FINAL DETAILED PROJECT REPORT (DPR) OF NATIONAL WATERWAY NO. 07

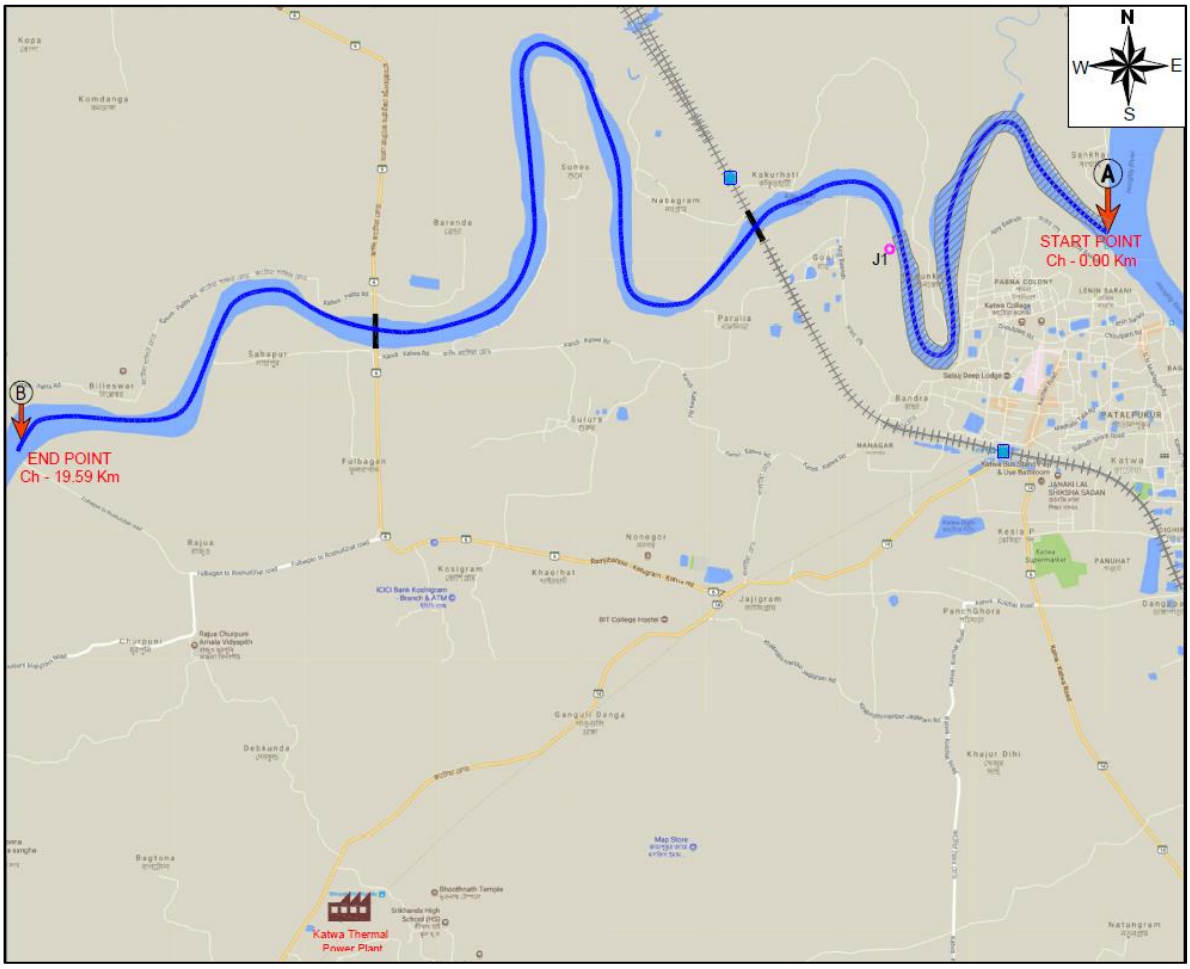
RIVER: AJOY (STATE OF WEST BENGAL)

KATWA TO DHANYARUKHI (19.59 KMS)

(Volume – I: Main Report)

(Volume – II: Drawings)

Submission Date: 23/05/2019



Inland Waterways Authority of India

FINAL DETAILED PROJECT REPORT

REVISION - 3

May 2019

FINAL DETAILED PROJECT REPORT (DPR) OF NATIONAL WATERWAY NO. 07
RIVER: AJOY (STATE OF WEST BENGAL)
KATWA TO DHANYARUKHI (19.59 KMS)
(Volume – I: Main Report)
(Volume – II: Drawings)
Submission Date: 23/05/2019

Project: Consultancy Services for preparation of Two Stage Detailed Project Report (DPR) of Cluster 1 National Waterways

Owner: IWAI, Ministry of Shipping

Consultant: Egis India Consulting Engineers

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Final DPR

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LIST OF VOLUMES

VOLUME – I	**:**	**MAIN REPORT**
VOLUME – II	**:**	**DRAWINGS**
VOLUME – III A	**:**	**HYDROGRAPHIC SURVEY REPORT**
VOLUME – III B	**:**	**HYDROGRAPHIC SURVEY CHARTS**
VOLUME – IV	**:**	**GEO-TECHNICAL INVESTIGATION REPORT**

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IWAI	Inland Waterways Authority of India
IWT	Inland Water Transportation
MOS	Ministry of Shipping
NW	National Waterway
DPR	Detailed Project Report
WW	Waterway
AtoN	Aid to Navigation
VC	Vertical Clearance
HC	Horizontal Clearance
CD	Chart Datum
SD	Sounding Datum
MSL	Mean Sea Level
DGPS	Differential Global Positioning System
RTK	Real Time Kinematic
GPS	Global Positioning System
SBES	Single Beam Echo Sounder
TS	Total Station
CRP	Common Reference Point
SBAS	Satellite-based augmentation systems
DGLL	Directorate General of Light House & Light ships
UTM	Universal Transverse Mercator
WGS	World Geodetic System
MT	Metric Ton
GNSS	Global Navigation Satellite System
BM	Bench Mark
TBM	Temporary Bench Mark
HAD	Haldia Development Authority
WBSTC	West Bengal Surface Transport Corporation Ltd.
WBTIDC	West Bengal Transport Infrastructre Development Corporation Ltd.
HNJPSS	Hooghly Nadi Jalpath Paribahan Samabai Samity Ltd.
IMO	International Maritime Organisation
VHF	Very High Frequency
RIS	River Information System

SALIENT FEATURES OF AJOY WATERWAY (NW 07)

Sr. No.	Particulars	Details		
A.	**GENERAL**			
1.	***Location***			
a)	Cluster	1		
b)	State(s)	West Bengal		
c)	Co-ordinates & Name of Place	**Start**	**End**	
	Place	Katwa	Dhanyarukhi	
	Latitude	23°39'23.33"N	23°38'22.85"N	
	Longitude	88°7'56.73"E	88°1'53.90"E	
B.	**TECHNICAL**			
1.	***Waterway***	Waterway is proposed for IWT from Chainage 0.0 Km to 5.0 Km (3.5 Km along proposed channel alignment) out of total 19.59 Km stretch.		
a)	National Waterway Number	07		
b)	Class	IV		
c)	Type (Tidal/Non-Tidal)	Non Tidal		
	Length (Km.)	**Total**	**Tidal**	**Non-Tidal**
		5.0 Km	0.0 Km	5.0 Km
d)	Sounding Datum			
	Existing SD (As per Hydrographic Survey)	Existing SD of 8.114 m is considered for transferring at the newly established BM's.		
	Value w.r.t MSL (m) as per Hydrographic Survey.	**Chainage (Km)**	**Sounding Datum w.r.t. MSL (m)**	
		0.0 to 5.0	8.114	
		5.1 to 8	9.3	
		8.5 to 9.5	9.58	
		9.5 to 10.5	9.64	
		10.5 to 11.5	9.73	
		11.5 to 12.5	10.05	
		12.5 to 13.5	10.42	
		13.5 to 14.5	10.79	
		14.5 to 15.5	11.1	
		15.5 to 16.5	11.2	

Sr. No.	Particulars	Details				
		16.5 to 17.5		11.29		
		17.5 to 18.5		11.31		
		18.5 to 19.59		11.39		
e)	LAD Status (w.r.t. SD of 8.114m)					
		Stretch 1 (Km)	**Stretch 2 (Km)**	**Stretch 3 (Km)**	**Stretch 4 (Km)**	**Total (Km)**
	Stretch (From……To……)	**0-5**	**5-10**	**10-15**	**15-19.59**	
	Length with LAD < 1.2 m	3.40	4.70	5.00	4.59	17.69
	With LAD from 1.2-1.4 m	0.23	0.06	0.00	0.00	0.29
	With LAD from 1.5-1.7 m	0.06	0.01	0.00	0.00	0.07
	With LAD from 1.8-2.0 m	0.12	0.10	0.00	0.00	0.22
	With LAD > 2.0 m	1.19	0.13	0.00	0.00	1.32
f)	Target Depth of Proposed Fairway (m)	3.0m below SD level of 8.114 m				
g)	Conservancy Works Required (along the proposed fairway with Option 3)	**Stretch 1 (Km)**	**Stretch 2 (Km)**	**Stretch 3 (Km)**	**Stretch 4 (Km)**	**Total**
		0-5	**5-10**	**10-15**	**15-19.59**	
	Dredging Required (M. Cum.)	0.27	Nil	Nil	Nil	0.27
	Bandalling	Nil	Nil	Nil	Nil	Nil
	Barrages & Locks	Nil	Nil	Nil	Nil	Nil
	River Training (Km.) (Channel)	1.0	Nil	Nil	Nil	Nil
	Bank Protection (Km.)	1.0	Nil	Nil	Nil	Nil
h)	Existing Cross Structures (along the proposed fairway)					
	Name of Structure	**Type**	**Nos.**	**Range of Horizontal Clearance**	**Range of Vertical Clearance w.r.t. HFL**	
	Dams/Barrages/Weirs/Aqueducts	Nil	Nil	Nil	Nil	

Sr. No.	Particulars	Details			
	etc.				
	Bridges	Nil	Nil	Nil	Nil
	HT/Tele-communication lines	Nil	Nil	Nil	Nil
	Pipelines, underwater cables, etc.	Nil	Nil	Nil	Nil
2.	***Traffic***				
a)	Present IWT Operations (type of services)	Not Available			
b)	Major industries in the hinterland (i.e. within 25 km. on either side)	Katwa Super Thermal Power Plant (Proposed)			
c)	Connectivity of major industries with Rail/Road network (Distances/Nearest Railway Stations etc.)	State Highway – 14 Shripat and Katwa Railway Stations			
d)	Commodities	**In-bound**		**Out-bound**	
	Existing	Not Available (NA)		Not Available (NA)	
	Anticipated	Coal		Fly Ash	
e)	Existing and Future Potential				
	Name of Commodity	**Existing**	**5 years**	**10 years**	**15 years**	**20 years**
	Coal (million tonnes annually)	NA	3.00	3.41	3.88	4.41
	Fly Ash (million tonnes annually)	NA	1.20	1.36	1.55	1.76
3.	***Terminals/Jetties***				
a)	Terminal/Jetty				
	Existing Terminal/Jetty	Not Available			
	Proposed Terminal				
	Location	(Left Bank/Goai village/Katwa/Bardhmann district)			
	Type/Services	Dry Bulk Cargo Terminal			

Sr. No.	Particulars	Details	
	Proposed Infrastructure/Facilities	Gangway, Pontoon Platform, RCC Jetty, Mobile harbour Crane, Parking, Open Storage Area, Fly Ash Silo, Terminal complex	
	Approach	River Bank Road	
	Land Ownership		
	Area (sq.m.)	**Govt.**	**Private**
			18,375
4.	***Design Vessel***		
a)	Type	Self-propelled vessel	
b)	No. & Size	7 No. & 2000 DWT Barges	
c)	Loaded Draft	2.5	
d)	Capacity	2000 DWT	
5.	***Navigation Aids***	• RIS System (1 No) • Marine Buoys (50 Nos)	
C.	**FINANCIAL**		
1.	***Cost***	***Capital Cost*** (INR Lakhs)	***O&M Cost*** (INR Lakhs)
	a) Fairway Development	4,641.68	146.30
	b) Terminal Structure	10,371.92	950.38
	c) Vessels	4,900.00	614.00
	d) Land	1,635.94	-
	Total Project Cost including Vessel and Land Cost	**22,394.90**	**2084.89**
	Total Project Cost including Vessel Cost	**20,758.96**	**2084.89**
	Total Project Cost without Vessel and Land cost	**15,858.96**	**1,470.89**
2.	***User Charges (INR/Ton/Km)***	5 6 7 8 9 10 11 12 13 14 15 16	

Sr. No.	Particulars	Details											
3.	***Financial Internal Rate of Return (%)***	Not Calculable	Not Calculable	Not Calculable	-12.64	-7.93	-4.95	-2.76	-1.02	0.42	1.67	2.76	3.75
4.	***Economic Internal Rate of Return (%)***		-8.06	-4.11	-1.58	0.31	1.84	3.12	4.23	5.23	6.12	6.94	7.69

EXECUTIVE SUMMARY

1.0 INTRODUCTION

Inland Waterways Authority of India appointed M/s Egis India for providing Consultancy Services for preparation of Two Stage Detailed Project Report (DPR) of Cluster 1 National Waterways. Ajoy waterway is one of the 4 rivers clubbed in Cluster 1.

This final detailed project report of 19 km stretch of Ajoy waterway is prepared on the basis of recommendations from feasibility report, detailed survey & investigations, preliminary engineering and design and suggestions from IWAI.

2.0 WATERWAY/DETAILED HYDROGRAPHIC SURVEY

The 19 Km stretch of Ajoy National waterway proposed for DPR study lies from the river confluence with Bhagirathi river near Katwa Lat 23°39'23.33"N, Long 88°7'56.73"E to Dhanyarukhi at Lat 23°38'22.85"N, Long 88°1'53.90"E. Whole stretch of Ajoy waterway from Katwa to Dhanyarukhi is non-tidal.

River width in the waterway stretch varies from 290 m to 67 m. Whole stretch of the waterway is dry except initial 5.0 km of stretch due to back water flow from Bhagirathi river. Maximum and minimum reduced depth in the initial 5.0 Km stretch of the waterway with respect to existing sounding datum of 8.114 m are 7.1m and -0.3m respectively. Average flow velocity in the waterway is 0.16 m/sec.

Two (2) RCC road bridge and one (1) Rail Bridge is located along the waterway at Chainage 6.554 Km and 13.898 Km.

3.0 FAIRWAY DEVELOPMENT

On the basis of inputs from bathymetric and traffic survey it is proposed to develop Ajoy river from its confluence with Bhagirathi river for IWT as a Class IV. The waterway is proposed for navigating of vessels/barges upto 2000 DWT. The proposed fairway shall provide a navigational route to connect the National waterway 1, i.e. Bhagirathi river, with proposed Dry Bulk cargo terminal at a Chainage of about 5.0 Km in Ajoy river. Following options is studied for development of fairway along Ajoy waterway:

a) Dredging the entire river stretch of 5.0 Km for channel dimensions of 2.5 m draft and 30m bottom width.
b) Constructing a reservoir with draft of 2.5 m by providing ungated weir, each on upstream and downstream end of fairway and a navigational lock.
c) Constructing a navigation channel of 1.0 km length from Chainage of 0.5 Km, which will avoid Bend 1 (refer Table 6) and dredging on the remaining porting of river stretch upto proposed terminal structure. Also proposed, a turning circle of 100.0 m radius at Bend 2.

Technical feasibility done on above 3 options is tabulated as below:

Sl. No.	Option Description	Technical Challenges	Cost of Fairway development (INR Lacs)	
			Capital Cost	O&M Cost
1.	Dredging only	a) Huge amount of initial and maintenance dredging is involved. b) Fairway need to be trained to avoid sharp bends.	1,094.58	109.46
2.	Two weirs and a navigational lock	a) High initial cost due to construction of weirs and navigational lock. b) Extensive maintenance dredging after each flood season. c) Risk of flooding of low lying areas along the river bank during floods after weir construction. d) Fairway need to be trained to avoid sharp bends.	2837.72	168.98
3.	New navigation channel of 1.0 Km length	a) Land acquisition leading to R&R issues. b) Considerable initial investment cost in construction of new navigational channel.	4,641.68 (excluding land cost) 6,104.24 (including land cost)	146.30

Based on the above table, Option 3 is recommended and considered further for techno-commercial studies.

4.0 TRAFFIC STUDY

On the basis of detailed traffic survey and studies done during DPR stage, it is concluded that locally operated passenger ferry service is operational at Sankhai Ghat, the confluence point of Ajoy and Bhagirathi rivers for Bhagirathi river crossing. However, no passenger traffic is located along Ajoy waterway.

NTPC is developing a Super Thermal Power Plant of 1320 MW capacity at Srikhanda village, Katwa. It is anticipated that about 3.0 million tonne annual coal demand and 1.2 million tonne annual fly ash generation from thermal power plant can be catered with IWT from the start date of operation of Katwa thermal power plant. At this stage of DPR studies the details regarding transport of coal and fly ash and expected commissioning date of thermal plant is not available and hence the DPR study is based on certain assumptions as follows:

a) 40% of total import of coal for power plant can be shifted to IWT.
b) 50% of total export of fly ash can be shifted to IWT.
c) Power plant will be operational in next 5 years.

5.0 TERMINALS

A dry bulk cargo terminal is proposed to be developed at a Chainage of 5.0 Km in the waterway to cater the cargo generated or required to be terminated at Katwa Thermal power plant. The terminal comprises of office complex, coal handling system, floating Pontoon and Gangway for Fly Ash handling, RCC Jetty and Mobile harbour crane for Coal handling.

The total cost of terminal and jetty structures works out on the basis of preliminary engineering design is provided as below:

Sl. No.	Item	Amount in Lacs (INR)
1.0	Capital cost for Terminals (excluding land cost)	10,371.92
2.0	Capital cost for Terminals (including land cost)	10,545.30
3.0	O&M cost for Terminals	950.38

6.0 PRELIMINARY ENGINEERING DESIGNS

Preliminary engineering design is done for terminal structures and necessary infrastructure required for waterway development. Following basic facilities are provided for the proposed cargo terminal structure to be developed to import coal & export fly ash generated for the proposed Katwa super critical 1320 MW thermal power plant:

- Cargo Berths
- Approach jetty
- Driver Rest Area
- Parking Facilities
- Weigh Bridge
- Open storage area
- Bulk carrier unloading area
- Substation
- Fly ash silo
- Administrative Building
- Workers amenities Building
- Internal road
- Temporary cargo storage area/Temporary parking

Relevant Indian and International codes are used for preliminary design of all structures.

7.0 VESSEL DESIGN

Self-propelled bulk carrier of 2000 DWT for cargo transportation is proposed to be operated in Ajoy waterway.

About 7 numbers of barges are anticipated to be operated daily in the waterway with total procurement cost of INR 4900 Lacs and O&M cost of INR 614.00Lacs.

8.0 NAVIGATION & COMMUNICATION SYSTEM

1 no of RIS system and 50 nos. of marking buoys are proposed for Ajoy Waterway. Capital and maintenance cost for the same is estimate to INR 737.93 Lakhs and INR 318.85 Lakhs respectively.

9.0 ENVIRONMENTAL & SOCIAL ASPECTS

The major objective of this study is to establish present environmental condition along the Ajoy River through available data /information supported by field studies to evaluate the impacts on relevant environmental attributes due to the construction & operation of the proposed project; to recommend adequate mitigation measures to minimize / reduce adverse impacts and to prepare an Environmental Management Plan (EMP) for timely implementation of the mitigation measures to make the project environmentally sound and sustainable. The study basically includes:

- Establishment of the present environmental scenario
- Study of the specific activities related to the project
- Evaluation of the probable environmental impacts
- Recommendations of necessary environmental control measures.
- Preparation of Environmental Management Plan

The entire project is the Bardhaman district. Barddhaman (Burdwan) district lies between 22°56' to 23°53' North latitude and from 86°48' to 88°25' East longitude. The climate in the district is tropical. The climate of Barddhaman (Burdwan) district is winter season starts from about the middle of November and continues till the end of February. March to May is dry summer. June to September is monsoon while October and November is autumn.

Assessment of impact on environment including social considerations are done in the DPR. The total Environmental estimated cost for the project is INR 90.10 Lacs.

10.0 INSTITUTIONAL REQUIREMENTS

The proposed development of IWT services in Ajoy waterway shall be developed and maintained by a separate Project Management Unit (PMU) under the jurisdiction of Director, Inland Waterways Authority of India, Kolkata.

Four no. of Permanent staff and four no. of project/support staff is proposed for Ajoy waterway. The total capital cost for Institutional set up works out to INR 38.60/- Lacs, and annual cost works out to INR 34.08/- Lacs.

11.0 PROJECT COSTING

The basis of cost estimates worked out as per following:

a) Schedule of Rates of PWD, Govt. of West Bengal;
b) "Unified Schedule of Rates" prepared by Irrigation and Waterways department, Government of West Bengal.
c) The consultant's references from various projects/sites proximity to the project area.
d) Local enquiries at the time of conducting surveys.
e) Market surveys and enquires
f) Judgement based on Consultant's Experience
g) https://www.wbidc.com/industrial_parks/available_land.htm

Ajoy waterway is proposed to be developed for dry bulk cargo transportation. The development cost for waterway comprises of:

a) Cost for fairway development comprising dredging and navigation & communication system
b) Cost of RCC Jetty, Mobile harbour crane, floating pontoons, gangway and terminal buildings
c) Vessel Cost
d) Cost of Aids to Navigations
e) EMP cost.
f) Institutional Set-up Cost

The total capital cost for development of waterway, construction of terminals, and procurement of vessels including other expenses works out to INR 20,758.96 Lacs excluding land cost & INR 22,394.90 Lacs including land cost. Annual operation and maintenance cost of Ajoy waterway including O&M expenses for terminal/ jetty structures and vessels works out to INR 2,084.89 Lacs.

12.0 IMPLEMENTATION SCHEDULE

The project is scheduled to be completed in 60 months from the start date of construction.

13.0 ECONOMIC & FINANCIAL ANALYSIS

An attempt has been made to estimate the possible revenue available from this service. Although this has been calculated in a thorough and logical manner the study is based on many assumptions and it should therefore be taken as a guide to the magnitude of possible revenue.

The techno-economic model has been run with the various assumptions as stated below:

a) Dry Bulk Cargo Terminal

i. 2 vessels of 2000 DWT per day for Fly Ash
ii. 5 vessel of 2000 DWT per day for Coal.

A downtime of about 2 months is assumed, which could be occurred due to weather, operational or other factors Hence, it is assumed that the full service is operating for 300 days annually.

The revenue has been worked out by considering the tariff of commodity movement by IWT as INR 1.0/- per ton per km for Cargo operations.

The financial analysis of the project is done on the basis of estimated cost proposed to be incurred for construction/development of fairway, terminal and procurement of vessels including other miscellaneous expenses, O& M cost proposed to be incurred during proposed project life cycle of 20 years and revenue that could be generated.

The financial analysis done on the basis of above assumptions envisaged negative returns from the proposed project. The cost benefit analysis, calculations done for financial internal rate of return (FIRR) and Economic internal rate of return (EIRR) concludes that at the present IWAI tariff of INR 1.0 per ton per km., both FIRR & EIRR cannot be worked-out due to heavily negative cash-flows.

Calculations excluding Land Cost

Sr. No.	Tariff (INR/Ton/km.)	FIRR (%)	EIRR (%)
1	5	Not Calculable	Not Calculable
2	6	Not Calculable	-7.8
3	7	Not Calculable	-3.78
4	8	-12.52	-1.21
5	9	-7.75	0.71
6	10	-4.72	2.25
7	11	-2.5	3.56
8	12	-0.73	4.7
9	13	0.74	5.7
10	14	2.01	6.62
11	15	3.12	7.45
12	16	4.13	8.22
	Not Calculable	All/majorly negative cash-flows	

Calculations including Land Cost

Sr. No.	Tariff (INR/Ton/km.)	FIRR (%)	EIRR (%)
1	5	Not Calculable	Not Calculable
2	6	Not Calculable	-8.06
3	7	Not Calculable	-4.11
4	8	-12.64	-1.58
5	9	-7.93	0.31
6	10	-4.95	1.84
7	11	-2.76	3.12
8	12	-1.02	4.23
9	13	0.42	5.23
10	14	1.67	6.12
11	15	2.76	6.94
12	16	3.75	7.69
	Not Calculable	All/majorly negative cash-flows	

14.0 CONCLUSIONS & RECOMMENDATIONS

From the estimated FIRR and EIRR, the following may be concluded:

a) Ajoy river, in its present topographic & hydrographic conditions, is not favourable for being developed as Waterway.
b) Availability of cargo traffic is not assured, due to non-availability of authentic information regarding commissioning of Katwa Thermal Power Plant.
c) Construction of separate navigation channel & other associated infrastructure require heavy capital & operation cost, making it financially as well as economically un-viable.
d) Construction of separate navigation channel shall require acquisition of fertile land, which may result in the severe R&R issues.
e) Diversion of river flow in the navigation channel shall end in drying-up of the existing river, downstream of starting point of the channel, having significant Environmental impact.

In view of all above factors, it may be concluded that the development of Ajoy River as waterway is not techno-commercially feasible; hence *Ajoy River is not recommended for IWT operations as per current studies.*

1.0 INTRODUCTION

Inland Waterways Authority of India (IWAI), an undertaking of Ministry of Shipping, Government of India intends to develop 106 new National Waterways in addition to the exiting 5 National waterways. The National waterways are proposed to be developed as a composite and integrated water transport system with the existing rail and road infrastructure across the country.

In view of this, IWAI invited online bids for "Consultancy Services for preparation of Two Stage Detailed Project Report of the 106 National Waterways in a set of eight clusters Each waterway is to be explored for the potential of year round commercial navigation during Stage-1 (Feasibility Studies) of the project. The second stage comprises of preparation of techno-commercial detailed project report of the river/stretches approved by IWAI for stage -2 studies. Egis India Consulting Engineers Pvt. Ltd (EICEPL) was awarded the work for two stage DPR studies of two out of eight clusters respectively. Ajoy River was clubbed under Cluster -1 for the two stage DPR studies.

This final detailed project report of 19 km stretch of Ajoy waterway is prepared on the basis of recommendations from feasibility report, detailed survey & investigations, preliminary engineering and design and suggestions from IWAI. The report is prepared in accordance with detailed ToR as per the agreement **(Refer Annexure 1)**.

1.1 PROJECT BACKGROUND AND SUMMARY OF PREVIOUS STUDY

Ajoy Waterway is declared as National Waterway-07 as per "The National Waterway Act, 2016", No. 17 of 2016, published in the Gazette of India, Part – II- Section 1 no. 18, New Delhi, Saturday, March 26/2016/Chaitra 6, 1938 (Saka), by Ministry of Law and Justice (Legislative Department).

As per the Gazette notification, following section of the river is declared as National Waterway and recommended for Feasibility studies by IWAI:

Length	Co-ordinate at Start	Start Location	Co-ordinate at End	End Location
96 Km	23°39'23"N 88°07'57"E	Confluence of river Ajoy with river Bhagirathi at	23°36'56"N 87°31'58"E	Bridge on Morgram-Panagarh State Highway No 14 at

Length	Co-ordinate at Start	Start Location	Co-ordinate at End	End Location
		Katwa		Illambazar

Following conclusions were made in the feasibility study for 96 km stretch of Ajoy waterway:

- The horizontal and vertical clearance of existing cross-structures is in the range of 15.0 m to 8.0m and 6.0 m respectively.
- Taking in to account the water availability, 2.08 Km stretch of waterway have draft more than 2.0 m, 0.42 Km stretch have draft of 1.50 m to 2.0 m, 0.20 km have draft of 1.0 m to 1.50 m and remaining 93.30 km stretch of waterway have less than 1.0 m draft with respect to chart datum
- Availability of Katwa Super Thermal power plant gives an additional economic advantage to the waterway, as the waterway can be used for coal transportation to the power plant located about 4.5 Km from the waterway. The project will require seven million tonne of coal annually.
- The capacity of the waterway can be enhanced by constructing check dams and lockgates at suitable locations on the basis of detailed survey to be done in Stage – 2.
- Considering the availability of Katwa Super Thermal power plant and connectivity with rail and road network within 5km reach across the bank , the river has huge economic potential for development as a Waterway.
- Also the connectivity of Ajoy waterway with National Waterway - 1 creates an added advantage for triggering new traffic.

All the above conclusions were made on the basis of findings during the feasibility study stage. Detailed survey and investigations are done including preliminary engineering studies as per the scope of work defined in the ToR to validate above conclusions and to identify the development works required for making a techno-economically viable IWT in Ajoy WW.

Based on the above conclusions/observations done during feasibility studies i.e. first stage of the studies, IWAI recommended following stretch of Ajoy River for second stage of the studies i.e. for detailed project report.

Length	Co-ordinate at Start	Start Location	Co-ordinate at End	End Location
19 Km	23°39'23.33"N, 88°7'56.72"E	Confluence of river Ajoy with river Bhagirathi at Katwa	23°38'22.85"N 88°1'53.90"E	Dhanyarukhi

1.2 PROJECT LOCATION / DETAILS OF STUDY AREA

Complete 19 Km stretch of Ajoy waterway is located in Bardhaman district of West Bengal. As observed during from the detailed bathymetric survey and investigations, complete stretch of waterway is non-tidal.

Ajoy waterway project location as per DPR is shown in **Figure 1**. The detailed layout plan of waterway and terminal structures are provided in Drawings PT/EIPTIWB003/2017/DPR/0001 to 0003 attached as **Volume-II**.

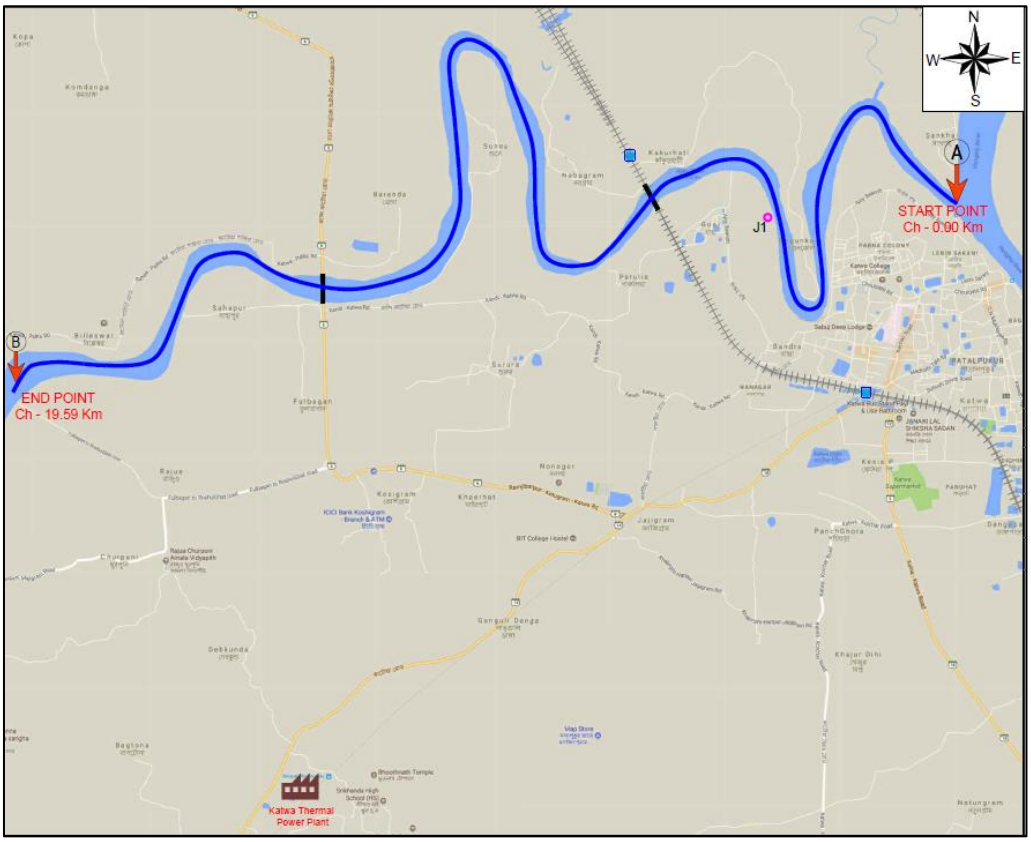


Figure 1: Ajoy National Waterway Project Location

1.3 BRIEF SCOPE OF WORK AND COMPLIANCE STATEMENT

The brief scope of work for the project comprises of:

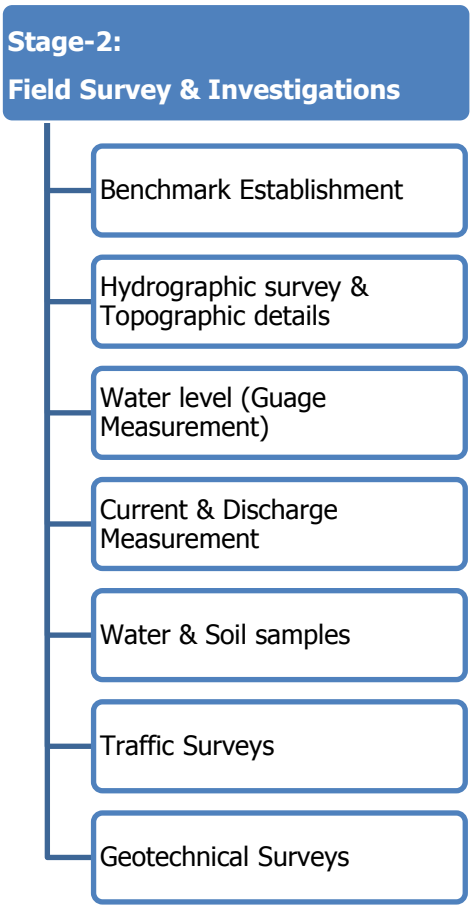
a) Hydrographic and Hydomorphological Survey and Investigations
   i. Installation of bench mark pillars
   ii. Installation of water level gauges and observations as per TOR
   iii. Bathymetric & Topographic Survey
   iv. Current velocity and discharge measurements
   v. Collection of water & bottom samples and analysis as per TOR
   vi. Collection of Topographical features.
   vii. Survey chart preparation
b) Traffic Survey
c) Geotechnical investigations
d) Environmental & social impact assessment
e) Analysis of collected data and preliminary engineering design
f) Scheduling and costing
g) Economic & Financial analysis for assessment of techno economic feasibility
h) Conclusion and recommendations.

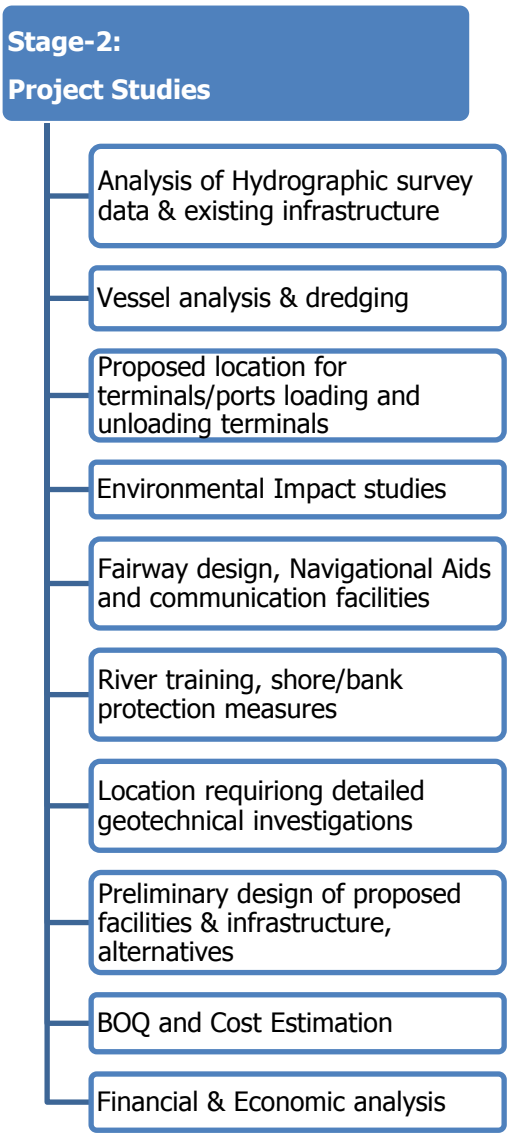
The scope of work mentioned above, under Hydrographic and hydromorphological survey was covered in the Hydrographic Survey Charts and Report, submitted as part of first deliverable under Stage-II of the project. The compliance statement of Draft Detailed project report covering the remaining scope of work as per TOR is provided as below:

Sl. No.	Section – 6 Terms of Reference Clause No. 1.2	Covered under Chapter No./ Title
1.0	Assessment of Hydrographic Survey Report	Chapter 2: Waterway/Detailed Hydrographic Survey
2.0	Traffic Survey	Chapter 4: Traffic Study
3.0	Geotechnical investigations	Chapter 5: Terminals & Volume –IV: Geotechnical Investigation Report
4.0	Environmental & Social impact assessment	Chapter 9: Environmental and Social Aspects

Sl. No.	Section – 6 Terms of Reference Clause No. 1.2	Covered under Chapter No./ Title
5.0	Analysis of collected data and preliminary engineering design	Chapter 6: Preliminary engineering Designs
6.0	Scheduling and costing	Chapter 11: Project Costing Chapter 12: Implementation Schedule
7.0	Economic & Financial analysis for assessment of techno economic feasibility	Chapter 13: Economic and Financial Analysis
8.0	Conclusion and recommendations.	Chapter 14: Conclusion and Recommendations

The above scope of works shall be executed as per the framework shown below;





1.4 BRIEF METHODOLOGY & APPROACH

The stretch of waterway, recommended for DPR studies is surveyed and studied in detail for techno-economic development of IWT along the proposed stretch.

Detailed hydrographic, hydro morphological survey and investigations, traffic, environment and social survey is done out along the stretch. The data collected from survey is further analysed in detail for design of waterway, estimating of dredging quantity and finalising location and type of jetties/terminals required along the waterway. On the basis of DPR level design and drawings, cost estimate, financial and economic evaluation is done. The

techno-economic viability of IWT development along the proposed stretch is assessed and concluded in the report.

A detailed DPR methodology and the expected outcome in fulfilling the assignment are presented as below:

1.4.1 Classification of Waterways

For safe plying of self- propelled vessels up to 2000 tonne Dead Weight Tonnage (DWT) and tug-barge formation in push tow units of carrying capacity up to 8000 tonne, National waterways can be classified in the following categories as suggested by IWAI:

Table 1: Classification of National Waterway -Rivers

Class of Waterway	Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance Between Piers (m)	Self propelled vessel Carrying Capacity
CLASS-I (Rivers)	1.2	30	300	4	30	100 tonne Dead Weight Tonnage (approx. size 32m overall length, 5m moulded breadth and 1.0m loaded draft or one tug and two barges combination of 200 tonne Dead Weight Tonnage (approx. size 80m overall length, 5m moulded breadth and 1.0m loaded draft).
CLASS-I (Canals)	1.5	20	300	4	20	
CLASS-II (Rivers)	1.4	40	500	5	40	300 tonne Dead Weight Tonnage (approx. size 45m overall length, 8m moulded breadth and 1.2m loaded draft or one tug and two barges combination of 600 tonne Dead Weight Tonnage (approx. size 110m overall length, 8m moulded breadth and
CLASS-II (Canals)	1.8	30	500	5	30	

Class of Waterway	Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance Between Piers (m)	Self propelled vessel Carrying Capacity
						1.2m loaded draft).
CLASS-III (Rivers)	1.7	50	700	6	50	500 tonne Dead Weight Tonnage (approx. size 58m overall length, 9m moulded breadth and 1.5m loaded draft or one tug and two barges combination of 1000 tonne Dead Weight Tonnage (approx. size 141m overall length, 9m moulded breadth and 1.5m loaded draft).
CLASS-III (Canals)	2.2	40	700	6	40	
CLASS-IV (Rivers)	2.0	50	800	8	50	1000 tonne Dead Weight Tonnage (approx. size 70m overall length, 12m moulded breadth and 1.8m loaded draft or one tug and two barges combination of 2000 tonne Dead Weight Tonnage (approx. size 170m overall length, 12m moulded breadth and 1.8m loaded draft).
CLASS-IV (Canals)	2.5	50	800	8	50	
CLASS-V (Rivers)	2.0	80	800	8	80	1000 tonne Dead Weight Tonnage (approx. size 70m overall length, 12m moulded breadth and 1.8m loaded draft or one tug and two barges combination of 4000 tonne Dead Weight Tonnage (approx. size 170m overall length, 24m moulded breadth and 1.8m loaded draft).
CLASS-V (Canals)	Not Defined					

Class of Waterway	Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance Between Piers (m)	Self propelled vessel Carrying Capacity
CLASS-VI (Rivers)	2.75	80	900	10	80	2000 tonne Dead Weight Tonnage (approx. size 86m overall length, 14m moulded breadth and 2.5m loaded draft or one tug and two barges combination of 4000 tonne Dead Weight Tonnage (approx. size 210m overall length, 14m moulded breadth and 2.5m loaded draft).
CLASS-VI (Canals)	3.5	60	900	10	60	
CLASS-VII (Rivers)	2.75	100	900	10	100	2000 tonne Dead Weight Tonnage (approx. size 86m overall length, 14m moulded breadth and 2.5m loaded draft or one tug and two barges combination of 8000 tonne Dead Weight Tonnage (approx. size 210m overall length, 28m moulded breadth and 2.5m loaded draft or with higher dims).
CLASS-VII (Canals)	Not Defined					

In addition to the above, IWAI also given guidelines regarding vertical clearances with respect to transmission lines for National waterways as below:

Type of Transmission Lines	Vertical Clearance
Low voltage transmission lines including telephone lines	16.5
High voltage transmission lines, not exceeding 110 kilo volt	19.0
High voltage transmission lines, exceeding 110 kilo volt	19.0
	+1 centimetres extra for each additional 1 kilovolt

Also:

a) Waterway side slopes should be kept as 1(V): 5(H);
b) Minimum depth of channel should normally be available for about 330 days of the year;
c) Vertical clearance at cross structure over the waterway should be available at least in central 75% portion of each of the spans in entire width of the waterway;
d) For rivers, vertical clearance should be kept over Navigational High Flood Level (NHFL), which is the highest flood level at a frequency of 5% in any year over a period of last twenty years

1.4.2 Measures to Improve the Depth

The basic parameters considered for the fairway design are:

- Depth
- Width
- Side slopes
- Bends

As explained above, as the classification of waterways in India is based on the experience gained in various waterways, the characteristic features of the design waterways based on studies carried out by IWAI are furnished below and the same shall be followed.

Fairway Design

The fairway depth should be good enough to ensure steerability of the vessel and to prevent bottom feel. To meet this requirement, the minimum depth that is needed in a channel would commonly be the sum of the draught (draft) of the vessel and other tolerance factors The tolerance factors to be considered are listed as:

- Factor of keel clearance to avoid touching of the vessel to the ground and minimum free water below the keel for maintaining control on manoeuvring,
- Wave tolerance for the heaving and pitching of the vessel due to wave motion,
- Squat, increase of draft due to ship motion,
- Tolerance for siltation and dredging,

- Increase of draught due to trim and heaving due to unequal loading and steering manoeuvre respectively, and
- Tolerance for the change of draught during the transition from salt water to fresh water.

The keel clearance factor is the prime concern of the all tolerance factors considered. As per the standards laid down by German Code of practice (EAU 80), a 0.3 m layer of water column below the keel of the loaded ship is sufficient for free manoeuvrability of the vessel.

IWAI's experience in inland waterways in India and sub-continent (Bangladesh and Myanmar) shows that the under keel clearance for free manoeuvrability of the vessel varies between 0.2 and 0.5 m depending upon the soil characteristics of the channel bed and other parameters

Width of a Channel

The total width of a navigation waterway (W) in general is expressed in terms of a beam of a vessel (B). The design width for the proposed two-way navigation can be obtained as:

W = BM + BM1 + C + 2C1

Where: W = Navigation channel width for two-way navigation.

BM = Maneuvering zone for the design vessel which takes into account the directional stability of vessel.

BM1 = Maneuvering zone for the upcoming vessel which takes into account the directional stability of vessel.

C = Width of separating zone.

C1 = Width of the security area, between the maneuvering zone and the channel side which is accounted for environmental and human factors including bank suction.

Values recommended by various authorities for the above equation vary within wide limits. Some of the recommended values are presented here:

BM = 1.3 B to 3.0 B

BM = BM1

C = 0.5 B to 1.0 B

C1 = 0.3 B to 1.5 B

Where, B = Beam of a design vessel.

Based on the experience and recommendations of experts on Inland Waterways, the factors considered for the present design are:

BM = 1.8 B

BM = BM1

C = 0.5 B

C1 = 0.5 B

The designed channel width = 1.8B+1.8B+0.5B+2x0.5B for two way navigation at draft level = 5.1B. The bottom width of the channel for two-way navigation for the design vessel can generally be considered as 5 x B.

Slopes

The selection of slope is in accordance with the soil characteristics of the bed and banks, width of the waterway etc. The adopted channel slope shall be 1:5

Width Allowance at Bends

In bends, the width of the fairway should be more than the width of the canal that is designed for a straight reach to allow for a drift of the vessel in a curved portion of the waterway. It means that the vessel occupies a greater width in bends than in a straight stretch of the waterway. The drift of the vessel depends on the radius of the bend, the speed of the vessel, wind forces, the flow pattern and the loading of the vessel. The drift angle is larger for vessels traveling in the downstream than the upstream direction. The drift angle is inversely proportional to the bend radius 'R', that is, the larger the radius the smaller the value of drift angle. Unloaded ships normally subjected to more drift and consequently take up a greater width in bends than loaded ships and therefore the proposed allowance at the keel level of the unloaded ships is larger than the loaded ships.

Dredging of Navigational Channel

The dredging quantities for the above design channel shall be worked out based on the bathymetric surveys carried out. The system and different type of navigation marks shall be proposed in the DPR are given as follows:

- Lateral marks, to mark the left and right sides of the navigation route to be followed by navigator;
- Bifurcation marks, to mark the middle ground between the navigation channel, bifurcated channel and isolated dangers in the middle of the navigational channel;
- Shore marks;
- Bank wise marks, to indicate the channel at point where it approaches a bank;
- Crossing marks, to indicated crossing and alignment of the channel from one bank to another;
- Marks of prohibited areas, to indicate no permission of entry;
- Sound signal marks, to indicate use of horning or other sound signals;
- Marks for traffic control, to control up bound or down bound vessel in one way or sequence passage or to prohibit navigation;
- Marks on bridges, to indicate the passage through bridges;
- Depth indicator marks, to indicate shallow areas ahead in the navigation channel;
- Width indicator marks, to indicate the narrow stretches ahead in the navigational channel;
- River training marks, to indicate the ongoing river training works in the river to the navigators

1.4.3 IWT Terminal Planning

The terminal planning and design includes selection of suitable sites in the vicinity of cargo potential considering all the relevant technical variables such as choosing the type of berthing facility and providing of covered/open storage facility, cargo handling systems and other ancillary facilities required for efficient terminal operation. Based on the projected traffic, the selection of various facilities shall be planned. The cost estimate including capital and operating costs shall be estimated for each of the proposed system considering the design. These above aspects are briefly explained in the following subsequent sections.

Planning Considerations

The terminal facilities proposed for this project shall include the following:

i) Berthing Facilities for vessels;
ii) Cargo Storage Facilities;
iii) Cargo Handling Facilities;
iv) Other ancillary Facilities.

Terminal Facilities

The type of cargo handling system required at the terminal is generally dependent on the type of cargo, the annual volume required to be handled and the size of the vessels.

The various type of cargo foreseen to be handled at the proposed IWT Terminals are primarily grouped into:

i) Incoming Cargo, and
ii) Outgoing Cargo.

These above two groups are further subdivided into bulk, bagged and other miscellaneous general cargo for the purpose of planning the cargo handling equipment. The quantum and other cargo compositions shall be based on the traffic study. The same may be classified as below:

- Bulk Cargo - Construction materials such as Sand, stone, bricks, Marble, Iron steel, Machinery – Light, Heavy and ODC, Mineral Ore such as coal, lime stone, iron, fly ash, copper ore etc., bamboo, etc.
- Bagged Cargo - Cement, Fertilizer, wine and beverages, acids, cereals, cash crops, wheat, rice, Bajra, gram, pulses, cotton, etc.
- Misc. General Cargo – Consumer goods, animals, oil cake, edible oil, refined oil, paper products, jute products, etc
- Ferry – Passenger vessels for Tourists

1.4.4 Identification of IWT Terminals

Site selection is the most important as it decides the investment for establishing the terminal facilities. Hence, proper consideration has to be given to select the most optimum location which will minimise the capital investment and other recurring cost during operation. The selection of suitable site shall be carried out with the view of following considerations:

- Water availability near the terminal land throughout the year especially during lean season;
- Stable river channel with sufficient depth;
- Favourable hydraulic conditions for berthing and cargo handling;
- Availability of terminal land for infrastructure, cargo storage and handling;
- Traffic potential and cargo characteristics; and
- Navigational safety.

The proposed IWT Terminals shall be planned with the following infrastructure facilities for operation:

i) RCC Jetty and Steel Gangway resting on a floating pontoon. The detailed engineering & design of gangway arrangement shall be carried out during the construction stage. The preliminary layout drawing shall be proposed in the DPR;
ii) Administration Building and Bank protection arrangement;
iii) Covered Storage Shed/Transit Shed;
iv) Open storage area;
v) Security Shed;
vi) Forklift Trucks, Pay loaders & Dumper tracks; and
vii) Weigh Bridge, Watch and ward, Compound wall, Firefighting arrangement, Electrical & PH Facilities including DG.

The terminal shall be proposed with suitable mooring facilities, firefighting water line, water supply pipeline, power line for shore connection to barges, fenders etc. Preliminary planning and master plan shall be prepared in the DPR stage as per the relevant IS codes. It is envisaged and proposed that to the extent possible, all shore/river bank based buildings / godown are prefabricated, pre-engineered type conforming to the best standards in vogue in logistic / supply chain industry.

Other Alternatives to Improve for Navigation

Based on our earlier study for Ganga River between the reach from Allahabad to Ghazipur, there are many methods available to improve river navigation. Bandalling work – it has to follow closely falling stage of river, closing minor channels and diverting river flow in single channel to increase depth in the navigable channel in mainly due done by bandalling. In some reaches this method becomes successful but some river stretches remain shallow and need other training measures including dredging. Channelization of river and Construction of barrages at suitable locations, creating ponding conditions with required depth and navigational locks for ships and vessel movement shall be studied. The examination of various options/measures to improve the water depth shall be studied. The most suitable method for development shall be identified with consideration on the likely morphological, sediment transport, and dredging aspects of different options. This task is expected to be fed back into from the financial and economic analysis providing refinement to the proposed development until a recommended solution is reached. The most appropriate type of river development including drudging option along the river shall be identified and likely impacts of these developments on river flow depths as well as sedimentation and morphology shall be investigated. This analysis will constitute an iterative process in which problems relating to LAD will be addressed to find more successful solutions where necessary. This will however, not be an open-ended process as the assessment of techno-economic feasibility updation only requires an indication of the likely costs of building and maintaining the structures which are shown to support achievement of LAD as intended.

1.4.5 Concept Design and Cost Estimates

Preliminary Design shall be performed for all the structures /developmental works proposed as per the above analysis and mathematical model studies carried out conforming to relevant IS Codes. Design drawings shall be prepared and submitted based on the preliminary design. Bill of quantities and cost estimates shall be prepared for all the proposed structures / developmental works. Based on the cargo potential and other considerations necessary for locating an IWT terminal, extent of land required for setting up of IWT terminals and other suitable locations shall be identified. Preliminary topographic survey shall be carried out and layout plan for all suggested locations shall be prepared clearly indicating all facilities e.g. jetty, approach to jetty, bank protection, covered and open storage, roads, office, sentry hut, boundary wall, bank protection, bunkering facility, water facility, turning circle for IWT vessels location of depth contours of 2m and 2.5m in

the river near the terminal sites. Preliminary engineering design and drawings for setting up of terminals with related facilities including mechanical loading/ unloading at the proposed sites shall be prepared. Also inter modal cargo transfer facilities required at these terminals shall be indicated.

