activities in terminal building are given below –

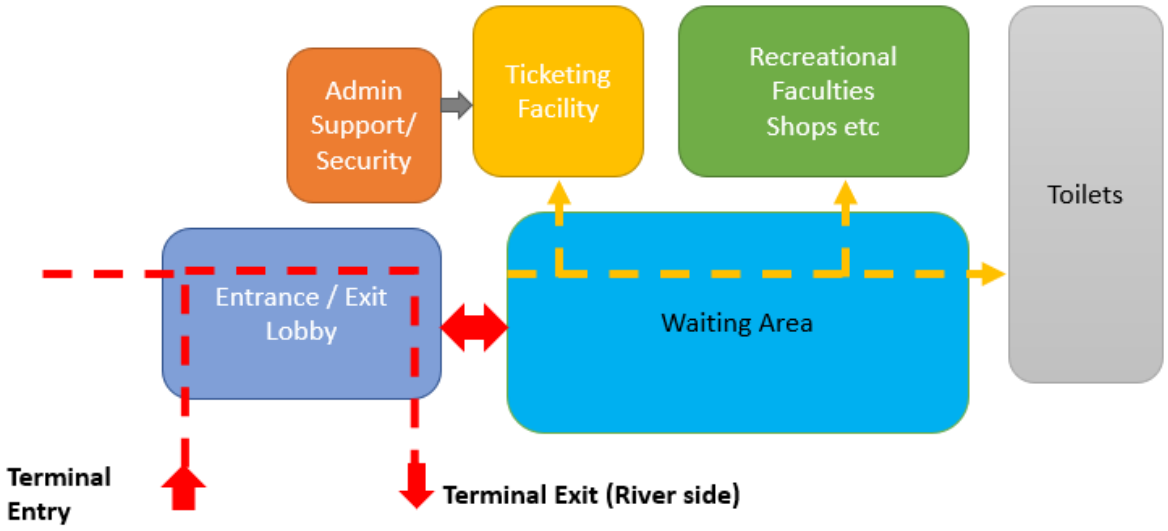


Figure 8-26: Design Criteria for Terminal Building.

Based on the traffic analysis and forecast in previous chapter, terminal building areas and infrastructure requirement will be finalized.
Based on feasibility study following area the area was considered as part of terminal building planning.

Table 8-6: Landside facility-Area requirements

External Development		Nos.	Size		Area (SQM)
Land side					
1	PATHWAY				70.97
2	RAMP & STEPS				12.24
3	BUILDING FOOTPRINT				142.18
				TOTAL	**225.39**
				LANDSIDE DEVELOPMENT AREA	**225.39**
Building			**(M)**	**(M)**	**(SQ.M)**
GROUND FLOOR					
1	WAITING AREA (46 SEATS)		20.45	5.45	111.45

			10.455	0.775	8.10
2	SHOP-1		2.35	2.50	5.88
3	SHOP-2		2.30	2.50	5.75
4	SHOP-3		2.30	2.50	5.75
5	INVERTER / BATTERY ROOM		2.35	2.50	5.88
6	TOILET		2.70	1.7	4.5
7	TOILET		2.70	1.39	3.74
				TOTAL	**142.18**
				TOTAL BUILDING AREA	**142.18**

8.3.8.7 Terminal Internal Circulation

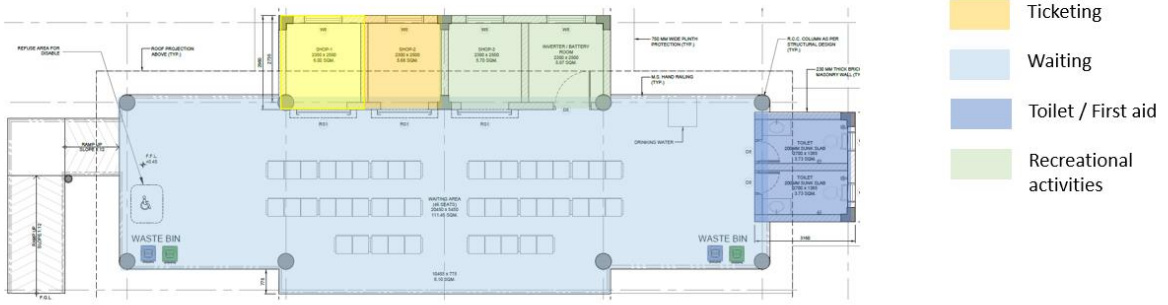


Figure 8-27: Typical circulation on terminal Ground floor.

For Ground Floor Plan details refer drawing number DI1530-RHD-ZZ-UA-DR-A-2221

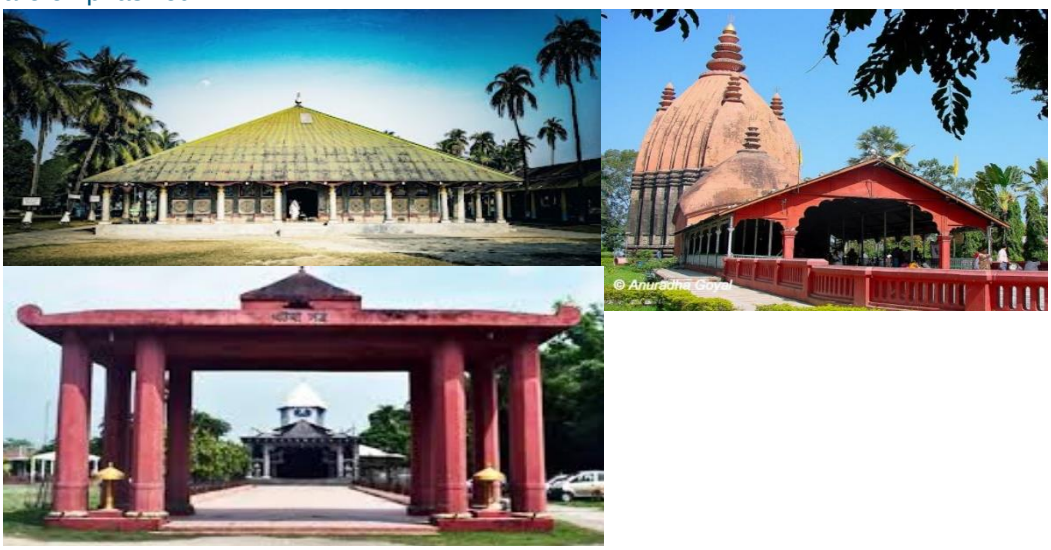
The circulation is linear providing,

- Shortest distance for people visiting temple till the entry of temple site
- Separate area for waiting showing river views,
- Recreational area is segregated to avoid circulation conflicts
- Last moment traveller can purchase ticket and go to river facilities without entering terminal waiting for smooth access.

8.3.8.8 Terminal Architecture

The form of terminal building is a modern interpretation of the vernacular architecture of the site. It is an amalgamation of state of the art and local materials.

Architectural features such as shopping roofs, local sculptural features shall be adopted in building elevation and around as shown in the below.
The elevation is primarily inspired by Satras, where use if local forms like, sloping roof, ornamented columns are emphasized.



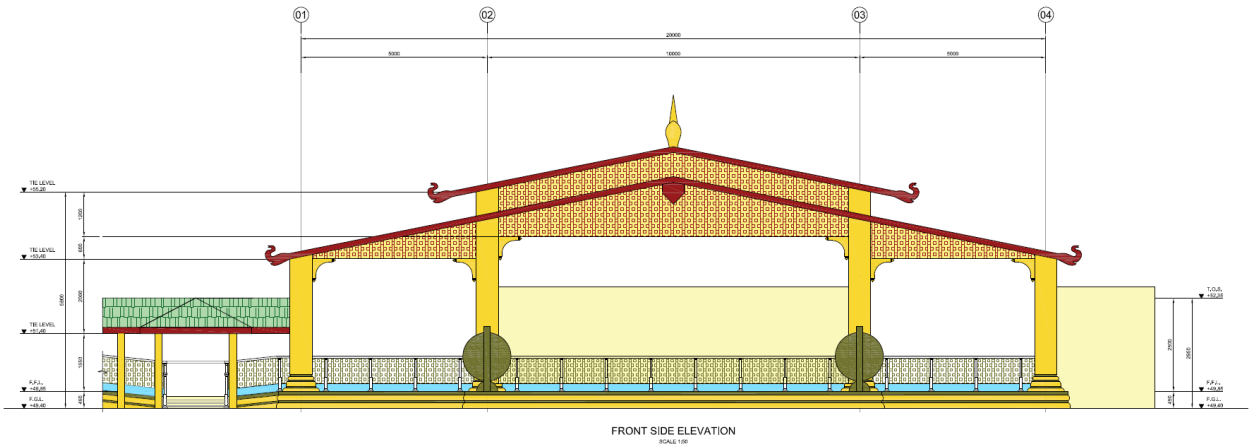


Figure 8-28: Typical elevation of terminal building

For Ground Floor Plan details refer drawing number DI1530-RHD-ZZ-UA-DR-A-2222.

Interior of building will also be decorated considering local art, murals, column arrangements etc.

The following main components are considered to form the basic infrastructure required at North Guwahati: -

- Ticketing office
- Administration and Security
- Passenger waiting area
- Public Amenities: toilet facilities, drinking water fountain, vending area
- Shops

a) Ticket (service) counter

One ticket counter is considered within the terminal building.
Ticket counters will also have lockers for the customers as required in any terminal.

Area considered for one ticket counter is approximately 6m²

b) Administration and security

One office room of size 6m2 has been considered for administration and security departments. The office will be equipped with workstation, cupboard and visitor sitting place. This room will also suffice any small office meeting for the working staff. External walls of the staff room are glazing to maximize usable floor area.

c) Passenger waiting area

As explained in traffic handling capacity and passengers waiting area provided at Umananda terminal, this waiting area is split on two floors, for type 1 and type 2 passengers as explained earlier

Total waiting of 50 nos. is proposed at the terminal building. Waiting area will have the necessary amenities, such as toilets, food kiosk, dustbins, and drinking water. Waiting area is proposed such a way that people will have beautiful river views all the time during their wait period. It is equipped with led signage boards and announcement systems.

Terminal building has interior spaces, such as plain walls, columns, which can be used for display of local art in terms of mural work and paintings

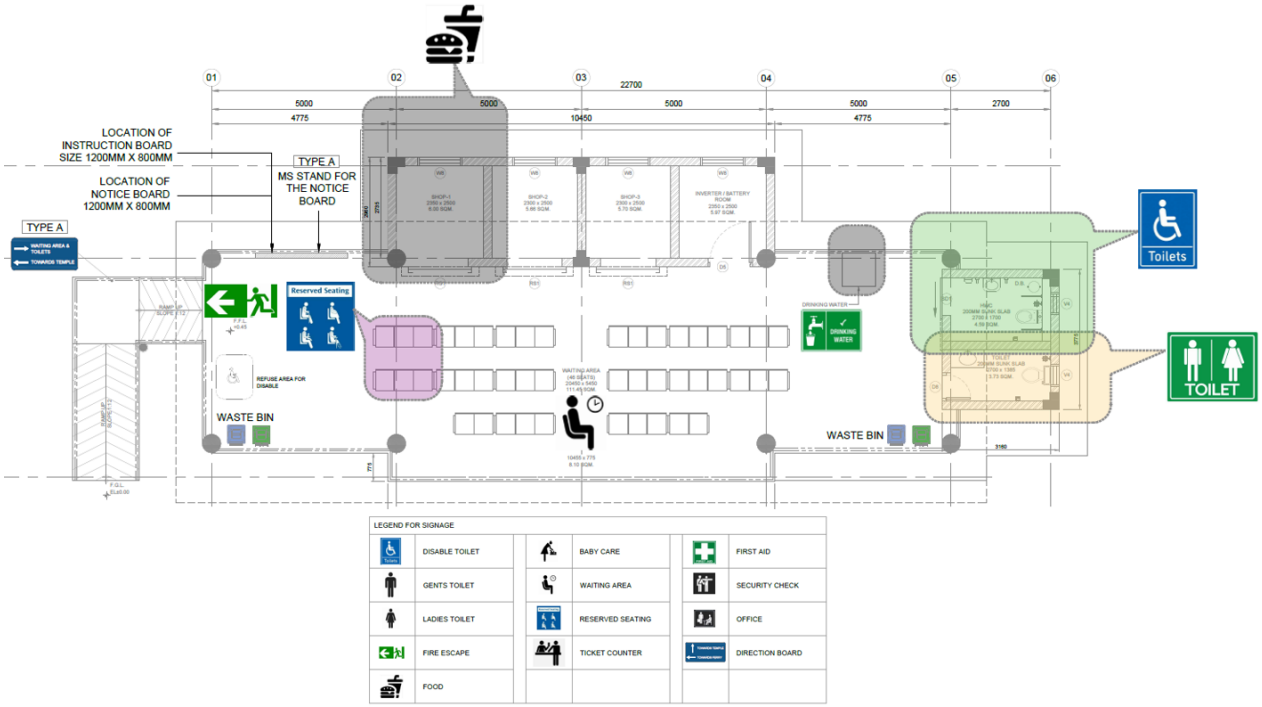


Figure 8-29: Typical signage layout- terminal building

d) Public Amenities

For a compact and feasible structure, the administrative functions and public amenities have been arranged next to the waiting area. Public amenities include two unisex toilet blocks

Entire building and terminal complex is equipped with all necessary services like, firefighting, electrical, plumbing, public address, HVAC, IT SLP, telephone etc. all these services are further detailed in subsequent sections below.

8.3.8.9 Roads

Due to site constraints no specific roads has been planned as no vehicular traffic is expected within island.

8.3.8.10 Walkways/footpaths

1.5m wide walkways are planned all along the building as well as entry and exit routes for easy logistics, the pathways will ne 150m high made with light duty 40mm thick paver block laid on PCC.

8.3.8.11 Boundary wall

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Boundary wall will be constructed all along the periphery of the facilities. Boundary wall will be of average height 2.5 meters above maximum of finished ground of inside and outside the campus with fabricated MS angles 'Y' shaped and concertina fencing of 0.75 meters on the top. Boundary wall will be provided with gates, gate lights, guard room complete in all respect. The boundary wall is in RCC framed structure with brickwork in CM 1:4 and shall be plastered in CM 1:4. The top of wall will be provided with 75 mm thick RCC coping. 50 mm thick DPC shall be provided at plinth level before starting the masonry work. Outer face (i.e., rough side) of all brick walls shall have 18 mm thick and inner face (i.e., smooth side) of all walls shall have 12 mm thick cement sand plaster 1:6. Exterior masonry paint shall be of two coats of waterproof cement paint of approved manufacture and of approved colour to the plaster surfaces including scaffolding including primer coat. The paint shall be applied on a coat of primer over dried, prepared plastered surface as per manufacturer's guidelines. The final, finished coating shall be fungus resistant, UV resistant, water repellent, alkali resistant, and extremely durable with colour fastness.

8.3.8.12 Gate

The entrance gate has been planted such a way that the entry and exit traffic can be segregated with security booth island. All gates shall be MS sliding gates with minimum clear width for Exit and Entry of vehicles. The height of gate shall be same as that of the Boundary wall. Each gate shall have provision for wicked gate. The gate shall be complete with fabricated hinges, MS aldrops with locking arrangement etc. The security booth is basically small porta cabin which can house one security personnel.

8.3.8.13 Landscape

Due to space constraints landscape will be planned in small patches.

8.3.8.14 General Finishing

Terminal building will follow general finishing as below but not limited to,

All material mentioned below will be selected keeping sustainability as prime requirement.

Roofing / Cladding & wall finishes

- Roofing will be mainly Zinc Alum sheets
- RC buildings will be covered with RC slabs on top. All terraces shall have waterproofing treatment
- All RC building will be finished with concrete block walls plastered, finished with Emulsion paint, as
- All wet areas will have Ceramic wall dado tiling up to 2.4m level. All wet areas shall water waterproofing floor as well as wall treatment as wall treatment.
- Locally available stone for wall cladding as decorative element.

Floor Finishing

The floor requirements shall be set out below.

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- Kota stone for office and waiting area
- Ceramic tiles with anti-slip finish for toilets and change rooms
- Vitrified tiles for staircase

Doors & Windows

- All other doors wooden flush panel doors with vision panels
- FRP doors for wet areas
- GI Rolling shutter doors for shops and technical areas
- Wooden windows as per design

Ceiling Finishes

- No ceiling for waiting areas
- RC slab shall be painted underside with emulsion paint

Staircases and Platforms

- All railing will SS
- All access staircases to platforms will be of SS handrails and Vitrified flooring

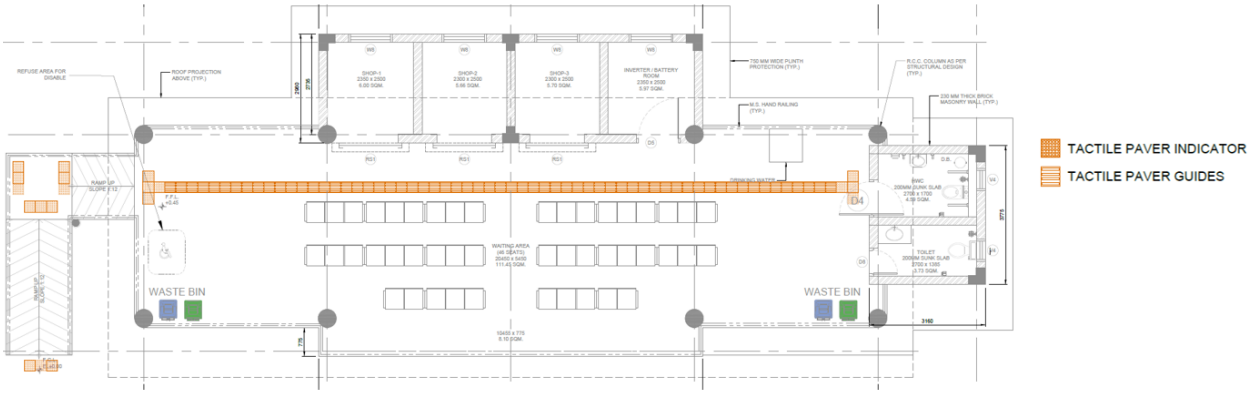
8.3.8.15 Barrier Free Design

As part of ***Accessible India Campaign,*** all designs will be given great emphasis on encouraging the less fortunate members of the society, who, for the reasons of certain physically handicaps are not at par with their counterparts. To create circumstances, environment, and conditions of work, suitable for those who are physically handicapped, certain basic requirements shall have to designed, augmented, or executed in all terminal buildings.

All Barrier free facility designs will be designed in compliance with.

- CPWD Guidelines– Handbook on barrier free and accessibility 2019
- Harmonised Guidelines and Space standards for Barrier Free Environment for Persons with Disabilities and Elderly Persons, February 2016
- Nation Building Code 2016
- IS 4963-1987 (2020)- Recommendations for Buildings and Facilities for the Physically Handicapped
- Local State and Municipal requirements

The intent is to make buildings and facilities accessible to and usable by all people including those living with disabilities and may include those with inability to walk or difficulty in walking, reliance on walking/ mobility aids, blindness and visual impairments, speech and hearing impairments, limited coordination of motor movements, reaching and manipulation, lack of stamina, difficulty in interpretation and reacting to sensory information and extremities of physical size.



. Figure 8-30: Typical tactile floor marking

8.4 Planning of Utilities and services

8.4.1 Water Supply System

8.4.1.1 Reference Standards

CPHEEO:1999 - Manual on water supply and treatment
SP35:1987 - Handbook on water supply and drainage
NBC:2016 - National building code

8.4.1.2 Source of Water

Currently, there is no water supply to the area. Therefore and, in line with existing practice, non-potable water from river/bore well will be pumped into the Ground Level Service Reservoir (GLSR). Packaged Drinking water will be made available in the shops in the vicinity of the Ghat.

8.4.1.3 Quality of Drinking Water

An earlier water quality monitoring study carried by Arkitechno Consultants found that the river water quality near Umananda ghat meets the Best Designated Use (BDU) Class C criteria of Central Pollution Control Board (CPCB). Parameters such as pH & DO meet Class A criteria of CPCB. Observed values of Chloride, Sulphate, Nitrate, Calcium & Magnesium & metals are well within the acceptable limit of IS 10500 Drinking water standards. Similarly, physico-chemical characteristics of the ground water samples collected from the project area were compared with prescribed drinking water standard, i.e., IS: 10500. Since all parameters are within the permissible limits of drinking water as per IS: 10500 (for both river water as well as municipal water), only an industrial water dispenser may be provided in units where drinking water is required. Water quality standards shall be maintained as per CPHEEO standards, which are quite stringent compared to IS: 10500 and WHO. Additionally, Baseline Monitoring Study for the terminal sites along Brahmaputra was carried out as part of the ESIA for this project by WAPCOS. The study concluded that across 10 sampling locations, including Umananda, “water quality was observed to be quite good, as parameters are well below the permissible limits specified for meeting drinking requirements.”

Although there are suspicions of Fluoride, Iron and Arsenic contaminations in the ground water in Assam, but these problems are not reported in the Umananda site. A detailed list of contaminated sites can be found at the Central Ground Water Board website.

Summary of the Treated water quality requirement as per IS 10500, CPHEEO, and WHO is indicated in Table 8-7 below.

Table 8-7Treated water quality

Parameters	IS:10500	CPHEEO	WHO
Turbidity (NTU)	1	1	1
Colour (Hz)	5	5	5
Taste	Agreeable	Agreeable	Agreeable
Odour	Agreeable	Agreeable	Agreeable
pH	6.5-8.5	7-8.5	6.5-8.5
Total Dissolved Solids (mg/l)	500	500	500
Total Hardness (as CaCO3) (mg/l)	300	200	100
Chloride (mg/l)	250	200	200
Sulphate (mg/l)	(mg/l)	200	200
Fluoride (mg/l)	1	1	0.7-1.0
Nitrate (mg/l)	45	45	45
Calcium (mg/l)	75	75	75
Magnesium (mg/l)	30	≤30	30
Iron (mg/l)	0.3	0.1	0.3
Manganese (mg/l)	0.1	0.05	0.1
Copper (mg/l)	0.05	0.05	0.05
Aluminium (mg/l)	0.03	0.03	0.1
Alkalinity (mg/l)	200	200	200
Residual Free Chlorine (mg/l)	0.2	0.2	0.2
Zinc (as Zn) (mg/l)	5	5	5
Mercury (as Hg) (mg/l)	0.001	0.001	0.001
Coliform Count MPN/100 ml	-	Absent	Absent
Fecal coliforms MPN/100 ml	-	Absent	Absent

8.4.1.4 Demand Estimation

Provision of safe, adequate water is a necessity for the healthy living. Water demand is estimated based on the unit demand norms as per average number of passengers (to and fro) projected per day for design phases of development up to year 2045. The water requirement for vendor and staff at ferry terminal is also

considered. Potable water required for the terminal amenities is computed as per NBC 2016 norms. In absence to water demand requirement for ferry terminal, the per capita water demand for Interstate bus terminal/Metro stations is considered. The water demand calculation given in Table 8-8

Table 8-8 Water Demand calculation

User Type	Average Daily Numbers	Unit Demand Per Day (lpcd)	Total Demand (lpcd)
Passenger	520	15	7800
Staff	23	45	1035
		Total Demand (lpcd)	8835
		Water Demand (kld)	8
		Raw Water requirement after losses @ 15% (kld)	9

8.4.1.5 Storage Reservoir

The GLSR will have one potable water compartment. The potable water compartment will have storage for 24 hours of demand i.e., 9 KL. The water will be filled into the potable water compartment to maintain water circulation. From this GLSR, water will be pumped to the terrace tank (TT)/ overhead tank (OHT) of the building using a submersible pump. The TT/OHT will have a capacity of 8 KL 1-day potable water demand due to capacity restraints on the terrace. Pump capacity has been designed such that it can fulfil the demand of 8 KL within 1 hours of pumping. All external water pipes will be of 50 mm diameter and Galvanised Iron pipe material. The water pumps will have minimum capacity of 350 lpm (4 HP). Additionally, supply will be provided to Pontoon via PE-ALPE material flexible pipes.

8.4.2 Firefighting System

Potable fire-fighting system will be provided for the internal building.

8.4.3 Sewage Management

8.4.3.1 Reference Standards

CPHEEO:2013 - Manual on sewerage and sewage treatment
SP35:1987 - Handbook on water supply and drainage
NBC:2016 - National building code
CPCB/ SPCB/ MoUD guidelines
Guidelines on Bio-Tank for Indian Railways

8.4.3.2 Demand Estimation

Only flushing water has been considered for treatment; therefore, estimation has been picked from NBC 2016 norms. The sewage generation has been summarised in Table 8-9 below.

Table 8-9 Sewage Generation estimation

User Type	Average Daily Numbers	Sewage generated Per Day (lpcd)	Total sewage (lpcd)
Passenger	520	5	2600
Staff	23	20	460

Total Sewage (lpcd)	3060
Total Sewage (kld)	3
Capacity of treatment setup (KL)	4

The inland vessels operating in the ghat shall have all the facilities for waste management and disposal as per the provisions specified in the Inland Vessel Rules, 2022. All the inland vessels shall have a holding tank of adequate capacity to store all sewage generated on board, for subsequent discharge into a shore reception facility. During operations suitable measure shall be taken by DIWT/AIWCL for collecting the sewage from the vessel.

8.4.3.3 Treatment

The sewage treatment at the site has been recommended via a bio-digestor tank. Provision for an STP has not been provided due to the limited availability of space, the high capital cost and difficult maintenance. A bio-digester tank is a better alternative to a septic tank as septic tanks are not adequate for elimination of pathogens and foul smell and also require periodical cleaning.
Defence Research & Development Establishment (DRDE) – an R&D organization of DRDO has developed a technology of bacterial inoculums for sewage treatment under diverse geo-climatic conditions. The zero-waste bio-digester technology breaks down human excreta completely into usable water and gas through anaerobic process. It does not have any geographical or temperature limitation and goes away with the need to set up large sewage tanks and regular sludge cleaning. Bio-digestor tanks or Bio tanks are an excellent low-cost alternative.

Table 8-10 Advantages of Bio tank over Septic Tank

SEPTIC TANK	BIO TANK
Requires larger space, bigger volume	Requirement is 40 to 70% less.
Not efficient	Effluent is well treated and safe
Sludge needs periodic evacuation	No such needs
Obnoxious smell	No smell. Generation of odourless and inflammable biogas
Maintenance intensive	Only one time charging of Inoculums
Unhygienic disposal	No such requirement
Water requirement is high	Minimizes water consumption
Cost intensive	Cheaper in long run

A bio-tank of 4 KL occupying 4 sqm (2m X 2m) would be sufficient for the site. The sewage from the terminal building will be conveyed to the bio-tank from the inspection chamber. The effluent from the bio-tank will be connected to a reed bed, with at least 1:250 slope to achieve self-cleaning velocity. From the reed bed, the effluent will be further treated for discharge to river. All sewer pipes will be of HDPE DWC type with a nominal diameter of 150 mm. The outlet parameters of the bio-digester plus reed bed system will be as follows:

DETAILS	RANGE

pH	7.0-7.2
Turbidity (NTU)	2-5
TSS (mg/L)	50-80
TDS (mg/L)	100-300
VS (mg/100ml)	5-12
COD (mg/L)	15-25
BOD (mg/L)	2-4
Coliforms (MPN/ml)	0-12

The sludge from the Biodigestor tank will need to be removed and transported following all safety protocols. The responsibility of safe collection and transportation of the sludge will be with the municipal body, which deals with the collection and transportation and final disposal of sludge from septic tanks in the locality as well.

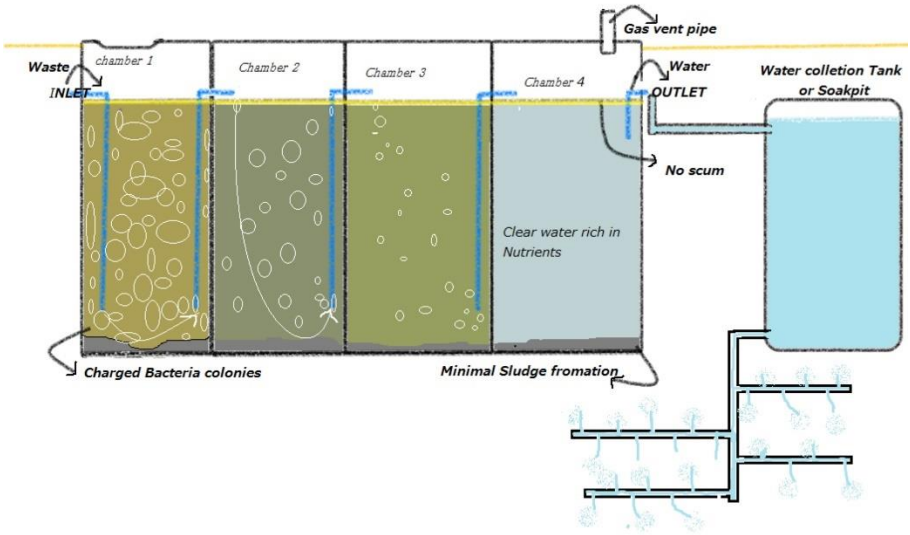


Figure 8-31 Schematic of biobank sourced from DRDO

The grey water from the terminal building gully trap will be connected to the biotin. However, an oil/grit separator will be used to intercept sediment and hydrocarbons before the grey water can be conveyed to the biobank. Soluble pollutants will pass through oil/grit separators.

The oil/grit separator will have two chambers. The greywater will enter the first chamber, which will contain a permanent pool of water and coarse sediment will be trapped by settling. The first chamber will also trap floating trash and debris, such as leaves. The runoff will be drawn from the lower part of the pool with an inverted pipe elbow to trap floating oils and hydrocarbons, which will eventually be discharged from to the

second chamber. The second chamber will also contain a permanent pool of water for a second settling opportunity. Hydrocarbons which may have been adsorbed to sediment particles will be settled out in this chamber.

There are several proprietary oil/grit and oil/water separator devices available for the treatment or pre-treatment. Since the performance of oil/grit separators is dependent on the frequent removal of trapped sediments and floating products and should be cleaned out at least twice a year.

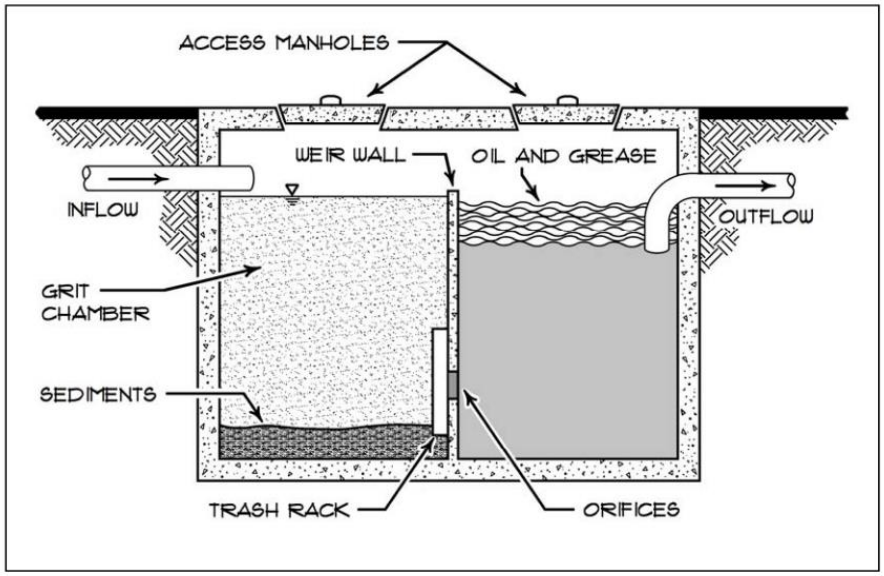


Figure 8-32 Schematic of Oil/Grit Separator

8.4.4 Storm Water System

Due to site constraints, there is no provision of storm water drainage. The gradient of the site will be maintained to facilitate flow towards river.

Further, rain water harvesting has been considered but not planned due to the presence of high water table at the location of the terminal.

8.4.5 External Electrical System

8.4.5.1 Source of Power Supply.

The project site is typically an river island and thus it is not possible/practical to tap the Electricity from SEB tapping point Hence a suitable rating of DG (Diesel Generator) Set to be considered as a Primary power source for this site. Additionally, an appropriate rating of Inverter system to be considered for the site. The 415V Switchgear consists of two incomers i.e. Incomer-1 for DG Set and Incomer-2 as spare for future Mains supply, which are coupled by bus coupler & electrical interlock and shall be serving as normal-cum emergency Switchgear A bus coupler is provided in bus section of MLDB and one more incomer is also provided to feed power from solar plant for lighting loads. When EDG incomer is closed, the bus coupler breaker of MLDB is tripped and thus power is restricted to emergency bus of
MLDB and power is supplied to emergency lighting bus.

Power Supply to the Pontoon shall be fed from the Main Electrical Switchgear Panel through XLPE, Armoured Cables. These cables shall be rounded over the Cable reels fixed at suitable location considering

the HFL of the site. As per the location of the pontoon which will be based upon the change in water level, these XLPE armoured cables shall be reeled out or reeled in. An industrial outlet socket shall be installed at each Pontoon for plug in/plug out of electrical supply.

8.4.5.2 System design philosophy.

The electrical system shall be designed to provide:-

- Safety to personnel and equipment both during operation and maintenance.
- Implementing Energy efficient LED lighting fixtures
- To supply reliable and quality power.
- Reliability of Service
- Minimal fire risk
- Ease of maintenance and convenience of operation
- Automatic protection of all electrical equipment through selective relaying system.
- Electrical supply to equipment and machinery within the design operating limits.
- Adequate provision for future extension and modification.
- Suitability for applicable environmental factors.
- Maximum interchangeability of equipment.
- Expandability provision for future.

8.4.5.3 Load Assessment

For assessing the overall load of the Plant area, The below listed table shall be referred.

S. No.	Land Use	Area (Sq. Meters))	Area (Sq. Feet)	W/Sq. FT. (as per latest Indian practice)	Diversity factor applied	Consumption in kW
1	Mixed Use (Developable land)	240.00	2575.20	5	0.9	7.53
2	Utility like bridges, ferry etc.	400.00	4292.00	3	0.9	11.59
3	Pumps for Fire water/Potable water & other utilities					3.70
						22.82
					Power factor	0.95
					KVA	24.02
					Line Losses @ 10%	2.4
					Gross	26.42

				Say (KVA)	**25.00**

The maximum running plant load for DG set shall be determined as follows:

- This following shall be used to verify the rating of Emergency Diesel Generator, Rating (peak load) = 100 % continuous load + 15% intermittent load or single largest load whichever is higher + 10% standby load or largest standby load whichever is higher + 10% future margin.
- Generator shall be capable to re-start of largest motor without exceeding permissible voltage drop.

8.4.5.4 LT Switchgear

Suitable removable type lifting hooks and / or jacking pads shall be provided on each panel or shipping section for ease of lifting of switchboard. These hooks when removed shall not leave any opening in the panels.
It shall be of fixed type, single/double front execution. Circuit breakers (ACBs) panels shall be in single front execution only. Motor starter and power feeders / switch fuse modules accommodated at front and rear of incomer and bus coupler panel are not acceptable. Also vacant space on incomer and bus coupler panel shall not be used for mounting the starter and switch fuse modules. Access to all operating devices shall be from the front of the switchboard.
All metering and protection equipment associated with a particular circuit shall be housed in separate and independent compartment earmarked for that circuit and in the fixed portion of the vertical panel in case of breaker panels.

The 415V switchgear shall be designed to ensure maximum safety during operation, inspection, connection of cables and maintenance with switchgear energized. The switchgear shall be totally dust and vermin proof. The details of LT switchgear and feeder ratings are given in single line diagram.

Each unit of the switchgear shall have necessary internal sheet metal barrier to form separate compartments for buses instruments/ relays/ cable connections etc. Compartment for cable connection shall allow cable pulling, termination and connection work with switchgear energized. Suitable arc propagation barriers shall also be provided. Independent pressure release flaps shall preferably be provided for each different compartment of the switchgear.