1.4.6 Financial and Economic Analysis

Financial and economic analysis through FIRR and EIRR of the project including SWOT analysis shall be carried out for the project. For the Financial Internal Rate of Return shall be computed as follows:

- Costs shall be calculated as total capital investment for the Project components, net rate of interest charges during construction and operations & maintenance costs for the Project;
- Income flows shall be calculated based on gross revenues of projected goods to be transported through private operators with permissible assumptions such as project life etc.;
- Economic Internal Rate of Return shall be computed taking into account the following factors;
- The assumed life of the project as per norms;
- Costs shall be calculated as Government contribution and other sources. A standard conversion factor shall be used to reduce financial costs to economic costs;
- Benefits shall be estimated as Government revenues, calculated as net profit share, royalties and tax;
- Social Benefits like fuel saving, reduction in environment pollution and carbon emission, accident reduction, decongestion of rail and roads, etc.

The financial viability and sustainability of this project depend upon the adaptation to the prevailing context in which they operate. In working out the Financial Viability and sustainability, the following factors shall be considered.

- budgeting and cost accounting systems,
- resource mobilization for capital investments,
- cost recovery and operational financing,
- cost reduction and control.

The Profitability projections and financial analysis for each of the project components shall be worked out in detail and presented in the report. The financial statements shall be prepared on the basis of the suitable assumptions. The cost benefit analysis for the proposed project shall be calculated. IRR and preliminary expenses shall be suitably considered and estimated. Break-even analysis shall be performed and presented in the report.

2.0 WATERWAY / DETAILED HYDROGRAPHIC SURVEY

2.1 HYDROGRAPHIC SURVEY

As detailed above, the National Waterway stretch of Ajoy river under DPR study is from the river confluence with Bhagirathi river at Katwa, Lat 23°39'23.33"N, Long 88°7'56.73"E to Dhanyarukhi at Lat 23°38'22.85"N, Long 088°1'53.90" E. The total length of this stretch is about 19 Km. The scope of the work to conduct hydrographic and topographic survey of this stretch of Ajoy waterway comprises of:

- Undertake bathymetric and topographic survey of proposed waterway
- Establishing horizontal and vertical control stations.
- Construction of benchmark pillars and establishing its reduced level w.r.to Mean Sea Level.
- Transfer of sounding Datum.
- Setting up and deployment of water level gauges.
- Current velocity and discharge measurements.
- Collection and analysis of water and bottom samples.
- Collection of topographic features including existing cross structures.
- Preparation of inventory of industries in the project influence area (PIA).
- Analysis of survey data, including assessment of water availability for navigation.
- Preparation of survey charts and report.

2.1.1 Waterway in General and Hydro-Morphological Characteristics

The Ajoy River originates on a small hill about 300 metres high, southwest of Munger in Bihar. It then flows through Jharkhand and enters West Bengal at Simjuri, near Chittaranjan. It first forms the border between Bardhaman District and Jharkhand and then between Bardhaman District and Birbhum District, and finally it enters Katwa sub-division of Bardhaman district at Nareng village. It then joins the Bhagirathi River at Katwa Town. Total length of the Ajoy is 288 kilometres, out of which 152 kilometres is in West Bengal.

The proposed 19 Km stretch of Ajoy waterway is located in the Bardhhaman district of West Bengal. Whole stretch of proposed Ajoy waterway of DPR study, from its confluence with Bhagirathi river to Dhanyarukhi is non – tidal. As observed during the survey, most of the river stretch is dry with water available only in starting 5.0 Km stretch.

River width in the waterway stretch of 5.0 km varies from 290 m to 67 m. Maximum and minimum reduced depth in the initial 5.0 Km stretch of the waterway with respect to existing sounding datum of 8.114 m are 7.03m and -0.3m respectively. Reduced depth at every 1 Km intervals w.r.t SD of 8.114m is provided in **Annexure 2**. Average flow velocity in the waterway varies from 0.16 m/sec

Two (2) RCC road bridge and one (1) Rail Bridge is located along the waterway at Chainage 6.554 Km and 13.898 Km.

2.1.2 Existing Hydrological / Topographical Reference levels

There was no GTS Station available near the survey area. As per IWAI guidelines, a 24 hour observation was carried out at newly established BM, AJ-01 and simultaneously 4 hour observation were carried out at AJ -2, AJ -03 BM's and data was logged in rinex format which was post processed in Auspos and Spectra software and value of BMs w.r.t. MSL were obtained.

An irrigation department Tide Gauge was found at Katwa and thereafter post discussions with client the SD value (8.114m) was provided. And the same was transferred to newly constructed BM AJ-01 using RTK system. The values of BM's w.r.t sounding datum were established by using base line processing method. Total Three in number BM's pillars (naming AJ-01, AJ-02, AJ-03) were constructed and erected along the river from Katwa to Dhanyarukhi

The Final accepted WGS 84 coordinates and details of Benchmarks established during the conduct of survey are provided in **Table 2**.

Table 2: Description of Bench Marks

BM	Location	Chainage (km)	Latitude (N)	Longitude (E)	Easting (m)	Northing (m)	BM Height above MSL (m)	SD w.r.t MSL (m)	BM Height above SD (m)
AJ-01	Katwa	1.0	23°39'20.77"	88°07'55.30"	615449	2616574	14.903	8.114	6.789

BM	Location	Chainage (km)	Latitude (N)	Longitude (E)	Easting (m)	Northing (m)	BM Height above MSL (m)	SD w.r.t MSL (m)	BM Height above SD (m)
AJ-02	Barenda	12.5	23°39'06.49"	88°04'52.18"	610264	2616095	16.381	8.114	8.267
AJ-03	Rosui	19.94	23°38'21.11"	88°01'56.90"	605308	2614662	19.762	8.114	11.648

2.1.3 Sounding Datum and Reduction details

Existing Sounding Datum was transferred at all the newly established BM's using IWAI provided value i.e. 8.114 m. Standard method was adopted for transfer of datum for tidal reaches areas as per Admiralty Manual. Details of Sounding Datum (SD) and reduction details are provided in **Table 3** as below:

Table 3: Details of Sounding Datum

Sl. No	Location	Tide Gauge Chainage (Km)	Stretch for corrected soundings and topo levels (Km)	Established Sounding Datum w.r.t. MSL (m) at col. A. (+ve indicates above MSL, -ve indicates below MSL)	Sounding Datum of Tide Gauge w.r.t. MSL (m)	Correction in WL data for Bathymetric survey (m)	Topo level data to be converted as depth for volume calculation wrt SD (m)
	A	B	C	D	E	F = (E-WL data in MSL)	G = ((E-topo levels in MSL)
1	Katwa	0	0.0 to 5.0	8.114	8.114	No Tidal effect	8.114
2	Kakurhati	6.5	5.1 to 8	Nil	9.3	No Tidal effect	9.3
3	Kakurhati	9	8.5 to 9.5	-	9.58	River is dry in this stretch	9.58
4	Kakurhati	10	9.5 to 10.5	-	9.64		9.64
5	Sunea	11	10.5 to 11.5	-	9.73		9.73

Sl. No	Location	Tide Gauge Chainage (Km)	Stretch for corrected soundings and topo levels (Km)	Established Sounding Datum w.r.t. MSL (m) at col. A. (+ve indicates above MSL, -ve indicates below MSL)	Sounding Datum of Tide Gauge w.r.t. MSL (m)	Correction in WL data for Bathymetric survey (m)	Topo level data to be converted as depth for volume calculation wrt SD (m)
	A	B	C	D	E	F = (E-WL data in MSL)	G = ((E-topo levels in MSL)
6	Sunea	12	11.5 to 12.5	-	10.05		10.05
7	Sunea	13	12.5 to 13.5	-	10.42		10.42
8	Sunea	14	13.5 to 14.5	-	10.79		10.79
9	Sunea	15	14.5 to 15.5	-	11.1		11.1
10	Rosui	16	15.5 to 16.5	-	11.2		11.2
11	Rosui	17	16.5 to 17.5	-	11.29		11.29
12	Rosui	18	17.5 to 18.5	-	11.31		11.31
13	Rosui	19	18.5 to 19.59	-	11.39		11.39

With the DPR proposal of Weir at start and end locations, the SD datum in the proposed 5.0 Km waterway stretch is modified to the weir crest level of 10.5m. As the bed level all along the 5.0 Km river stretch varies from 8.0 to 7.0 m amsl, minimum navigable water depth of 3.0 m below SD of 10.5m is confirmed.

2.2 EXISTING CROSS STRUCTURES

2.2.1 Bridges

There are total three bridges including 1 Railway and 2 Road bridges exists in the entire survey stretch of Ajoy River. The details of the existing Bridges and crossings over waterways are provided in **Table 4**.

Table 4: Details of Bridges

Sr. No.	Structure Name and for road / rail	Chainage (KM)	Type of Structure (RCC / Iron/ Wooden)	Location	Position (Lat/Long)				Position (UT M)				Length (m)	Width (m)	No of Pillars	Horizontal clearance (clear distance Between pillars) (m)	Vertical clearance w.r.t. MHWS (m)	Remarks (complete/ under-construction),in use or not, condition
					Left Bank		Right Bank		Left Bank		Right Bank							
1	Railway Bridge	6.554	Iron	Kakurhati	$23^0$39′27.80″	$88^0$6′10.56″	$23^0$39′21.92″N	$88^0$06′14.07″E	612581E	2616587N	612480E	2616767N	204m	12.5	10.0	20.0	0.488	In Use
2	Road Bridge	6.554	RCC	Kakurhati	$23^0$39′27.80″N	$88^0$06′10.56″E	$23^0$39′21.92″N,	$88^0$06′14.07″E	612581E	2616587N	612480E	2616767N	206m	5.5	10.0	20.0	0.248	In Use
3	Road Bridge	13.898	RCC	Charkhi	$23^0$28′51.57″N	$88^0$04′19.67″E	$23^0$39′2.05″N	$88^0$04′19.48″E	609347E	2615629N	609339E	2615951N	323m	9.0	14.0	31.39	0.320	In Use

As shown in **Table 4** above, one road and one rail bridge are located at a Chainage of 6.554 Km. The clearance of the above bridges are insufficient for vessel navigation as per **Table 1**, which means the bridges may either be removed or modified for navigating along the waterway. This option of removing or modifying the above two bridges is not considered at this stage of studies and hence as an alternative to bridge removal, the terminal for Ajoy waterway is proposed before the bridges at a Chainage of about 5.0 Km.

2.2.2 Electric Lines / Communication Lines

There are six High tension lines crossing the Ajoy River. The details are as follows.

Table 5: List of Electric/HT Lines

Sr. No.	Type of Line	Chainage (KM)	Location	Position (Lat/Long)				Position (UTM)				No. of Piers	Horizontal clearance (clear distance Between pillars) (m)	Vertical clearance w.r.t. MHWS (m)	Remarks (complete/ under-construction), condition
				Left Bank		Right Bank		Left Bank		Right Bank					
1	Electric Line	6.376	Kankurhati	$23^0$39'28.67"	$88^0$06'14.50"	$23^0$39'26.39"	$88^0$06'16.13"	612591.48 E	2616794.59 N	612638.21 E	2616724.75 N	2	244.0	3.842	Complete
2	High Tension Line	14.037	Charkhi	$23^0$39'0.17"	$88^0$04'7.04"	$23^0$38'53.81"	$88^0$04'17.04"	609270.37 E	2615892.59 N	609271.59 E	2615697.11 N	4	345.0	23.151	Complete
3	High Tension Line	14.017	Charkhi	$23^0$39'0.14"	$88^0$04'17.77"	$23^0$38'53.85"	$88^0$04'18.17"	609290.85 E	2615891.85 N	609303.80 E	2615698.40 N	4	345.0	23.227	Complete
4	Electric Line	13.942	Charkhi	$23^0$39'0.10"	$88^0$04'20.60"	$23^0$38'53.55"	$88^0$04'21.01"	609371.07 E	2615891.39 N	609384.33 E	2615690.03 N	2	345.0	9.139	Complete

Sr. No.	Type of Line	Chainage (KM)	Location	Position (Lat/Long)				Position (UTM)				No. of Piers	Horizontal clearance (clear distance Between pillars) (m)	Vertical clearance w.r.t. MHWS (m)	Remarks (complete/ under-construction), condition
				Left Bank		Right Bank		Left Bank		Right Bank					
5	Electric Line	13.860	Charkhi	$23^0$39'0.18"	$88^0$04'22.14"	$23^0$38'53.55"	$88^0$04'22.17"	609414.70 E	2615893.93 N	609417.19 E	2615690.03 N	2	345.0	9.573	Complete
6	Electric Line	13.833	Charkhi	$23^0$39'0.15"	$88^0$04'23.07"	$23^0$38'53.87"	$88^0$04'23.85"	609441.35 E	2615893.18 N	609464.63 E	2615700.18 N	2	345.0	5.929	Complete

2.2.3 Pipe Lines / Cables

No cross-structures, pipe lines, underwater cables are located along the 19 Km stretch of waterway.

2.2.4 Dams / Barrages / Locks / Weirs / Anicuts / Aqueducts

No dams, barrage, weir or any other cross structure are located along the 19 Km stretch of waterway.

2.3 BENDS

Few sharp bends are located along the waterway as detailed below in **Table 6**.

Table 6: Detail of Bends along Ajoy Waterway

Sl. No.	Start Chainage (Km)	End Chainage (Km)	Bend Radius (m)
1.0	1.207	1.378	123.95
2.0	3.349	3.756	141.60
3.0	4.841	5.573	400.00
4.0	7.054	7.863	350.00
5.0	9.767	10.439	250.00
6.0	14.493	15.059	355.78
7.0	15.652	16.443	481.14
8.0	18.117	18.926	400.00

As shown in **Table 6** above, sharp bends are located at Chainage 1.207 Km and at Chainage 3.349 Km. As per the classification of National waterways as given by IWAI (refer **Table 1)** the minimum bend radius for a national waterway is 300 m.

A detail study on the proposal for fairway development along these sharp bends is done in Chapter 3: Fairway Development and the recommendation on proposed waterway is provided accordingly.

2.4 VELOCITY AND DISCHARGE DETAILS

Current meter observation was carried out at each location at required depths using virtual ware Current meter. The observations were carried out at the deepest route of the channels. Discharge calculations are from the observed data. The current meter and discharge details are provided in **Table 7**.

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Table 7: Current Meter and Discharge Details

Stretch No.	Chainage (Km)	Position				Observed Depth (m)	Velocity (m/sec.) @ 0.5 D	Average Velocity (m/sec.)	Area (sq. m.)	Discharge (cu. m)
		Latitude	Longitude	Easting (m)	Northing (m)					
1	1.8	23°39'51.99"	88°07'20.73"	614462.00	2617526.30	4.6	0.16	0.16	14.73	2.36

2.5 WATERWAY DESCRIPTION

The Waterway of Ajoy River within survey limits can be broadly divided in to four stretches in accordance with the gradient of the river. **Table 8** below provides the details of sub-stretches of Ajoy waterway.

Table 8: Sub-Stretches of Ajoy Waterway

Sub-Stretch No.	Location		Chainage	
	From	To	From	To
1	Katwa	Kakurhati	0 Km	5 Km
2	Kakurhati	Sunea	5 Km	10 Km
3	Sunea	Sahapur	10 Km	15 Km
4	Sahapur	Teora	15 Km	19 Km

Detail descriptions of each sub-stretch are provided in below sections.

2.5.1 Sub Stretch 1: From Katwa to Kurthali (Chainage 0 Km to 5 Km)

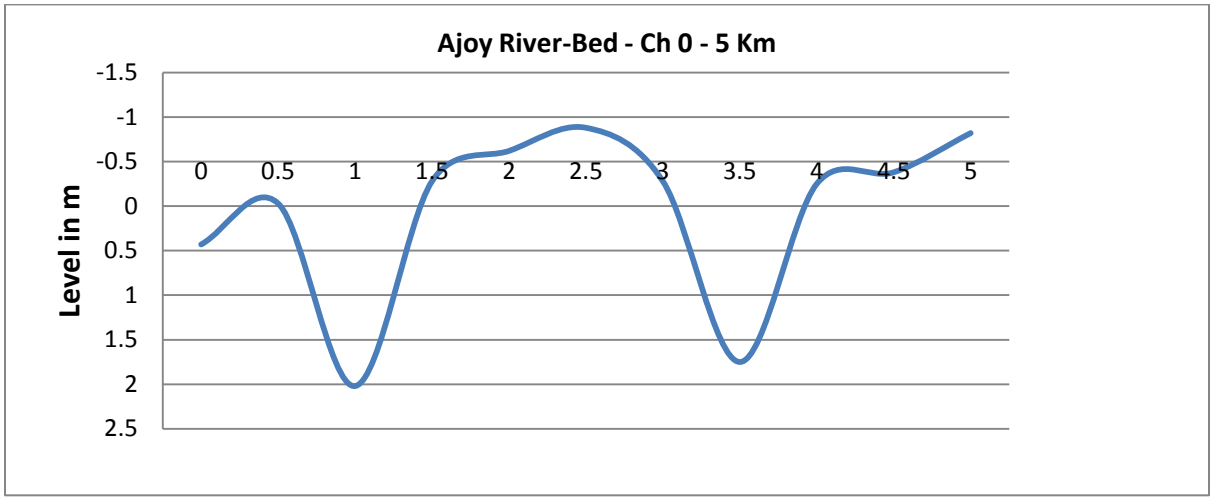
Both Bathymetric and Topographic Survey was carried out for this stretch between 0 to 05 km chainage of the Ajoy River. It is the downstream portion of the Ajoy river where it confluences with the Hooghly River. This stretch is considerably narrow with max width of approx 300 m with no portion of the river bank being protected.

Figure 2: Google Image showing Sub-Stretch -1 of Ajoy Waterway

Figure 2 above shows the alignment of Sub-stretch 1 (Ch. 0.0 Km to 5.0 Km) of Ajoy Waterway. The quantity of dredging required for varying WW Classes for this stretch is provided in **Table 9**. **Figure 3** shows the bed profile of sub-stretch 1.

Table 9: Dredging Quantity (cum) for Sub-Stretch 1

Class	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum (Refer Table 3 for SD)			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cum)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cum)
I	0	5	0	6.42	3500	55211.11	-0.30	7.03	4677	191567.82
II	0	5	0	7.30	3500	108663.20	-0.30	7.03	4898	298698.34
III	0	5	0	7.54	4200	219718.10	-0.30	7.03	5000	455431.28
IV	0	5	0	7.57	4300	966382.10	-0.30	7.03	5000	547290.18
2.5 draft x 30m bottom width	0	5	0	7.07	3900	257551.10	-0.30	7.03	5000	463472.20
VI	0	5	0	7.42	4800	474664.30	-0.30	7.03	5000	1193733.51
VII	0	5	0	7.42	4900	1060310.0	-0.30	7.03	5000	1477744.92



(Refer Table 3 for SD)

Figure 3: Bed Profile of Waterway Sub-Stretch 1 (Chainage 0Km – 5Km)

Sounding datum is 8.114 m.

Irrigation Tide Gauge at Katwa

Ferry Ghat at Katwa

	
River Bank Chainange 2.3	**River Bank At Chainage 4.2**

Figure 4: Photographs of Sub-Stretch 1

2.5.2 Sub Stretch 2: From Kurthali to Sunea (Chainage 5 Km to 10 Km)

Both Bathymetric and Topographic Surveys were carried out for this stretch between 05 to 10 km chainage of the Ajoy river. The water in the river was available for approx 1.5 Km in this stretch and rest of the area being dry. The depth is less as compare to stretch 1. Farming is main source of livelihood & the fields in the area are dependent on the rainfall. This stretch is narrow and average width being approx 200 m with unprotected river banks. Since most of the river stretch was dry and the watered stretch had still water, no current observation was carried out.

There is one Railway and one Road bridge and one High tension wire in this stretch.

There are no prominent dams & Barrage available in this stretch.

Figure 5 below shows the alignment of Sub-stretch 2 (Ch. 5.0Km to 10.0Km) of Waterway.

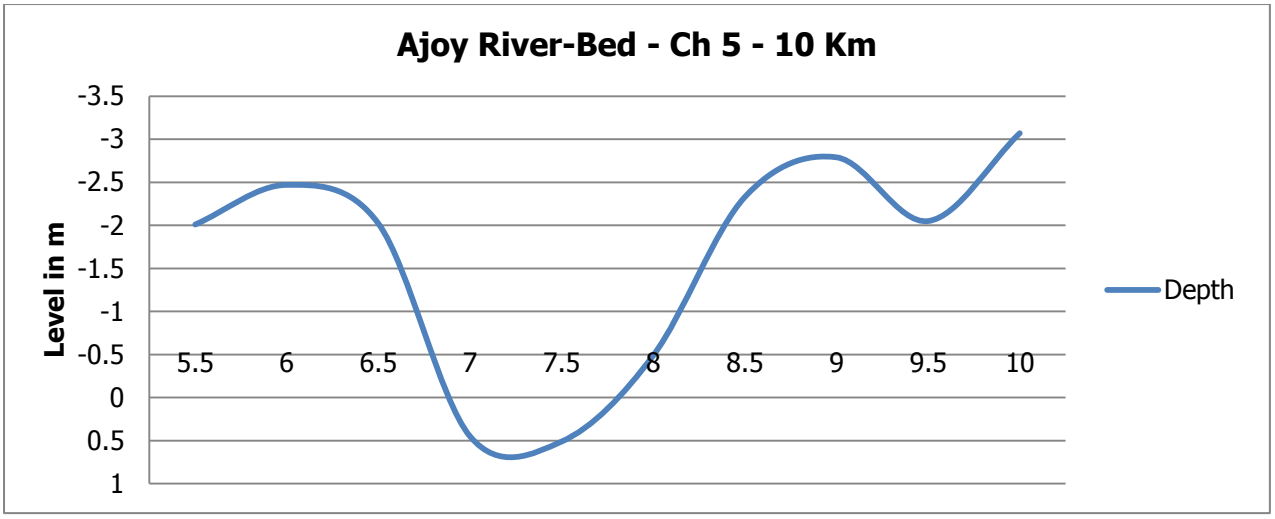
Figure 5: Google Image showing Sub-Stretch -2 of Waterway

The quantity of dredging required for varying Classes for this stretch is provided in **Table 10**. **Figure 6** shows the bed profile of sub-stretch 2.

Table 10: Dredging Quantity (cum) for Sub-Stretch 2

Class	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum (Refer Table 3 for SD)			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cum)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cum)
I	5	10	0	3.89	5000	218670.21	-0.3	2.74	5000	203332.27
II	5	10	0	4.16	5000	359898.20	-0.3	2.75	5000	319191.12
III	5	10	0	4.22	5000	439052.50	-0.3	2.75	5000	478955.34
IV	5	10	0	4.5	5000	647791.40	-0.3	2.75	5000	558700.47
2.5 draft x 30m bottom width	5	10	0	4.30	5000	568756.80	-0.3	2.75	5000	506835.09
VI	5	10	0	4.51	5000	1372192.0	-0.3	2.75	5000	1224457.25

Class	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum (Refer Table 3 for SD)			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cum)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cum)
VII	5	10	0	4.51	5000	1669649.0	-0.3	2.75	5000	1482328.67



(Refer Table 3 for SD)

Figure 6: Bed Profile of Waterway Sub-stretch 2 (Chainage 5Km – 10Km)

Road Bridge at Kakurhati

Rail Bridge at Kakurhati

Figure 7: Photographs of Sub-stretch 2

2.5.3 Sub Stretch 3: From Sunea to Sahapur (Chainage 10 Km to 15 Km)

Only Topographic Survey could be carried out as the entire stretch between 10 to 15 km chainage of the Ajoy river was dry. Farming are main source of livelihood & the fields in the area are dependent on the rainfall. This stretch is narrow and average width being approx 200 m with unprotected river banks. Since the entire river stretch was dry no current observation was carried out.

There is 1 road bridge and five high tension wire in this stretch.

There are no prominent dams & Barrage available in this stretch.

Figure 8 above shows the alignment of sub-stretch 3 (Ch. 10.0 Km to 15.0 Km) of Waterway. The quantity of dredging required for varying WW Classes for this stretch is provided in **Table 11. Figure 9** shows the bed profile of sub-stretch 3.

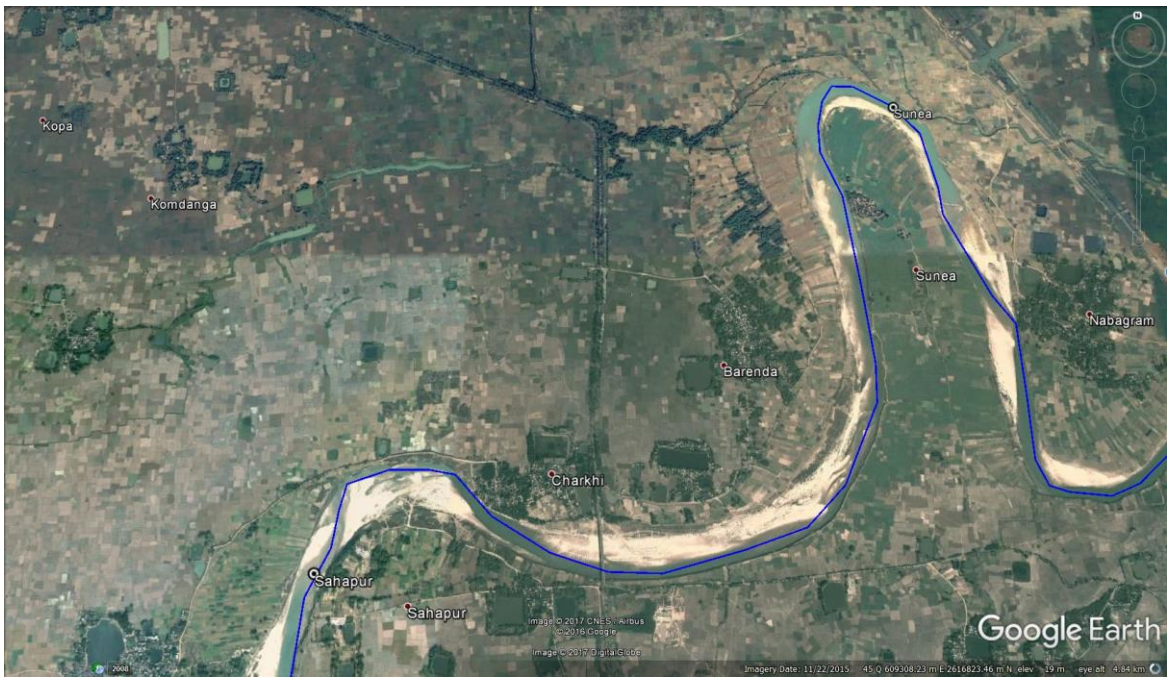
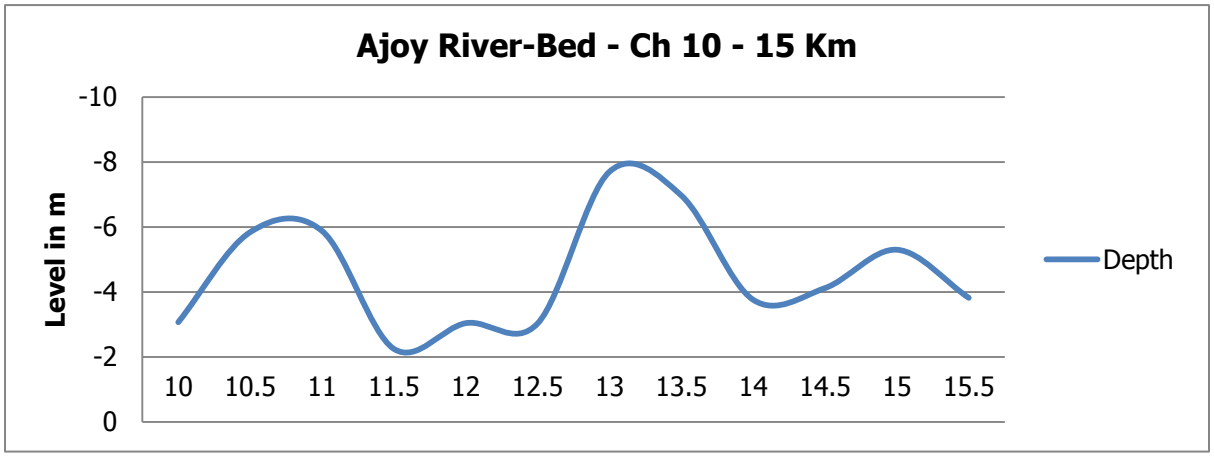


Figure 8: Google Image showing Sub-Stretch -3 of Waterway

Table 11: Dredging Quantity (cum) for Sub-Stretch 3

Class	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum (Refer Table 3 for SD)			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cum)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cum)
I	10	15	0	0	5000	261255.50	-0.30	0	5000	240111.23
II	10	15	0	0		476701.60	-0.30	0		353733.63
III	10	15	0	0		606002.10	-0.30	0		549195.79
IV	10	15	0	0		735934.10	-0.30	0		649796.48
2.5 draft x 30m bottom width	10	15	0	0		633510.50	-0.30	0		544212.18
VI	10	15	0	0		2543772.40	-0.30	0		1380566.44
VII	10	15	0	0		1881564.0	-0.30	0		1669692.78



(Refer Table 3 for SD)

Figure 9: Bed Profile of Waterway Sub-stretch 3 (Chainage 10Km – 15Km)

View of Complete dry area -Stretch 3 of Ajoy River

Figure 10: Photograph along Sub-Stretch 3

2.5.4 Sub Stretch 4: From Sahapur to Dhanyarukhi (Teora) (Chainage 15 Km to 19 Km)

Only Topographic Survey could be carried out as the entire stretch between 15 to 19.59 km chainage of the Ajoy river was dry. Farming are main source of livelihood & the fields in the area are dependent on the rainfall. This stretch is narrow and average width being approx 200 m with unprotected river banks. Since the entire river stretch was dry no current observation was carried out.

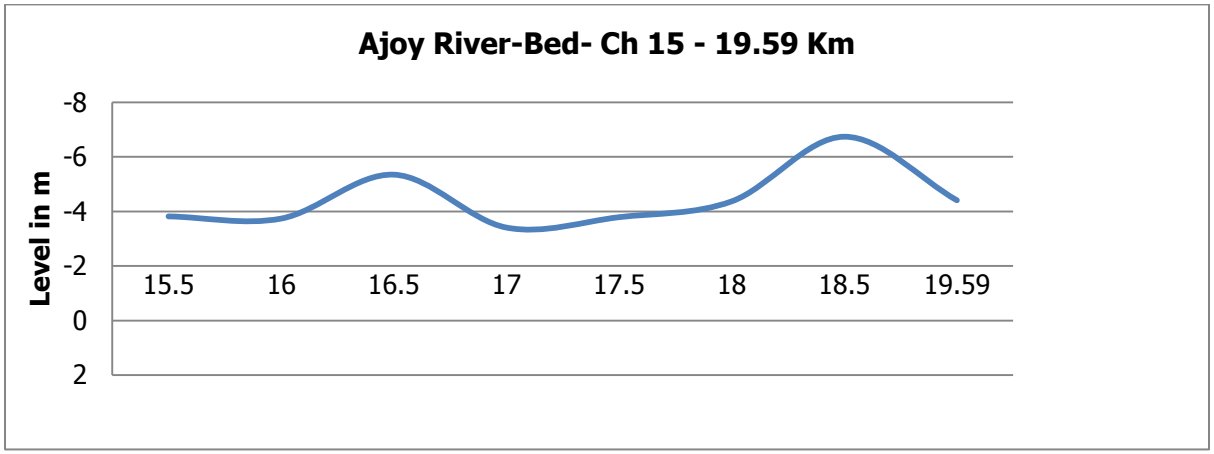
There are no prominent dams & Barrage available in this stretch.

Figure 11 above shows the alignment of sub-stretch 4 (Ch. 15.0 Km to 19.59 Km) of Waterway. The quantity of dredging required for varying WW Classes for this stretch is provided in **Table 12. Figure 12** shows the bed profile of sub-stretch 4.

Figure 11: Google Image showing Sub-Stretch -4 of Waterway

Table 12: Dredging Quantity (cum) for Sub-Stretch 4

Class	Chainage (km)		Observed				Reduced w.r.t. Sounding Datum (Refer Table 3 for SD)			
	From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cum)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cum)
I	15	19.59	0	0	4590	254145.50	-0.30	0	4590	202140.22
II	15	19.59	0	0		357704.90	-0.30	0		320015.56
III	15	19.59	0	0		551114.70	-0.30	0		480938.53
IV	15	19.59	0	0		510376.70	-0.30	0		559364.45
2.5 draft x 30m bottom width	15	19.59	0	0		556020.50	-0.30	0		482643.25
VI	15	19.59	0	0		1404406.24	-0.30	0		1217977.83
VII	15	19.59	0	0		1709261.79	-0.30	0		1515075.71



(Refer Table 3 for SD)

Figure 12: Bed Profile of Waterway Sub-stretch 4 (Chainage 15Km – 19Km)

Figure 13: Photograph along Sub-Stretch 4

2.6 SOIL AND WATER SAMPLES ANALYSIS AND RESULTS

River bed Soil and water samples were collected using Vanveen Grab & Niskin type sampler at respective locations. The samples were collected at one location each in the river stretches. The location and depth of the collected samples are appended in **Table 13.**

Table 13: Soil & Water Sample Locations

Sample No	Chainage (Km)	Latitude	Longitude	Easting (m)	Northing (m)	Soil Sampling Depth (m)	Water Sampling at 0.5D Depth (m)
1	1.5	23°39'51.98"N	088°07'20.72"E	614462.00	2617526.30	4.6	2.3
2	6.5	23°39'13.32"N	088°06'04.61"E	612315.10	2616320.30	1.2	0.6

The collected soil & water samples were analyzed for the following properties:-

Soil Samples

- Grain size
- Specific gravity
- PH Value
- Cu, Cc
- Clay Silt percentage

Water samples

- Sediment Concentration

Test result of samples is provided in **Table 14** and **Table 15**.

Table 14: Soil Sample Test Results

Sample No.	Location	Observed Depth (m)	Description	Particle Size Analysis				Specific Gravity	pH Value	Uniformity Coefficient. Cu	Coefficient of Curvature. Cc
				By Sieve Analysis		By Hydrometer Analysis					
				Gravel (%)	Sand (%)	Silt (%)	Clay (%)				
1	Sankhai	4.60	Sandysilt with Clay	0	86	12	2	2.67	7.68	4.41	2.00

Sample No.	Location	Observed Depth (m)	Description	Particle Size Analysis				Specific Gravity	pH Value	Uniformity Coefficient. Cu	Coefficient of Curvature. Cc
				By Sieve Analysis		By Hydrometer Analysis					
				Gravel (%)	Sand (%)	Silt (%)	Clay (%)				
2	Parulia	1.20	Sandysilt with Clay	0	94	4	2	2.68	8.00	2.25	1.14

Table 15: Water Sample Test Results

Sample No.	Location	Observed Depth (m)	Sediment Concentration Test (%)
1	Sankhai	2.3	1.93
2	Parulia	0.6	8.55

From the above analysis, it is observed that the river bed soil is sandy silt with clay in nature. The sediment concentration in river water is in the range of 8.55 % to 1.93 %.

3.0 FAIRWAY DEVELOPMENT

In most of the countries where inland navigation is developed, such as in Europe, China, Russia etc., the waterways have been classified in different classes depending on their physical characteristics and development potential in future. Generally, with larger waterway dimensions bigger IWT vessels can operate resulting in lower shipping cost per tonne of cargo as compared to the shipping cost of smaller vessels. One of the important factors contributing to lower shipping cost by operation of bigger vessels is the improvement in power to load ratio, i.e. capacity of cargo carrying per unit of engine power. Hence, every waterway should be developed to larger dimensions (depth and width of navigation channel) subject to the physical characteristics of the waterway. However, for developing a waterway to larger dimensions (in other wards waterway of higher class) additional investment would be required. Therefore, there would be an optimum waterway class for a particular waterway whereby total cost to the system (i.e., increase in cost due to development work vis-a-vis reduction in shipping cost) is minimum. This optimum solution is required for each waterway and for this purpose classification of waterways would facilitate planning for the optimum class of the waterway and its development.

3.1 PROPOSED CLASS / TYPE OF WATERWAY

IWAI gives a classification of waterways on the basis of width and depth of rivers/canals, radius of bends, vertical clearance, horizontal clearance between bridge piers and self-propelled vessel carrying capacity of vessels. On the basis of these criteria's, classification of waterways was done by IWAI as detailed in Paragraph **1.4.1** and **Table 1**.

On the basis of inputs from bathymetric and traffic survey it is proposed to develop Ajoy river from its confluence with Bhagirathi river for IWT as a Class IV. The waterway is proposed for navigating of vessels/barges upto 2000 DWT. The proposed fairway shall provide a navigational route to connect the National waterway 1, i.e. Bhagirathi river, with proposed Dry Bulk cargo terminal at a Chainage of about 5.0 Km in Ajoy river. Following options is studied for development of fairway along Ajoy waterway:

a) Dredging the entire river stretch of 5.0 Km for channel dimensions of 2.5 m draft and 30m bottom width.
b) Constructing a reservoir with draft of 2.5 m by providing ungated weir, each on upstream and downstream end of fairway and a navigational lock.

c) Constructing a navigation channel of 1.0 km length from Chainage of 0.5Km, which will avoid Bend 1 (refer Table 6) and dredging on the remaining porting of river stretch upto proposed terminal structure. Also proposed, a turning circle of 100.0 m radius at Bend 2.

A detailed study on the above three options are done herewith, to assess the technical feasibility of Ajoy Waterway.

3.2 DETAILS OF SHOALS

Whole stretch of waterway is dry except initial 5.0 Km stretch which receives continues backwater flows from Bhagirathi river. In order to maintain minimum navigable depth of 3.0 m below SD, weirs are proposed at start and end locations of the waterway. Details of shoals to be dredged from Chainage 0 Km to 5.0 Km is provided in **Table 9** of Para 2.5.1.

3.3 PROPOSED CONSERVANCY ACTIVITIES

Conservancy activities proposed for Ajoy waterway varies with the above options of fairway development. Hence all the three options are studied separately as below:

Option 1:

Dredging is proposed under conservancy works for the proposed fairway stretch of 5.0 Km to maintain the waterway depth of 2.50m as per Class IV of waterway classification.

3.3.1 Dredging

A defined waterway is required to make throughout the year navigation in the IWT stretch of Ajoy waterway possible. Dredging is proposed in the 5.0 Km stretch of Ajoy waterway to remove silt deposits in the channel bed in order to maintain required navigable depth of 2.0 m below SD and 0.5 m of additional clearance.

As the lower reaches of Ajoy river basin carries huge sediments, siltation along the waterway stretch cannot be ignored. Also the waterway intends to carry silt from backwaters of Bhagirathi river which will accumulate within the waterway boundaries.

In view of the above, extensive dredging is required initially for starting waterway operations in the proposed fairway. The quantity of dredging required for proposed channel sections, as calculated from HYPACK software is provided in **Table 16**.

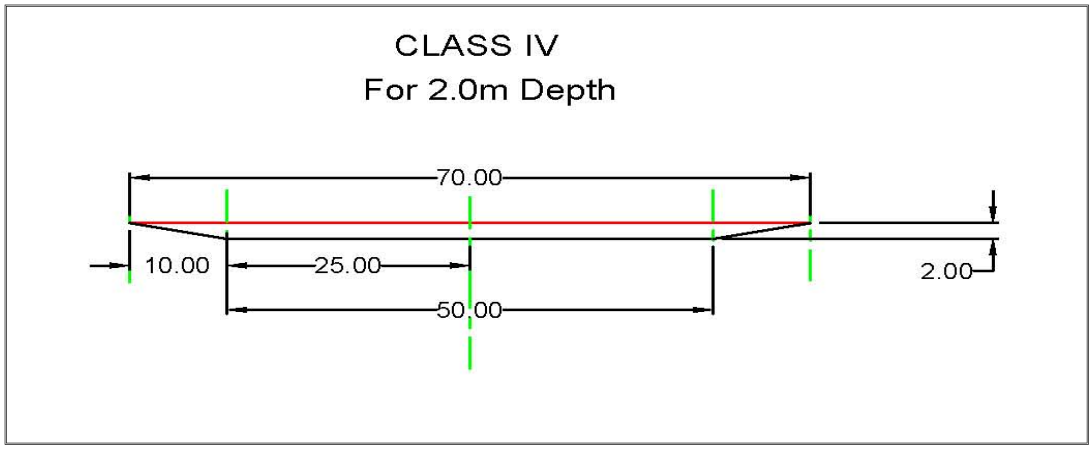


Figure 14: Fairway Dimension Class IV Waterway

Table 16: Dredging quantity

Chainage (km)		Observed					Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
0	1	0.58	5.8	400	18539.89	18539.89	-0.3	3.41	1000	71467.53	71467.53
1	2	0	7.57	900	54139.66	72679.6	-0.3	7.03	1000	88848.24	160315.77
2	3	0	1.97	1000	774862.49	847542.0	-0.3	0.41	1000	146858.69	307174.46
3	4	0	6.41	1000	32498.49	880040.5	-0.3	3.56	1000	80622.67	387797.13
4	5	0	1.52	1000	86341.57	966382.1	-0.3	0.49	1000	159493.05	547290.18
5	6	0	0	1000	137822.12	1104204.2	-0.3	0	1000	119489.08	666779.26
6	7	0	1.33	1000	140771.12	1244975.3	-0.3	0.98	1000	105329.75	772109.01
7	8	0	4.5	1000	81923.72	1326899.1	-0.3	2.76	1000	69900.04	842009.05
8	9	0	0	1000	139528.54	1466427.6	-0.3	0	1000	133065.85	975074.9
9	10	0	0	1000	147745.91	1614173.5	-0.3	0	1000	130915.75	1105990.65
10	11	0	0	1000	146384.43	1760557.9	-0.3	0	1000	120364.02	1226354.67
11	12	0	0	1000	147425.68	1907983.6	-0.3	0	1000	130987.95	1357342.62
12	13	0	0	1000	145812.18	2053795.8	-0.3	0	1000	129437.18	1486779.8
13	14	0	0	1000	148316.15	2202112.0	-0.3	0	1000	134799.99	1621579.79
14	15	0	0	1000	147995.68	2350107.6	-0.3	0	1000	134207.34	1755787.13
15	16	0	0	1000	142104.19	2492211.8	-0.3	0	1000	127949.1	1883736.23

Chainage (km)		Observed					Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
16	17	0	0	1000	11021.48	2503233.3	-0.3	0	1000	127738.28	2011474.51
17	18	0	0	1000	138544.07	2641777.4	-0.3	0	1000	128127.98	2139602.49
18	19	0	0	1000	144428.4	2786205.8	-0.3	0	1000	117956.75	2257559.24
19	19.59	0	0	590	74278.58	2860484.4	-0.3	0	590	57592.34	2315151.58
			Total	18890	2860484.4			Total	19590	2315151.6	

For total stretch of 19.59 Km, the dredging quantity required for an Class IV waterway with dimensions as shown in **Figure 14** is 23,15,151.6 cum.

For the proposed waterway stretch of 5.0 km from Chainage 0.0 km to 5.0 km, the required dredging quantity as provided in **Table 16** is 5,47,290.18 cum.

Disposal of Dredging Material

The dredged material is proposed to be dumped on low lying areas located on both sides of the river bank all along the waterway or in 5 Km reach of the banks. The dredge material should be dumped providing gabion walls along the banks. The gabion walls should be adequately provided to prevent the dredged material to fall back in the waterway.

Figure 15: Photograph showing arrangement of Gabion Wall along River Bank

Selection of dredging equipment

Dredging is usually carried out with a cutter-suction dredger and trailing suction hopper dredger. There are various types of dredgers available in the market viz., suction dredger, bucket dredger, grab dredger, backhoe / dipper dredger, water injection dredger, pneumatic dredger etc. While most of these dredgers are ideally suited for sea conditions to dredge harbour and approach channels, the selection of a dredger for inland waterway is rather critical due to various mobility factors, seasonal variation of water levels (floods/dry season) and shallow depths.

The cutter suction dredgers having conventional centrifugal pumps or modern jet pumps will be more effective to dredge out the material. In a cutter-suction dredger or CSD, the suction tube has a cutter head at the suction inlet, to loosen the bed and transport it to the suction mouth. The cutter can also be used for hard consolidated type of bed. The dredged

soil is usually sucked up by a wear resistant centrifugal pump and discharged through a pipe line or to barge.

A cutter suction dredger with dredging depth of about 10.0m is recommended for Ajoy waterway.

3.3.2 River Training

Option 2:

Option 2 comprises of constructing reservoir by providing two (2) ungated weirs and one (1) navigational lock.

Two numbers of weirs are proposed at a Chainage of 0.2 Km and 5.0 Km respectively. The ungated weirs are proposed to maintain a minimum draft of 2.5 m along the entire stretch of 5.0 Km. Overtopping is allowed in both the weirs.

A navigational lock is proposed in weir at Chainage 0.2 Km to provide a fairway route for vessels.

Option 3:

In this option following works are proposed:

a) a navigation channel of about 1.0 Km length to avoid Bend 1, located at Chainage 1.207 Km (refer
b) Table 6). The channel is constructed to provide a draft of 2.5m and bed width of 50.0 m.
c) dredging as per Class VI waterway from Chainage 0.0 Km to 0.5 Km and from channel end to proposed terminal structure.
d) Turning circle of 100.0 m at Bend 2.

A tentative layout of the above option is provided as below.

Figure 16: Proposed Channel Alignment

As shown above, this option required acquisition of about 1.0 Km length of farm land. The natural ground level along the proposed channel alignment is in the elevation range of 16m to 18m. The bed level of channel is kept at 3.0 m (2.5m draft + 0.5 m clearance) below SD (EL. 8.114m). Hence, proposed bed level of channel is 5.0 m above MSL. With a slope of 1V:3H and providing 1.5m wide berms at every 3.0 m vertical height, the top width of channel works out to be 135m. Additional 10.0 m of land along both the banks of proposed channel alignment is provided for maintenance road and other allied works. Hence total land required to be acquired for channel construction is about 15.5 hectare of farm land.

At bend 2, located at Chainage 3.349 Km, turning circle of radius 100.0 m is proposed. This will avoid the sharp bend in addition to providing turning radius for cargo vessels.

The detail preliminary engineering design of the proposed channel is provided in Chapter 6 of the DPR.

3.4 BANK PROTECTION / EMBANKMENT STRENGTHENING

The river bank in the proposed fairway stretch is unprotected but fairly stable. No bank protection works is envisaged in the proposed fairway stretch for option 1 and option 2. However, in case an alternate channel is constructed as suggested in option 3, channel bank protection works is required.

3.5 NAVIGATION MARKINGS / NAVIGATION AIDS

Navigation markings/aids, proposed for safe navigation along the proposed fairway stretch are discussed in detail in Chapter 8.

3.6 MODIFICATION REQUIREMENT IN EXISTING BRIDGES / CABLES / DAMS / BARRAGES / LOCKS / WEIRS / ANICUTS / AQUEDUCTS

No Bridges / Cables / Dams / Barrages / Locks / Weirs / Anicuts / Aqueducts are located along the navigation channel for all the three options.

3.7 PROPOSED DAMS / BARRAGES / LOCKS / WEIRS TO IMPROVE DEPTH

Proposed Weirs (In Option 2 only)

a) A weir is proposed at Katwa near confluence point of Ajoy and Bhagirathi river (0.2 Km Chainage) to maintain required water depth in the upstream section of weir.
b) Another weir is proposed at 5.5 Km Chainage to restrict/reduce the entry of sediments in the navigational channel during high flows from the catchment.

Proposed Navigational Locks (In Option 2 only)

Navigational Lock will be necessary for providing waterway in case of dam, weir and barrages. A Navigational Lock is proposed on the weir proposed at 0.2 Km Chainage.

3.8 LAND ACQUISITION

Land acquisition is not required for option 1 and 2. For option 3 about 15.5 hectare (1,55,000 sqm) of private farm land is required to be acquired.

3.9 TECHNICAL FEASIBILTY OF AJOY WATERWAY

Technical feasibility of Ajoy waterway is assessed on the basis of options evaluated for fairway development. From the above following conclusions are made:

Option 1: (Dredging of 5.0 Km)

a) Huge amount of initial and maintenance dredging is involved.
b) Fairway need to be trained to avoid sharp bends.

Option 2: (Construction of 2 Weirs and a Lock)

a) High initial cost due to construction of weirs and navigational lock.
b) Extensive maintenance dredging after each flood season.
c) Risk of flooding of low lying areas along the river bank during floods after weir construction.
d) Fairway need to be trained to avoid sharp bends.

As provided in **Table 1** (Classification of waterways by IWAI), the minimum bend radius for a waterway is 300.0 m. The available bend radius in Ajoy waterway at Chainage 1.2 Km and 3.3 Km is 124 m and 142 m respectively. Training of above bends is not possible considering small stretch of waterway and the habitation near the Bend-2.

In view of above constraint, the above options are not recommended for fairway development.

Option 3: (Construction of new navigation channel)

a) Land acquisition leading to R&R issues.
b) Considerable initial investment cost in construction of new navigational channel

The above option of constructing a new navigation channel of about 1.0 Km and turning circle of 100.0 m radius at bend 2, does not possess any technical hindrance. Land acquisition and R&R may become an issue for Ajoy waterway development in this option.

For this DPR, option -3 is recommended for detailed techno-commercial studies.

3.10 FAIRWAY COSTING

The cost estimate for fairway development of IWT system including O&M of the system has been worked out. The cost estimates for development of the system are considered as Capital cost while for operation of the system is termed as maintenance or operating cost (O & M cost). The fairway development cost is estimated for navigation channel proposed in Ajoy waterway.

3.10.1 BASIS OF COST

The basis of cost estimates worked out as per following:

a) Schedule of Rates of PWD, Govt. of West Bengal;
b) "Unified Schedule of Rates" prepared by Irrigation and Waterways department, Government of West Bengal.
c) The consultant's references from various projects/sites proximity to the project area.
d) Local enquiries at the time of conducting surveys.
e) Market surveys and enquires
f) Judgement based on Consultant's Experience

3.10.2 Capital Cost

Though option 3 is recommended for further DPR studies, capital cost for all the options is provided below:

Table 17: Capital Cost for Fairway Development (Option 1)

Sl. No	Description	Quantity	Unit	Rate (INR)	Amount (INR)
1.	Dredging Cost from chainage 0.00 Km to 5 Km (For class IV waterway from HYPACK)	5,47,290.18	Cum	200.00	10,94,58,036
	Total (In INR Lacs)				**1,094.58**

Table 18: Capital Cost for Fairway Development (Option 2)

Sl. No	Description	Amount (INR Lacs)
1.	Navigation Lock (123 m X 18 m)	
	Civil Part	1,038.70
	Mechanical Part	92.25
2	Weir at Chainage 0.2 Km	706.42
3	Weir at Chainage 5.0 Km	1,000.35
	Total (in INR Lacs)	**2837.72**

Table 19: Capital Cost for Fairway Development (Option 3)

Sl. No	Description	Quantity	Unit	Rate (INR/unit)	Amount (INR) in Lacs	Reference
A						
1	Dredging Cost from chainage 0.00 Km to 0.5 Km (For Class IV waterway from HYPACK)	35,734	Cum	200.00	71.47	As considered by IWAI as per comments on Final DPR (R1)
2	Excavation including sorting out and stacking of useful materials and disposing of the excavated stuff upto 50 metre lead. Soft rock not requiring blasting for chainage 0.5 Km to 1.5 Km	1,50,000	Cum	225.00	2,587.50	Unified Schedule of Rates (Government of West Bengal, Irrigation and Waterways Department), w.e.f 19.01.2018 - Sl. No. 1.02 (c), page C1
3	Dredging Cost from chainage 1.5 Km to 3.5 Km (For Class IV waterway from HYPACK)	2,31,594	Cum	200.00	463.19	As considered by IWAI as per comments on Final DPR (R1)
4	Precast cement concrete blocks or lining units as per designed size and specification, with well graded stone metal aggregate, including dressing, ramming, shuttering, finishing the top surface with 1:3 cement and sand mortar, curing,	21000.00	Cum	4693.00	985.53	Unified Schedule of Rates (Government of West Bengal, Irrigation and Waterways Department), w.e.f 19.01.2018 - Sl. No. 2.54 (b)

Sl. No	Description	Quantity	Unit	Rate (INR/unit)	Amount (INR) in Lacs	Reference
	transporting and laying the blocks or lining units at worksite in position, over filter, layer, keeping a gap of 6mm between the adjacent units, by sue of removable plyboards or non removable thermocol boards, with all leads and lifts, including supply and carriage of all materials complete.					
	Total of B				4,107.69	(excluding Land Cost)
B	Cost of Detail Engineering			4%	164.31	
C	Construction Supervision			6%	246.46	
	Total of A + C + D				4,518.45	
D	Contingency			3%	123.23	

	Total Cost for Fairway Development (A +B + C +D)				**4,641.68**	**Excluding land cost**

E	Land Cost	1,55,000	sqm	916.10	1419.96	Average Land cost of nearest locations as obtained from https://www.wbidc.com/industrial_parks/available_land.htm
F	Contingency			3%	42.60	
	Total Land cost (E + F)				**1462.56**	

	Total Cost for Fairway Development (A + B +C + D +E + F)				**6,104.24**	**Including land cost**

3.10.3 O&M Cost

The O&M cost for proposed fairway comprises of:

Option 1:

Dredging cost @ INR 200/cum for 10% of 5,47,290.18 cum = INR 1,09,45,803.60/-

Total O&M cost for Option 1 = **INR 109.46/- Lacs**

Option 2:

Weirs and navigation lock	=	2% of total civil cost + 5% of total mechanical cost
	=	2% of INR 2745.47 Lacs + 5% of INR 92.25 Lacs
	=	INR 54.91 Lacs + INR 4.61 Lacs
	=	INR 59.52 Lacs
Annual dredging cost	=	INR 109.46 Lacs

Total O&M cost for Option 2 = **INR 168.98 Lacs**

Option 3:

a) Cost of dredging required during operation of fairway

Actual quantity of dredging required during operation stage can be worked out from model studies only. For DPR studies, it is assumed that 10% of dredging is required annually for smooth and safe navigation.