The draw out carriage on the switchgear shall have three positions viz., ‘service’, ‘test’ and ‘drawn out’. It shall not be possible to operate the circuit-breaker unless it is fully in service or test or isolated position. The similar rating of breaker compartment shall be interchangeable. Automatic safety shutters shall be provided to ensure the inaccessibility of all live parts after the breaker is drawn out. Busbars and supports shall withstand specified short circuit level without permanent deformation. Busbars shall be preferably sleeved and joints shall be taped/ shrouded. Minimum clearances between live parts, between live parts to Earth and Neutral shall conform to IS:4237.

Starting of motors from substation shall not be allowed and switch boards shall not have close push button at switchgear for motor starting. Emergency diesel generator incomer shall be rated at least equal to 110% of the continuous rating of generator and transformer incomer shall be rated at least 110% of transformer rating as applicable. In no case shall the tie breaker rating be less than the bus-bar current rating. Circuit breakers/ contactors controlling motor feeders shall have a rating of at least 125% of the maximum continuous rating of the connected motors.

All circuit breakers of LT switchgear and MLDB shall be of the draw out type housed in individual metal enclosed compartments. The air circuit breakers shall be three pole electrically operated with motor driven stored energy operating mechanism. The continuous rating shall be as per single line diagram. The motor for operating the spring loading device shall be for 240V AC supply. The closing and tripping coils shall be suitable for 110V DC. The closing mechanism shall be trip free and wired so that pumping is not possible. Manual charging and operation of the breakers shall be possible. The provision for remote indication and operation shall be made.

All MCCBs of LT switchgear and MLDB shall be draw out type housed in individual metal enclosed compartments. Each MCCB shall be mounted on a carriage assembly with wheels running on tracks secured to the inside of the compartment. A mechanical interlock shall prevent moving of the MCCB from the connected position while the breaker is closed and also prevent the access door being opened unless the breaker is in withdrawn position. All relays shall be numerical type providing comprehensive protection as required for each feeder. Relays shall be provided with communication interface. It should be possible to program the relays from the work station as well as relay face.

8.4.5.5 LT Batteries.

Batteries to be furnished shall be nickel cadmium (Ni-Cd) type. Nickel hydroxide and cadmium hydroxide shall be used for the positive and negative electrodes, respectively. An aqueous solution of potassium hydroxide with small quantities of lithium hydroxide shall be used as the electrolyte. It shall be used only for ion transfer and shall not be chemically changed during charging or discharging.
The containers shall be transparent and shall be made of toughened glass or plastic and provided with an acid level indicator.
The batteries shall be rated on a 5-hour basis at the specified ambient temperature. Each battery shall have a maximum recharge time of 8 hours. The batteries shall be sized for an operational period of 24 hours, in case of power failure. The amp-hour capacity shall be selected to cater to all of the emergency loads, operation of control gear, indication lamps, annunciation panels, emergency lighting, incoming breaker(s) spring charging currents, short time loads, etc. A margin of about 25% shall be allowed for to accommodate any contingencies.
Terminal posts shall be designed to accommodate external bolted connections conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the inter-cell connection. The top hole shall be left for external terminal connections. Bolts, heads and nuts, except seal nuts, shall be hexagonal and shall be lead covered. The junction between terminal posts and cover, and between cover and container shall be so sealed as to prevent any seepage of electrolyte.

8.4.5.6 Uninterrupted Power Supply(UPS) system

The UPS shall be floor mounted; self-contained and metal clad and shall be suitable for supplying a non-linear load. It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact to touch.
The UPS shall be an on-line type incorporating a six-pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch which shall operate in the event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply.
The UPS shall incorporate a dc under voltage trip circuit to electronically trip the UPS output in order to protect the batteries.
The noise level of the unit shall not exceed 60dB(A) at 1 m from the UPS cabinet. The output of the inverter shall be a sine wave having less than 2% THD for linear loads and less than 4% for 50% non-linear load. It shall be suitable for load power factors 0.7 lag to 0.9 lead. The unit shall have a dynamic response such that a 100% step load causes an output voltage transient of less than ± 4% with a recovery time of less than

4 ms. For three phase output units the output voltage shall not vary by more than ± 1% for an unbalance of 10%. The load crest factor shall not be less than 3:1. The efficiency at full load and 0.8 power factor shall be greater than 88%. The UPS System shall communicate the following status data to the plant SCADA system to monitor: (Note: To be demonstrated during FAT)

- UPS status
- UPS alarm conditions
- Battery capacity
- Bypass status
- Fault
- The UPS shall provide a volt free contact output to indicate:
- warning, i.e. low battery capacity
- fault
- static bypass in use.

8.4.5.7 Motor

In general, three phase squirrel cage induction motors designed for direct online starting shall be used. Motors shall be totally enclosed, fan cooled type and enable for continuous use. All motors shall be continuous maximum rated which may be rated for the envisaged duty cycle. Generally, Motors up to and including 200 kW shall be rated for low voltage i.e. 415V. The vertical motors shall have thrust bearings suitable for the load imposed by the driven machinery, unless otherwise specified. Winding insulation shall be class F and temperature rise limited to that specified in the
applicable IS for class B insulation. Motors with anti-condensation heaters shall have a separate terminal box provided for the same. Space heaters shall be provided for the motors rated10kW and above. The motors shall be suitable for starting under specified load conditions with 75% of the rated voltage at the terminals.

8.4.5.8 Power Cables and Wires

MV power cable shall be stranded Aluminium construction, multi-core/ single core, XLPE insulated, extruded black FRLS PVC inner sheathed and overall FRLS extruded black PVC sheathed armoured cables.
LV power cables shall be with stranded Aluminium conductor, multi-core/ single core, XLPE insulated, PVC inner sheathed & FRLS PVC outer sheath armoured cables.
The control cables shall be with stranded Copper conductor, XLPE insulated, PVC inner sheathed & FRLS PVC outer sheath. Twisted pair or shielded control cables shall be used where electromagnetic / electrostatic interference is expected.
All power and control cables shall have extruded inner and outer sheaths.
The cables shall be sized based on the maximum continuous load current, the voltage drop, system voltage, system earthing, and short circuit withstand criteria. The derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, thermal resistivity of soil, etc. shall be taken into account.
All incoming cables to switchgear / MCC/ DBs and other equipment shall be sized for actual rated capacity of the equipment.
Multicore / multi pair control cables shall have minimum 20% spare cores.
All power and control cables shall be in continuous lengths (except for long feeders) without any splices or intermediate joints. The cables used for lighting and wires in conduits shall have appropriate junction boxes with adequately sized terminals.

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8.4.5.9 INTERNAL AND EXTERNAL ILLUMINATION.

8.4.5.9.1 General

The illumination system shall consist of lighting poles, lighting distribution boards, lighting panels / power panels complete with FSU/ELCB/MCB, Fixtures, Cables, Junction Boxes, terminal blocks, cable glands, 3 pin 5A/15A convenience socket outlets, conduits and accessories and supporting and anchoring materials, lighting fixtures with fluorescent tubes, LED Lighting fixtures with Solar back up panels, wires, etc. All materials, fittings and appliances use in electrical installation shall conform to the relevant IS specifications, required area classification and environmental conditions and shall be anticorrosive painted / FRP enclosures.
The wiring for lighting circuits shall be done by wires run in PVC conduits for indoor areas. For outdoor lighting, wiring shall be done by armoured cables.

8.4.5.9.2 Illumination Level

The following minimum levels of illumination (avg. lux level) shall be provided in the respective areas:

Sr. No.	Area / Building	Illumination Level
1	Pump House	150 Lux
2	Control Room / Laboratory	300 Lux
4	Office	200 Lux
5	Switchgear/MCC Rooms	200 Lux
6	Sub-Station (Switchyard)	50 Lux
7	Toilet block / Washroom etc.	100 Lux
8	Roads / Walkways	10 Lux
9	Yard / Outdoor Area	10 Lux
0	General Process / Outdoor Eqpt. Area	100 Lux

8.4.5.10 FRP Cable Trays

Cables in FRP trays shall be cleated individually or in a group using GI saddles. The interval for cleating shall not exceed 1,500 mm.
Power and control cables shall be laid in separate cable trays or racks. The order of laying of various cables shall be as given below:
HV cables on top tiers
LV cables on subsequent tiers less than 85 microns.
GI cable tray shall be with perforation not more than 17.5%..
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8.4.5.11 Emergency and Standby Power Supply

The emergency generator set shall be procured as a complete package and shall be designed to start automatically on power failure and feed the selected loads. It shall be capable of taking care of the load variations (e.g. starting of the largest rated motor). The unit shall be complete with necessary starting equipment, associated automatic mains failure control panel (AMF panel) and shall be suitable for

auto/manual remote starting (in case of failure of AMF panel). AMF panel shall have facility to local manual starting of DG set.

The emergency generator set shall comprise of silent type Diesel Generating set having prime mover rating of 25KVA, 415 Volts at 1500RPM, 0.8 lagging power factor at 415V suitable for 50 Hz, 3 phase system consisting of following Diesel Engine. The Diesel Engine 4 stroke water cooled electric start of suitable BHP at 1500 RPM suitable for above output of alternator and conforming to BS 5514, BS 649, IS 10000.

8.4.5.12 Solar Power

A Grid Tied Solar Rooftop Photo Voltaic (SPV) power plant consists of SPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), Net Meter, Inverter, and Controls & Protections, interconnect cables and switches. PV Array is mounted on a suitable structure. Grid tied SPV system is without battery and should be designed with necessary features to supplement the grid power during day time. Components and parts used in the SPV power plants including the PV modules, metallic structures, cables, junction box, switches, PCUs etc., should confirm to the BIS or IEC or international specifications, wherever such specifications are available and applicable.

Solar PV system shall be installed on following location in given approximate area.

The area given for the various location shall be as per sizes of buildings and these values shall be as the 80% of rooftop available area. Values to be ascertained by the Contractor after Submitting design calculations subject to approval. The roof top Solar panels shall be connected with respective MLDB/LDB (Main Lighting Distribution Board) of the building to cater supply for Lighting, AC, Ventilation loads of that building with Net Metering.

8.4.5.12.1 Introduction

In grid-connected solar photo-voltaic (PV) systems, solar energy is fed into the building loads that are connected to the DISCOMs grid through a service connection with surplus energy being fed into the grid and shortfall being drawn from the grid. Production of surplus energy may happen when solar energy produced exceeds the energy consumption of the building. This surplus is fed into the grid. During the night, or when during the day energy demand in the building exceeds solar energy generation, energy is drawn from the grid. Grid-connected solar PV systems have no battery storage and will not work during grid outage. For buildings with grid-connected solar PV systems, the service connection meter needs to be of the bidirectional type, whereby import kWh and export kWh are separately recorded.
A grid-connected solar PV system consists of the solar panels, solar panels mounting structure, one or more solar grid inverters, protection devices, meters, interconnection cables and switches.
Components and parts used in solar PV systems should conform to the BIS or IEC or other international specifications, wherever such specifications are available and applicable.

8.4.5.12.2 Quality and Workmanship

Solar PV modules are designed to last 25 years or more. It is therefore essential that all system components and parts, including the mounting structures, cables, junction boxes, distribution boxes and other parts also have a life cycle of at least 25 years. Therefore, all works shall be undertaken with the highest levels of quality and workmanship. During inspection special attention will be given to neatness of work execution and conformity with quality and safety norms. Non-compliant works will have to be redone at the cost of the Installer.

8.4.5.12.3 System Sizing

As per the Latest solar net metering orders of Assam Electricity Regulatory Commission (AERC) regulations,

8.4.5.13 Earthing and Lightning Protection

Earthing system design and installation shall generally be as per IS:3043. All metallic non current carrying parts of electrical apparatus, current and potential transformer secondaries, columns, vessels, towers, stacks, storage tanks, etc. shall be earther at least by two distinct separate earth conductors from the earth plate connected to main earthing loop. Earthing & Lightning system in general shall cover the following:-

- Equipment earthing for personnel safety
- System neutral earthing
- Static and lighting protection.

The size of main earth grid around the substation shall be as per earthing calculation. All utility / process pipelines shall be earthed on entering or leaving the hazardous areas. In addition, steel pipe racks shall be earthed at every 25 meters. Earth continuity shall be ensured across all the flanges in process units and other hazardous areas. Equipment located remote from main earth network, may be earthed by means of individual earth conductors and earth electrodes.
The numbers of connection points shall be as given below:-

- Equipment such as tanks, vessels & Heat exchangers etc. 2
- EDG SET 2
- LT Switchgear/MLDB 2
- Lighting Transformer 2 (for neutral)
- (for body)
- UPSDB/Lighting and power panels/PDB/Battery charger 2
- Control panels 2
- Low Voltage Motors 2
  - Motor up to 7.5kW 2
  - 9.3Kw to 37kW 2
  - Above 37Kw to 90kW 2
  - Above 90kW 2
- 9 Local Control Station 2
- 10 Lighting Pole 2

8.4.5.14 As a minimum, lightning protection shall be provided for the equipment, structures and buildings as per IS-2309. Vessel Information Display

The large screen for Vessel Information Dis[lay shall be connected to both network switches through CPU and capable to display the same graphics as displayed by the screen on any location. On screen commands shall be possible with the click of the mouse located on respective system.
It shall have following features:

Diagonal size: Minimum 50’’
Resolution: Full HD (1920x1080)
Screen Brightness: 450
Contrast Ratio: 1600:1

Pixel Shape: Square
Lifetime: 60000 hours
Screen Type: Ag screen, 3 layer
Screen to screen gap: <0.7Mm
Brightness uniformity: >95%
Colours: 16.7 Million
Operating Temperature: 0-50 degree C
Serviceability: Full Rear Access
Power Supply: 2240V AC 50 Hz
Noise: 40-50 db
Control: IR Remote, RS-232/Rj45 Ethernet TCP/IP
Screen Dimension: Minimum 43.6''(W) x 31.3''(H)
The above screen shall be suitable for continuous operation for display of arrival/departure. It shall operate jointly with PC or connected to server to receive information of each arrival /departure for display on the screen.

8.4.5.15 Surveillance System

Surveillance CCTV system is required to ensure surveillance of required locations as well as create secured record for post event analysis. The system shall provide an online display of video images on LED monitors located on each Slat System shall facilitate viewing of live and recorded images and controlling of all IP cameras by the authenticated/authorized personnel. The core of the surveillance system shall be NVR servers. System shall also have operating systems, appropriate software, networking equipment and other essential components.

System shall have expansion possibility with the available hardware (system shall have the facility of additional camera installations beyond the originally planned capacity). It shall be an open standard based integrated system with IP network aimed at providing high-speed automatic operation for best performance. It shall use video signals from various types of indoor/outdoor cameras installed at different locations. Joystick and mouse-keyboard controller shall be used for Pan, Tilt, Zoom, and other functions. System shall have a combination of Digital colour video cameras with individual IP address. It shall also have raid backup device of recording, application software, colour video monitors and keyboards.

Camera server shall be NVR server based with appropriate Audio and Video Management System backup system and software. Each camera server shall handle 60 or more cameras. CCTV system shall ensure that once recorded, the video cannot be altered; ensuring the audit trail is intact for evidential purposes. System shall provide sufficient storage of all the camera recordings for a sufficient period. The recording resolution and frame rate for each camera shall be user programmable.

Surveillance system shall comprise of control console, monitor, switching unit, line unit, coupling unit, TV cameras with remote control of pan and tilt video recorder. The CCTV is intended for remote monitoring of different operations. The TV image can also be recorded on the video recorder. The visual surveillance facility with control console and video recorder will be located in the Electrical room. TV cameras shall be located as per the layout drawings. Suitable no's, of dome cameras and PTZ outdoor cameras with bracket shall be installed. The CCTV shall be able:

- To monitor and supervise in colour the objects, outdoor and indoor areas,
- To control TV cameras and pan and tilt units remotely from Electrical Room,
- To overview simultaneously images on one monitor from several TV cameras (up to 4),
- To operate in the automatic mode according to the programme specified by the operator,
- To transmit video signal and supply power to TV camera over a signal cable,

- To operate jointly with PC,
- To tag current time, date, TV cameras for recording on video recorder,

The CCTV system shall comprise control console, monitor, switching unit, line unit, coupling unit and TV cameras.

8.4.5.16 Communication System

The Communication system shall comprise of the following:

- General Telephone System
- Intercommunication System
- Loud speaking and staff locating system.

Automatic Telephone Communication shall have Digital automatic exchange, telephone sets of desk and wall type. It shall have following devices/components:
a) Intercommunication system: Operator's switchboard (master control multifunctional station), recording and playback facility (recorder)
b) Staff location (paging) and public address system: The amplifier stations, speakers of 2 W, speakers of 6 W, cone speakers of at least 10 W and subscribers' speakers
c) Cable Work:

Telephone box, junction boxes, multi pair telephone cables, single pair telephone drop wires.
The automatic telephone services as per above features shall be provided by digital programmable automatic) exchange of EPABX type of 6 P&T ports, 30 extension ports (Upgradeable up to 140 extensions) to be installed in Electrical Room with facilities for:

- Connection of subscribers' lines,
- Connection of digital subscribers' lines,
- The lines with automatic exchange of phase 2.
- The subscribers' telephone terminals shall include:
- Analog push button telephone sets permitting operation in the tone and pulse mode,
- Digital multifunctional telephone set to be installed in different areas.

The communication system shall include the facility (recorders) for automatic recording of the conversation and its playback which are to be connected to the multifunctional telephone sets. The recorder can be coupled to the line both automatically and by hand. The automatic telephone exchange shall provide the following services:

- Subscriber shall have facility using one telephone set to organize several independent talks with possibility of mutual inter connection, joint conversations and listen in functions,
- a new call while holding up the conversation in progress,
- Diversion of calls,
- Conference coupling,
- Circulating conference.