Dredging cost @ INR 200/cum for 10% of 2,67,328 cum (=35,734 cum + 2,31,594 cum)
= INR 53,46,558.20/-
= **INR 53.47 Lacs**

b) Maintenance cost of channel	=	2% of channel capital cost
	=	2% of INR 4,641.68 Lacs
	=	**INR 92.83 Lacs**
Total O&M cost for Option 3	=	INR 53.47 Lacs + INR 92.83 Lacs
	=	**INR 146.30 Lacs**

4.0 TRAFFIC STUDY

4.1 GENERAL

Barddhaman district extends from $22^0$56' to $23^0$53' North Latitudes and from $86^0$48' to $88^0$25' East Longitudes. Lying within the Barddhaman division, the district is bounded on the north by Jharkhand, Birbhum and Murshidabad, on the east by Nadia, on the south by Hugli, Bankura and Puruliya and on the west by Jharkhand. The river Barakar forms the State boundary to the west, the river Ajay separates Birbhum and Jharkhand to the north with the exception of a portion of Katwa Sub-division, where a small portion lies to the north of Ajay. In shape the district resembles a hammer of which the handle consisting of the Asansol Sub-division is some 96 km. in length. The head is formed by the delta to the east lying between two great rivers which form the main boundaries and the greatest breadth here is 112 km. The eastern portion is a wide alluvial plain enclosed by the Ajay, the Bhagirathi and the Damodar river on the north-east and south. To the west the district narrows to a mere strip of rocky, undulating land, some 15 miles wide, lying between the Ajay and the Damoder rivers The total length of the district from Barakar to the Bhagirathi river below Kalna is 208 km. Barddhaman district is the third in West Bengal in respect of its area in the State covering 7,024 sq. km. while it is the 3rd district in terms of its population which consists of 77,17,563 persons accounting for 8.4 per cent of the State's total population. Elevation of the district from the mean sea level is 296 metres.

4.2 INFLUENCE AREA / HINTERLAND

Ajoy River is one of the main rivers of West Bengal State. The Ajoy River has a length of nearly 288.0 km from its source Deogarh in Jharkhand Plateau to the mouth at Bhagirath river at Katwa town. The waterway stretch, recommended by IWAI for DPR study is from its confluence with Bhagirathi river near Sakhai ghat, Katwa to Dhanyarukhi having a length of 19 Km. However, on the basis of detailed survey and investigations, traffic analysis and demand assessment, it is recommended to develop navigable channel for initial 5.0 Km stretch upto Goai village. The proposed navigable channel will provide the waterway connectivity from Bhagirathi river (National waterway 1) to the proposed Dry bulk cargo terminal at Goai village to cater the cargo demand of Katwa Thermal Power Plant, proposed at about 5-6 Km from Goai village.

Total influence area/hinterland extending on either side of waterway is provided in **Table 20**.

Table 20: Project Influence Area/ Hinterland

State	District	Area (Km^2)	C.D. Block	Area (Km^2)	Total Hinterland area (Km^2)
West Bengal	Bardhaman	7,024	Katwa-I	164.00	323.62
			Ketugram-II	159.62	

4.2.1 Population of Hinterland area

Population of hinterland area for proposed IWT in Ajoy waterway is provided in **Table 21** below:

Table 21: Population of Hinterland

State	District	Population (Nos.)	C.D. Block	Population (Nos.)	Total Hinterland Population (Nos)
West Bengal	Bardhaman	77,17,563	Katwa-I	1,73,087	2,91,654
			Ketugram-II	1,18,567	

4.2.2 Existing and proposed Industries

There are no major industries existing in the nearby area except for a few brick factories near Sahapur. Hence presently no large and consistent amount of cargo movement is present through this river. The riverbanks including hinterland are having good road and rail connectivity. . The settlements are sparsely distributed on the river banks except Katwa.

There is a proposed NTPC's thermal power plant near Srikhanda Village, 8 km from Katwa town of 1320 MWQ capacity. The power plant is one of the coal based power plants of NTPC. There may be a demand for import of the coal and export of the fly ash for the proposed power plant from Ajoy waterway for which an IWT is proposed. The consultant made a detailed site visit to the site office of proposed Katwa thermal power plant and mailed to NTPC officials for collecting data and informations required for preparing DPR and assessing the techno-economic viability of Ajoy waterway IWT. However, it is to be noted that no detailed information or inputs is shared by NTPC in this matter.

In the absence of inputs from NTPC, consultant prepared DPR on the basis of information's and inputs available through media and online portal, as referred in DPR. The site photographs of the proposed Katwa thermal power plant is provided in **Figure 17**.

Site Photo -1/4

Site Photo -2/4

Site Photo -3/4

Site Photo -4/4

Figure 17: Site photographs of NTPC Katwa thermal power plant

It is assumed that the power plant will be fully operational in next 5 years

4.3 COMMODITY COMPOSITION / CATEGORIZATION

As the waterway is proposed to be developed to cater the traffic demand generated from proposed Katwa super thermal power plant. The major commodities anticipated to be used by proposed waterway and terminal is dry bulk cargo.

4.3.1 Dry Bulk Cargo

The dry bulk cargos proposed for IWT are:

a) Coal
b) Fly Ash

The proposed INR 8,000-crore Katwa Thermal Power project was first conceived by West Bengal Power Development Corporation Limited (WBPDCL) but could not be executed due to land acquisition related issues. It was later handed over to the NTPC. The Project is envisaged to require 7 million tonnes of coal annually and to produce 2.7 million tonnes of ash annually.

The total anticipated quantity (refer **Table 36** and **Table 37** for detailed calculation) of dry bulk cargo estimated to be handled by IWT through Ajoy waterway is as follows:

a) Coal :- 3.0 million tonnes annually i.e. about 43% of total annual coal requirement of 7 million tonnes
b) Fly Ash :- 1.2 million tonnes annually i.e. about 50% total annual fly ash production of 2.7 million tonnes

The capacity of proposed Ajoy waterway terminal in the DPR, is worked out on the basis Vessel parcel size, draft availability and Vessel turnaround time.

4.4 ORIGINATING / TERMINATING COMMODITIES

Following commodities are anticipated to and fro the proposed dry bulk cargo terminal on Ajoy waterway:

Originating Commodity - Fly Ash

Terminating Commodity - Coal

4.5 PASSENGER/ RO-RO TRAFFIC

No passenger/RO-RO traffic is available along the waterway.

4.6 TOURISM TRAFFIC

No tourism traffic is available along the study stretch of waterway.

4.7 GROWTH TREND

No existing traffic is located in the waterway. The terminal is proposed to cater the anticipated future demand for Coal and fly ash transportation. Hence, forecasting of growth trend for this anticipated cargo is not recommendable at this stage of project. However, growth of 2.6% per annum [*On the basis of average coal consumption growth of 2.6% for India (2015 – 2040) forecasted by United States Energy Information Administration (US EIA)*] is considered for future potential planning upto the maximum proposed plant capacity. The graph with 2.6% annual growth pattern from start date of power plant (assumed to be 5 years from now) and terminal operation is shown in **Figure 18**.

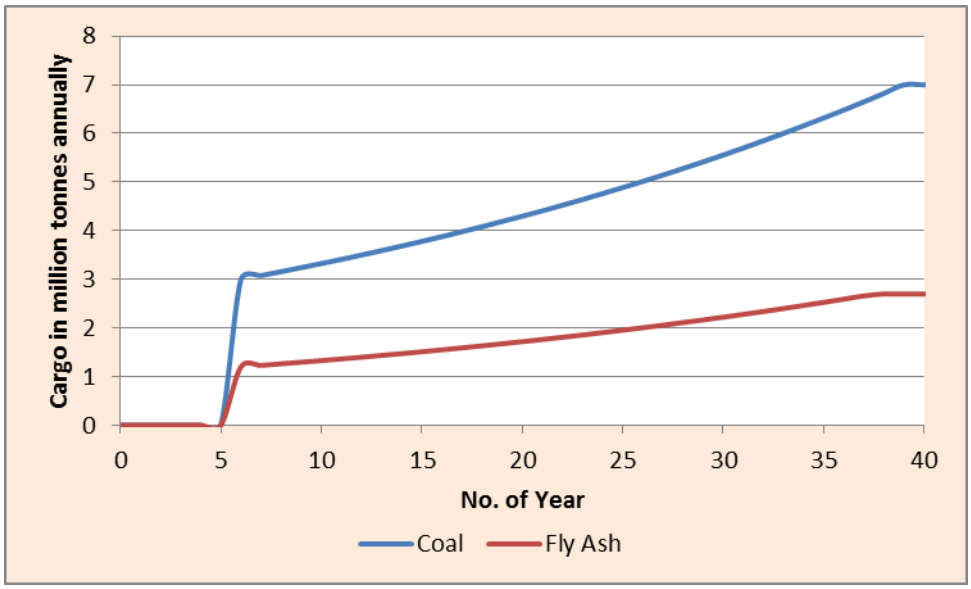


Figure 18: Projected Cargo Traffic in Ajoy Waterway

5.0 TERMINALS

The terminal planning and design includes selection of suitable sites considering all the relevant technical variables such as choosing the type of berthing facility and providing of covered/open storage facility, cargo handling systems and other ancillary facilities required for efficient terminal operation. Based on the projected cargo traffic, the selection of various facilities is planned. The cost estimate including capital and operating costs was planned for each of the proposed system considering the design. These above aspects are briefly explained in the following subsequent sections.

5.1 GENERAL REVIEW

The proposed waterway section of 19 Km under DPR study does not have any existing commercial or industrial units along its bank. No IWT traffic is located throughout the waterway stretch. However, Ajoy river stretch of about 5.0 Km is expected to have huge potential for Inland Water Transport due to its proximity with Katwa thermal power plant proposed at about 5-6 Km from river bank.

During the DPR stage, detailed bathymetric and topographic survey is done to assess the basic infrastructure, needs to be developed at proposed terminal location. Connectivity of proposed location with major roads and nearest railway stations is also assessed in detail during the DPR phase.

5.2 IDENTIFICATION AND SITE LOCATION

Site selection is most important as it decides the investment for establishing the terminal facilities. Hence proper consideration has been given to select the most optimum location which will minimise the capital investment and other recurring cost during operation. The selection of suitable site was carried out with the view of following considerations:

- Water availability near the terminal land throughout the year especially during lean season,
- Stable river channel with sufficient depth,
- Favourable hydraulic conditions for berthing,
- Availability of land for terminal infrastructure, cargo storage and handling,
- Traffic potential, and
- Navigational safety.

On the basis of detailed bathymetric and traffic survey done during DPR studies on the 19 Km stretch of Ajoy river waterway from the river confluence with Bhagirathi river, near Katwa (chainage 0.0 Km) to Dhanyarukhi (chainage 19 Km), following location is identified for development and construction of terminal:

Sl. No	Name	Type	Latitude	Longitude
1.	Goai Village (Left Bank on the river, while moving upstream from 0.0 km Chainage	Dry Bulk Cargo Terminal	23°39'20.68"N	88° 6'52.82"E

5.3 TERMINAL LAYOUT / MASTER PLANNING INCLUDING PHASES OF DEVELOPMENT

Terminal facilities need to be developed according to an adequate Master Plan providing development concept and framework indicating the phased developmental solutions to meet the ultimate requirements. The Master Plan will include solutions for the actual planning periods as well as point out possibilities for further expansions in the more distant future. Normally, a master plan is developed for a time horizon of 20-25 years as any prediction of cargo throughput and the matching development requirements, in terms of terminal operational needs. Beyond this period may not be very accurate. Hence a master plan need to allow development in stages to meet the demands as they come and grow and also be flexible to incorporate mid-course modifications and to be responsive to emerging scenarios as time goes on. At this stage, based on the traffic, land and water front availability a concept layout is presented for the proposed dry bulk cargo terminal.

Proposed IWT dry bulk cargo terminal layout is planned for handling an anticipated proportion of inbound coal for Katwa Thermal power plant and outbound Fly ash through the waterway from 2020 onwards. Scope for future development for the design life of 20 years upto 2040 is also considered in the terminal layout.

The following simple basic assumptions were considered for the purpose of IWT terminal planning:

a) Terminal facilities are initially planned for handling the requirement of coal for the proposed power plant and the amount of fly ash generated. The proposed power plant is envisaged to be constructed and start in a phased manner and thus terminal shall be expanded in the subsequent development phases. System is planned that any additions to the facility will be possible for handling future traffic. Terminal facilities are planned and can be expanded to the ultimate traffic projected.

b) Based on the water level data analysis and other weather dominant factors, the designed master plan has been considered available for berth operation of 300 days per year.

c) Average time required for to and fro movement from anchorage to berth, berthing time, and other formalities is considered as 1 to 2 hour per cargo vessel.

d) Storage capacities provided at the facility will be adequate to guarantee loading and unloading of cargo during disruption of traffic.

e) Maximum truck size assumed is 10 Tonnes pay load.

f) All bulk cargo which is not affected by weather will be stored in open stock pile.

g) The storm water drain proposed at the terminal shall discharge into the river.

The terminals facilities proposed for the dry bulk cargo terminal shall include the following:

- Berthing Facilities for vessels
- Cargo Handling Facilities
- Cargo Storage Facilities
- Other ancillary Facilities

5.3.1 Dry Bulk Cargo Terminal Facilities

This section details the layout plan development options and facilities considered for dry bulk cargo terminal proposed. These options have been evolved with due consideration to various parameters like environmental aspects, geotechnical data, navigational aspects, adequacy of back up area, operational efficiency, the number of berths along the water area and development phasing strategy of proposed Katwa power plant. The terminal layout is presented in Drawing attached. The various waterside and land side facilities are presented in the mentioned drawing.

1. LAND AVAILABILITY

The multi-cargo Inland Water Transport (IWT) terminal is proposed near Goai Village (at 5.0 km Chainage) on Ajoy waterway. Terminal is proposed on the private land available along the river bank, as no government land is located nearby the proposed terminal site.

2. WATERFRONT FACILITIES

The waterfront facilities for jetty are presented in drawing provided in this report. The dry bulk berth is planned of a total length of 118.0m & 1 pontoon platform along with gangway for fly ash handling from proposed terminal.

3. BACKUP AREA DEVELOPMENT

In order to make the terminal functional and subsequently making the terminal capable of running with increasing efficiency and transportation between terminal site to proposed Power plant etc., location of each facility should be such that it becomes as a whole highly interactive making the terminal performance most efficient with minimum cargo transportation cost. These land side facilities are enumerated as follows.

- Jetty and approach for berthing of vessels (2000 DWT for coal)
- Pontoon platform & gangway (2000 DWT for Fly Ash)
- Stockpile area for Coal
- Coal handling system
- Storage Silos for Fly ash
- Pneumatic loading and unloading units for handling of Fly ash
- Jetty office
- Administration building

4. MATERIAL HANDLING

The following options have been considered for handling of coal at the proposed terminal:

- **Option 1: Coal handling through Conveyors to Thermal power plant & Fly ash be Bulker trucks:**

In this option, it is envisaged that the incoming coal from barges shall be unloaded directly into the conveyor belts using mobile harbour crane. The conveyor system shall consist of series of conveyors along with the necessary structures such as transfer towers, conveyor structure, dust suppression system, etc. The conveyor system shall carry the coal from the jetty either to the stockpile area or directly to the location of the proposed power plant via long distance conveyor (7km approx.). The proposed system shall ensure continuous supply of coal directly from the terminal without involvement of any trucks or intermediate vehicles whereas generated fly ash from the power plant to the cargo terminal shall be handled by the bulker trucks.

It is envisaged that the whole conveyor system from exit of IWT terminal boundary till power plant boundary shall be elevated to minimize the obstructions as conveyor shall pass through the farmer's land, above road crossings, etc.

- **Option 2: Coal & Fly Ash handling by Pipe conveyor belt:**

Mechanized material handling system through pipe belt conveyor system has been proposed to receive the coal on carrying side from mobile harbour crane at cargo terminal to transfer same directly to Power plant and transfer fly ash on return side upto cargo terminal. It is envisaged that the single conveyor shall be utilized for transfer of coal from cargo terminal to power plant & fly ash from power plant to cargo terminal. Similar to option-1 complete pipe conveyor route shall be elevated so as not to avoid any hindrance to local people.

- **Option 3: Coal & Fly Ash handling through bulker trucks to Thermal power plant:**

Under this option, it is envisaged that both, the coal from cargo terminal to power plant and generated fly ash from power plant shall bbe carried and transferred by the bulker trucks.

The incoming coal from barges shall be unloaded into mobile hoppers (capacity of min. 1 grab) and thereby transported to the proposed power plant location using bulk trucks. The trucks shall carry the coal directly to the power plant or shall dump coal at coal storage area. The coal from the storage area shall be loaded into trucks with the help of frond end loaders, when required to dispatch from the IWT terminal.

Note: For handling of Fly Ash from inland waterway terminal, a pontoon platform with Gangway is proposed in both the options.

- **Comparison of options**

The following table depicts the comparison between the above two options:

Table 22: Comparison table of options

Sl. No.	Parameter	Option -1	Option 2	Option-3
1	Initial Investment	Initial investment is huge as about 7 km long conveyor has to be involved	Initial investment is huge as about 7 km long Pipe conveyor has to be involved	Comparatively low.
2	Land	Beside land requirement of terminal setup another huge land has to be acquired for installation of conveyor	Beside land requirement of terminal setup another huge land has to be acquired for installation of conveyor	Comparatively low, as land required for terminal setup has to be acquired only
3	Bulk Trucks	Required for Fly ash handling	No need	Trucks can be hired
4	Maintenance	Comparatively high due to 7 km long conveyor.	Comparatively high due to 7 km long pipe conveyor.	Low.
5	Fly ash handling system	By bulker trucks	By pipe conveyor (return)	By bulker trucks

Based on the above comparison table, it is envisaged that Option -1 (Conveyor system) & 2 (Pipe Conveyor system) requires huge initial investment and maintenance cost as compared to Option-3 (Bulk Trucks). Detailed cost comparison is provided in Para 5.6.3.

Facility Requirement

The IWT river infrastructure and shore based infrastructure shall be planned and developed to cater to the cargo forecast. Development of the terminal infrastructure shall also be suitably planned in such as a way that the projected capacity can be handled efficiently with minimum transportation cost.

River Infrastructure

The marine infrastructure comprises of RCC jetty, approach, pontoon, gangway and manoeuvring areas like approach channels, holding area, etc.

Navigational and Operational requirements

The basic navigational and operational requirements to service the vessels calling at a terminal are:

- Sufficient depth in manoeuvring area and at the jetty/pontoon.
- Sufficient depth and width in approach/navigational channel
- Adequate berthing infrastructure including berth fixtures like fenders
- Mooring system
- Navigational aids

Vessels Proposed for Cargo

The dimensions of manoeuvring areas are dependent on the design vessels arriving at the terminal and details of the same is presented in table below.

Vessel Type	Vessel Size (DWT)	LOA (m)	Beam (m)	Loaded Draft (m)
Barges (for Coal)	2000	95	15	2.5
Barges (for Fly Ash)	2000	95	15	2.5

The detail design and proposed vessel specifications are provided in **Chapter 7: Vessel Design.**

5.4 LAND DETAILS

The tentative quantity of land required for terminal development and construction of jetties is about 18,375 m^2 (175m x 105m) for terminal complex. The land is privately owned agricultural land.

5.5 GEOTECHNICAL INVESTIGATIONS

Geological investigations are proposed to have a preliminary assessment of the foundation profile at the terminal location. At the initial stage of DPR studies, during survey and investigation period, the terminal is proposed near Phulbagan village; about 3-4 Km uspteram of Goai village and the geotechnical investigations was done at this site. Phulbagan location was envisaged on the basis of feasibility studies and discussion with IWAI thereafter. However, on the basis of detailed survey and investigations done during DPR stage of studies and discussions done with IWAI on this basis, new location for Dry bulk cargo terminal is proposed at Goai village. As the strata is approximately similar for such small distance, the result of investigations obtained from Phulbagan site are used for preliminary engineering design of jetties and terminal buildings proposed at Goai village, in the DPR.

5.5.1 Regional Geology

The district is covered by alluvium along the Ajoy river basin. The deposits which cover the immense alluvium plain of the Ganges and Brahmaputra and their tributaries belong in part to an older alluvial formation, which is usually composed of massive argillaceous beds of a rather pale reddish-brown hue often weathering yellowish, disseminated throughout which occur *kankar* and pisolitic ferruginous concretions. The soil is partly laterite clay more or less altered and partly a red coloured coarse grained sand, characteristic of the eastern ranges of the Vindhya formation, large surfaces composed of which are to be found in the bed of the Ajoy river.

5.5.2 Physical Condition and Drainage

The region covers the western portion of the district. It is sort of an extended portion of the hill ranges of Central India and Chhotanagpur plateau in the north. It is characterised by the narrow strip of rocky and undulating land with laterite soils between the Ajay river on the north and the Damodar river on the south, with the Barakar as a river boundary line on the west. The highland range rises at places to over 60 metres and runs to the south of the Ajay river. The general slope is from north-west to south-east. Most of the streams of the region fall into the Damodar river which flows towards the south-east direction. The laterite soil mostly occurs in the region. The land surface is generally covered with red loamy clay

and sand. There is no big forest except some areas which are covered with Sal and other small scattered trees.

The Ajay rises in the Munger district of Bihar. It is a torrential stream and floods quickly. The bed is sandy and the banks are low. Owing to extensive soil erosion in its upper reaches, the Ajay carries down enormous load of coarse sand making the agricultural land infertile. Formerly the river was the only route through the dense forest that once covered this part of Bengal and its importance is evidenced by the line of forts found along its banks. The river turns east-southeast a few miles east of Chittaranjan to describe the district boundary between Jharkhand and Barddhaman (West Bengal). The Birbhum-Barddhaman boundary runs through the centre of the stream till the Ajay enters Katwa. It flows east in a meandering channel thus forming the boundaries between C.D. Blocks of Mangalkot – Ketugram-I, Mangalkot – Ketugram-II and Ketugram-II – Katwa-I until it joins the Bhagirathi river above Katwa-I C.D. Block. The Tumuni and the Kunur are the two largest tributaries of the Ajay river in the district.

5.5.3 Sub-surface Investigations

Soil Boring was carried out by Shell & Auger followed by Rotary Mud Circulation tools, operated by mechanical winch, to sink nominal 150 mm diameter boreholes. Auger was turned through auger pipes to cut soil at the bottom of the hole, which were in turn held in the auger & were drawn to the surface by pulling the auger out of the hole each time the auger was filled. In continuation to auger boring, Shell was used which is a 140 mm diameter heavy steel cylinder with a cutting edge under a hinged one-way flap valve, at the bottom. The borehole was advanced by raising the Shell upto desired height & allowing it to fall freely repeatedly till sufficient amount of soil enters in the Shell. The details of Geotechnical Investigations & Lab Reports are placed at **Volume-IV**.

Geotechnical Laboratory tests on the soil samples were conducted as per the relevant provisions of different Sections of BIS Code. For proper identification and classification of the subsurface deposits and for deriving adequate information regarding the physical and engineering properties, the required laboratory tests pertaining to the soil types were conducted on the representative soil samples collected from boreholes.

Following laboratory tests have been conducted on the selected soil, rock & water Samples:

a) Grain Size Analysis (Sieve)
b) Liquid Limit
c) Plastic Limit
d) Bulk Density
e) Direct Shear Test
f) Specific Gravity

5.5.4 Geotechnical Results and Analysis

Phulbagan Site, Katwa

For geotechnical analysis purpose, the sub-soil at this site can be broadly distinguished in 3 (three) different strata upto the maximum depth of exploration of 25.0 m. At this jetty site, below the top, 0.6 m thick, top river deposit, there exists a medium dense, whitish / brownish grey, silty Sand deposit (Stratum-I) continued upto a depth of 6.0 m from the Existing Ground Level (EGL). This is followed by a dense, whitish / brownish grey, silty Sand layer (Stratum-II) extended upto a depth of 10.4 m. Below this & upto the maximum depth of exploration of 25.0 m, there exists a very dense, whitish / brownish grey, silty Sand deposit (Stratum-III)

The detailed report on Geotechnical Investigation is provided in **Volume – IV** of the DPR. The bore log data sheet is also provided below.

BORE LOG DATA SHEET								JOB NO.	P-SUR-027-EGIS
Site	Phulbagan, Ajoy		**Location**	Jetty Ghat		**BH No.**	1	**Client**	EGIS/IWAI
Date of Commencement :			04.03.17	**Date of Completion :**		04.03.17		**BH Depth (m)**	25.05
Soil Boring Method		Shell & Auger		**Size**	150 mm	**Co-ordinate**		23° 38' 54.62"N, 88° 4' 42.75" E	
Rock Drilling Method		-		**Size**	-	**Reduced Level (m)**		16.38	**Sheet No.**1

SAMPLE & INSITU TESTS				N - Value	Strata Depth (m)	DESCRIPTION
Depth (m)		Type	No.			
From	To					
					0.00	
						Top river transported soil deposit of silty clay/Clayed Silt mixed with sand
0.50		D	1	-		
					0.60	Medium dense, compacted whitish/brownish grey silty fine sand mixed with mica and clay as binder.
1.00		D	2	-		
1.50	1.95	P	1	16		
2.00		D	3	-		
3.00		D	4	-		
3.00	3.45	P	2	-		
4.00		D	5	-		
4.50	4.95	P	3	1		
5.00		D	6	-		
6.00		D	7	-		
					6.00	
6.00	6.45	P	4	37		Dense, whitish/brownish grey silty fine sand mixed with mica.
7.00		D	8	-		
7.50	7.95	P	5	43		
8.00		D	9	-		
9.00		D	10	-		
9.00	9.45	P	6	48		
10.00		D	11	-		
					10.40	
10.50	10.95	P	7	56		Very dense, whitish/brownish grey silty fine sand mixed with mica.
11.00		D	12	-		
12.00		D	13	-		
					12.00	
12.00	12.45	P	8	61		Very dense, whitish/brownish grey silty fine sand mixed with mica.
13.00		D	14	-		
13.50	13.95	P	9	53		
14.00		D	15	-		
15.00		D	16	-		

BORE LOG DATA SHEET							JOB NO.	P-SUR-027-EGIS
Site	Phulbagan, Ajoy	**Location**	Jetty Ghat	**BH No.**	1	**Client**	EGIS/IWAI	
Date of Commencement :	04.03.17	**Date of Completion :**	04.03.17			**BH Depth (m)**	25.05	
Soil Boring Method	Shell & Auger	**Size**	150 mm	**Co-ordinate**		23° 38' 54.62"N, 88° 4' 42.75" E		
Rock Drilling Method	-	**Size**	-	**Reduced Level (m)**		16.38	**Sheet No.**1	

SAMPLE & INSITU TESTS				N - Value	Strata Depth (m)	DESCRIPTION
Depth (m)		Type	No.			
From	To					
15.00	15.45	P	10	69		
16.00		D	17	-		
16.50	16.95	P	11	63		
17.00		D	18	-		
18.00		D	19	-		
18.00	18.45	P	12	72		
19.00		D	20	-		
19.50	19.95	P	13	68		
20.00		D	21	-		
21.00		D	22	-		
21.00	21.45	P	14	78		
22.00		D	23	-		
22.50	22.95	P	15	84		
23.00		D	24	-		
24.00		D	25	-		
24.60	25.05	P	16	89		
					25.05	

Remarks – .	Water Struck at (b.g.l)
Borehole is terminated at 25.05 m below existing ground level.	

D – Disturbed Sample; **B** – Bulk Sample; **W** – Water Sample; **U** – Undisturbed Sample; **P** – Standard Penetration Test; **V** – Vane Shear Test

5.6 TERMINAL INFRASTRUCTURE INCLUDING EQUIPMENT

IWT Terminals proposed to be constructed with the following infrastructure facilities for operation.

a) 1 no. of 118 m long X 30 m wide RCC jetty (Jetty no. 1) along with 25 m long X 15 m wide RCC approach jetty founded on friction piles.
b) 1 No. of floating pontoon platform along with Gangway for handling of fly ash.
c) Mobile harbour crane (800 TPH capacity)
d) Administration Building
e) Bank protection arrangement,
f) Vehicle Parking area,
g) Open storage area,
h) Security Shed,
i) Fly Ash Silos
j) 4 nos. Fort lift Trucks (3T capacity), Pay loaders & Dumper tracks, and
k) Weight bridge, Watch and ward, Compound wall, Fire fighting arrangement, Electrical & PH Facilities including DG.

As per the scope of work mentioned in ToR preliminary engineering design is done in the DPR. The detailed engineering & design of terminals shall be carried out during the construction stage. The preliminary layout shown in **Volume-II** drawing is proposed for the DPR purposes only.

The terminal is envisaged to have third party waste collection facility from the terminal as well as on-board vessels. Third party shall provide a portable waste collection tank equipped with necessary pumping arrangements

Major facilities provided at proposed terminals for safe and efficient terminal operation are discussed in detail as below:

5.6.1 Cargo Handling

5.6.1.1 Mobile Harbour Crane

Mobile harbour cranes are the most versatile port cranes, suitable for handling general cargo, containers and bulk materials. The cranes offer high flexibility in combination with

relative low operating costs. Mobile harbour cranes are available in different sizes, optimised for working in small barges up to unloading capsize bulk carriers

There are essentially two types of unloaders: Viz intermittent unloaders and continuous unloaders In case of intermittent unloaders, the unloading operation is cyclic involving many elements in the operation. An example of this is the grab bucket type unloader. The working cycle of such an unloader involves lowering of the bucket in to the barge's hatches, opening and closing of the grab buckets for collection of coal, filling up of buckets, lifting the buckets back from the barge's hatches and leading the bucket to the receiving hopper or directly into bulk trucks for unloading the coal, opening the grab bucket, discharging the material and resetting the bucket for the next operation. Because of the cyclic nature of operations, the throughput gets fixed by the cycle time.

In case of continuous unloaders the number of such operations is far less and therefore the cycle time is less and so the throughput is expected to be higher than intermittent unloaders Throughput also gets affected by the unloading of coal owing to the shape of the pile. The unloading rate is not constant throughout the height of the pile. Because the amount of material available for unloading is less at the top of the pile, the unloading rate that can be achieved at this location is smaller.

The ratio of average rate (also called the through the ship capacity) and the peak capacity varies with the type of unloader as it is governed not only by the pile configuration but also by the nature of operation of the unloader viz cyclic in the case of intermittent unloaders and almost continuous type of operations in case of continuous unloaders For an intermittent unloader the ratio can be 50 to 60 percent and for a continuous unloader it can be about 75 percent. In case self-unloading vessels fitted with belt conveying systems for unloading, this ratio can be as high as 90 percent.

In the proposed IWT terminal for unloading of the coal from the coal barges, tyre mounted grab crane of unloading rate of min. 800 TPH is proposed. The grab crane shall unload coal from the barge with the help if adequate capacity grab and shall unload same directly into the mobile hoppers and thus into bulk trucks.

In case truck is not available the crane shall unload the coal on the jetty area and same shall be loaded into trucks by the help of front end loaders

The Proposed crane shall have following parameters:

Material handling capacity bulk (min.)	800 t/h (minimum)
Hoisting/lowering speed	90 m/min or as per actual requirements
Slewing speed	1.60 rpm or as per actual requirements
Luffing speed	83 m/min or as per actual requirements
Travel speed	5.40 km/h or as per actual requirements
Mobility	Rubber tyred
Bucket Type	Grab
Fields of application	Bulk handling /General cargo operation
Lifting height max.	42 m or as per actual requirements

5.6.1.2 Jetty Structure and Approach Jetty

The approach jetty is an open piled structure, 25 m long and 15 m wide with a deck elevation of +6.0 m CD. The pile spacing of 0.750 m dia pile is 4m in longitudinal direction and 5 m in transverse direction. Beams of 1.0m wide and 1.2m deep in both directions connect the piles. The deck slab, which accommodates the deck furniture, is 0.35 m thick.

The cargo berth is 118m long and 30m wide piled structure. The structure is supported by 1.0m dia piles. The spacing in longitudinal direction is 5m and transverse direction is 5.5m. The deck slab is 0.35m thick and elevation of the same is +6.0m CD

5.6.1.3 Open Storage Areas

A common open Storage shed for temporary storage of coal of area 95m X45 m is proposed for storage of Coal. The space shall be used a halt for the receiving/dispatch of the coal for the short duration only with the help of dumper trucks & frond end loaders

For bottom of the storage area sufficient ground improvement shall be done as envisaged during construction stage. The area shall be with adequate drainage facility around the perimeter boundary. The storage area shall be equipped with high mask of adequate lux/illumination at the corners of the area

Ground improvement, shall be required to achieve required bearing capacity accordingly for the storage areas. The ground is well compacted for a depth of 2 m in layers of 225 mm with the road roller; in which the top layer of the ground is then compacted with stone aggregate of specified sizes in uniform thickness by a vibratory roller to proper grade and camber.

5.6.2 Fly Ash handling

5.6.2.1 Pontoon

A pontoon also known as a floating platform uses floats or shallow-draft boats to support a continuous deck for pedestrian and vehicle travel. The buoyancy of the supports limits the maximum load they can carry. The level of the pontoon will vary as per the tide variations. Floating pontoon shall provide the support to the other end of the approach bridge and also provide berthing to the cargo vessel/barge. The pontoon is to be stationed at proposed terminal locations along river. The pontoon will be moored at site via sets of catenary and anchors The pontoon shall be suitably chained anchored to the river bed for the horizontal & vertical stability.

The pontoons shall be as per Indian Register of Shipping rules / regulations for dumb barge / pontoon applicable to inland waters The pontoon shall be designed and built in accordance with the requirements of the rules and regulations of:

a. IRS (Indian Register of Shipping) or any Classification Society who is member of International Association of Classification Society (IACS)
b. The Inland Vessel Act 1917 and as amended in 2007.

The Pontoon shall comply with IMO's stability requirements. The Pontoons shall not have any trim by fore in any of the operating conditions at terminal. The pontoon shall be shaped with rounded corners and swims ends. The hull shall be divided into watertight subdivisions for the stability.

The steel to be used for the construction of the pontoon shall comply with IS 2062 Grade B or equivalent. The welding works shall be of excellent quality and using high quality electrodes and shall be done by certified welders Necessary hull preservation and painting shall be done for the prevention of corrosion. Draft marks shall be suitably placed on pontoon of 3 mm in welded steel plate and painted with at least two coats. They shall be located at intervals of 200 mm vertical (P&S) and at forward aft and amidships. The accuracy of these marking will be checked & verified.

The pontoon shall be designed to encounter current of maximum 2m/sec during flood. Suitable mooring arrangements along with anchors shall to be provided along the sides. The winches, anchor chain, mooring ropes, shackles etc. shall be as per the class requirement.

The Steel fenders shall be of min. 300 mm dia (6 mm thick) shall be placed on either side for 95 percent of the length of pontoon. Tyre fenders of sufficient size shall also to be provided on both sides in such a manner that the spacing between them does not exceed 1250 mm. Lugs of not less than 16 mm to tie up these tyres shall be welded to the sides.

5.6.2.2 Gangway

A Gangway is passageway through which to enter or leave. It is an articulating bridge or ramp, such as from land to a dock/platform or a ship.

The gangway is envisaged at proposed terminal to embark and disembark of fly ash hoses/pipes form the terminal to the vessel. The gangway proposed shall be of 30 m length and 2.2 m wide for the placement of the hoses and the man movement. The gangway shall be designed considering OSHA and other relevant standards. The gangway shall be built according to the rules and regulations of Indian Register of Shipping.

A number of factors have to be considered for the proper design:

- Environmental impact,,
- Wind loads
- Tidal Fluctuations and traffic

- Present and future vessels to be served

Periodic maintenance shall be performed to ensure safe operation of the gangway. Gangway shall be designed using only the best materials and components, together with intelligent design and to reduce maintenance.

Gangway shall be constructed with shore side pivot and fixed to landing pontoon with hooks and pin allowing vertical motion during tidal fluctuations.

The installation of gangway shall be with Roller arrangement on pontoon and on yoke foundation on the bank.

Steel used for construction of gangway shall confirm to IS 226 – 1975 or IS 2062 – 1984. All electrodes are to confirm to relevant Indian Standard and IRS Rules. The gangway shall be of all welded construction. The skilled welders and updated technology shall be utilised for undertaking construction of gangway.

All the internal and external surface of gangway shall be thoroughly cleaned and painted to prevent corrosion. Minimum Two coats of anti-corrosive paints shall be done following one coat of zinc chromate primer.

5.6.2.3 Fly Ash Silo

1 No. silo to store 2000 MT of dry fly ash with plus 10% margin shall be provided in front of pontoon. Storage silo shall be of conical bottom type with the provision of air slides / fluidizing pads at the bottom. Storage silos shall be provided to store precipitator fly ash with adequate air space. This silo shall be used to collect dry fly ash from the bulk carrier trucks and further loaded to barges.

The silos shall be Steel constructed, water tight and relatively air tight with minimum 12 mm thick MS plate conforming to relevant Indian Standards and Specifications. The silo shall be completed in all aspect including stair case, civil foundations, lugs, supporting structures etc. and designed for minimum 30 year life.

Design shall be as per IS: 9178 (Part 1 to Part 3).

All silo components shall have Zinc coating. ISO 12944 shall be followed for carrying out the painting job for taking care of Cleaning, Protective Coating and Painting designed for service life of 15 years

The Silos are to be top loading and bottom discharge. The intake capacity of each Silo shall be minimum 300 Tons per Hour (TPH) and discharge capacity is about 250 Tons per Hour (TPH).

The silo shall be provided with following arrangement for loading and unloading the fly ash.

1) There shall be pneumatic unloading fly ash facility consist of electrical operated compressor, pneumatic pipe up to silo top with all necessary fitting.
2) Bag filter type Dust Extraction System shall be fitted on silo to collect dust from the silo. The system shall be complete in all respect, the system shall be capable to collect the dust from bottom discharge conveyor also.
3) Bag filters shall be provided on the storage silo for cleaning the aeration and displaced air before venting out.
4) The dust loading from the outlet of the bag filters shall not exceed 50 mg/Nm3 under any operating condition with 10 per cent bags plugged.
5) The provision of a proven dust collection system in the storage silo that separate out bulk of the ash from the conveying air shall be provided before the air is extracted through the bag filter.
6) Storage silo shall be provided with a separate and dedicated floor aeration system. This aeration should only be required during silo unloading and should not be in operation during storage periods.
7) The pressure / vacuum relief valves in the storage silo shall be provided.
8) Flow control for the ash shall be adjusted with the help of flap gate (electric operated).

COMPONENTS OF SILO

1) Manhole for maintenance to be provided at top of silo.
2) Level scanner shall be provided at silo top to monitor the level of ash in silo.
3) Silo roof to be equipped with peripheral walkway with railing at eave height and middle of the roof.
4) Roof step ladder with railing to be provided and it should also have access with overhead walkway.

INSTRUMENTS

The Silo shall be provided with following instruments as a minimum:

a)	Level switches (High and Low)	:	1 No.
b)	Differential pressure gauge across the bag filter	:	1 No.
c)	Differential pressure switch across the bag filter	:	1 No.
d)	Pressure gauge at the inlet of the bag filter	:	1 No.
e)	Differential pressure gauge across the vent filter	:	1 No.
f)	Differential pressure switch across the vent filter	:	1 No.
g)	Pressure gauge at the inlet of the vent filter.	:	1 No.

The Ash Handling System shall be designed for operating at wind speed of 24 m/sec and at 45^{o} C temperature.

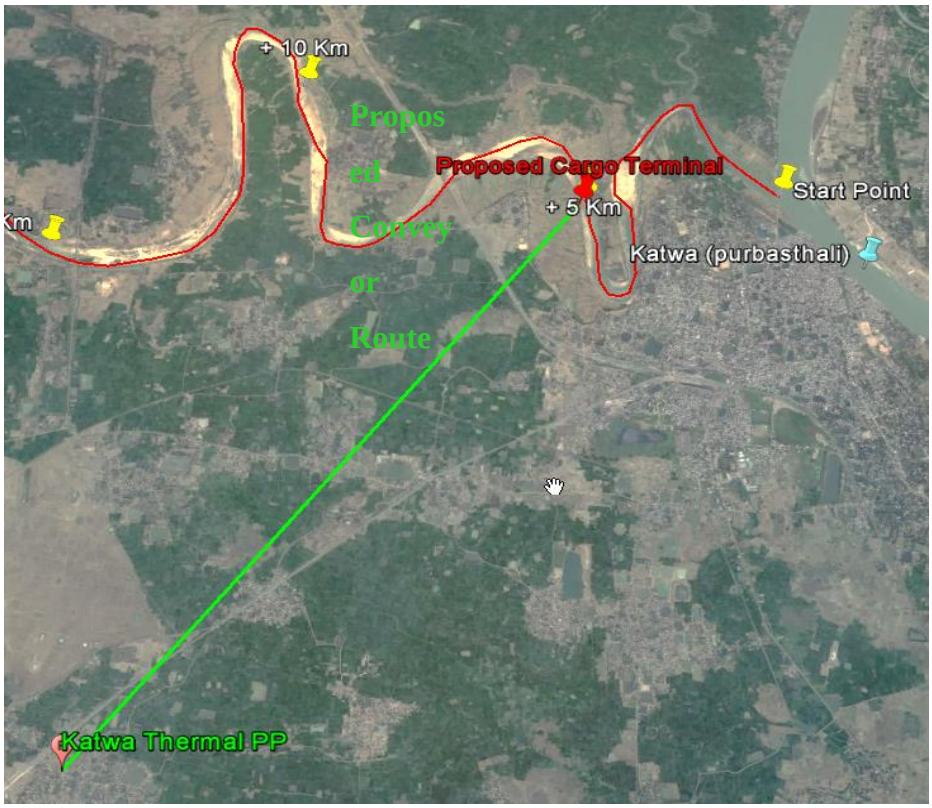
5.6.3 Comparison with Conveyor System

Option-1

Material	Mode of Conveyance
Coal	Trough Belt Conveyor
Flyash	Bulker trucks

In Option 1 it has been envisaged that coal from Cargo terminal to Proposed power plant shall be conveyed by the Mechanised conveyor whereas generated fly ash from the power plant to the cargo terminal shall be handled by the bulker trucks.

Mechanized coal handling system through 45 degree trough belt conveyor System has been proposed to receive the coal from mobile harbour crane at cargo terminal to transfer same directly to Power plant at a distance of about 6.9kM. It is envisaged that complete conveyor route shall be elevated so as not to avoid any hindrance to local peoples.



Belt Conveyors shall be complete in all respects and shall include but not limited to conveyor belting (steel cord), idler rolls with supports, pulleys, drive units (dual drive) with base frames, head and tail frames, take-up units, skirt boards, scrapers, elevated conveyor structure, stringer frames, short supports, deck plates, gates, etc. and all bolts including anchor bolts. The components of conveyors proposed in the facility shall be standardized to the extent possible. Since single conveyor hand been envisaged for 6.9Km distance, so to take care of operating tensions of conveyor Steel cord belting shall be used. Belt ratings are selected in such a way that normal working tension in the belt will not exceed 80 % of the maximum allowable working tension.

Table 23: General Data Sheet for Belt Conveyor System

S. no.	Description	Parameters
1.	Material	Coal
2.	Conveyor Capacity (Design)	1000 TPH

S. no.	Description	Parameters
3.	Length	6.9 Km Approx.
4.	Conveyor route	Elevated
5.	Belt Width	1200mm, Steel Cord type (FR Grade)
6.	Motor	TEFC Squirrel cage Induction motors X Dual Drive
7.	Gear boxes	Helical or bevel helical type
8.	High speed couplings	Scoop controlled / delayed chamber type
9.	Low speed couplings	Geared type
10.	Brakes	Thrustor type (as applicable)
11.	Carrying idlers	Fixed type with three equal rolls with 45° troughing angle
12.	Return idlers	Fixed type and provided with two equal rolls with 10° trough ('V' type)
13.	Pulleys	Mild steel construction keyed to forged steel shafts with vulcanized natural rubber lagging
14.	Belt cleaners	**External belt cleaners** Double bladed, spring loaded modular segmented and replaceable polyurethane scrapper **Internal belt cleaners** V plough type made of mild steel flats and hard rubber strips
15.	Take-up	Automatic take-up of gravity type
16.	Protection Switches	Pull chord switches, Belt sway switches, Zero speed switches, Chute blockage switches, etc.

Table 24: Costing for Belt Conveyor System*

S. no.	Description	Quantity	Units	Cost per unit INR	Total cost in INR
1	Conveyor belt	6900	m	1,500	1,03,50,000
2	Conveyor Drive Unit (including Motors, Gear Boxes, Couplings, etc.)	2	per piece	70,00,000	1,40,00,000
3	Carrying idlers assembly	6,273	unit/set	70,000	43,91,10,000
4	Return idlers assembly	2,300	unit/set	65,000	14,95,00,000
5	Pulleys assembly with plummer block	15	unit	2,00,000	30,00,000
6	Conveyor Frame, gallery Structures (Elevated) & towers	lot	-	-	80,00,00,000
7	Take-up	1	unit	25,00,000	25,00,000
8	Protection Switches	2,300	set	1,500	34,50,000
9	Other misc. equipments	lot	-	-	50,00,000
Total for conveyor system					**1,42,69,10,000**
10	Fly ash handling charges (as per table 24)	12,00,000	T	110	13,20,00,000
Total					**1,55,89,10,000**

**Figures shown are tentative / calculated on the basis of initial available data, may vary ±15% during detail engineering*

Option-2

Material	Mode of Conveyance
Coal	Pipe Belt Conveyor
Flyash	Pipe Belt Conveyor

Mechanized material handling system through pipe belt conveyor System has been proposed to receive the coal on carrying side from mobile harbour crane at cargo terminal to transfer same directly to Power plant and transfer fly ash on return side upto cargo terminal. It is envisaged that the single conveyor shall be utilized for transfer of coal from

cargo terminal to power plant & fly ash from power plant to cargo terminal. Similar to option-1 complete pipe conveyor route shall be elevated so as not to avoid any hindrance to local peoples.

Table 25: General Data Sheet for Pipe Belt Conveyor System

S. no.	Description	Parameters
1.	Material	Coal
2.	Conveyor Capacity (Design)	1000 TPH
3.	Length	6.9 Km Approx.
4.	Conveyor route	Elevated
5.	Pipe Dia.	600mm
6.	Belt Type	2200mm, Nylon-Nylon type (FR Grade)
7.	Motor	TEFC Squirrel cage Induction motors X Dual Drive
8.	Gear boxes	Helical or bevel helical type
9.	High speed couplings	Scoop controlled / delayed chamber type
10.	Low speed couplings	Geared type
11.	Brakes	Thrustor type (as applicable)
12.	Carrying idlers	Fixed type with three equal rolls with 45° troughing angle
13.	Return idlers	Fixed type and provided with two equal rolls with 10° trough ('V' type)
14.	Pulleys	Mild steel construction keyed to forged steel shafts with vulcanized natural rubber lagging
15.	Belt cleaners	**External belt cleaners** Double bladed, spring loaded modular segmented and replaceable polyurethane scrapper **Internal belt cleaners** V plough type made of mild steel flats and hard rubber strips
16.	Take-up	Automatic take-up of gravity type
17.	Protection Switches	Pull chord switches, Belt sway switches, Zero speed switches, Chute blockage switches, etc.

Table 26: Costing for Pipe Belt Conveyor System*

S. no.	Description	Quantity	Units	Cost per unit	Total cost in INR
1	Conveyor belt	6900	m	1,500	1,03,50,000
2	Conveyor Drive Unit (including Motors, Gear Boxes, Couplings, etc.)	2	per piece	80,00,000	1,60,00,000
3	Carrying idlers assembly	6,273	unit/set	2,00,000	1,25,45,45,455
4	Pulleys assembly with Plummer block	15	unit	2,00,000	30,00,000
5	Conveyor Frame, gallery Structures (Elevated) & towers	lot	-	-	80,00,00,000
6	Take-up	1	unit	25,00,000	25,00,000
7	Protection Switches	2,300	set	1,500	34,50,000
8	Belt turning & Cleaning arrangement	1	unit	50,00,000	50,00,000
9	Other misc. equipments	lot	-	-	15,00,000
Total					**2,09,63,45,455**

**Figures shown are tentative / calculated on the basis of initial available data, may vary ±15% during detail engineering.*

Option - 3

Material	Mode of Conveyance
Coal	Bulker trucks
Flyash	Bulker trucks

In option 3 it has been envisaged that both coal from cargo terminal to power plant and generated fly ash from power plant shall be carried and transferred by the bulker trucks.

Table 27: Costing for Option 3

S. no.	Description	Units	Quantity
1	Total Quantity of Coal to be transfer per annum (as per table 24)	T	30,00,000

S. no.	Description	Units	Quantity
2	Avg. handling charges of coal per tonne (for 12-15Km diatsnce)	INR/T	100
3	Total Expense of coal per annum	INR	30,00,00,000
4	Total Quantity of Fly ash to be transfer per annum (as per table 24)	T	12,00,000
5	Avg. handling charges of coal per tonne (for 12-15Km diatsnce)	INR/T	110
6	Total Expense of Flysh per annum	INR	13,20,00,000
7	Total per annum for Coal & Flyash	INR/Annum	43,20,00,000
8	Maintenance Cost	@10%	4,32,00,000
9	Misc cost for tolls and other charges	@10%	4,32,00,000
10	**Total**		**51,84,00,000**

Table 28: Cost Comparison

S. no.	Description	Option-1	Option-2	Option-3
1	Total Cost (in INR Lacs)	15,589.10	20,963.45	5,184.00
2	Capital Cost (excluding land and road cost (In INR Lacs)	15,589.10	20,963.45	Nil (Bulker trucks envisaged to be hired)
3	Annual O&M cost (In INR Lacs) (@ 15% for conveyor system including Power, Man power, spares, maintenance, lubrications etc.)	2,338.00	3,145.00	5,184.00

As arrived from above table it can be observed that:

- Initial cost for installation of conveyor is much higher than that required for transportation by trucks (annually).
- Additional cost for acquiring land for construction of towers required to support elevated corridor of conveyor shall be taken care in case conveyor option is opted for further development.
- O&M cost for the conveyor option is high as compare to hiring of trucks where same shall be taken care by the owner.