The system shall include the PA and staff locating (paging) system. For this purpose provision shall be made for amplifier station of 500W to be installed in the communication centre located in Electrical Room. The

amplifier station shall permit paging of the personnel and passing of important messages to all areas over different feeders as well as to distribute music or speech programs. The feeders shall be programme controlled remotely from the operator's switchboard. The programme shall provide both selective and collective control of the feeders and distribute music or speech programs. Wired Broadcasting station:

8.4.6 Buildings Internal Electrical System

8.4.6.1 Statutory Compliances

- Indian Electricity Rules as enforced by State Electricity Authority shall be complied with and adhered to.
- Safety Standards as per relevant codes/norms/practices and as per guidelines of State Electricity Authority shall be applicable.
- CEA regulations as applicable.

8.4.6.2 Design Philosophy

The design of power distribution system and selection of equipment shall be based on the main consideration of simplicity, safety and reliability, ease of operation & maintenance.

The equipment shall conform to relevant IS specifications and codes of practice to meet the operational requirements and to ensure reliable and safe operation. Generally, all electrical equipment shall be of type tested design.

8.4.6.3 Design Parameters

Table 8-11 Electrical Design parameters

Sr. No.	Description	
1	LT consumers	415V, 3 phase, 50 Hz, AC, 3 ph., 50 Hz from State Board
2	Normal / Essential	415V 3-Phase or 240V 1-Phase + 5%, AC, 3 ph., 50 Hz +3% from localised substation
3	Metering	If provided at 415V by State Board then LV metering and room will be considered in line with state board requirements
4	System earthing: a) At 415V level	Solidly earthed (TNS System)
5	Maximum Symmetrical Short Circuit level for LT bus	Fault current calculated at respective level for duration of 1 sec
6	Cable sizing	Based on Rated current carrying capacity, derating factors, short circuit capacity, Voltage drop etc.
7	Internal Illumination	LED lamps considered to meet Lighting power density (LPD) as per IS 3646- part I and II. Suitable energy saving lighting fixtures are considered.
8	Earthing & Lightening Protection	To comply with IS 3043

8.4.6.4 Electrical Design Requirements

The design of the electrical system shall be in accordance with relevant IS standards.

- Internal building electrification including lights, 6/16A socket outlets, AC points, etc.
- LT power & control cables and accessories
- Earthing and Lightning Protection Systems
- Internal wiring as required.

8.4.6.4.1 General

Main Distribution Board shall supply power to following Distribution (DBs): -

- Lighting Distribution Board
- Power Distribution Board

Lighting Distribution Board (LDB) and Power Distribution Board (PDB) are fed from Main Distribution board. LDB for Lighting and Fans, PDB for Small Power Sockets and Split A. C's.

8.4.6.4.2 LT Distribution switchboard

Table 8-12 Standards and codes for LT Distribution Switchboard

Code	Title
IEC 61439	Low-voltage switchgear and control gear assemblies
IS 10118	Code of practice for selection, installation and maintenance of switchgear and control gear

LT distribution boards shall be in sheet steel enclosed, fixed type, multi-tiered and compartmentalized with separate compartments for each feeder in free standing design comply to IEC standards.

The incoming feeder shall be 4 pole MCCB and the outgoing feeders shall be 3 pole MCCBs/ MCBs as per requirement defined in SLD. DBs shall be provided with TPN aluminium busbars in separate compartment.

Separate compartments shall be provided for incoming feeder, busbars, outgoing feeders and for the outgoing cable terminations as per IEC standards (Form 3B or 4B).

8.4.6.4.3 Lighting Distribution Board (LDB)

The LDBs shall be sheet steel enclosed, PPI suitable for wall/structure mounting. The incoming feeders shall be TP MCB, DP RCBO for each phase and the outgoing feeders shall be SP MCBs of suitable ratings as per requirement. Compartments shall be provided for incoming feeder, outgoing feeders and for the outgoing cable terminations.

8.4.6.4.4 Power Socket Distribution Board (PDB)

The PDBs shall be sheet steel enclosed, PPI suitable for wall/structure mounting. The incoming feeders shall be TP MCCBs/MCBs DP RCBO for each phase and the outgoing feeders shall be SP MCBs of suitable ratings as per requirement. Compartments shall be provided for incoming feeder, outgoing feeders and for the outgoing cable terminations

PDBs shall cater to the 240V sockets outlets viz. 6A/16 A Universal switch socket, AC points, etc.

8.4.6.5 Illumination

8.4.6.5.1 Codes

Illumination systems shall be designed as per the requirements of the latest issues and most recent revisions and amendments of the standards listed below: -

Table 8-13 Standards for illumination

Code	Title
IS: 3646, Part-I & Part II,	Code for practice for interior illuminations.
BS EN 12464-1 & 2	Light and Lighting- Lighting of Workplaces- Part 1: - Indoor Workplaces
IEC 62031	LED modules for general lighting - Safety specifications
IEC 61347-2-13	Lamp control gear - Part 2-13: Particular requirements for DC or AC supplied electronic control gear for LED modules
IEC 60838-2-2	Particular requirements - Connectors for LED-modules
IEC 62384	Performance requirements for electronic control gear for independent LED modules.

8.4.6.5.2 Lux Levels

Following Lux levels shall be considered: -

Table 8-14 Lux level for rooms

Rooms/Areas	Illumination (LUX)
Waiting room	300
First aid	250
Tolilets	100
Shops	200

8.4.6.5.3 Lighting

LED Lighting shall be considered for all areas of lighting with minimum following requirements: -

- LED lamps considered to meet Lighting power density (LPD) as per Indian standards IS 3646 part I & part II
- Suitable energy saving lighting fixtures are considered.
- Luminous Efficacy > 100 lumens per watt
- CRI >80

- CCT:
  - Warm white light = 3500 K (Minimum)
  - Cool white light = 5000 K (Minimum)
- Driver Efficiency > 85%
- Power factor = 0.9 or better
- Total harmonic distortion < 10%

8.4.6.6 Small Power Outlets

Small Power Outlets shall be designed as per the requirements of the latest issues and most recent revisions and amendments of the standards listed below: -

Table 8-15:codes for small power outlets

Code	Title
IS 1293	Plug and socket outlets of rated voltages up to and including 250 volts and rated currents up to 16A.
IEC 60309	Plugs, socket-outlets and couplers for industrial purposes

Modular enclosed type and flush mounted shutter type switch socket outlets shall be considered as per NBC guidelines for all areas.

8.4.6.6.1 Switchbox/Socket outlet boxes

(For lighting, fan & socket points)

Switchboxes shall be G.I/powder coated suitable for recess /surface mounting and modular type suitable for modular type switches / socket outlets of required ratings and step less fan regulators

8.4.6.6.2 System of Wiring

System of Wiring shall be designed as per the requirements of the latest issues and most recent revisions and amendments of the standards listed below: -

Table 8-16 Codes for system Wiring

Code	Title
IS 732	Code of practice for electric wiring installations
IS 9537	Conduits for electrical installation

- Wiring shall be of surface conduit/ armoured cable type wherever required.
- Concealed conduit wiring shall be provided at areas such as Ticket Office / Control Booths/ Waiting lobby etc.
- Lights, fans and 6A socket outlets on a same switch board may be wired on a common circuit. However, loading on such circuit shall not exceed 800 Watts.
- Balancing of circuits in the poly-phase installations shall be ensured.
- Looping of maximum 2Nos. 16A socket points shall be considered per circuit.
- Sub main / circuit wiring from MCB to switchbox shall be done using PVC insulated FRLS 2.5 sq.mm Copper wire including earth wire in (minimum) 19 mm dia. GI conduit.

- Point wiring of 3 pin 6A socket outlets/light and fan points shall be done using 1.5 sq.mm PVC insulated FRLS copper wire in (minimum)19 mm dia. GI conduit.
- Armoured XLPE cables of min 1.5 sq.mm. shall be considered for lighting in External areas.
- Power wiring of 3 pin 6A/16A socket outlets shall be done using 4 sq.mm PVC insulated FRLS copper wire in (minimum) 25mm dia. GI conduits.
- Armoured XLPE cables of min 4 sq.mm. shall be considered for industrial socket outlets.
- Colour code for circuit and sub main wiring installation shall be strictly followed. The colours to be followed are Red, Yellow, and Blue for R, Y & B phases respectively, black for neutral and green for earth

8.4.6.7 Cables

Cables shall be designed as per the requirements of the latest issues and most recent revisions and amendments of the standards listed below: -

Table 8-17 Codes and Standards for Cable

Code	Title
IS 7098 (Part-1) 1988	Cross linked polyethylene insulated PVC sheathed cables For working voltage up to and including 1100 V
IS 1554 (Part-1) 1988	PVC insulated (heavy duty) electric cable: Part 1 For working voltages up to and including 1100V
IS 3961 (Part-2) 1967	Recommended current rating for cables: Part 2 PVC insulated and PVC sheathed, heavy duty cables
IS 10418-1982	Drums for electric cables
IS 10810-1984	Method of tests for cables
IS 5831-1984	PVC insulation and sheath of electrical cables

LT power and control cables shall be 1100V grade, heavy duty, aluminium /copper conductor, multi core, XLPE insulated, galvanized steel strip/round wire armoured, extruded PVC type ST-2 inner and outer sheathed type conforming to IS-1554 FRLS cables.

Cables shall be selected on basis of following parameters: -

- Rated Voltage
- Fault Current withstand capacity
- Rated current carrying capacity
- Derating factors
- Voltage drops

8.4.6.8 Cable Tray Routing

- Cables shall generally be laid on cable trays either in trenches or overhead supported from embedded plate grouted in concrete.
- AC and DC circuit shall be considered in separate cable trays. A minimum separation of 250 mm as far as possible shall be maintained from other services such as instrumentation ducts, process and utility piping.
- Ladder type GI cable trays shall be used for power cables and perforated type cable trays shall be used for control cables.

8.4.6.9 Fireproof Sealing System

Table 8-18 Fireproof sealing system

Code	Title
IS 12459: 1988	Code of practice for fire safety in cable runs
IS 12458: 1988	Method of fire resistance test of fire stops

Fire stop / breaks adopted for cables or cable trays penetrating through walls and floor openings, or cables passing through embedded conduits/pipes/ pipe-sleeves, constitutes a Fireproof Sealing system which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

Fire barriers/fire stops, and fire breaks are provided along the run of cables in cable vaults/ galleries, cable shafts, cable tunnels/trenches and cable trays to prevent spread of fire from one area to other and to contain the damage.

Fire barriers/fire stops are rated for 3-hour fire rating.

8.4.6.10 Earthing System

Earthing system shall be designed in accordance with the provision of IS 3043 – 1987.

The type of earthing system foreseen is TN-S. The same shall consist of GI pipe electrode earth stations, buried flat GI protective conductors. The design of protective earth conductors shall be done for minimum 50 kA considering a fault clearing time of 1 second. The resistance of earth grid shall be less than 1 ohm.

Parts of all electrical equipment and machinery not intended to be alive shall have two separate and distinct earth connections. All joints of bare earth strips shall be welded / braced to form a rigid earthing ring. All the earth electrodes in the site will be interconnected by GI earthing conductors buried directly in ground.

In electrical panel rooms, workshops, earthing flats (or use centralized earthing bars) will be run along walls, column, horizontal and vertical structural members using clamps.In corrosive areas, aluminium disconnecting plates along with suitably sized PVC insulated aluminium conductor cables shall be used for earthing grid connections. The main earthing networks will be used for earthing of equipment to protect against static electricity.

8.4.6.11 Lightning Protection

The lightning protection system shall be in accordance with IEC 62305 standards.

8.4.7 Buildings Fire Alarm and Security System

8.4.7.1 Fire Alarm and Detection System

8.4.7.1.1 General

An Intelligent, Automatic Fire Detection and Alarm System (FDA), is envisaged to cater to the safety against Fire Hazards and to detect the fire at its incipient stage for the proposed Facilities/Buildings.The FDA System comprises mainly of programmable and configurable Main Fire Alarm Panel (MFAP), linked up and looped with Addressable Smoke Detectors, Sounders, Strobes, Manual Call Stations, Relays etc.

Alarms to Fire Fighting System, AC system (SCADA), Elevators, and Security systems shall be suitably configured based on the requirement and inputs provided by other Facilities which needs to be hooked up the FAP for Alert and Alarm functionalities.

As per National Building Code (NBC), provision of fire detectors in car spaces not required. Henceforth not considered. The standards and design feature of the FDA System envisaged is as follows:

- The fire detection system shall conform to UL/FM/LPCB/VDS/NFPA Standards. The Fire Detection & Alarm System shall be designed, manufactured, supplied, erected, and tested as per the requirement laid in relevant NFPA/ Indian Standard specifications- IS 2189-1999 and TAC norms. The detectors shall be located and spaced as per latest NFPA/ BIS codes.
- The fire detection system shall be networkable with Ethernet TCP/IP.

Fire Alarm Panels shall also have the following minimum features: -

- Logging an alarm, time and action test on printers.
- 'NO & NC' contact for common fire/fault signal of individual loop for sending the information to the Automation system within battery limit.
- Auto dialling facilities with security office, central fire brigade station etc.
- Programmable activation of control output relays for tripping Air Conditioning & Ventilation Systems.
- The equipment related to the intelligent Addressable Automatic Fire Detection and Alarm system shall include the following:
    - All Control Cable shall be 1.1 kV, PVC insulated and sheathed, stranded copper conductor, armoured type. All Control Cables considered are multi-stranded copper cable of 1.5/2.5 sq.mm.
    - Detector circuit cables shall be class ‘A’ wiring with return Loop.

8.4.7.1.2 Manual Call Point (MCP)

- Manual call points shall be so located that no person in the premises has to travel a distance of more than 30 m to initiate an alarm. When MCP is installed external to the building, this travel distance shall be maximum 45 m.
- MCP shall be fitted in conspicuous and easily accessible points on escape routes. It should be mounted at a level of 1.4 m above floor level.
- MCP shall be located at the exit of a building and in case of multi-story building, at the exit of each floor.
- MCP shall be wall mounting type. The housing shall be dust and moisture proof with proper rubber sealing.
- The glass surface shall be minimum 30 sq. cm in area and the thickness shall not exceed 2 mm.

- Once the glass is broken, the alarm shall sound on the floor as well as on the control and indicating equipment and light shall glow to indicate its operation.

8.4.7.1.3 Detectors

- The detectors shall be intelligent addressable type with capability of communication with the FACP using both broadcast and polling protocols.
- Each detector shall have two LEDs one each for displaying communication and alarm status.
- Detectors shall have self-diagnostic facility. Self-diagnostic codes shall be provided for easy identification of possible problem in the detector.
- Each detector shall be capable of transmitting pre-alarm and alarm signals in addition to the normal and trouble information.
- It shall be possible to program each decision-making level separately for each detector.
- It shall also be possible to program each detector to change its sensitivity settings during day and night conditions.
- Each detector shall have history log facility and it shall be possible to call its history from central control panel.
- Each detector shall be able to operate on standalone mode in case there is a communication failure with central control panel. It shall continue registering data during this time. These data shall be available to the central control panel on resumption of communication.
  Following data shall be available at the central control panel / central PC against each detector:
    - Detector serial no., address, type
    - Date of manufacture, hours of operation and last maintenance date.
    - Current detector sensitivity values and the extent of environmental compensation
    - Original detector sensitivity value
    - History of recorded alarms and troubles
    - Time and date of last alarm
    - Analog signal pattern just before the last alarm
    - Detector trouble diagnostic codes

8.4.7.1.4 Spacing Of Detectors

8.4.7.1.5 Multi sensor detector

- Under flat ceilings, the horizontal distance between any point in a protected area and the detector nearest to that point shall not exceed 7.0 m.
- The detector sensing radius shall cover entire room.
- In case of a sloping roof or pitched ceiling (where the distance between the top of apex and bottom of the roof exceeds 600 mm), spacing of detectors at or in the vicinity of apex shall be spaced between 7.5 m and 8.5 m or as recommended by manufacturer.
- Detectors shall not be mounted within 500 mm of any wall.
- Detectors shall be located at least 1 m away from air conditioning units.
- An obstacle e.g., beam shall be very well taken care of during designing of FDAS system. For multi sensor detectors, ceiling with beam depth of 200 mm shall be considered as smooth ceiling however if it exceeds 200 mm the spacing between detectors should be reduced to twice the depth of obstruction. If the beam projects more than 450 mm below and are more than 2.5 m on centres, each bay formed should be treated as separate area.
- A detector shall be placed on the ceiling 1.5 m from any door, window or any opening in the wall partition.

- All stairwells lift shafts etc. shall have a detector at the top.
- The detector shall also be provided in the cable tunnels, ducts, false floors, AC and AHU room.
- Every enclosure (room or cabin) shall have a detector at ceiling level and under false ceiling, if provided.

8.4.7.1.6 Audible Alarms (Sounders)

- One sounder shall be located near to the control panel or entrance, on a separate circuit.
- Sounder shall have programmable multiple tone.
- All sounders shall sound similar to avoid confusion.
- Audible alarm level within buildings shall generally be accepted as 65 dB at 1 metre or 5 dB above any background noise which persists for more than 30 sec. Sound level shall be reduced to 60 dB in rooms smaller than 60 sq.m, in stairwells or in specific limited points of the building.
- Visual indications such as strobes shall be required where high noise level exists.

8.4.7.1.7 Cabling And Wiring

- All field devices of fire detection and alarm system like fire detectors, multi sensors, manual call points, electronic hooter & linear heat sensors shall be connected by a single pair cable.
- Detectors of a zone shall be connected in a loop and loop shall be wired to fire alarm control panel (FACP) kept in a block.
- Wiring for Fire detectors, devices and repeater panels in each block shall be carried out with 2/4 core 1.5 sq.mm, copper conductor, unscreened, armoured FRLS PVC insulated cables including cable termination at both ends complete as required.

8.4.7.2 Data And Communication

- RJ-45 LAN Sockets will be provided for Main Rooms like Ticket counter, Terminal Office room, Security Room, Storerooms & Shops etc.
- WIFI points will be provided in Main Areas and common spaces, WIFI Point consist of 2 No’s RJ-45 Socket and 2 No’s 6/16A twin Sockets.
- For Data Cat-6 Cable will be used for connection from Ethernet Switch to RJ-45 Points.
- RJ-11 Telephone Sockets will be used for Telephonic connections for Main Rooms like Ticket counter, Office room, Security Room, Police room & Shops etc.
- Telephone System consist of EPABX with Krone distribution Box using multipair telephone cables.

8.4.7.3 Security System

- CCTV SYSTEM consisting of PoE cameras shall be used for monitoring of major and critical spaces.
- CCTV will use same LAN network.
- Ticket / card reader shall be provided and main entries for security Entry and Exit.

8.4.8 Internal HVAC

HVAC system shall be designed in detail, manufactured, supplied, delivered, installed, tested, commissioned, and set to work as described herein.

HVAC system shall be proposed to terminal building & spaces associated with terminal building.

System Description:

Inverter battery room shall be provided with Split air conditioning unit. Toilets, shops shall be provided with exhaust fans.

Natural ventilation will be there inside the premises (which are proposed with exhaust system) through louvers, openable windows etc.

Ceiling fans shall be provided to all areas including forced ventilated areas.

HVAC system shall be designed in accordance with NBC/ISHRAE standards with the consideration of COVID-19 guidelines.

HVAC layout for ground floor plan is shown in DI1530-RHD-ZZ-UA-DR-M-2286.

8.5 Solid Waste Management

In this building the waste generated are mainly Municipal Solid Wastes consisting of paper/plastic waste from passengers & offices.

2 bin system for separating Wet and Dry waste will be placed at various locations throughout terminal building for convenience of users/commuters.

For external areas, 2 bin system with 240 litre containers having lids and handles will be located in pedestrians traffic areas including riverine locations i.e., approach bund, approach trestle, landing platforms, main pontoons.

The site will have designated waste collection area where all the waste will be collected daily and segregated. Further, since this site is not within Municipal limits, waste will be transported in bins by ferries across the river to the nearest terminal/ghat where the facility for collection and disposal shall be available.

8.6 Emergency Evacuation

8.6.1 Emergency Planning

- Emergency response plan specifically tailored for the terminal, including evacuation procedures, assembly points, and communication protocols will be developed by Terminal operations team.
- Clear roles and responsibilities for employees and emergency response teams will be established.
- Regular drills and exercises to test the effectiveness of emergency plans will be conducted to enhance the preparedness of staff.
- Local fire departments and emergency services will be well collaborated to ensure coordination and support during an incident.

8.6.2 Evacuation and Escape Routes

- Terminals are designed with designated clearly marked emergency/fire exit routes as per NBC norms. The locations of all emergency routes are easily accessible. These exits will be always kept unobstructed and clearly indicated with signage.
- All emergency routes will be well lit with emergency lighting system. Periodical maintenance and testing of emergency lighting systems will be conducted.
- Well planned access routes equipped with ramps, refuge areas, etc for individuals with disabilities have been provided as per NBC and CPWD norms, including designated evacuation assistance points. Further reference is drawn to DPR section 8.3.7.10 Barrier Free Design.
- All these exits will be clearly marked in comprehensive evacuation plan. Such plans, evacuation routes signages will be placed at all strategic locations clearly visible to all occupants.
- Plans with designated assembly points for passengers and staff, as well as clear instructions on how to evacuate the terminal safely will be shown in plans as well as will be announced during emergencies. Such plans will be pasted at all strategic locations.
- Detailed procedures to follow in the event of an emergency will be well established and such training will be given to all terminal staff.
- This plan should include designated assembly points for passengers and staff, as well as clear instructions on how to evacuate the terminal safely.

8.6.3 Communication and Notification Systems

- Terminal are equipped with integrated public address system to broadcast emergency instructions and updates to occupants. Passengers will be provided with information regarding fire safety measures and emergency procedures. This will be done through public announcements, signage, brochures, or briefings at the beginning of the cruise.
- Multiple channels for communication, such as Audible Alarms (Sounders), hooters, Manual call points and visual alerts, have been planned to ensure warning will be noticed by everyone in the terminal. This is further elaborated in DPR section 8.4.8.

8.6.4 Training and Education

- Regular fire safety training sessions for employees, focusing on prevention, response procedures, and the proper use of firefighting equipment will be conducted. This includes knowledge of evacuation routes, the use of fire extinguishers, and effective communication during emergencies.
- Periodical awareness among employees and visitors about potential fire hazards and the importance of adhering to safety protocols will be conducted.
- Training on first aid and basic life-saving techniques to selected staff members will be provided.
- Regular drills and exercises can be conducted to test the effectiveness of emergency plans.

8.7 Operation and Maintenance

The ferry terminal consists of three main elements, namely the landside facilities including the approach to the riverside facilities, link span and the floating pontoon. The operation of the facility would facilate regular to and fro movement of passenger/vehicles from the landside end to the pontoon end and thereafter on to the ferry.

At the landside end are primarily the buldings facilities which will basically need regular upkeep and housekeeping, garbage collection and disposal besides the operation of essential amenities required for regular and differently abled passengers like fresh water, wheel chairs, first aid box, light snacks canteen, ticketing counter, vehicle parking, lifts, washrooms.

The link span is provided for safe movement of passengers/vehicles from the landside terminal to the pontoon. This is a steel structure which is either fixed or movable. The movable arrangement consists of wheels attached to the steel structure which move on rails. The movement is anticipated to be carried out through tow trucks/winches. Any deposition of silt needs to be cleaned by a water jet. It is best if the cleaning of the link span is carried out on a daily basis to avoid any built up of slit deposits. To provide smoothness in the movement of link span it would be advisable to apply water insoluble grease on the parts of the rails.

The link span being a steel structure will require cleaning and preservation as undertaken for other steel structures.

The pontoon is a floating structure which is anchored to the sea bed using steel chain cables for mooring. The periodic maintenance of the pontoon, chain cables and anchors is to be undertaken as per the rules and regulations of the classifications society namely the Indian Register of Shipping.

The normal operation of the pontoon consists of receiving the ropes from the barge and releasing the same time to time. For this a suitably skilled person would be required on the pontoon. For movement of the pontoon inward and outward there will be a requirement of tug for disengaging the anchor from sea bed, towing the pontoon and re-positioning of the anchor. Also a windlass operator and a diver will be required for this operation.

The complete Operation and Maintainance of the terminal can be undertaken through an O&M contract. It is estimated that the annual O&M cost would be in the range of 3-5 % of the CAPEX.

8.8 Quality Assurance of Works

The scope of work primarily consists of civil works, floating pontoon with anchoring/mooring facilities and associated equipments.

All material, item and equipment used in the work shall be procured as per appropriate IS/BS specifications and subject to inspection at facility or site. For this purpose quality assurance plan shall be prepared by the contractor and submitted to the General Consultant (Engineer’s representative) for approval within 28 days of the work commencement. All works shall be progressed as per this approved document.

The floating pontoon and its anchoring, mooring arrangement shall be as per approval of reputed Classification Society (Class Authority) like Indian Register of Shipping, LLOYD Register of Shipping etc. For this purpose the contractor will immediately get the design approval of the Class Authority and thereafter engage the authority for stage inspection and final testing and trials. The copy of the agreement made with the chosen Class Authority shall be submitted to the society within 28 days of work commencement.

All items brought to the site and execution of work including remeasurements shall be subject to inspection by the General Consultant (Engineer’s representative) who shall be the Engineer for the project.

The decision of the Engineer shall be final & binding in all matters of quality assurance.

9 Terminal Design

9.1 Design Criteria for Land & River Infrastructure

9.1.1 Units

The international system of units (S.I.) will be used for the design and detailing of all items unless specified otherwise.

9.1.2 Design Life

The design life of various components of the project is broadly summarized in along with relevant maintenance criteria.

Table 9-1 Design life and Maintenance Intervals

Element	Design Working Life (Years)
Reinforced concrete structures	50
Steel strcutures	50
Linkspan, Walkways (Steel structures)	25
Fenders & Bollards	25
Rail Systems	20
Terminal building	50
Substation	50

9.1.3 Design Vessel Dimension

Cluster or Location	Capacity (MT)	Principal Dimensions (m)		
		Length	Breadth	Draft
Umananda	236	17 m	4.30 m	1.50 m
	200	32 m	10 m	1.80 m

9.1.4 Water Level

Site locations	HFL (m)	LWL (m)	Variation (m)
Umananda	48.38	41.55	6.83

9.1.5 Current Speed

Based on the maximum discharge and corresponding water level, cross-section averaged flow velocity has been studied at CWC HO sites, which is around 3.5 to 4 m/s. Thus, the maximum velocity would be in the range of 5 to 6m/s (1.5 times cross-section averaged velocity). Moreover, literature and interaction with experts revealed that local maximum velocity of 5.5m/s have occurred or can occur in Brahmaputra River. Thus, in this study, value of 6m/s is considered for the design.

9.1.6 Scour

Scour assessment of individual locations based on available morphological and geological data. Following shows the anticipated scour depth at Umananda location.

Table 9-2: Anticipated scour depth

Location	Scour depth
Umananda	1m below riverbed level

9.1.7 Material

9.1.7.1 Concrete

All reinforced and unreinforced concrete structures will be in accordance with the requirement of IS 456 and will be of minimum strength as mentioned in below table.

Table 9-3: Concrete Strength

Design Element	Minimum Strength Class
Reinforced Concrete	M40
Plain Cement Concrete	M25

9.1.7.2 Reinforcement

The Reinforcement steel will be of grade Fe 500D (corrosion resistant) and comply with the requirements of IS 1786.

9.1.7.3 Structural Steel

The grade of structural steel considered for pontoons, linkspans, steel tubular pile and other superstructures is mentioned in the table below. The structural steel work of rolled sections, plates, bars, hollow sections, nuts, bolts, and washers for structural connections will comply with the requirements of IS 2062, IS 1161 and IS 4923. The minimum yield stress requirement for various structural members is presented in below table.

Table 9-4 Steel grades

Structure type	Structural Steel Grade	Minimum Yield Strength (N/mm2)
Pontoon	E250	250N/mm2
Linkspan	E350	350 N/mm2
Steel tubular pile	E275	275 N/mm2
Other Structures	E250	250N/mm2
Misc. items like plates, gratings, handrails, chequered plates etc	E250	250N/mm2

9.1.8 Design Loads

9.1.8.1 Dead Load

Dead load for structures will be self-weight of the element, which will be based on the density of the material. The following unit weight of materials will be considered for calculating the dead weight of members:

Table 9-5 Unit Weights of Materials

Material	Unit Weight
Concrete (reinforced)	25kN/m^3 (IS:875 Part-1: Table-1)
Steel	78.50kN/m^3 (IS:800 Cl.2.2.4.1)
Concrete (plain)	24kN/m^3 (IS:875 Part-1: Table-1)
Reclaimed filled soil	18kN/m^3

Note: *These values should be checked with local materials.*

9.1.8.2 Live Load

The following live loads summarized in the table below considered in the design of pontoon and linkspan.

Description	Live Load kN/m2	Remarks
Pontoon	10	-
Link Span (Foot passenger+ Two wheelers)	5	-
Link Span (Foot passenger+ Two wheelers+ Four wheelers)	10	i.e. 16.2 tonne truck

9.1.8.3 Wind Load

The wind load on various elements will be calculated in accordance with IS 875: Part III.

Extreme Case

Basic wind speed at 10 m Height = 50 m/s

Operational case
Basic wind speed at 10 m Height = 30 m/s

9.1.8.4 Current Load

Current forces have been estimated based on the current velocity of the river.

9.1.8.5 Seismic Load

The project site falls under Zone V as per the seismic map of India shown in IS 1893- 2016. Earthquake loads will be adopted as applicable for the site as per IS 1893 – 2016.

9.1.8.6 Berthing Load

Berthing force shall be in accordance with BS 6469 and PIANC guidelines. The following criterion have been adopted for fender design from WG-33, Guidelines for the design of fender systems-2002.

- Berthing condition : Good berthing
- Berthing Velocity : 0.5 m/s
- Berthing Angle : 10° to 15°
- Abnormal berthing energy factor : 2 or higher

9.1.8.7 Mooring Load

The mooring loads are the lateral loads caused by the mooring lines when they pull the vessel into or along the dock or hold it against the forces of wind or current. The maximum mooring loads are due to the wind forces on exposed area on the broad side of the vessel in light conditions and current loads perpendicular to structure away from the berth. Mooring force shall be considered as per BS 6349-4, clause 9.2.4.

BS 6349-4, Clause 9.2.4. Method 3: Working line loads: For vessels less than 20 000 t displacement, or for a particular vessel using specified mooring ropes and mooring pattern, the mooring points should be designed at normal working stresses for a force equal to the minimum breaking load of the ropes.
NOTE Typical rope characteristics are given in IMO MSC/Circ 1175 [4].

9.1.9 Deflection

Vertical deflection limit:

- For cantilever beams : Length/180
- For spanning beams : Span/250

Horizontal deflection limit:

- For operating condition : L/300, maximum 100mm
- For extreme condition : 200mm

Where, “L” is the distance between deck centre lines to the point of fixity of the pile.

9.1.10 Crack Width

The structural elements shall be checked for crack width for serviceability cases considering that the width of cracks nearest to main reinforcement should not exceed 0.004 times the cover of the main reinforcement. The below snapshot from the IS 4651-4. presents the crack width limits for various zones to be considered in the design

Table 3 Maximum Crack Width in Different Zones

(*Clause* 8.3.4)

All dimensions in millimetres.

Sl No.	Exposure Zone	Maximum Crack Width	
		Sustained Load	Transient Load
(1)	(2)	(3)	(4)
i)	Atmospheric zone — above splash zone and where direct wave or spray impingement is infrequent	0.2	0.3
ii)	Splash zone — zone between the chart datum and the design wave height above the mean high water springs	0.1	0.2
iii)	Continuous seawater immersion zone — below splash zone upto seabed level	0.2	0.3
iv)	Below seabed level	0.3	0.3

NOTES

1 *Sustained load* — Dead load plus 50 percent of full uniformly distributed live load + earth pressure.

2 *Transient load* — Dead load plus berthing load and full crane load or full live load uniformly distributed + earth pressure.

9.1.11 Load Combination

The load combinations as per IS: 4651 (Part-4): 2014 will be adopted for the design of Pontoon, and Linkspan/walkway.

9.2 Design of Riverine Facility

9.2.1 Floating Pontoon with Integrated Ramp

9.2.1.1 Trim and Stability

The pontoon must comply with IMO's and classification requirements for stability. The pontoon shall be capable of being maintained on even keel and not have any trim in any of the operating loading conditions. Permanent ballasting will not be allowed. An inclining experiment is to be conducted for establishing the 'in-service' stability.

9.2.1.2 Tests, registrations and certifications

Following documents are required along with the pontoons

a) Issued by appropriate authorities as applicable for this class of vessel.
   1) Inclining Experiment Report.
   2) Trim and Stability booklet.
   3) Certificate of tonnage (GRT/NRT).
   4) Certificate of Registry

b) To be issued by classification society
   1) Classification Certificate
   2) All Certificates of machinery and equipment if any
   3) Certificates in respect of anchors, chain cables, shackles, hawsers, mooring ropes and equipment.

c) To be issued by Supplier
   1) Builder's Certificate
   2) Official Deadweight Certificates.

Inspection During Construction.

The inspection during construction to be undertaken by Buyer's representatives/consultants and IRClass/Classification Society.

Registration.

The pontoon to be registered as per the relevant rules and regulations of Inland Vessel Act, 1917 and DG Shipping order of 2017.

9.2.1.3 Codes and certificates

The pontoons are to comply with following rules, regulation and guidelines as regards their design and construction:

(a) IRS (Indian Register of Shipping) rules or similar rules of any classification society who is a member of International Association of Classification Society (IACS)
(b) The Inland Vessel Act 1917 and as amended in 2007
(c) Reference documents in accordance with Ministry of Ports, Shipping and Waterways guidelines issued vide their letter File No M-25021/20/2020-SM dated 03 February 2021.

- IS 875 (Part-3) Design Loads for Buildings and Structures
- IS 800: 2007 – General Construction in Steel – Code of Practice
- IS 4651 - Planning and Design of Ports and Harbours – Code of Practice (all Parts)
- IS 2062: 2011 – Hot Rolled Low, Medium and High Tensile Structural Steel - Specification
- AS 1170 Minimum design loads on structures
- AS 1170.1 Part 1: Dead and live load and load combinations
- AS 1170.2 Part 2: Wind loads
- AS 1428 Design for access and mobility (all parts)
- AS 1657 Fixed platforms, walkways, stairways and ladders—Design, construction and installations
- AS 1851 Maintenance of fire protection equipment (all parts)
- AS 3962-2020 Marina Design
- AS 3004 Electrical installations—Floating Jetty and pleasure crafts at low voltage
- AS 4100 Steel structures.
- AS 4586 Slip resistance classification of new pedestrian surface materials.

Following standards may also be referred

- IS 4374/ IS 3381 – for Bollards
- IS 4484/IS 4692 Anchor chain links
- IS 3267 General Requirements for Anchors
- Material For Construction: Shipbuilding quality steel of IS-2062 Grade "B" or equivalent/ superior with all welded construction.

Tests, registrations, and certifications Following documents are required along with the pontoons

a) Issued by appropriate authorities as applicable for this class of vessel.
    1) Inclining Experiment Report.
    2) Trim and Stability booklet.
    3) Certificate of tonnage (GRT/NRT).

4) Certificate of Registry

b) To be issued by classification society
1) Classification Certificate
2) All Certificates of machinery and equipment if any
3) Certificates in respect of anchors, chain cables, shackles, hawsers, mooring ropes and equipment.

c) To be issued by Supplier
1) Builder's Certificate
2) Official Deadweight Certificates.

Inspection During Construction.

The inspection during construction to be undertaken by Buyer's representatives/consultants and IRClass/Classification Society.

Registration.

The pontoon to be registered as per the relevant rules and regulations of Inland Vessel Act, 1917 and DG Shipping order of 2017.

9.2.1.4 Pontoon Hull Structure

The pontoon hull form is a flat bottom, cambered deck, with planar (and vertical) side shells. The fore and aft body of the barge has been provided with the raked bottom (swim ends). Hull form & dimensions are as shown in the figures below.