5.6.4 Terminal Buildings

The following terminal buildings are proposed for proposed IWT terminal:

5.6.4.1 Terminal Administration Building

It will be 2-storied building housing the following:

- Administration wing of the terminal including documentation
- Terminal operations wing

It is assessed that the terminal administration building shall be of size 18m X 20m and will have a total floor area of 720 sqm (360 sqm per floor).

5.6.4.2 Security Office

This will be a single storied building for security personnel with a storage shed of size 2.5m X 2.5m, and shall be provided near the terminal entrance.

5.6.4.3 Weigh Bridge Building

This will be a single storied weigh bridge building with operator's cabin, and shall be provided near the terminal entrance.

5.6.4.4 DG / Transformer Room

The DG / Transformer room of size 10m X 11m shall be located near STP as shown in layout drawing.

5.6.4.5 Electrical Panel / Control Room

The Electrical Panel / Control room of size 18m X 15m shall be constructed beside admin building to install electrical panels and control equipments required for the terminal operation.

5.6.4.6 Worker's Amenity Building

Worker's Amenity Building with bath and lavatory facilities shall be located near terminal administration building. This will be a single storied building of overall size of 15m X 15m.

5.6.4.7 Underground reservoir / Fire Pump room

An underground sump/reservoir of 10m X 11m X 2.5 m of RCC structure is proposed for the storing of water. The minimum capacity of the tank shall be 150 m^3 (Potable Water) + 125 m^3 (Fire Water) = 275 $m^{3.}$ Beside Underground reservoir for stroring of the water, each building in the terminal shall have respective water storage tank on the roof for one day water requiremnts. A pump of suitable capacity shall be installed to pump water from tank to fill tanks on the roof.

The fire pumphouse shall also constructed over the underground sump/reservoir shall draw fire water for the same in care of fire.

5.6.5 Parking Area

An ample parking space within the terminal premises shall be provided for the bulk coal carrier trucks, Fly Ash carriers, Front end /pay loaders, cars, etc. The parking area shall be planned in considering the smooth movement of the vehicles without hindering the terminal operations.

5.6.6 Maintenance Shed

Maintenance shed is envisaged in the proposed IWT for the purpose of the in-house maintenance / repairs of the Front end /pay loaders, terminal equipment's and the minor repairs of trucks and bulk carriers

5.6.7 Boundary Wall / Fencing

It is proposed to provide boundary wall of 2.4 m height using brick masonry with barbed wire fencing. The boundary wall shall be provided along the periphery of the terminal area.

5.6.8 Internal roads

Based on the traffic study, it is implicit that both the import and export cargoes will be carried to and from the hinder land through road from IWT to power plant. Therefore, providing well-planned internal road network is essential for effective functioning of the terminal. Accordingly, the internal roads shall be provided with the capacity to cater the proposed traffic.

Inside the terminal area, a 2-lane road (min. 8 m) is proposed for movement of the bulk carriers/trucks/maintenance trucks/office cars

5.6.9 Dust Extraction System

a) Dust control and abatement systems shall be provided to contain escape of dust into atmosphere while the facilities at the terminal are in operation. The systems shall be designed to conform to the permissible limit of dust emission by the concerned statutory pollution control authorities.
b) However, the concentration of RSPM-10 shall be limited to an average 5 mg/normal cum over and above the ambient dust concentration measured at a circumferential distance of 5 m from the dust generation source.
c) The filtering efficiency shall not be less than 95%.
d) Dust Extraction System shall be designed in accordance with ACGIH & APPCB norms.

The following Dust Control System shall be provided

S. No	Facilities	Type	Description
1.	At top of Fly Ash Silo	Dust Extraction (DE) type	Insertable Pulse Jet compact bag filter type DE system mounted on the top of the silo

S. No	Facilities	Type	Description
2.	Mobile unit at pontoon for Fly ash handling.	Dust Extraction (DE) type	Mobile unit placed at pontoon connected via flexible hoses connecting form opening of the hatch of the vessel to the Insertable Pulse Jet compact bag filter for collection of the generated dust while loading of the barge/vessel
3	Coal Storage Area	Manual / water tanker mounted	Mobile water tanker mounted unit shall be utilised for sprinkling of water and thus controling dust from coal storage area.

The Dust Extraction System for silo shall consist of, but not limited to:

i) Compact reverse pulse jet unit with Insertable bag filters suitable for working at the ambient conditions.

ii) The filter media shall be of standard dimension using surface filtration technique so as to reduce the need of formation of primary cake for better reverse air jet cleaning process. The fabric shall be abrasion and static charge resistant, non-woven needle felt made from polyester or polypropylene. The bag filters shall be suitably supported from within with steel cages.

iii) The Air to Cloth ration shall be suitable maintained for the efficient working of filter

iv) Filter bags under cleaning cycle shall be 25 – 30% depending upon the system design.

v) Centrifugal air fans with backward curved blades. The capacities of the fans shall be as required at each potential dust generation point.

vi) A common Air Compressor shall be provided for the supply of reverse air jet to each dust extraction unit in the dust control system. The air compressor shall be able to deliver air at the required pressure at the inlet to pulse jet valve but shall not be less than 7 Kg/cm^2. The system provider may arrive at the capacities and operating pressure based on his system design. However, other parameters specified shall be adhered to.

5.6.10 Sewerage System

Sewerage system for the proposed IWT has been proposed considering the requirement of the proposed terminal vis-à-vis the development control regulation. An independent system has been proposed for the terminal considering the new CRZ regulation (if applicable).

5.6.11 Firefighting System

The main cargo commodities for proposed IWT Terminal have been grouped into following categories:

- **Dry Bulk** – Fly Ash, Coal.

A comprehensive single headed hydrant type firefighting facility is proposed for the terminal area. The fire pump house shall be constructed over underground water reservoir. Main fire header running from the pump house shall be laid inside the terminal.

The Hydrant type Fire Fighting System along has been envisaged exclusively for the facility:

- At the Jetty/Pontoon
- Along terminal boundary
- Coal Storage Area
- Near Fly Ash Silo
- Truck Unloading Area
- Truck Parking area, etc.

However for terminal building, pump room and Worker's Amenities Building Dry type fire extinguishers will be provided. Beside above, a continuous back up support will be provided by fire tenders round the clock.

The complete firefighting system shall be designed as per TAC guidelines. The system provided shall cater to the jetty and terminal area. However, for future developments, separate dedicated firefighting system may be required based in the future requirements.

CLASS OF FIRE

Class A: Fires involving materials such as wood, paper, fibers and the like which are in a solid form.

Class B: Fires involving materials such as kerosene, petrol, paints, grease, solvents and the like which are in a liquid form.

Class C: Fires of an electrical nature involving electric equipment resulting from combustion of circuit breakers, wires, and other electric devices and equipment.

Class D: Fires involving materials such as magnesium, aluminium and the like which are reactive chemicals or active metals.

Class K: Fires involving cooking media like vegetable oils, animal oils and fats and those which generally occur in Kitchen.

Fire Water Pumping System

Fire water shall be drawn from the underground water tank constructed near STP. For pumping the fire water to hydrant system one (1) electric engine driven pump & one (1) diesel engine driven pump and one electric driven jockey pump (1W) shall be provided inside the pump house envisaged to be constructed over underground water tank. The exact capacity of the pumps required shall be worked out during detail engineering.

The fire water requirement has been worked out for 2 hours of continuous operation under ordinary hazard as Per TAC guidelines.

Hydrant system

Wet and Pressurised type fire hydrant system shall consist of a fire water ring main network of carbon steel pipes along with Isolation valves installed above ground around areas to be protected, hydrant valves (external / internal), hoses of suitable length, couplings, branch pipe, nozzles and along with all standard accessories.

Wet and pressurised type fire hydrant system shall be envisaged and shall be provided for every 45m regular interval & 3.5kg/cm2 pressure shall be maintained at the most remote point. The GA of proposed firefighting system is shown in above referred drawing. All the aboveground piping shall be adequately supported at regular intervals.

Each hydrant shall have one 63 mm (2 ½") outlet provided with an instantaneous coupling with cap and chain. Outdoor type fixed water monitors shall be provided for locations where water cannot reach from hydrant hose reel. Fire water pipes shall be of Carbon Steel conforming to IS: 1239 and IS: 3589. Underground piping at road crossings shall be protected with hume pipes.

Portable Fire Extinguishers (PFE)

Portable Fire extinguishers (PFE) are small hand held appliances that are used to put out fires in the very early stage of their inception. There are different types of extinguishers in use and their classification is based on the types of fires on which they are effective. Hence an understanding of the types of fire is very essential in selecting the appropriate type of extinguisher for use in a particular location.

Quantity

As per Standards / TAC (Tariff Advisory Committee) at least two extinguishers are to be provided in every area/ room. The appliances are to be so distributed over the entire floor such that a person has to travel not more than 15 metres to reach the nearest appliance.

As per TAC Guidelines - For any property, basic protection shall be appliances suitable for class A fires, since class A fires are of universal character.

Where class B fires are anticipated, a suitable number of appliances as determined above shall be replaced with appliances suitable for B class fires.

As a thumb rule the requirements specified above would mean approximately 2 extinguishers for every 600 m^2 of floor area or part thereof which would however be slightly less in case of light hazard occupancies having larger than 600 m2 floor area in a single fire compartment.

In rooms containing only electrical equipment such as electrical transformers, switch gears, motors or other electrical apparatus, not less than 2 KG Dry Powder or carbon Dioxide type extinguishers are to be provided within 15 metres of the apparatus.

In rooms containing motors and/or other electric equipment along with other machineries or facilities one 5 Kg. DCP or Carbon Dioxide extinguisher is to be installed within 15 metres of the equipment in addition to the requirements that were earlier specified.

Location

Generally Portable Fire Extinguishers (PFE) are to be placed as near as possible to exits or staircase landings by also taking into consideration (wherever possible) the normal routes of escape of persons. Placing PFE in such positions will enable these to be seen by persons following the natural impulse to get out of danger.

Standards further prescribe that PFE's be so located that the top of the extinguisher is located at a height of 1.5 metres from the finished floor level or that the bottom of the extinguisher is located at a height of 1 metre from the finished floor level.

Based upon the above the Selection of Fire Extinguishers shall be as follows:

A. For Terminal Administrative Building

a. Ground Floor:

Area = 20m X 18m : 360 m^2

Type of Fire Extinguishers Selected : (i) 1 X 5kg, DCP (Dry Chemical powder) Type ABC inside Electrical panel /Control room

(ii) 1 X 5kg, CO_2 inside office Area

b. First Floor:

Area = 20m X 18m : 360 m^2

Type of Fire Extinguishers Selected : 2 X 5kg, DCP (Dry Chemical powder) (Type ABC)

c. Terrace Floor (Inside Lift Room):

Type of Fire Extinguishers Selected : 5kg, CO_2 (Type ABC)

B. For Worker Amenity Building

Area = 15 m X 15m : 225 m^2

Type of Fire Extinguishers Selected : 1 x 2kg, CO_2

C. Maintenance Shed

Area = 25 m X 18m : 360 m^2

Type of Fire Extinguishers Selected : (i) 1 X 5kg, DCP (Dry Chemical powder) Type ABC

(ii) 1 X 5kg, CO_2 inside office Area

D. Electrical Panel / Control Room

Area = 15 m X 18m : 270 m^2

Type of Fire Extinguishers Selected : (i) 1 X 5kg, DCP (Dry Chemical powder) Type ABC

(ii) 1 X 5kg, CO_2 inside office Area

E. DG / Transfromer Room

Area = 15 m X 18m : 270 m^2

Type of Fire Extinguishers Selected : (i) 1 X 5kg, DCP (Dry Chemical powder) Type ABC

(ii) 1 X 5kg, CO_2 inside office Area

F. Truck Unloading Area

Type of Fire Extinguishers Selected : 1 X 5kg, DCP (Dry Chemical powder) Type ABC

G. Truck Parking Area

Type of Fire Extinguishers Selected : 1 X 5kg, DCP (Dry Chemical powder) Type ABC

H. Car Parking Area

Type of Fire Extinguishers Selected : 1 X 5kg, DCP (Dry Chemical powder) Type ABC

I. Drivers Rest Area

Type of Fire Extinguishers Selected : 1 X 2kg, DCP (Dry Chemical powder) Type C

J. Weigh Bridge Area

Type of Fire Extinguishers Selected : 1 X 5kg, DCP (Dry Chemical powder) Type ABC

K. STP

Type of Fire Extinguishers Selected : 1 X 5kg, DCP (Dry Chemical powder) Type ABC

L. Fire Pump Room

Type of Fire Extinguishers Selected : (i) 1 X 5kg, DCP (Dry Chemical powder) Type ABC

(ii) 1 X 5kg, CO_2 inside office Area

5.7 BERTHING STRUCTURE

The berthing structure for dry bulk cargo terminal at Goai village near 5km Chainage for Ajoy waterway should have:

- Berthing facility for dry bulk cargo vessel (jetty & pontoon),
- Equipment for loading/unloading of bulk cargo & fly ash,
- Sufficient draft to have safe navigation of ships to and from the terminal,
- Land based facilities for transit storage of bulk cargos,
- Berth should be accessible for cargo vessels having adequate turn-around space,
- Scope for future development.

In order to work out the Jetty/berth requirements to meet the projected requirement, it is necessary to define the following governing parameters:

- Average Parcel Size
- Cargo handling arrangement
- Cargo handling rates
- Number of operational days per year
- Number of working hours per day
- Effective working hours per day
- Time required for peripheral activities

The jetty shall have utility trench/duct to carry Hoses, pipe lines, cables etc., and it shall run all along the berth. The trench covers shall be seated properly and shall be intact with the trench side walls.

The jetty/pontoon shall have all the required accessories/fixtures including but not limited to the following:

- Fenders including all its ancillaries
- Bollards
- Mooring rings on berth face
- Safety ladders
- Handrails
- Wooden / stainless steel rubbing strip for the protection of edges of berth from rubbing of mooring ropes.
- Drain pipes shall be embedded at regular intervals. The proposed jetty shall be provided with suitable slope to drain off storm water.
- Galvanized iron edge angles at various locations including on the sides of openings/pits.
- Marking on top of deck slab

The proposed Jetty & Pontoon shall be connected by jetty approach/gangway from terminal area as shown in Layout drawing.

The approach proposed for Jetty no. 1 to have a clear width of 15 m (14 m for movement of vehicles & 1 m wide utility corridor for the placement of pipes, cables and other utilities. Floating pontoon of size 20m x 10m is proposed connected with gangway of 2.2 m wide for man movement and utility corridor for the placement of fly ash hoses, pipes, cables, etc.

Approach shall be designed to cater the movement of vehicular traffic in addition to the movement of crane.

AVERAGE PARCEL SIZE

Though the design vessel size is the guiding parameter in arriving at the dimensions of the navigable water ways, in actual practice vessels of various sizes will arrive at the IWT terminal. For ascertaining the requirement of number of berths, it is prudent to consider the

average parcel size for each proposed commodity and details of the same are presented below.

Table 29: Average Parcel Size for proposed commodity

Commodity	Average Parcel Size (MT)	Import/Export
Coal	2,000	Import
Flyash	2,000	Export

As already described in cl. 4.3.1 the total anticipated quantity of Coal for the proposed IWT is about 3.0 million tonnes annually and Flyash is 1.2 million tonnes annually.

5.8 TERMINAL COSTING

The cost estimate for proposed terminal, including O&M of the system has been worked out. The cost estimates for development of the system are considered as Capital cost while for operation of the system is termed as maintenance or operating cost (O & M cost).

5.8.1 Capital Cost

Capital cost for proposed terminal is provided in **Table 30** respectively.

Table 30: Capital Cost for Dry Bulk Cargo Terminal

Sl. No.	Facilities	Unit	Quantity	Unit Rate (INR.)	Cost (INR)
1	Pontoon X 1 No	No	1	50,00,000	50,00,000
2	Gangway (30m long X 2.2 m wide)	m^2	66	7,500	4,95,000
3	Berth / Jetty X 1 nos. (118m X 30m)	m^2	3540	75,000	26,55,00,000
4	Jetty Approach 25m X 15m wide (for Jetty no-1)	m^2	375	75,000	2,81,25,000
5	Supply & installation of Fenders	Nos	36	6,00,000	2,16,00,000
6	Mobile Harbour Crane (800 TPH capacity)	No.	1	30,00,00,000	30,00,00,000
7	Admin /Operating Building (18m X 20m), 2 floors	m^2	360	30,000	1,08,00,000

Sl. No.	Facilities	Unit	Quantity	Unit Rate (INR.)	Cost (INR)
8	Lift for Admin building	no.	1	10,00,000	10,00,000
9	Worker's Amenity Building (15m X 15 m)	m^2	225	25,000	56,25,000
10	Maintenance Shed/ Workshop (18m X 20m)	m^2	360	18,000	64,80,000
11	Driver's Rest Area (15m X 15m)	m^2	225	5,000	11,25,000
12	Parking Area	m^2	975	3,000	29,25,000
13	Open storage area (95m X 45m)	m^2	4275	7,000	2,99,25,000
14	Underground Water Reservoir (10m X 11m X 2.5m)	m^3	275	25,000	68,75,000
15	Fire Pump House (above underground water Reservoir) (10m X 10m)	m^2	100	25,000	25,00,000
16	Electrical Panel / Control room (18m X 15m)	m^2	270	30,000	81,00,000
17	Bulk Carrier Unloading Area (46m X 25m)	m^2	1150	8,000	92,00,000
18	Bulk Carrier parking Area (31m X 23m) (paved & compacted)	m^2	713	7,000	49,91,000
19	Pneumatic Unloading System including hoses	No.	15	6,00,000	90,00,000
20	Fly Ash storage Silo (2000 T) with foundation, Bag filter unit, level scanner, unloading system and all other necessary facilities	No.	1	3,00,00,000	3,00,00,000
21	Electrical, Water& Utility			lumpsum	1,00,00,000
22	Sewage Treatment Plant	No.	1	50,00,000	50,00,000
23	Road Weigh Bridge including installation	No.	1	12,00,000	12,00,000
24	Weigh Bridge Control room	m^2	30	18,000	5,40,000
25	Security Office (2.5m X 2.5m)	m^2	6.25	18,000	1,12,500
26	Boundary Wall (175m X 105M- opening lengths)	m	7810	12,000	9,37,20,000
28	Front End Loaders (3 t)	no.	3	35,00,000	1,05,00,000
29	Internal Roads (including land filling, levelling, compaction, ect. For 10m wide road)	m	640	60,000	3,84,00,000

Sl. No.	Facilities	Unit	Quantity	Unit Rate (INR.)	Cost (INR)
30	Fire Fighting System including Pumps, headers, hydrants, etc.			lumpsum	45,00,000
31	Overhead Tank (above admin building)	No.	1	10,00,000	10,00,000
32	Submersible Pump (2500lpm min.) including borehole digging, installation of pump, accessories, electrical & controls, pipes & laying etc. for potable water requirement	No.	1	12,00,000	12,00,000
				Total	91,54,38,500
33	Cost of Detail Engineering			4%	3,66,17,540
34	Construction supervision			6%	5,49,26,310
				Total	1,00,69,82,350
				Contingency @3%	3,02,09,471
	Total Capital Cost excluding land cost				**1,03,71,91,821**
	Total Capital Cost excluding land cost (in INR Lacs)				**10,371.92**
35	Land Cost for terminal building for 18,375 sqm of land @916.10 INR/sqm				1,68,33,360
				Contingency @3%	5,05,000
				Total of Land Cost	1,73,38,360
				Total of Land Cost in INR Lacs	173.38
	Total Capital cost including Land cost				**1,05,45,30,182**
	Total Capital Cost including land cost (in INR Lacs)				**10,545.30**

From above table, the total capital cost for proposed dry bulk cargo terminal in Ajoy waterway works out to **INR 10,371.92 Lacs** excluding land cost and **INR 10,545.30 Lacs** including land cost**.**

5.8.2 O&M Cost

Operation and Maintenance cost to be incurred for running terminal facilities are provided as below.

a) Manning

The efficient IWT operation requires a substantial number of staff. These include:-

- The Management comprising the Terminal Manager, Operating Superintendent and their deputies;
- The operating staff comprising Terminal Manager, traffic marshals etc;
- The Accounts Department comprising the Financial Manager and clerical assistants;
- Security Staff comprising the Security Chief and security officers
- Maintenance Engineering Staff comprising the maintenance engineer, his deputy, mechanical, electrical and civil engineers, foremen, fitters, welders, electricians, plumbers, joiners, painters, riggers and their mates and labourers;
- Administration staff comprising administrators, personnel, property managers, their assistants, secretaries and cleaning staff.

The total number of staff required to operate the terminal is estimated and provided in **Table 31.**

Table 31: Manpower Requirement for IWT Terminal Operation

Sl. No	Staff	Numbers
1	Management	6
2	Operating Staff	57
3	Accounts Staff	6
4	Security Staff	9
5	Maintenance Engineering Staff	15
6	Administration Staff	22
7	Misc. Staff for Field Works	6
	Total	**121**

Table 32: Manpower Cost per annum

Sl. No.	Location	No./ Shift	No. of Shift required	Total no. of Personnel required	Rate (INR)	Cost (INR)
1	Pontoon / Berth @3 persons per berth	6	3	18	4,00,000	72,00,000
2	Security Office	3	3	9	4,00,000	36,00,000
3	Maintenance Shed / Work shop	3	3	9	4,50,000	40,50,000

Sl. No.	Location	No./ Shift	No. of Shift required	Total no. of Personnel required	Rate (INR)	Cost (INR)
4	Weigh Bridge	1	3	3	3,50,000	10,50,000
5	Fire pump house	1	3	3	4,00,000	12,00,000
6	Admin Building	6	3	18	5,00,000	90,00,000
7	Accounts	2	3	6	5,00,000	30,00,000
8	Designer /Draught men	2	2	4	4,50,000	18,00,000
9	Senior Officers	3	2	6	10,00,000	60,00,000
10	Bulker unloading Area + Silo	3	3	9	3,50,000	31,50,000
11	Control Room	2	3	6	5,00,000	30,00,000
12	Open Storage Area	3	3	9	3,50,000	31,50,000
13	Front End Loader operators	3	3	9	3,50,000	31,50,000
14	Plumper	1	3	3	3,50,000	10,50,000
15	Electrician	1	3	3	3,50,000	10,50,000
16	Misc. for Field Works	2	3	6	3,50,000	21,00,000
	Total			**121**		**5,35,50,000**

From the above table, the total annual manpower cost required for running the terminal facilities works out to INR 5,35,50,000/- (**INR 535.50 Lacs annually**).

b) Utilities and Services

The annual cost of providing water, electricity and other services is considered as about 1.0% of the capital cost. Thus, the annual cost for providing Utilities and Services works out as **INR 103.72 Lacs.**

c) Maintenance

To ensure that the terminals are kept in an efficient and safe condition, it will be necessary to ensure that money is set aside for annual maintenance. In the first four years of operation, maintenance costs are comparatively low but would then build up as structures and equipment begin to be affected by wear and tear.

The annual cost of maintaining terminal structures including all civil, mechanical and electrical components is considered to be about 3% of the capital cost. Thus, the annual maintenance cost for all the terminals from fifth year onwards works out as **INR 311.16 Lacs.** The total O&M cost of proposed terminals are provided in terminal **Table 33** below

Table 33: Annual O&M cost of terminals

Sl. No	Item	Cost (INR) Lacs
1.	Manpower	535.50
2.	Utilities and Services	103.72
3.	Maintenance	311.16
Total annual O&M cost		**950.38**

6.0 PRELIMINARY ENGINEERING DESIGNS

The main objective of preliminary engineering is to ascertain quantitatively the feasibility of engineering works. Preliminary engineering is carried out to arrive at the preliminary sizing of all major facilities required at the terminal and waterway for safe navigation. The preliminary sizing, design and engineering of the facilities are presented in following sections.

6.1 RIVER TRAINING WORKS

As stated in Chapter 3- Fairway development, for ajoy waterway, a navigation channel of about 1.0 Km length is proposed from Chainage 0.5 Km to avoid bend 1. At bend 2 turning circle of 100.0 m radius for vessel movement and turning is provided.

The remaining section of fairway in the river is proposed for dredging as per waterway class IV. The total fairway stretch will start from the confluence point of Ajoy river with Bhagirathi river and ends near the proposed terminal structure.

The channel is proposed to be constructed as per waterway Class IV with bottom width of 50.0 m and min 2.5 m draft. The bed level of channel is proposed to be kept at EL 5.0 m, which is about 3.0 m below sounding datum of 8.114 m. Side slope of channel is kept as 1V:3H and 1.5 m wide berms are provided at every 3.0 m of vertical height. Stone pitching is proposed along the channel bed and banks upto channel top. A layout plant and section detail of the proposed channel is provided in **Figure 19** and **Figure 20.**

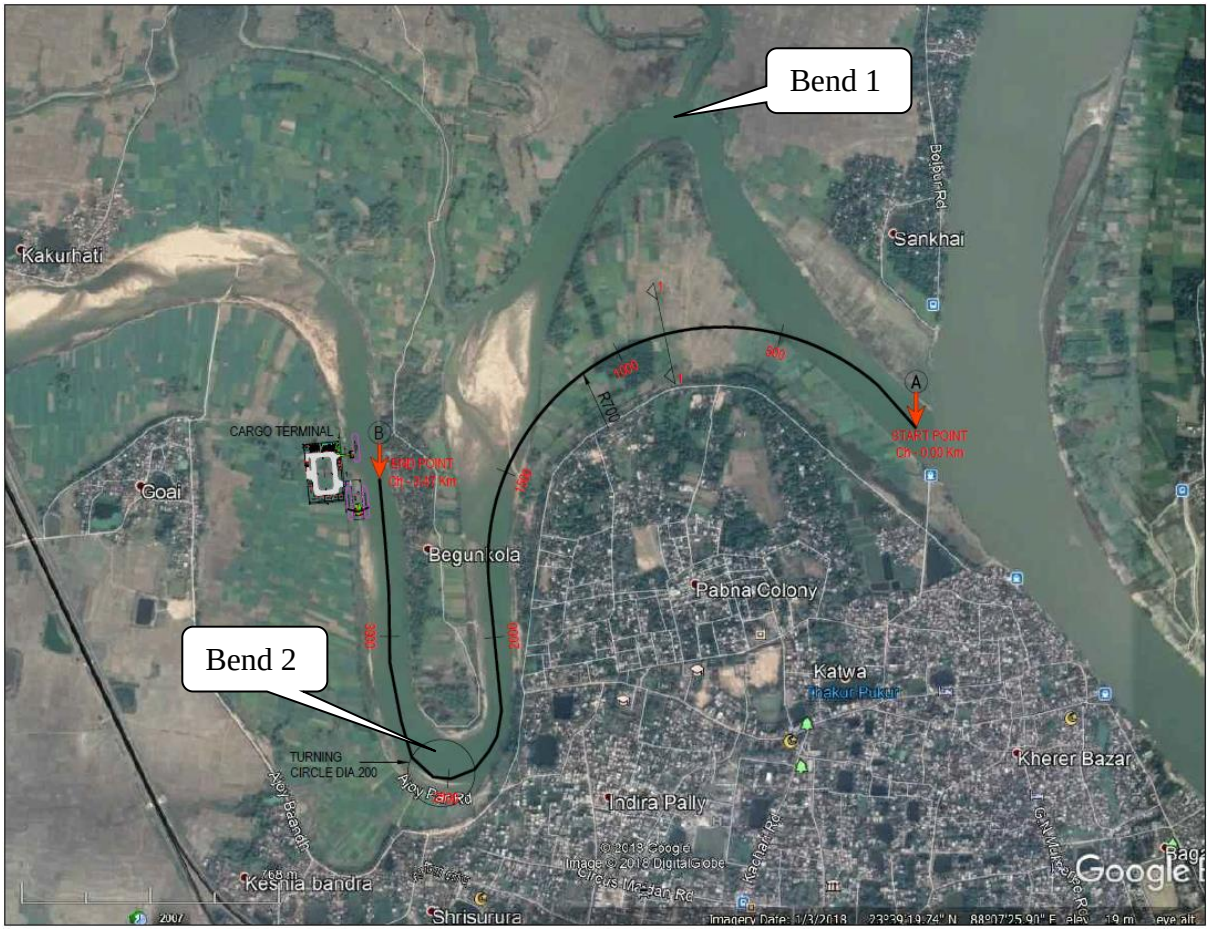


Figure 19: Layout plan of proposed fairway stretch for Ajoy Waterway

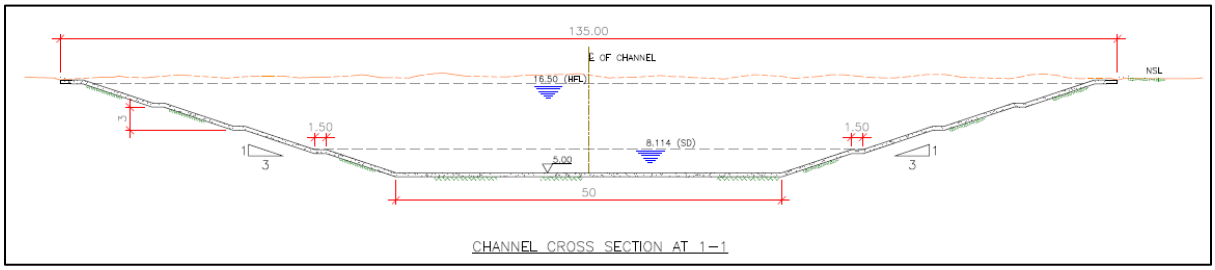


Figure 20: Section details of proposed channel for Ajoy Waterway

6.2 BANK PROTECTION

Stone pitching on slopes using stones weighing not less than 40 kg and stone spalls minimum 25 mm size to fill up voids between the stones is proposed along channel bed and banks upto the top.

6.3 NAVIGATION AIDS

The total navigation operation, ranging from arrival to departure, can be subdivided in to the following operations,

- Navigation through the waterway
- Arrival at Jetty
- Preparation for berthing, including possible turning of the ship and pre-berthing procedures
- Berthing including mooring, etc. to the berth structure
- Loading and unloading operation while at berth
- Unberthing from the berth structure
- Departure from the Jetty

Navigation aids for the waterway and terminals are required to ensure safe and efficient navigation of ships navigating through the waterway and berthing/un-berthing at terminals.

As for Ajoy waterway, one station can be set up as there are 2 stations in the near vicinity of the proposed waterway i.e. Swaroopganj and Kumarpur. The proposed waterway lies in between the two stations and one more RIS will further improve the navigability and accuracy. The details of proposed Navigation aids are provided in below **Table 34**. For further details please refer Chapter 8.

Table 34: List of Proposed Navigational Aids

Sr. No.	Equipment	Qty
A	**RIS System**	
1	AIS Base Station	1
2	RADAR	1
3	Meteo Sensor	1
4	ATG	1

Sr. No.	Equipment	Qty
5	VHF	1
6	DG Set 10 KVA	1
7	UPS	1
8	RIS Software	1
9	RIS Hardware	1
10	Installation Testing & Commissioning	1
11	Porta cabin	2
12	Trestle Tower	1
B	**Marine Lantern/Buoys**	**50**

6.4 TERMINAL STRUCTURE AND JETTIES

Preliminary engineering design required for DPR level costing and analysis for jetty, terminal structures and access infrastructure is done and provided as below:

Following codes and standards are used for preliminary design of structures.

Civil Works:

- IS 4651 (Part 1-5): Codes of Practice for Planning and Design of Ports and Harbors
- IS 456 - 2000: Code of Practice for Plain and Reinforced Concrete
- IS 800 – 1984: Code of Practice for General Construction of Steel
- IS 2911: Code of Practice for Design and Construction of Pile Foundations
- IS 1893 – 2002 (Part 1): Criteria for Earthquake resistant design of Structures
- IS 9527 (Part 3): Code of Practice for Design and Construction of Port and Harbor Structures
- IS 875 (Part 3): Code of Practice for Design Loads for Building and Structures-Wind Load
- IRC-6: Standard Specifications and code of Practice for Road Bridges, Section 2 Loads and Stresses

Geotechnical

- IS 2991 (Part 1 – Sec 2) 2010: Code of Practice for Design and Construction of Pile Foundations – Bored Cast in-situ Piles
- IS 14593 - 1998: Design and Construction of Bored Cast in-situ Piles founded on Rocks- Guidelines

Where applicable the following International Standards are referred

- BS 6349 Maritime Structures
- BS 8110 & 5400 Reinforced Concrete Structures
- BS 449 & API-RP 2A-WSD Offshore Platforms-Working Stress Design
- BS 5950 Structural Steel Work
- BS 8004 & 8000 Foundations
- MJ Tomlinson: Pile Design and Construction Practice, Fourth edition
- Joseph E Bowles: Foundation Analysis and Design, Fifth edition.

6.4.1 Design

The objective of this chapter is to present design of jetty structure proposed for Cargo terminal.

A. STRUCTURAL SYSTEM

The overall Layout showing location of facilities is shown in drawing provided in DPR **Volume-II**.

The approach jetty is an open piled structure, 25 m long and 15 m wide with a deck elevation of +17.5m. The pile spacing of 0.750 m dia pile is 4.5 m in longitudinal direction and 4 m in transverse direction. Beams of 0.9m wide and 1.2m deep in both directions connect the piles. The deck slab, which accommodates the deck furniture, is 0.35 m thick.

The cargo berth is 118m long and 30m wide piled structure. The structure is supported by 1.0m dia piles. The spacing in longitudinal direction is 5m and transverse direction is 5.5m. The deck slab is 0.35m thick and elevation of the same is +6.0m CD. Beams of 1.2m wide and 1.35m deep in both directions connect the piles.

Pontoons are also deployed to load/unload cargo.

Parking facilities are provided on land. Bulk carrier parking facility is provided with an area of 690m^2. Open coal storage is provided with an area of 4275m^2. Officer's car parking is provided with an area of 324m^2. Coal Dumper/Truck parking area is provided with an area of 600m^2. Bulk carrier unloading area is provided with an area of 1035m^2. A fly ash silo is provided with an area of 64 m^2.

Administrative building is provided for efficient management of port operations. Other facilities like maintenance shed for bulk carrier (360m^2), driver rest area (225m^2).

B. CONSTRUCTION METHOD

The construction method proposed for jetty and approach platform is as described below:

PILING

1) Drive steel liner up to refusal.
2) Bore inside the liner up to the founding level.
3) Lower Reinforcement cage and concrete the pile up to bottom of Pile muff.
4) Place sacrificial precast pile muff over the piles and concrete the annular space between the pile and pile muff.

ERECTION & CONCRETE WORK

1) After the in-situ concrete attains strength, place the precast pile cap U beams over the Pile muffs. Note that the Precast U beams are designed as part of permanent structure.
2) Concrete inside the U beam upto the soffit level of bottom slab.
3) After the in-situ concrete attains strength place precast planks and precast Fender wall panel over the U beams.
4) Cast the in-situ portion of the bottom slab.
5) On completion of concrete works fixtures like fenders, bollards, pipes and cable support system shall be installed
6) All equipment, pipes, cables, light poles shall be installed at the end.

C. DESIGN CRITERIA

LOADING DATA

The principal loads considered for design of various components are listed as below:

1) Dead Load
2) Live Load
3) Wind Load
4) Wave Load
5) Current Load
6) Berthing Load
7) Mooring Load
8) Seismic Loads
9) Temperature and Shrinkage Effects

The values of intensities of the above loads considered in design are detailed in the following sections

1) Dead Load:

The following unit weights are used in design

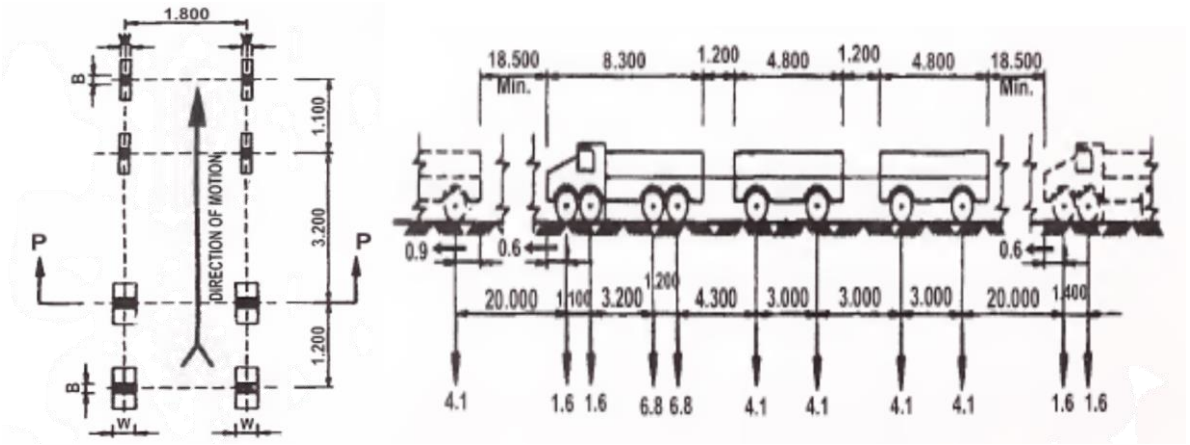
Reinforced Cement Concrete	2.5 T/m^3
Structural Steel	7.85 T/ m^3
Density of Water	1.0 T/ m^3

2) Live Load:

Live load on the jetty and approach structure is as per relevant Indian standards and the same is given below.

Load	**Intensity**
UDL – Jetty	25 kN/m^2
UDL – Terminal Building	5 kN/m^2

In addition to the above load the jetty and approach is also checked for Class B truck load as per IRC: 6-2014. The details of the same are presented below for ready reference.



Driving Vehicle: **Class B Train of Vehicles**

3) Wind Load:

The basic Wind Speed in the region are as given below:

Operational Wind speed	24 m/s
Extreme Wind Speed	47 m/s

Based on the above parameters, the calculated wind pressures are as follows

Calculated Wind Pressure-Normal Condition	0.339 kN/m2
Calculated Wind Pressure-Extreme Condition	1.3 kN/m2

4) Wave Load:

Based on observed wave conditions, the effects of wave are found to be insignificant and hence not considered in design.

5) Current Load:

Design current velocity considered for calculation of current load is as given below

Condition	Velocity
Operational	0.5 m/s
Extreme	1.5 m/s

Based on the above parameters, the calculated current force are as follows

Condition	Load
Operational	0.089 kN/m
Extreme	0.699 kN/m

6) Berthing Load:

The details of proposed ship are summarized below.

Overall Length (LOA)	95 m
Length Between Perpendiculars (LBP)	87 m
Beam of the vessel (B)	15 m
Depth of the vessel (D)	5 m
Fully Laden Draught	2.5 m
Dead weight Tonnage (DWT)	2000 T
Berthing Velocity (V)	0.25 m/s

Based on parameters in design basis, Berthing load is calculated and the same is furnished below for ready reference.

Berthing Energy – Operational Condition	69.1 kNm
Berthing Energy – Extreme Condition	13.8 kNm
Recommended fender	Cylindrical 1200 x 600
Fender Reaction – Operational Condition	385 kN
Fender Reaction – Extreme Condition	614 kN
Spacing of fender	10 m

7) Mooring Load:

Mooring load is calculated for the following conditions:

- Normal condition- Wind Speed at 18m/s & Current speed at 0.5m/s
- Extreme Condition- For full Capacity of Bollard (Recommended bollard Capacity is 75MT)

Based on parameters in design basis, mooring load is calculated and the same is furnished below for ready reference.

Mooring Load – Operational Condition	71 kN
Mooring Load – Extreme Condition	548 kNm
Recommended Bollard	Pipe Bollard
Bollard Capacity	75 T

8) Seismic Load:

The site falls in Zone 3 as per seismic map of India presented in IS 1893 (Part I) – 2002. Design horizontal seismic coefficient is evaluated as per provisions mentioned in code for the following parameters.

Zone Factor	0.16
Importance Factor	1.5
Response	3

9) Temperature and Shrinkage Effects:

The maximum and minimum temperature in site location is 41° and 7.2° respectively as per IS -875 part 5. Hence the mean temperature is 24.1°. Temperature during construction is considered mean temperature +/- 10°. Shrinkage strain in reinforced concrete elements is taken as 0.0002 as per IRC 6: 2010. Effects of shrinkage are also converted into equivalent temperature.

LOAD COMBINATIONS

The structure will be analysed as per load combinations presented in IS 4651 (Part IV) – 2014 for ultimate limit state and serviceability limit state.

SL.No	Loading	Partial Load factor					
		Serviceability Limit State			Ultimate Limit State		
		Short Term	Long Term	Normal	Extreme/ Survival	Temporary	Reverse
1	Dead Load (DL)	1.0	1.0	1.5	1.2	1.2	0.9

SL.No	Loading	Partial Load factor					
		Serviceability Limit State			Ultimate Limit State		
		Short Term	Long Term	Normal	Extreme/ Survival	Temporary	Reverse
2	Live Load –Dynamic (DyL)	1.1	0.5	1.5	1.2	1.2	0.9
3	Live Load –Static (LL)	1.0	0.5	1.5	1.2	1.2	0.9
4	Earth Pressure (EP)	1.0	1.0	1.2	1.0	1.0	1.0
5	Hydrostatic Force (HyF)	1.0	-	1.0	1.0	1.0	1.0
6	Wave & Current Force (WL-CL)	1.0	-	1..2	1.0	1.0	1.0
7	Berthing Force (BF)	1.0	-	1.5	1.0	-	1.5
8	Mooring Force (MF)	1.0	-	1.5	-	-	1.5
9	Working Wind Force (WWiF)	1.0	-	1.0	-	-	
10	Extreme Wind Force (EWiF)	-	-	-	1.2	-	1.5
11	Shrinkage	-	1.0	-	-	-	-
12	Creep	-	1.0	-	-	-	-
13	Temperature Load (TempL)	-	1.0	-	-	-	-
14	Seismic Load (SL)	1.0	-	-	1.2	-	1.5
15	Tsunami Load (TL)	-	-	-	1.2	-	-
16	Secondary Stress (SS)	1.0	-	-	-	-	-

SERVICEABILITY CRITERIA

1) Deflection Limit

Deflection of Pile at Pile cut-off level shall be L/350 under operating condition and L/250 under extreme condition, where L is the length of the pile from pile fixity to cut-off level.

2) Crack width Limit

Crack width in structural elements shall be maintained as per IS 4651 (Part IV) – 2014. The same has been reproduced here for ready reference.

Sl. No:	Exposure Zone	Maximum Crack width	
		Sustained	Transient
1	Atmospheric Zone (Above Splash Zone)	0.2 mm	0.3 mm
2	Splash Zone (Between CD & MHWS)	0.1 mm	0.2 mm
3	Continuous sea water immersion Zone (Below Splash	0.2 mm	0.3 mm
4	Below Seabed Level	0.3 mm	0.3 mm

MATERIAL PROPERTIES

All reinforced cement concrete works shall be carried out with M40 grade concrete and reinforcement steel shall be of Fe500 grade. Clear cover to reinforcement shall be as per IS 4651 (Part IV) – 2014 which is as shown below.

Sl. No:	Exposure Zone	Clear Cover
1	Atmospheric Zone (Above Splash Zone)	50 mm
2	Splash Zone (Between CD & MHWS)	75 mm
3	Continuous sea water immersion Zone (Below Splash Zone	75 mm
4	Below Seabed Level	75 mm

DESIGN LIFE

The jetty and associated structure shall be designed for the following design life

Sl. No:	Structural Element	Design
1	RCC Pile and deck superstructure	50 Years
2	Fender	8 Years

DESIGN METHODOLOGY

The structure shall be idealized in STAAD Pro with all mentioned loads and design criteria to analyse and design the structural elements. Fixity method shall be adopted in modelling of piles. All design is based on IS 456-2000 and IS 2911 (Part 1/Section 2) – 2010.

GEOTECHNICAL PARAMETERS

Geotechnical parameters of the soil are provided in related chapter. Based on geotechnical investigation and available bore holes, the top layer of soil is identified as silt or silty clay upto a depth of maximum 1m. This layer is a result of siltation in river. Below this, it is soft to medium stiff clay. The pile fixity level calculation has been carried out based on IS 2911-Part1-Section 2 (2010) and is presented in geotechnical report. The fixity length is worked out to 1.74m below bed level. On a conservative side, the same is taken as 2m and hence final fixity level of pile is identified as -6m CD.

D. METHOD OF ANALYSIS

The following software have been used in design

- STAAD Pro V8i

STRUCTURAL STAAD MODEL

3-dimensional STAAD model has been idealized for each of the structure envisaged. Piles and beams have been modelled as beam elements while deck slab is idealized as plate elements. Length of the pile has been assessed based on sea bed level as presented in available data. The following figures give an in-sight of the modelling undertaken for analysis.

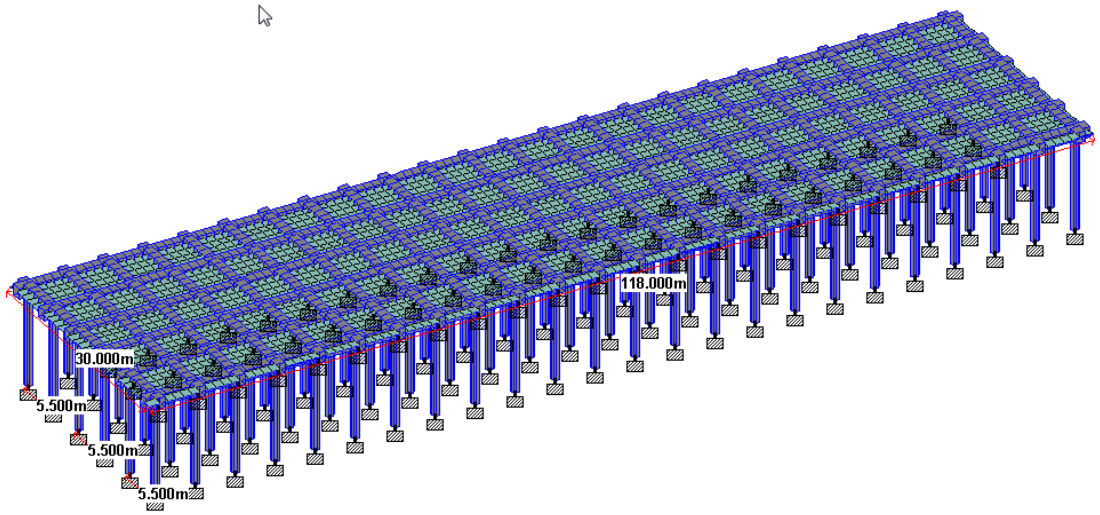


Figure 21: 3D View of STAAD Model – Cargo Berth

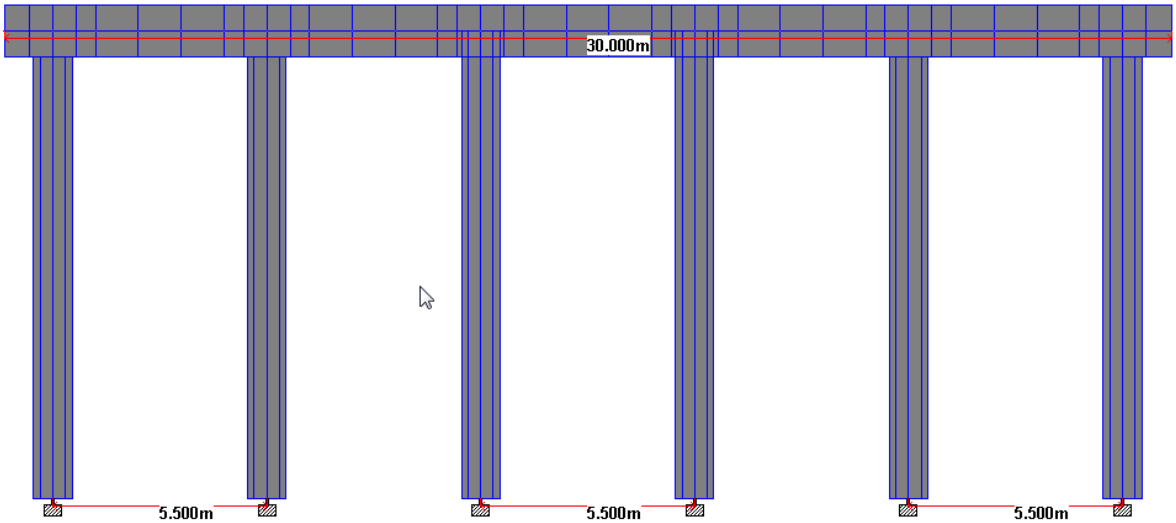


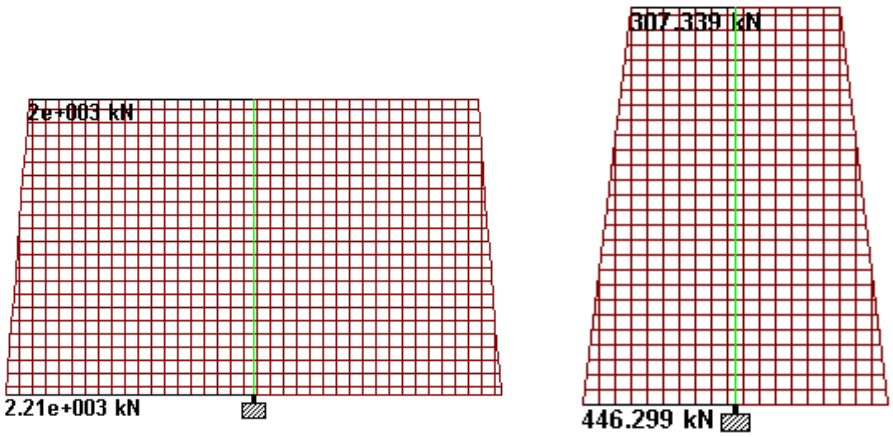
Figure 22: 2D View of STAAD Model – Approach Platform

P-Δ analysis is carried out on the idealized model to include secondary effects. All possible loads and load combinations as per IS4651 (Part 4): 2014 is considered and applied in a logical way to analyse the structure to determine the design forces.

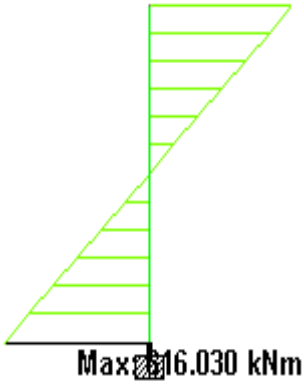
Limit State Design Method is used for design of structural components. All possible limit states are checked which includes serviceability and collapse limit states.

ANALYSIS RESULTS

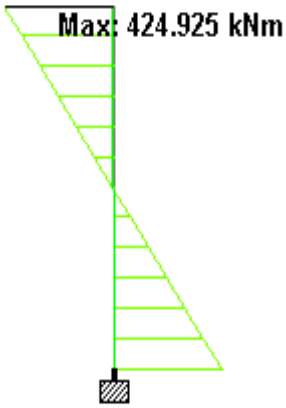
Results of the STAAD analysis for piles of the structure is given below



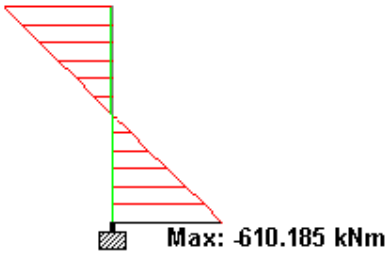
Max. Axial force (ULS) Min. Axial force (SLS)



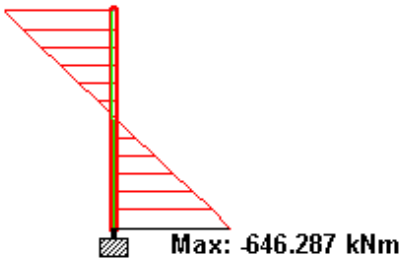
Max. Bending Moment My (ULS)



Max. Bending Moment My (SLS)



Max. Shear Force (ULS)



Max. Bending Shear Force (SLS)

Design of pile reinforcement

Design of longitudinal and helical reinforcement of pile is done as per IS:456-2000 & SP 16. Piles are checked for all possible severe combination of resultant forces and design for governing forces.

Development length (Refer IS: 456-2000, Cl. 26.2.1)

Development length,	L_d	$= \Phi \sigma_s / 4 T_{bd}$
Bond stress,	T_{bd}	= 1.9 MPa

60% increase in bond stress for deformed bars (Refer IS: 456-2000, Cl. 26.2.1.1)

Hence, Design Bond Stress = 3.04 MPa

Stress in bar, $\sigma s = 0.87 f_y$ = 435 MPa

L_d = 35.8 Φ

Say = 36 Φ

6.5 CONSTRUCTION SCHEDULE

The time schedule for construction activities of the project is considered as five (5) years The proposed project schedule is provided in **Figure 23.**

Sl. No.	Activities	1st Year				2nd Year				3rd Year				4th Year				5th Year			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Approval of DPR and Project Financial Closure																				
2	Environmental, Forest and CRZ clearances																				
3	Setting up of Implementing Establishment & infrastructure																				
4	Fairway development																				
a)	Procurement of Hardware and other equipment's																				
b)	Capital Dredging for Initial Reach																				
c)	Construction of Navigation Channel																				
d)	Capital Dredging for Last Reach																				
5	Procurement and installation of Aids to Navigation																				
6	Setting up of IWT terminals																				
a)	Land acquisition																				
b)	Construction of terminal building, landside facilities and dry bulk cargo jetties at Jamtiya																				
7	Upgrading existing road to terminals																				
8	Procurementof Vessels																				

Figure 23: Construction Schedule

7.0 VESSEL DESIGN

The major principal parameters governing Inland Waterway Fleet designs are:

- Terminal facilities and obstructions enroute,
- Waterway characteristic like river course, depth of water, radius of bends, current/velocities of water etc.,
- Navigational aspects and improvements to navigation,
- Cargo characteristic like type of cargo, quantum of cargo and distance of transportation,
- The vessel dimension like length, beam, moulded depth, minimum and maximum draft,
- Haulage distance
- Physical constrains like clearance under bridges, navigation locks size etc., and
- Capital, operation and maintenance cost.

7.1 GENERAL REVIEW

India has a long history of river based water transport. Among operators, the government owned CIWTC (Central Inland Water Transport Corporation) is the largest owner of vessels and barges. Private operators have a substantial fleet, but have not been investing in new vessels in the last decade. In fact, there has been scrapping vessels of late, and all operators may require some help in reviving them and investing in new vessels.

7.2 DESIGN BASIS

The type and size of vessels proposed to be operated in Ajoy waterway is designed on the basis of following factors:

a) Cargo Characteristics
b) Cargo Factors
c) Waterway and Other Features
d) Operational Factors

7.2.1 Cargo Characteristics

The cargo consists of Coal and Fly ash. The volume of total cargo originating and terminating from different terminal is shown in Traffic Studies chapter.

7.2.2 Waterway and Other Features

The field investigations done in the total stretch of the river bring out the following characteristic of the waterway which shall influence selection of the vessel for transportation.

- No bridge is located along the proposed fairway.
- Fairway is proposed for dry bulk cargo transportation.
- Shoals located along the waterway.

Hence, the waterway condition during lean season would dictate the selected vessel to have shallow draft to ensure navigation all around the year.

7.2.3 Operational Factors

The following factors are generally considered as operational factors in the process of study on vessels for IWT.

- Speed of vessel under varying hydraulic condition,
- Relation between speed, propulsive power and energy consumption,
- Rate of loading/unloading of cargo,
- Number of unworkable days per year, and
- Susceptibility of vessel to damage and crew efficiency.

7.3 TYPE OF PROPOSED VESSELS

The selection of vessels shall depend on the existing traffic in the waterway, available draft and other local conditions affecting the manoeuvring of vessels. For Inland Water Transportation, there are mainly two types of vessels namely self-propelled barges and dumb barges in tow. The two common vessels used for IWT are briefly discussed below.

7.3.1 Self Propelled Barge

Self-propelled cargo boats move under their own power and attain a higher speed than dumb barges in tow. These boats are also more effective against strong currents and are designed to meet particular requirement of traffic and route. In Shallow River, low draught vessels are designed with twin screws in tunnels. These vessels are not economical to run in deeper waters. Similarly vessel designed for deeper draft cannot be used in Shallow River. Costly cargoes which can stand a high

freight rate like perishable goods requiring scheduled navigation are transported by self-propelled river vessel. These vessels have a low turnaround time in IWT ports (since no time is lost in anchoring and making up tows), are speedy and can call at many ports along the enroute. With proper scheduling of sailing of such vessels and full cargo availability, these can be an economic proposition inspite of the high cost of procurement.

7.3.2 Dumb Barge

Dumb barges are cheap and apart from being used for carriage of cargo, are also used for storing, as floating warehouses or even as pontoon jetties. These vessels require very little care and withstand rough handling. Small dumb barges do not normally have any permanent crew and lie unattended. Transportation of cargo in dumb barges is a slow process and there is normally no fixed schedule. Hence, bulk, unpacked and imperishable cargo is transported in such barges which offer a low freight rate. In Europe and USA. river transportation is normally carried in dumb barges in private sector.

7.3.3 Towing Arrangement

Dumb barges are grouped together to form flotilla which are towed by river tugs. Three methods of towing have been used internationally depending upon channel depth and width as well as the weather conditions experienced along the route. The following are the general methods.

- Towing astern,
- Towing alongside, and
- Push towing.

The first method, towing astern or pull towing has been used in European waters. A long towline is paid out from the river tug (moving in front) to the foremost barges of the flotilla. The flotilla may be made up of a number of rows of barges secured to each other or held together by a tie line passed from barge to barge. Sometimes, barges may be tied to the center barge alongside. In this system, the propeller race of the tug impinges on the front thus increasing the resistance of the barge flotilla. Due to this, there can be an augmentation of resistance as high as over 80% of the individual barge. To reduce this increase in resistance, a minimum length of towline equal to 1.25 times the length of the tug is recommended. This increases the total length of tow considerably. Further, when the tow is to take a turn, the radius of bend must be quite large. Therefore, this form of transportation is good where only long straight stretches of waterway are available.

In towing alongside or abreast, one barge is secured fast to one side of the tug or two barges are secured to either side of the tug. This is an efficient method of towing, the only disadvantages being that the width of the waterway required should be more to accommodate flotilla of twin barge width. The conventional method on the NW -1/river Ganga in India has been towing abreast or side towing.

In push towing, flotilla, consisting of a number of barges arranged abreast and in row, is formed by securing all the barges to one another tightly. The pusher tug pushes the flotilla from behind. The propeller race does not affect resistance. Since all the barges and tugs are close together, the incidence of increasing in resistance due to inference is minimum. This system is prevalent in USA and is now being adopted in Europe and elsewhere including India (eg. CIWTC) for its obvious advantages over pull towing. The individual units of barges are normally full with rectangular bilge with/without end shapes.

7.3.4 Towing Tug

River tugs are designed and built as per particular requirements. The designs are different for pull towing and push towing. In push towing, the foredeck is made square to facilitate matching of barge end. Bollards and fairleads are mostly in the forward. In pull towing, the mooring arrangements are astern and there is arrangement for paying out rope (winch or capstan). Either of the tugs can be used for side towing by suitable provision of bollards on their sides.

Various types of propulsion systems have been used on river/canals. The systems most extensively used are paddle wheel propulsion, propulsion with other sophistication such as multiple propellers and rudders, "Kort" nozzles, raised tunnels and rudder-propeller propulsions.

The paddle wheel propulsion has disappeared since quite long from most of world waterway although it offered good maneuverability, good stopping and backing abilities, easy repair without dry docking and its suitability of use in shallow water with efficient propulsion. The disadvantage which outweighed its advantages was heavier hull construction with associated problems, big reduction gear and overall low efficiency.

The propeller propulsion system consisting of propellers and complete rudder system comprising of normal rudder behind propellers and flanking rudder in the front of propellers for reverse and stopping maneuvers is being widely used. In number of shallow draft vessels, with this type of propulsion, Kort nozzles and raised tunnels have been provided with propeller of lower diameter to get better efficient and thrust, provide protection to waterway bottom and the banks and to protect

the propeller from damage. However, construction is difficult in case of tugs provide with Kort nozzle or tunnel.

The third type i.e. rudder propeller system was initially developed for motorizing dumb barges and small vessels with ready-to-install unit but it has been developed for propelling even the bigger size vessels. The advantage of this type is its high maneuverability, simple installation without requiring floating dry docking facilities. The disadvantages are lower efficiency as compared with system of fixed propeller with nozzles, vulnerability of freely suspended propulsion arm and complicated machinery parts.

In pull towing, the propeller race of the tug impinges on the front barge thus increasing considerably the resistance of the barge fleet. Moreover, pull towing requires deployment of crew for steering the towed barges and has, in addition, the disadvantages of being less manoeuvrable.

7.3.5 Push Tug

The important parameter for selection of the tug is the power requirement which depends upon the displacement of tug and barges, the maximum dimension of the convoy, current velocity, the parameters of waterway and the speed. Out of these factors speed largely governs the power requirement. Researchers have suggested limiting value of speed in shallow and narrow canals. In shallow water of unrestricted width, the economic speed in m/s should be less than $2.5*\sqrt{h}$ where H is the depth of water. In narrow canals, economic speed should be less than $1.2*\sqrt{A/C}$ for a blockage ratio of 5 (The ratio of wet canal cross section to area of submerged mid ship section) where A and C are canal cross section area and canal perimeter respectively. The blockage ratio should not be less than 4.5 to prevent erosion of canal bed and slopes caused due to return currents and waves. Thus the mid ship cross section on this route should be less than 13.67 m^2. The vessel speed on the above consideration should not be higher than 8.0 knots/hr in waterway. The power requirement of push tug has been based on the speed in river section.

In push towing, barges are lashed together by wire ropes to form a single unit and this, in turn, is lashed rigidly to the towing knees of the pusher tug. The tug working at the rear can handle a fleet of barges at a greater speed and with greater control is possible in pull towing operation. The tug is equipped with a set of steering and flanking (backing) rudders which afford maximum control for forward, backward and sideward movements as are required in restricted channels. For this reason, push towing has been recognized as the most efficient. It requires 20% less power than pull towing for comparable loads.

7.3.6 Towed Flotilla v/s Self Propelled Vessel

The merits and demerits of both alternatives that will help in making final choice are:

a) In a towed flotilla, the cargo carrying unit and the engine unit are separate. Therefore, they can be scheduled independent of each other and thus ensure maximum transport efficiency. As the self-propelled vessels are expected to be more economical over long lead, both the alternatives have to be compared for cargo transportation.

b) In towing system when towing unit is down for engine survey, maintenance and repair, the cargo units need not be down and can be moved with another available towing unit, whereas in self-propelled barge system, one engine unit is always tied up with cargo unit.

c) Flotilla can be formed with varying units of barges. Therefore, this system can adjust to a fluctuating or uncertain transportation environment in an efficient manner. This system efficient is much higher since only limited numbers of barge that can be fully loaded are utilized. But this cannot be done for self-propelled vessels. If regular cargo is available in sufficient quantity, transport efficiency of self-propelled vessel can be more than flotilla.

d) Dumb barges are simply and less expensive to build and comparatively few towing tugs are required to operate the flotilla combination. Self-propelled barges are comparatively larger vessels and are more complex for building since the engine; supporting bunkers and crew accommodation are to be housed. The procurement price is generally 3 to 3.5 times that of a dumb vessel of same capacity.

e) It is well known in naval architecture that long slender vessels experience less resistance in motion. Well designed (ends properly shaped) dumb barges in flotilla experience proportionately less resistance than single vessels. Two single units in tandem experience 1.36 times the resistance of a single unit and a flotilla of 4 barges with two abreast in two rows experience 3.16 times the resistance of a single unit. The average resistance per single barges in a flotilla can be taken as 0.75 times that of a single barge on its own. With this resistance there would be net saving of 25% fuel, if barges are well designed and are moved in closely packed flotillas as against self-propelled barges.

f) A dumb barge can remain unattended in voyage and need not house any crew member. For a flotilla of 2 barges and one towing 4 crew members are sufficient. But for 2 independent self-propelled vessels at least 8 crew members would be required. Thus crew wage bill is reduced by half in case of towed system.

g) Maintenance for a flotilla system is easier and cheaper since barges are repaired separately from tugs. Downtime due to repair is also reduced.

7.4 PROPOSED VESSEL SIZE AND SPECIFICATIONS

The size of vessels calling at the proposed IWT terminal is restricted by the availability of draft in the navigation channel of National Waterway. It is proposed to ensure minimum LAD of 2.5 m in the waterway for movement of vessels. Based on the LAD of 2.5 m in the navigational channel, IWAI recommended that self-propelled barges of sizes presented in **Table 35** below can ply in the inland waterways

Table 35: Vessels that can Ply in Inland Waterways with LAD of 2.50 m

Tonnage (T)	Length (m)	Beam (m)	Draft (m)
650 - 1000	60 - 80	8.20	2.20
1000 - 1500	80 - 85	9.50	2.20
1500 - 3000	85 - 95	15.00	2.50

7.5 TURNAROUND TIME

Turnaround time for vessels is defined as the length of time between arriving at a point and being ready to depart from that point. It is used in this sense for the Clearance, safety checks, berthing, loading/unloading, de-berthing, etc. of vessels.

Turnaround time varies with type of vessel, efficiency of jetties and available cargo handling facilities on the jetties. Turnaround time for dry bulk cargo vessels are discussed in detail in following paragraphs.

The concern calculation for Throughput handled annually & turnaround time of Coal & fly ash is shown in **Table 36** & **Table 37** below**.**

A. COAL HANDLING

As shown in Table below, IWT is anticipated to handle 43% of the total expected Coal requirements of Katwa power plant.

Table 36: Throughput handled annually (Coal)

Sr. No.	Description	Symbol	Unit	Formula/Ref.	Value
1	Parcel Size of Vessel	Pz	tonne	…	2000
2	Unloading rate of mobile crane	C	TPH	…	800
3	Unloading time (max.)	T1	hrs	T1 = Pz / C	2.5
4	Clearance & Berthing time require at jetty,	T3	hrs	…..	0.5
5	Clearance & unberthing time require at jetty,	T4	hrs	…..	0.5
6	Time consideration for miscellaneous activities, minor maintenance of crane	T5	hrs	….	0.3
7	Turnaround Time of Vessel at jetty	T	hrs	TA=T1+T2+T3+T4+T5	3.80
8	Vessels expected to handled at jetty per day (conidering 20 hours of operation per day)	TA	day	TA = 20/ T	5
9	Expected Quantity of Coal handled per day	Qday	tonne	Qexp=Pz X TA	10000
10	Expected Quantity of Coal handled per annum considering 300 working days per year	Qannum	tonne	Qannum = Qday X 300	3000000
11	Expected Quantity of coal to be required at Katwa power plant	Qexp	Tonnes /annum	…	7000000
	% of Quantity handled out of total expected to be generated	Q%	%	…	40
Note -IWT Terminal is proposed to handle 40% of expected Coal required by Katwa Power Plant.					

B. FLY ASH HANDLING

As shown in Table below, IWT is anticipated to handle 50% of the total expected fly ash generated from the Katwa power plant.

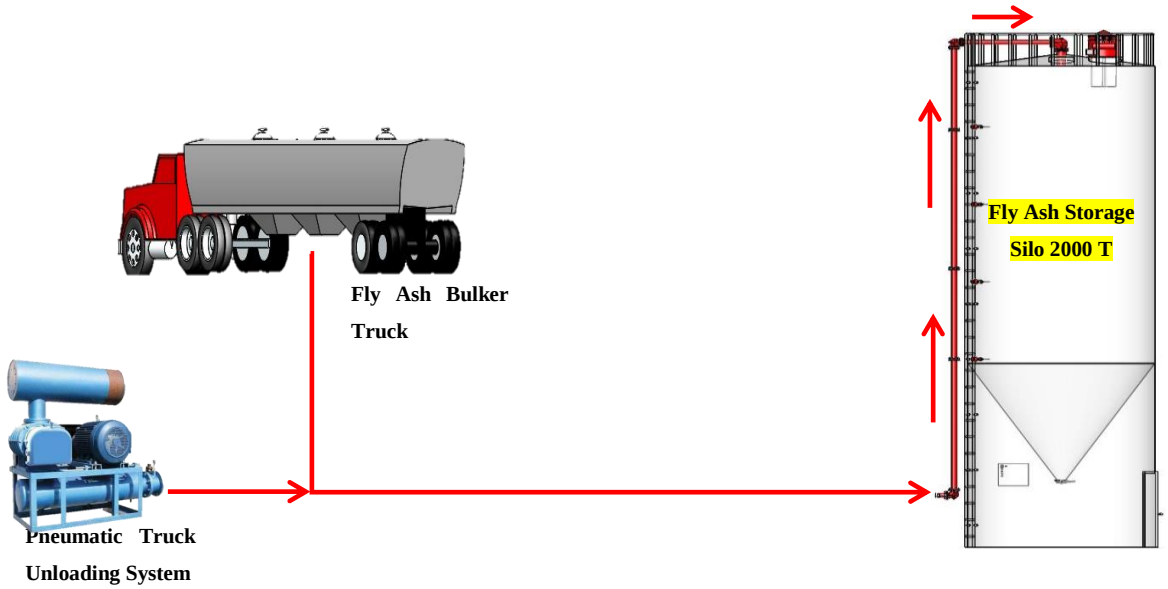
A pontoon platform is proposed for handling Fly ash at proposed IWT. A steel silo shall be constructed in front of pontoon for storing of one(1) barge load i.e. 2000 T, as a buffer storage in case of non-availability of bulker trucks and vessel is ready for loading of fly ash.

Table 37: Throughput handled annually (Fly Ash)

Sr. No.	Description	Symbol	Unit	Formula/Ref.	Value
1	Parcel Size of Vessel	Pz	tonne	…	2000
2	Maximum Loading time (Option-2)	T_1	hrs	…	10.19
3	Berthing time required	T_3	hrs	…	0.5
4	Unberthing time required	T_4	hrs	…	0.5
5	Time consider for miscellaneous activities	T_5	hrs	…	0.5
6	Turnaround Time of Vessel	T	hrs	$T_A=T_1+T_2+T_3+T_{4+}T_5$	11.69
7	Vessels expected to handled at single Pontoon per day (considering round the clock operation)	TA	day		2
8	Expected Quantity of Fly Ash handled per day@ 200 DWT	Q_{day}	tonne	$Q_{exp}=P_z$ X TA	4000
9	Expected Quantity of Fly Ash handled per annum considering 300 working days per year	Q_{annum}	Tonnes /annum	$Q_{annum} = Q_{day}$ X 300	1200000
10	Expected Quantity of Fly ash to be generated	Q_{exp}	Tonnes /annum	…	2400000
11	% of Quantity handled out of total expected to be generated	Q%	%	…	50%
Note -IWT Terminal is proposed to handle 50% of expected fly ash generated form Katwa Power Plant.					

The following option has been anticipated for fly ash handling at proposed IWT:

Option-1: Loaded Bulker trucks arrived at terminal and needs to be evacuated by unloading system and fly ash will be stored into the siloes (when vessel/ship is not available).



Option-1 has been envisaged that bulker truck of 25t to 45t shall be loaded with fly ash form Katwa Power plant under ESP unit and shall arrive at proposed IWT terminal at Goai. The trucks shall be bought in a 4 fleet (45t) consisting of 3 X 12 trucks + 1 X 09 trucks respectively. At berth there will an unloading area equipped with pneumatic truck unloading system of transfer rate/capacity of 45-50 TPH & required piping system capable of unloading six(6) numbers of bulker trucks simultaneously. The unloaded fly ash shall be stored in silo of 1500 tonne capacity i.e. equivalent of one barge load.

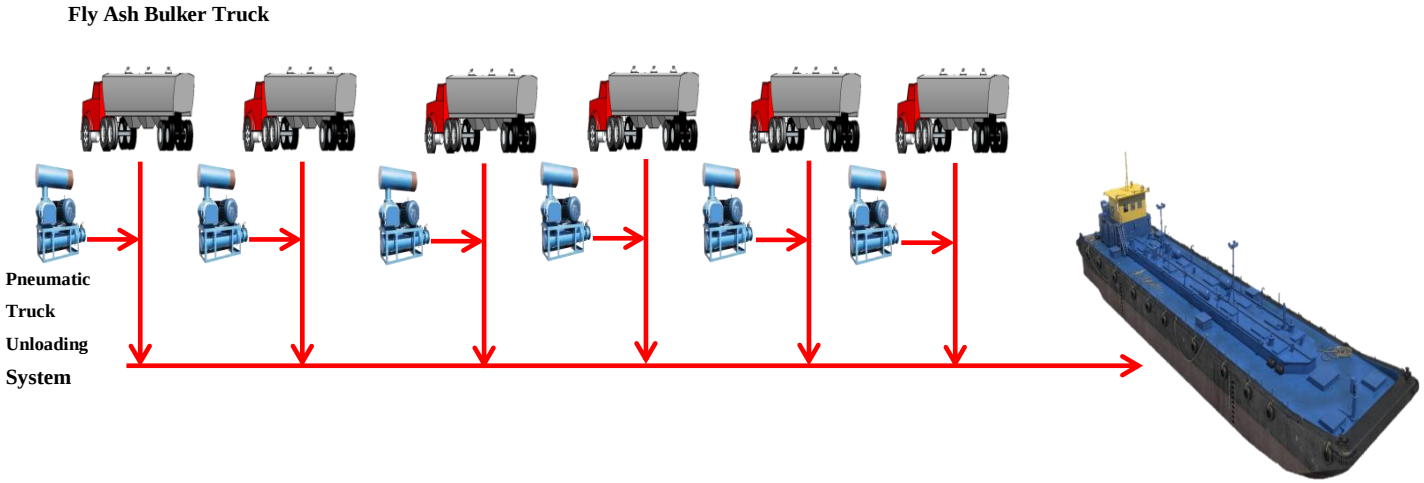
The Cycle time calculation for the Option-1 is provided in **Table 38**.

Table 38: Cycle Time Required for Fly Ash transfer from Fly Ash Bulker Truck to Silo at Jetty

Sl. No	Description	Symbol	Unit	Formula/Ref.	Value
1	Capacity of Silo at Jetty	Pz	tonne	…	2000
2	Max. available Silo loading time	T1	hrs	…	8
3	Payload of a single fly ash bulker truck	C	tonne	…	45

Sl. No	Description	Symbol	Unit	Formula/Ref.	Value
4	No of bulker trucks per fleet of trucks	N	no	…	12
5	Quantity of Fly ash handled per fleet	Nf	tonne	Nf=C*N	540
6	Unloading capacity of Pneumatic equipment for Fly ash transfer from a Bulker truck to Silo	Qu	tph	….	50
7	No. of trucks unloading simultaneously	n	no.	…	6
8	Placement time of a truck at unloading station and connection of unloading equipment	t_1	min	…	10
9	Unloading time required for a fly ash bulker truck to unload	t_2	min	t_2 = (C X n)/Qu	54
10	Time required for removing of truck from unloading area after disengagement of pneumatic unloading system	t_3	min	…	5
11	Total cycle time required for a Truck to get parked, unload and remove (considering 10% extra time for misc. tasks)	Tt	min	Tt=t1+t2+t3	76
12	Unloading time required for 6 trucks to unload simultaneously into silo	t4	min	t4=Tt	76
11	Unloading time required for a fleet of Carrier (12 nos. of trucks)	t_4	min	t_3=(t1+t2+t3) X N/2	151.8
			hrs		2.53
12	No. of Truck fleets required (3 X 12 trucks@45t + 1 x 9 trucks @45t)	Fr	nos.	Fr = Pz/Nf	3.70
13	Total Time required for all (~4) truck fleets to unload into Silo	Tfr	hrs	Tfr = t4 X Fr	9.37

Option-2: Unloading of Bulker truck directly into vessels/ship (2000 DWT) with the help of unloaded system.



In Option-2, it has been envisaged that bulker truck of 45t shall be loaded with fly ash form Katwa Power plant under ESP unit and shall arrive at proposed IWT terminal at Goai. The trucks shall be bought in a 4 fleet consisting of 3 X 12 trucks + 1 X 9 trucks respectively. At berth there will an unloading area equipped with pneumatic truck unloading system of transfer rate/capacity of 45-50 tph & required piping system capable of unloading six(6) numbers of bulker trucks simultaneously. The ship shall arrived at pontton form Geonkhali. As soon as ship shall reach the IWT terminal, it shall be berthed after performing all necessary clearances and security checks.

Hatches of the vessel shall be connected with the hoses/pipes of required dia. and shall be connected to the six (6) numbers of the pneumatic unloading units to transfer fly ash in minimum planned time.

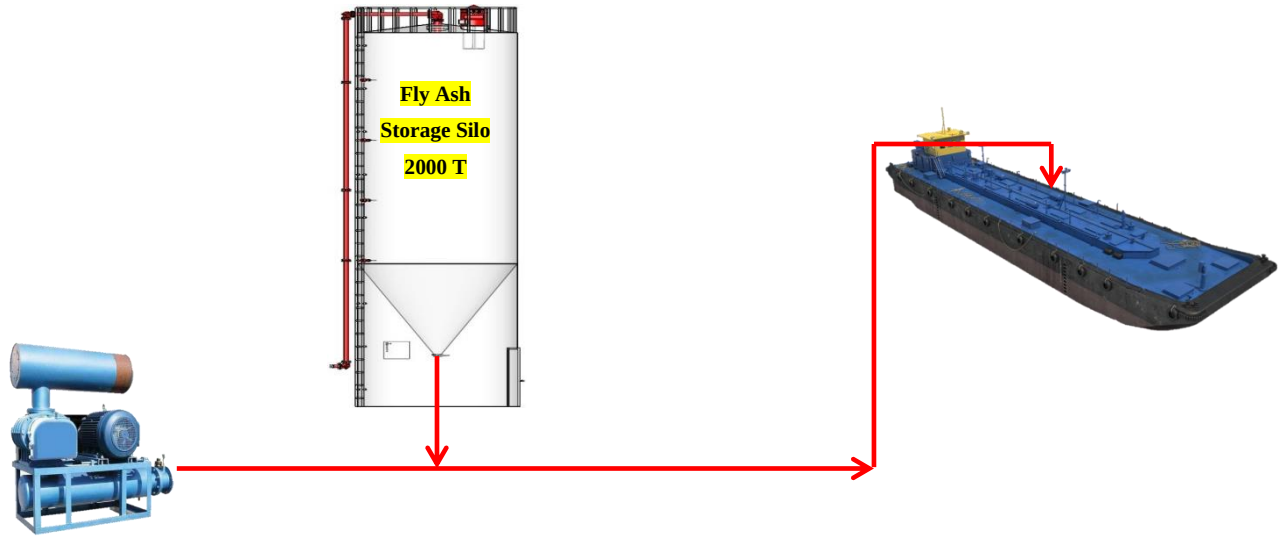
The Cycle time calculation for the Option-2 is shown in **Table 39**.

Table 39: Cycle Time Required for Fly Ash transfer from Fly Ash Bulker Truck to Vessel/Ship Directly

Sl. No	Description	Symbol	Unit	Formula/Ref.	Value
1	Capacity of Vessel	Pz	tonne	…	2000
2	Max. available vessel loading time (when vessel is parked at berth excluding travel time from Geonkhali to Jamitya and vice versa)	T1	hrs	…	8

Sl. No	Description	Symbol	Unit	Formula/Ref.	Value
3	Payload of a single fly ash bulker truck	C	tonne	…	45
4	No of bulker trucks per fleet of trucks	N	no	…	12
5	Quantity of Fly ash handled per fleet	Nf	tonne	Nf=C*N	540
6	Unloading capacity of Pneumatic equipment for Fly ash transfer from a Bulker truck to Ship/Vessel	Qu	tph	….	45
7	No. of trucks unloading simultaneously at unloading area	n	no.	…	6
8	Placement time of a truck at unloading station and connection of unloading equipment	t_1	min	…	10
9	Unloading time required for a fly ash bulker truck to unload	t_2	min	t_2 = (C X n)/Qu	60
10	Time required for removing of truck from unloading area after disengagement of pneumatic unloading system	t_3	min	…	5
11	Total cycle time required for a Truck to get parked, unload and remove (considering 10% extra time for misc. tasks)	Tt	min	Tt=t1+t2+t3	83
12	Unloading time required for 6 trucks to unload simultaneously into ship/vessel	t4	min	t4=Tt	83
11	Unloading time required for a fleet of Carrier (12 nos. of trucks)	t_4	min	t_3=(t1+t2+t3) X N/2	165
			hrs		2.75
12	No. of Truck fleets required (3 X 12 trucks@45t + 1 x 9 trucks @45t)	Fr	nos.	Fr = Pz/Nf	3.70
13	Total Time required for all (~4) truck fleets to unload into vessel directly	Tfr	hrs	Tfr = t4 X Fr	10.19

Option-3: When Ship/vessel shall be arrived at terminal (2000 DWT) them fly ash from siloes shall be unloaded and feed into vessel with the help of unloaded system at maximum transfer rate.



Option-3 has been envisaged that bulker truck is not available and silo is fully loaded with one vessel load. In this case the ship arrived at pontoon shall be berthed after performing all necessary clearances and security checks and thereafter Five (5) numbers of unloading systems (25-45 TPH capacity) shall be connected with the bottom of the silo extracting the fly ash form silo and transferring same into hatches of the vessel through transfer hoses/pipes.

The Cycle time calculation for the Option-3 is shown in **Table 40**.

Table 40: Cycle Time Required for Fly Ash transfer from Fly Ash Bulker Truck to Vessel/Ship Directly

Sl. No	Description	Symbol	Unit	Formula/Ref.	Value
1	Capacity of Vessel	Pz	tonne	…	2000
2	Max. available vessel loading time (when vessel is parked at berth excluding travel time from Geonkhali to Jamitya and vice versa)	T1	hrs	…	8

Sl. No	Description	Symbol	Unit	Formula/Ref.	Value
3	Payload of silo (considering already laoded silo)	S	tonne	…	1500
4	Handling capacity of Pneumatic equipment for Fly ash transfer from Silo to Ship/Vessel	Qu	tph	….	45
5	Numbers of Pneumatic equipment working simultaneously	N	no.	…	5
6	Total Fly ash handling rate	Qt	tph	Qt = Qu X N	225
7	Time required to prepare Pneumatic equipment for Fly ash transfer form Silo to vessel	T1	min	…	30
8	Time required to transfer ash from Silo to vessel	T2	min	T2 = Pz /Qt	533
9	Time require to disengage Pneumatic equipment form Silo to vessel	T3	min	…	30
10	Total Cycle time required	Tt	min	Tt = T1+T2+T3	593
			hrs		9.89

As already described in option-1 for ash handling, Five (5) numbers of pneumatic unloading units shall be utilised to manually unloading of the vessel/carrier into the trucks.

Note:- To reduce the overall construction & O&M cost of the pontoon no. 2 manual unloading system is proposed (in case of no Self-unloading carrier) instead of ship unloader at jetty.

7.6 NUMBER OF VESSEL REQUIRED

As already described in cl. 4.3.1 The total anticipated quantity of dry bulk cargo for IWT through Ajoy waterway is about 4.2 million tonnes per annum. The anticipated quantity of Flyash is about 1.2 million tonnes per annum and for coal it is about 3.0 million tonnes per annum. The number of vessels required for handling this quantity of cargo is analysed and provided in **Table 41** as below.

Table 41: Estimate of No. of vessel required

S. No	Commodity	Anticipated Capacity of Commodity to be handled		Design Capacity of Commodity	Proposed Vessel Size	Qty. of Commodity proposed to be handle per day	Turnaround time of vessel	Jetty Proposed	Vessels Required per day (24 hours)
		MT/annum	MT/Month	MT/Mon	DWT	T/Day	hours	No.	Nos.
1	Flyash	12,00,000	1,00,000	1,00,000	2000	4000	10.19 hours (max.)	Jetty No.-1	2
2	Coal	30,00,000	2,50,000	2,50,000	2000	10,000	3.8 hours (max.)	Pontoon-1	5

7.7 VESSEL COSTING

The procurement and operating cost of the 2,000 DWT barge is provided as below:

7.7.1 Capital Cost

As per estimates vessels of Class III to Class VI will cost IWAI anywhere between INR 4 crore to INR 7 crores. Considering IWAI will buy the required no. of barges the total capital cost works out as below:

Table 42: Capital Cost of Vessels

Sl. No.	Description	No. of Vessel	Rate per Vessel (INR Lacs)	Total Cost (INR Lacs)
1.	2000 DWT barges	7	700	4,900

7.7.2 O&M Cost

The O&M cost of vessels are estimated as below:

a) Officers and Crew Costs

Three (3) crews have been allocated for each vessel to enable continuous operation of vessels for 24 hour. Each crew comprise of 6 staff members for running/operating of vessel and on-board safety and security. Total nos. of crew members proposed is tentatively as below:

Sl. no.	Type of Crew	Number of crew for each vessel (8 hour operation time)	Number of crew for each vessel for 24 hour	Total number of crew for 7 vessels per day	Tentative Annual Rate (INR)	Annual Cost (INR)
1.	Pilot	1	3	21	5,00,000	1,05,00,000
2.	Electrical Engineer	1	3	21	5,00,000	1,05,00,000
3.	Mechanical Engineer	1	3	21	5,00,000	1,05,00,000
4.	Support staff/Life Guards	3	9	16	3,00,000	1,89,00,000
Total		**6**	**18**	**126**		**5,04,00,000**

Hence, for seven (7) vessels with total of 126 crew members, the annual cost of crew works out to be INR 5,04,00,000/- (**INR 504.00 Lacs** annually)

b) Consumables and Repair/Maintenance Cost

Consumables such as oil and lubricants are generally used at a predictable rate and we have adopted a figure of INR 0.02 lacs per day derived for a vessel similar to those considered in this study. Similarly we have adopted a figure of INR 0.02 lacs per day for maintenance and repair of the vessels to cover the regular maintenance programme. Annual consumables and repair/maintenance cost works out to **INR 12.00 Lacs**.

c) Fuel Cost

As the origin point of Coal to be required and destination point of flyash to be produced by proposed Katwa thermal power plant is not know at this stage of DPR studies. Annual fuel cost is considered as 2% of the vessel cost. Annual fuel cost of vessels works out to **INR 98.0 Lacs**.

Table 43: Annual O&M cost of Vessels

Sl. No	Item	Annual Cost (INR) Lacs
1.	Officer and Crew Costs	504.00
2.	Consumables and Repair/Maintenance Cost	12.00
3.	Fuel Cost	98.00
	Total	**614.00**

8.0 NAVIGATION AND COMMUNICATION SYSTEM

In SOLAS-V/13 ("Safety of navigation" IMO, 1974), IMO established that each State shall provide the aids to navigation appropriate to the level of traffic and the degree of risk. International Association of Lighthouse Authorities (IALA) defines aids to navigation as systems external to the ship capable of helping determine its position and course, warning about dangers and obstacles and indicating the best route to follow.

As defined by IMO, the absolute horizontal accuracy of aids to navigation regarding vessel position on inland waterways should be 10 metres, with a probability of 95%. The accuracy of nautical charts is also very important. The national authority responsible for their publication must work in coordination with the body responsible for aids to navigation.

Aids to navigation include visual aids (lighthouses, beacons, buoys and leading lines), electronic navigation (AIS, DGPS, VTMS etc.), a pilotage service and traffic organisation boats.

The objectives of e-navigation are: to facilitate the safe navigation of vessels with regard to hydrographical, meteorological and navigation information, facilitate maritime traffic management, facilitate communication and provide opportunities to improve the efficiency of transport and logistics. E-navigation is a concept that incorporates systems and services.

8.1 GENERAL REQUIREMENTS

The information system for navigation and communication aims to improve the navigational capability and safety in the inland waterways, key points of River Information System are:

- The information system will help to track the real time position of ships plying on the inland waterways
- The system will also provide real time weather reports and help in building communication among the vessels
- Under the project, radars and sensors will be installed in boats and river ports
- The information will be sent via Very High Frequency (VHF) wireless communication between the operators and the user

For safe navigation of the ships throught the waterway, state of the art navigation and communication system are to be provided in the waterway stretch. These services should be supported by currently available technical systems like:

- Mobile radio communication systems for inland navigation (VHF radio)
- Ship and shore based radar
- Mobile data communication systems
- Global navigation satellite system (GNSS)
- Internet
- Electronic chart and display and information system for inland navigation (Inland ECDIS)
- Automatic identification system for inland navigation (Inland AIS)
- Ship reporting systems.

8.1.1 VHF / HF

One of the main characteristics of the River Information Service is efficient and reliable flow of information. It can be effectively achieved in real time through VHF communication, which is of key importance in maritime navigation and has been implemented to meet the requirements of inland waterway shipping services.

VHF communication is in use in inland navigation to ensure safe flow of information among vessels and services coordinating SAR operations within the RIS operation range.

The RIS operating centre is proposed to be located in one of the terminal building. Within a usable floor area of 200 sq. m, a room shall be arranged for the maintenance of constant radio watch by three system operators who can control the system modules. The foreground item of the equipment's will be a display consisting of six LCD screens.

It will display a view of the AIS and views from CCTV cameras, which, combined, support real time view of the situation on the waterway. The RIS Centre shall also provide electronic charts for the purposes of the Inland ECDIS, transmits Notices to Skippers (NtS), receives ERI messages and ensures system users reliable VHF radio communication. Signals received by VHF radio stations are transmitted directly to the RIS Operating Centre via a relay network.

8.1.2 DGPS

The Differential Global Positioning System (DGPS) is an enhancement to GPS that improves accuracy to under 3 metres, by means of a ground-based network of reference stations.

Ajoy waterway is proposed for 3.5 Km. IWAI have a DGPS station at Swaroopganj which is around 60 Km from the proposed reach. So the DGPS consideration is dropped off for Ajoy waterway.

8.1.3 RIS / AIS / Radar / VTMS

An objective is the description of intention. The objective may also be called the goal or aim. RIS have three main objectives:

1) Transport should be *safe*:

- Minimise injuries
- Minimise fatalities
- Minimise voyage incidents

2) Transport should be *efficient*:

- Maximise throughput or effective capacity of waterways
- Maximise the carrying capacity of vessels (length, width, draught and height)
- Reduce travel time
- Reduce workload of RIS users
- Reduce transport costs
- Reduce fuel consumption
- Provide efficient and economical link between transport modes
- Provide efficient harbours and terminals

3) Transport should be *environmentally friendly*:

- Reduce environmental hazard
- Reduce polluting emissions and spills due to accidents, illegal actions or normal operations

These objectives should be met under the constraints that all RIS are supplied in a manner that is reliable, cost efficient and legally sound.

As for Ajoy waterway, one station can be set up as there are 2 stations in the near vicinity of the proposed waterway i.e. Swaroopganj and Kumarpur. The proposed waterway lies in between the two stations and one more RIS will further improve the navigability and accuracy.

8.2 EXISTING SYSTEM

From the 19 Km length of Ajoy waterway, fairway is proposed for a stretch of 3.5 Km only (along the proposed channel alignment) for providing a waterway route to cargo destined/originated for Katwa Thermal power plant. Dry bulk cargo terminal is proposed on the left bank (while moving upstream from 0.0 Km Chainage) of waterway as shown in **Figure 19**. No safety, aids to navigation and communication system exists currently along the waterway.

8.3 ADDITIONAL REQUIREMENT

Once the terminals on Ajoy River gets developed, all these basic safety norms need to be installed for safe navigation of vessels and to have complete control on traffic handled at terminal.

8.4 COSTING

The cost of Navigation and communication system comprises of equipment cost, cost of operation and maintenance.

8.4.1 Capital Cost

The following criteria have been adopted for estimating the quantity and cost of navigational aids, proposed for Ajoy waterway. .

i) Quantity of the equipment/s has been decided depending on the distance of the river to be covered.
ii) Ideally distance between two sites should be 30 km to 50 km depending upon the terrain/ geography of the area. We select the number of sites, according to these criteria.
iii) To operate the system, proper certified operators are to be deployed at site along with the security guards.

iv) CAMC for minimum three years has been considered after one year warranty from the date of commissioning.

Table 44: Capital Cost for Aids to Navigation and Communication

Sr. No.	Equipment	Qty	Unit Price (INR)	Total (INR Lacs)
A	**RIS System**			
1	AIS Base Station	1	30,00,000.00	30.00
2	RADAR	1	2,50,00,000.00	250.00
3	Meteo Sensor	1	7,00,000.00	7.00
4	ATG	1	9,00,000.00	9.00
5	VHF	1	5,00,000.00	5.00
6	DG Set 10 KVA	1	7,00,000.00	7.00
7	UPS	1	5,00,000.00	5.00
8	RIS Software	1	35,00,000.00	35.00
10	Installation Testing & Commissioning	1	20,00,000.00	20.00
11	Porta cabin	2	12,00,000.00	24.00
12	Trestle Tower	1	10,00,000.00	10.00
			Total cost of RIS system	**402.00**
B	**Marine Lantern/Buoys**	**50**	**5,50,000**	275.00
			Total Cost in Lacs	**677.00**
C	3% Contingencies and 6% Supervision charges on Base cost			60.93
D	**Total Navigation & Communication Cost in Lacs**			**737.93**

8.4.2 O&M Cost

The operation and maintenance cost works out to as below:

Table 45: O&M Cost for Aids to Navigation and Communication

Sr. No.	Manpower	Qty	Unit Price (INR)	Total (INR) in Lacs
1	Engineer 1 * Site 1 * Months 12 per year	12	35,000.00	4.20
	Operator 3 * Site 1 * Months 12 per year	36	20,000.00	7.20
	Security 3 * Site 1 * Months 12 per year	36	15,000.00	5.40
2	Second Year			17.98
3	Third Year			19.23
4	Fourth Year			20.58
			Total	**74.59**
	CAMC for 4 Years			
1	1st Year	1	73,79,300.00	73.79
2	2nd Year	1	81,17,230.00	81.17
3	3rd Year	1	89,28,953.00	89.29
			Total	**244.25**
	Overall O&M Cost in INR Lacs			**318.85**

9.0 ENVIRONMENTAL AND SOCIAL ASPECTS

9.1 OBJECTIVE OF ENVIRONMENTAL AND SOCIAL STUDIES

Inland Waterway Authority of India (IWAI), Ministry of Shipping, Government of India intends to explore the potential of additional waterways across the country for year round commercial navigation, and recommending the possibility of Composite and Integrated development of National waterways to achieve navigation and to develop water transport facilities across India.

Among many rivers, the Ajay River is also considered for waterway and declared as National Waterway No. 7 (NW-7). The Ajoy River originates on a small hill about 300 metres high, southwest of Munger in Bihar. It then flows through Jharkhand and enters West Bengal at Simjuri, near Chittaranjan. It first forms the border between Bardhaman District and Jharkhand and then between Bardhaman District and Birbhum District, and finally it enters Katwa sub-division of Bardhaman district at Nareng village. It then joins the Bhagirathi River at Katwa Town. Total length of the Ajoy is 288 kilometres, out of which 152 kilometres is in West Bengal. The catchment area of Ajoy River is 6,093 square kilometres. The upper reaches of the Ajoy pass through hilly regions with laterite soil. It is only from Ausgram in Bardhaman district that the Ajoy flows through alluvial plains. The important tributaries of the Ajoy are Pathro and Jayanti in Jharkhand, and Tumuni and Kunur in Bardhaman district of West Bengal.

The major objective of this study is to establish present environmental condition along the project corridor through available data /information supported by field studies to evaluate the impacts on relevant environmental attributes due to the construction & operation of the proposed project; to recommend adequate mitigation measures to minimize / reduce adverse impacts and to prepare an Environmental Management Plan (EMP) for timely implementation of the mitigation measures to make the project environmentally sound and sustainable. The study basically includes:

- Establishment of the present environmental and social scenario
- Study of the specific activities related to the project
- Evaluation of the probable environmental and social impacts
- Recommendations of necessary environmental control measures.
- Preparation of Environmental Management Plan
- To identify the requirement of various regulatory clearances, NoCs

9.2 ENVIRONMENTAL SETTING IN THE PROJECT AREA

9.2.1 Physiographic

Barddhaman (Burdwan) district lies between 22°56' to 23°53' North latitude and from 86°48' to 88°25' East longitude. The district is bounded on the north by Dumka (of Jharkhand), Birbhum and Murshidabad, on the east by Nadia, on the south by Hooghly, Bankura and Purulia and on the west by Dhanbad (of Jharkhand) districts.

The river Barakar forms the State boundary to the west. River Ajay separates Birbhum and Dumka to the north with exception of a portion of Katwa subdivision. River Damodar forms a southern boundary with Purulia and Bankura, while Bhagirathi forms the main eastern boundary with a few exceptions. The maximum length from east to west is 208 Km while the maximum breadth from north to south is 112 Km.

Physiography of Barddhaman (Burdwan) district can be divided into three units: i) Plateau area (extension of Chotanagpur area) the westernmost Asansol-Kulti sector. ii) Undulatory area-Asansol-Durgapur sector. iii) Flat alluvium terrain-From Durgapur eastwards.

The western half of the district resembles a promontory jutting out from the hill ranges of Chotonagpur plateau and consists of barren, rocky and rolling terrain with a laterite soil rising into rocky hillocks, the highest being 227 m. These diversify the otherwise monotonous landscape and lend a special charm to the skyline around Asansol subdivision.

Ajoy-Barakar divide is a convex plateau, the average altitude being 150 m. The gradient is westerly to the west and to the east it is northerly towards Ajay and southerly towards Damodar below the latitude. The Ajoy- Damodar inter-stream tract is made up of several stows consisting of vales and low convex spurs which run in almost all directions except north-east and thus lends a very complicated character to local relief. The relief and slope feature of Barddhaman (Burdwan) District is presented in **Figure 24.**

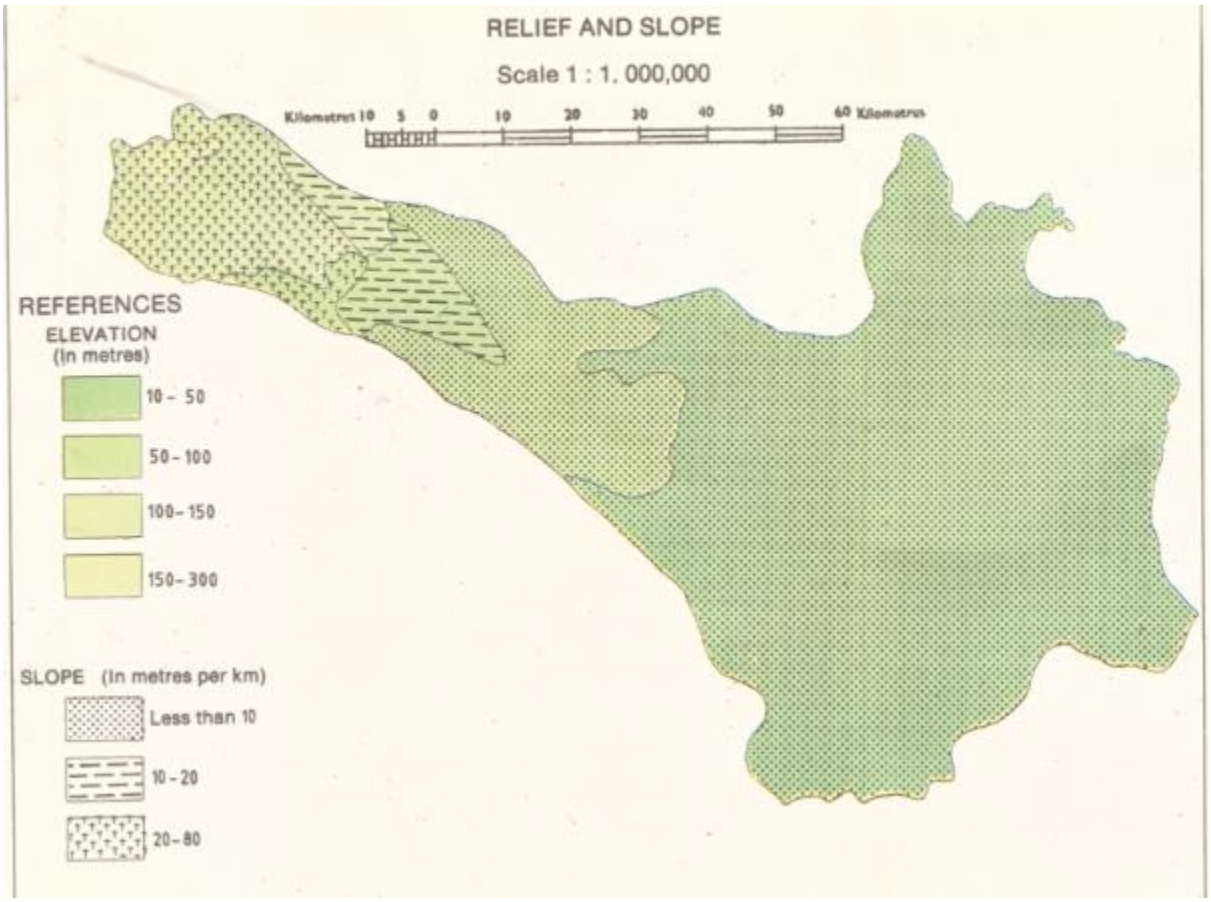


Figure 24: Relief and Slope Map of Barddhaman (Burdwan) District

9.2.2 Geology and Seismicity

Geology:

Geologically the Barddhaman (Burdwan) district is divided in to three parts. A) The extreme northwestern small part of this district, near Rupnarainpur in Salanpur Block, is occupied by the Achaean metamorphic rock, viz. granite gneiss, hornblende schist, which is traversed by bands/patches of amphibolites, pegmatites and quartz veins. B) The western part of about 2063 sq.km is covered by Up-Palaeozoic-Mesozoic-Tertiary sequence of Gondwana Super group of sedimentary rocks of fluviatile-lacustrine origin, deposited in intracratonic basins. The Lr. Gondwana Damuda Group of rock of Permo Carboniferous age contains valuable resources of coal seams. C) The major central and the eastern parts of about 4965 sq.km of the district is covered by alluvium blanket comprising of Older Alluvium, Younger Alluvium, Laterite, Sand, Gravel, lithomargic clay, etc. of Up-Tertiary-Quaternary age.

The master slope of the district is from west to east and southeast with the land having the highest altitude at the extreme western corner of approx. 150 m msl to about 10 m near Kalna at the eastern border of the district. Laterite and red soil in the western part of the district and Vindhyan and Gangetic alluvium in rest of the area observed. The district remarkably presents the entire geological succession from Archaean to recent. The western part of the district comprising the Raniganj coalfield is underlain by the Gondwana sedimentary rocks and contains valuable coal deposits. The central part and eastern part of the district are underlain by alluvial formations. The Rock and Mineral Map of Barddhaman (Burdwan) District is presented in **Figure 25**.

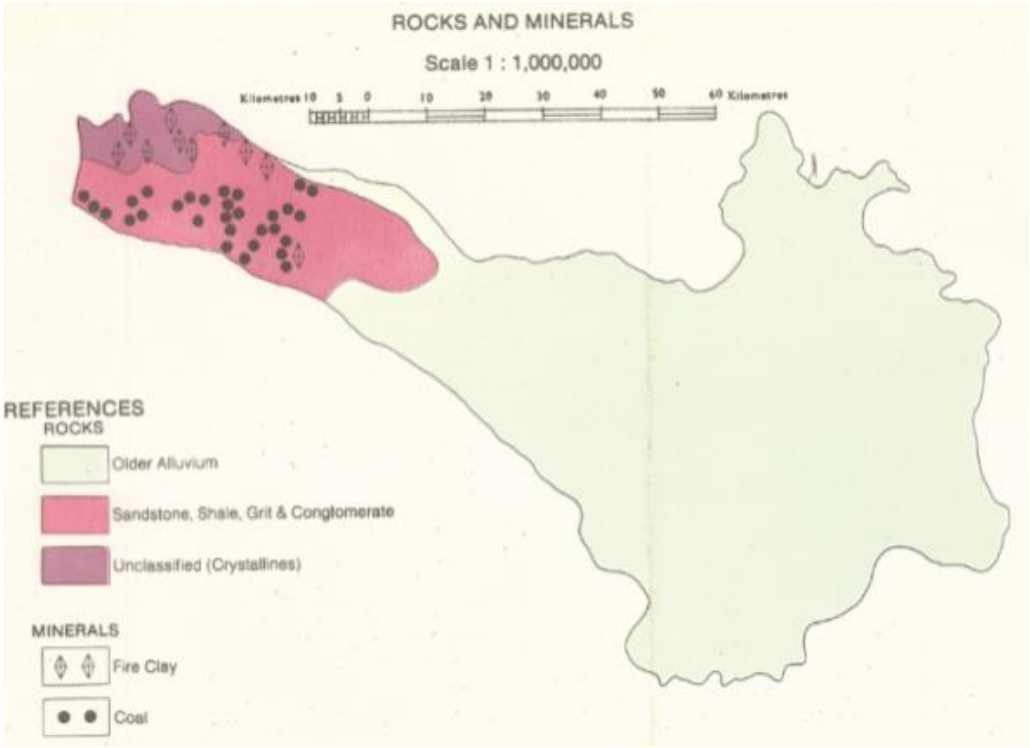


Figure 25: Rock and Mineral Map of Barddhaman (Burdwan) District

Seismicity:

According to Global Seismic Hazard Assessment Programme (GSHAP) data, the state of West Bengal falls in a region of low seismic hazard in the south-west that rises steadily towards the east and the north of the state. As per the 2002 Bureau of Indian Standards (BIS) map, the districts Barddhaman (Burdwan) comes under zone III, which is known as moderately stable zone. The details are furnished in **Figure 26**.