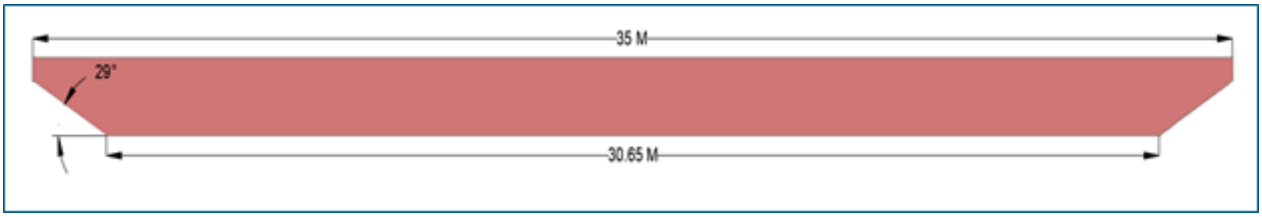


Figure 9-1 35 m Pontoon Hull form – Profile View

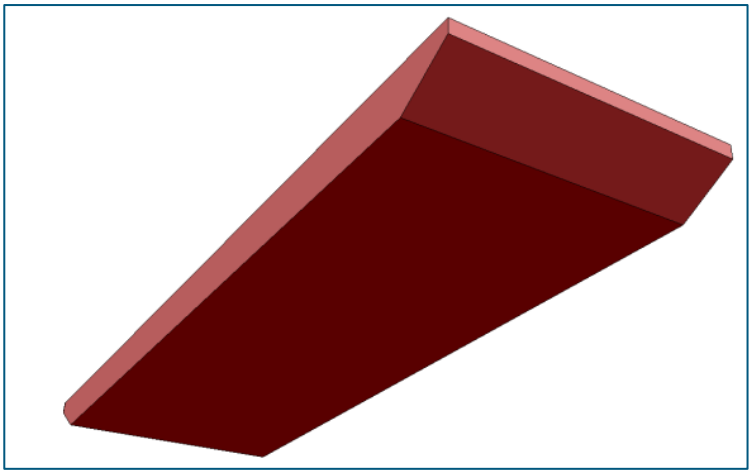


Figure 9-2 35 m Pontoon Hull Form – Perspective View

The raked bottoms' linear length at fwd. and aft is assumed as 2.175 m + 2.175 m (~9.67% of the Hull Length) for enhanced hydrodynamic performance in comparison to rectangular and orthogonal planar sections, in line with the swim-end requirement which would facilitate efficient towing of the barge in case of relocation activities.

9.2.1.5 Anchor and Mooring arrangement

9.2.1.5.1 Mooring, Anchoring, and Towing Fittings

For the selection of mooring and towing fittings, the IRS Rules and Regulations for the Construction and Classification of Inland Waterways Vessels along with Rules and Regulations for Construction and Classification of Steel Ships have been followed as applicable and appropriate.

The Pontoon is envisaged to be moored as per the catenary mooring arrangement as shown in the drawings. Through gravity the catenaries will have the typical shape of a free hanging line. The catenary configuration provides a restoring force on vessel motions through the weight of the catenaries. A catenary mooring line length and other parameters have been calculated.

The catenary anchor chain cable will be connected the anchor windlass through the hawser pipe and the anchors dropped in a cross manner (Port anchor to Starboard and Starboard anchor to Port). The windlass shall be used to tighten/loosen the catenary mooring lines across tide variations. An anchoring configuration of nature as depicted in the drawings is envisaged to facilitate keep the anchoring lines clear off the berthing vessel. The angle of the catenary shall be configured such that the anchoring chains doesn't rub against each other in the crossing. In addition to the depicted arrangement, anchor-disposition-indicator-buoys are also envisaged to provide visual aid to the operators and avoid any consequent difficulties of entanglement of the anchoring chains with the incoming vessels.

9.2.1.5.2 Towing Lines Specifications

Towing lines specifications required are as follows when being pushed.

- No. of Towing Lines 04.00 Nos
- Min. Breaking Strength 440 kN

When the pontoon is towed, towing line on the tug is envisaged to be used.

9.2.1.5.3 Mooring Bollards & Roller Fairleads

06 Nos of Double Bitt Mooring Bollards (3 Nos each Side – Port and Stbd) and Roller Fairleads (4 Nos each Side – Port and Stbd) along with deck rollers for directional guidance, with Safe Working Load (SWL) of 50 T (Based on Min. Breaking strength of mooring lines) are envisaged as per IRS rules and regulations.

9.2.1.5.4 Fixed/Portable Anchor Windlass and Anchor

Anchor windlass of capacity as shown below will be required to handle the catenary system.

- Continuous Duty Pull (for 30 Mins) 140 kN
- Hoisting speed Shall not be less than 9m/Min.

- Anchor type shall be of drag anchor type with chain cable of 34 mm diam and weight of 26 kg/m

Anchor: 4 No of Anchors (HHP) of 10 Tonnes each is envisaged to be used for Anchoring.

9.3 Geotechnical Design

9.3.1 Foundation Feasibility

The present section discusses on foundation feasibility for Umananda terminal location from the outcome of geotechnical investigation works. Modular and economical terminal facilities are proposed considering the current traffic volumes and passenger mobility in the feasibility studies. In addition to that, morphological study reveals Brahmaputra River is more dynamic in nature with relatively high fluctuation in water levels and flow direction. Keeping the socio-economic scenario in consideration, it shall be noted that permanent establishment for ferry terminals will not be feasible due morphological conditions at this terminal location.

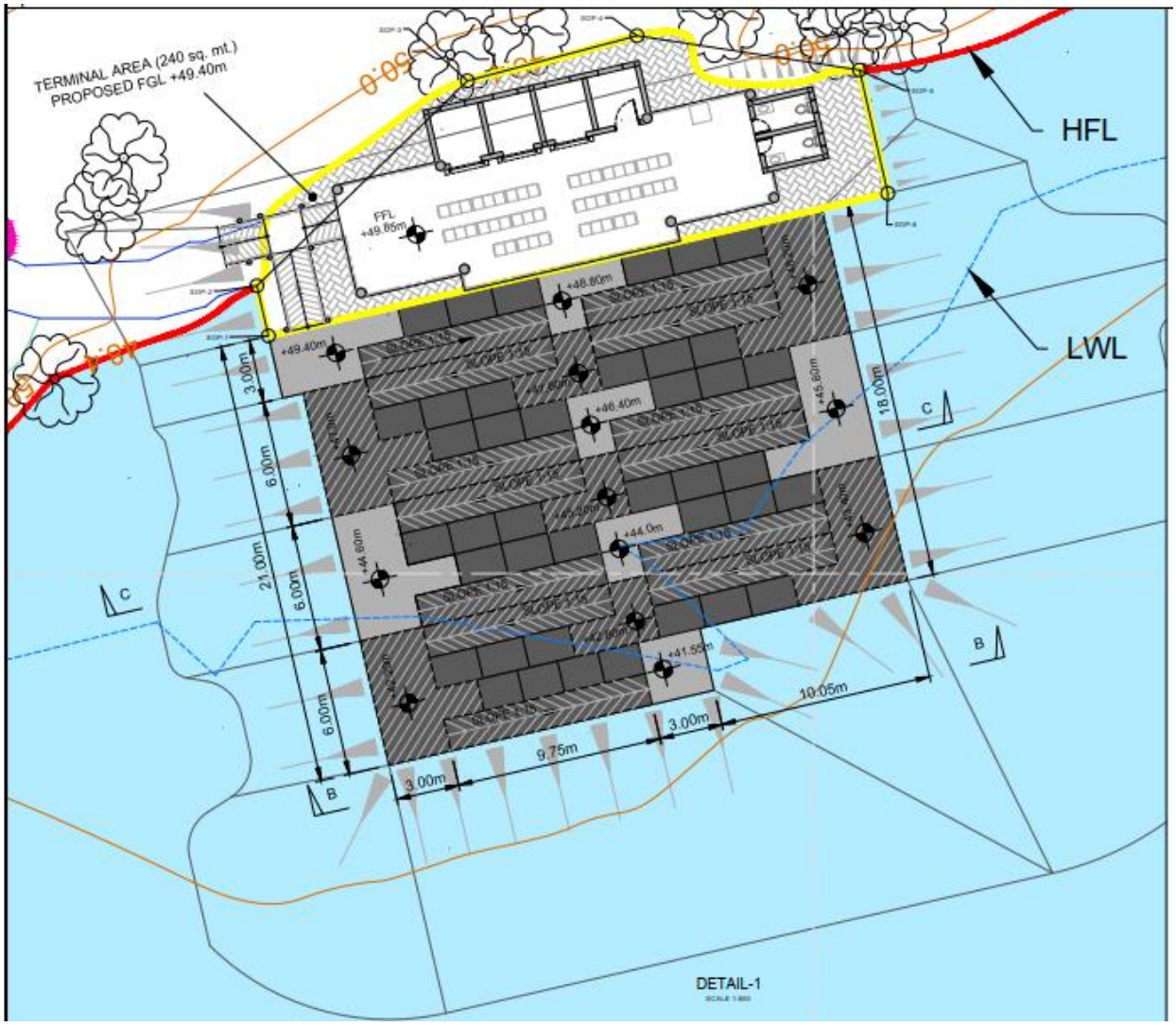


Figure 9-3: Layout of proposed modular ferry terminal at Umananda location

9.3.1.1 Landside Facility

Based on the available survey information, site specific foundation feasibility study was conducted. Various foundation techniques such as pile foundation, ground improvement by replacement or stone columns are taken into consideration. Upon preliminary study, it is understood that subsoil is observed to silty sand of

1m thick followed by weathered rock. At some part of locations exposed rock also observed due to hill outcrop. Considering these available condition, it proposed that no ground improvement is required.

Table 9-6: Location wise Foundation feasibility summary for Land side

Location	Requirement of Ground Improvement
Umananda	No

However, engineered soil fill shall be placed for levelling the ground for terminal development. Following table summarises the viable foundation option for Umananda ferry terminal location. With this engineered fill in place, all the landside facilities can be rested on shallow foundation with a minimum foundation embedment of 2.0m below finished ground level. It is estimated that 120 to 150 kPa of safe bearing capacity is available at proposed foundation level. This fill materials shall be placed in layers of 250mm to 500mm thick followed by vibro roller compaction of 8 to 10T capacity. Following Table 9-7 shows the summary of available bearing capacity for individual buildings after proposed ground improvement.

Table 9-7: Summary of SBC & Settlements for facilities rested on Open Foundation

Building Name	Foundation Type	Foundation Size	Safe Bearing Capacity	Post Construction Long-term Settlement
Terminal Building	Isolated	2.5m × 2.5m	~12 to 15T/m^2	< 50mm
Parking yards	Raft	--	~8 to 10T/m^2	< 75mm

9.3.1.2 Riverside Facility

Based on the available survey information, site specific foundation feasibility study was conducted. Considering the soil condition, it is envisaged that few locations at central cluster shows presence of silty sand followed by exposed rock outcrop. Hence ground improvement is not at these terminal locations.

It is considered that the landside facilities are connected to floating pontoon on river side by an approach ramp as shown in Figure 9-3. Cross sectional view of the proposed connecting ramp is presented in the following Figure 9-4. These approach ramps shall be rested on granular fill which will act as bearing element.

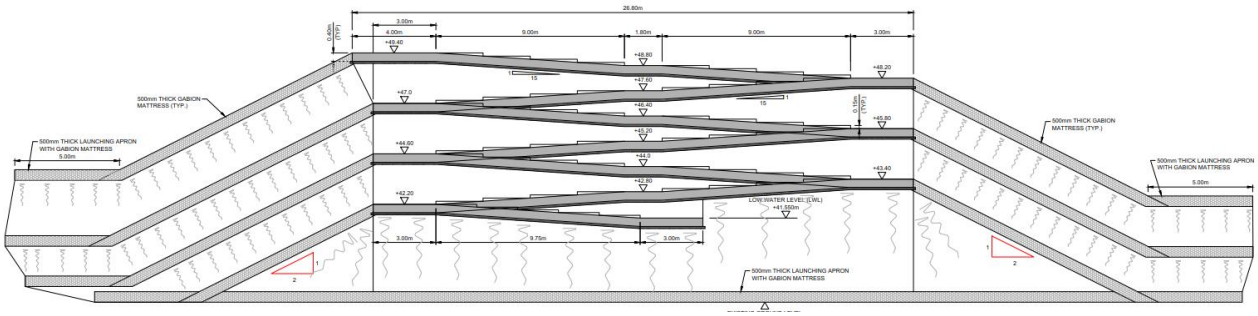


Figure 9-4: Cross section view of approach ramp at Umananda terminal

The side slopes of approach ramp is placed at 1 V : 2H stable slopes by placing granular fill. However, to address the scour and slope protection due to river flow, approach ramp slopes on all over three sides shall be protected by Gabion mattress filled with aggregate. This layer will act as slope protection element for drag and lift caused by river flow. As an outcome of design, a 0.5m thick gabion mattress has been proposed. These gabion mattresses shall be filled with suitable aggregate material. Figure 9-5 shows the schematic section showing gabion mattress as slope protection element for approach ramp.

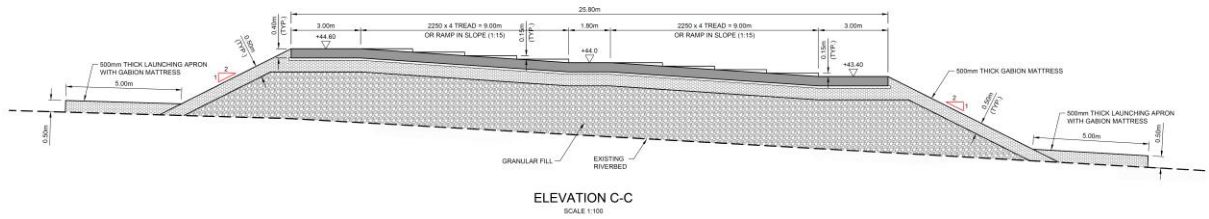


Figure 9-5: Schematic section showing slope protection scheme for approach bund with Gabion mattress

9.4 Utilities and Services Design Criteria

9.4.1 Water Distribution

To meet the water requirements of Umananda Terminal building, Overhead tanks (OHT) are provided on the top of Toilets and shops separately to feed water to various points of consumption by gravity. Design life of the system shall be 20 years.
To meet the above requirement, 4 No's PVC circular water tanks of 1.3 m dia. with a height of 2 m for both Shops and Toilets are provided on their respective terrace.
Isolation valves and check valves are located strategically throughout the distribution network to isolate any branches in building in case of maintenance.
Water supply pipes and fittings of CPVC make are routed from the overhead tank to the building shaft and connection sizes to various fixtures are provided as per NBC.

9.4.2 Fire fighting

Fire extinguishers of ABC type as per IS: 14609 are provided at the entry and exit of the building and near restaurant along with exit signages as per IS 9457.

9.4.3 Sewage network

The sewage network caters to the wastewater flow generated from hand wash & Soil from the toilets located in the building which shall be connected to the external network by gravity. Design life of the system shall be 20 years.

Single stack pipe sewage system with vent facility is provided as per NBC standard. The soil and waste will be carried out from various points in separate independent pipes. The soil, waste shall be watertight, and gas tight designed to prevent escape of foul gas and odour from various fixtures. Vent cowl is provided for individual stacks.All necessary appurtenances like "P" traps, Floor traps, Gully traps, Inspection Chambers etc shall be provided for the quick and safe transportation of soil and wastewater.

Soil and wastewater from water closets and toilets shall be collected as per NBC. Soil pipes are connected to Inspection chambers and wastewater pipes are connected to external trap (Gully Traps). All sewage pipes from Inspection Chambers and gully traps are routed through External sewage network.

Minimum diameter of wastewater collection pipe is 75mm, Soil waste collection pipe is 110 mm diameter. For transportation and collection of soil and wastewater uPVC SWR Type B, pipes conforming to IS 13592-1992 shall be used.

If the minimum velocity is not fulfilled in initial reach in practice, during the operation and maintenance of sewers, the initial reaches should be flushed periodically to clear out settled solids.

Gully trap of 300 x 300 mm is provided and following sizes of inspection chambers is provided:
-600 x 600 mm up to depth of 600 mm
-800 x 900 mm up to depth 900mm.

9.4.4 Storm water network

The rainwater accumulated at the terrace level will be collected through uPVC SWR pipes of 110 mm diameter and drained out from terrace.

The minimum slope will be maintained at terrace level which helps the water flow towards drain points and flush out from the roof through rainwater pipe.

Each drain point at terrace will be installed with a khurra at the top to avoid solid waste to enter the rainwater pipe.

Design life of the system shall be 20 years.

9.4.5 Internal HVAC

Based on weather data published by ISHRAE-2014 Standards, the outdoor design conditions of Guwahati (which is nearer site to Umananda site), shall be considered for equipment design or load calculations for air conditioning areas of Umananda site.

Outdoor design conditions:

Sr. No.	Stations/ Regions/ City	Outside design data (as per ISHRAE standards)								
		SUMMER			MONSOON			WINTER		
		DB (deg. F)	WB (deg. F)	RH (%)	DB (deg. F)	WB (deg. F)	RH (%)	DB (deg. F)	WB (deg. F)	RH (%)
1	Guwahati	90	78	59	82	78	84	52	51	95

Indoor Design Conditions (for Air conditioning area):

	Summer/Monsoon	Winter
Dry Bulb Temp. Deg. C	24 +/-2 deg. c	20+/-2 deg. c
Relative Humidity %	< 60 %	< 60%

Ventilation /Exhaust system shall be designed based on the equipment heat loads and other loads or number of air change per hours as per NBC /ASHRAE/ ISHRAE standards whichever is higher. 10% extra shall be taken on the calculated value and accordingly, the capacity of ventilation /exhaust equipment shall be determined. For large areas/rooms, there shall be provision of fresh air supply system. Fresh air fan supply capacity shall be 50% of total capacity of exhaust fan capacity whereas remaining 50% fresh air supply can be maintained by opening windows inside the premises.

For internal and external noise criteria (specific to limiting parameters for noise), shall be as per the rules and regulations of Central Pollution Control Board (CPCB).
Eco friendly refrigerant shall be used –R134A or R410A or R-32 for the split AC system having 5-star BEE rating with invertor technology.