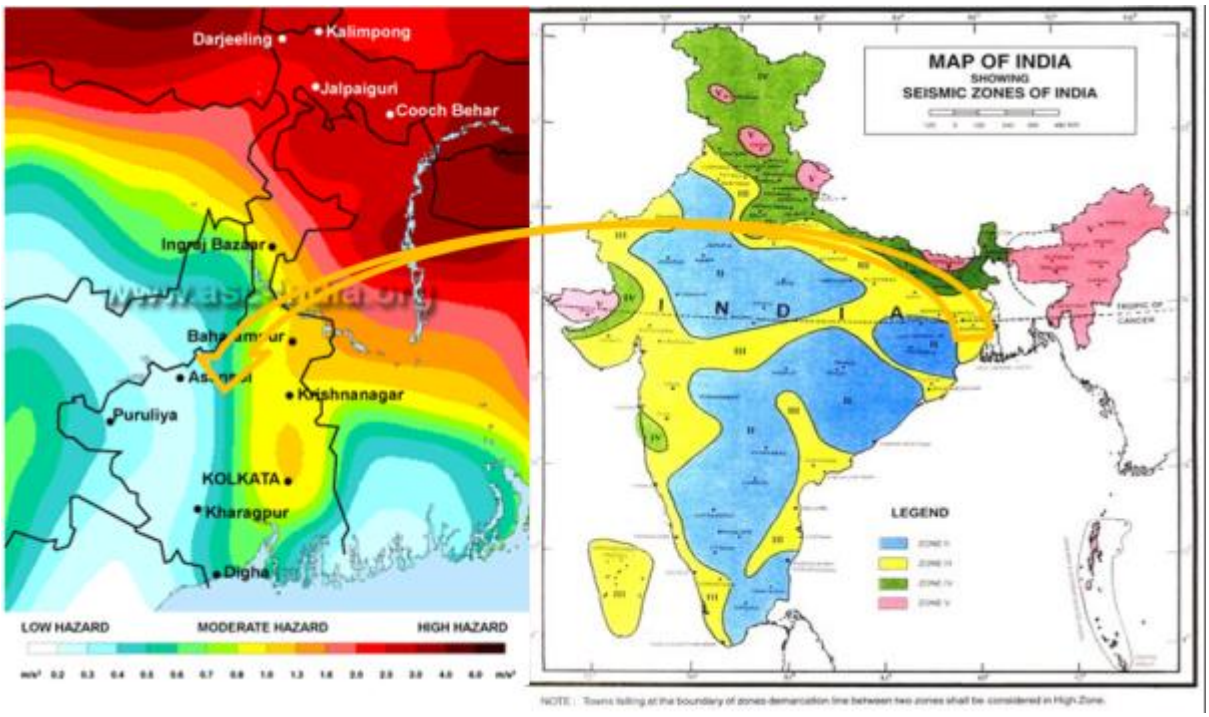


Figure 26: Seismic map

9.2.3 Climate

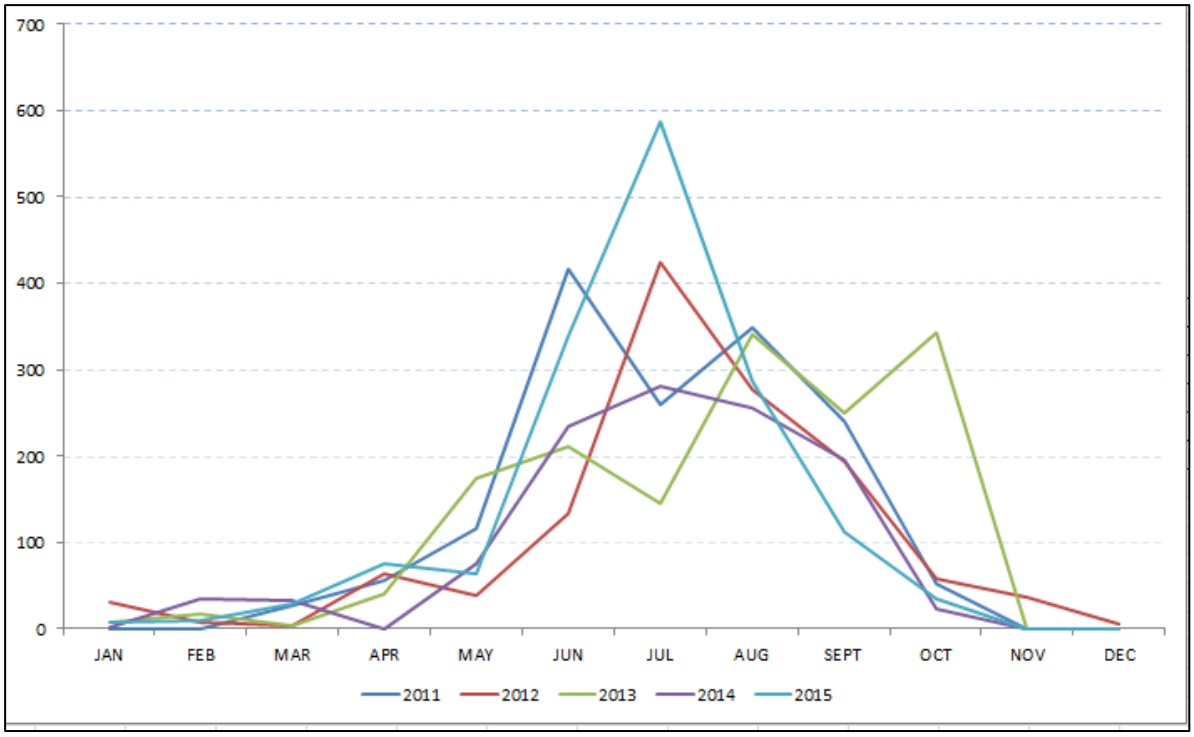
The summers are much rainier than the winters in Barddhaman (Burdwan). The climate in the district is tropical. The climate of Barddhaman (Burdwan) district is winter season starts from about the middle of November and continues till the end of February. March to May is dry summer. June to September is monsoon while October and November is autumn. The Köppen-Geiger climate classification is Aw. The average annual temperature is 26.3 °C in Barddhaman (Burdwan). In between 2011 to 2015 a year, the average rainfall is 1402.12 mm. The pattern of Rainfall in Barddhaman (Burdwan) District is furnished in below table and figure.

Table 46: Rainfall Pattern of Barddhaman (Burdwan) District

Year	Month wise Rainfall Pattern (mm)											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
2011	0	0.7	27.1	55.4	116.8	417	259.5	348.8	240.3	51.4	0.6	0
2012	31.1	7.8	3.2	63.3	39.4	133.9	424.5	277.9	194.6	57.2	37.5	6.2
2013	6.8	17.5	4.6	41.5	175.1	210.2	145.5	341.1	250.7	342.5	0	0
2014	1.1	35.1	32	0.7	74.6	233.9	280.6	256.5	195.3	23.9	0	0.7

Year	Month wise Rainfall Pattern (mm)											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
2015	8.5	10.1	29.4	76.3	64.2	338.1	587.3	285.8	111.8	34.1	0	0.9

Source: India Meteorological Department



Source: India Meteorological Department

Figure 27: Rainfall Pattern of Barddhaman (Burdwan) District

The observatory of Indian Meteorology Department located in Suri is the nearest station from project area. Based on observations in 1971-1993 the temperature profile of the project area is furnished in below table. April is the warmest month of the year. The temperature in April averages 38.1 °C. The lowest average temperatures in the year occur in January, when it is around 11.6 °C.

Table 47: Daily (Mean) Maximum and Minimum temperature by month in the Project Area (1971-1993)

Month	Temperature in ° C (Mean)	
	Daily Maximum	Daily Minimum
January	25.2	11.6
February	28.5	14.1
March	34.2	18.6
April	38.1	22.9
May	37.5	24.1
June	35.1	25.1
July	32.7	24.6
August	32.2	24.6
September	32.4	24.0
October	31.9	21.9
November	29.6	17.1
December	26.1	12.5

Source: India Meteorological Department

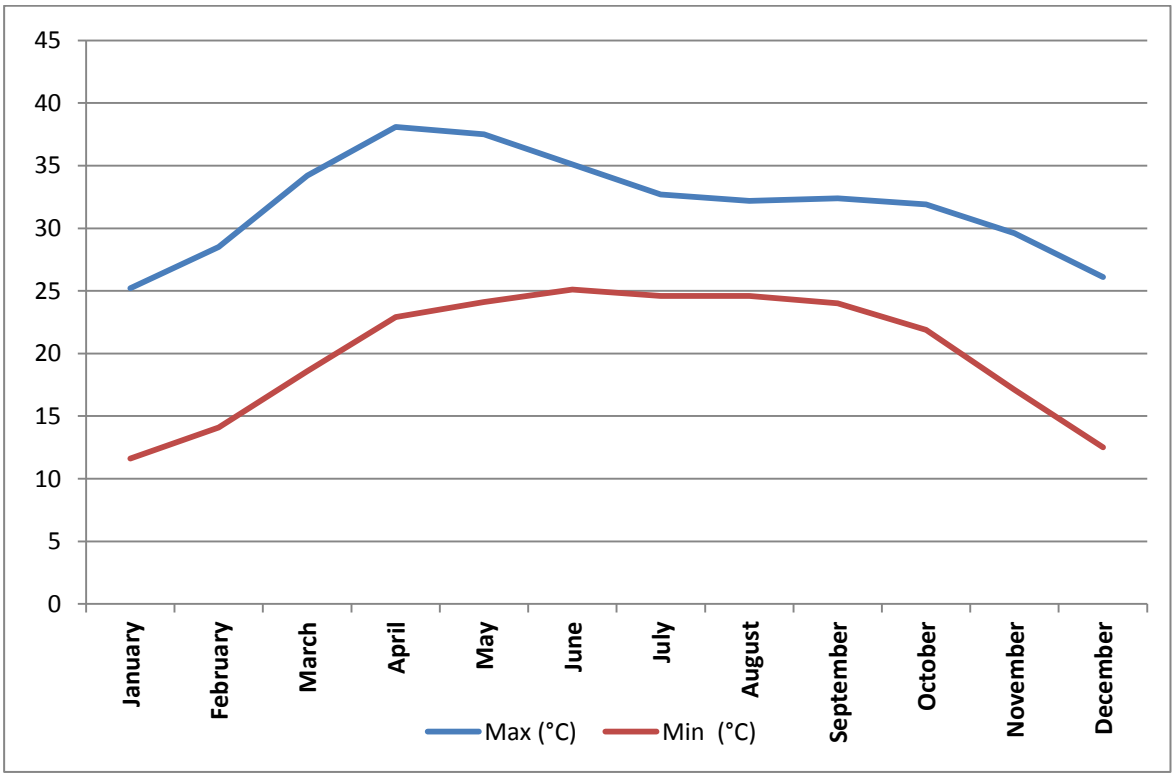


Figure 28: Temperature Graph

The **Figure 29** showing climatic condition of Barddhaman (Burdwan) district is furnished below.

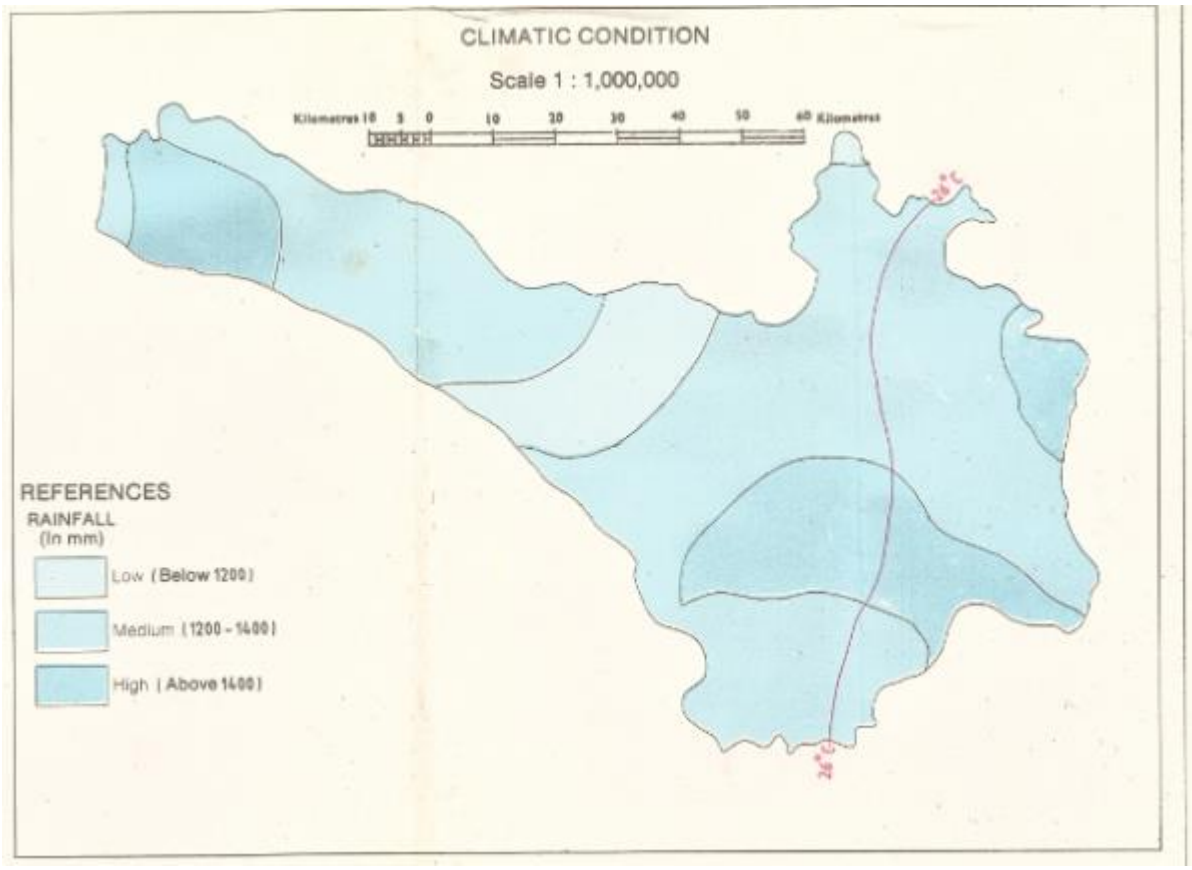


Figure 29: Climatic condition of Barddhaman (Burdwan) District

9.2.4 Soils

Different types of soil are encountered in different topographical, biological and hydrological as well as geological condition within Burdwan district. Laterite and red soil in the western part of the district and Vindhyan and Gangetic alluvium in rest of the area observed. The district remarkably presents the entire geological succession from Archaean to recent. The western part of the district comprising the Raniganj coalfield is underlain by the Gondwana sedimentary rocks and contains valuable coal deposits. The central part and eastern part of the district are underlain by alluvial formations. The soil of the eastern part of Burdwan district is of rich alluvial variety and is suitable for intensive cultivation of paddy, wheat, potatoes and other crops and vegetables. This alluvial soil is formed of alluvium brought down by the Ajay, Damodar, Bhagirathi and numerous other rivers The soil of the western part of the district is not that fertile. The soil map of Barddhaman (Burdwan) District is presented in below Figure.

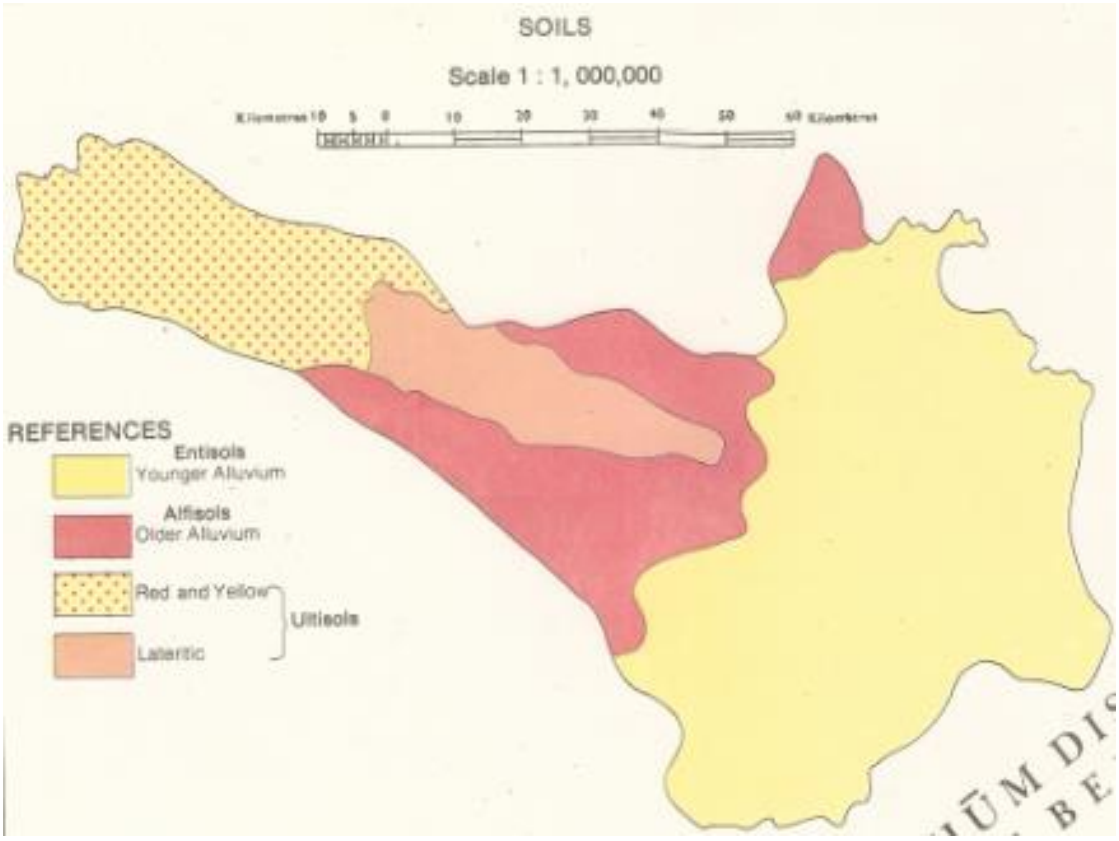


Figure 30: Soil Map of Bardhhaman (Burdwan) District

9.2.5 Land Use Pattern

Barddhaman is the only district in the state of West Bengal that is fortunate both in industry and agriculture. On an average about 58 percent of the total population belongs to the agricultural population while the non-agricultural sector accounts for the remaining 42 percent.

The eastern, northern, southern and central areas of the district are extensively cultivated but the soil of the western portion being of extreme lateritic type is unfit for cultivation except in the narrow valleys and depressions having rich soil and good moisture. The cultivation in the district has improved since 1953 with the implementation of the irrigation projects undertaken by the Damodar Valley Corporation. Up to 1953 the cultivation was entirely dependent on the monsoon, and irrigation facilities were rather inadequate and more or less primitive. The position has since been changed and an all-round agricultural development has become possible.

Rice is the most important crop of the district and in the alluvial plains to the east little else is grown. The rice grown with its numerous varieties can broadly grouped under the three primary classes

distinguished from one another by distinct characteristics and there are: The Aus or autumn, the Aman or winter and the Boro or the summer rice. Paddy covers maximum of the gross cropped area. Among commercial crops Jute, Mesta and Sugarcane, potato, oil seeds are cultivated in marginal area. The land use pattern of Burdwan District is presented in below table.

Table 48: Land use Pattern of Barddhaman districts (Area in '000 ha.)

S. No.	Land use pattern of Barddhaman district (Area in '000 ha)	
1	Geographical area	698.8
2	Cultivable area	470.5
3	Forest area	21.2
4	Land under non-agricultural use	206.0
5	Permanent pastures	0.32
6	Cultivable wasteland	7.6
7	Land under Misc. tree crops and groves	1.2
8	Barren and uncultivable land	1.04
9	Current fallows	7.40
10	Other fallows	1.96

Source: *National Innovations on Climate Resilient Agriculture (NICRA)*

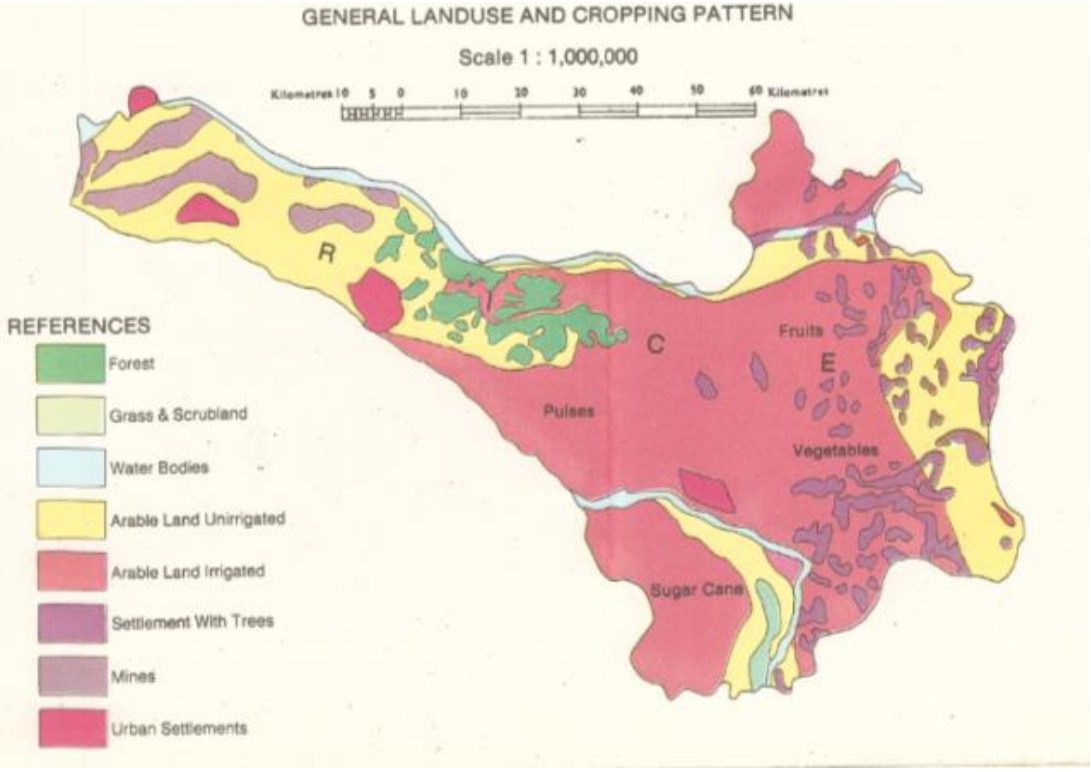


Figure 31: Land Use Map of Barddhaman

9.2.6 Ambient Air Quality

During the reconnaissance survey, it was the found that the Air quality of the study area along Ajoy River was free from dust. It was also confirmed from the local people that there is no problem with Air pollution in the project area. They also confirmed that there is no major industry located in the vicinity of project area. **Table 49** shows the Ambient Air Quality of Bardhaman District.

Table 49: Average Ambient Air Quality of Project District

S. No.	Year	Parameters		
		SO_2	NO_2	PM_{10}
1.	2016	7.05	23.56	82.37
2.	2017	7.33	23.34	84.52

9.2.7 Ambient Noise Levels

During the reconnaissance survey, it was the found Noise is not a significant concern in the surrounding areas of the proposed stretch of Ajay River. There is not any noise generating sources in the nearby areas also.

9.2.8 Susceptibility to Natural Hazards

River and coastal flooding are the most frequently occurring natural disaster and are increasing in occurrence more rapidly than any other disaster. Urbanization and deforestation reduce the capability of the earth to hold excess water. As asphalt- and concrete-covered surfaces expand and open spaces disappear at the edges of urban areas, it takes less rain to flood communities as water running over the pavement collects quickly and easily disrupts storm drain systems. Those areas which are most at risk for floods include low-lying areas, coastal regions and communities on rivers downstream from dams. Flood waters are extremely dangerous; a mere six inches of swiftly moving water can knock people off their feet.

In some places flooding is caused by excessive monsoons, while in others flooding is caused downstream from dams when reservoirs, which normally help to prevent downstream areas of rivers from flooding, are opened due to unusually high levels of rain to prevent the reservoir from overflowing the dam. Dam breaks are also a cause of catastrophic flooding. West Bengal has 37,660 sq. km flood prone area spread over 111 blocks where the total geographical area of the state is 88,752 sq. km. An analysis of the statistics of flood that occurred during last 41 years (from 1960 - 2000) shows that only on 5 occasions the state has not faced any severe flood. The total devastated area crossed 20,000 sq. km in 4 different years and the flood of medium magnitude i.e. between 2,000 to 10,000 sq. km. occurred on 10 occasions.

Types of Floods

It is a temporary inundation of large regions as a result of an increase in reservoir, or of rivers flooding their banks because of heavy rains, high winds, cyclones storm surge along coast, tsunami, melting snow or dam bursts.

Flash Flood: It is defined as a flood which occurs within six hours of the beginning of heavy rainfall, and is usually associated with cloud bursts, storms and cyclones requiring rapid localized warning and

immediate response if damage is to be mitigated. In case of flash floods, warning for timely evacuation may not always be possible.

River Flood: Such floods are caused by precipitation over large catchment's areas. These floods normally build up slowly or seasonally and may continue for days or weeks as compared to flash floods

Coastal Flood: Some floods are associated with the cyclonic activities like Hurricanes, tropical cyclone etc. Catastrophic flooding is often aggravated by wind-induced strom surges along the coast.

Causes of Flood

- Excessive rainfall in river catchments or concentration of runoff from the tributaries and river carrying flows in excess of their capacities
- Backing of water in tributaries at their confluence with the main river.
- Synchronization of flood peaks of the main rivers and tributaries.
- Landslides causing obstruction to flow and change in the river course.
- Poor natural drainage.
- Cyclone and very intense rainfall.
- Intense rainfall when river is flowing full.

Elements at Risk

Anything in the flood plains will get inundated. Building built of earth, weak foundations, and soluble materials will collapse endangering humans and their property. Basements of buildings are under risk. Utilities such as sewerage, water supply, communication lines, and power are put at risk. Food stock in the godowns, agricultural fields, livestock, vehicles, machinery and equipments mounted on the ground, fishing boats are also put at risk.

Due to climate condition, geographical location and industrial belt areas Burdwan district faces various disaster throughout the year. The major thrust is being given on 'flood' as it causes maximum damage and loss of property and human lives. Some cases of Arsenic hazard are being studied by the Public Health Engineering Department.

9.2.9 Estuary and Coastal Zone

The project stretch is located far away from the estuary or any coastal area. River Ajay joins Bhagirathi River near Katwa.

9.2.10 Archaeological and Heritage Locations

No such notified Archaeological Site or Heritage location is located along the project stretch. However, in recent times exploration revealed various remains of an ancient civilisation. Chalcolithic and Early-historic sites like Pandu Rajar Dhibi, Basantapur, Berenda are located on the right bank of the river Ajay. This zone comprising thick compact brown sand and sandy loam is favourable for agrarian work and therefore the early people preferred this zone for settlement.

Sites on the left bank of the river Ajay are Chella-kamarpara, Bergram, Kalyanpur, Supur etc. The Chalcolithic site of Basantapur and the Early-historic sites of Aral and Kogram are on the left bank of the river Kunur whereas the early-historic site of Deuli is on the left bank of the river Ajay. The Early-historic site of Sagira is on the right bank of the river.

Mangalkot is on the left bank of the river Ajay and is towards the downstream of the river. Settlements came up due to this favourable agrarian context. This particular zone is the confluence point of the river Ajay and its tributary Kunur, the scope for riverine trade also helped in the development of the Early-historic settlement. Artefacts have been found from the modern village settlements of the Ajay basin.

9.2.11 Flora and Fauna

Flora

The Forests in Barddhaman is categorised as the tropical dry deciduous type where the principal flora include *Shorea robusta*, *Anogeissus latifolia*, *Boswellia serrata*, *Terminalia belerica*, *T. tomentosa* etc.

The flora of the district is characterized by the arborescent species such as Simul (*Salmalia malabarica Schott. & Endl.*), Neem (*Azadirachta indica*), Amlaki (*Phyllanthus emblica*), Lannea coromandelica Merr., Narikel (*Cocos nucifera*), Khejur (*Phoenix dactilofera L.*), Tal (*Borassus flabellifer L.),* Bat (*Ficus bengalensis L.*), Asvattha (*Ficus religiosa L.*), Palas (*Butea frondosa*) , Krishnachuda (*Caesalpinia Pulcherrima*), Am (*Mangifera indica L.*) and shrubby species such as ashsheoda (*Glycosmis pentaphylla Corr.*), Pianj, Rasun, Rajanigandha (*Polyanthes tuberosa Wild.*), Ghentu or Bhat (*Clerodendron infortunatum Gaertn.*), Kurabaka (*Barleria Cristata*), Gulancha (*Tinospora cordifolia*),

Tulsi (*Ocimum sanctum*), *Solanum torvum SW., S. Verbascifolium L., Trema orientalis Bl.*, Shiora *(Streblus asper Lour.*) and Dumur (*Ficus hispida L.*).

The uplands of Asansol subdivision and the laterite area of the district are in places covered with Sal (*Shorea robusta Gaertn.*), Mahua (*Madhnea latifolia*),Palas (*Butea monosperma*), Bans (*Bambusa arundinacea*), Shireesha (*Albizzia lebbek*), Arka (*Calotropis gigantea*), Kend (*Diospyros melanoxylon*), Arjun (*Terminalia Arjuna*) and Ashan (*T. tomentosa*). The common plants in hedges and wastelands are lal-bharenda(Jatropha gossypifolia L.), Ban-okra (*Urena lobata L.*), *Heliotropium strigosum Willd.*, Hati-soond *(H. indicum L.),* Ulu (*Imperata arundinecea*), *Sida veronicifolia Lam., S.cordifolia L.,* etc.

The common aquatic and marsh weeds found in the jheels ans swamps in the eastern parts of the district are Keshe (*Saccharum spentaneum*), Bena (*Andropogon squarrosus*), Caesulia axillaries Roxb., Ganj or pata-sola (*Vallisneria spiralis L.*), Jhangi (*Hydrilla verticillata lasp.*), Pond weed (*potamogeten indicus Roxb. and P. crispus L.*), Kesar-dam (*Jussiaea repens L.*), Kush (*Eragrostis cynosuroides*), common Jhangi (*Utricularia stellaris L.F. and U. flexuosa Vahl.*), Pana (*Lemna pancicostata Hegelm*), Wodffia arrhiza Wimm., Mootha (*Cyperus rotundus*), Ceratopteris thalictroides Brogn, Monochoria hastaefolia and M. Vaginalis Presl.., Water hyacinth (*Eichornia crassipes*), Ottelia Alismoides pers, Bara-pana (*Pistia stratiotes L.*), Sagittaria guayanansis H.B.K., Najas graminea Del., Hogla (*Typha angustata Chub. & Bory*), Hygrorhiza aristata Nees, Leersia hexandra Sw and Padma (*Nelumbium speciosum*).

Fauna

The carnivora of the district comprise leopard (*Panthera pardus*), wolf (*Canis lupus)*, hyaena *Hyaenidae,* jackal (*Canis aureus)* and other smaller species, but hyaenas and leopards are not common. Tigers were formerly common in the district, especially in the jungles of the Asansol subdivision adjoining the Jharkhand, but have now entirely disappeared. Wolves (*Canis lupus*) are scarce, and are mostly met with in the jungles north of Kanksa. Wild pigs are numerous throughout the district and monkeys also abound including the variety known as Hanuman *(Semnopithecus entellus)*. In the hilly areas an occasional python (*Python sp.*) is met with. Poisonous snakes are very common and include several kinds of cobra (*Naja naja*), the *karait* (*Bungarus caeruleus*) and the deadly Russell's viper (*Vipera russelli*). Other most frequently seen varieties are the Dhamna (*Ptyas mucosa***)** and various species of harmless grass snakes.

Birds include Grey and Black Patridges, Pea-fowl (*Pavo cristatus*) and Jungle fowl *Gallus*. On the Damodar River and in the marshes and jhils (big ponds) Goose, Duck and Teal are found in fair numbers The other common birds are Crow (*Corvus sp.)*, Redwhiskered Bulbul (*Pycnonotus jocosus)*, Red-spotted Bluethroat (*Luscinia svecica)*, Brown-backed Robin (*Copsychus fulicatus)*, *Shama* (*Copsychus malabaricus)*, Tailor bird (*Ploceus philippinus*), *Mayna* (*Acridotheres tristis)*, *Munia*, Sparrow (*Passer domesticus)*, Woodpecker, Cuckoo (*Cuculus micropterus)*, *Nilkantha* (*Coracias benghalensis)*, Parakeet (*Psittacula krameri)*, Kingfisher (*Alcedo atthis)*, Hornbill (*Ocyceros birostris)*, Owlet (*Athene brama*), Vulture *(Gyps indicus)*, small spotted Eagle (*Clanga pomarina*)., Shikara (*Accipiter badius)*, various types of Pigeon and Dove (*Spilopelia chinensis)*, Storks and Herons etc.

Rohu *(Labeo rohita),* Mrigel *(Cirrhinus cirrhosis*), Katla *(Katla katla),* Bata *(Labeo bata*), Bagda Chingri (Shrimps), Maurala *(Amblypharyhgodon mola),* Pabda *(Ompok sp),* Tengra *(Mystus sp*), Chela *(Chela sp),* Galda Chingri (Lobstar), etc. are the principal catches from the rivers of the district.

No threatened or endangered species of flora and fauna are available along the project waterways.

9.2.12 National Parks, Forests, Wildlife Sanctuaries and Reserves

National Parks and Wildlife sanctuaries play a vital role in protecting the wildlife of a particular area and providing them their natural habitat. There are no national parks, forests, wildlife sanctuaries and Biosphere Reserves adjacent to the project section of Ajay River. The nearest protected area (under purview of Wildlife Act, 1972) is Bethuadahari Wildlife Sanctuary which is located about 26 Km from the project area.

Purbasthali, also known as Chupi Char, lies on the banks of a large oxbow lake created by the Ganges River supports significant population of migratory birds. Migratory birds gather here from far-off places including Siberia in winters

The various wildlife and protected areas in West Bengal is given in **Figure 32**.

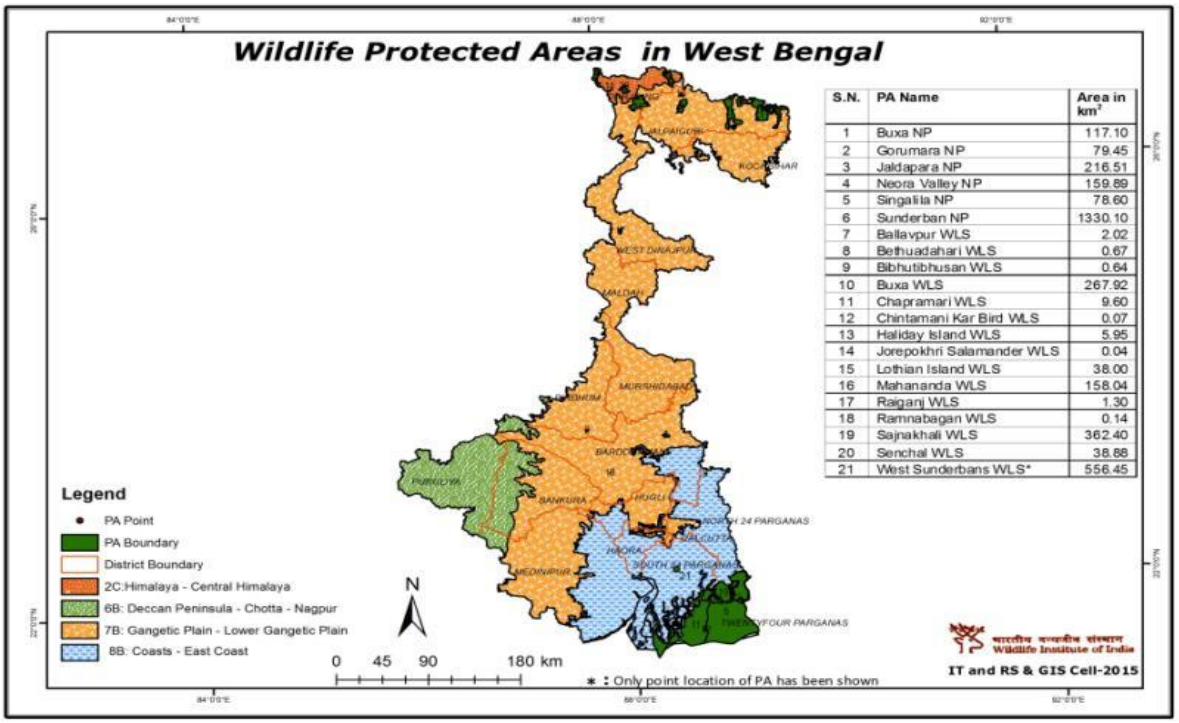


Figure 32: Wildlife Protected Area of West BengalSocio Economic Profile

Social Profile

According to the 2011 census Barddhaman district has a population of 7,723,663. This gives it a ranking of 7th in India (out of a total of 640). The district has a population density of 1,100 inhabitants per square kilometre (2,800/sq mi). Its population growth rate over the decade 2001-2011 was 12.01%. Barddhaman has a sex ratio of 943 females for every 1000 males and a literacy rate of 77.15%.

However, the following tows/village given in Table 9.2 is along the study stretches of Ajay River. As per Census of India Report, 2011, these towns/villages comprises of population of 28198 persons.

Table 50: Population along the project stretch

S. No.	Village/ Town name	Population (nos.)
1	Katwa	6473
2	Sankhai	1985
3	Begunkola	782
4	Goai	1415
5	Kakurhati	1125
6	Parulia	573
7	Nabagram	1683
8	Sunea	266
9	Barenda	4562
10	Charkhi	3727
11	Sahapur	965
12	Billeshwar Rasui	3625
13	Dhanyarukhi	1017
	Total	**28198**

Economic Profile

Agriculture: Owing to its favourable soil, climatic conditions and present irrigation facilities, the district Burdwan is a highly fertile and is sometimes called the Rice Bowl of West Bengal.

In the year 2010-2011, the Area under cultivation for rice was 562.9 thousand hectares, for potato 53.0 thousand hectares, for total oilseeds (mustard, rapeseed & others) 39.5 thousand hectares and for jute 12.6 thousand hectares. Other principal crops listed are pulses having 3.2 thousand hectares, mesta (fibre) 0.2 thousand hectares, sugarcane 1.2 thousand hectares. Ginger and dry chillies are

also principal crops. Out of total rice varieties viz. Aus, Aman and Boro, the latter two have the majority area.

Production figures for the same year show the production of rice at 1665.9 thousand tonnes, of which Aman was 1053.6 thousand tonnes, Boro 585.9 thousand tonnes. Among others, total pulses produced was 3.2 thousand tonnes, total oilseeds was 37.6 thousand tonnes, Total fibers (99 per cent jute) was 265.9 thousand bales (of 180 kg. each), potato was 1997.1 thousand tonnes, dry chillies was 3.6 thousand tonnes and ginger 0.3 thousand tonnes.

It is observed that the cropping pattern is increasingly dominated by potato, rice, in particular and oilseeds (including rapeseed and mustard). The crops are either HYV (boro) or cash crops and hence are more remunerative over other crops. The oilseeds have another advantage. Besides being remunerative, they also require less irrigation which makes them ideal for cultivation in the areas of less rainfall or irrigation. Pulses as a whole, have lost both in terms of acreage and production.

Irrigation: The major Irrigation Projects in the district are the Mayurakshi Project (which mainly serves the Birbhum district and also irrigates a vast tract of arable land of Ketugram Police Station of Barddhaman district) and the Damodar Valley Corporation. Apart from these, several small and minor irrigation schemes were implemented in the district in recent years Lift Irrigation and tubewells are also installed for water the field under crop.

According to the report of Water Investigation and Development Department, Govt. of West Bengal, the Damodar Irrigation Circle and Department of Land and Land Revenue, Government of West Bengal, out of a Net Cropped Area of 458.5 thousand hectares, the area irrigated by the Government Canals is 245.63 thousand hectares, that irrigated by High Capacity Deep Tube Well is 7.82 thousand hectares, that irrigated by Middle Capacity Deep Tube Well is 0.75 thousand hectares, that by Low Capacity Deep Tube Well is 11.78 thousand hectares and 12.0 thousand hectares is irrigated by River Lift Irrigation.

Animal Husbandry: Like other districts of West Bengal, Burdwan district has also got a very good amount of cattle, buffaloes and goats. As per Cattle Census Report, West Bengal and Livestock Census Report, in 2007, out of a total livestock of 37,01,705 numbers, total cattle (cows, bulls, young stock) was 17,30,618 numbers The number of buffaloes was 1,20,359 and Others (sheep, goat, pigs etc.) was 1,66,227. Apart from Live Stock, the figure for Poultry was 64, 29,429 numbers

Fishery: The Bhagirathi, the Damodar and the internal rivers and channels are the sources of a variety of fresh water fishes in the district. The considerable portion of the supply is also obtained from the numerous tanks in the eastern part of the district. The types of fish available in the district are - ruhi, katla, mrigel, kalbose, ilsa (hilsa), chital, boal, tangra, punti, mourala, chela, bata, sal, sol, lata, koi, chanda, magur, pabda, rita etc. According to the Directorate of Fisheries, Bardhhaman, a Net Area of 24,754 hectares is dedicated to pisciculture. The number of persons engaged in the profession was 1,47,023. The annual production was around 1,06,71,900 quintals.

Industry: Burdwan enjoys certain favourable characteristics on which industrialisation largely depend. These are availability of natural resources, good power position and good connectivity. Barddhaman is only about 100 km. from Kolkata and is well connected to neighbouring states of Jharkhand and Bihar. Most of the potential areas of forward and backward linkages are connected with motorable roads. Availability of water is also satisfactory.

The most industrialized zone of the district comprise areas under Asansol Subdivision and Durgapur Sub-division, The various five year plans created the new industrial areas of Durgapur and Chittranjan, adding to the urban centres of the region, such as Asansol, Kulti, Burnpur and Raniganj. The traditional industrial base of the region chiefly supported by coal, iron and steel has undergone a rapid diversification. New industrial ventures include mainly heavy engineering, fertilizers and coal-based chemicals. A number of small industries also grew up to serve these bigger industries and small industries. The principal industries beside Durgpaur Steel Plant and Durgapur Projects Limited are production of cement making machinery, boilers, pressure vessels etc. Alloy Steel Plant produces a variety of alloy steels, Durgapur Chemicals Limited produces basic organic and inorganic heavy chemicals. Mining & Allied Machinery Corporation produces coal mining and bulk handling equipment and other heavy machinery. There is one Industrial Estate at Saktigarh.

The other type of industries that are existed in the district includes Modern Rice Mills, Rice Bran Oil, Cold Storage, Oil Mill, Chira (flatted rice) Mill, Bakery, L.P.G. Gas Filling Plant, Transformer manufacturing/repairing automobile spare parts manufacturing and repairing factories etc.

This district is rich in handicrafts also. The degree of excellence of products like, Sola craft of Bonkapasi Village and Dokra work of Dariapur is now acceptable to European markets. Many traditional industries are still found in the district, include cutlery, cartmaking, clay image making, dairy, gold and silver smithy, lime making, mat-making, pottery, tile making, leather work, carpentry, black smithy, oil crushing, crushing, cane work, basketry and bamboo works, gur (molasses) making; wood and stone carving, etc. The handloom weaving, an important cottage industry of the district, is

at present mainly located at Katwa. These medium and small scale industries support a good number of people in the rural areas and the State Government has taken up various measures to improve production, marketing and skill-building in these sectors The potential places for Industries are Barddhaman Sadar, Kalna and eastern part of Barddhaman.

Trade & Commerce: Owing to its advantageous position in transportation network and good resource endowments, Barddhaman spontaneously responded to commercialisation especially of agriculture. Barddhaman is sometimes called the Rice Bowl of Bengal. Rice trade was carried on regularly in an organised way in Barddhaman and expanded considerably from the last quarter of the nineteenth century. The business acumen as well as entrepreneurial activities of the traders and merchants of Barddhaman was successfully demonstrated with the expansion of commercialisation of agriculture. The rice merchants and rice millers dominated the rice trade of Barddhaman, forming associations for protecting and promoting their business.

This district enjoys a good position as far as marketing is concerned because it is very well connected with the huge market of Kolkata on the one hand and the towns of Bolpur, Bankura and also the North Indian States on the other hand. Barddhaman district serves as a centre from where different types of consumer durables are supplied to the coal belt of Bihar and to the neighbouring districts like Birbhum and Bankura and it serve as ready markets for the varied products of Barddhaman district.

Moreover, the district itself provides a large market for its own products. The aggregate size of the consumer goods market of the district is significantly large. Field investigation also reveals that the urban centres, viz. Durgapur, Barddhaman, Asansol, Raniganj, Chittaranjan, Kalna and Katwa have a large and growing middle class and upper middle class population and provide an attractive market for various consumer durables and non-durable articles. These urban centres also serve as wholesale markets as far as consumer goods are concerned and another basic function of these markets is to act as intermediate points for procuring consumer products from Kolkata and Barddhaman and other parts of the State and for distributing the same to various markets both in the urban and rural areas in and outside the district.

Transport: The district of Burdwan has a very good Railway Network with junction stations. A good number of important trains pass through the district with the destination of many important towns / cities of the country. The district has an extensive road network with inter state corridors The G.T Road (N.H - 2) has been upgraded for better traffic movement from Barakar in the west to Panagarh in the east and further being extended upto Palsit at the junction point of Durgapur Express Highway.

The Durgapur Express Highway has been commissioned for vehicular movement and it is now easy to connect with NH- 2, N.H - 34 and N.H-7 also.

9.3 POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS OF THE PROJECT

Environmental and Social Assessment helps in identifying the likely impacts due to project activities for all stages of the project viz, design, construction and operation stage on the physical, biological and social environment.

The three major activities involved in the project development which may have impacts on environment at different stages are construction and operation of civil interventions, dredging and operation of barges. These activities may impact different environmental components at different stages of project life cycle. The details are follows:

9.3.1 Impacts during Construction Phase

A. IMPACTS DUE TO EXCESS SOIL/ DREDGING MATERIAL/ WASTE

The excess soil and muck generated from various construction activities, waste from construction vehicles, fuel lubricants, machinery & maintenance equipment needs to be properly disposed, so as to avoid adverse impacts. The impacts however, shall be marginal. The solid waste generated due to various construction activities should be disposed off at designated disposal ground.

Dredging is required for construction of proposed waterway and cargo terminal in Ajoy river Dredging may changes the water quality, river bed topography and benthos if not prevented. These activities must not occur in sites protected for drinking water supply and fish spawning.

The muck generated due to dredging will disposed at low lying area for flood protection measures.

B. IMPACTS ON LAND

The impact associated with the land environment during design and construction phases area as follows:

- Loss of land / land acquisition: The total land required to be acquired for the construction of proposed dry bulk cargo terminal is about 2.0 hectare and the total land required to be acquired for the construction of channel is about 15.5 hectares

- Change in topography
- Change in land use
- Deterioration of soil quality due to spillage of fuel, disposal of muck and any other construction material.

Mitigation Measures:

- ✓ Excavation and filling tasks should be carried out simultaneously so as to minimize the soil erosion. Unusable debris material should be suitably disposed off at designated site with prior approval from concerned authority
- ✓ Compaction of soil should be undertaken by controlled sprinkling the water to minimize the surface runoff and erosion.
- ✓ Agricultural land should be avoided for setting up construction camps, plant site or any other construction purpose
- ✓ Water sprinkling to be carried out for dust suppress
- ✓ Dredging soil should be properly utilized and may be proposed for flood protection measures around the terminal area.

C. IMPACTS ON SOIL

The site clearance process includes excavation and vegetation clearance for construction of channel, jetties and terminal building, which ultimately induces vegetation loss as well as loss of top soil. Since, the vegetation clearance shall be confined to the minimum area; the area affected would be very less. The activities associated with the site preparation and excavation plus movement of vehicles and equipment's can disturb the surrounding lands.

Contamination of Soil: Contamination of soil is primarily due to construction and allied activities. The sites where construction vehicles are parked and serviced are likely to be contaminated because of leakage or spillage of fuel and lubricants. Refuse and solid waste from labour camps can also contaminate the soil. Contamination of soil during construction might be a major long-term residual negative impact. Unwarranted disposal of construction spoil and debris will add to soil contamination. This contamination is likely to be carried over to the River in case of dumping being done near River locations. However, by following mitigation measures such as maintenance of vehicles and machines and fuel refilling carried out in a confined area contamination of soil can be avoided to a great extent. The provision for oil interception chamber is suggested in EMP for treating the waste water generated from vehicle washing, refilling and maintenance areas. Fuel storage and refilling sites should be kept

away from cross drainage structures and important water bodies. All spoils shall be disposed off as desired and the site shall be fully cleaned before handing over. These measures are expected to minimise the impact on soil contamination.

Compaction of Soil: Compaction of soil is anticipated due to the movement of construction vehicles and heavy machines. Thus regulation of movement of heavy equipment's and vehicles shall be essential to prevent this.

Mitigation Measures:

- ✓ Rehabilitate all sites during construction including construction camps, stockpile area, temporary access and hauling routes, as soon as possible after the disturbance has ceased.
- ✓ Contractor to exercise strict care in the disposal of construction waste, with proof of disposal at an approved site provided after offloading each waste load and this logged/registered.
- ✓ Waste containing contaminated water to dispose off site at an approved disposal site in consultation with State Pollution Control Board.
- ✓ Dispose of waste from the oil interceptors only through suitable waste-handling contractor and request for safe disposal certificates.
- ✓ The movement of construction vehicles and equipment's will be restricted to only designated route.
- ✓ Mix cement, concrete and chemicals on a concrete plinth and contain spillages or overflows into the soil.
- ✓ Vehicle maintenance are not allowed on site.
- ✓ If oil spills occur, disposing contaminated soil at a disposal site in consultation with State Pollution Control Board.
- ✓ Stockpiling of subsoil and overburden in all construction and lay down areas.

D. IMPACTS ON AIR

The air quality parameter is the most common environmental feature, which is being affected by any infrastructure projects at different stages i.e. during constructional as well as operational phase. The major indicators of Ambient Air Quality relevant to the project are the concentration of suspended Particulate matters (SPM), Particulate matters of size less than 10µ (PM_{10}), Particulate matters of size less than 2.5µ ($PM_{2.5}$), Sulphur dioxide (SO_2), Nitrogen oxides (NOx), Carbon monoxide (CO) in the atmosphere.

Sensitive receptors and nearby habitation area may be affected temporarily by increased of traffic due to movement of construction vehicles and transportation of material. Fugitive dust can also impact on air quality due to various construction activities. Exhaust fumes from construction machinery, and potential smoke from cooking fires of labour camp, burning of waste and cleared vegetation also affect the air quality. The improper sanitation at worker camps and waste disposal usually lead to odour problem. The problems related to the deterioration of air quality, however, will temporal in nature till the construction period only.

Vegetation existing at proposed terminal site will be removed. Bare & loose soil after vegetation uprooting/removal will be exposed to wind and will add on to the concentration of ambient dust levels. Air quality will also be affected in case tree cutting is undertaken at site as the tree act as air purifiers

Mitigation Measures:

- ✓ All the Construction vehicles and machineries will be regularly maintained to conform to the emission standards stipulated under Environment (Protection) Rules, 1986.
- ✓ All the DG sets will conform to the emission standards as stipulated under Environment (Protection) Rules, 1986.
- ✓ Undertaking monitoring of air pollution levels in potential problem areas.
- ✓ Avoid dust generating construction activities during strong winds.
- ✓ Cover soil loads in transit.
- ✓ Cover stockpiles of soil or apply suitable dust palliative such as water or commercial dust suppressants.
- ✓ Regularly service vehicles off-site in order to limit gaseous emissions.
- ✓ No open fires permitted on site
- ✓ Place portable toilets on-site and maintain on a daily basis.
- ✓ Water will be sprayed in construction area and other excavation areas for suppressing fugitive dust.
- ✓ Transportation material should be Water sprinkled and covered with tarpaulin.
- ✓ Dust emission from stock piles of excavated material will be controlled either by covering the stockpiled materials or water spraying over it.
- ✓ Special attention will be given when working near educational institutions and health centers and settlement areas.

- ✓ As soon as construction is over all the surplus earth will be utilized properly and all loose earth will be removed from the site.
- ✓ Plantation of trees having adequate canopy should be implemented.

E. IMPACTS ON AMBIENT NOISE AND VIBRATION

The proposed construction activities are expected to increase the noise levels mainly due to plying of construction vehicles, pumping machines, use of portable generators, mechanical machinery etc. These activities will occur round the clock and the noise pollution thus created may affect human habitations, particularly during the night time. Increase of noise level at night may cause discomforts to population in the vicinity of the site in case construction activity is extended into the night hours

Sensitive receptors and nearby habitation may be affected temporarily by increased traffic due to movement of heavy construction vehicle and equipment's, which may generate high levels of noise.

Vibrations resulting from bulk earthworks, micro-tunnelling and compaction may create significant disturbances to nearby area.

Mitigation Measures:

- ✓ All noise generating equipment's and construction camps will be installed sufficiently away from settlement and sensitive areas.
- ✓ Restrict construction activities to reasonable working hours where near sensitive receptors
- ✓ Keep adjacent landowners informed of unusually noisy activities planned.
- ✓ The main stationary noise producing sources such as generator sets shall be provided with noise shields around them. The noise shields can either be a brick masonry structure or any other physical barrier which is effective in adequate attenuation of noise levels.
- ✓ The plants and equipment used for construction will strictly conform to CPCB noise standards and ensures that machinery in a good state of maintenance
- ✓ Vehicles and equipment's used will be fitted with silencer and maintained accordingly.
- ✓ Noise to be monitored as per monitoring plan and if the noise level at any time found to be higher than immediate measure to reduce noise in that area will be ensured.
- ✓ An awareness programme may be organized for drivers and equipment operators to make them aware of the consequences of noise and to act properly at site.

F. IMPACTS ON ECOLOGY AND BIODIVERSITY

The proposed development is situated along the Ajoy River. No such significant ecologically diverse area occurs within the proposed project location. Hence no major impact on ecology is anticipated. However due to excavation of proposed channel and construction

of proposed cargo terminal at Katwa some shrubs may be affected. Likely impact on population of phytoplankton, zooplankton, benthic communities and fishes are envisaged due to capital and maintenance dredging, but temporary in nature.

Mitigation Measures:

- ✓ Permission will be obtained from Competent Authority for the cutting/felling of trees prior to start of civil works if tree felling is absolutely unavoidable.
- ✓ Ensure any landscaping to be undertaken will be done with locally indigenous species and low maintenance requirements.
- ✓ Capital and maintenance dredging should be avoided during breeding season of aquatic fauna.
- ✓ Construction workers should be strictly instructed not to harm any unknown/rarely seen fauna if encountered
- ✓ The generated muck due capital and maintenance dredging should not be disposed off in the waterway
- ✓ Construction vehicles should run along specified access to avoid accidents to cattle

G. IMPACTS ON RIVER WATER

The impact on water arises due to the following:

- Discharge of sewage and wastewaters from construction sites and camps to surface waters
- Re-suspension of sediments contaminated with heavy metals during the construction of the terminal.
- Risk of accidental spillages of oils, fuels, and other materials
- Siltation due to surface runoff
- Improper handling and stacking of construction material

Mitigation Measures:

- ✓ The site surface should be engineered and shaped in such a way that rapid and efficient evacuation of runoff is achieved.
- ✓ Provide containment areas for potential pollutants at construction camps, refueling, depots, asphalt plants and concrete batching plants.
- ✓ Implement waste management practices.
- ✓ Control and manage transport, storage, handling and disposal of hazardous substances.
- ✓ Use of tarpaulin sheets during transportation of construction material. Proper stacking of material
- ✓ Use of Silt fencing during construction
- ✓ Stockpiling of subsoil and overburden in all construction and lay down areas

H. IMPACTS DUE TO LABOUR CAMP

Construction workers are neglected group in the country. Unless the workers are provided proper amenities to live at the construction site the environmental issues of project cannot be properly met. Location of the Construction camp also has certain impacts on surrounding environment if not properly managed.

At labour and construction camps lot of wastes are likely to be generated. These wastes are refuge from the plants, and equipment's, waste water and other domestic waste. These wastes are solid as well as liquid waste mainly refuse water and kitchen waste. The disposal of such waste material to the surrounding land can potentially damage the land and would generate health risk to not only surrounding area but within the premises itself. Improper drainages system within the premises also creates insanitation condition thereby enhancing health risk.

Maximum labour to be employed in the project shall come from nearby areas. Some labour is expected to be migrated from other areas and is likely to put some stress on account of the following:

- ✓ Generation of sewage from labour colony.
- ✓ Generation of solid waste from labour colony.

Mitigation Measures:

- ✓ The Construction/labour camps will be established only on approved area.

- ✓ The worker's/labour camp will be located away from water bodies, schools and residential areas. The camp will be constructed with proper accommodation facilities.
- ✓ The workers camp will be provided with drinking water supply system so that local water sources are not disturbed.
- ✓ The camp should be provided with fuel for cooking like kerosene and /or LPG to avoid any cutting of trees for fuel wood.
- ✓ Camp will be provided with proper sanitation facilities, separate toilets and bathrooms for female and male workers, septic tanks with soak pits of sufficient size, dust bins etc.
- ✓ Waste water from domestic uses and solid wastes will be disposed of without violating environmental norms. The measures will be site specific.
- ✓ The labour camps will be provided with crèche, first aid facilities, etc as required under Factory Act.
- ✓ After completion of construction, the contractor will dismantle the camp and restore it to the original condition of the area before handing over the site to the land owner.

I. SOCIAL IMPACTS

- **Impacts on Socio-economic environment**

Land is required to be acquired for construction of channel, cargo Terminal and jetties. The total amount of land will be affected is about 2.0 hectare for terminal and jetties and about 15.5 hectare for excavation of channel. The affected land owners should be compensated by proper compensation as per the norms of Government of West Bengal/Government of India.

- **Impacts on the Regional Economy**

There would be benefits to the local and regional economy through the direct demand for construction goods and services associated with construction activities.

- **Health and Safety**

One of the potential impacts of the proposed project will be on the air quality due to the dust generated during construction. The amount of dust generation will depend upon the level of digging and the prevailing weather conditions. Based on past experience, the air pollution due to entrainment of fugitive emission is marginal in nature and is observed up to a distance of 100 to 200 m from the point of entrainment. Thus, it is expected to lead to marginal impact on ambient air quality. No major

health related issues due to air pollution during construction phase of the proposed project are anticipated.

Construction related activities may lead to injuries. Open fires in construction camp can result in accidents. Safety of workers and general public may be compromised due to difficult site conditions. Poor waste management practices and unhygienic conditions at temporary ablution facilities can breed diseases. Standing water due to inadequate storm water drainage systems, inadequate waste management practices, pose a health hazard to providing breeding grounds for disease vectors such as mosquitoes, flies and snails. The use of hazardous chemicals in the micro-tunnelling and restoration of roads can pose potential environmental, health and safety risks. Road safety may be affected during construction, especially when traffic is detoured.

Mitigation Measures:

- ✓ Implement good housekeeping practices at the construction camp.
- ✓ Strictly implement health and safety measures and audit on a regular basis.
- ✓ Secure enclosed construction site.
- ✓ Use reputable contractors
- ✓ Provide warning signs of hazardous working areas.
- ✓ The plants and equipment's will be installed sufficiently away from the settlement.
- ✓ All the construction equipment's and vehicles will conform to the emission standards stipulated by the CPCB.
- ✓ Clearly demarcate excavations and provide barriers (not just danger tape) to protect pedestrians from open trenches.
- ✓ Thoroughly train workers assigned to dangerous equipment.
- ✓ Workers have the right to refuse work in unsafe conditions.
- ✓ Undertake waste management practices (Planned disposal of sludge from pumping stations within surrounding areas of PS) particularly for Pumping Station
- ✓ Control speed and movement of construction vehicles
- ✓ Exclude public from the site
- ✓ Ensure all workers are provided with and use Personal Protective Equipment.
- ✓ Ensure the visibility of workers through their use of high visibility vests when working in or walking through heavy equipment operating areas
- ✓ Ensure that qualified first-aid can be provided at all times. Ensure equipped first-aid stations are easily accessible throughout the site;

- ✓ Provide medical insurance coverage for workers
- ✓ Provide clean eating areas where workers are not exposed to hazardous or noxious substances;
- ✓ Provide visitor orientation if visitors to the site can gain access to areas where hazardous conditions or substances may be present. Ensure also that visitor/s do not enter hazard areas unescorted;
- ✓ Ensure moving equipment is outfitted with audible back-up alarms;
- ✓ Mark and provide sign boards for hazardous areas such as energized electrical devices and lines, service rooms housing high voltage equipment, and areas for storage and disposal. Signage shall be in accordance with international standards and be well known to, and easily understood by workers, visitors, and the general public as appropriate.
- ✓ Safe working techniques will be followed up and all the workers will be trained
- ✓ Proper caution signage, barricading, delineators etc. will be installed at Construction zone and temporary diversions
- ✓ Proper traffic management will be ensured at the Construction zone as per IRC.
- ✓ An Emergency Response system in case of any incidence will be developed and implemented
- ✓ Periodical health check facility will be provided at camp sites.

- **Aesthetics**

The presence of heavy duty vehicles and equipment, temporary structures at construction camps, stockpiles, may result in impacts on aesthetics and landscape character.

Mitigation Measures:

- ✓ Properly fence off storage areas.
- ✓ Collection of all domestic solid waste central point of disposal and feed into the city waste collection system.
- ✓ Contractor to exercise strict care in disposing construction waste.
- ✓ Identifying suitable waste disposal site with enough capacity to hold additional waste to be generated by the construction activities.
- ✓ Retaining mature trees on and around the site where possible.
- ✓ Removing unwanted material and litter on a frequent basis.
- ✓ Reinstate pathways and other local infrastructure immediately to at least their pre-project condition upon completion of construction.

- **Employment Generation**

The project will provide employment opportunities for local people during construction. Expectations regarding new employment will be high especially among the unemployed individuals in the area. Labor gathering at the site for work can be a safety and security issue, and must be avoided. The training of unskilled or previously unemployed persons will add to the skills base of the area.

Mitigation Measures:

- ✓ Employment of local labour
- ✓ Training of labour to benefit individuals beyond completion of the project.
- ✓ Ensure recruitment of labors will take place offsite.
- ✓ Ensure at least 50% of all labor is from surrounding communities in the contractual documentation.

9.3.2 Impacts during Operation Phase

A. IMPACTS ON AIR

Sensitive receptors and nearby habitation area may be affected temporarily by increased traffic and other related impacts. Air pollution may generate at jetty/terminal area during transportation and storage activities of material, loading and unloading of material.

Exhaust gases from moving vessel are source of air pollution. However, vessels emit least air emissions compared to the road and railway modes. The impact on air quality due to vessel movement is anticipated insignificant considering the emission levels and projected vessel traffic.

Mitigation Measures:

- ✓ Ensure compliance with the Air Act.
- ✓ Ensure compliance with emission standards
- ✓ Regularly service vehicles off-site in order to limit gaseous emissions
- ✓ Material generating dust should be transported under covered condition
- ✓ Uses of cleaner fuel
- ✓ Material should be stored under cover sheds
- ✓ Water sprinkling should be carried out during all loading and unloading activities and storage period.

B. IMPACTS DUE NOISE AND VIBRATION

Noise generated during operation phase are primarily loading and unloading of material at site and vessel/barges, movement of dumpers & vessel, operation of backup power generators, pumps and other equipment. However, the main effect on the environmental noise level will be from increased transportation of goods entering and leaving the terminal site. Sensitive receptors and nearby habitation areas may also be affected by increased traffic and related impacts.

Improper handling and irregular maintenance of operating machines may lead to increased noise pollution during operation phases, which would affect the daily life of the surrounding neighbourhoods. However, impacts on this account are expected to be marginal.

Mitigation Measures:

- ✓ Restrict maintenance activities to reasonable working hours where near sensitive receptors
- ✓ Keep adjacent landowners informed of unusually noisy activities planned.
- ✓ Fit and maintain silencers to all machinery on site.
- ✓ Monitor noise levels in potential problem areas
- ✓ Personal Protective Equipment (PPE) should be provided to the worker working in the Terminal/Jetty area.
- ✓ Use of DG set with acoustic enclosure.

C. IMPACTS DUE TO OIL SPILLAGE FROM BARGES AND VESSELS

There may be possibility of oil spillage from barges/vessels during transportation. This will affect the water quality and aquatic ecology of the river.

Mitigation Measures:

- ✓ All waste water and solid waste or maintenance waste should be disposed at the designated barge maintenance facility only.
- ✓ The wastewater from vessels can be sent to STP for treatment and the treated water can be used for landscaping and dust suppression at terminal site.
- ✓ Vessels also may have some facilities for treatment of the waste generated
- ✓ Provision of oil water interceptors

- ✓ Vessels should not be washed or cleaned at terminal/jetty facility and washings should not be discharge at the terminal/jetty location. Washing should be undertaken only at the maintenance facility only.

D. IMPACTS ON WATER

During operation phase water will be required at terminal/jetties sites for purpose of consumption, dust suppression, cleaning, washing, cooling and landscaping, etc. Water can be used from ground water resources by taking prior permission from the concerned authority. It is proposed to treat the wastewater generated at site in STP. Hence, the impact on water resources is anticipated to be low.

Maintenance dredging & on-shore dumping of dredged material are another sources which may impact the water quality of river.

Mitigation Measures:

- ✓ STP to be provided to treat the waste water generated.
- ✓ No wastewater should be received from vessels and vessels should not be allowed to discharge their wastewater and solid waste in river
- ✓ No waste/wastewater should be discharged in river or dumped into the ground
- ✓ Fuelling of vessels is not proposed at terminal facility
- ✓ Toilets to be provided with running water facility to prevent open defecation.

E. IMPACTS ON FLORA AND FAUNA

The proposed development is unlikely to have any significant impact on biodiversity. However, maintenance dredging may impact the growth of aquatic life. Impacts may also arise during the movement of vessel/barges.

Mitigation Measures:

- ✓ Capital and maintenance dredging should be avoided during breeding season of aquatic fauna.
- ✓ Vessel Operators should be strictly instructed not to harm any unknown/rarely seen fauna if encountered
- ✓ The generated muck due capital and maintenance dredging should not be disposed off in the waterway

F. IMPACTS ON HEALTH AND SAFETY

Danger of operations and maintenance-related injuries and accidental drowning may occur during operation stage. Safety of workers and general public must be ensured.

Poor waste management practices and unhygienic conditions at the improved facilities can breed diseases.

Mitigation Measures:

- ✓ Implement good housekeeping practices at terminal and jetty area.
- ✓ Strictly implement health and safety measures and audit on a regular basis.
- ✓ Provision of warning signs of hazardous working areas.
- ✓ Training of workers assigned to dangerous equipment.
- ✓ Undertaking waste management practices- specifically periodic removal of sludge from pumping stations.
- ✓ Provision of life tubes at jetty locations as well as in vessels
- ✓ Ensuring all workers are provided with Personal Protective Equipment.
- ✓ Provision of medical insurance coverage for workers

G. IMPACTS ON REGIONAL ECONOMY

The project is expected to bring the economic benefits of the region directly through expansion of regional trade, increase new business opportunity, development of new industries.

9.4 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The main aim of the Environmental Management Plan (EMP) is to ensure that the various adverse impacts are mitigated and the positive impacts are enhanced. The EMP identifies the potential issues of various activities that are anticipated in the design and development, construction, and operation phases of the proposed project. The EMP ensures to suggest appropriate mitigation measures against the issues/ concerns identified during the environmental study.

9.4.1 Implementation of EMP

A copy of the EMP must be kept on site during the construction period at all times. The EMP will be made binding on all contractors operating on the site and will be included within the Contractual

Clauses. Non-compliance with, or any deviation from, the conditions set out in this document constitutes a failure in compliance.

The contractor shall be responsible to implement the EMP primarily in assistance with the Supervision Consultant team. The Environmental Specialist from the Supervision Consultant shall monitor the compliance of the EMP.

9.4.2 Environmental Management Action Plan

This section describes the Environmental Management Action Plan for the proposed project during different stages of project. The Environmental mitigation measures have been incorporated at all the stages of the project right from Designing phase to Construction and Operational Phase. The Management Plan has been formulated for implementation of environmental mitigation measures to be carried out and to ensure that the provisions of the EMP are strictly followed and implemented by strengthening implementation arrangements to prevent and minimize the adverse environmental impacts during Construction phase of the project. EMP has also addressed certain environmental measures to be taken to prevent further deterioration of environment components for various stages of the project.

Appropriate measures have also been identified for action during various stages of the project, viz, Design and Pre-Construction, Construction and Operational phases. The measures identified for all three phases, are tabulated in **Table 51** which describes the nature of the potential environmental impact, the measures, which have or will be taken, the timeframe in which they are taken, the implementing agency and responsible organization.

Table 51: Environmental Management Plan (EMP)

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
A. DESIGN AND DEVELOPMENT/ PRE-CONSTRUCTION PHASE				
1.	Loss of Land	• The acquisition of land will be carried out in accordance with the entitlement framework for the project. • Early identification of entitlement for Compensation of the Losses. • All the affected people will be compensated as norms of Government of	IWAI	IWAI

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
		West Bengal/Govt. of India before commencement of construction works and the cost of compensation will be finalized by the Competent Authority and the Project Proponent will pay the compensation at all the entitles persons through the Competent Authority.		
2.	Tree cutting	• No major felling of trees has been envisaged for the project. Few trees standing at proposed terminal sites can be saved. • The statutory permission for tree felling will be obtained prior to cutting of trees. • All efforts will be made to preserve trees. Special attention will be given for protecting giant trees, and locally important trees (having cultural importance). • The tree will be compensated in the ratio of at least 1:3	Contractor	IWAI
3.	Arrangements for temporary land for Establishing Camps/Plants/ Temporary diversions	• The Contractor as per prevalent rules will carry out negotiations with the landowners for obtaining their consent for temporary use of lands for workers camp, construction sites/hot mix plants/ traffic detours etc. • The Contractor will submit the legal agreement/ written Consent letter from the owner of the land for using fir specific purpose along with its rehabilitation plan as agreed by the owner. • The Contractor will ensure that the site is properly restored to the satisfaction of the land owner prior to handling over to the owner and shall submit satisfactory certificate from the Land Owner.	Contractor	Supervision Consultants, IWAI
4.	Establishment of Construction Camp	• The locations of construction camp to be identified by the Contractor. Construction camps will not be proposed within 500 m from the nearest settlements to avoid conflicts and stress over the infrastructure facilities with the local community. Location for stockyards for construction materials will be identified at least 1000m from water sources / and 10	Contractor	Supervision Consultants, IWAI

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
		Km from Wildlife Sanctuary boundary. • The Contractor will submit the legal agreement/ written Consent letter from the owner of the land for using fir specific purpose along with its rehabilitation plan as agreed by the owner. • The Camp site will be provided with all the necessary facilities as per norms.		
5.	Establishment of Stone crushers, hot-mix plants, WMM Plant, Concrete Batching plants etc.	• Stone crushers, Hot mix plants, WMM Plants and Concrete Batching plants will be sited sufficiently away from settlements, agricultural operations and any commercial establishments. Such plants will be located at least 500 m away from the boundary of the nearest village/settlement preferably in the predominant downwind side. • The Contractor shall submit a detailed layout plan for all such sites and approval of the Environmental Expert of Supervision Consultants shall be necessary prior to their establishment. • All plants will be fitted with adequate dust suppression and emission control equipments and facilities. • Specifications of crushers and hot mix plants will comply with the requirements of the relevant current emission control legislations and Consent/NOC for all such plants shall be obtained from the State Pollution Control Board. • The Contractor shall not operate the plants till the required legal clearance, permits are obtained and submitted.	Contractor	Supervision Consultants, IWAI
6	Material Sources	• Finalization of material sourcing and all logistic arrangements are well as compliance to environmental requirements, as applicable, will be the sole responsibility of the Contractor	Contractor	Supervision Consultants, IWAI
B. CONSTRUCTION PHASE				
1.	Impact on Soil			
(i)	Soil Erosion	• Maintaining the excavation by shoring trench sides by placing sheeting, timber	Contractor	Supervision Consultants,

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
		shores, trench jacks, bracing, sheet piling materials to resist pressures surrounding the excavation • Exposed surface will be resurfaced and stabilized by making the sloping sides of trench to the angle of repose at which the soil will remain safely at rest • Proper stock piling of excavated soil and must be bordered by berms • Soil erosion checking measures as the formation of sediment basins, slope drains, etc, will be carried out.		IWAI
(ii)	Loss of Topsoil	• The topsoil from all areas of cutting and all areas to be permanently covered will be stripped to a specified depth of 150 mm and stored in stockpiles of height not exceeding 2m. • The stored topsoil will be spread back to maintain the soil physico-chemical and biological activity. The preserved top soil will be used for restoration of sites, in landscaping and avenue plantation • To prevent excessive disturbance of natural vegetation, the top soil excavated should be stored and utilized for re-vegetation after completion of work. • Topsoil and subsoil must be placed on opposite sides of the trench and must be kept separate throughout construction and rehabilitation.	Contractor	Supervision Consultants, IWAI
(iii)	Compaction of soil	• Construction vehicles, machinery and equipment will move, or be stationed in the designated area to avoid compaction of soil. • If operating from temporarily hired land, it will be ensured that the topsoil for agriculture remains preserved & not destroyed by storage, material handling or any other construction related activities.	Contractor	Supervision Consultants, IWAI
(iv)	Contamination of land from fuel and lubricants	• Impervious platform and oil and grease trap for collection of spillage from construction equipment vehicle maintenance platform will be appropriately provided at construction	Contractor	Supervision Consultants, IWAI

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
		camp, servicing area and liquid fuel and lubes at storage areas.		
(v)	Contamination of land from construction wastes and spoils	• All spoils will be disposed off as desired and the site will be fully cleaned before handing over. The non-usable bitumen spoils will be disposed off in a deep trench providing clay lining at the bottom and filled with soil at the top (for at least 0.5m)	Contractor	Supervision Consultants, IWAI
2.	Impact on Air			
(i)	Emission from construction vehicles and machinery	• All vehicles, equipment and machinery used for construction will be regularly maintained to ensure that the pollution emission levels conform to the SPCB norms. • The asphalt plants, crushers and the batching plants will be sited at least 500 m in the downwind direction from the nearest human settlement (Boundary of town/village). • Vehicles transporting earth materials will be covered • Mixing equipment will be well sealed and equipped as per PCB norms.	Contractor	Supervision Consultants, IWAI
(ii)	Emission from Construction Vehicles, Equipment and Machineries	• Contractor will ensure that all vehicles, equipment and machinery used for construction are regularly maintained and confirm that pollution emission levels comply with the relevant requirements of SPCB. • The Contractor will submit PUC certificates for all vehicles/ equipment/machinery used for the project. Monitoring results will also be submitted to 'PIU' through the 'Engineer'. • Periodical monitoring of fine Particulate Matters (PM10 and PM2.5) will be carried out as per Environmental Monitoring Plan. • Workers at mixing sites will be provided with good quality personal protective equipment's (PPE) reduce the chances of ill effect of dust.	Contractor	Supervision Consultants, IWAI

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
(iii)	Dust Pollution	• The Contractor will take every precaution to control dust nuisance at all the construction zones and allied sites where works are under progress. • Every equipment's and machinery will be fitted with dust suppression devices such as water sprinklers, dust bags, cyclone etc. as appropriate. • The Contractor will provide necessary certificates to confirm that all crushers used in construction conform to relevant dust emission control legislation. • At all the construction zones and unpaved lead roads, earthen temporary diversions and plant premises periodical water sprinkling will be carried out to suppress dust. • Transportation of loose earth, sand will be done in covered vehicles. • All equipment's and machineries will be maintained properly. • Periodical monitoring of fine Particulate Matters (PM_{10} and $PM_{2.5}$) will be carried out as per Environmental Monitoring Plan. • Workers at mixing sites will wear masks to reduce the chances of exposure to fugitive dusts.	Contractor	Supervision Consultants, IWAI
3.	Impact on Noise Pollution			
(i)	Noise from vehicles and construction equipments	The Contractor will confirm the following: • All plants and equipments used in construction shall strictly conform to the MoEFCC/CPCB/SPCB noise standards. • All vehicles and equipment used in construction will be fitted with exhaust silencers • Servicing of all construction vehicles and machinery will be done for exhaust silences and will be checked and if found defective will be replaced. • All the construction sites within 150m of the nearest habitation, noisy construction work such as crushing, concrete mixing will be stopped during the night time between 10.00 pm to 6.00 am.	Contractor	Supervision Consultants, IWAI

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
		• No noisy construction activities will be permitted around educational institutions/health centers (silence zones) up to a distance of 100 m from the sensitive receptors • Monitoring shall be carried out at the construction sites and results will be submitted to Supervision Consultants (SC) and IWAI. • Environmental Expert of SC will be required to inspect regularly to ensure the compliance of EMP.		
4.	Impact on Flora and Fauna	• If required, Vegetation will be removed from the construction zone before commencement of construction • Construction vehicles, machinery and equipment will move or be stationed in the designated area only to prevent compaction of vegetation • Construction workers will be directed not to disrupt or damage the fauna. • Capital and maintenance dredging should be avoided during breeding/spawning season of aquatic fauna. • The generated muck due to capital and maintenance dredging should not be disposed off in the waterway • Construction vehicles should run along specified access to avoid accidents to cattle	Contractor	Supervision Consultants, IWAI
6.	Safety			
(i)	Accidents due to construction activities	• To ensure safe construction in the temporary accesses during construction, lighting devices and safety sign boards will be installed. • Traffic rules and regulations will be strictly adhered to. • Safety of workers undertaking various operations during construction will be ensured by providing helmets, masks, safety goggles, etc • The electrical equipment will be checked regularly • At every camp site, a readily available first aid unit including an adequate supply	Contractor	Supervision Consultants, IWAI

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
		of dressing materials, a mode of transport (ambulance), para medical staff and an attending doctor will be provided. • Road safety education will be imparted to drivers running construction vehicles. In case of negligent driving, suitable action will be taken. • Adequate signage, barriers and persons with flags during construction to control the traffic will be provided.		
(ii)	Occupation Health and Safety	• The Contractor will provide adequate good quality Personal Protective Equipments (PPE) to all the workers working at construction zones and Plant sites and will ensure that these PPEs are used by workers at all time during works. • Adequate drainage, sanitation and waste disposal will be provided at workplaces. • Proper drainage will be maintained around sites to avoid water logging leading to various diseases • Adequate sanitation and waste disposal facilities will be provided at construction camps by means of septic tanks, soakage pits etc. • A health care system will be maintained at construction camp for routine check up of workers and avoidance of spread of any communicable disease • Readily available First Aid kit bearing all necessary first aid items will be proved at all the work sites and should be regularly maintained.	Contractor	Supervision Consultants, IWAI
7.	Wastes	• Ensure that no litter, refuse, wastes, rubbish, rubble, debris and builders wastes generated on the premises must be collected in rubbish bins and disposed of weekly at registered refuse facility sites. • Toilet facility must be provided at construction site and should be maintained properly. Toilets must be emptied regularly at treatment plants and every effort must be made to prevent the contamination of surface or sub-surface water	Contractor	Supervision Consultants, IWAI

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
		• Muck generated due to dredging should be disposed as per the proposal of disposing around the proposed terminal area for flood protection		
8.	Camp Site management	• Contractor will follow all relevant provisions of the Factories Act, 1948 and the Building and the other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labour camp. • The location, layout and basic facility provision of each labour camp will be submitted to the Engineer and IWAI prior to their construction. • The construction will commence only upon the written approval of the Engineer. • The contractor will maintain necessary living accommodation and ancillary facilities in functional and hygienic manner and as approved by the Engineer. • Periodical medical check up will be ensured for all the workers • The Contractor will provide potable water facilities within the precincts of every workplace in an accessible place. • The sewage system for the camp will be designed, built and operated in such a fashion that it should not pollute the ground water or nearby surface water. • Separate toilets/bathrooms, will be arranged for men and women • Adequate water supply is to be provided in all toilets and urinals • The Contractor will provide segregated garbage bins in the camps and ensure that these are regularly emptied and disposed off in a hygienic manner as per the Comprehensive Solid Waste Management Plan approved by the Environmental Expert of SC.	Contractor	Supervision Consultants, IWAI
9.	Monitoring of Air, Water & Noise Quality Pollution	• The periodic monitoring of the ambient air quality, noise level, water (both ground and surface water) quality, soil	Contractor	Supervision Consultants, IWAI

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
	Monitoring	pollution/contamination in the selected locations as suggested by SC will be the responsibility of Contractor		
C.	**OPERATION PHASE**			
1.	Monitoring of Operation Performance	• The IWAI will monitor the operational performance of the various mitigation/enhancement measures carried out as a part of the project.	Contractor	IWAI
2.	Air	• Ensure compliance with the Air Act. • Ensure compliance with emission standards • Regularly service vehicles off-site in order to limit gaseous emissions • Material generating dust should be transported under covered condition • Uses of cleaner fuel • Material should be stored under cover sheds • Water sprinkling should be carried out during all loading and unloading activities and storage period.	IWAI	IWAI
3.	Noise	• Restrict maintenance activities to reasonable working hours where near sensitive receptors • Keep adjacent landowners informed of unusually noisy activities planned. • Fit and maintain silencers to all machinery on site. • Monitor noise levels in potential problem areas • Personal Protective Equipment (PPE) should be provided to the worker working in the Terminal/Jetty area. • Use of DG set with acoustic enclosure	IWAI	IWAI
4.	Water and Waste water	• STP to be provided to treat the waste water generated • No wastewater should be received from vessels and vessels should not be allowed to discharge their wastewater and solid waste in river • No waste/wastewater should be discharged in river or dumped into the ground	IWAI	IWAI

S. No.	Environmental issue/ Activity	Mitigation Measures	Institutional Responsibility	
			Implementation	Supervision
		• Fuelling of vessels is not proposed at terminal facility • Toilets to be provided with running water facility to prevent open defecation.		
5.	Oil Spillage from Vessel/barges	• All waste water and solid waste or maintenance waste should be disposed at the designated barge maintenance facility only. • The wastewater from vessels can be sent to STP for treatment and the treated water can be used for landscaping and dust suppression at terminal sites • Vessels also may have some facilities for treatment of the waste generated • Provision of oil water interceptors • Vessels should not be washed or cleaned at terminal/jetty facility and washings should not be discharge at the terminal/jetty location. Washing should be undertaken only at the maintenance facility only.	IWAI	IWAI

9.5 APPLICABLE LEGAL AND REGULATORY FRAMEWORK

The increase of environmental concern also necessitated appropriate tools/actions to protect environment. During Stockholm Conference, first exclusive Environmental Protection Act was enacted in India in 1986. Prior to this umbrella act, Water (Pollution Prevention and Control) Act was enacted in India in 1974 & Air Pollution act, 1981. In accordance with EPA act (1986) Central and State Boards for Prevention and Control of Water Pollution were set up. Later these boards were renamed into Central Pollution Control Board and respective State Pollution Control Boards. Department of Environment was set up in 1980. Subsequently in 1985, it was upgraded to a full-fledged Ministry of Environment and Forests and Climate Change (MoEFCC) under Government of India to serve as the focal point in the administrative structure for the planning, promotion and coordination of environmental and forestry programmes. The name of MoEF has been revised in the year 2014 to Ministry of Environment, Forests and Climate Change (MOEFCC). This ministry has overall authority for the administration and implementation of government policies, laws and regulations related to the environment, including conservation, environmental assessment, sustainable development, forest conservation and pollution control. MOEFCC identifies the need to enact new laws and amend existing

environmental legislation when required, in order to continue to conserve and protect the environment. At the state level, the MOEFCC authority is implemented by the Department of the Environment and the Department of Forests.

In 1976, the 42nd Constitutional Amendment created Article 48A and 51A, placing an obligation on every citizen of the country to attempt to conserve the environment. As a result, a number of laws related to environmental conservation were passed to strengthen existing legislation. Environment (Protection) Act, 1986 is the landmark legislation as it provides for the protection of environment and aims at plugging the loopholes in the other related acts and this Act is called as umbrella Act. Under this Umbrella Act all the environmental acts and rules have been formed.

The laws and regulation applicable under the progamme:

- Policy and Regulatory Framework of Government of India
- Environmental Policy of respective State Government
- Legislation applicable to construction activities

9.5.1 Key Environmental Laws and Regulations

The relevant Acts and Rules are given in the **Table 52**.

Table 52: Key Environmental Laws and Regulation

Acts/Rule/ Policy	Year	Objective/ criteria	Authority	Applicability		Remarks
				Yes	No	
Environmental (Protection) Act	1986	To protect and improve the overall environment.	MOEFCC. GoI; CPCB, West Bengal State Pollution Control Board	√	..	This act is applicable to all environmental notifications, rules and schedules are issued under this act.
Environment Impact Assessment Notification	2006	To provide environmental clearance to new development	MOEFCC	--	√	Environment Impact Assessment Notification has

Acts/Rule/ Policy	Year	Objective/ criteria	Authority	Applicability		Remarks
				Yes	No	
		activities following environmental impact assessment				been issued for requirement of EIA and activities requiring clearance from Central Government in the Ministry of Environment and Forests (MoEFCC). The proposed project does not requires environmental clearance as per MoEFCC letter No. F. No. 14-9/2016-IA-III dated 21st December 2017.
Municipal Solid Waste (Management and Handling) Rules	2000	To manage collection transportation, segregation, treatment and disposal of municipal solid waste	MOEFCC, GoI, West Bengal State Pollution Control Board	√	..	Applicable for the project for the management of Solid waste
Indian Forest Act The Forest (Conservation) Act	1927 1980 1981	To check deforestation by restricting conversion of forested areas into	Forest Department, Govt. of West Bengal, MOEFCC-	..	√	No diversion of Forest land required for this project

Acts/Rule/ Policy	Year	Objective/ criteria	Authority	Applicability		Remarks
				Yes	No	
The Forest (Conservation) Rules		non forested areas.	Regional Office and MOEFCC.			
Wildlife (Protection) Act	1972	To protect wildlife through creation of National Parks and Sanctuaries.	Chief Conservator. Wildlife, Wildlife Wing, Forest Department, Gov. of West Bengal and National Board For Wildlife, GoI.	--	√	This act will not be applicable
Water (Prevention and Control of Pollution) Act	1974	To control water pollution by controlling discharge of pollutants as per the prescribed standards.	West Bengal State Pollution Control Board	√	..	Applicable during construction and operation stage
Air (Prevention and Control of Pollution) Act	1981	To control air pollution by controlling emission of air pollutants as per the prescribed standards.	West Bengal State Pollution Control Board	√	..	Applicable during construction stage
Noise Pollution (Regulation and Control) Rules The Noise	2000	To regulate and control noise producing and generating sources with the objective of maintaining the	CPCB; SPCB & Transport Department; Govt. of West Bengal	√	..	This act will be applicable during construction phase of the project.

Acts/Rule/ Policy	Year	Objective/ criteria	Authority	Applicability		Remarks
				Yes	No	
Pollution (Regulation and Control) Amendment Rules	2006	ambient air quality standards in respect of noise				
Central Motor Vehicle Act Central Motor Vehicle Rules	1988 1989	To check vehicular air and noise pollution.	Transport Department and West Bengal State Pollution Control Board	√	..	For construction vehicles (Construction Stage) – Pollution Under Control Certificate
Ancient Monuments and Archaeological Sites and Remains Act	1958	These Acts are applicable in case any development activity is undertaken in close vicinity of any archaeological site or any are discovered during the construction stage. The Act requires prior authorization of the Archaeological Survey of India (ASI) for development within 300 m of a Protected Property	Archaeological Dept. GOI, Indian Heritage Society and Indian National Trust for Art and Culture Heritage (INTACH).	--	√	This act will not be applicable
Wetland	2010	The rule specifies	Central Wetland	…	√	Not applicable

Acts/Rule/ Policy	Year	Objective/ criteria	Authority	Applicability		Remarks
				Yes	No	
Conservation and Management Rules		the activities which are harmful and prohibited in the wetlands such as industrialization, construction, dumping of untreated waste and effluents and reclamation.	Regulatory Authority; MOEFCC			

9.5.2 Need for Environmental Clearance

The proposed project will not require Environmental Clearance as per MoEFCC letter No. F. No. 14-9/2016-IA-III dated 21st December 2017. The letter is enclosed as **Annexure 4**.

9.5.3 Other Major Clearances / Approvals / Permits Applicable to the Project

The other clearances and permits required for project at different stages is given in **Table 53.**

Table 53: Other Statutory Clearances required for the Project

S. No.	Type of Clearances / Permits	Applicability	Project Stage	Responsibility
1	NOC and consents under Air & Water Act	For development of Waterway	Pre-construction Stage	IWAI
2	NOC (Consent to Establish and Consent to Operate) under Air and Water Act from SPCB	For siting, erection and operation of stone crusher, Hot Mix Plant, batching plant, WMM Plant etc.	Construction Stage	Contractor

S. No.	Type of Clearances / Permits	Applicability	Project Stage	Responsibility
3	Explosive License from Chief Controller of Explosives,	For storing fuel oil, lubricants, diesel etc.	Construction stage (Prior to storing fuel, lubricants and Diesel, etc.)	Contractor
4	Quarry Lease Deed and Quarry License from State Department of Mines and Geology	Quarry operation	Construction stage (Prior to initiation of Quarrying)	Contractor
5	Environmental Clearance for stone quarry from District Level environmental Impact Assessment Authority,	Opening of new Quarry and Borrow area for earth material	Construction stage (Prior to initiation of Quarrying)	Contractor
6	Permission for extraction of ground water for use in road construction activities from State Ground Water board	Extraction of ground water	Construction stage (Prior to initiation of installation of Bore wells and abstraction of water from such source)	Contractor
7	Permission for use of water for construction purpose from irrigation department	Use of surface water for construction	Construction stage (Prior to initiation of abstraction of water from such source)	Contractor
8	Labour license from Labour Commissioner Office	Engagement of Labour	Construction stage (Prior to initiation of any work)	Contractor

9.6 ENVIRONMENT COST

The estimated cost is as follows:

(A) Estimated cost at Pre-construction Stage:

The estimated cost for EIA-EMP & SIA studies have been summarized in **Table 54**:

Table 54: Summary of Estimated Cost of EIA_EMP and SIA Studies

Sl. No.	Particulars	Unit	Amount (Lakh INR)
1.	Man Power Cost	Lump sum	30.00
2.	Cost of one Time Baseline Data Generation at Pre-Construction Stage	One season cost (**Table 55**)	4.175
3.	Public Consultation Meeting (PCM)	Lump sum	1.50
4.	Surveys/ Reports / Document Printing	Lump sum	5.00
5.	Travelling Cost for Site Visits	Lump sum	3.00
6.	Lodging & Boarding Cost	Lump sum	5.00
7.	Cost for collection of metrological data and other information like Maps *etc.*	Lump sum	2.00
Total			**50.675**

Table 55: Estimated cost for Baseline data generation

Sl. No.	Environmental Attributes	Parameters	Monitoring Frequency	Unit	No. of Tentative Locations	Unit Rate (Rs)	Amount (Lakh INR)
1.	Ambient Air Quality	PM 2.5, PM10, CO, SO2, NO2 etc.	24 Hourly sampling (Day & Night time) to be done at each location.	No.	1 (Twice a week for four week): 24 Nos.	10000	2.40
2.	Surface Water Quality monitoring	***Physical Properties:*** pH, Temp., DO, Conductivity, ***Chemical Properties:*** TSS, Alkalinity, Hardness, BOD, COD, NO3, PO4,	Grab Sampling	No.	1	8000	0.08
3.	Ground Water Quality Monitoring		Grab Sampling	No.	1	8000	0.08

Sl. No.	Environmental Attributes	Parameters	Monitoring Frequency	Unit	No. of Tentative Locations	Unit Rate (Rs)	Amount (Lakh INR)
		Cl, SO4, Na, K, Ca, Mg, Silica, Oil & grease, Phenolic compounds, Residual Sodium Carbonate. ***Bacteriological Properties:*** Total Coliform.					
4.	Noise Quality monitoring	Day & Time time monitoring to be done at each location	24 Hourly sampling (Day & Night time) to be done	No.	1	4000	0.04
5.	Soil	Bulk Density, Colour, Texture, Soil Type, pH, Electrical Conductivity, N, P, K *etc.*	Composite sample shall be prepared based on at least 3 replicates from each location.		1	7500	0.075
6.	Aquatic Ecology	Trophic Status, Primary Productivity, Species diversity & densities of Phytoplankton, Zooplankton, Benthic Organism (Benthos, Macro-benthos), Fish and Macrophytes, Shanon Weiner Diversity Index.	One time study	No.	1	150000	1.5
	Sub-Total						**4.175**

(B) Estimated cost at construction Stage:

Table 56: Estimated Cost during Construction Stage

Sl. No.	Particulars of Estimated Budget	Unit	Amount (Lakh INR)
1.	Environmental Monitoring Cost at Construction Stage for one year	**Table 57**	5.15
2.	Greenbelt Development nearby terminal Premises by Contractor	Lump sum	5.00
3.	Solid Waste Management	Lump sum	2.50
4.	Sanitary facilities at labour camps	Lump sum	2.50
5.	Disaster Management Plan	Lump sum	2.00
6.	Environmental Training	Lump sum	1.00
Total			**18.15**

Table 57: Environmental Monitoring Cost during Construction Phase

S. No.	Item	Unit	Quantity	Rate (INR.)	Amount (Lakh INR.)
1.	Ambient Air Quality monitoring of PM10, PM2.5, CO, SO_2 &NO_2 (2 locations in the interval of 3 months for 1 years except monsoon) **Break up: 2 Locations X 3 Seasons X 1 Years = 6**	No.	6	10,000	0.6
2.	Ambient Noise level monitoring Leq dB(A) Day & Nighttime (2 locations in the interval of 3 months for 1 year except monsoon) **Break up: 2 Locations X 3 Seasons X 1 Years = 6**	No.	6	4,000	0.24
3.	Monitoring of River water Quality (1 locations in the interval of 3 months for 1 years during HFL and LFL except monsoon) **Break up: 1 Locations X 3 Seasons X 1 Years X 2 (HFL&LFL) = 6**	No.	6	8000	0.48
4.	Monitoring of ground water (1 locations in the interval of 3 months for 1 year except monsoon) **Break up: 1 Location X 3 Seasons X 1 Year**	No.	3	8000	0.24

S. No.	Item	Unit	Quantity	Rate (INR.)	Amount (Lakh INR.)
	= 3				
5.	Soil Quality monitoring (1 location along the Bank of River and 1 location at Construction site for three season for on year except monsoon) **Break up: 2 Locations X 3 Seasons X 1 Year = 6**	No.	6	7,500	0.45
6.	Monitoring of drinking water quality at construction camp (1 location in the interval of 3 months for 1 year except monsoon) **Break up: 1 Locations X 3 Seasons X 1 Years = 3**	No.	3	8,000	0.24
7.	Study of Acquatic and terrestrial fauna (2 location twice a year for two year) **Break up: 1 Locations X 2 Seasons X 1 Years = 2**	No	2	150000	3.00
Sub-Total					**5.15**

(C) Estimated cost during operation Stage

Table 58: Estimated Cost during Opertaion Stage

S. No.	Particulars of Estimated Budget	Unit	Amount (Lakh INR)
1.	Environmental Monitoring Cost at Operational Stage for one year	**Table 59**	3.275
2.	Maintenance & Supervision of Greenbelt Developed	Lump sum	3.00
3.	Solid Waste Management	Lump sum	5.00
4.	Sanitary facilities nearby terminals	Lump sum	5.00
5.	Miscellaneous	Lump sum	5.00
Total			**21.275**

Table 59: Environmental Monitoring cost during operation stage

S. No.	Item	Unit	Quantity	Rate (INR.)	Amount (Lakh INR.)
1.	Ambient Air Quality monitoring of PM_{10}, $PM_{2.5}$, CO, SO_2 &NO_2 (1 locations once in a year for 1 year except monsoon **Break up: 1 Location X 1 Season X 1 Year =6**	No.	1	12000	0.12
2.	Monitoring of River water Quality (2 locations once in a year for 1 years during HFL and LFL except monsoon) **Break up: 1 Location X 1 Season X 1 Years X 2 (HFL&LFL) = 2**	No.	2	10000	0.10
3.	Monitoring of drinking water (1 location in a interval of 3 month except monsoon for 1 year) **Break up: 1 Locations X 3 Season X 1 Year = 3**	No.	3	10000	0.30
4.	Ambient Noise level monitoring Leq dB(A) Day & Nighttime (1 location once in a year for 3 year) **Break up: 1 Locations X 1 Season X 1 Years = 1**	No.	1	5,500	0.055
5.	Soil Quality monitoring (1 locations along the Bank of River once in a year for 1 year except monsoon) **Break up: 1 Locations X 1 Season X 1 Years = 1**	No.	1	9,500	0.95
6.	Study of Acquatic and terrestrial fauna (1 location once in a year for 1 year) **Break up: 1 Location X 1 Season X 1 Years = 1**	No.	1	175000	1.75
Sub-Total					**3.275**

The total estimated Environmental cost for the project is given in **Table 60.**

Table 60: Estimated Environmental and Social Cost for the Project

Sl. No.	Project Stages	Cost (INR)
1.	Pre-Construction Stage	50.675
2.	Construction Stage	18.15
3.	Operational Stage	21.275
Total Estimated Budget (Except Statutory Fee & Land Acquisition & R&R Costs)		**90.10**

10.0 INSTITUTIONAL REQUIREMENTS

The proposed development of IWT in Ajoy waterway shall be operated and maintained by a separate Project Management Unit (PMU) under the jurisdiction of Director, Inland Waterways Authority of India, Kolkata.

10.1 ORGANIZATIONAL SET UP / ESTABLISHMENT

The total stretch of Ajoy waterway proposed for fairway development in this DPR is about 5.0 Km. The proposed PMU organisation structure for proposed waterway stretch is as below:

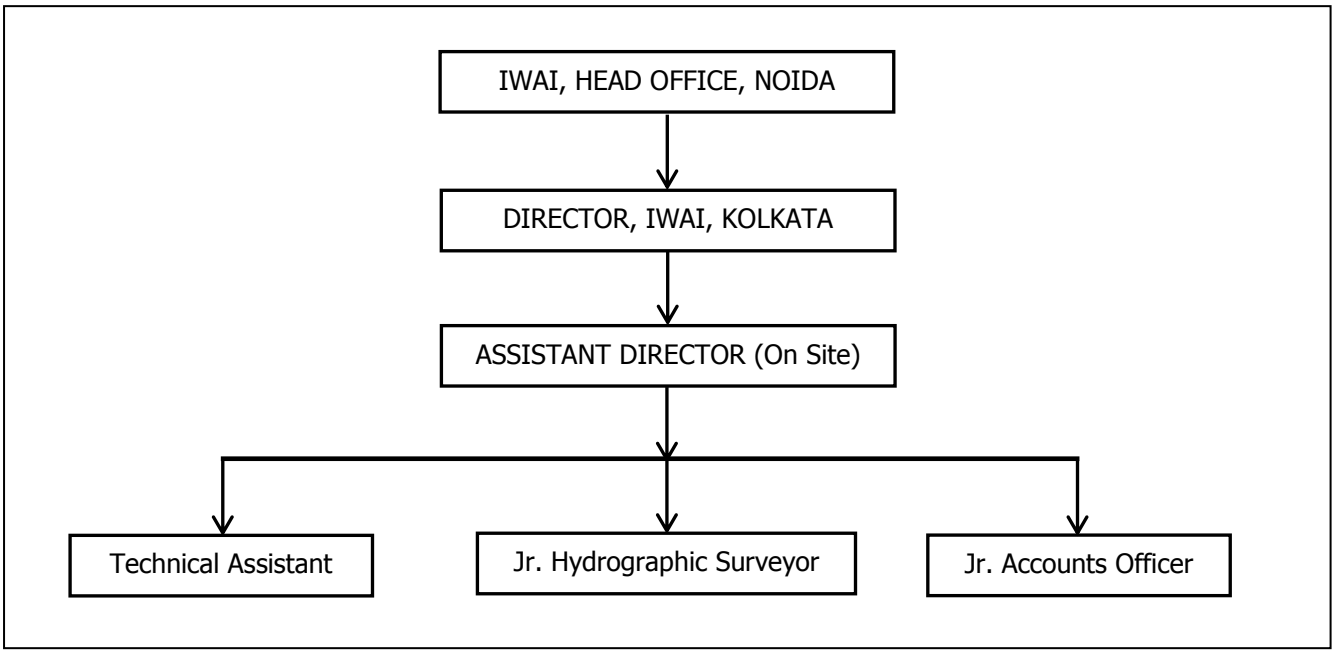


Figure 33: Organisation Structure of Project Monitoring Unit (PMU)

10.2 MAN POWER REQUIREMENT

Following man power is estimated to be required for efficient terminal operations:

a) Assistant Director – 1 No.
b) Technical Assistant – 1 No.
c) Jr. Hydrographic Surveyor – 1 No
d) Jr. Account Officer – 1 No

In addition to these 4 additional project/support staff are required to be engaged on contract/outsourcing basis. These support staff will work as a Multi-Purpose worker in PMU.

10.3 TRAINING REQUIREMENT / CAPACITY BUILDING

1 month of Training is proposed for all technical assistants and surveyors per year, at IWAI HO and other regional offices for skill development. The training to be provided is on latest software's, tools and plants, to upgrade technical skills and to increase awareness of Quality, Health, Safety and Environment (QHSE) policies.

10.4 INFRASTRUCTURE

Infrastructure required for running the organisational set up for Ajoy waterway is covered under this head. The basic infrastructure required for running the services are office complex, computers/laptos and printers/plotters, e-pbax facility, pantry, inspection vehicles etc.

10.4.1 Immovable

In order to optimise the cost to be incurred in purchasing/hiring land for office complex, it is proposed the required office complex including pantry/canteen and toilets will be housed in one of the terminal building.