The internal noise level inside the respective premises shall be maintained by proposing suitable sound reducing devices/equipment like sound attenuator or acoustic insulations etc.
Ducting works, air distribution network and its supports, ducting material shall be as per the ISHRAE standards & SMACNA Standards.

HVAC system shall be interconnected with Fire detection system.

All HVAC equipment shall be suitable for corrosive atmosphere.

9.5 Summary of Land & River Infrastructure

Table 9-8 Summary of land & river components

Components	Nos	Dimension	Remarks
A. Riverine structures			
I. Type of berthing arrangement		Concept Solution 4-	
II. Floating pontoon	1	35x12 m	Steel pontoon
III. Pontoon Integrated Ramp	2	8.0 m x 3.0 m	Mechanical/Hand winch
IV. Approach bund	6.5	26 m length with 1 in 15 slope with landing at every 9.75 m and 3.0 m wide	Lane for passengers and physically disabled person
V. Type of slope protection	-	0.5 m thick	Gabion mattress with aggregate as a filling material
B. Land side facilities			
I. Total land area		240 Sqm	
II. Building area • No. of floors		170 sqm G	

10 Environmental and Social Aspects

10.1 General

AIWTDS has engaged M/s WAPCOS Ltd as the Safeguards Consultant for conducting Environment and Social Impact Assessment (ESIA) and CIA studies for the proposed passenger ferry terminals, slipways, and Crew Training Centre (CTC).

The Safeguards Consultant has undertaken field visits to the proposed terminal locations and have submitted an inception report. A copy of the inception report was received through AIWTDS on 20 May 2022. Subsequently, the revised inception report was received through AIWTDS on 15 July 2022.

Based on the information available with the Consultant, an initial appreciation of the Environmental sensitivity is outlined below.

Assam has Four National Parks, One Tiger Reserve and 18 Wildlife Sanctuaries, which constitutes the Protected Area network of the State covering 4.87% of its geographical area. In order to identify the eco-sensitivity of the project area, the proposed ferry terminal locations were superimposed on the map of Wildlife protected areas of Assam. The same is presented in the figure below.

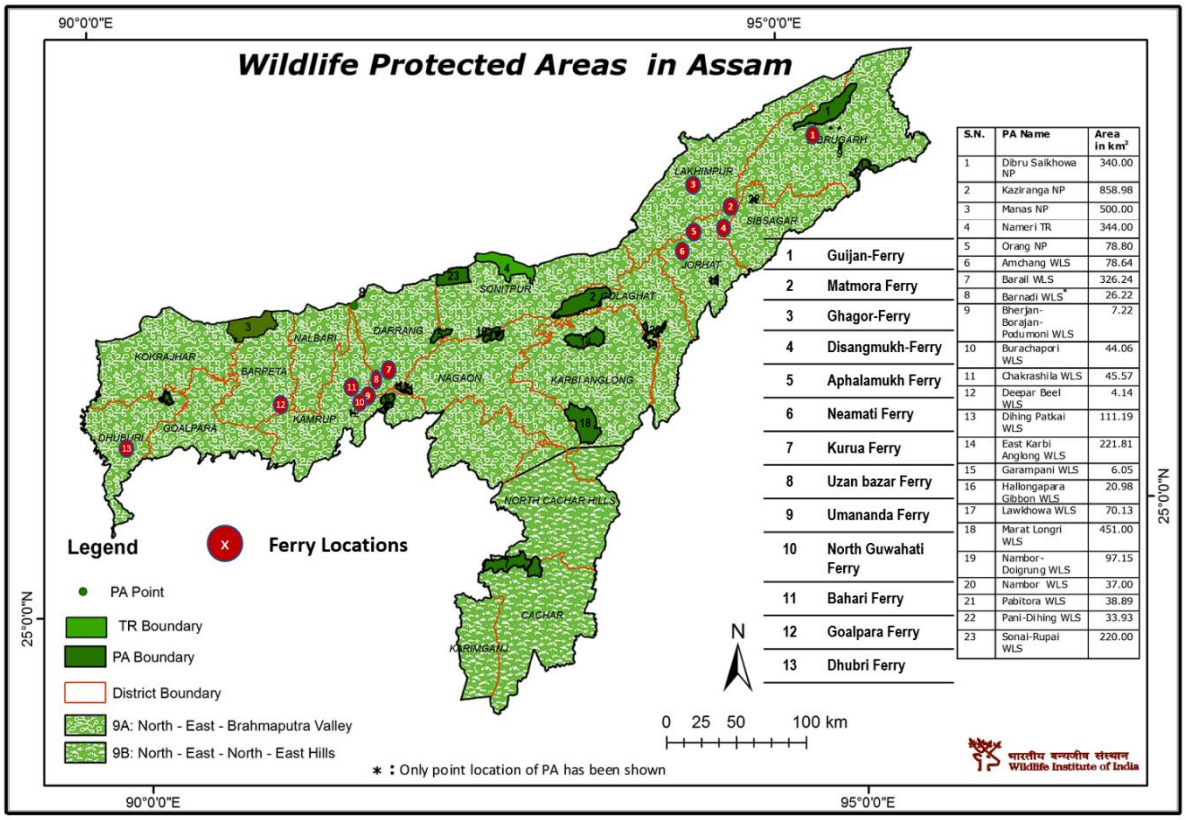


Figure 10-1 Ferry terminal locations on Wildlife Protected Areas of Assam

The distance of ferry locations to nearby wildlife sanctuaries and national parks is given in below table.

Table 10-1 Ferry location and Distance from Protected Areas

S.No.	Terminal	No. of PAs within 15 km	Remarks
1	Umananda Ferry	1	Deepar Beel Ramsar Site/WLS appears to be within 15 km from the proposed ferry terminal. Draft ESZ Notification was declared vide FRM.140/2005/260, dated 21st February, 2009.

Integrated Biodiversity Assessment Tool (IBAT) is high-level early-stage biodiversity risk screening tool which is being widely used by biodiversity experts worldwide. As a part of screening exercise, IBAT was used for all ferry terminal locations in order to identify the Key Biodiversity Areas (KBA) around the ferry locations.

Key Biodiversity Areas (KBA) are 'sites contributing significantly to the global persistence of biodiversity', in terrestrial, freshwater and marine ecosystems. Key Biodiversity Areas (KBAs) is an umbrella term commonly used to include areas that contribute to the global persistence of biodiversity, including vital habitat for threatened plant and animal species in terrestrial, freshwater and marine ecosystems. KBA includes Bird Nesting sites and Water bodies. The details are given in the table below.

Table 10-2 KBA around the ferry location

S.No.	Activity	No. of KBAs around the ferry locations
1	Umananda Ferry	8

10.2 Screening and Scoping

Further, the Safeguards Consultant has prepared and submitted the scoping and screening report for the proposed terminal. A copy of the recent submission was received through AIWTDS on 10 March 2023. current version. The key environmental and social aspects that are to be considered during the construction and operation of the proposed terminal are summarised below. Further reference is made to the recent submission of the scoping and screening report for details.

- The proposed terminal zone is one of the highest current areas of the river so this needs to be accounted for in the construction activities at this site.
- Likelihood of erosion of the ghat due to construction activities.
- The proposed terminal is in the flood prone area and shall affect the construction activities.
- Spillage of construction material into the river.
- Disposal of solid and liquid waste into the river shall be a source for contamination of river water. It may also hamper the aquatic ecosystem.
- Presence of Gangetic Dolphin in and around the project site which is a schedule I species as per Wildlife Act, Endangered species as per IUCN and Appendix I as per CITES. Thus, the construction activities may have an impact on this valuable aquatic species.
- Impact on livelihood of vendors operating tea stall, selling fruits, drinking water etc. near the proposed site.

- The proposed terminal is the only access route for the pilgrimage, tourist and other commuters from the ferry terminal to the Umananda temple. Hence, alternative access route needs to be provided during the construction phase.
- The absence of municipal water supply needed for domestic and construction purpose shall lead to extraction of ground water.
- There is no space for storage of construction material at site. Sound vessels and skilled operators are required for safe transportation of construction material to avoid collision and failure.
- Labour camps and other utilities cannot be placed at site due to space constraints. The work force will have to travel every day to this site through ferry/boat.
- The proposed terminal is a famous pilgrim place and archaeological site with the presence of stone sculptures and carvings belonging to the early medieval period, which may be impacted due to the construction activities.

10.3 Land Records

In respect of information and details on land records to be collected for various terminal locations, the respective Mandal or the Circle officer have been approached and a request for data has been submitted. Letters addressed to the Deputy Commissioner and Circle Officer have also been issued by AIWTDS to accelerate the process.

With regards to the land records for Umananda, a communication has since been received from the Circle Officer informing that there is no land record available in the Circle Office. The same is placed under **Appendix B** and can be referred for further details.

10.4 ESIA

The project has been categorized as Category A project considering the environmental and social aspects identified during the screening and scoping phase, thereby requiring a detailed ESIA study to be conducted.

Environmental and social impact assessment has been carried out by the Safeguards Consultant taking into account both national and international legal requirements (as per World Bank). Baseline environmental status including aquatic and terrestrial ecology have been carried out. Various environmental components relating to the project site and activities have been identified and their probable environmental consequences have been considered both for construction and operation phases. Various mitigative measures for minimizing the environmental impact have been worked out. The results of the environmental investigation are presented in the ESIA report.

Public consultations at different stages during the course of study both formally and informally has been conducted to take into account the views of the key stakeholders and common public in general. The positive environmental impacts of the Project are development of all weather navigation routes for transportation of passengers and generation of employment opportunities during construction, operation and maintenance stages. The negative environmental impacts related to the construction phases are temporary in nature and can be addrressed with proper implementation of suggested mitigation measures.

EMP has been formulated to mitigate the negative impacts during various phases especially for Dolphin habitats. The main monitoring parameters biological monitoring and enhancement, environmental quality monitoring (air, noise, surface water, river bed sediment), health and safety, etc. Most of the potential impacts are short-term that can be addressed by adopting mitigation measures and relevant ECoPs. To keep the project influence area environmentally friendly, AIWTDS should ensure that the Contractor prepare site specific EMPs including Emergency response plan, Oil Spill Contingency Plan and Workers Health and

Safety plan and Environmental Pollution Abatement and Mitigation Measures Plan in line with the EIA report. Regular and effective monitoring of environmental quality parameters as indicated in this EIA report need to be conducted by the Contractor. AIWTDS will follow the EMP for improvement of navigation and environment quality of the area. Further reference is made to the ESIA report for details.

11 Cost Estimates

11.1 Introduction

The ferry terminal is proposed to be developed, by AIWTDS as per public service model. The ferry terminal development shall include Project Preliminaries & Site Development, Excavation,Filling, Ground Improvement, Revetment and Shore Protection, Bund/Ramp, Pontoon, Linkspan/Gangway, etc.

The ferry terminal development is visioned at the initial stage of development. Facility details for all the terminals are provided in the earlier section.

A detailed CAPEX (Capital Expenditure) estimate has been prepared for the project development and is placed under **Appendix E**. Actual costs may vary from the provided cost estimates, depending on the construction timeline, changed market conditions, availability of materials, change of policy and other unlisted factors.

11.2 Cost Estimate Breakdown Structure

The cost estimate is divided into the following components and subcomponents.

- Riverine Works comprising of:
  - Floating steel pontoons including enclosures, storage, deck machinery, deck fittings, deck furniture etc for berthing and mooring of ferry vessels
  - Steel linkspans as a link pin between the approach/access from the land and the pontoon
  - Approach/access from the riverbank

- Terminal Building and Water Tank Works comprising of:
  - Building civils
  - Internal water supply, sewerage and storm water
  - Sanitary fixtures
  - Firefighting
  - Heat, ventilation and air conditioning
  - Electricals and illumination

- Site development and External utilities within the terminal boundary comprising of:
  - Site development
  - Footpath and horticulture
  - Boundary wall
  - Water supply
  - Sewerage network
  - Power supply, distribution and area lighting

The measurement sheets and the cost backup sheets prepared as part of the detailed estimates have been placed after the respective components for ease of reference.

11.3 Basis of Estimates

Following considerations were made to prepare the cost estimates for the proposed development.

- The quantities have been estimated from the drawings which were prepared after carrying out engineering of various components/subcomponents of the project.
- Rates for civil works are based on CPWD schedule of rates 2021.
- Rates for electrical and mechanical works are based on CPWD schedule of rates 2022.
- Other published schedules of rates such as MES, MSR, RUIDP etc have been used for items not available in the CPWD schedule of rates.
- Rates for certain items which are a close match with the items available in published schedule of rates have been derived.
- Some items for which rates are not available in published schedule of rates are based on market rates.
- Some items for which rates are neither available in published schedule of rates nor from market are based on previous projects.
- Contingencies have been provisioned at 3% as per prevailing norms and industry practice for such type of projects.
- All mobilization costs are deemed to be included in the respective items of work.
- Costs towards project preliminaries for site establishment, temporary utilities, traffic management are deemed to be included in the respective items of work.
- The construction methodology presumed is based on experience of similar projects.
- All cost estimates are represented in INR.

11.4 Exclusions

Following costs have been excluded from these cost estimates as being provisioned separately.

- Costs for project management consultancy services.
- Escalation for the period from the date of preparation of estimates and contract award.
- Land acquisition and/or compensation costs to project affected people.
- Upgradation/development of any existing/new external utilities, services, connectivity

12 Project Organisation and Implementation Schedule

12.1Contract Type & Packaging Strategy

RHDHV have submitted a separate report on the Contract Types and Packaging Strategy in August 2022. The report compares various types of Contracts along with their advantages, dis-advantages, and suitability.

The conclusions of the study are included in this section. For further details and the full report please refer DI1530-RHD-ZZ-ZZ-RP-CM-0004 status S4 P01.

It is seen that there exist contractors capable of undertaking river jetty construction in India of the size of around ten crores to around fifty crores per terminal and delivering within a time period of around two years. Packaging the work packages into single contracts within the proximity of a geographical cluster would make it more attractive to bidders. With this in mind, a study of possible distribution by geographical locations was undertaken.

Further options for the packaging strategy were studied including having a single contract for all the 13 locations. The other 2 options included classification based on geographical locations and separation by waterside facilities and landside facilities.

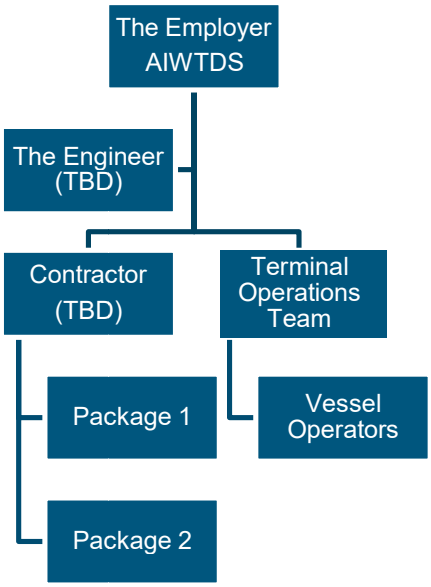
Also, distribution of the 13 terminals across 2 or 3 packages would make the work packages attractive to tenders insomuch that they could distribute and manage their resources in close proximity of each location.

12.2 Organization Structure

This section describes the project organization structure for the construction stage and the operational stage. Various stake holders involved during the construction stage of the project would largely depend on the contracting strategy however, a broad organization structure is presented here.

The various stake holders involved during the construction phase include the Employer (AIWTDS), the Engineer (Consultant TBD) and the Contractor (TBD).

A typical organization structure is presented below:



RHDHV shall prepare the Tender Document for the various packages as part of the scope for the assignment. After issue of tenders to various bidders, AIWTDS and RHDHV will conduct a pre-bid meeting for addressing the bidder's queries and to give a better understanding of the project scope and terms and conditions. Addendum as necessary will be issued after the pre-bid meeting. Bidders will be allowed reasonable time for submission of bids after which Technical Evaluation of the bids shall be completed. The selected bidder will then be appointed as the Contractor for the project.

AIWTDS shall also appoint the Engineer for PMC services including review and approval, day-to-day site supervision of the Contractor, programme management, cost management and contract management. A proposed site organisation for construction supervision is indicated in the figure below.

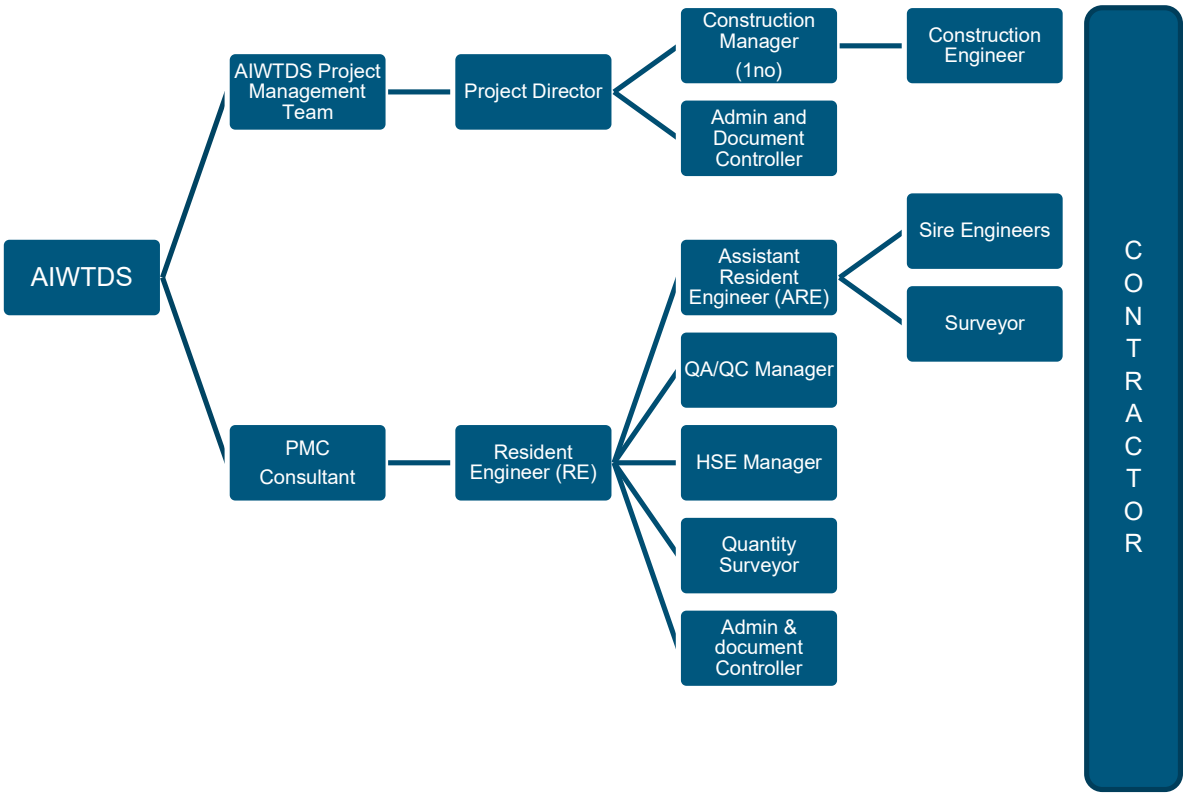


Figure 12 1 Site Supervision Team

AIWTDS shall appoint their Project Management Team for each site for the overall supervision of the day-to-day activities at site and bill approvals. An indicative team composition is shown in the figure above, however the details of the project management team can be worked out and finalized based on specific requirements for each terminal.

The PMC shall act as a link between AIWTDS and the Contractor. A typical PMC team for managing the terminal construction would consist of a Resident Engineer (RE), an Assistant Resident Engineer (ARE), Site Engineers, Surveyor, QA/QC Manager, HSE Manager, Quantity Surveyor and an Admin. and Document Controller.

The RE shall have the overall responsibility of the PMC including contractual communication. Whereas the ARE shall be responsible for the construction supervision team. Depending on the nature of work and the allowable working hours, a site supervision team shall be proposed for the PMC. The supervision team shall include site engineers and a surveyor for the supervision of riverine works. The site supervisors shall be responsible for the site inspection and certification of the work completed by the Contractor. The site supervisors shall also ensure that the Contractor carries out the construction in line with the approved methodology and to the required quality and safety standards. The Surveyor shall be responsible for the

certification of the riverine works related to the shore protection, filling and establishing the existing bed levels at the terminal location. The QA/QC Manager and HSE Manager shall be responsible for implementation of the quality assurance plan and ensuring safety at site. The quantity surveyor shall play a key role in assisting the RE/ARE for certification of bills and/or claims submitted by the Contractor. An Admin and Document Controller shall also be included in the PMC for overall site administration and document management.

The Contractor shall be responsible for the successful construction, testing and commissioning and hand over of the project. The Contractor shall be liable to rectify any defects for a period as stated in the Contract under the clause for Defect Liability Period.

AIWTDS shall designate or appoint a Terminal Operations Team who will take-over from the Contractor once the constriction and commissioning is complete. They will co-ordinate with AIWTDS and the Vessel Operators for day-to-day functioning of the terminals.

12.3 Implementation Schedule

A level 2 (L2) schedule is presented in this section for an overview of the project timelines for the construction of each terminal. The schedule is divided into two stages, the Pre-Construction Stage and the Construction Stage.

The pre-construction stage is essentially the tender stage which includes tender preparation and the tender process. It is expected that Contractors would have queries on the tender document. A pre-bid meeting shall be set-upto clarify all such queries and detail out the scope of work and the terms and conditions set out in the tenderdocument. As required, AIWTDS may issue certain amendments to the tender document based on the requests or clarifications by the bidders. Reasonable time shall be allowed for the Bidders to submit their techno-commercial bids for the project.

Once the bids are received, RHDHV shall complete the technical evaluation of each bidder. The evaluation process will include review of the proposed team, methodology, construction programme and other details submitted by the bidders. Based on the evaluation, RHDHV may issue clarifications to the bidders. RHDHV shall then submit a Technical Bid Evaluation report to AIWTDS, including their conclusions and recommendations.

The construction stage is divided into three major activities, mobilization and site set-up, construction of riverine facilities and landside development.

The mobilization and site set-up are the most critical start-up activities to set the pace for timely construction of the terminal. Considering that the Umananda terminal is located on an island, a mobilization period of 2.5 months has been allowed for the site set-up.

The other activity that dictates the project schedule is the lead time for procurement and delivery of the pontoon and linkspan. The estimated time taken for delivery of the pontoon and linkspan is about 10 months and a further 2-month period is foreseen for the installation of the same. The completion of the terminal largely depends on this activity as all other activities can be expedited with the deployment of additional resources.

The reduced productivity due to monsoon is taken into consideration from the months of June to September while preparing this schedule. The riverine activities will be most affected due to the on-set of monsoons.

The construction of the approach bund and shore protection works will mainly depend upon the planning and timely procurement of rock. This work will be affected during the monsoon; however, some progress has been assumed considering a few dry spells. Considering the difficulties in accessing the location a period of 9 months has been considered for the construction of the same. Very low productivity for the ramp construction has been assumed during the monsoon period considering its riverine nature of work. A total of 14 months is assumed for the completion of the riverine facilities at Umananda.

Umananda being a religious site, only a passenger terminal has been envisaged and the landside facilities are proposed to be completed within a period of 14 months. This includes a period of 4 months for the area development and about 10 months for the terminal building, utilities and finishing.

It is recommended to stop the construction activities in water part during breeding season of the Gangetic dolphin (for example piling, shore protection works, etc.) in between mid of March to Mid of June.

The overall programme has been planned such that the award of the construction contract is stated to be achieved in the third month and the final commissioning of the terminal 16 months from the award of contract.

ID	Task Name	Duration
1	**Implementation Schedule for Terminal at Umanan**	**410 days**
2	**Pre-Construction Stage**	**60 days**
3	DPR approval and EC Clearance	0 days
4	Design-Build Tender Preparation	2 mons
5	Tender Process - Prebid to evaluation	1 mon
6	Award of Construction Contract	0 days
7	**Construction Stage**	**350 days**
8	Mobilization, site set-up, site surveys & GI	2.5 mons
9	**Riverine Facilities**	**300 days**
10	Pontoon & Link Span - procurement	10 mons
11	Approach Bund & Shore Protection	10 mons
12	Concrete Ramps Pre Dolphin Breeding	10 mons
13	Dolphin Breeding Season	3 mons
14	Concrete Ramps Post Dolphin Breeding	2 mons
15	Pontoon and Link Span installation	2 mons
16	**Landside Development**	**300 days**
17	Area Development	4 mons
18	Terminal Building	9 mons
19	Utilities	5 mons
20	Comissioning of the Terminal	0 days
21		

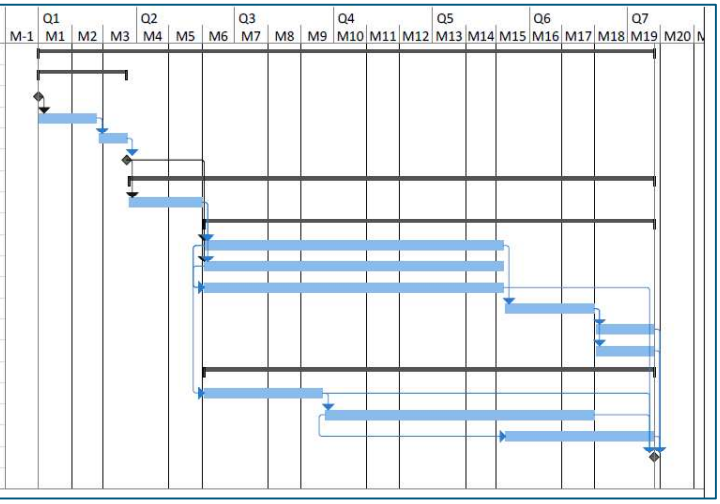


Figure 12-1 Project Schedule - Umananda

13 Financial and Economic Analysis

13.1 Financial Analysis

AIWTDS envisions of promoting cost effective water transport system in the state of Assam. For this purpose, AIWTDS is intending to augment water transport infrastructure to cater for passengers and vehicular traffic with the requisite safety features. As part of this objective, financial analysis has been undertaken to provide a comprehensive picture for the intended facility development.

During discussions with AIWTDS officials, it has been given to understand that a new SPV shall be formed to administer the proposed water transport terminals. This necessitates development of a financial model for each of the water transport terminal separately by allocating reasonable resources to the terminal as per the requirements.

Assumptions:-

1. Commencement of Terminals operations from FY25 and Capex has been distributed equally for 2 years although construction period is 18 months to provide for stabilization of the operations.
2. Debt-equity ratio has been considered as 80:20.
3. Interest of 4% on debt and no interest on equity has been considered as the equity is being funded by state government for the betterment of water transport system in the state of Assam.
4. GST/tax assumed to be not applicable for the operation of water transport.
5. Depreciation rate of 3% has been considered for all riverine, civil, and M&E works.
6. Below tariff has been considered.

Type of traveler	Tariff (Rs)	Escalation per annum (%)
Passenger	42	5

7. Operating days of 300 has been considered in a year.
8. Vessel operating cost has been excluded from this model.
9. Below operating costs for the terminal has been considered.

Works	Operating cost (%)	Escalation per annum (%)
Riverine Civil works	3	3
Civil works	4	3
M&E	3	3

10. Manning cost for each terminal has been considered as below.

Assam Inland Water Transport Project (AIWTP)								
S. No.	Particulars	Nos.	No. of Staff	No. of Shifts	Leave/ off reserve	Total Manpower (Nos.)	Salary per Annum (lakhs)	Total Expenditure (lakhs)
A	Project Offie for all 13 Locations							
1	Chief Civil Engineer	1	1	1	0	1	25	25
2	Chief MEP Engineer	1	1	1	0	1	25	25
3	Chief Operations Engineer	1	1	1	0	1	25	25

4	Chief of Commercial	1	1	1	0	1	25	25
5	Chief of Finance & Accounts	1	1	1	0	1	25	25
6	Technical Support Staff	1	5	1	0	5	15	75
7	IT Staff	1	5	1	0	5	8	40
8	Non-Technical Support Staff	1	15	1	0	15	5	75
B	Standard Staff Requirement at each terminal							
1	Terminal Supervisor	1	1	1	0	1	8	8
2	Technical Support Staff (Assisting Terminal Supervisor)	1	2	1	0	2	6	12
3	Ticket Counter	3	1	1	0	3	3	9
4	Accounts	1	1	1	0	1	5	5
5	Cloak Room	1	1	1	0	1	3	3
6	Main Gate Complex Security	1	2	2	0	4	3	12
7	Terminal Building Security at Entry & Exit	2	4	1	0	8	3	24
8	Non-Technical Support Staff at each floor	2	1	1	0	2	2.5	5
9	Entire Terminal Area Cleaning and Gardnening	1	1	1	0	1	2.5	2.5
10	Total Manpower and Expenditure for 1 Ferry Terminal Administration					53		104.7
11	Total Manpower and Expenditure for 13 Ferry Terminal Administration					329		1361.5

The outcome of financial analysis carried out based on the assumptions outlined above is placed under Appendix F.

13.2 Economic Analysis

It is important and imperative to study the social benefits to the region due to implementation of transportation infrastructure projects which will ease the public requirements as below.

1. Transportation safety
2. Cost effectiveness
3. Timely availability
4. Incremental employment
5. Reach to education and health centers
6. Improvement in regional businesses
7. Reduction in carbon footprint

In this chapter, the benefits of the proposed infrastructure in the region which will impact the overall growth are examined and discussed. If found significant, the social benefit will be examined in terms of monitory benefit and the same will be considered as part of revenues to the project to compute economic internal rate of return (EIRR).

Typically, above mentioned public requirements can be categorized under the below 3 types

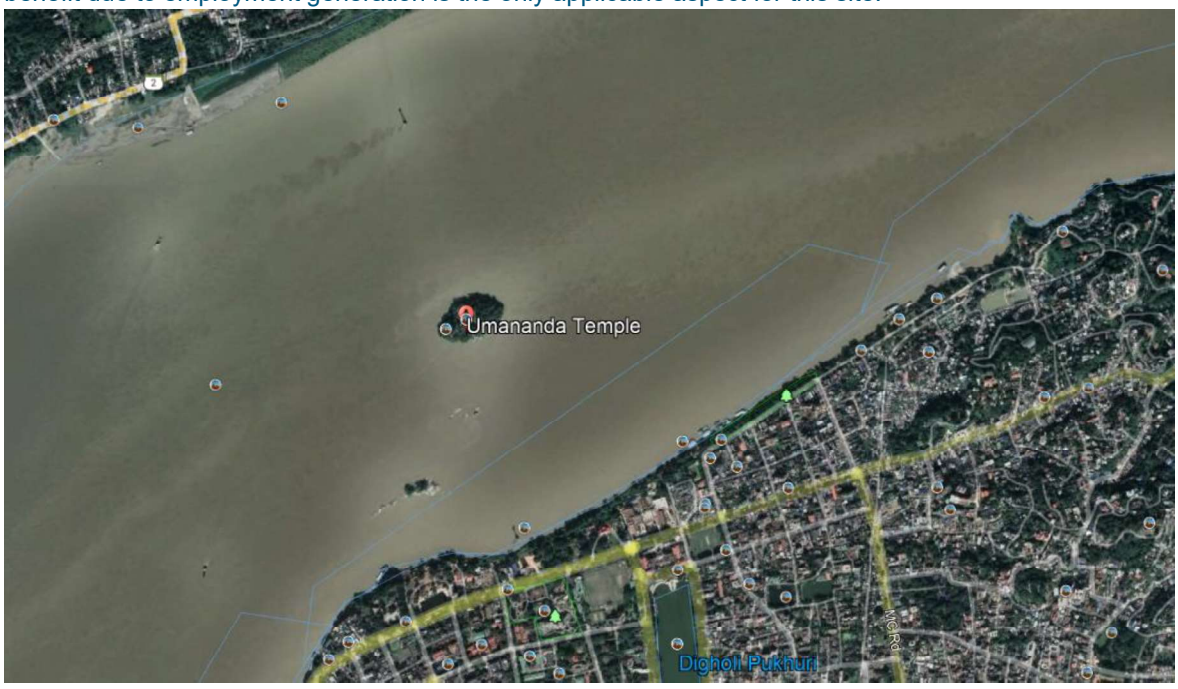
1. Benefit due to direct impact
2. Benefit due to indirect impact
3. Benefit due to induced impact

Since the proposed infrastructure is limited to the terminal infrastructure wherein all the vessels and its operating model will remain same and caters the existing traffic in the region, it is appreciated that the benefits due to induced impact are not significant. Hence, the subsequent examination and evaluation is undertaken only of onlythe benefits which have direct and indirect impact.

Although the terminal infrastructure at all the locations is similar in nature, its impact is case specific and depends on various factors as given below

1. Alternate mode of transport such as rail or road. In all the cases rail is not available and hence in this assessment road route will be analyzed to understand significant benefit due to waterway
2. Timely availability of alternative route vis a vis to waterway
3. Time taken for travelling between ferry points including embarking and disembarking vis a vis road travel time
4. Safety of travel
5. Cost of travel
6. Volume of traffic which can be catered in operating as well as peak traffic scenarios
7. Ease of expansion as and when required
8. Employment generation and impact on overall regional growth
9. Reduction in carbon footprint

It is to be noted that to reach Umanand ghat, only available transport network is waterway. Hence social benefit due to employment generation is the only applicable aspect for this site.



Umananda Ghat Location

From the above figure, it can be observed umananda ghat is accessible from various other ghats in the region. Tourists and local personnel visit this place mainly due to the pilgrimage importance.

1. Economic benefit due to employment creation

Particulars	Value	Unit
Direct Employment Creation		
Ferry	26	persons
Employment cost	4.0	Rs Lakhs per Annum

It is estimated that the total employees required for operating the waterway terminal at Neamati location would be 26 personnel. Considering 4 lakhs per annum as an employment cost benefit we have considered total benefit in the economic IRR calculation

The outcome of economic analysis undertaken based on the assumptions outlined above is placed under Appendix F.

14 Way Forward

Whilst the detailed project report has been prepared and finalised, the next task or milestone as part of the subsequent stage of work on the assignment relates to publishing of the tender documents for national open competitive bidding.

14.1 Key Steps

Key steps and actions to be undertaken prior to publishing of the tender documents comprise of the following.

- Acceptance of the final detailed project report by AIWTDS.
- Technical sanction of the detailed estimate from the Public Works Department (PWD).
- Completion of proof checking by the third party agency.
- Completion and publishing of ESIA by the Safeguards Consultant.

Further, NOC is required to be obtained from various authorties prior to implementation of works. The concerned authorities and the NOC required is summarised below and not limited to these:

- Inland Waterways Authority of India (IWAI) for NOC with regard to the extent of the riverside infrastructure in relation with the positioning of the Thalweg line.
- Brahmaputra Board/Water Resource Department (WRD) for NOC with regard to river slope and river bank protection works.
- Land Revenue Department for NOC with regard to utilisation of land required at the terminal location for the proposed development .

These NOCs are being processed separately by AIWTDS with necessary technical assistance and support from RHDHV. No works shall commence till the time requisite permits are obtained.

14.2 Status

The status of key steps and actions to be undertaken prior to publishing of the tender documents is as follows.

- Technical sanction of the detailed estimate has been accorded by the Public Works Department (PWD) and the same is placed under Appendix G.
- The third party agency (IIT Guwahati) has completed the proof checking and the vetting report has also been received, which is placed under Appendix G.
- ESIA report prepared by the Safeguards Consultant has been published and stakeholder meet conducted on 06 February 2023.

Further, NOC has been received Inland Waterways Authority of India (IWAI) and the same is placed under Appendix G.

Appendix A

Data Collection

Appendix B

Reports on Site Surveys, Investigations and Land Records

Appendix C

Ground Improvement Feasibility Matrix

Appendix D

Drawings

Appendix E

Cost Estimates

Appendix F

Financial and Economic Analysis

Appendix G

Technical Sanction, NOC Information and TPR Vetting Report

Appendix H

Design Calculations