10.4.2 Movable

Office stationary including computers/laptops, printers/plotters, inspection vehicles and other miscellaneous items are covered under movable assets. The detail list of movable assets required is as follows:

Sl. No.	Movable Asset	No.	Remark
1.	Computer/Laptop	4	For permanent Staff
		2	Additional for support staff
2.	Colour Printers & Scanner	2	
3.	Plotter	1	
4.	Air conditioners	6	
5.	Car	1	
6.	Inspection Vehicle (All wheel drive)	1	

Sl. No.	Movable Asset	No.	Remark
7	Office stationery and other miscellaneous items		

10.5 COST IMPLICATIONS

Cost proposed to be incurred for organisational set up is divided in the following sub heads:

Capital Cost:

Infrastructure: As it is proposed that office complex for the staff shall be located in one of the terminal building, no expense is considered here for immovable infrastructure. Cost implication for purchasing/hiring movable assets is provided as below:

Table 61: Cost for developing infrastructural works for Institutional Setup

Sl. No.	Movable Asset	No.	Rate (INR)	Cost (INR)
1.	Computer/Laptop	6	50,000/-	3,00,000/-
2.	Colour Printers & Scanner	2	10,000/-	20,000/-
3.	Plotter	1	5,00,000/-	5,00,000/-
4.	Air conditioners	6	40,000/-	2,40,000/-
5.	Car	1	7,00,000/-	7,00,000/-
6.	Inspection Vehicle (All wheel drive)	1	20,00,000/-	20,00,000/-
7	Office stationery and other miscellaneous items		LS	1,00,000/-
	Total			**38,60,000/-**

Annual Cost:

Man power: The tentative manpower cost on the basis of 7th CPC is provided in **Table 62** as below:

Table 62: Manpower Cost

Sl. No.	Manpower	Level as per pay matrix	Min. gross salary (INR/month)	Numbers of staff	Annual Cost (INR Lacs)
1	Assistant Director	L-10	56,100	1	6.73
2	Technical Assistant	L-6	35,400	1	4.25
3	Jr. Hydrographic	L-6	35,400	1	4.25

Sl. No.	Manpower	Level as per pay matrix	Min. gross salary (INR/month)	Numbers of staff	Annual Cost (INR Lacs)
	Surveyor				
4	Jr. Accounts Officer	L-6	35,400	1	4.25
6	Project/support staff		20,000	4	9.60
	Total				**29.08**

The total manpower cost for Rupnarayan waterway project works out to **INR 29.08 Lacs** annually.

Training/ Capacity Building: An annual budget of INR 5,00,000/- (**INR 5.0 Lacs**) is considered for the same.

Hence total annual O&M cost works out to **INR 34.08 Lacs**

11.0 PROJECT COSTING

The project cost estimates for development of the Inland Water Transport system as well as for maintenance of the system have been worked out. The cost estimates for development of the system are termed as capital cost while for operation of the system is termed as maintenance or operating cost.

11.1 BASIS OF COSTING

The basis of cost estimates worked out as per following:

a) Standard Schedule of Rates of PWD, Govt. of West Bengal;
b) "Unified Schedule of Rates" prepared by Irrigation and Waterways department, Government of West Bengal.
c) The consultant's references from various projects/sites proximity to the project area.
d) Local enquiries at the time of conducting surveys.
e) Market surveys and enquires
f) Judgement based on Consultant's Experience
g) https://www.wbidc.com/industrial_parks/available_land.htm

11.2 DEVELOPMENT COST

Ajoy waterway is proposed to be developed for dry bulk cargo transportation to cater the cargo traffic originated or terminated for Katwa Thermal power plant. The development cost for waterway comprises of:

a) Cost for fairway development comprising dredging and navigation & communication system
b) Cost of jetties and terminal buildings
c) Vessel Cost
d) EMP cost.

11.3 CAPITAL EXPENDITURE

The expenses expected to be incurred in construction and development of the waterway, terminal structures including jetties and procurement of vessels are considered as capital expenditure. The detail capital cost estimated to be incurred on the basis of proposed infrastructure and preliminary design at this stage of studies is provided in **Table 63**.

The capital cost worked out is excluding land cost for construction of terminals.

Table 63: Summary of Capital Cost of Project

Sl. No.	Item	Reference Table	Amount in Lacs (INR)
1.0	Capital cost for Fairway Development	**Table 19**	4,641.68
2.0	Capital cost for construction of terminal complex, RCC jetties, Gangway and floating Pontoons	**Table 30**	10,371.92
3.0	Procurement cost for 7 nos. of 2000 DWT barges	**Table 42**	4,900.00
4.0	Capital Cost for Aids to Navigation and Communication	**Table 44**	737.93
5.0	Cost allotted for EMP	**Table 60**	68.825
6.0	Capital cost for Institutional requirement	**Table 61**	38.60
	Total Capital Cost excluding Land Cost		**20,758.96**
7.0	Land cost for Fairway	**Table 19**	1,462.56
8.0	Land cost for Terminal	**Table 30**	173.38
	Total Capital Cost including Land Cost		**22,394.90**

11.4 OPERATIONAL AND MAINTENANCE EXPENDITURE

The detail capital cost estimated to be incurred on the basis of proposed infrastructure and preliminary design at this stage of studies are provided in **Table 64** as below:

Table 64: Summary of annual O & M Cost of Project

Sl. No.	Item	Reference Table	Amount in Lacs (INR)
1.0	O&M cost for Fairway Development		146.30
2.0	O&M cost for Terminals	**Table 33**	950.38
3.0	O&M Cost for Vessels	**Table 43**	614.00

Sl. No.	Item	Reference Table	Amount in Lacs (INR)
4.0	O&M Cost for Aids to Navigation and Communication	**Table 45**	318.85
5.0	EMP Cost during operation stage	**Table 60**	21.275
6.0	Operational cost under Institutional requirements		34.08
	Total Capital Cost		**2,084.89**

11.5 PHASING OF EXPENDITURE

Based on the analysis of the Construction Schedule for a period of 5 years, the phasing of expenditures has been established during construction period. The detail of cost repartition during construction period is provided in **Table 65** and also shown in **Figure 34** & **Figure 35** below.

Table 65: Phasing of Expenditure

Months >	M1 – M6	M7 – M12	M13 – M18	M19 – M24	M25 – M30	M31 – M36	M37 – M42	M43 – M48	M44 – M54	M55 – M60
% of Cash Flow	5%	5%	8%	10%	12%	18%	15%	12%	5%	10%
Total Cash Flow INR Lacs excluding Land cost	1037.95	1037.95	1660.72	2075.90	2491.07	3736.61	3113.84	2491.07	1037.95	2075.90
Total Cash Flow INR Lacs including Land cost	1119.75	1119.75	1791.59	2239.49	2687.39	4031.08	3359.24	2687.39	1119.75	2239.49

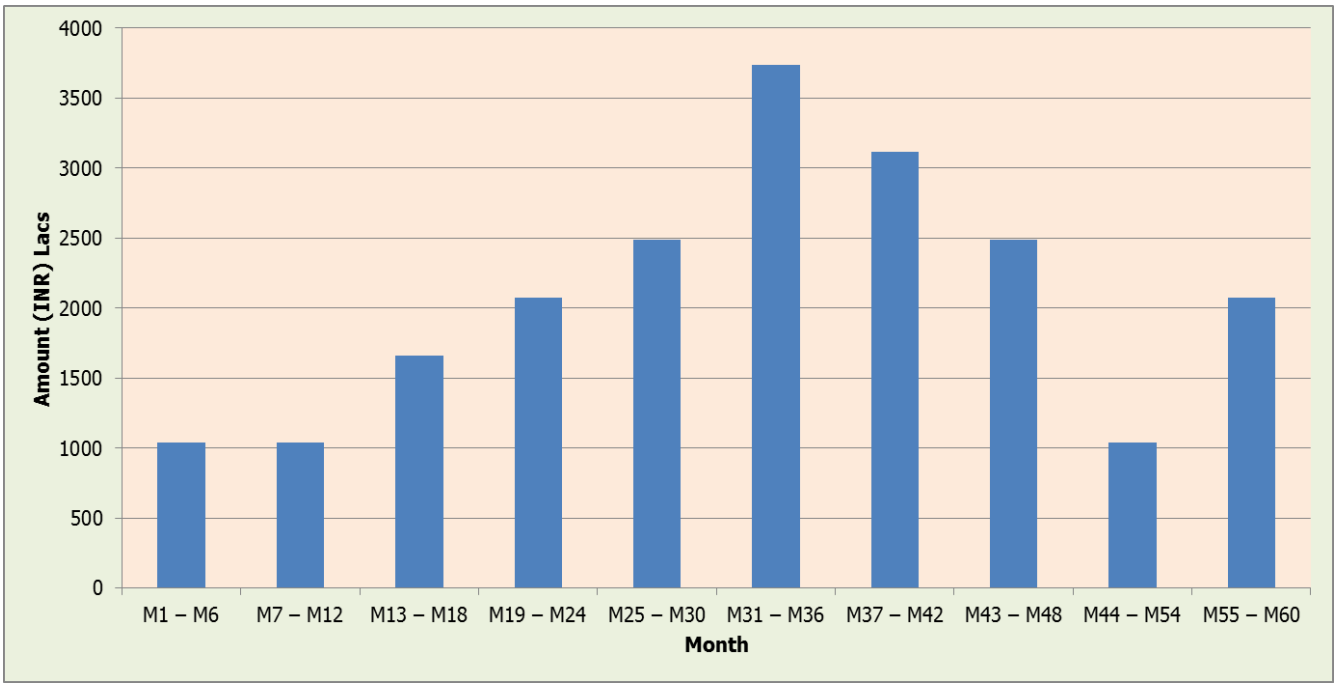


Figure 34: Phasing of Expenditure (excluding Land Cost)

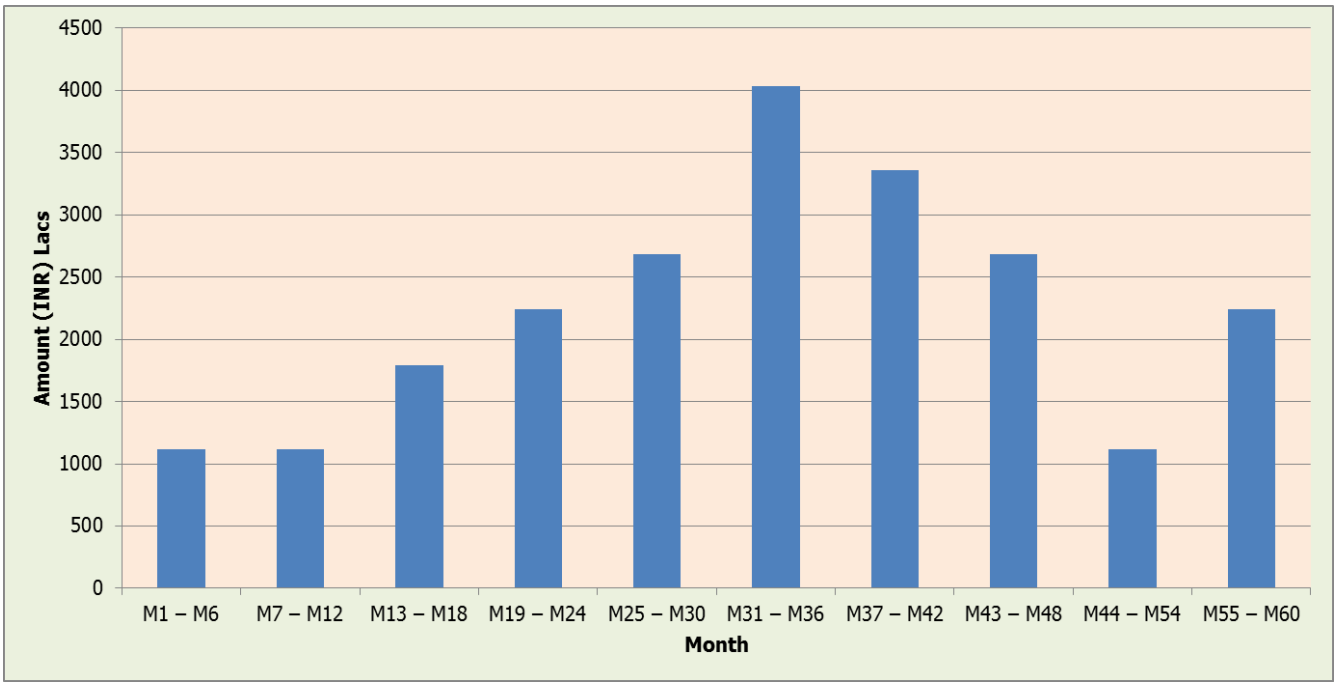


Figure 35: Phasing of Expenditure (including Land Cost)

12.0 IMPLEMENTATION SCHEDULE

The implementation schedule for the development of Ajoy waterway and its associated facilities are presented in this chapter. The probable time schedule for various activities from onset to completion of the project and commencement of operation are also discussed in this chapter.

12.1 TIME FRAME

The total project is scheduled to be completed in 60 months from the start date of construction.

12.2 PHASING

For timely completion of the project, identification of major project components and sequential planning of various modules is very important for any project. The major components of Ajoy waterway include both the construction of offshore and onshore facilities, apart from installation of mechanical and electrical equipment's.

The offshore facilities includes development of pontoon, gangway, approach platform and dredging whereas the development of onshore facilities includes site development, construction of terminal building and providing utilities like water supply system, sewerage system, storm water drainage system and firefighting facility.

The schedule has been prepared with the presumption that IWAI will be developing the project in single phase through EPC contract.

12.3 SUGGESTED IMPLEMENTATION MECHANISM

The various activities to be carried out prior to commencement of construction, includes selection of site, preparation of detail engineering drawings & Report, survey and investigation, Social and Environmental Impact Assessment, preparation of tender document, Bid process management, selection of EPC contractor and award of work to the selected contractor. It is assessed that the lead time required to carry out the bid process management and selection of EPC contractor would be 3 months.

The schedule for the project also depends on the schedule of various Statutory Clearances required from different Statutory Agencies for the development of the project and therefore, all the requirement clearances need to be in place before the start of the construction activities.

The following are the major activities involved for effective completion of Ajoy waterway project, which involves engineering, procurement, construction and commencement of operational activities.

- Detailed Engineering;
- Environmental clearance;
- Financial closure and Statutory approvals from all concerned authorities;
- Land acquisition and site development;
- Construction of onshore facilities for terminal;
- Construction of offshore facilities for terminal;
- Procurement of vessels;
- Up gradation/construction of access roads;
- Supply, installation and commission of electrical and mechanical equipment's.

12.4 PROJECT IMPLEMENTATION SCHEDULE

Sl. No.	Activities	1st Year				2nd Year				3rd Year				4th Year				5th Year			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Approval of DPR and Project Financial Closure																				
2	Environmental, Forest and CRZ clearances																				
3	Setting up of Implementing Establishment & infrastructure																				
4	Fairway development																				
a)	Procurement of Hardware and other equipment's																				
b)	Capital Dredging for Initial Reach																				
c)	Construction of Navigation Channel																				
d)	Capital Dredging for Last Reach																				
5	Procurement and installation of Aids to Navigation																				
6	Setting up of IWT terminals																				
a)	Land acquisition																				
b)	Construction of terminal building, landside facilities and dry bulk cargo jetties at Jamtiya																				
7	Upgrading existing road to terminals																				
8	Procurementof Vessels																				

13.0 ECONOMIC AND FINANCIAL ANALYSIS

Financial feasibility is a key determinant in a business oriented investment decision. In case of the projects of public/national interest like development of Inland Water Terminals, the viability of the project depends on the economic feasibility which act as the deciding factor. In this chapter, the financial and economic viability for development of Ajoy Waterway is worked out.

13.1 REVENUE

An attempt has been made to estimate the possible revenue available from this service. Although this has been calculated in a thorough and logical manner the study is based on many assumptions and it should therefore be taken as a guide to the magnitude of possible revenue.

The techno-economic model has been run with the various assumptions as stated below:

a) 2 vessels of 2000 DWT per day for Fly Ash
b) 5 vessel of 2000 DWT per day for Coal.

A downtime of about 2 months is assumed, which could be occurred due to weather, operational or other factors. Hence, it is assumed that the full service is operating for 300 days annually.

The revenue has been worked out by considering the tariff of commodity movement by IWT as INR 1.0/- per ton per km for Cargo operations. Present cargo traffic has been considered as 3.0 million Tons per annum for Coal & 1.2 million ton per annum for fly ash. A nominal increment of 2.6% per annum has been adopted for forecasting future traffic. On the basis of above assumptions, the present revenue that could be generated from cargo transportation along Ajoy waterway is provided in **Table 66.**

Table 66: Annual Revenue Generation from Ajoy Waterway

Cargo Quantity per day	14000	Ton
Length of Waterway	2	km.
IWAI Tariff Rate =	1	INR/Ton/km.
No. of Days per year	300	
Annual Revenue	8400000	INR
	84.00	**INR Lakhs**

13.2 FINANCIAL ANALYSIS/ FIRR

The introduction of the IWT will yield tangible and non-tangible saving due to equivalent reduction in road traffic and certain socio-economic benefits. These include saving in road construction and maintenance, vehicle operation costs, travel time and other socio-economic benefits of travel time, better accessibility, better comfort and quantity of life, increase in mobility etc.

The direct and indirect benefits of the project are following:

- Reduced road stress.
- Better accessibility to facilities in the influence area.
- Economic stimulation in the micro region of the infrastructure.
- Increased business opportunities.
- Overall increased mobility.
- Facilitating better planning and up-gradation of influence area.
- Saving in vehicle operating costs that are using the existing transport network after the IWT is introducing due to decongestion effect on road stress.
- Saving in time of existing modes, because of reduced congestion on road.
- Saving on account of reduction of vehicular pollution

The financial analysis of the project is done on the basis of estimated cost proposed to be incurred for construction/development of fairway, terminal and procurement of vessels including other miscellaneous expenses, O& M cost proposed to be incurred during proposed project life cycle of 20 years and revenue that could be generated.

The FIRR for the river stretches of IWT system is worked. This analysis shows that the project is financially non-viable on the basis of tariff of commodities traffic alone. The Financial analysis for the project is worked out and provided in **Table 67** & **Table 68.**

Table 67: FIRR for IWT in Ajoy Waterway with Capital Cost (excluding Land Cost)

Sl. No	Year	Capital Cost (INR Lacs)	O&M Cost (INR Lacs)	Total Outflow (INR Lacs)	Cargo Quantity	Revenue (INR Lacs)	Net Cash Flow (INR Lacs)
-5	2018-2019	2075.90		2075.90			-2,075.90
-4	2019-2020	3736.61		3736.61			-3,736.61

Sl. No	Year	Capital Cost (INR Lacs)	O&M Cost (INR Lacs)	Total Outflow (INR Lacs)	Cargo Quantity	Revenue (INR Lacs)	Net Cash Flow (INR Lacs)
-3	2020-2021	6227.69		6227.69			-6,227.69
-2	2021-2022	5604.92		5604.92			-5,604.92
-1	2022-2023	3113.84		3113.84			-3,113.84
0	2023-2024		2084.89	2084.89	14000	84.00	-2,000.89
1	2024-2025		2189.13	2189.13	14364	94.80	-2,094.33
2	2025-2026		2298.59	2298.59	14737	106.99	-2,191.59
3	2026-2027		2413.51	2413.51	15121	120.75	-2,292.76
4	2027-2028		2534.19	2534.19	15514	136.28	-2,397.91
5	2028-2029		2660.90	2660.90	15917	153.81	-2,507.09
6	2029-2030		2793.95	2793.95	16331	173.59	-2,620.36
7	2030-2031		2933.64	2933.64	16756	195.91	-2,737.73
8	2031-2032		3080.32	3080.32	17191	221.11	-2,859.22
9	2032-2033		3234.34	3234.34	17638	249.54	-2,984.80
10	2033-2034		3396.06	3396.06	18097	281.63	-3,114.43
11	2034-2035		3565.86	3565.86	18567	317.85	-3,248.01
12	2035-2036		3744.15	3744.15	19050	358.72	-3,385.43
13	2036-2037		3931.36	3931.36	19545	404.86	-3,526.51
14	2037-2038		4127.93	4127.93	20054	456.92	-3,671.01
15	2038-2039		4334.33	4334.33	20575	515.68	-3,818.65
16	2039-2040		4551.04	4551.04	21110	582.00	-3,969.05
17	2040-2041		4778.59	4778.59	21659	656.84	-4,121.75
18	2041-2042		5017.52	5017.52	22222	741.31	-4,276.21
19	2042-2043		5268.40	5268.40	22800	836.64	-4,431.76
20	2043-2044		5531.82	5531.82	23392	944.24	-4,587.59
						IRR	**Not Calculable**

Table 68: FIRR for IWT in Ajoy Waterway with Capital Cost (including Land Cost)

Sl. No	Year	Capital Cost (INR Lacs)	O&M Cost (INR Lacs)	Total Out flow (INR Lacs)	Cargo Quantity	Revenue (INR Lacs)	Net Cash Flow (INR Lacs)
-5	2018-2019	2239.49		2239.49			-2,239.49
-4	2019-2020	4031.08		4031.08			-4,031.08
-3	2020-2021	6718.47		6718.47			-6,718.47
-2	2021-2022	6046.62		6046.62			-6,046.62
-1	2022-2023	3359.24		3359.24			-3,359.24
0	2023-2024		2084.89	2084.89	14000	84.00	-2,000.89
1	2024-2025		2189.13	2189.13	14364	94.80	-2,094.33
2	2025-2026		2298.59	2298.59	14737	106.99	-2,191.59
3	2026-2027		2413.51	2413.51	15121	120.75	-2,292.76
4	2027-2028		2534.19	2534.19	15514	136.28	-2,397.91
5	2028-2029		2660.90	2660.90	15917	153.81	-2,507.09
6	2029-2030		2793.95	2793.95	16331	173.59	-2,620.36
7	2030-2031		2933.64	2933.64	16756	195.91	-2,737.73
8	2031-2032		3080.32	3080.32	17191	221.11	-2,859.22
9	2032-2033		3234.34	3234.34	17638	249.54	-2,984.80
10	2033-2034		3396.06	3396.06	18097	281.63	-3,114.43
11	2034-2035		3565.86	3565.86	18567	317.85	-3,248.01
12	2035-2036		3744.15	3744.15	19050	358.72	-3,385.43
13	2036-2037		3931.36	3931.36	19545	404.86	-3,526.51
14	2037-2038		4127.93	4127.93	20054	456.92	-3,671.01
15	2038-2039		4334.33	4334.33	20575	515.68	-3,818.65
16	2039-2040		4551.04	4551.04	21110	582.00	-3,969.05
17	2040-2041		4778.59	4778.59	21659	656.84	-4,121.75
18	2041-2042		5017.52	5017.52	22222	741.31	-4,276.21
19	2042-2043		5268.40	5268.40	22800	836.64	-4,431.76
20	2043-2044		5531.82	5531.82	23392	944.24	-4,587.59
						IRR	**Not Calculable**

13.3 ECONOMIC ANALYSIS / EIRR

Economic analysis attempts to measure the overall impact of the project on improving the economic welfare of the citizens of the country. It would assess the project in context of national economy rather than project entity. Economic analysis of an investment proposed differs from the financial analysis in terms of identification of identification and evaluation of inputs and outputs and in measurements of cost benefits.

The economic analysis would be carried out by determining the economic cost involved in the project and economic benefits being accrued with the development of project. The economic cost and benefits associated with a project ultimately leads to EIRR computation.

ECONOMIC COST

For EIRR computation, economic cost shall be calculated as a percentage of total cost of project. The total cost for a project consists of capital cost during construction period and operation and maintenance cost over project life.

The economic benefits that will accrue with the development of waterways shall be classified as:

- Employment benefits
- Fuel savings
- Carbon credits earned
- Other benefits such as accidents, noise

For economic analysis, it is assumed waterway bound Cargo to/for Katwa thermal power plant will use Haldia or Diamond Harbour ports for offshore transportation to large vessels. Thereafter, the same shall use National Waterway -1 till confluence with Ajoy River and shall divert to Ajoy Waterway, towards proposed terminal, thereby, reducing the surface transport by about 5 km. Considering above scenario, the economic benefit analysis is done for the proposed fairway as provided in **Table 69.**

Table 69: Economic benefit from IWT as compared to Road Transport

Road distance covered by IWT =	5	Km
Cargo proposed to be diverted from road to IWT daily =	14000	Tonne
Saving in fuel cost for cargo transferred from road to IWT=	2.5	INR/Tonne/Km

Saving in fuel cost for Cargo transportation by IWT =	175000	INR per day
No of days service is operation per year =	300	days
Saving in fuel cost for Cargo transportation by IWT annually=	52500000	INR per year
	525	INR Lacs per year
Road accident cost savings for Cargo transferred to IWT=	0.2	INR/tons/Km/day
	14000	INR per day
	4200000	INR per year
	42	INR Lacs per year
Carbon savings for Cargo transferred to IWT=	0.1	INR/tons/Km/day
	7000	INR per day
	2100000	INR per year
	21	INR Lacs per year
Job creation per year =	247	numbers
Annual salary =	1039.5	INR Lacs
Average existing annual salary =	144000	INR
Annual earning by Job creation =	683.82	INR per year
	684	INR Lacs per year
Total savings by using IWT =	**1272**	INR Lacs per year
Incremental saving per year =	1%	

On the basis of above economic benefit, EIRR is calculated and provided in **Table 70** & **Table 71.**

Table 70: EIRR for IWT in Ajoy Waterway (excluding Land Cost)

Sl. No	Year	Economic Benefit (INR lacs)	Financial Income (INR Lacs)	Total Income (INR Lacs)
-5	2018-2019		-2075.90	-2075.90
-4	2019-2020		-3736.61	-3736.61
-3	2020-2021		-6227.69	-6227.69
-2	2021-2022		-5604.92	-5604.92
-1	2022-2023		-3113.84	-3113.84
0	2023-2024	1272.00	-2000.89	-728.89
1	2024-2025	1284.72	-2094.33	-809.61

Sl. No	Year	Economic Benefit (INR lacs)	Financial Income (INR Lacs)	Total Income (INR Lacs)
2	2025-2026	1297.57	-2191.59	-894.02
3	2026-2027	1310.54	-2292.76	-982.22
4	2027-2028	1323.65	-2397.91	-1074.26
5	2028-2029	1336.88	-2507.09	-1170.21
6	2029-2030	1350.25	-2620.36	-1270.10
7	2030-2031	1363.76	-2737.73	-1373.98
8	2031-2032	1377.39	-2859.22	-1481.83
9	2032-2033	1391.17	-2984.80	-1593.63
10	2033-2034	1405.08	-3114.43	-1709.35
11	2034-2035	1419.13	-3248.01	-1828.88
12	2035-2036	1433.32	-3385.43	-1952.11
13	2036-2037	1447.65	-3526.51	-2078.85
14	2037-2038	1462.13	-3671.01	-2208.88
15	2038-2039	1476.75	-3818.65	-2341.89
16	2039-2040	1491.52	-3969.05	-2477.53
17	2040-2041	1506.44	-4121.75	-2615.32
18	2041-2042	1521.50	-4276.21	-2754.71
19	2042-2043	1536.71	-4431.76	-2895.04
20	2043-2044	1552.08	-4587.59	-3035.50
	Internal Rate of Return (IRR)		**Not Calculable**	**Not Calculable**

Table 71: EIRR for IWT in Ajoy Waterway (including Land Cost)

Sl. No	Year	Economic Benefit (INR lacs)	Financial Income (INR Lacs)	Total Income (INR Lacs)
-5	2018-2019		-2239.49	-2239.49
-4	2019-2020		-4031.08	-4031.08
-3	2020-2021		-6718.47	-6718.47
-2	2021-2022		-6046.62	-6046.62
-1	2022-2023		-3359.24	-3359.24

Sl. No	Year	Economic Benefit (INR lacs)	Financial Income (INR Lacs)	Total Income (INR Lacs)
0	2023-2024	1272.00	-2000.89	-728.89
1	2024-2025	1284.72	-2094.33	-809.61
2	2025-2026	1297.57	-2191.59	-894.02
3	2026-2027	1310.54	-2292.76	-982.22
4	2027-2028	1323.65	-2397.91	-1074.26
5	2028-2029	1336.88	-2507.09	-1170.21
6	2029-2030	1350.25	-2620.36	-1270.10
7	2030-2031	1363.76	-2737.73	-1373.98
8	2031-2032	1377.39	-2859.22	-1481.83
9	2032-2033	1391.17	-2984.80	-1593.63
10	2033-2034	1405.08	-3114.43	-1709.35
11	2034-2035	1419.13	-3248.01	-1828.88
12	2035-2036	1433.32	-3385.43	-1952.11
13	2036-2037	1447.65	-3526.51	-2078.85
14	2037-2038	1462.13	-3671.01	-2208.88
15	2038-2039	1476.75	-3818.65	-2341.89
16	2039-2040	1491.52	-3969.05	-2477.53
17	2040-2041	1506.44	-4121.75	-2615.32
18	2041-2042	1521.50	-4276.21	-2754.71
19	2042-2043	1536.71	-4431.76	-2895.04
20	2043-2044	1552.08	-4587.59	-3035.50
	Internal Rate of Return (IRR)		**Not Calculable**	**Not Calculable**

13.4 SENSITIVITY ANALYSIS

Sensitivity analysis shows the uncertainty in the output values for different sources of uncertainty in its inputs. The financial and economic evaluation of proposed IWT operations in Ajoy waterway depends on factors like, fuel cost, demand ratio of IWT, serviceability and operational days in a year. These fluctuations will have a dramatic effect on the profitability of IWT. A detailed sensitivity analysis has not been carried out for each of the constituent cost elements.

Sensitivity analysis of IWT on Ajoy waterway is carried out for varying fare considering the basic operational and serviceability conditions as same. For varying fare, the change in FIRR is shown in **Table 72 & Table 73.**

Table 72: FIRR and EIRR for varying Tariff (excluding Land Cost)

Sr. No.	Tariff (INR/Ton/km.)	FIRR (%)	EIRR (%)
1	5	Not Calculable	Not Calculable
2	6	Not Calculable	-7.8
3	7	Not Calculable	-3.78
4	8	-12.52	-1.21
5	9	-7.75	0.71
6	10	-4.72	2.25
7	11	-2.5	3.56
8	12	-0.73	4.7
9	13	0.74	5.7
10	14	2.01	6.62
11	15	3.12	7.45
12	16	4.13	8.22
	Not Calculable	All/majorly negative cash-flows	

Table 73: FIRR and EIRR for varying Tariff (including Land Cost)

Sr. No.	Tariff (INR/Ton/km.)	FIRR (%)	EIRR (%)
1	5	Not Calculable	Not Calculable
2	6	Not Calculable	-8.06
3	7	Not Calculable	-4.11

Sr. No.	Tariff (INR/Ton/km.)	FIRR (%)	EIRR (%)
4	8	-12.64	-1.58
5	9	-7.93	0.31
6	10	-4.95	1.84
7	11	-2.76	3.12
8	12	-1.02	4.23
9	13	0.42	5.23
10	14	1.67	6.12
11	15	2.76	6.94
12	16	3.75	7.69
	Not Calculable	All/majorly negative cash-flows	

From the above table, it can be concluded that the proposed IWT operation along Ajoy waterway is financially viable for IWT fare of more than 13.0 INR/tonne/Km and economical viable for IWT fare of more than 9.0 INR/tonne/Km, which is not possible considering the current IWT tariff in other national waterways.

13.5 RISK FACTORS AND MITIGATION

The risks foreseen at this stage of the project for successful implementation and execution of the project are provided as below:

Pre-operative task risks	
External linkages	Refers to the risk that adequate and timely connectivity to the project site is not available, which may impact the commencement of construction and overall pace of development of the project.
Financing risks	Refers to the risk that sufficient finance will not be available for the project at reasonable cost (eg, because of changes in market conditions or credit availability) resulting in delays in the financial closure for a project.
Planning risks	Refers to the risk that the pre-development studies (technical, legal, financial and others) conducted are inadequate or not robust enough resulting in possible deviations from the outcomes that were planned or expected in the PPP project development.
Construction phase risks	

Design risk	Refers to the risk that the proposed design will be unable to meet the performance and service requirements in the output specification. It can result in additional costs for modification and redesign.
Construction risk	Refers to the risk that the construction of the assets required for the project will not be completed on time, on budget or to specification. It may lead to additional raw materials and labour costs, additional financing costs, increase in the cost of maintaining existing infrastructure or providing a temporary alternative solution due to a delay in the provision of the service.
Approvals risk	Refers to the risk that delays in approvals to be obtained during the construction phase will result in a delay in the construction of the assets as per the construction schedule. Such delays in obtaining approvals may lead to cost overruns
Operation phase risks	
Operations and maintenance risk	Refers to the risks associated with the need for increased maintenance of assets or machinery over the term of the project in order to meet performance requirements. In a brownfield PPP, where the private partner takes over operation of existing assets, O&M risk is very sensitive to the starting condition of the assets. In this case the private operator's O&M risk is related to the risk of poor or incomplete information about the quality of the assets that it will take over
Volume risk	Refers to the risk that demand for water or sanitation services will vary from the initial forecast, such that the total revenue derived from the project over the project life will vary from initial expectations
Payment risk	Refers to the risk that charges for services are not collected in full or are not set at a level that allows recovery of costs. Who bears the payment risk depends on whether the charges for services are paid directly by users, or are paid by the municipality. If charges are paid by the municipality (via taxes) the public sector bears this risk
Financial risk	Refers to the risk that the concessionaire introduces too much financial stress on a project by using an inappropriate financial structure for the privately financed components of the project. It can result in additional funding costs for increased margins or unexpected refinancing costs.
Performance risk	This is a risk that the quality of services delivered will not meet the performance standards agreed in the Concession Agreement. The Concession Agreement should stipulate penalties or compensation terms in this case.
Environmental risk	Refers to the risk of environmental damage in excess of what is planned for in the environmental impact mitigation plan. For example, ground water pollution from sewerage release.

Handover risks	
Handover risk / Terminal value risk	Refers to the risk that the concessionaire will default in the handover of the asset at the end of the project life, or that it will fail to meet the minimum quality standard or value of the asset that needs to be handed back to the public entity. This risk (and terminal value risk) generally relates to concession and BOT type PPPs. However, it may also be relevant to performance based management contracts in which the private partner is responsible for investing in meters
Other risks	
Change in law	Refers to the risk that the current legal / regulatory regime will change, having a material adverse impact on the project.
Force Majeure	Refers to the risk that events beyond the control of either entity may occur, resulting in a material adverse impact on either party's ability to perform its obligations under the PPP contract. These events are sometimes also called "Acts of God", to indicate that they are beyond the control of either contracted party
Concessionaire risk	Refers to the risk that the concessionaire will prove to be inappropriate or unsuitable for delivery of the project, for example due to failure of their company
Sponsor risk	Refers to the risk that the Sponsor will prove to be an unsuitable partner for the project, for example due to poor project management or a failure to fully recognise the agreed terms of the Concession Agreement
Concessionaire event of default	Refers to the risk that the concessionaire will not fulfil its contractual obligations and that the public Sponsor will be unable to either enforce those obligations against the concessionaire, or recover some form of compensation or remedy from the concessionaire for any loss sustained by it as a result of the breach.
Government event of default	Refers to the risk that the public Sponsor will not fulfil its contractual obligations and that the concessionaire will be unable to either enforce those obligations against the Sponsor, or recover some form of compensation or remedy from the Sponsor for any loss sustained by it as a result of the breach.

13.6 NECESSITY OF GOVT. SUPPORT (VGF/PPP)

The guide lines were notified by the ministry of finance, department of economic affairs for financial support to infrastructure project that are to be undertaken through Public Private Partnerships (PPP).

Proposal is to be made under this scheme shall be considered for providing Viability Gap Funding (GAF), one time or deferred with the objective of making a PPP project commercially viable.

The proposal shall relate to a public private partnership (PPP) project which is based on a contract or concession agreement between a Government or statutory entity (Inland Waterways Authority of India) on the one side and a private sector company on the other side, for delivering an infrastructure service on payment of user charges.

This scheme will apply only if the contract/concession is awarded in favour of a private company in which 51% or more of the subscribed and paid up equity is owned and controlled by a private entity.

A private sector company shall be eligible for VGF only if it is selected on the basis of open competitive bidding and is responsible for financing, construction, maintenance and operation of the project during concession period.

The project should provide a service against payment of a predetermined tariff or user charge.

The proposal for seeking clearance of the Empowered Institution shall be sent (in six copies, both in hard and soft form) to the PPP cell of the Department of Economic Affairs in the prescribed format. The proposal should include copies of all project agreements (such as concession agreement, state support agreement etc.) and the project report.

Once cleared by Empowered Institution, the project is eligible for financial support financial bids shall be invited by the concerned ministry, state Government or statutory entity, as the case may be, for the award of the project within four months of the approval of the Empowered Institution. This period may be extended by the Department of Economic Affairs

The private sector company shall be selected through a transparent and open competitive bidding process. The criterion for bidding shall be the amount of VGF required by a private sector company where all other parameters are comparable.

14.0 CONCLUSIONS AND RECOMMENDATIONS

The viability of Inland Water Transport project for introduction of navigation on any waterway can be judged by both technically and commercially. The technical viability of the project can be assessed based on availability of discharges to maintain navigable depth in a design channel suitable to ply design vessel. The commercial viability of the project can be gauged based on traffic potential and its growth over the project period and return on investment made besides several others socio-economic benefits such as employment generation, poverty alleviation in rural areas and so on. The recommendation for implementation of the project is based on the trade-off between costs to be incurred and benefits derived.

As per the traffic studies, at present no cargo or passenger traffic is available. However, in view of the upcoming Katwa Thermal Plant, in-bound traffic of 3.0 million ton/annum of Coal and out-bound traffic of 1.2 million ton/annum is expected after the commissioning of plant. In the present studies, it has been considered/assumed that the plant may be commissioned within 5 years, however, the same is not confirmed from any authentic/reliable sources as *"no information is received from NTPC to assess the present status or the commissioning schedule of the project".*

The existing river is technically not feasible for using as water-way in view of heavy dredging requirement & sharp bends of about 150 m. radius against the requirement of 300 m. However, an attempt has been made to work-out the feasibility of separate navigation channel.

A Dry bulk cargo terminal is proposed to cater the cargo demand generated by Katwa Thermal power plant. The capital cost for development of the system components of the project viz., development of the design waterway and construction of IWT terminal has been worked out as INR 20,758.96 Lacs excluding land cost & INR 22,394.90 Lacs including land cost and the estimated operating and maintenance cost per annum is INR 2,084.89Lacs.

The cost benefit analysis, calculations done for financial internal rate of return (FIRR) and Economic internal rate of return (EIRR) concludes that at the present IWAI tariff of INR 1.0 per ton per km., both FIRR & EIRR cannot be worked-out due to heavily negative cash-flows.

In the light of the above, the following may be concluded:

a) Ajoy river, in its present topographic & hydrographic conditions, is not favourable for being developed as Waterway.

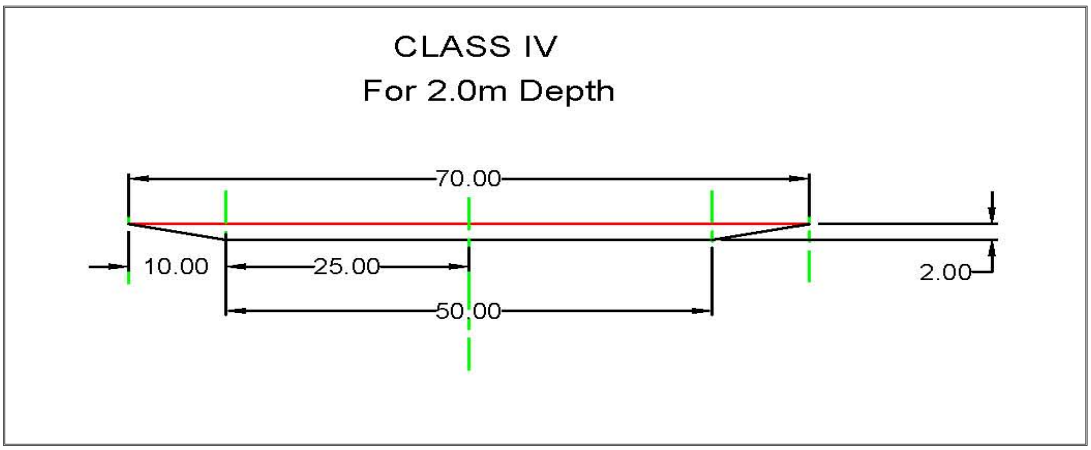
b) Availability of cargo traffic is not assured, due to non-availability of authentic information regarding commissioning of Katwa Thermal Power Plant.
c) Construction of separate navigation channel & other associated infrastructure require heavy capital & operation cost, making it financially as well as economically un-viable.
d) Construction of separate navigation channel shall require acquisition of fertile land, which may result in the severe R&R issues.
e) Diversion of river flow in the navigation channel shall end in drying-up of the existing river, downstream of starting point of the channel, having significant Environmental impact.

In view of all above factors, it may be concluded that the development of Ajoy River as waterway is not techno-commercially feasible; hence *Ajoy River is not recommended for IWT operations as per current studies.*

ANNEXURES

ANNEXURE 1: ToR OF THE AGREEMENT

ANNEXURE 2: MINIMUM AND MAXIMUM DEPTH W.R.T CD



Chainage (km)		Observed					Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
0	1	0.58	5.8	400	18539.89	18539.89	-0.3	3.41	1000	71467.53	71467.53
1	2	0	7.57	900	54139.66	72679.6	-0.3	7.03	1000	88848.24	160315.77
2	3	0	1.97	1000	774862.49	847542.0	-0.3	0.41	1000	146858.69	307174.46
3	4	0	6.41	1000	32498.49	880040.5	-0.3	3.56	1000	80622.67	387797.13
4	5	0	1.52	1000	86341.57	966382.1	-0.3	0.49	1000	159493.05	547290.18
5	6	0	0	1000	137822.12	1104204.2	-0.3	0	1000	119489.08	666779.26
6	7	0	1.33	1000	140771.12	1244975.3	-0.3	0.98	1000	105329.75	772109.01
7	8	0	4.5	1000	81923.72	1326899.1	-0.3	2.76	1000	69900.04	842009.05
8	9	0	0	1000	139528.54	1466427.6	-0.3	0	1000	133065.85	975074.9
9	10	0	0	1000	147745.91	1614173.5	-0.3	0	1000	130915.75	1105990.65
10	11	0	0	1000	146384.43	1760557.9	-0.3	0	1000	120364.02	1226354.67
11	12	0	0	1000	147425.68	1907983.6	-0.3	0	1000	130987.95	1357342.62
12	13	0	0	1000	145812.18	2053795.8	-0.3	0	1000	129437.18	1486779.8
13	14	0	0	1000	148316.15	2202112.0	-0.3	0	1000	134799.99	1621579.79
14	15	0	0	1000	147995.68	2350107.6	-0.3	0	1000	134207.34	1755787.13
15	16	0	0	1000	142104.19	2492211.8	-0.3	0	1000	127949.1	1883736.23
16	17	0	0	1000	11021.48	2503233.3	-0.3	0	1000	127738.28	2011474.51
17	18	0	0	1000	138544.07	2641777.4	-0.3	0	1000	128127.98	2139602.49
18	19	0	0	1000	144428.4	2786205.8	-0.3	0	1000	117956.75	2257559.24
19	19.59	0	0	590	74278.58	2860484.4	-0.3	0	590	57592.34	2315151.58
			Total	18890	2860484.4			Total	19590	2315151.6	

ANNEXURE 3: ENVIRONMENTAL SCREEING TEMPLATE

Screening Question	Yes	No	Details / Remarks
1. Is the project located in whole or part in / near any of the following Environmentally Sensitive Area? If yes, please provide the name and distance from the project site.			
a) National Park		√	
b) Wildlife/ Bird Sanctuary		√	
c) Tiger or Elephant Reserve		√	
d) Biosphere Reserve		√	
e) Reserved / Protected Forest		√	
f) Wetland		√	
g) Important Bird Areas		√	
h) Mangroves Areas		√	
i) Estuary with Mangroves		√	
j) Areas used by protected, important or sensitive species of fauna for breeding, nesting, foraging, resting, over wintering, migration		√	
k) World Heritage Sites		√	
l) Archeological monuments/ sites (under ASI's Central / State list)		√	
2. Is the project located in whole or part in / near any Critically Polluted Areas identified by CPCB?		√	
3. Is, there any defense installations near the project site?		√	
4. Whether there is any Government Order/ Policy relevant / relating to the site?		√	
5. Is the project involved clearance of existing land, vegetation and buildings?	√		
6. Is the project involved dredging?	√		
7. Is the project area susceptible to natural hazard (earthquakes, subsidence, erosion,	√		Prone to Flood, Cyclones and heavy winds

Screening Question	Yes	No	Details / Remarks
flooding, cyclone or extreme or adverse climatic conditions)			
8. Is the project located in whole or part within the Coastal Regulation Zone?		√	
9. Is the project involved any demolition of existing structure?		√	
10. Is the project activity requires acquisition of private land?		√	
11. Is the proposed project activity result in loss of direct livelihood / employment?		√	
12. Is the proposed project activity affect schedule tribe/ caste communities?		√	

S. No.	Result of Screening Exercise	(Yes / No)
1	Environment Impact Assessment is Required	Yes
2	CRZ Clearance is Required	No
3	Environmental Clearance is Required	No
4	Forest Clearance is required	No
5	Wildlife Clearance is required	No
6	NOC from SPCB is required	Yes
7	Social Impact Assessment is required	Yes
8	Abbreviated RAP is required	No
9	Full RAP is required	Yes
10	Any other clearance is required	Various NOCs for construction activities

ANNEXURE 4: MoEFCC Memorandum

No. F.No.14-9/2016-IA-III
Government of India
Ministry of Environment, Forest and Climate Change
(Impact Assessment Division)

Indira Paryavaran Bhawan
Jor Bagh Road, Aliganj
New Delhi-110003

Dated: 21st December, 2017.

OFFICE MEMORANDUM

Subject: Non-requirement of environment clearance for maintenance dredging in rivers for the purpose of navigation - regarding.

This has reference to your Office Memorandum IWT-11011/89/2016-IWT-(Vol.II) dated 7th December 2017 on the above mentioned subject.

2. The minutes of the meeting held under chairmanship of Hon'ble Minister, Road Transport & Highways, Shipping and Water Resources, River Development & Ganga Rejuvenation held on 24.10.2017 concluded that as per the extant legal position, no prior EC is required for maintenance dredging for navigational channel for Inland Waterways.

3. In view of the above the Ministry of Shipping may like to go ahead with the decision taken during the meeting held under chairmanship of Hon'ble Minister, Road Transport & Highways, Shipping held on 24.10.2017 subject to the implementation of the environmental safety measures as enclosed as annexure.

4. This issues with the approval of the competent authority.

Sharath Kumar Pallerla
Director

To

The Secretary,
Ministry of Shipping,
Parivahan Bhavan, 1, Parliament Street,
New Delhi - 110 001

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ANNEXURE

Environmental safety measures to be implemented

i. 'Consent to Establish' and 'Consent to Operate' shall be obtained from State Pollution Control Board under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974.
ii. The project authority shall ensure that no rivers or tributaries are blocked due to any activities at the project site and free flow of water is maintained.
iii. Shoreline shall not be disturbed due to dumping. Periodical study on shore line changes shall be conducted and mitigation carried out, if necessary.
iv. Dredging shall not be carried out during the fish/turtle breeding seasons.
v. All vessels used in the river will be fitted with noise control and animal exclusion devices so that aquatic life is not unduly disturbed.
vi. Spillage of fuel / engine oil and lubricants from the construction site are a source of organic pollution which impacts aquatic life, particularly benthos. This shall be prevented by suitable precautions and also by providing necessary mechanisms to trap the spillage.
vii. Construction waste including debris shall be disposed safely in the designated areas and in no case shall be disposed in the aquatic environment.
viii. Vessels shall not discharge oil or oily water such as oily bilge water containing more than 15 ppm of oil.
ix. The project authority shall ensure that water traffic does not impact the aquatic wildlife sanctuaries that fall along the stretch of the river.
x. All vessels will also have to comply with 'zero discharge' standards to prevent solid or liquid waste from flowing into the river and affecting its biodiversity.
xi. The dredging shall be carried by integrated and systematic planning by selective grid method by allowing migratory movement of Benthic fauna.
xii. All required Noise and vibration control measures are to be adopted in Dredgers. Cutter section Dredgers should be avoided as much as possible which produces more noise and vibration. No Drilling and Blasting is to be carried out.
xiii. Pre geo-tectonic studies has to be completed and the strata to be dredged is predetermined with complete data pertaining to hardness, compressive and tensile strengths.
xiv. Dredger type and other strata loosening methods shall be preconceived.
xv. Staggered dredging shall be carried based on turbidity monitoring to minimise the impact of turbidity.
xvi. Threshold level of turbidity, which has a minimal effect on fauna, has to be predetermined and Dredging planned accordingly.
xvii. Further silt screens needs to be used for minimising the spread of Turbidity.

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xviii. Disposal places of Dredged sediments needs to be predetermined, along the shore by assessment of suitability, which will not affect the shoreline (erosion) and also causing impacts during monsoon and flooding.

xix. As much as possible, it shall not be disposed off in the river itself, and the site should be such that the dispersion is quicker by undertaking modelling studies.

xx. Ballast water control and management measures shall be implemented.

xxi. Waste and waste water reception facilities in Jetty shall be implemented.

xxii. The Risk and Disaster management plan has been prepared in consonance with the manual of terminals and harbours issued by the Ministry of Environment and Forests dated 5th May 2010.

xxiii. Standard Operating Procedures (SOP) and Emergency Response Plan (ERP) for onsite and offsite emergencies shall be prepared and implemented based on Hazard Identification and Risk Assessment to handle, process, store and transport of hazardous substances.

xxiv. Oil spill contingency plan shall be prepared and part of DMP to tackle emergencies. The equipment and recovery of oil from a spill shall be assessed. Guidelines given in MARPOL and Shipping Acts for oil spill management shall be followed.

xxv. No diversion of the natural course of the river shall be made without prior permission from the Ministry of Water resources.

xxvi. All the erosion control measures shall be taken at water front facilities.

xxvii. Necessary Air Pollution Control measures shall be taken during loading, unloading, handling, transport of the material at the berthing and water front facilities.

xxviii. The Vessels shall comply the emission norms prescribed from time to time.

xxix. All safety measures are to be implemented in coordination with the respective state government departments such as State Forest Department, Public Works Department, State Pollution Control Board etc.

Sharath Kumar Pallerla
Director

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ANNEXURE 5: PHOTOGRAPHS

Topographic Survey Chainange 5.5

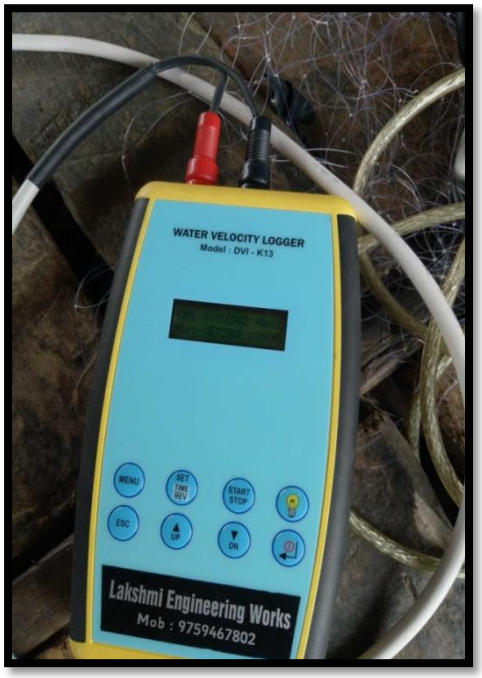
Bathymetric Survey Chainage 0.2

Data Logging system in Boat

BM AJ-01

Tide Pole near AJ- 01

High Tension Wire at Sankhai



Current meter Observation

Boat Preparing

Ferry Services from Katwa to Sankhai Chainange 1

Ferry Ghat at Katwa Chainange 1

DGPS Observation at BM AJ-02

Irrigation Tide Gauge at Katwa

Bathymetric Survey

River Bank Chainange 2.3

River Bank At Chainage 4.2

River near Kakurhati At Chainage 5.5

Current Meter Observation Chainange 6

Dry area of Ajoy River at Chainage 6.0 and Road Bridge at 6.5

Railway and Road Bridge at Chainage 6.5

Railway Bridge at Chainage 6.5

Bridge Under Construction at Chainage 6.5

River Condition at Chainage 7.0

High Tension Line Crossing at Chainage 6.4 Kakurhati

Dry area of Ajoy River at Chainage 5.4

Ajoy River at Chainage 7.5

Ajoy River at Chainage 8.0

Ajoy River at Chainge 10.0

Unprotected Bank at Chainage 11.0

High tension Crossing at Chainage 13.9

River Complete Dry at Chainage 15.0

River Complete Dry at Chainage 18.0

DGPS Observation- BM AJ-03 at Rosui Chainage 20.0

VOLUME – II

DRAWINGS